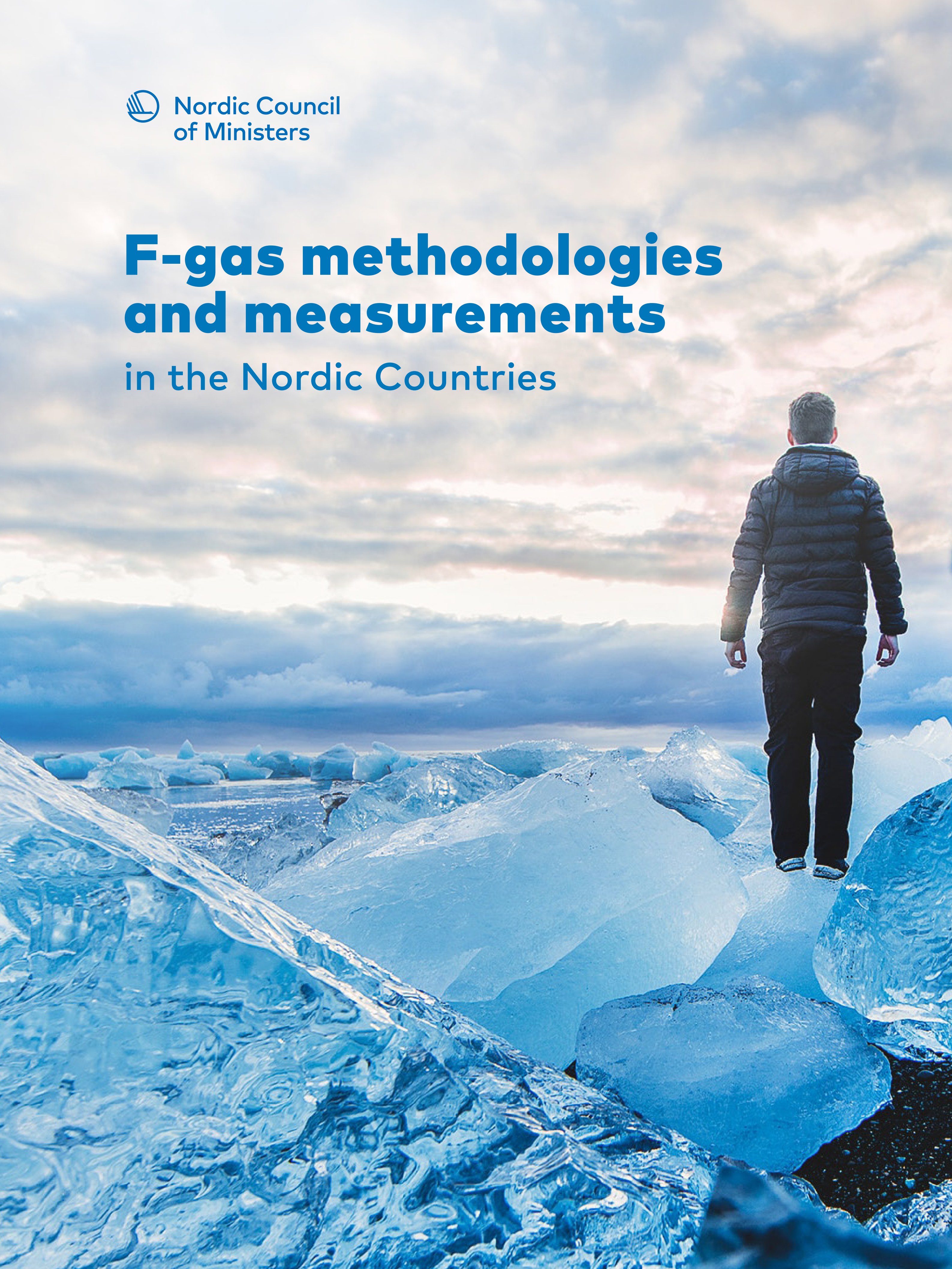

Nordic Council of Ministers

F-gas methodologies and measurements

in the Nordic Countries

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Contents


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Introduction

Background

This project report is a part of the project Nordic Policy Cluster for F-gases with the purpose of comparing the Nordic countries' methodologies and regulations related to the use of F-gases[1]. The project has been financed by the Nordic Climate and Air Pollution group (KOL) under the auspices of the Nordic Council of Ministers.

Fluorinated gases (F-gases, including HFCs, PFCs, SF6 and NF3) are a range of potent greenhouse gases that are used in a number of different applications and products for refrigeration, foams, aerosols, and technical installations.

The report contains a survey and an overview of F-gas methodologies used for UNFCCC reporting, as well as an account of emissions and regulations in the Nordic countries.

The project comprises the following Nordic countries:

- Denmark
- Finland
- Iceland
- Norway
- Sweden

An initial survey to collect country-specific data on emission estimation methodologies and data collection approaches were conducted in the period of April to June 2017. During this period, a questionnaire was distributed to appointed country contacts and received answers forms a part of this project report. The results are summarized in the report and the full survey is presented in Appendix 1.

During the project, the workgroup participants were:

- Kathrine Bjønness, Lene Skyrudsmoen, Statistics Norway, Norway
- Nicole Keller, Martina Stefani, Kári Jónsson, Umhverfisstofnun, Iceland

1 PFC formation arising from aluminium production is not included in the study

- Helena Danielsson, Tomas Gustafsson, IVL Swedish Environmental Research Institute, Sweden
- Tomas Sander Poulsen, Provice, Denmark
- Tommi Forsberg, Finnish Environment Institute, Finland

The workgroup was established in January 2017 and met 3-4 times a year during 2017 and 2018. The meetings were organized as workshops with varying topics for discussion, i.e.:

- Benchmark and comparison of the Nordic F-gas emissions and sources
- Refrigeration and air-conditioning (RACs) with particular focus on stationary air-conditioning (CRF[2] 2.F.1.f),
- Mobile air-conditioning (MAC) and transport refrigeration (CRF 2.F.1.e and CRF 2.F.1.d, respectively)
- Applied emission factors per sub-categories
- Recovery of F-gases at end-of-life of products
- Methods for data-collection

Furthermore, two Nordic workshops were organised for dissemination and discussion of the results. Invitees were Nordic representatives with experiences from F-gas regulation, the RAC industry, and other interested F-gas specialists. The first workshop took place in September 2017, the second workshop in May 2019, and 20-25 participants took part in each of them.

Objective

The objective with the analysis is to provide an overview of differences and similarities within the Nordic countries in relation to F-gases. The analysis shall enable harmonization of data collection, emission factors, choice of methods, and regulatory instruments.

- Interesting parameters for comparison include:
- Variation of identified F-gas products per country
- Variations of total emissions and consumptions
- Variation of data sources
- Variations in emission from disposal
- Legal differences

The following tables and figures provide comparable overviews of key results of the project. The overview is structured in the relevant themes.

2 CRF – Common Reporting Format. Standardised data tables used for reporting on emission data to the UNFCCC.

The analysis shall enable harmonization of data collection, emission factors, choice of methods, and regulatory instruments


Photo: Kylli kittus, Unsplash.com

Nordic F-gas emissions

The total Nordic F-gas emissions from handling, use and disposal of F-gases were in 2017 estimated to approx. 4.6 mio. tonnes of CO2 equivalents. The F-gas contribution averages approx. 2% of the total greenhouse gas emissions. During the past three years, the total Nordic emissions deriving from the use of F-gases have decreased by approx. 56,000 tonnes of CO2 equivalents. There is no obvious trend in total emissions or emissions per capita in the past three years. All emission data presented in this report are in accordance with the 2019 national inventory submissions to the UNFCCC.

Year	Emission, t CO2 eq.
2015	4,685,513
2016	4,828,025
2017	4,628,996

Table 1: The Nordic F-gas emission (HFCs, PFCs, SF6[1]) according to the 2019 national inventory submissions to the UNFCCC

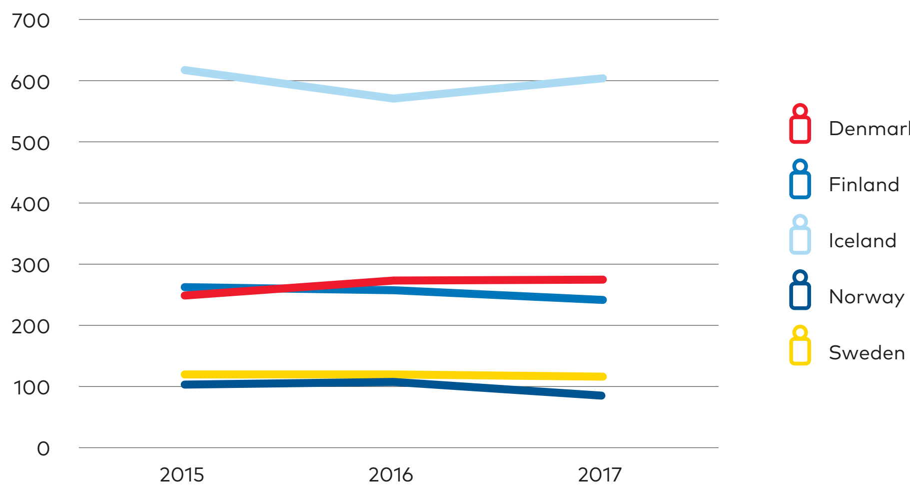
1 NF3 emissions are not occurring in the Nordic countries.

Overall, the sum of emissions of the Nordic countries have reduced from 2016 to 2017. Table 2 shows the development in each of the Nordic countries.

Total emission, 1000 t CO2 eq.	Denmark	Finland	Iceland	Norway	Sweden
2015	583.4	1,430.6	206.3	1,296.0	1,169.2
2016	607.8	1,411.6	193.3	1,428.0	1,187.4
2017	482.0	1,334.7	207.3	1,432.0	1,173.1

Table 2: Total F-gas emissions t CO2 eq. (HFCs, PFCs, SF6) according to the 2019 national inventory submissions to the UNFCCC

Figure 1: F-gas emission pr. capita, kg CO2 eq.



The relative contribution of F-gas emissions is illustrated per capita in Figure 1.

Iceland has the highest emission per capita. The main cause is that Iceland has a relatively large fishing fleet with emissions from refrigeration systems on-board fishing vessels, which contributed to approx. 65% of emissions from the refrigeration sectors in 2016. Furthermore, Iceland is a small society with approx. 350,000 inhabitants. At total levels, Sweden/Denmark and Finland/ Norway are relatively equal when comparing F-gas emissions per capita. Consequently, the Swedish/Danish emissions per capita are less than half of per capita emissions compared to Finland/Norway. With the exception of Iceland, special industrial conditions cannot explain the differences in emissions between countries. The relatively similar infrastructure and societal conditions in the Nordic countries suggest that differences are mainly caused by different methodological approached for calculating the F-gas emissions, e.g. emission factors and data collection. F-gas emissions arise during different life cycle stages: When charging a new equipment at manufacturing or assembly, during lifetime (operation and service), and at end-of-life (disposal).

2017, emissions, CO2 eq.	Charging of new equipment	During lifetime	Disposal	Total
Denmark	9,820	368,001	27,282	405,103
Finland	3,117	999,982	227,439	1,230,538
Iceland	5,109	188,304	10,612	204,025
Norway	2,629	504,394	822,413	1,329,436
Sweden	10,114	929,086	129,365	1,068,564
Sum	30,789	2,989,768	1,217,111	4,237,667
Share of total emissions				
Denmark	0%	9%	1%	10%
Finland	0%	24%	5%	29%
Iceland	0%	4%	0%	5%
Norway	0%	12%	19%	31%
Sweden	0%	22%	3%	25%
Sum	1%	71%	29%	100%

Table 3: Overview of the Nordic F-gas emission contribution between countries and life cycle stages (total and percentages)ww

Table 3 identifies the Nordic emission contributions at life cycle stage per country. The largest life cycle stage contributions are from Finland (24%) and Sweden (22%) at the operation phase and from Norway (19%) at the disposal phase. Norway differs from the other countries by having the largest contribution from the disposal phase. For the other countries, the largest contribution comes from the operation phase.

The majority of F-gas emissions in the Nordic countries stem from refrigeration and air-conditioning (RAC) equipment.

The figure next page summarizes the total Nordic emissions and stocks for all RAC categories.

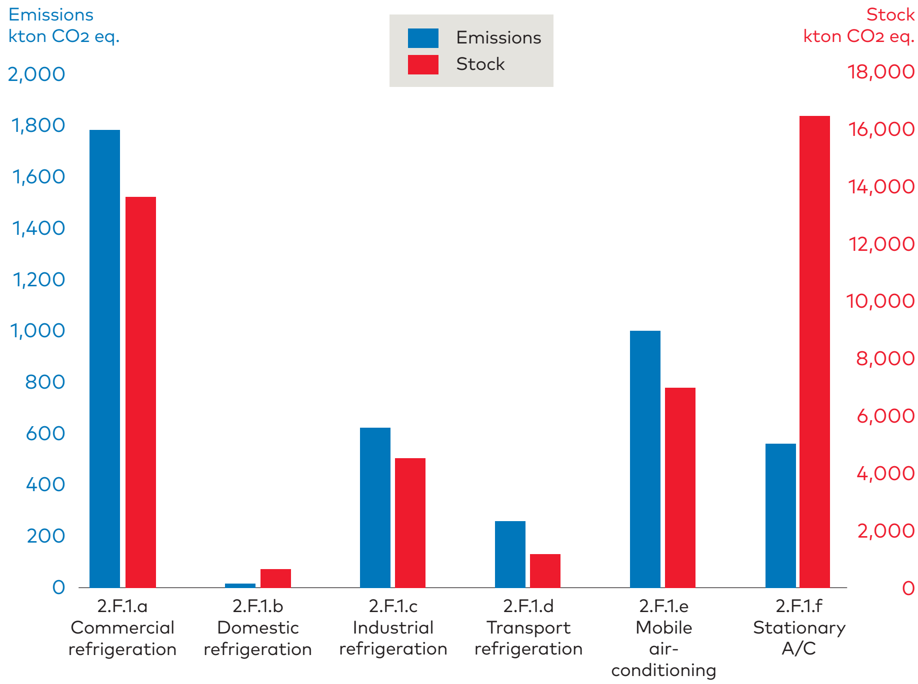


Figure 2: Nordic F-gas emission and stock from RAC

The total Nordic RAC emission is 4,237,557 tonnes of CO2 equivalents, and the total stock is 43,545,617 tonnes of CO2 equivalents.

The largest emission category is *commercial refrigeration*, which constitutes 42% of total emissions. *Mobile air-condition* (MAC) comprises 23.6% of total emissions, *Industrial refrigeration* covers 14.7%, *stationary air-condition* covers 13.2%, *transport refrigeration* covers 6.1% and *domestic refrigeration* constitutes 0.4%.

Based on the installed amount of refrigerant in equipment (stock), the total Nordic stock in RAC is estimated to approx. 36.2m tonnes of CO2 equivalents. *Stationary air-condition* covers 38.3% of the total stock, *medium and large commercial refrigeration* covers 31.7%, and *mobile air-condition* covers 16.2% of the stock.

Based on the overview in Table 3, Nordic efforts for alignment should concentrate particularly on exploration of stationary A/C, *medium and large commercial refrigeration, industrial refrigeration* and *mobile air-condition*. These sub-categories contain the majority of emissions and stocks.

The relatively similar infra-structure and societal conditions in the Nordic countries suggest that differences are mainly caused by different methodological approached for calculating the F gas emissions, e.g. emission factors and data collection.


Photo: Ryan Kwok, Unsplash.com

The Nordic HFC consumption

The consumption of HFCs in the Nordic countries differs. In recent years, the total bulk import of HFCs was approx. 2,000 – 2,100 tonnes HFCs. The amount has been relatively stable during the past years. However, the amounts of HFOs have increased, but the total amount of HFOs is still minor with only a few tonnes per country.

The countries use different approaches for calculating F-gas imports in products. This is reflected in the relative national amount of registered F-gases in products. Figure 3 present an overview of the country variation in import of HFCs as bulk and in products for 2015.

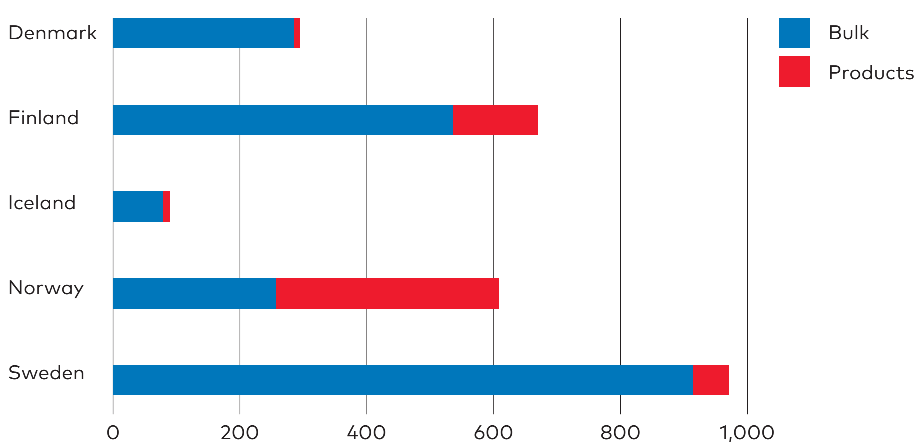


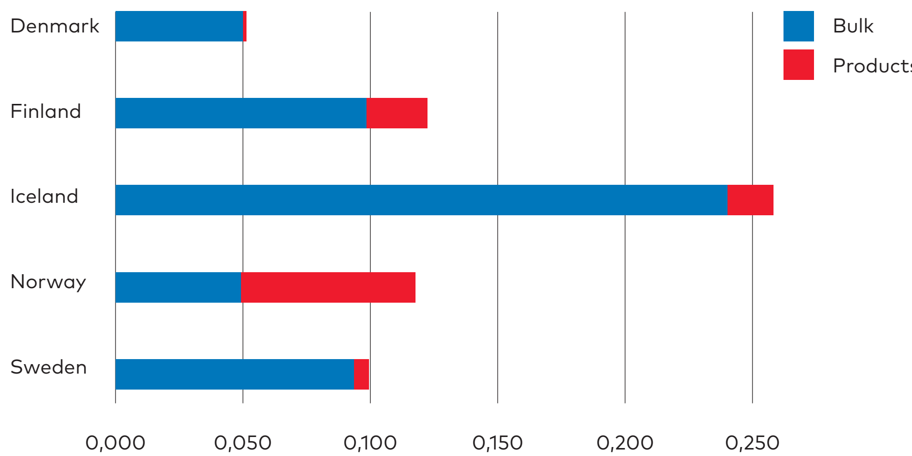
Figure 3: The Nordic HFC import in bulk and product, 2015 (tonnes)

Figure 3 illustrates that Norway registers a substantially larger amount of HFCs imported in products than the other Nordic countries. In contrast, the Danish import of HFCs in products is considerably low. Thus, from 2017 onwards, the registration of Danish import of HFCs was amended, so that HFCs imported in heat pumps are included. This has increased the registered Danish import level with approx. 100 tonnes of HFCs/year.

The figure below shows the Nordic HFC consumption per capita (kg).

Iceland has the highest per capita consumption because Iceland is a small country with a large fishing sector and food sector.

Figure 4: The Nordic HFC consumption per capita (kg, 2015)



The countries use different approaches for calculating F-gas imports in products. This is reflected in the relative national amount of registered F-gases in products.


Photo: Jon Flobrant, Unsplash.com

Emission and emission factor benchmark for RAC (CRF 2.F.1)

The following tables summarize the benchmark results of the Nordic country emissions per capita and emission factors used at the different subcategories for RAC.

The tables categorise the emissions at the different life-cycle stages (charge, operating, disposal), total sum, and total stock.

The various emission factors used for calculating the F-gas emissions were compared and evaluated for all categories and applications where F-gases are used (CRF sub-categories according to the 2006 IPCC guidelines). Generally, there are no country-specific emission factors available, apart from some exceptions, and the values from the 2006 IPCC guidelines default ranges[3] have been applied. The following sections include comparisons of the Nordic emission factors applied for the most important IPCC sub-categories.

In sum, the largest differences in emission factors between the countries are:

- Different operation phase emission factors in some of the main categories, e.g. stationary air-condition
- Different disposal emission factors because of different recovery assumptions

There are also large differences in RAC stock (installed amount of refrigerants in equipment) per capita. These differences have impacts on the amount of registered emissions.

Key findings from the overall assessment of the Nordic F-gas emission calculation:

- The data sources and methods for collecting data on import of F-gases in bulk and in products vary between countries.

3 Table 7.9 in Volume 3, Chapter 7, of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_7_Ch7_ODS_Substitutes.pdf

- The Nordic countries follow the IPCC methods and apply factors within the IPCC default ranges.
- Generally, there are only few country-specific emission factors available.
- Countries have applied different values from the IPCC default ranges, which results in artificial differences in F-gas stocks and emissions per capita.
- Some actual differences in types of equipment and practices can be observed.

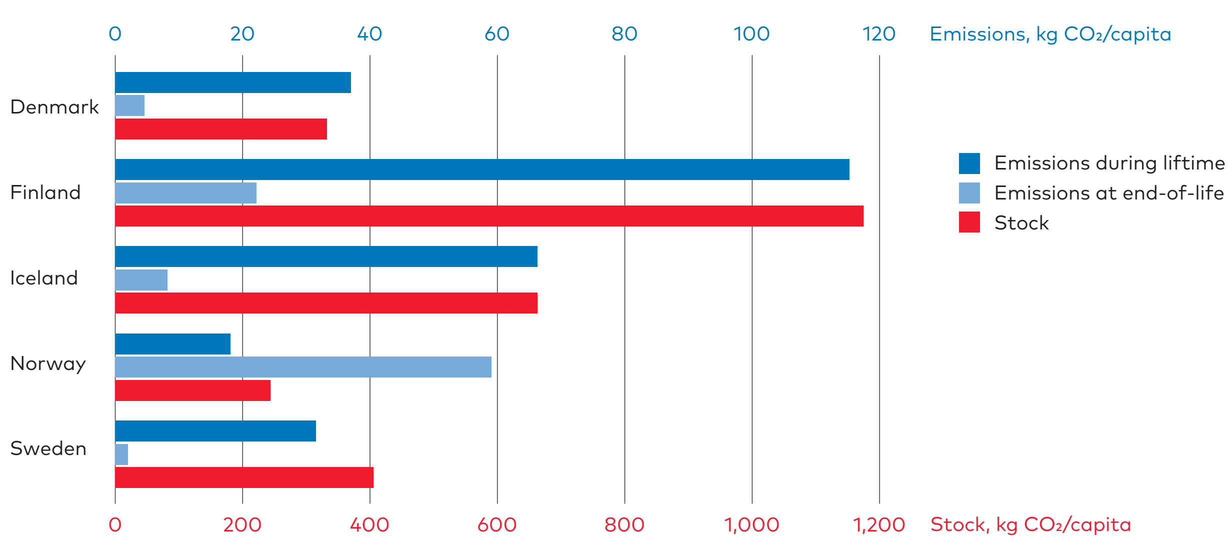
Commercial refrigeration (2.F.1.a)

This category includes both medium and large refrigeration and stand-alone applications. Stand-alone commercial applications are defined as *"smaller hermetically sealed plug-in appliances commonly used in retail food stores and also in pubs, restaurants, and other, hospitality and catering outlets such as hotels, hospitals, and schools".*

There are large differences in estimated stock per capita, ranging from 243,6 to 1,175.1 kg of CO2 equivalents. All countries have applied the same emission factor for medium and large sized equipment for operation. Finland has the highest operation emissions because of a large stock. The cause of Finland's comparatively higher level of stocks is a large share of direct centralized refrigeration systems using HFCs, which are still in use. The refrigerant charge level is considerably higher in the direct systems compared to the indirect HFC systems more commonly used because of strengthened regulation in the other Nordic countries. Norway has high emissions from disposal, while no recovery at all is calculated at end-of-life.

The benchmark per capita emphasizes large differences between the countries, particularly in relation to stock- and operating emissions as well as disposal emissions.

Figure 5: Benchmark of emissions, commercial refrigeration (2.F.1.a), kg CO2 per capita



Finland uses higher emission factors from the 1996 IPCC guidelines when estimating emissions for the 1990s. These were reduced to the level of the 2006 IPCC guideline during the 2000s. Recovery efficiency for Denmark, Iceland, and Sweden is above levels set out by the IPCC guidelines (maximum 70%). Norway has no recovery despite a legal framework for collection. Sweden, Denmark and Norway have a relatively equal estimated stock per capita.

Table 4: Emission factors for medium and large commercial refrigeration (2.F.1.a)

	Lifetimes (years)	Initial Emission	Operation Emission	Recovery Efficiency	Initial Charge Remaining
IPCC 2006 Guidelines	$7 \le d \le 15$	$0.5 \le k \le 3$	$10 \le x \le 35$	$0 < \eta rec,d < 70$	$50 < p < 100$
Sweden	7	0.5	10	95	90
Norway	15	2	10	0	100
Denmark	15	1.5	10	88.5	
Finland	12	5/0.5	17/10	70	90
Iceland	8	2	10	80	

Denmark and Iceland do not report emissions separately for stand-alone commercial applications. In the case of Denmark, a relatively high emission factor for domestic refrigeration is applied. This is to compensate for the fact that some of the bulk data calculated as domestic use are also used for stand-alone applications.

Table 5: Emission factors for stand alone commercial applications (2.F.1.a)

	Lifetimes (years)	Initial Emission	Operation Emission	Recovery Efficiency	Initial Charge Remaining
IPCC 2006 Guidelines	$10 \le d \le 15$	$0.5 \le k \le 3$	$1 \le x \le 15$	$0 < \eta rec,d < 70$	$0 < p < 80$
Sweden	10	0.5	1	95	90
Norway	10	NO	3.5	0	65
Denmark	-	-	-	-	-
Finland	10	5/0.5	17/1	70	80
Iceland	-	-	-	-	

Key findings on *commercial refrigeration:*

- All countries have used more or less the same emission factors.
- Finland has a higher concentration of units based on direct systems with larger charge compared to the indirect HFC systems which are wider used in e.g. Denmark because of regulation.
- Norway has high emissions from disposal since no recovery is assumed at end-of-life.
- For Denmark, industrial refrigeration is included in *commercial refrigeration*.
- The introduction of CO2 as a substitute has not been analysed.
- Sweden, Denmark and Norway have a relatively equal estimated stock per capita.

Domestic refrigeration (2.F.1.b)

Domestic refrigeration is a minor source of F-gas emissions in the Nordic countries.

The category includes household stand-alone refrigerators, freezers and coolers and combinations of the two. The stock per capita ranges from 5.5 to 85.2 kg of CO2 equivalents. Denmark estimates zero emissions from disposal, because the disposal procedures are efficient and Denmark exports large amounts of waste household appliances to Germany for recycling and disposal.

The benchmark per capita illustrates that Denmark differs from the other countries with a higher emission and stock. The Danish stock data for stand-alone household appliances are detailed and based on information from manufactures and import/export data collected since 1998.

Table 6: Benchmark of emissions, Stand alone household appliances (2.F.1.b), kg CO2 per capita

2017, kg CO2 eq.	Charge	Operating	Disposal	Sum	Stock
Denmark		0.8	0.0	0.8	85.2
Finland		0.0	0.4	0.5	5.5
Iceland		0.0	0.1	0.1	
Norway		0.1	1.1	1.2	13.2
Sweden		0.1	0.2	0.2	12.9

Sweden uses a long average lifetime for the applications, but it is still within the IPCC guideline.

In Denmark and Sweden, there are manufacturers of domestic refrigerators, but emission factors are not adjusted to the IPCC 2006 guideline as for the case of Finland.

The recovery efficiency for Denmark, Norway and Sweden is higher than the IPCC guideline (max. 70%).

Denmark and Norway register both HFC 134a (used for fridges) and HFC 404a (used for freezers). Finland, Iceland and Sweden register HFC 134a only. This explain a.o. the higher Danish stock per capita, where HFC 404a is included.

The most commonly used refrigerant in this application area is the non-HFC gas isobutane (R-600A), which was introduced on the market in the 1990s at the same time as HFCs. Under the EU F-gas regulation (517/2014), use of refrigerants with GWPs of 150 or higher in new household refrigerators and freezers is prohibited as of 2015.

Table 7: Emission factors for Domestic refrigeration (2.F.1.b)

	Lifetimes (years)	Initial Emission	Operation Emission	Recovery Efficiency	Initial Charge Remaining
IPCC 2006 Guidelines	$12 \le d \le 20$	$0.2 \le k \le 1$	$0.1 \le x \le 0.5$	$0 < \eta_{rec,d} < 70$	$0 < p < 80$
Sweden	20	2	1	95	90
Norway	15	NO	0.5	100	92.5
Denmark	15	2	1	100	85
Finland	12	NO	0.3	70	
Iceland	12	2.7/0.61	1/0.31	70	80

1 Higher emission factor for 1990s and lower for later years (data sources: 1996 IPCC guideline and 2006 IPCC guideline)

Industrial Refrigeration (2.F.1.c)

With regard to industrial refrigeration, the Nordic countries use different methodological approaches. Denmark does not explicitly report industrial refrigeration, but includes these applications in medium and large *commercial refrigeration*. This demonstrates the diversity of this application area: From major food and beverage industries and cold storage to specialised smaller capacity equipment, e.g. specialised environmental simulation chambers or laboratory equipment. The category can also be applied to large-scale customised on-site build systems and factory build equipment from series production. Natural refrigerants, mainly ammonia, have been widely used in this sector in larger scale systems.

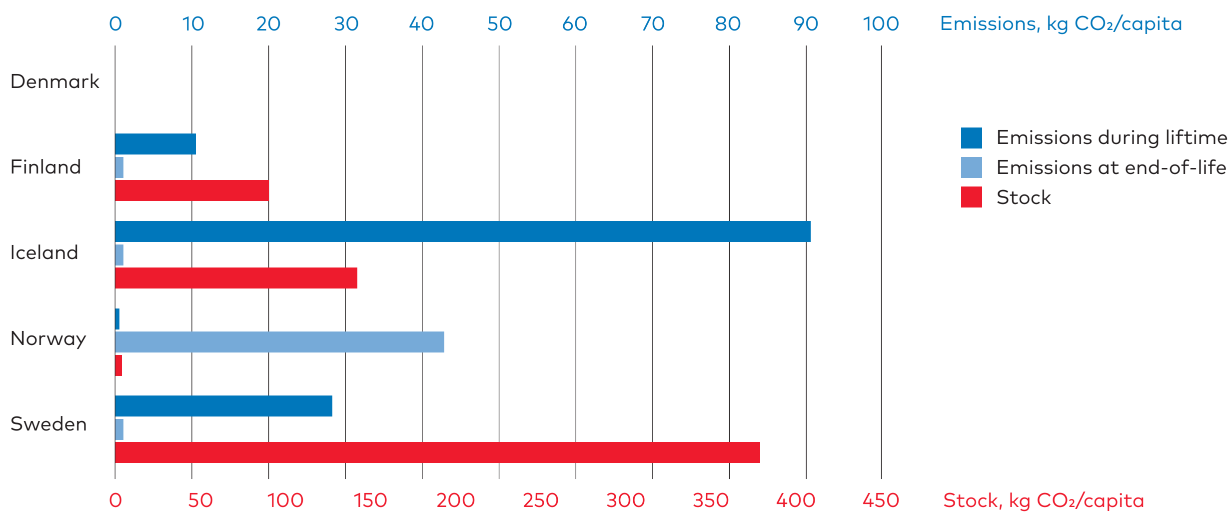


Figure 6: Benchmark of emissions, Industrial refrigeration (2.F.1.c), kg CO2 eq. per capita

The industrial emissions of Iceland consist mainly of the food industry such as fish farming, meat processing (slaughter houses), and vegetable production. Emissions from the fishing industry falls mainly in the category of *transport refrigeration* (2.F.1.d)

Sweden has a high level of stock per capita, Finland and Iceland have relatively similar levels, and Norway has a low level. There are no clear explanations of the difference. Norway has a high emission from disposal, because the emission factor is set to 100% emission at end-of-life.

Finland uses old and new emission factors from the 1996 IPCC guideline and 2006 IPCC guideline. The new emission factors are introduced from 2000-2005 and onwards.

Denmark calculates and reports Industrial refrigeration as *medium and large commercial refrigeration* and does not use CRF 2.F.1.c in reporting.

The recovery efficiency for Sweden is above the level of the IPCC guideline (max. 90%) and Norway calculates with no recovery at all, despite the fact that there is a legal framework for collection.

	Lifetimes (years)	Initial Emission	Operation Emission	Recovery Efficiency	Initial Charge Remaining
IPCC 2006 Guidelines	$15 \leq d \leq 30$	$0.5 \leq k \leq 3$	$7 \leq x \leq 25$	$0 < \eta_{rec,d} < 90$	$50 < p < 100$
Sweden	15	0.5	7	95	90
Norway	15	2	10	0	100
Denmark	15	1.5	10	88.5	
Finland	15	2	10	85	
Iceland	15[1]/20[2]	2/1	17/10[1], 17/9[2]	80	90

1 Industrial refrigeration
2 Ice rinks

Table 8: Emission factors for Industrial Refrigeration (2.F.1.c)

Key findings on *industrial refrigeration*:

- All countries have used more or less the same emission factors.
- There are large emissions per capita in Iceland due to e.g. fish farming.
- For Denmark, industrial refrigeration is included in commercial refrigeration.
- Norway has high emissions from disposal since no recovery is assumed at end-of-life.
- Natural refrigerants, mainly ammonia, have been widely used in this sector in larger scale systems.

Transport Refrigeration (2.F.1.d)

Transport refrigeration consists mainly of refrigerated trucks and trailers or containers, which can be transported by road, sea or rail. When comparing the per capita operation emission from *transport refrigeration*, the levels between Denmark, Finland, Sweden and Norway are relatively similar. However, Sweden differs with a relatively higher stock per capita even though the operation emission is lower. A lower emission factor for operation may explain this. Iceland differs because of their large fishing fleet, which constitute the vast majority of the stock. Norway differs with a high emission from disposal because the emission factor is set to 100% emission at end-of-life.

Sweden uses a high emission factor for initial emissions and above IPCC guidelines.

2017, kg CO2 eq.	Charge	Operating	Disposal	Sum	Stock
Denmark	0.0	3.2	0.2	3.4	15.8
Finland	0.0	2.0	0.6	2.6	13.4
Iceland	9.8	365.6	15.6	391.0	1,852.7
Norway		3.5	8.8	12.3	17.5
Sweden	0.2	2.2	0.4	2.8	31.0

Table 9: Benchmark of emissions, transport refrigeration (2.F.1.d), kg CO2 per capita

The recovery efficiency for Denmark, Iceland and Sweden are above IPCC guidelines (max. 70%) and Norway has no recovery at all, despite the fact that there is a legal framework for waste collection and a refund of F-gas tax.

This sub-category contributes the most to the Icelandic F-gas emissions. The Icelandic fishing fleet replaced the refrigeration system to ammonia-based systems, but due to the spatial requirements of these systems, a number of ships retrofitted their systems to the use of HFCs. The initial emission is calculated as a linear decrease from 50% emission in 1993 to 20% in 2012 and onwards.

	Lifetimes (years)	Initial Emission	Operation Emission	Recovery Efficiency	Initial Charge Remaining
IPCC 2006 Guidelines	$6 \leq d \leq 9$	$0.2 \leq k \leq 1$	$15 \leq x \leq 50$	$0 < \eta_{rec,d} < 70$	$0 < p < 50$
Sweden	10	4.5	7-30	85	90
Norway	9	1	20	0	100
Denmark	7	0.5	17	88.5	
Iceland (fishing Vessels)	7	2 1	20	75	
Iceland (reefers)	NE	NO	15	NE	
Finland	6	5/0.6/0.32	17/152	50	50

Table 10: Emission factors for transport refrigeration (2.F.1.d)

1 Linear decrease from 50% in 1993 to 20% in 2012; 20% since 2012
2 Higher emission factor for 1990s and lower for later years (data sources: 1996 IPCC guideline and 2006 IPCC guideline)

Mobile air-condition (2.F.1.e)

In countries where stocks are estimated (Finland, Norway and Sweden), stocks from *mobile air-conditioning* range from 239.7 to 433.8 kg of CO2 equivalents. Finland and Sweden are on same emission levels in all life-cycle stages. Norway is slightly higher in the operation phase because of larger estimated stock, and much higher in disposal phase, because the applied emission factor is 100% at disposal. Norway receives import/export data from customs. It is a possibility that Norway overestimate the amount of HFCs in cars because importers can choose to use a general amount of HFC instead of actual amount. The general amount is higher than the actual. The Danish operation emission from MAC are approx. half of the Norwegian. The Danish estimates are based on data from sold refrigerant for MAC service and do not include calculation of stock. Regarding emissions from disposal, Denmark estimates zero emissions because of efficient disposal procedures.

	Vehicle type	Passenger cars in use	Light lorries in use	Heavy lorries in use	Buses in use
2017, total	Sweden	4,845,609	555,363	83,025	14,421
	Finland	3,422,792	452,894	151,591	18,115
	Norway	2,719,395	470,855	73,808	16,041
	Iceland	258,486	26,556	11,747	0
	Denmark	2,530,050	395,746	28,264	13,482
	Total	13,776,332	1,901,414	348,435	62,059

Table 11: The Nordic fleet statistics, 2017

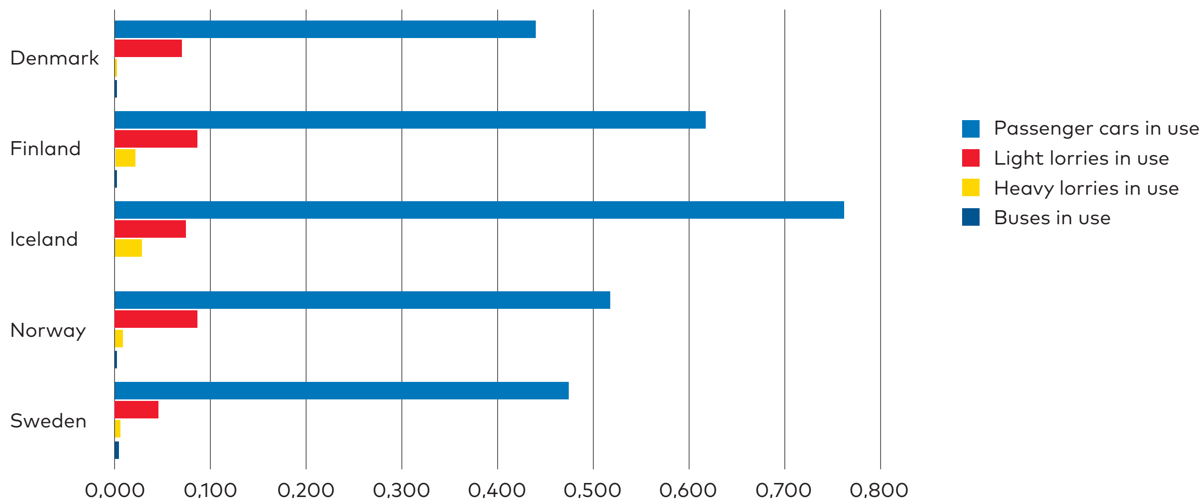


Figure 7: The Nordic vehicle fleet per capita, 2017

2017, kg CO2 eq.	Charge	Operating	Disposal	Sum	Stock
Denmark	0.5	13.2	0.0	13.7	0.0
Finland	0.0	24.0	9.8	33.8	239.7
Iceland		31.6	4.5	36.1	305.2
Norway		43.4	35.9	79.2	433.8
Sweden	0.1	23.1	7.2	30.4	319.4

Table 12: Benchmark of emissions, mobile air-condition (2.F.1.e), kg CO2 per capita

Finland and Sweden calculate the stock in a similar way. The basis is the data of first registrations, which is considered very precise data. In addition, they use estimates for the share of vehicles with AC and refrigerant fills per vehicle and what refrigerants are used. Norway calculates the stock with the help of direct data from the customs.

The Swedish emission factors are related to following vehicles: Passenger car, Light duty, Heavy duty, Bus, Tractor, Other non-road vehicles and Working machinery. Finland includes the following vehicle types: Road vehicles (passenger cars, vans, trucks and busses), Non-road vehicles (tractors and motorised working machines) and Rail vehicles (trains, trams and metro).

The Danish calculation of MAC changed to a Tier 2 top down approach from 2011 and onwards. Sales data from importers/suppliers of MAC refrigerants = sold gas to MAC = use for refilling = emission the particular year. There are no car manufacturers in Denmark, and consumption is therefore used for service only.

Sweden uses a high charge and operation emission factor for non-road and tractors (5% and 30%).

Norway and Iceland have no recovery and Sweden has a high recovery.

Norway and Iceland calculate a disposal emission from an assumption of 100% remaining charge at disposal time.

Sweden and Finland include the new alternative HFO-1234yf in the calculation (voluntary). The EU MAC Directive (2006/40/EC) prohibits the use of F-gases with GWP larger than 150 in all new passenger cars and light duty vehicles manufactured in 2017 or later. HFO-1234yf has replaced HFC-134A, which was formerly used in new passenger cars and vans registered in the EU. In addition, CO2 is used in a very small scale in some specific passenger car models.

	Lifetimes (years)	Initial Emission	Operation Emission	Recovery Efficiency	Initial Charge Remaining
IPCC 2006 Guidelines	9 ≤ d ≤ 16	0.2 ≤ k ≤ 0.5	10 ≤ x ≤ 20	0 < ηrec,d < 50	0 < p < 50
Sweden					
Cars	11	1/0.5	15/5	85	90
Light	11	1/ 0.5	15 /5	85	90
Heavy	6	1 /0.5	15 /5	85	90
Bus	12	1 /0.5	10	85	90
Tractor	7	5	30	85	90
Non road	8 /20	5	30	85	90
Norway	12	NO	10	0	100
Denmark	NE	4.5 (until 2011)	30 (until 2011)	NE	NE
Iceland	14	NO	10	0	100
Finland	9/12/20	5/0.21	30/20/101	50	50

Table 13: Emission Factors for mobile air-condition (2.F.1.e)

1 Higher emission factor for 1990s and lower for later years (data sources: 1996 IPCC guideline and 2006 IPCC guideline)

Key findings on *mobile air-condition* (MAC):

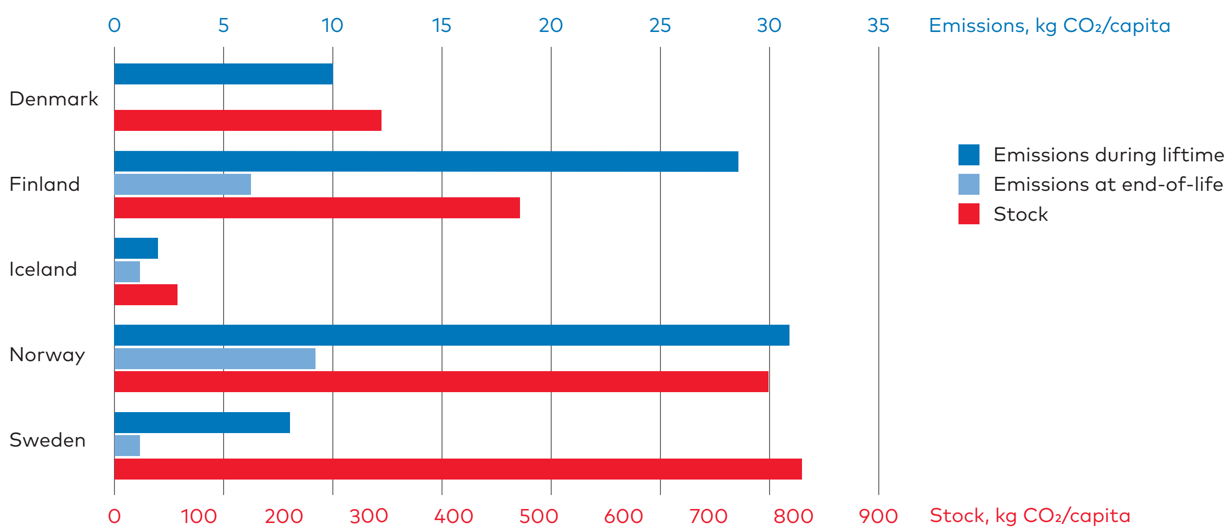
- There are relatively large differences in stock and emissions per capita between the Nordic countries and the different cannot be explained with differences in the vehicle fleet
- The highest emissions per capita are in Norway and the lowest in Denmark.
- Norway has a high stock per capita, and high emissions from disposal since no recovery is assumed at end-of-life.
- Danish emission statistics are based on data on sales to service stations.
- Norway, Iceland and Finland use the same emission factor (10%) for lifetime emissions.
- Sweden uses emission factors lower than IPCC values for passenger cars (5%).

Stationary air-conditioning (2.F.1.f)

The category *stationary air-conditioning* includes different types of heat pumps and other stationary equipment from large water coolers to small room air conditioners used air conditioning in buildings. The estimated stock ranges from 78.7 to 813.9 kg of CO2 equivalents per capita. Sweden and Norway have the highest stock per capita. This is because of the fact that Norway and Sweden use of different applied emission factors, where Norway use 4% and Sweden use 1% emission from stock. Finland has the relatively highest factor on operation emission from stock (6%). Norway has a high emission from disposal, because no recovery from end-of-life is calculated.

The benchmark per capita emphasizes large differences between the countries. Especially in relation to stock/operating emissions and disposal emissions.

Figure 8: Benchmark of emissions, stationary air-condition (2.F.1.f), kg CO2 per capita



2017, kg CO2 eq.	Charge	Operating	Disposal	Sum	Stock
Denmark	0.1	10.0	0.0	10.1	313.1
Finland	0.0	28.4	6.4	34.9	473.6
Iceland	0.1	2.4	1.2	3.7	78.7
Norway		30.7	9.2	39.9	768.6
Sweden	0.2	8.1	1.4	9.8	813.9

Table 14: Benchmark of emissions, mobile air-condition (2.F.1.F), kg CO2 per capita

All countries include heat pumps in the category of *stationary air-conditioning*. However, heat pumps are not common in Iceland due to the sufficient availability of geothermal heat for space heating.

Finland and Denmark used a high operation emission factor until 2000 (Finland) and 2010 (Denmark).

The operation emission factor between the Nordic countries varies between 1% to 6%, where Sweden had the lowest emission factor and Finland had the highest emission factor.

Denmark and Sweden use higher factor for recovery efficiency than the IPCC guidelines. Norway calculates remaining charge to be 100% (and no recovery).

Table 15: Emission factors for Stationary air-condition (2.F.1.f)

	Lifetimes (years)	Initial Emission	Operation Emission	Recovery Efficiency	Initial Charge Remaining
IPCC 2006 Guidelines	10 ≤ d ≤ 20	0.2 ≤ k ≤ 1	1 ≤ x ≤ 10	0 < ηrec,d < 80	0 < p < 80
Sweden (heat pumps)	20 - 15	1	1	95	90
Sweden (other)	10	0.2	1	95	90
Norway	15	1	4	0	100
Denmark	15	1.5 /0.5	10/3	100	NE
Iceland	12	1	3	75	
Finland	10-20	5 /0.21	17/10/61	80	80

1 Higher emission factor for 1990s and lower for later years (data sources: 1996 IPCC guideline and 2006 IPCC guideline)

Key findings on *stationary refrigeration*:

- Sweden and Norway have the highest stock per capita.
- Large differences in emission factors for annual emissions during lifetime (all in line with IPCC guidelines).
- Norway has high emissions from disposal since no recovery is assumed at end-of-life.

Summary of emission per capita

The analysis demonstrates that Denmark and Sweden have similar and low emissions per capita, whereas Finland and Norway's emission per capita are 2.5 times higher. Emissions from Iceland are high due to the fishing industry, and therefore comparison on per capita-data is challenged.

Looking at the figures, it is clear that the assumption in the Norwegian data (that all HFC in end-of-life equipment is released as emissions) has significant impact on the total emissions. Furthermore, Finland has a high total per capita emission. A core reasons for this is its large stock of HFCs in direct centralized commercial refrigeration systems in use, compared to Sweden and Denmark.

The main issues are:

- Use of different emission factors within the main categories and large variations in stock pr. capita. For example, the emission factors range from 1% to 6% in operation emission from stationary A/C (2.F.1.f) among the countries. Finland uses the highest emission factor[4], and for *medium and large commercial refrigeration*, Finland has a substantially large stock per capita.
- Use of different emission factors for recovery of emissions at end-of-life. Norway calculates no recovery of emissions, whereas Denmark and Sweden calculates up to 85–100% recovery at end-of-life.
- Different data sources for identifying imported/exported products containing F-gases, especially MAC, heat pumps and coolers. Norway receives data directly from customs because taxes are imposed on F-gases in bulk as well as in products. New product areas and reports on exact volumes are therefore assumed to be accurate. For the other Nordic countries, the methods are based on statistic sources, extrapolations and data collection from the market.
- Special conditions in terms of industrial and commercial activities in a particular country. For example, Iceland has a large fishing fleet, which affects its per capita data.
- Identification of the country-specific sectoral details in the equipment stock, that are independent of the methodological choices applied in emission estimation. For example, there is still a large share of direct commercial HFC refrigeration systems in use in Finland.

4 At detailed level, when comparing refrigerant charge levels etc. it has to be kept in mind, that the countries may not have similar devices/applications in all sectors. For example, Finland has more direct centralised refrigeration systems in use with larger refrigerant charge and also leakage rate.

Photo: Eivind Sætre/norden.org

Other CRF codes and methodological aspects

The Nordic countries have other CRF codes, e.g. 2F4 (Aerosols), 2F5 (Cleaning Agents), 2G1 (Switchgear) 2G2 (Sound proof windows, laboratory etc.) and 2F3 (Fire Extinguishers). Because these CRF codes are almost similar regarding emission factors and product included among the Nordic countries, and because they follow the 2006 IPCC guidelines, these categories are not discussed further in this report.

Foam

The Nordic emission factors used for calculating the F-gas emissions from foam (CRF 2F2) reflect two different approaches. Denmark and Norway use the simple IPCC guideline with an initial emission factor of 5-10% and an operation emission factor of 4,5% during the lifetime. Sweden and Finland use a more complex method. Sweden is calculating emissions based on data from producers of XPS. Finland uses the Tier 2a approach from IPCC 2006 guideline with six different foam types with a related initial loss between 7% and 95%, and annual loss between 0.5-25%.

Iceland reports no emission from foam products.

Fire exstinguishers with F-gases

The Nordic countries are collecting data for the same product groups and subcategories contributing to the majority of emissions. However, there are exceptions in relation to fire extinguishers, where Norway, Sweden and Finland receive data and calculate emissions thereof. The category is not included in the Danish and Icelandic calculations. National legislation can vary in relation to the allowed use of HFC-based fire extinguishers.

F-gas recovery

The Nordic countries are quite similar in their approach to waste management and handling. Organized collection and access to incineration, special treatment, and recycling facilities are a common part of the infrastructure. However, Iceland disposes parts of the waste at landfills. In addition to that, refrigerant systems are collected by certified companies and then send abroad for recycling. Regarding MAC systems, no collection of decommissioned systems is in place at the moment. Iceland is interested in a closer study of the current situation.

However, from a methodological point of view, there are big differences in estimating recovery and emissions from disposal between the Nordic countries. Recovery is defined as the difference between emissions at disposal and the amount of F-gas in a product at disposal. For all countries, the emission factors are defined based on expected quantities and not on monitored data. The differences do not correspond to the fact that the waste management frameworks are rather similar. One of the project recommendations is therefore to unify the recovery and disposal emission factors and to initiate studies to quantify the actual factors.

The Nordic countries' recovery rate is relatively high, and for Denmark and Sweden, the recovery rate actually exceeds the IPCC recommendations for some of the main sub-categories. Consequently, the workgroup has further discussed this fact. In addition, a recent Norwegian study indicates that the recovery rate in reality is rather low. The study indicates that there are large differences between amounts put into the market and amounts received for controlled destruction at end of life[5]. Even though stakeholders receive a high refund per kg F-gas (600 – 1,700 DKK per kg), only 16% of the gasses are received for destruction. The study also indicates that approx. 50% of all heat pumps delivered for disposal as WEEE waste, were emptied of F-gases. In theory, these charges could all have been emitted.

The recent study strongly indicates that the Nordic assumptions of efficient recovery of F-gases may be overestimated, and the issue needs further investigation. Depending on the country, the recovery rates applied for emission calculation are between 70% to 100% recovery.

The emission contributions from fire extinguishers have been investigated during the project, but due to sensitive data and the fact that the emissions are rather low, the figures are not presented in the report.

However, it should be noted that Norwegian emissions from fire extinguishers are notably higher compared to Sweden and Finland.

Data collection

All Nordic countries collect consumption data of F-gases from suppliers and main consumers. However, the systems and methods for data collection vary considerably.

Generally, two models are used:

1. Data collection from relevant importers and users supplemented with data from customs. In Norway, the regulatory framework requires all stakeholders importing or exporting F-gases in bulk or products to report the exact

5 (Utredning av flourholdige gasser i Næringsbyg, marts 2018)

quantities to customs. Customs are therefore able to provide detailed data of F-gas quantities to the entity calculating the emissions.

2. Data collection from manufacturers, importers, main users and product statistic. This approach is applied in Denmark, Finland, Iceland and Sweden.

Table 16: Bulk data

	Data from importers	Data from custom	Data from agencies	Use of ques-tionnaire
Denmark	X			X
Finland	X			X
Iceland	X			
Norway		X	X	
Sweden			X	

Table 16 illustrates the fundamental differences in used bulk data sources. Some countries use statistics and other countries use different sorts of questionnaires.

All Nordic countries have good and precise bulk data in terms of quantities of particular imported F-gases, whilst none of the Nordic countries have manufacturing of F-gases. Therefore, the input base for emission calculations from bulk seems to be accurate. However, there could be uncertainties in relation to import/export of F-gas bulk between Iceland and parts of the large ships in the Norwegian fishing fleet, because of incentives for buying refrigerant without taxes directly from harbours. Cross-bordering issues have not been a part of the study.

A challenge for data collection is to include and cover imported products containing F-gases. Because F-gases are used in various applications for various purposes, with changing charges and introduction of alternative substances, it can be difficult to ensure that data collection is up-to-date on the latest market trends. In this regard, the Norwegian legal framework with a tax on F-gases is a robust data source to ensure continuous, reliable data for existing and new applications containing F-gases.

Even though Denmark has a tax on F-gases, it is not possible for the tax entity to provide data on products containing F-gases or quantities.

	Data from importers/users	Data from custom	Data from agencies	Data from statistics
Denmark	GIS (Gas Insulat-ed Switch-gear)		Heat-pumps	MDI, (Cars)
Finland	GIS Refriger-ants in product (MAC , heat-pumps etc.) Aerosols			Vehicles, Various RAC sector data
Iceland	GIS		MAC, Domestic appliance, MDI	
Norway		MAC in cars MDI AC units Commercial and domestic applications Heat-pumps Fire protection Insulation foam	GIS	
Sweden	Heat-pumps Fire protection		MDI	Cars, Light and heavy duty vehicles

Table 17: Data for import of products containing F-gases

Table 17 illustrates differences when comparing data sources for import and export of products with F-gases. The survey indicates differences in which product there are included in the national inventories.

It would be relevant to continue the work and provide a detailed overview of products identified to contain F-gases and methods for data collection.

The following list contains examples of products potentially containing HFCs or PFC:

- Dehumidifiers
- Heat pumps
- Dry tumblers
- Special refrigerators/freezers (laboratory etc.)
- Water coolers
- Carbonate stream automates
- Milk coolers in large coffee machines
- Mobile air-conditioning
- A/C in busses and trains
- Ice machines
- Large ice water machines
- Stop leak to air-condition spray box which combines sealer and refrigerant
- Wine coolers
- Centrifuge to hospitals and laboratory
- Special low temperature freezers for hospital and laboratory use
- Medical Dose Inhalers
- Open refrigerators for buffets, salad bars etc.
- Aerosols with cooling/freezing spray
- Aerosols with compressed air, e.g. "Dust Off"
- "Pet corrector" aerosol spray
- Foam spray
- Blowing/foaming agents (gases for blowing, e.g. Solkane 365)
- Fire extinguishers for boats
- Laser coolers
- Applications for medical laser and freeze treatment

Photo: Johannes Jansson/norden.org

National F-gas regulation overview

All countries have implemented the EU F-gas regulation and MAC directive or similar regulations.

Only two countries (Denmark and Norway) have introduced taxes on F-gases to stimulate a wider use of alternatives. The tax regulation was introduced in the legislation in 2001-2002. Denmark has been the only country with a national phase out of F-gases in certain application areas (from 2001-2007), e.g. blowing agent for foaming and limitations for filling in *medium and large commercial refrigeration*. With regard to handling and disposal of F-gas refrigerants, and prior to the EU regulation, all countries have national arrangement. In Denmark, KMO (Kølebranchens Miljøordning) issue personal licences to operators for handling and disposal of F-gases given on the basis of training and examination. Only operators with a licence can buy F-gas refrigerants. In Norway, the F-gas tax is refunded when F-gas is delivered for disposal. It provides an incentive for correct disposal regarding requirements for destruction of foam containing F-gases. Both Sweden and Iceland have legislation for special treatment, recovery and destruction.

Table 18: National F-gas regulation

	Tax on F-gases	National phase out plan and regulation	Regulation on disposal of refrigerants (beside EU)	Regulation on disposal of foam containing F-gases
Denmark	0-80 € per kg de-pending on GWP	Yes	Yes. A licence scheme	No
Finland	No	No	No1	No
Iceland	No	Yes	Yes. Some requirements to recovery	Yes. Gases must be extracted and appropriately disposed of.
Norway	0-650 € per kg depending on GWP	Yes	Yes. Refund of tax when disposal is documented	No
Sweden	No	Yes	No	Yes. Foam is required to be treated at special incineration plants.

1 Prior to the EU regulations, there were already requirements for the appropriate handling of equipment containing refrigerants in the domestic waste legislation.

Table 18 show the differences in taxes and other national regulation initiatives at F-gases.

The survey has searched for national memos or reports, which assess or evaluates impacts from regulation. However, no internal or public reports have been found.

Denmark[6] and Norway[7] are the only Nordic countries using economical instruments such as tax on F-gases. In Norway, the tax is set at 0.5 NOK pr. kg x GWP (2019). In Denmark, the tax is also dynamic according to GWP. GWP above 4,000 is settled to the highest rate, which is 600 DKK pr. kg. The possibility of introducing taxes related to F-gases in Finland was investigated in a project in 2012. The project concluded that no taxes should be implemented, as the return of the tax would be too low compared to all the expenses related to setting up the and running the tax system.

Comparing with the other Nordic countries, there is no common trend that indicates a relatively lower consumption of F-gases in Denmark and Norway. The group had discussed the concern whether a tax on F-gases might stimulate creative initiatives on the market for refrigeration, where a recycled refrigerant can be sold with taxes twice or more.

Phase Down of F-gases

The EU F-gas Regulation No 517/2014 includes, as one of its most important elements, the provision for the phase down of the quantities of F-gases (and blends) placed on the EU market by producers and importers. This entails that each year, the quantity placed on the market and therefore available to contractors, will decrease in accordance with set targets set out in Annex V of the F-gas Regulation. The phase-down applies to all producers or importers of more than 100 tonnes of CO2 equivalents of F-gases, with a few exceptions.

The Commission specifies maximum quotas (quantities) for each producer or importer every year, beginning with the year 2015.

Annual maximum quantities are calculated by using the following percentages.

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6 Bekendtgørelse af Lov om afgift af CFC og visse industrielle drivhusgasser: BK nr 69 af 17/01/2017

7 Forskrift om særafgift: FOR-2018-12-14-2034 fra 01.01.2019

Years	Percentage (0%)
2015	100 %
2016 – 2017	93 %
2018 – 2020	63 %
2021 – 2023	45 %
2024 – 2026	31 %
2027 – 2029	24 %
2030	21 %

Table 19: EU F-gas reduction targets (GWP)

The phase down means that by 2030 the annual quantity of F-gases placed on the market and available will be reduced by 79 % compared to 2015.

In the Nordic countries, there are so far no reported measures of the GWP reduction on imported F-gases placed on the market as bulk or in products (according to the targets defined in the EU regulation No 517/2014). Thus, the effort to make such calculations is relatively simple, as the Nordic countries already collect this data for emission calculations. The workgroup will therefore discuss and clarify further whether such calculations could be supplemented to the 2019 emission calculation as an indicator for monitoring the substitution to low GWP refrigerants in the market.

In Iceland, the European F-gas regulation (517/2014) has been adopted in December 2018 (Reglugerð Nr. 1279/2018) with exception of the reduction targets. In Iceland the phase out of F-gases follow the steps shown in Table 19.

Years	Reduction	Yearly import allowed (in kt CO eq)
2019 – 2023	90%	243.9
2024 – 2028	60%	162.6
2019 – 2033	30%	81.3
2034 – 2035	20%	54.2
2036 –	15%	40.6

Table 20: Iceland reduction targets


Photo: Mitchel Henderson, Unsplash.com

Conclusion and recommendation

Points of discussion

Following questions would be discussed further in the workgroup. The list is generated based on review of the survey answers and identification of areas with clear differences between the countries.

Following questions have been identified and to some extent discussed in the workgroup meetings and workshops:

- How does the emissions differ between countries in total per capita and at subcategory level?
- How is recovery and disposal of F-gases actually handled in the Nordic countries and what are the associated emissions?
- Where are the main differences in applied emission factors and data collection?
- What key data are available for calculating import/export of F-gases in products, e.g. heat pumps?
- Is there a need for methods to measure development in equipment and the market?
- What is the Nordic countries' experience and plans with including non-required F-gases (HFOs etc.) in GHG inventories and projections?
- Use of consumption data, transparency in various categories and stock development
- List of trade name substances known in the countries
- Follow up actions on the comments from the international expert review teams

Overall project conclusions

Following overall conclusions from the project can be outlined:

- Emission factors for emission calculation should be more similar, especially for the RAC categories in relation to operation and disposal emission factors.
- The estimated reduction potential by improving methods are 600-800,000 tonnes of CO_2 equivalents corresponding to 10-20% of total Nordic F-gas emission/year. In particular, calculated emissions from disposal are too high.
- The harmonisation of methodologies in the Nordic are initiated and will

continue in the next submissions. Especially Iceland and Norway plans a thorough review and development of the scheme and methods for F-gas emission calculations.
- Revisions and some recalculations are already implemented or planned for submission in 2020.
- There is a need for improved data on import of HFCs in products.

Recommendations

- In most cases, the Nordic countries apply emission factors from the default ranges set out in the 2006 IPCC guidelines. Therefore, it is relevant to apply more similar emission factors for charge and operation for RAC categories, especially 2.F.1.a *(commercial refrigeration)* and 2.F.1.f *(stationary air-conditioning)*

- Mainstream emission factors for disposal emissions for all RAC categories as much as possible, including the assessment of background information to define current state of F-gas recovery from RACs

- Assess whether there is import of fire extinguishers with fillings to the Nordic countries.

- Further explore the frameworks for data collection of imported products containing F-gases in Norway (tax/reports from custom) and Finland (database setup) for improved data collection

- Introduce reporting at national level of the (GWP) amount of imported F-gases placed on the market as bulk or in products to monitor GWP reduction progress according to the reduction targets stipulated in the EU F-gas regulation.

Implemented or planned improvements as result of the project work

Denmark

The 2018 F-gas inventory has included a number of revision and improvements. A new operation emission factor for stationary air-condition was introduced from 2010 and onwards. The emission factor is reduced from 10% to 3%. Improved data for import/export and stock of heat pumps are included and historical stock data are revised. A new and more transparent structure for presenting the life-cycle emission calculations is included.

Finland

A number of updates and corrections that resulted in recalculation of emission estimates were done for submission 2019 to the category 2.F.1 calculation model, which was taken in use in submission 2018. The recalculations were done for categories 2.F.1.a, 2.F.1.d and 2.F.1.f.

In the case of lifetime emissions of air-to-air heat pumps in category 2.F.1.f, the charge estimate from 2001 was revised due to work done in the project. Other recalculations in category 2.F.1 were independent from the work of the project. Depending on the final conclusions and adequate documentation regarding the benchmarking of emission factors related to 2.F.1.f *stationary air*-condition, Finland may consider introducing new emission factors. The same applies to end-of-life emission factors across all 2.F.1 categories.

Iceland and Norway

During the implementation of the project, no recalculations or changes have been made to the Icelandic and Norwegian reporting of F-gas emissions. However, a thorough revision in data collection, methodology and assumptions is planned for the submission year 2020. The results of this project, in terms of harmonization of emission factors, will be taken into account and applied to the report.

Sweden

The following recalculations have been made in the submission of 2019 compared to the submission of 2018. Number 5 is a direct result of the project.

Due to a recurring one year lag in the updating of the data from the Products Register from the Swedish Chemicals Agency, data on bulk import and export in 2016 were updated.

Beside this update, many changes of emission estimates have been made for the submission of 2019. These include:

1. Adding amounts imported in products from 1990 to 2017, which affects reported emissions in 2.F.1.a, 2.F.1.c, and 2.F.1.f
2. Change of the factors used for emission estimates for light duty vehicles from 1993 to 2016. Earlier, emission factors for heavy duty vehicles were applied, but in the submission of 2019, the factor used for passenger cars is applied to light duty vehicles. This lead to a decrease in yearly emissions for light and heavy duty vehicles between 1 kilo tonnes to 17 kilo tonnes of CO2 equivalents (for 2016).
3. Minor correction in emission estimates for MAC in buses from 1990 to 1995 (less than 0.001 kilo tonnes of CO2 equivalents).
4. Correction of number of built passenger cars with HFC-134a from 2010 to 2016 and introduction of HFO-1234yf from 2012. This leads to a decrease in emissions of less than 1 kilo tonnes of CO2 equivalents for 2010 and 2011 and between 2 and 18 kilo tonnes of CO2 equivalents for 2012 and 2016, respectively.
5. Introduction of emission estimates for MAC in working machinery and off road vehicles from 2000 to 2017. This leads to increased emissions of between 2 kilo tonnes of CO2 equivalents in 2000 and up to 12 kilo tonnes of CO2 equivalents in later years.

Appendix 1 - Survey table[8]

Surveys of the Nordic countries' status regarding F-gas inventories and methodologies were conducted in the beginning of the project (Q2/Q3 2017). A questionnaire was distributed to each country. The survey answers are presented in the table below.

A.1. Methods for collection of data for F-gas import	
Specify bulk data sources (direct from importers, from statistics etc.)?	
Denmark	Data are collected annually directly from identified importers/wholesalers of F-gases. The stakeholders in the market are relatively few with detailed knowledge on the development in sectors. Bulk importers are usually specialized in supply for certain categories/consumption areas, e.g. domestic refrigeration, MAC and SF6 to switchgear. Bulk data represent main part of the total input of F-gases to the different categories. Supplementing data are from in-product import. Both bulk import and re-export data are collected. The actual import per year is import – export = consumption in year X.
Finland	Annually collected directly from the chemical importers via specific sectoral surveys (8 different surveys). Possible new importers are annually surveyed from different data sources - Industry associations (RAC sector – Finnish refrigeration enterprises association, FREA) - Chemical products registry (confidential list of companies who have reported data to the registry received annually from the Finnish Safety and Chemicals Agency, Tukes) - Google searches and other miscellaneous sources
Iceland	The amounts imported are recorded by Customs Iceland when it is reported to the Environment Agency of Iceland (EA). Since 1995, importers are required to apply at the EA for permits to import HFCs. Data is therefore collected from invoices sent to the EA for permit and compared to data from customs and survey data from importers. Discrepancies are investigated. No bulk data is received from statistics or other sources.

8 Note that some information presented in the survey results may have changed since the survey was conducted.

A.1. Methods for collection of data for F-gas import

Specify bulk data sources (direct from importers, from statistics etc.)?

Norway	We collect data on imports of HFCs and PFCs from two sources: the Directorate of Customs and the Norwegian Tax Administration. These data sources exist because there is a tax on the import of F-gases. The way a commodity is imported determines whether it is registered in one or the other data source. The data from the Directorate of Customs provides information on the imported amount of chemical by importer and type of commodity. The data from the Norwegian Tax Administration provides information on the amount of chemical by importer, but not on type of commodity. For SF6 used in electric equipment (2G1), such as gas insulated switchgear (GIS), data is received from the Ministry of Environment. The producers and most important users of such equipment report annually to the Ministry: imports, exports, recycling, accumulation in bank, technical lifetimes of products, and different rates of leakage from processes, products and production processes.
Sweden	Bulk data on import and export by chemical (i.e. HFC 134a, HFC 143a, etc.) is received from Swedish Chemicals Agency. Only data for bulk over 100 kg/year per company.

Specify in-product data sources (direct from bulk suppliers, equipment importers, domestic equipment manufacturers, domestic and international statistics etc.)?

Denmark	In-product import data are collected for following products: - MDI - SF6 switchgear MDI data are collected from national statistics for pharma products. The data contains sold units assumed to contain HFC. Emission calculations are based on adding unit numbers with fixed average amount per unit. Data for SF6 in switchgear are collected from supplier information of installed amount in year x. There are three identified suppliers (ABB, Alstom, Siemens). In-product export data are not collected from statistic, but for household refrigerants, an average estimate for total amount of HFC 134a and HFC 404a is made at category level. Previously (until phase-out), in-product import and export data were collected for shoes (SF6 and HFC) and SF6 in windows. In-product import of HFC 134a in MAC's were estimated from car sale statistic until methodical improvement was introduced.

A.1. Methods for collection of data for F-gas import

Specify in-product data sources (direct from bulk suppliers, equipment importers, domestic equipment manufacturers, domestic and international statistics etc.)?

Finland	The data of in-product imports of F-gases into Finland and the data of chemicals used in the domestic manufacturing of equipment is annually collected directly from the equipment importers and manufacturers via specific sectoral surveys
Iceland	EA acquires data for mobile air conditioning (NFR 2F1e), domestic refrigeration (NFR 2F1b) and Metered Dose Inhalers (NFR 2F4a). For mobile air conditioning, data is acquired from the National Transport Authority as the number of vehicles per vehicle group. Assumptions on charge per refrigerant per vehicle are made for each year from 1990. For domestic refrigeration, import data is acquired from Statistics Iceland. Assumptions are made that certain refrigerators contain HFCs and others not, depending on the country of import. Charge levels are assumed using IPCC 2006 guidelines. For Metered Dose Inhalers, data is acquired from the Icelandic Medicines Agency on sold inhalers per type of inhalers (11 types). Assumptions on the type of HFC and charge levels are made.
Norway	Same as last answer
Sweden	2.F.4.a – MDI, Swedish Health Agency, Medical Products Agency 2.F.1.d – Transport refrigeration, Transport Analysis and Statistics Sweden 2.F.1.e – MAC, Transport Analysis and Statistics Sweden 2.F.1.f – Heat pumps, Swedish Refrigeration & Heat Pump Association 2.F.3 – Fire protection, private companies

Use of questionnaires for data-collection?

Denmark	Yes. In Danish inventory, a questionnaire is distributed and collected to all known: - importers of F-gases - main manufactures using F-gases - main consumers using F-gases The questionnaire requests information per substance (trade name) on import/export, bought/sale and area for use. The procedure is following: - maintenance of stakeholder list by including or excluding contact persons, addresses, companies etc. - Updating questionnaire to new year and possibly with new substances. - Distribution by email to contact persons - Receiving data, QA and registering of data - Follow up actions for stakeholders who have not responded

A.1. Methods for collection of data for Fgas import

Use of questionnaires for data-collection?

Finland	Yes. In the Finnish inventory, 8 sectoral questionnaires are used for data collection Refrigeration and air conditioning (bulk importers/exporters, in-equipment importers/exporters, domestic manufacturers of factory charged equipment, companies performing on-site installations to new equipment and servicing existing equipment and delivering refrigerants to destruction) Mobile air conditioning (car importers, data collected on the share of cars equipped with mac devices and the refrigerants used in them, amounts of imported cars taken from the statistics of Finnish Transport Safety Agency, Trafi) Foam blowing (chemical importers, product importers, domestic product manufacturers) Aerosols and metered dose inhalers, including one-component foam (domestic product manufacturers and chemical importers, product importers) Electrical equipment (equipment importers and suppliers, domestic equipment manufacturers (manufacturing ceased in 2010) Semiconductor manufacturing (domestic manufacturers) Fire prevention systems (chemical importers, companies installing and servicing the systems) Specialty gases (chemical importers, a number of applications provided in the survey, the respondent chooses the applications where chemicals are imported)
Iceland	No
Norway	No
Sweden	No

A.2. Methods for determining F-gases use/consumption for the particular categories

Importer/supplier information, consumer data, technical data sheets, expert estimation, other?

Denmark	Refrigeration: Consumption of HFCs to manufacturing of household refrigerants/freezers is reported directly from producers. Consumptions of HFCs in commercial/industrial refrigerators and A/C's are calculated from bulk import data and combined with data for the total installed amount. Consumptions of HFC-134a for aerosol sprays are reported from manufacture. Consumptions of HFC-134a and HFC-404a for transport refrigeration (service) are collected from consumers. Consumptions of HFC-134a for foam blowing are phased out. Previously it was reported directly from manufac-tures. Consumptions of HFC-134a for MAC service/maintenance are reported from importers/wholesalers to this sector MDI data are collected from statistics. Consumption of PFC's are based on import data and allocated to categories based on information from importers. Consumption of SF6 divided into categories (laboratories and switchgear) based on expert estimation.
Finland	RAC sector – bulk import Some individual companies are known to import refrigerants only to certain sector (e.g. for MACs) and their data is allocated to that sector. The rest of the data (most of the bulk imports) is allocated to different sectors according to the reported data of the domestic manufacturing of factory charged equipment and on-site installations to new equipment. Those data is collected in the RAC survey in the level of 11 different categories (=equipment types, each category belongs to one of the six reporting categories). On-site installations in the survey can also be reported without distributing the data into different categories. In those cases the data is allocated to categories at SYKE as an expert estimation (using technical data sheets from refrigerant manufacturers and other material). The data of the servicing of existing equipment will also be utilized more in the future when allocating the bulk imports to different sectors (the data is not needed in the mass balance methodology calculations and therefore the collected data is not comprehensive, e.g. a lot of small companies performing only small scale servicing are not included in the survey).

A.2. Methods for determining F-gases use/consumption for the particular categories

Importer/supplier information, consumer data, technical data sheets, expert estimation, other?

Finland	RAC sector – bulk export Amounts of bulk exports reported are usually rather small and by very small number of companies. Therefore the companies are usually contacted for more information concerning the right sector or the data is simply allocated at SYKE as an expert estimation. RAC sector - in-equipment imports/exports and factory charged equipment manufacturing The data is collected in the RAC survey in the level of 11 different equipment types. One of the pre-determined equipment types is also 'other equipment' and companies can type the name of the equipment to the survey if they don't know where to allocate the equipment. In those cases the allocation to the categories is done at SYKE based on the equipment name or other information provided by the company in the survey. RAC sector - on-site installations to new equipment and servicing existing equipment The data is collected in the RAC survey in the level of 11 different equipment types ('other equipment' also available). The data can also be reported without distributing the data into different categories. In those cases the data is allocated to categories at SYKE as an expert estimation (using technical data sheets from refrigerant manufacturers and other material). RAC sector - delivering refrigerants to destruction At the moment it is assumed that the data is split between different sectors in the same way as the bulk imports. It is not a good enough methodology and a better one should be developed in the future. Other sectors than RAC In the Foam, Aerosols, Electrical equipment, fire prevention and semiconductor sectors the companies importing or consuming the gases are related only to specified sectors.
Iceland	To estimate the use of F-gases in CRF sectors, polling data of the majority of the companies designing, installing and servicing a range of refrigeration systems, was collected once and has been used since.

A.2. Methods for determining F-gases use/consumption for the particular categories

Importer/supplier information, consumer data, technical data sheets, expert estimation, other?

Norway	The imported amounts of chemical are assumed to be used within the same year. Through the available information in the data, combined with some assumptions, we establish whether the F-gas is imported in bulk or in a product, how the chemical imported in bulk is used, and what kind of imported equipment contained the chemical: For data provided by the Tax Administration, assumptions are made based on the name of the importer and the type of F-gas imported. The link between importer, type of gas and what is imported was established through searching the internet and contacting the importers by e-mail and telephone. However, this information is in need of an update, as it was mainly collected in 2006. For data provided by Customs, the commodity code provides information on whether a chemical was imported in bulk or in a product, and what kind of product. Assumptions as described above are used to allocate bulk imports to categories.
Sweden	Statistic information collected for shoes and MDI. No specific information on amounts of F-gases for service/maintenances. 2C4: Mg production: Data on SF6 as a cover gas from companies 2E1: Semiconductor manufacture: Occurred until 2004 in Sweden. Data on F-gases used at manufacturing and associated emissions from company 2.F.1.a/2.F.1.c/2.F.1.f: In submissions prior to 2018 emissions from commercial, industrial and stationary applications were reported together in commercial refrigeration, 2.F.1.a. As there are currently no national statistics that can be used for allocation between 2.F.1.a, 2.F.1.c and 2.F.1.f, an alternative reallocation model has been used. This model is based on information from Germany's reporting of installed amounts of F-gases in 2.F.1.a, 2.F.1.c and 2.F.1.f from Submission 2016. The gases reported by Germany in these codes are also included in the Swedish reporting for 2.F.1.a, 2.F.1.c and 2.F.1.f. Most of the gases show similar trends in quantities used in Germany as used in Sweden in the period 1990 - 2014. 2F1b: Domestic refrigeration: Number of sold equipment from trade association. 2F1d: Transport refrigeration: Data on number of vehicles with refrigeration from official sources.

A.2. Methods for determining F-gases use/consumption for the particular categories

Importer/supplier information, consumer data, technical data sheets, expert estimation, other?

Sweden	2F1e: Mobile air-conditioning: Official statistics from Statistics Sweden and data from trade association. Data on number of manufactured, imported, exported and registered vehicles by type (cars, trucks and busses). Problem with confidentiality in data since 2011 for heavy duty vehicles and buses. Partly solved. Emissions from working machinery and off road vehicles are also included. Activity data from the national model used to estimate other emissions than HFCs (number of working machinery/off road vehicles and lifetime) and EF from the Finnish inventory . 2F2: Foam blowing agents: Amounts of HFC used for manufacturing of XPS, emissions at manufacturing and share of HFC in exported XPS 2F3: Fire protection: Import statistics from companies together with assumptions 2F4a: Metered dose inhalers For metered dose inhalers, statistics on the numbers of sold inhalers was, for the years 1990 until 2008, received from the Swedish retailer for medical products, Apoteket. From 2009 - 2013 the corresponding information has been received from the company Pharmacy Service AB and from 2014 onwards, the data are received from Swedish eHealth Agency. Information concerning the content of HFC in the inhalers is provided by the Swedish Medical Products Agency. 2F4b: Technical aerosols: Data from manufacturers on the used amount of HFC-134a as well as emissions from production, and exported amounts of HFC-134a in products. 2G1: Electrical equipment - Gas-insulated switchgear: Data from manufacturing company on SF6 used for manufacturing, in exported products, emissions from manufacturing and SF6 sent for destruction 2G2: Doubles glazed windows: Data on annual use of SF6 and emissions from manufacturing companies. Shoes: Rough estimate using Norwegian data scaled to the Swedish population 2G1: Electrical equipment - SF6 installed in distribution systems: All bulk SF6 from the Swedish Chemicals Agency not accounted for in any other source category

A.2. Methods for determining F-gases use/consumption for the particular categories

Use of estimates for allocation of bulk import to use/consumption in categories (household refrigerant, domestic commercial refrigerants etc.)?

Denmark	Total import of HFC-152a is allocated to the single application area "thermostates" All import of HFC-407C, HFC-410A, HFC-413A and similar refrigerants are only applicable and allocated to commercial refrigerators and A/C. It is not relevant to distinguish between refrigerators and A/C's while both have same emission factor. 100% of imported HFC-134a from two specific importers is allocated to MAC as they claim to provide the total market of HFC-134a for refilling in MAC. Import and sale of HFC-23 is presumably used for fibre optics production. Import and sale of PFC-14 and PFC-318 is presumably used for fibre optics production.
Finland	
Iceland	Estimates are made for allocating bulk import, based on poll results. The following allocation is assumed: • All R-407C and R-410A amounts are allocated to Residential and Commercial AC. • Since reefers are refilled, the amount of R-134A and R-404A leaking from reefers is replaced by corresponding amounts of imported R-134A and R-404A. • 65% of the import of each remaining refrigerant - all refrigerants with the exceptions of R-407C, R-410A and fractions of R-134A and R-404A - are allocated to fishing vessels (transport refrigeration) • 20% of all remaining refrigerants are allocated to industrial refrigeration • 15% of all remaining refrigerants are allocated to commercial refrigeration
Norway	Same as last answer
Sweden	The amount of HFCs and PFCs not allocated to other codes within 2.F that are allocated to 2.F.1.a, 2.F.1.c and 2.F.1.f based on information from Germany's reporting of installed amounts of F-gases in 2.F.1.a, 2.F.1.c and 2.F.1.f.

A.3. Measurement of stock

Maintenance of stock development

Denmark	Stock is calculated and updated every year for all categories. Stock calculation is based on a mass-balance approach using the input data on consumption (trade names) and particular emission factors per category to estimate the stock. The principal method for stock calculation is following: Stock = bulk input/consumption (kg) + (import in products – export in products) – (emission from production and/or maintenance the actual year + emission from stock the actual year) + existing stock the actual year. The stock for each category and input substance (trade names) is extrapolated to year 2030. Extrapolations are conducted with a "steady state" scenario where consumptions the actual year is assumed the same in following years to 2030 or when a phase out is introduced. Stock exist for following categories: HFC/PFC - Household appliances (foam and refrigeration) - Commercial refrigerators and stationary A/C (refrigeration) - Mobile refrigeration - MAC - Foam - Other (thermostates) SF6: - Themo windows - Swich gear - Shoes.
Finland	RAC sector In the currently used mass balance approach no stocks are estimated since they are not needed in the emission estimation. However, the new emission calculation model for the RAC sector is based on emission factor methodology and the stocks are estimated there. The new calculation model is divided into 15 different sub-categories (equipment types). In most of the categories the stocks are calculated via annual new additions with the basic methodology: + bank (previous year) + total charge in new equipment - retired equipment These categories are: Mobile Air-Conditioning (Road vehicles, On-ground railways, Other off-road machinery, Underground railways and trams), Transport Refrigeration, Domestic Refrigeration, Stationary Air-Conditioning (Heat pumps, Large heat pumps, Other Stationary air-conditioning equipment) and Industrial refrigeration (Indoor ice rinks, Other Industrial refrigeration).

A.3. Measurement of stock

Maintenance of stock development

Finland	In the category Commercial refrigeration, the stocks are estimated in other way. There are four sub-categories in this category: Centralised supermarket refrigeration systems, Commercial stand-alone refrigeration equipment, Professional kitchens and Stand-alone equipment of professional kitchens. In the case of centralized super-market systems and commercial stand-alone equipment, the estimation of the bank is based on the number shops/stores in operation annually (data from statistics, 9 different categories based on the size of the stores) and on the estimated refrigerant fill in one average centralized system (different estimate for all the 9 store categories) and in one average stand-alone equipment (same estimate for all the 9 categories). In the case of professional kitchens (=centralized systems in prof. kitchens) and stand-alone equipment of professional kitchens, the estimation of the bank is based on the number professional kitchens in operation annually (data from statistics, 3 different categories) and on the estimated refrigerant fill in one average centralized system (different estimate for all the 3 categories) and in one average stand-alone equipment (same estimate for all the 3 categories). In the case of centralized systems in prof. kitchens, one additional parameter is taken into account: the share of the kitchens in different categories that are equipped with a centralized system. FOAM sector (closed-cell foams) Stocks are calculated with the methodology: + bank (previous year) + total charge in the manufacturing of products + total charge in the imported products - total charge in the exported products - leakage in the manufacturing of products - annual leakage from the bank Electrical equipment sector Stocks are calculated with the methodology: + bank (previous year) + total charge in new equipment - retired equipment
Iceland	A baseline stock calculation is conducted.
Norway	HFCs and PFCs for use in products (2F) The original baseline: We assume zero use of HFCs and PFCs in products prior to 1990. The stock per category is built from data/assumptions on imports and exports per species of F-gases and categories, in combination with emissions from production, emission from use of products and decommissioning. For SF6 used in electric equipment (2G1), we do not calculate the stock ourselves. See answer to question A.1.

A.3. Measurement of stock

Maintenance of stock development

Sweden	+ bank (previous year) + total charge in new equipment + added at service/maintenance - annual leakage - retired equipment (emissions, destruction or recovery)

A.3. Measurement of stock

Different methodologies used for estimating the stocks in different categories

Denmark	No
Finland	No
Iceland	Similar methodology is used for estimating stocks in the different categories, the difference mostly being in the use of different emission factors.
Norway	
Sweden	Similar for all codes where emissions from stock are relevant

A.3. Measurement of stock

How is original baseline for stock determined?

Denmark	Stock baselines were estimated first time in 1999 where DK changed approach to actual emission calculation. Stocks were then simulated back to 1990 based on import and consumption data for all years.
Finland	

A.3. Measurement of stock

How is original baseline for stock determined?

Iceland	Original baseline for stock is based on data allocation and emission factors. Annual stock levels are generally calculated as: (last years stock per category)+(Import of refrigerant per category)-(initial emissions per category) Last year's stock per category is then calculated from the annual stock level by sub-tracting lifetime and end-of-life emissions. For SF6 used in electrical equipment (NFR 2G), stock levels are received annually from a few companies.
Norway	
Sweden	Not relevant for MAC and stationary refrigeration. For SF6 in electrical equipment the baseline is set to 1975. For SF6 in windows, we have used 1990 as baseline (which is probably not fully accurate).

A.3. Measurement of stock

Experiences with rewriting stock data, fx. as a consequence of new more accurate data?

Denmark	No experience
Finland	
Iceland	No experience on rewriting stock data. Some stock changes have recently occurred as a consequence of emission factor review.
Norway	
Sweden	We don't have any measure of verification when making recalculation.

A. 4. Methodologies for the new emission types (IPCC 2006 GL)

Emissions from recovery?

Denmark	There are no recovery activities. Polluted HFC/PFC refrigerants are destroyed. Non-polluted refrigerants are reused directly. Foam are not recovered but disposed to incineration plants SF6 in switchgear are reused directly or disposed. SF6 in windows are not recovered.
Finland	The recovery in the CRF tables is treated as recovery itself and not emissions from recovery in the Finnish inventory. In the current inventory reporting recovery is estimated in the electrical equipment sector. Recovery is calculated with the simplified way of subtracting disposal emissions from the amount of SF6 in products at decommissioning. In addition, recovery is calculated in the new RAC emission calculation model. The methodology is the same as in the electrical equipment sector.
Iceland	Following approach may be applied generally: Recovery= "amount remaining in products at decommissioning" minus "disposal emissions".
Norway	We assume no recovery for reuse (HFCs and PFCs for use in products -2F)
Sweden	Emissions from disposal are reported for all relevant CRF codes

A. 4. Methodologies for the new emission types (IPCC 2006 GL)

Emission from disposal activities?

Denmark	Expert judgement determines no emissions from disposal activities related to household appliances and other refrigeration systems. Refrigerants are emptied under controlled conditions before destruction and insulation foam are not recovered but incinerated.
Finland	Disposal activities are related to the sectors 2F1 and 2E1 in the Finnish inventory. In the current inventory reporting in the sector 2F1 (mass balance methodology), disposal activities are related to the destruction of F-gases. In the RAC survey, companies report the amounts of refrigerants that are sent for destruction annually. Some of the companies know (or estimate) the composition of their waste refrigerant mixtures or they deliver only individual refrigerants for destruction. The total amount of destructed refrigerants is annually obtained from the only destruction facility in Finland. They are unable to estimate the composition of their waste refrigerant mixtures. The estimate of the composition is made at SYKE based on the data from the RAC survey.

A. 4. Methodologies for the new emission types (IPCC 2006 GL)

Emission from disposal activities?

Finland	In the new RAC calculation model, disposal activities are related to the estimation of emissions from the end-of-life/disposal phase. Emissions are estimated according to the equation 7.14 of chapter 7.5.2.1 of the 2006 IPCC GL. The parameters Recovery efficiency and Initial charge remaining are taken from the 2006 IPCC GL. In the electrical equipment sector, disposal activities are also related to the estimation of emissions from the end-of-life/disposal phase. Data of SF6 in retiring equipment is annually received from company called Adato Energia Oy (owned by Finnish Energy, the trade association that represents the Finnish energy industry). They calculate the SF6 emissions annually for their own purposes. The data is available from 2002 onwards. Emissions are estimated with the methodology $E=D_t*f_D$ (where Dt = amount of SF6 in retired equipment in year t and f_D = emission factor for equipment disposal).
Iceland	End-of life emissions distributed over the assumed lifetime from the year of import estimated with the following equation: Recovery emission = (charge in year t-n) * (y/100) * (1-Z/100) – (amount of intentional destruction). N = lifetime of product, Y= remaining charge, Z = recovery efficient factor
Norway	We assume no emissions from the destruction process. We receive information from Stiftelsen Returgass (SRG) once a year, on quantities of HFCs and PFCs delivered to them for destruction. We have no information on what equipment the gases are taken from.
Sweden	Assumptions on emissions rates.

Emissions from container management?

Denmark	Not considered
Finland	No emissions of container management have been estimated. According to the industry, no transfer of refrigerants from larger bulk containers (typically 40 tonnes according to the IPCC 2006 GL) to containers with smaller capacities have taken place in Finland since the late 1980s. All the refrigerants are imported to Finland in smaller containers.
Iceland	Not considered
Norway	Emissions from container management are not included in the estimates.
Sweden	Included in emissions manufacturing when relevant.

A. 5. Measurement of development within categories and new F-gases

Existing categories – which sources contribute to knowledge (supplier information, reports...)

Denmark	There is no specific routines for measuring developments in the sectors, however the main source for new knowledge is through dialogue with importers and suppliers of F-gases.
Finland	
Iceland	Currently there is no established procedure to develop methods and EF's used for different categories and to implement such changes in the inventory.
Norway	
Sweden	All different gases are covered by the bulk statistics from Swedish Chemicals Agency.

Identification of new categories and new f-gases (are certain screening efforts etc. applied)?

Denmark	Screening of new F-gases and categories were conducted in 2015 by supplementing the new gases to the questionnaire, dialogue with main importers of F-gases and briefly assess the relevant consumption sectors. No import and sectors are identified.
Finland	
Iceland	Currently there is no screening efforts used to identify new categories and F-gas use.
Norway	New categories and F-gases are identified through the data from Customs and through the update of the IPCC Guidelines. We have not made any efforts in addition to these sources.
Sweden	No system for finding new categories.

Good practise experience to mention?

Denmark	No
Finland	No
Iceland	No
Norway	No
Sweden	No

A.6. List of used substances and relevant categories

Identified specific F-gas substances in year 2015 (HFC's, PFC's, SF6, NH3)

Denmark	The DK survey use trade names. Following F-gases were used in 2015: HFC-23 HFC-125 HFC-134a HFC-152 HFC-245ea HFC-404A HFC-407C HFC-410 HFC-427 HFC-507 PFC-14 PFC-318 SF6
Finland	List send separately.
Iceland	List send in separate file. Identified F-gas substances are shown in green. Categories for use: Refrigeration and air conditioning Commercial refrigeration Domestic refrigeration Industrial refrigeration Transport refrigeration MAC Stationary A/C Aerosols MDI Electrical equipment
Norway	
Sweden	List send in separate document.

A.6. List of used substances and relevant categories

Identified categories where F-gases are used as bulk or imported in products in year 2015

Denmark	HFC, PFC Domestic refrigeration (bulk), Commercial refrigeration (bulk) Stand alone equipment (bulk) Transport refrigeration (bulk) Stationary A/C (bulk) MAC (bulk) MDI (product) Aerosol sprays (bulk) SF6 Switchgear Laboratories
Finland	Imported in bulk 2E1, 2F1a-f, 2F2a-b, 2F3, 2F4, 2G1 Imported in products 2F1a-f, 2F4, 2G1
Iceland	Referring to the attached document mentioned above, most of the categories use F-gas in bulk. The following categories are, currently in the inventory, assumed to contain F-gases in imported products: 2F1b Domestic refrigeration (HFC-134a) (refrigerators from certain countries) 2F1e Mobile air conditioning – Road vehicles (HFC-134a) 2F4a Metered dose inhalers (HFC-134a)
Norway	HFC, PFC Domestic refrigeration (product), Commercial refrigeration (bulk, product) Stand alone equipment (bulk, product) Industrial refrigeration (bulk, product) Transport refrigeration (bulk) Stationary A/C (bulk, product) MAC (bulk, product) Fire supression (product) Hard Foam (product) Solvent (product) MDI (product) Aerosol sprays (bulk, product) SF6 Electronics industry Electrical equipment Windows Tracer gas Medical use (retinal surgery)
Sweden	

A.6. List of used substances and relevant categories

Experiences with estimation of consumption and emissions of new F-gases not required for reporting under the UNFCCC (e.g. HFO's, HFE's, PFPE's, fluorinated ketones)?

Denmark	No experience
Finland	Information on the use of these new substances has been collected in Finland since 2010 and emissions have been calculated for 2010 to 2015. The emissions have been estimated in every sector with the same methodologies as the F-gases required for reporting under the UNFCCC. Emissions totalled 0.4 kt CO2 eq. in 2015. Included emissions are HFO-1234yf (mobile air conditioning, for 2013 to 2015), HFO-1234ze (stationary air conditioning, for 2014), C6F12O ('Novec', fire protection, for 2010, 2013 to 2015), HFE-347 mcc3 (HFE-7000, aerosols, for 2014 to 2015), HFE-449sl (HFE-7100, aerosols, for 2010 to 2015) and HFE-569sf2 (HFE-7200, aerosols, for 2010 to 2015). A vast majority of the emissions originate from HFEs in the aerosol sector. In addition, the use of some gases (e.g. HFE-7100, Novec-1700 and Galden HT-110) as heat transfer fluids in semiconductor manufacturing have been reported, but the emissions have (at least not yet) not been estimated.
Iceland	No experience
Norway	We have not estimated emissions from these substances yet. We do however have some information on imports of HFOs through the data from Customs.
Sweden	HFO-1234yf included in submission 2019.

A.7. Actual emission – Tier and EF methods per category

Used method, fx. Tier 2, top down for domestic refrigerants etc (specify if possible per category)?

Denmark	For the calculation of F-gases it is basically a Tier 2 bottom up approach which is used, while data is reported from identified importers and users of F-gasses in DK. As for verification using import/export data a Tier 2 top down approach is applied. In annex there is a specification of the applied approach for each sub source category. Inventory agencies should use the Tier 1 potential emissions method for a check on the Tier 2 actual emission estimates. This comparison has been carried out in 1995-1997 and for all three years it shows a difference of approx. factor 3 higher emissions by using potential emission estimates. Inventory agencies should compare bottom-up estimates with the top-down Tier 2 approach, since bottom-up emission factors have the highest associated uncertainty. This technique will also minimise the possibility that certain end-uses are not accounted for in the bottom-up approach. This exercise has been partly conducted since data from importers (top down) are assessed against data from users (bottom up) to ensure, that import and consumption are more or less equal. The consumption reported from users is always adjusted to the import of substances, which are the most exact data we have. The uncertainty due to this is, if not all importers are identified because new imported are introduced to the DK market.
Finland	2C4 (SF6 emissions occur in the time series, reported in 2H3): Tier 2 (IPCC 2006 GL) 2E1: Tier 2a (IPCC 2006 GL) for 2002-2015 and Other for 1990-2001 (details found in the NIR, chapter 4.6.2.2) 2F1a-f: Tier 2b mass balance approach (IPCC 2006 GL) for 2000-2015 and emission factor approach of the IPCC 1996 GL for 1990-1999. The new RAC calculation model uses Tier 2a emission factor approach of IPCC 2006 GL for the whole time series. 2F2: Tier 2 (IPCC 2006 GL) for 1998-2015 and IPCC 1996 Guidelines methodology for 1994-1997 2F3: Other ("direct reporting" method, i.e. the companies that sell, install and service the systems keep statistics on the quantities released in fires and the quantities released due to system malfunction) 2F4: Tier 2 (IPCC 2006 GL) 2G1: Tier 2 (IPCC 2006 GL)

A.7. Actual emission – Tier and EF methods per category

Used method, fx. Tier 2, top down for domestic refrigerants etc (specify if possible per category)?

Iceland	Emissions for the refrigeration and air conditioning sector are estimated using the 2006 IPCC Guideline Tier 2a - Emission-factor approach. For some sectors, however, the approach had to be modified since no information on the amount of units and their average charge could be collected. Instead the bulk import of HFCs was allocated to subsource categories based on expert judgement.
Norway	HFCs and PFCs mainly estimated using Tier 2a (emissions calculated at a disaggregated level, emission factor approach). Exceptions are mobile air conditioning that is estimated using a hybrid Tier 2a/2b (b=mass balance approach) and fire protection, aerosols and solvents that are estimated using Tier 1a (emissions calculated at an aggregated level, emission factor approach). SF6 – Tier 1
Sweden	All categories are more or less based on the same approach: Mix of top-down bulk statistics and bottom-up data from various sources. Hybrid tier 2A-2b.

Provide list of emission factors and lifetime per category?

Denmark	Refer to the tables in the report
Finland	Refer to the tables in the report
Iceland	Refer to the tables in the report
Norway	Refer to the tables in the report
Sweden	Refer to the tables in the report

Are UNFCCC guidance factors or country specific factors (where is country specific factors used)?

Denmark	Consumption data of F-gases are provided by suppliers and/or producers. Emission factors are primarily defaults from GPG, which are assessed to be applicable in a national context. In case of commercial refrigerants and Mobile Air Condition (MAC), emission are defined as similar to consumption in year X. Comsumption are determined from data directly from suppliers. In case of PUR foam blowing of shoe and use of system foam EF are stated by the producer. Because of the relative low consumption from PUR foam blowing of shoes and system foam a certain uncertainty is assessed as acceptable.

A.7. Actual emission – Tier and EF methods per category

Are UNFCCC guidance factors or country specific factors (where is country specific factors used)?

Denmark	*Import/export data* Import/export data for sub category sources where import/export are relevant (fridge/freezers for household) are quantified on estimates from import/export statistic of products + default values of amount of gas in product. Import/export data for system foam and commercial refrigerators and stationary air condition are specified in the reporting from importers and users
Finland	Mostly IPCC default emission factors are used in every category, the only exception are described below in the next question.
Iceland	No country specific emission factors are used.
Norway	Factor for HFCs and PFCs are default IPCC 2006 Guidelines. SF6-factors are a combination of default and country specific.
Sweden	Mainly based on national (old) expert judgments by the Swedish EPA. Volvo and Scania have verified MAC factors. CS factors mainly, tough, most factors are within the IPCC ranges. Some exemptions exist ...

Information sources for country specific EF's (expert estimate, measurement data, other).

Denmark	For commercial refrigeration a survey of emission data from approx. 2,000 COOP supermarkets forms the basic for a national EF of 10% per year (2002). For SF6 national EF in switchgear an analysis covering the total sector and installed units has been conducted and reported (2001).
Finland	In the case of manufacturing of domestic refrigeration equipment, a national emission factor has been used for the years 1993-1999. In the mid-1990s there were three Finnish manufacturers of domestic appliances and the use of R-134a as refrigerant began in 1993. The emission factor is based on identical data reported by two manufacturers. The emission rate has been estimated as the difference between the total annual R-134A consumption in manufacturing reported by the plants and the calculated total refrigerant fill in manufactured equipment (based on number of manufactured equipment and refrigerant fill in one equipment reported by the plants). 2E1: In the 2E1 Electrical equipment sector, the country-specific emission factors required for the Tier 2 method were developed by an expert group during 2014. The group was appointed by SYKE. In addition to SYKE, the group consisted of members from the industry using SF6 equipment (electricity transmission and distribution companies), a Finnish SF6 equipment manufacturer, a research institute (Tampere University of Technology) and the National Authority for the GHG inventory (Statistics Finland). More detailed information can be found from the NIR (chapter 4.8.2.2).
Iceland	No country specific emission factors.

A.7. Actual emission – Tier and EF methods per category

Information sources for country specific EF's (expert estimate, measurement data, other).

Norway	None
Sweden	Mainly expert judgments except for CRF 2.F.1.a, 2.F.1.c and partly for 2.F.1.f where IPCC default values are used.

A.8. Uncertainty

Estimated uncertainty levels, overall and specific at activity data level?

Denmark	Uncertainties due to poor definitions are not expected as an issue in the F-gas inventory. The definitions of chemicals, the factors, sub source categories in industries etc. are well defined. Uncertainties from natural variability are probably occurring in a short term time period, while estimating emissions in individual years. But in a long time period – 10-15 years, these variabilities levels out in the total emission , because input data (consumption of F-gases) are known and are valid data and has no natural variability due to the chemicals stabile nature. Uncertainties that arise due to imperfect measurement and assessment are probably an issue for: Emission from MAC (HFC-134a) emission from commercial refrigerants (HFC-134a) It leads to inexact values of the specific consumption of F-gases. The uncertainty varies from substance to substance. Uncertainty is greatest for HFC-134a due to a widespread application in products that are imported and exported. The greatest uncertainty in the areas of application is expected to arise from consumption of HFC-404a and HFC-134a in commercial refrigerators and mobile refrigerators. The uncertainty on year to year data is influenced by the uncertainty on the rates at which the substances are released. This results in significant differences in the emission determinations in the short term (approx. five years), differences that balances in the long term. I connection to the work on the Danish National Inventory report general uncertainty estimates for F-gases has been worked out to make the uncertainties for the Danish inventories complete. Refer this report given in the reference list in the main report. Further improvement of uncertainty analysis with respect to the calculation of F-gas emissions are to be considered in future calculations.

A.8. Uncertainty

Estimated uncertainty levels, overall and specific at activity data level?

Denmark	No QA/QC plan specifically for the F-gas calculation is developed. However, QC procedures were carried out as described below. The spread sheets containing activity data has incorporated several data-control mechanisms, which ensure, that data estimates do not contain calculation failures. A very comprehensive QC procedure on the data in the model for the whole time-series has for this submission been carried out in connection to the process which provided (1) data for the CRF background Tables 2(II).F. for the years (1993)-2002 and (2) provided data for potential emissions in CRF Tables 2(I). This procedure consisted of a check of the input data for the model for each substance. As regards the HFCs this checking was done according to their trade names. Conversion was made to the HFCs substances used in the CRF tables etc. A QC was that emission of the substances could be calculated and checked comparing results from the substances as trade names and as the "no-mixture" substances used in the CRF.
Finland	Uncertainty levels of emissions in the Finnish 2015 inventory (based on Monte Carlo simulation in each category): *2E1* Uncertainty in HFC emissions in 2015 was estimated at -34% to 38%, in PFC emissions at -43% to 46% and in SF6 emissions at -79% to 84%. Correlation analysis of the simulation results suggests that most of the uncertainty is due to the fraction of each gas destroyed or transformed and to the amounts of gases consumed in semi-conductor manufacturing. *2F1* Uncertainty in HFC emissions from category 2.F.1 was estimated at -9% to 9% and in PFC emissions at -19% to 19%. The uncertainty of HFC emissions between different 2.F.1 subcategories varies slightly with highest uncertainties in domestic refrigeration and in mobile air conditioning and lowest in commercial refrigeration and stationary air conditioning. The simulation results suggest that most of the uncertainty in total HFC emissions from category 2.F.1 was due to the imported amount of HFC-134a for the mobile air conditioning sector and the HFC-134a charge in the retiring equipment in the same sector. In the case of PFC emissions, the simulation results suggest that most of the uncertainty was due to the PFC-218 charge in the retiring commercial refrigeration equipment.

A.8. Uncertainty

Estimated uncertainty levels, overall and specific at activity data level?

Finland	*2F2* Uncertainty in HFC-134a emissions in 2015 was estimated at -21% to 22%. A correlation analysis of the simulation results suggests that most of the uncertainty is due to uncertainty of the emission factors for the leakage of HFC-134a banked in appliance and XPS foams and the sizes of the appliance and XPS HFC-134a banks. The uncertainty in HFC-152a emissions (reported in the category 2.H.3 in the unspecified mix of HFCs due to confidentiality) in 2015 was estimated at -21% to 21%. Most of the uncertainty is due to uncertainty of the amount of HFC-152a banked in XPS foam products and emission factor for the leakage from the bank. Uncertainty in HFC-227ea emissions in 2015 was estimated at -24% to 24%. Most of the uncertainty of HFC-227ea emissions is due to uncertainty of the amount of HFC-227ea used for the manufacture of integral skin foams. Uncertainty in HFC-245fa emissions in 2015 was estimated at -25% to 28% and in HFC-365mfc at -20% to 21%. Most of the uncertainty of HFC-245fa emissions is due to uncertainty of the emission factor and amount of HFC-245fa used for the manufacture of injected foams. In the case of HFC-365mfc, most of the uncertainty is due to uncertainty of the amount of HFC-365mfc used for the manufacture of integral skin foams and the emission factor for leakage of HFC-365mfc banked in sandwich panel foams. *2F4* Uncertainty in HFC-134a emissions in 2015 was estimated at -29% to 32%. The simulation results suggest that most of the uncertainty was due to the amount of HFC-134a imported in bulk and to the emission factor. Uncertainty in HFC-152a emissions in 2015 was estimated at -21% to 23%. The simulation results suggest that most of the uncertainty was due to the emission factor and amount of HFC-152a imported in products. Uncertainty in HFC-245fa emissions (reported in the category 2.H.3 in the unspecified mix of HFCs due to confidentiality) in 2015 was estimated at -24% to 27%. The simulation results suggest that most of the uncertainty was due to the emission factor and amount of HFC-245fa imported in products. *2G1* Uncertainty in SF6 emissions in 2015 was estimated at -33% to 38%. According to the simulation results, most of the uncertainty is related to the emission factor for the leakage of SF6 from the gas bank and the size of the bank itself. *2H3* Uncertainty in HFC emissions (reported as an unspecified mix of HFCs) in 2015 was estimated at -18% to 18%, in PFC (reported as an unspecified mix of PFCs) emissions at -50% to 50% and in SF6 emissions at -59% to 59%. Most of the uncertainty of PFC and SF6 emissions was related to the emissions from the electronics industry. In the case of HFC emissions, most of the uncertainty was due to the uncertainty of HFC-152a emissions from XPS foams.
Iceland	Listed in separate document

A.8. Uncertainty

Estimated uncertainty levels, overall and specific at activity data level?

Norway	Both the leakage rate (emission factor) and the stored amount of chemicals (activity data) are considered quite uncertain. The total uncertainties for the emission estimates by the consumption of halocarbons are estimated to be +50 per cent for both HFC and PFC. For the consumption of SF6 the uncertainty figure is 60 per cent (expert judgement).
Sweden	Uncertainties are defined at two levels – activity data and emission factors. Uncertainties defined for all categories (see separate table in appendix)

Data sources for uncertainty levels (expert estimation, domestic/international literature, other)?

Denmark	Expert assessment
Finland	Mostly expert estimations and in many cases without any proper background information. The uncertainty analyses should be revised in every category but there is a lack of resources to perform a proper evaluation of the whole process. No uncertainty analysis has yet been performed for the new RAC calculation model (should somehow be done in the near future).
Iceland	Expert assessment in combination with IPCC guideline EF ranges.
Norway	Expert assessment.. See report: http://www.ssb.no/a/english/publikasjoner/pdf/rapp_201135_en/rapp_201135_en.pdf
Sweden	Expert estimation

Are there any key source categories?

Denmark	HFC 134a in MAC is key source category
Finland	Key source category for F-gases in the Finnish 2015 inventory was 2F1 Refrigeration and air conditioning (according to the level and trend).
Iceland	HFC from 2F1 is key source category
Norway	Categories 2F1-2F6, HFC and PFCs in product use, are grouped together in the key category analysis. It is identifies as a key category for Norway.
Sweden	HFC from 2F1 is key

A.9. Quantified comparable F-gas data for 2015 in the Nordic

Total emission

Denmark	Total emission, 2015: 742,006 CO2 eq. Emissions were divided as following: HFC's: 633,928 CO2-eq. PFC's: 4,996 CO2-eq. SF6: 103,082 CO2-eq.
Finland	Total emissions in 2015: 1,591,600 CO2 eq. HFC's: 1547.4 kt CO2-eq. PFC's: 6.6 kt CO2-eq. SF6: 37.6 kt CO2-eq.
Iceland	Total emissions of F-gas consumption were estimated in 2015 to be 207 kt CO2eq.
Norway	Total emission: 1,288,150 CO2 eq. 2015 HFCs and PFCs: 1,232,900 GWP tonnes or 611 metric tonnes SF6: 55,250 GWP tonnes or 2.42 metric tonnes (PFC is also emitted from metal industry: 146,000 GWP tonnes or 19 metric tonnes)
Sweden	829,000 GWP tonnes in 2015

Per substance and category

Denmark	See table in attached spreadsheet
Finland	2F1a: HFCs: 816.9 kt CO2-eq. PFCs: 4.27 kt CO2-eq. 2F1b: HFCs: 2.89 kt CO2-eq. 2F1c: HFC's: 115.88 kt CO2-eq. PFCs: 0.15 kt CO2-eq. 2F1d: HFCs: 27.47 kt CO2-eq. 2F1e: HFCs: 328.02 2F1f: HFCs: 196.66 kt CO2-eq. 2F2: HFCs: 2.21 kt CO2-eq. 2F4: HFCs: 50.65 kt CO2-eq. 2G1: SF6: 10.85 kt CO2-eq. 2H3: HFCs: 3.24 kt CO2-eq. PFCs: 2.20 kt CO2-eq. SF6: 26.70 kt CO2-eq.

A.9. Quantified com-parable F-gas data for 2015 in the Nordic

Per substance and category

Iceland	See table in attached spreadsheet No NF3 emissions have been estimated for Iceland.
Norway	See table in appendix
Sweden	See table in appendix

Total consumption

Denmark	Total import in bulk and products were in 2015: HFCs: 289 tonnes PFCs: 0.3 tonnes SF6: 1.5 tonnes
Finland	
Iceland	Consumption is assumed to be the same as imports, no information on exports are currently available. Imports in 2015 were around 79.8 tons in bulk and estimated around 6 tons in imported products (90 kg in refrigerators+600 kg in metered dose inhalers + 5,200 kg in MACs).
Norway	Import of HFCs and PFCs to Norway in 2015: 612 tonnes (255 tonnes imported in bulk, 357 tonnes imported in products).
Sweden	

A.10. Time series

Specification of the period for the F-gas time series?

Denmark	1990-2030 The time series are consistent as regards methodology. No potential emission estimates are included as emissions in the time series and same emission factors are used for all years.
Finland	The time-range in the scenarios in every sectors reaches until 2050 (beginning from 1990).
Iceland	1993-2015 for emissions from bulk import. 1995-2015 for MACs. 2002-2015 for metered dose inhalers and 1993-2015 for imported refrigerators. 1990-2015 for aluminium production. For metered dose inhalers, extrapolation from 1990-2001 was done by correlating population size and imports of metered dose inhalers containing HFCs.
Norway	HFCs and PFCs: 1990-2016
Sweden	1990-2015

Used principles and parameters for extrapolation, e.g. steady state consumption, considered impact from taxes etc.?

Denmark	Basically all extrapolation is based on a steady state assumption. For categories where legislation states phase out dates, the extrapolation is steady state to the date of phase out. For commercial refrigeration an extra dimension is included in the extrapolation. Impact on consumption by introducing green taxes is simulated and assumed with a percentages reduction over a number of years phase in of the taxes.
Finland	In the case of other sectors than RAC, the scenario estimation is performed with very simplified methodologies. The RAC sector scenarios are performed in a more detailed level and the details of the sector specific work is described in a separate report.
Iceland	or metered dose inhalers, extrapolation from 1990-2001 was done by correlating population size and imports of metered dose inhalers containing HFCs.
Norway	No extrapolation
Sweden	Bulk statistics have one years lag, i.e. for 2015, 2014 is extrapolated coping the same data. Due to large imported amounts of HFCs 2014 (due to new F-gas regulation), extrapolation for 2015 is based on trend analysis 2008-2013.

A.11. UNFCCC review process

The most significant issues related to F-gases in the recent years

Denmark	Estimate the AD for HFCs remaining in hard foam and verify that, consistent with Danish law, emissions from disposal are not occurring. Report the SF6 emissions remaining in double- glazed windows at decommissioning separately from the emissions from stocks. The ERT recommends that Denmark assesses the assumption of 100% of F-gas consumption (PFC-318, PFC-14) from industrial plants (fibre optics) The ERT recommends that Denmark investigate all users of SF6, to collect data and information and recommends that the Party report information on the particle accelerator and other SF6 sources in the next submission for transparency and comparability among Parties. ERT recommends that Denmark assess the assumption of 100% of F-gas consumption from possible sources (e.g. laboratories, universities, research laboratories and medical centres), to improve estimations and the consistency of time-series
Finland	Transparency of the reporting of sector 2F1 has been a frequent issue in the reviews since e.g. the stocks are not estimated in the mass balance approach and therefore not reported in the CRF tables. Other minor issues in the recent reviews have been related e.g. to the reporting of end-of-life emissions and recovery in different sectors and also to some individual notation keys in the CRF tables.
Iceland	Minor issues related to interannual fluctuation in emissions and missing estimation for certain sources.
Norway	
Sweden	The ERT recommends that Sweden provide additional documented information in order to justify its use of a country-specific product life factor for HFC-125 emissions for category 2.F.1 The ERT encourages Sweden to undertake an independent monitoring study and report the appropriate findings in the NIR in order to technically validate the use of the very high country-specific HFC recovery factors for this category. The ERT encourages Sweden to initiate development projects aimed at supporting the implementation of a QA/QC procedure that will allow the comparison of equipment/product-based estimates at the subapplication level (tier 2a) with the massbalance tier 1b or tier 2b approach. 2014 ARR: The ERT recommends that the Party document the methodology used to derive the uncertainty data using expert judgement in the NIR of the next annual submission and revise the uncertainty estimates, if appropriate.

A.11. UNFCCC review process

Effects to the F-gas inventory (recalculations, recommendations …)

Denmark	Minor effect.
Finland	Only recommendations given by the reviewers.
Iceland	Minor recalculations.
Norway	There are usually quite a few questions regarding the emissions of HFCs and PFCs during the review process. It often leads to minor corrections on data that have little impact on total emissions. Transparency (explanations in the NIR) has been improved.
Sweden	No recalculations due to ERT recommendations.

A.12. Background information

Provide overview of relevant conducted reports or analysis of F-gases, e.g. emission revisions etc.

Denmark	Danish Environmental Protection Agency (DEPA), 2015: The greenhouse gases HFCs, PFCs and SF6. Danish consumption and emissions. Environ-mental Project No 1842. http://mst.dk/service/publikationer/publikationsarkiv/2016/mar/danish-consumption-and-emission-of-f-gases/ Re-evaluation of emissions from commercial refrigerators, mobile A/C systems and refrigerators (only available in Danish). Poulsen, T.S, COWI; Environmental report no. 766, Danish EPA, 2002. Collection and reuse of SF6 from high-voltage plants (only available in Danish). Tomas Sander Poulsen et al., Danish EPA 2000.
Finland	The latest NIR report (2017 submission) can be downloaded from http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php
Iceland	No reports or analyses have been conducted to our knowledge.
Norway	Emissions of HFCs and PFCs from product use in Norway. Report from 2013: http://www.ssb.no/natur-og-miljo/artikler-og-publikasjoner/_attachment/126338?_ts=13f85bebb88 • A more thorough description of the methodology Emissions from consumption of HFCs, PFCs and SF6 in Norway. Report from 2007: ssb.no/a/english/publikasjoner/pdf/doc_200708_en/doc_200708_en.pdf • Contains more details on the data sources

A.12. Background information

Provide overview of relevant conducted reports or analysis of F-gases, e.g. emission revisions etc.

Sweden	3 SMED reports in English: Kindbom (2005): http://www.smed.se/wp-content/uploads/2012/01/Revision-of-Methodology-and-Emissions-of-Fluorinated-GHG-in-Sweden.pdf Gustafsson (2011): http://www.smed.se/wp-content/uploads/2012/01/Fluorinated-Greenhouse-Gases-in-Sweden.pdf Danielsson (2014): http://www.smed.se/wp-content/uploads/2015/04/SMED-PM-Fluorinated-greenhouse-gases-%E2%80%93-underestimation-of-reported-Swedish-emissions-from-disposal-of-products-and-equipment-2014.pdf

Part B – National regulatory efforts due to F-gases

B.1: Taxes

Taxes on F-gas consumption (bulk)? If yes, please specify or refer to link with taxes.

Denmark	Since 2004, taxes have been applied to F-gas bulk import and import of products containing F-gases. Taxes are defined for each particular substance according to its total GWP. The maximal tax per kg. HFC/PFC/SF6 are 80 € (600 DKK). Link to tax table: http://www.skat.dk/SKAT.aspx?oID=1921422&chk=212649
Finland	No
Iceland	Currently there are no specific taxes on F-gas consumption. A small processing fee (ISK 2.5/kg ~EUR 0.02 as of April 2017) is collected on import to finance the collection and destruction of F-gas refrigerants.
Norway	Yes, tax of 450 NOK per GWP-tonnes of HFC/PFC imported (and produced, but Norway has no production). Equal amount is refunded for gas delivered for destruc-tion. Link: www.skatteetaten.no/globalassets/saravgifter/avgiftsrundskriv/2017-avgift-pa-hfk-og-pfk.pdf
Sweden	No

Taxes on products containing F-gas?

Denmark	Yes
Finland	No
Iceland	There are no taxes on products containing F-gases beyond those applicable to products in general.
Norway	Same as above.
Sweden	No

Other taxes related to F-gas use?

Denmark	No
Finland	No
Iceland	No
Norway	No
Sweden	No

B.1: Taxes

Evaluation of success?

Denmark	Yes. The taxes have pulled the market for alternative commercial refrigeration systems, e.g. CO2 refrigeration. Further, it has pushed customers to improve and renovation elder refrigeration systems. Thus, the tax system also made speculations in illegal trade more attractive.
Finland	N/A
Iceland	Only a small amount of the processing fee collected has been claimed by the recycling facilities meaning that relatively small amounts of refrigerant gases are being turned in for processing.
Norway	The tax has contributed to slower growth in the emissions of HFCs compared to business-as-usual scenario. The reason for this is that the tax has encouraged the use of lowest possible GWP HFCs and natural refrigerants in refrigeration and AC equipment. The tax has also encouraged better maintenance (lower leakage) and technological innovation. The refund has led to more recovery of used refrigerant (even though intended release of refrigerant I prohibited by law).
Sweden	

B.2: F-gas regulations

National act and orders reference

Denmark	*BEK nr 525 af 21/05/2017 - Gældende* Bekendtgørelse om regulering af visse industrielle drivhusgasser (F-gas bekendtgørelsen) Miljø- og Fødevareministeriet *LBK nr 69 af 17/01/2017 - Gældende* Bekendtgørelse af lov om afgift af cfc og visse industrielle drivhusgasser (Cfc-afgiftsloven) Skatteministeriet *BEK nr 118 af 19/02/2001 - Gældende* Bekendtgørelse om beregning af den afgiftspligtige vægt for produkter, der indeholder visse industrielle drivhus-gasser Skatteministeriet
Finland	No
Iceland	

B.3. Recovery and destruction

Regulation and procedure for recovery and destruction of F-gases from refrigerators?

Denmark	There are requirements for the appropriate handling of: - equipment containing refrigerants - switchgear containing SF6 KMO – The refrigeration sectors environmental scheme – is a certification system for suppliers of refrigerants. Suppliers are not allows to sell or handle HFCs without a KMO certificate. KMO assures competences to correct handling and recovery, registration of recovered refrigerants and maintenance of personal log-books. https://www.kmo.dk/Dokumenter/regels%C3%A6t%206,3.pdf https://www.retsinformation.dk/forms/R0710.aspx?id=190016
Finland	Prior to the EU regulations, there have already been requirements for the appropriate handling of equipment containing refrigerants in the domestic waste legislation.
Iceland	The regulation on electrical and electronic equipment waste stipulates that end-of-life refrigerators should be turned in to licenced waste processing units. Said regulation also stipulates that CFCs, HCFCs, HFCs and HCs should be recovered and that when equipment contains ODSs or gases with GWP exceeding 15, in for example foam or piping, they need to be recovered and handled in an appropriate manner.
Norway	Refund of NOK 450 per tonnes of HFC/PFC delivered for safe destruction. HFCs and PFCs classified as hazardous substances that are required by law to be displaced of securely (EU regulation). Tight co-operation with the GIS users as regards recovery of SF6. Infrastructure for recovery in place (however, SF6 appears NOT to be included in EU list on hazardous substances
Sweden	The regulation and procedure is regulated by waste handling regulation.

B.3. Recovery and destruction

Regulation of recovery of F-gases in foam at end of life?

Denmark	No requirement for handling of hard foam containing F-gases.
Finland	No
Iceland	Yes, in foam as part of electronic equipment, as described above.
Norway	According to EU regulation (if any specif-ic). No specific national regulation. One in-stallation for recovery has been in operation, but this is now closed down.
Sweden	No recovery but according to interpretation of Swedish legislation concerning waste, foam with F-gases should be handled as hazardous waste and combusted at special combustion plants.

Other regulation concerning recovery of F-gases?

Denmark	No
Finland	No
Iceland	No
Norway	No specific national regulation (but Norway has implemented the EU F-gas regulation 842/2006 and is preparing the implementation of 517/2014)
Sweden	No

Regulation or requirements to recycling of refrigerants?

Denmark	No
Finland	No
Iceland	No
Norway	No specific regulations (recycling done nationally is not affected by the tax/refund schemes).
Sweden	Recycling of refrigerants is handled by the operators. We have no special regulation about recycling.

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F-gas methodologies and measurements in the Nordic Countries
This project report is a part of the NMR KOL project Nordic Policy Cluster for F-gases with the purpose of comparing the Nordic countries' methodologies and regulations related to the use of F-gases .

Fluorinated gases (F-gases, including HFCs, PFCs, SF6 and NF3) are a range of potent greenhouse gases that are used in a number of different applications and products for refrigeration, foams, aerosols, and technical installations.

The report contains a survey and an overview of F-gas methodologies used for UNFCCC reporting, as well as an account of emissions and regulations in the Nordic countries.

The objective with the analysis was to provide an overview of differences and similarities within the Nordic countries in relation to F-gases. The analysis shall enable harmonization of data collection, emission factors, choice of methods, and regulatory instruments.