Proposed Renewable Cooling Calculation Methodology

Guidance Document for Renewable Cooling share calculation

Part 4 of the study
"Renewable Cooling under the Revised Renewable Energy Directive ENER/C1/2018-493"

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1. Introduction to this study report

As part of the “Clean Energy for all Europeans” package [1], the EC proposed an update of the Renewable Energy Directive (RED - 2009/28/EC [2]). The revised RED was adopted in December 2018[3]). The RED II includes a specific chapter on mainstreaming renewable energy into heating and cooling (H&C), Article 23 and district heating and cooling (DHC), Article 24. To do so, the RED II requires Member States (MSs) to raise the share of renewable energy in H&C yearly by an average of 1.3 percentage points (ppt) from 2021 to 2030. MSs are allowed to count waste heat and cold in 1.3 ppt up to 40% of the increment. In case a MS decides not to use waste heat and cold to the average annual increase, it must implement an annual average of 1.1 ppt increase in the share of renewables in H&C. Additionally, the RED II also promotes renewable energy sources (RES) in district heating and cooling (DHC), requesting MSs to raise the share of RES and waste heat and cold by at least 1 percentage point yearly (2021-2030). MS can fulfil this 1 ppt increase by waste heat and cold without limitation.

While the RED II outlines the methodology to calculate RES shares for electricity, transport and heating, it does not provide methods on how to take into account renewable cooling. The RED II specifies that the EC shall adopt delegated acts to supplement the directive at the latest by the 31st of December 2021, including a methodology for calculating the amount of renewable energy utilized for cooling and district cooling (DC), and amend the directive accordingly.

In this context, the European Commission launched this study to develop a methodology for defining renewable cooling and for calculating corresponding RES-HC and RES shares. This also requires a rigorous analysis of the status quo of cooling technologies and the cooling related energy demand. The specific goals of the study are:

- Providing an overview of technologies for cooling, related technologies and their technological development trends;
- Quantifying actual cooling demand as well as its development until 2030 and 2050;
- Providing options of renewable cooling definitions, which are in line with the RED II as well as elaborating options of possible methods for calculating renewable energy shares;
- Investigating impacts of proposed definitions on renewable cooling, related methods on calculations;
- Delivering well-grounded recommendations for choosing a fitting definition of renewable cooling, calculation methods as well as on how statistical reporting can be improved and utilized for renewable cooling;

During the project duration (from end of 2019 until August 2021) a series of stakeholder consultation events took place, including a survey of EU Member States energy statistics representatives and Eurostat, presentation and consultation at the CA-RES and CA-EED, two dedicated stakeholder workshops as well as bilateral meetings and consultations. These numerous feedbacks served to continuously improve and further develop the project results.

This fourth report provides a guidance document focusing on a clear presentation of the proposed calculation methodology and its implementation. The following sections should be considered as the guidance document.

The purpose of this guidance document is to assist Member State representatives and statistical staff in calculating the quantity of renewable energy used for cooling following the delegated act under the Renewable Energy Directive.

The guidance document is focused on how to do the calculation as specific as possible and only including definitions and technological descriptions, where it is needed.

For further details and the analyses behind the methodology, please see the methodology report.[1]

1 Kranzl L., Mascherbauer P., Fallahnejad M., Pezutto S., Novelli A., Zambito A., Miraglio P., Belleri A., Bottecchia L., Gantioler S., Riviere P., Etienne A., Stabat P., Berthou T., Viegand J., Jensen C., Hummel M., Müller A. Renewable cooling definition options and calculation methodology, Report 2 of the study Renewable Cooling under the Revised Renewable Energy Directive ENER/C1/2018-493, 2020

2. How to calculate the amount of renewable cooling energy

The renewable cooling energy quantity for each Member State is the sum of the quantities for each relevant cooling system in scope of the calculation in the Member State.

The calculation takes place in the following 5 steps, though some are alternative steps depending on local conditions and data availability in the individual Member States:

- Step 1: Simplified calculation for cooling generators with cooling capacity below 1.5 MW with no local renewable energy input to the cooling generator
- Step 2: Simplified calculation for cooling generators with cooling capacity below 1.5 MW with local renewable energy input to the cooling generator
- Step 3: Calculation for cooling generators with cooling capacity above 1.5 MW using site data
- Step 4: Calculation of waste heat and cold contribution
- Step 5: Sum up the total renewable cooling energy and the waste heat/cold based cooling that can satisfy the heating and cooling target (Article 23 of REDII) and the district heating and cooling target (Article 24 of REDII).

Step 1 is the simplest calculation capturing renewable cooling energy for smaller systems (cooling capacity below 1.5 MW per system), which is simplified by using default values for several of the factors in the calculations and only little data input is required.

Step 2-4 requires collection of measured data and/or more complex calculations. These are relevant, if the Member State wants to include in the reporting to the European Commission the following systems:

- Cooling systems, where cooling generators are supplied with local renewable energy input e.g. PV (photovoltaic) electricity to run the cooling compressor
- Larger cooling systems (cooling capacity above 1.5 MW per system)
- Systems using waste heat and waste cold for cooling

Not all types of cooling systems and cooling usages are in the scope of the calculation method. Therefore, in the following, the scope and related definitions are explained.

3. Scope

3.1. Scope

In the context of the renewable cooling calculation methodology, **cooling** is defined as the extraction of heat from an enclosed space (to ensure human comfort) or from a process in order to reduce or maintain the space or process temperature at a specified (set) temperature.

The following applications are not in the scope:

- Cooling systems in means of transportation.
- Cooling systems for which the primary function is the purpose of producing or storing perishable materials at specified temperatures (refrigeration).
- Cooling systems with space or process cooling temperature set points lower than 2 °C.
- Cooling systems with space or process cooling temperature set points above 30 °C
- Processes with excess heat generation (such as in thermal power plants and other combustion and chemical processes), where part of the heat is not useful and thus needs to be removed (cooled), i.e. the cooling of waste heat

The extraction of heat from a process is limited to sites where no processes take place other than those with a temperature range of 0-30°C.[2]

In the context of the calculations, we consider systems, where cooling is delivered by an **active cooling system**, which is either a free cooling system or a cooling system embedding a cooling generator, and for which cooling is one of the primary functions.

A **free cooling system** is a cooling system using a natural cold source to extract heat from the space or process to be cooled via fluid(s) transportation with pump(s) and/or fan(s) and which does not require the use of a cooling generator.

A **cooling generator** refers to the part of a cooling system that generates a temperature difference allowing heat extraction from the space or process to be cooled, using a vapour compression cycle, a sorption cycle or another energy-driven thermodynamic cycle.

The **renewable energy quantity for cooling E_{RES-C}** can be calculated as the cooling supply that is generated with a certain energy efficiency expressed as a Seasonal Performance Factor, which quantitatively corresponds to a portion of the heat released by a cooling system to ambient air, ambient water or to the ground.

In the context of defining renewable cooling energy quantity, **renewable energy input** refers to the self-consumption of local renewable energy generation by the cooling system. Hereby, local renewable energy generation can be one of the following:

- Renewable heat generation
- Off-grid renewable electricity or gas generation
- Local renewable energy generation supplied under the same interconnection between the transportation and distribution grid as the cooling system in the case of grid electricity and gas, or a renewable electricity or gas generation source located nearby the cooling system, where the distance corresponding to the term “nearby” as used in the EPBD is to be defined by each Member States.

[2] According to the information available to the study team, only the agricultural sector complies with this requirement.

- Renewable fuel generation not already accounted for elsewhere (in renewable electricity, renewable heat or renewable gases used in other sectors) in the gross consumption of renewable energy sources.

3.2. Detailing the scope

Heat can be extracted from space or process when the supply temperature from the cooling system is lower than the temperature of the space or process to be cooled. The extracted heat is rejected into and absorbed by the ambient air, ambient water or the ground. The environment (air, ground, and water) provides a sink for the heat extracted and thus functions as a cold source.

The energy input to the cooling system can be electricity (e.g. electric heat pump), gas (e.g. gas driven heat pump) or heat (e.g. ab/adsorption cooling). In all cases, the energy input can be renewable, fully or partly.

In a free cooling system, a natural heat flow from hot to cold is available and used, and it is intensified by use of pumps or fans. Comfort fans are however outside the scope of the renewable cooling energy.

The cold source is also called heat sink and it is where the heat to be extracted is transferred to. For free cooling, the cold source has a lower temperature than the temperature of the space or process to be cooled. The cold source can also have a higher temperature and in this case a cooling generator is needed.

Energy input is needed for a cooling generator and/or heat transportation using pumps and fans in the case of free cooling.

A central parameter for the calculations is the **SPF_p** , the **Seasonal Performance Factor calculated in primary energy.** **SPF_p** is a ratio expressing the efficiency of cooling systems during the cooling season. It is calculated as cooling supply divided by the primary energy input. Higher SPF_p is better, because more cooling is produced for the same primary energy input.

The share of **the cooling supply, which can be considered as renewable** is determined according to the efficiency of the system expressed as Seasonal Performance Factor. It is called $\mathbf{s_{SPF_p}}$. This percentage is needed to calculate the quantity of renewable energy from cooling.

4. Step 1: Simplified calculation for cooling generators with cooling capacity below 1.5 MW with no renewable energy input to the cooling generator

This calculation method is used for calculating the amount of renewable cooling energy for a broad range of cooling systems in the Member State without collecting data for each of the specific cooling systems. Step 1 applies for cooling generators with cooling capacity below 1.5 MW with no renewable energy input to the cooling generator e.g. PV (photovoltaic) electricity to run the cooling compressor. If cooling systems with renewable energy input to the cooling generator exist in the Member State and should be included in the report, skip step 1 and go to step 2.

The only data input needed for the calculations in step 1 are:

- The total standard rated cooling capacity for the cooling systems in scope for a number of categories of cooling systems and usages.
- The number of cooling degree days (CDD) (base: 18 °C) for the Member State
- An activity factor for process cooling indicating average annual operation time

The Member State can select not to use this simplified calculation and instead use a more precise calculation using measured site data for each cooling system. In this case, step 1 and 2 should be skipped and the Member State should start with step 3.

Step 1.1: Collect data for rated cooling capacity of cooling systems

Collect data for rated cooling capacity (P_c) for the year to report of all relevant cooling systems in scope (see Section 3.1 Scope) for the types of cooling systems and usage categories in Table 1. The rated cooling capacity is the power of the cooling output and not the electricity input to the cooling system. The data should be provided in GW.

Table 1: Data to collect for rated cooling capacity for the year to report of all relevant cooling systems in scope.

Rated cooling capacity GW	**Usage category**		
Cooling system technology	Space cooling in the residential sector	Space cooling in the tertiary sector	Process cooling
Small split (<5 kW)			
Big split (≥5 kW, incl. ducted)			
VRF (Variable Refrigerant Flow)			
*Rooftop factory packaged system			
*Chillers (air/water) < 400 kW			
*Chillers (air/water) ≥ 400 kW			
Chillers (water/water) < 400 kW			
Chillers (water/water) ≥ 400 kW			
*Mobile			

To fill in with collected data in GW

Data for technologies marked with * need only to be collected if step 2 is used.

Step 1.2: Collect data for cooling degree days

Collect data for the cooling degree days (CDD) (base: 18 °C) for the year to report. CDD can be either a single CDD value for the whole Member State or distinct values for different climate zones if larger variations exist in the Member State. For the latter case, the data in Table 1 should be provided for each climate zone; the following calculations should be performed for each climate zone and the resulting data for all climate zones should be summed up.

Step 1.3: Calculate the number of equivalent full load hours

Based on the data in step 1.2, calculate the number of equivalent full load hours (EFLH) for each usage category with these equations:

- For space cooling in the residential sector: EFLH = 96 + 0.85 * CDD
- For space cooling in the tertiary sector: EFLH = 475 + 0.49 * CDD
- For process cooling: EFLH = τ_s * (7300 + 0.32 * CDD)

The number of full load hours (EFLH) indicates how many hours a cooling system should run with full load to produce the amount of cooling that it actually produces during a year but at varying loads.

τ_s is an activity factor for the process cooling i.e. the approximate proportion of the year that process cooling is taking place as an average of process cooling for each cooling system technology and process sub-sector (e.g. all year long, full time: τ_s=1, not on week-ends: τ_s=5/7). Activity data should be collected and/or estimated.

Step 1.4: Calculate the cooling supply $Q_{CSupply}$

Based on the data in step 1.1 and step 1.3, calculate the cooling supply by multiplying rated cooling capacity for each cooling system technology and usage category (Table 1) with the corresponding equivalent full load hours for each usage category, see Table 2. The resulting data is in GWh.

Table 2: Cooling supply for each cooling system technology and each usage category for the year to report of all relevant cooling systems in scope.

Cooling supply GWh/year	**Usage category**		
Cooling system technology	Space cooling in the residential sector	Space cooling in the tertiary sector	Process cooling
Small split (<5 kW)			
Big split (≥5 kW, incl. ducted)			
VRF (Variable Refrigerant Flow)			
Rooftop factory packaged system			
Chillers (air/water) < 400 kW			
Chillers (air/water) ≥ 400 kW			
Chillers (water/water) < 400 kW			
Chillers (water/water) ≥ 400 kW			
Mobile			

Multiply the data in each cell in Table 1 (step 1.1) with the corresponding EFLH value for the specific usage category (step 1.3)

Step 1.5a: Calculate the renewable cooling energy quantity $E_{RES\text{-}C}$ using default values for the share of cooling supply to be included as renewable energy

Based on the data in step 1.4, calculate the renewable cooling energy quantity $E_{RES\text{-}C}$ by multiplying the cooling supply for each cooling system technology group and usage category (residential and tertiary space cooling, process cooling) (Table 2) with the factors in Table 3. These factors are thus the share (called s_{SPF_p}) of the cooling supply that satisfies the SPF threshold and can be counted as renewable cooling. The same share is used for all three usage categories (space cooling in the residential sector; space cooling in the tertiary sector and process cooling).

An alternative and more precise method is provided in step 1.5b, where Member States calculate the share based on data on the SPF_p distribution for the cooling systems.

The resulting data (Table 4) is in GWh.

Table 3: Default values of the share of the cooling supply for each cooling system technology, which can be counted as renewable energy, expressed as a percentage.

Cooling system technology	**Share of cooling supply to be included as renewable energy**
Small split (<5 kW)	2.4%
Big split (≥5 kW, incl. ducted)	1.0%
VRF (Variable Refrigerant Flow)	1.1%
Rooftop factory packaged system	0.0%
Chillers (air/water) < 400 kW	0.0%
Chillers (air/water) ≥ 400 kW	0.0%
Chillers (water/water) < 400 kW	0.7%
Chillers (water/water) ≥ 400 kW	3.2%
Mobile	0.0%

Table 4: Renewable cooling energy quantity $E_{RES\text{-}C}$

Renewable cooling energy quantity GWh/year	**Usage category**		
Cooling system technology	Space cooling in the residential sector	Space cooling in the tertiary sector	Process cooling
Small split (<5 kW)			
Big split (≥5 kW, incl. ducted)			
VRF (Variable Refrigerant Flow)			
Rooftop factory packaged system			
Chillers (air/water) < 400 kW			
Chillers (air/water) ≥ 400 kW			
Chillers (water/water) < 400 kW			
Chillers (water/water) ≥ 400 kW			
Mobile			

Multiply the data in each cell in Table 2 (step 1.2) with the corresponding renewable energy share (Table 3) for the specific cooling system technology

The figures of each cell in Table 4 should be summed up.

Step 1.5b: Calculate the renewable cooling energy quantity E_{RES-C} using own values for SPF_p distribution for cooling systems

This step 1.5b is an alternative to step 1.5a, which can be used where Member States will calculate the share based on data on the SPF_p distribution for cooling systems.

Table 2 should be split up by relevant intervals of SPF_p values, where SPF_p is calculated as:

- Space cooling: $SPF_p = \frac{SEER}{\frac{1}{\eta}} - F(1) - F(2)$
- Process cooling: $SPF_p = \frac{SEPR}{\frac{1}{\eta}} - F(1) - F(2)$

η is the average ratio of total gross production of electricity to the primary energy consumption for electricity production. At EU level, 1/η is 2.1[3].

s_{SPF_p} should be calculated with the following formula:

If $SPF_p < SPF_{p\_LOW}$, $s_{SPF_p} = 0$ %.

If $SPF_{p\_LOW} \leq SPF_p \leq SPF_{p\_HIGH}$,

$s_{SPF_p} = \frac{SPF\mathrm{p} - SPF\mathrm{p}_{\_LIM\_PROG1\_LOW}}{SPF\mathrm{p}_{\_LIM\_PROG1\_HIGH} - SPF\mathrm{p}_{\_LIM\_PROG1\_LOW}}$ %.

If $SPF_p > SPF_{p\_HIGH}$, $s_{SPF_p} = 100$ %.

Where $SPF\mathrm{p}_{\_LIM\_PROG1\_LOW}$=2.8 and $SPF\mathrm{p}_{\_LIM\_PROG1\_HIGH}$= 9.5.

Calculate the renewable cooling energy quantity E_{RES-C} by multiplying the cooling supply for each cooling system technology group, usage category (residential and tertiary space cooling, process cooling) and SPFp interval (adapted Table 2) with the calculated s_{SPF_p} values for each SPFp interval. The results will be an adapted Table 4, where the figures of each cell in should be summed up.

[3] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency, OJ L 328, 21.12.2018, p. 210–230.

5. Step 2: Simplified calculation for cooling generators with cooling capacity below 1.5 MW with local renewable energy input to the cooling generator[4]

This calculation method is used for calculating the amount of renewable cooling energy for a broad range of cooling systems in the Member State without necessarily collecting all data for each specific cooling system. Step 2 applies for cooling generators with cooling capacity below 1.5 MW where at least some of the cooling generators are supplied with renewable energy input e.g. PV (photovoltaic) electricity to run the cooling compressor.

The data input needed for the calculations in step 2 are:

- The total standard rated cooling capacity for the cooling systems in scope for a number of categories of cooling systems and usages.
- The number of cooling degree days (CDD) (base: 18 °C) for the Member State
- An activity factor for process cooling indicating average annual operation time
- Share of renewable energy input to the cooling generator based on measured site data or a well substantiated calculation for the cooling systems with renewable energy input to the cooling generator

The Member State can select not to use this simplified calculation and instead use a more precise calculation using measured site data for all the cooling systems. In this case, step 2 should be skipped and the Member State should start with step 3.

Step 2.1: Collect data for rated cooling capacity of cooling systems

Collect data for rated cooling capacity (P_c) for the year to report of all relevant cooling systems in scope (see Section 3.1 Scope) for the types of cooling systems and usage categories in Table 5. The data should be provided in GW.

[4] Considering local renewable energy input in the calculation may be understood as a bonus to further promote corresponding systems. It is up to the Commission to decide whether this shall be considered or not. If not, this chapter is not relevant.

Table 5: Data to collect for rated cooling capacity for the year to report of all relevant cooling systems in scope.

Rated cooling capacity GW	**Usage category**		
Cooling system technology	Space cooling in the residential sector	Space cooling in the tertiary sector	Process cooling
Small split (<5 kW)			
Big split (≥5 kW, incl. ducted)			
VRF (Variable Refrigerant Flow)			
Rooftop factory packaged system			
Chillers (air/water) < 400 kW			
Chillers (air/water) ≥ 400 kW			
Chillers (water/water) < 400 kW			
Chillers (water/water) ≥ 400 kW			
Mobile			

To fill in with collected data in GW

Step 2.2: Collect data for cooling degree days

Collect data for the cooling degree days (CDD) (base: 18 °C) for the year to report. CDD can be either a single CDD value for the whole Member State or distinct values for different climate zones if larger variations exist in the Member State. For the latter case, the data in Table 5 should be provided for each climate zone; the following calculations should be performed for each climate zone and the resulting data for all climate zones should be summed up.

Step 2.3: Calculate the number of equivalent full load hours

Based on the data in step 2.2, calculate the number of equivalent full load hours (EFLH) for each usage category with these equations:

- For space cooling in the residential sector: EFLH = 96 + 0.85 * CDD
- For space cooling in the tertiary sector: EFLH = 475 + 0.49 * CDD
- For process cooling: EFLH = τs * (7300 + 0.32 * CDD)

The number of full load hours (EFLH) indicates how many hours a cooling system should run with full load during a year to produce the amount of cooling that it actually produces but at varying loads.

τs is an activity factor for the process cooling i.e. the approximate proportion of the year that process cooling is taking place as an average of process cooling for each cooling system technology and process sub-sector (e.g. all year long, full time: τs=1, not on week-ends: τs=5/7). Activity data should be collected and/or estimated.

Step 2.4: Calculate the cooling supply $Q_{CSupply}$

Based on the data in step 2.1 and step 2.3, calculate the cooling supply by multiplying rated cooling capacity for each cooling system technology and usage category (Table 5) with the corresponding equivalent full load hours for each usage category, see Table 6. The resulting data is in GWh.

Table 6: Cooling supply for each cooling system technology and each usage category for the year to report of all relevant cooling systems in scope.

Cooling supply GWh/year	**Usage category**		
Cooling system technology	Space cooling in the residential sector	Space cooling in the tertiary sector	Process cooling
Small split (<5 kW)			
Big split (>5 kW, incl. ducted)			
VRF (Variable Refrigerant Flow)			
Rooftop factory packaged system			
Chillers (air/water) < 400 kW			
Chillers (air/water) > 400 kW			
Chillers (water/water) < 400 kW			
Chillers (water/water) > 400 kW			
Mobile			

Multiply the data in each cell in Table 5 (step 2.1) with the corresponding EFLH value for the specific usage category (step 2.3)

Step 2.5: Determine the share of renewable energy input to the cooling generator τ_{RE}

For each cooling system technology, the average share of renewable energy input to the cooling generator should be determined. Renewable energy input is the consumption of local and concomitant renewable electricity or renewable fuel, gas or heat energy input by the cooling system. Hereby, local renewable energy generation can be one of the following:

- Renewable heat generation
- Off-grid renewable electricity or gas generation
- Local renewable energy generation supplied under the same interconnection between the transportation and distribution grid as the cooling system in the case of grid electricity and gas, or a renewable electricity or gas generation source located nearby the cooling system, where the distance corresponding to the term “nearby” as used in the EPBD[5] is to be defined by each Member State.
- Renewable fuel generation not already accounted for elsewhere (in renewable electricity, renewable heat or renewable gases used in other sectors) in the gross consumption of renewable energy sources.

The renewable energy input can be calculated based on measurement of both the renewable energy input to the cooling system and the total energy input to the cooling system for each cooling system in scope.

In case of integrated systems (i.e. where the renewable energy generation unit is integral part of the cooling system), only cooling loads need to be considered. For all other systems, i.e. where the renewable energy generation unit is not an integral part of the cooling system, other loads, e.g. due to electric household appliances need to be subtracted from the renewable generation for each acquisition time step in order to derive the net renewable energy generation to be considered as concomitant local renewable energy input to the cooling system.

τ_{RE} (share of renewable energy input) should be computed as the integral of the ratio of the renewable energy input to the total energy input to the cooling system at each time step over the year and then integrated:

[5] Energy Performance of Building Directive (Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings)

$$\tau_{RE} = \int \frac{E_{INPUT_{RE}}(t)}{E_{INPUT}(t)} dt$$

where:

- t is each time step of the year
- dt is the length of the time step (acquisition time period between two outputs of the measurement system)
- $E_{INPUT_{RE}}$ is the renewable energy input during the time step
- E_{INPUT} is the total energy input during the time step

Alternatively, a well substantiated calculation of concomitant renewable energy input may be done for each group of cooling systems, considering generation profiles for renewable energy generation and cooling loads for each time period (maximum 15 minutes for electricity and one hour for gas, fuel and heat). These calculations need to consider the high number of diverse variants of systems in terms of different ratio of renewable energy generation and cooling load, the relevance of non-cooling related loads, electrical as well as thermal storage and practical, real-life management of these storage systems. See further details and an exemplary calculation in this study's Report 2[5].

Based on the calculation of the renewable energy input, the average share of renewable energy input for each cooling system technology group of the total average energy input for the cooling system technology should be calculated. The result to be rounded to the nearest 10%, 20%, 30% etc.

Step 2.6a: Calculate the renewable cooling energy quantity E_{RES-C}

Based on the data in step 2.4 and 2.5, calculate the renewable cooling energy quantity E_{RES-C} by multiplying the cooling supply for each cooling system technology group and usage category (residential and tertiary space cooling, process cooling) (Table 6) with the factors in Table 7 for the relevant percentage of renewable energy input to the cooling generator τ_{RE}. These factors are thus the share (called s_{SPF_p}) of the cooling supply that satisfies the SPF threshold and can be counted as renewable[6] cooling. The same share is used for all three usage categories (residential and tertiary space cooling, process cooling).

An alternative and more precise method is provided in step 2.6b, where Member States calculate the share based on data on the SPF_p distribution for the cooling systems.

The resulting data (Table 8) is in GWh.

[6] Thermodynamically this is part of "the quantity of heat released by the cooling system that can be absorbed by ambient air, ambient water or the ground in a renewable, replenishable way.

Table 7: Share of the cooling supply for each cooling system technology group and for each percentage share of renewable energy input to the cooling generator, which can be counted as renewable energy, expressed as a percentage.

Cooling system technology	Percentage of renewable energy input to the cooling generator T_{RE}										
	0%	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Small split (<5 kW)	2.4%	4.8%	9.1%	15.1%	23.9%	36.9%	56.5%	81.8%	96.9%	100%	100%
Big split (≥5 kW, incl. ducted)	1.0%	2.4%	5.7%	10.8%	18.5%	30.3%	48.2%	75.2%	95.7%	100%	100%
VRF (Variable Refrigerant Flow)	1.1%	2.3%	4.9%	9.1%	15.9%	26.7%	43.4%	68.7%	92.6%	100%	100%
Rooftop factory packaged system	0.0%	0.0%	0.1%	0.3%	1.0%	4.5%	11.1%	27.1%	58.8%	94.9%	100%
Chillers (air/water) < 400 kW	0.0%	0.0%	0.1%	1.1%	3.6%	11.4%	24.3%	46.6%	85.2%	100%	100%
Chillers (air/water) ≥ 400 kW	0.0%	0.0%	0.3%	2.0%	5.9%	14.7%	28.8%	52.7%	89.9%	100%	100%
Chillers (water/water) < 400 kW	0.7%	1.8%	5.1%	10.3%	18.5%	30.5%	48.7%	77.0%	97.8%	100%	100%
Chillers (water/water) ≥ 400 kW	3.2%	6.1%	11.0%	17.9%	27.6%	41.6%	62.1%	87.1%	98.8%	100%	100%
Mobile	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	16.7%	46.4%	100%	100%

Table 8: Renewable cooling energy quantity E_{RES-C}

Renewable energy quantity GWh/year	**Usage category**		
Cooling system technology	Space cooling in the residential sector	Space cooling in the tertiary sector	Process cooling
Small split (<5 kW)			
Big split (>5 kW, incl. ducted)			
VRF (Variable Refrigerant Flow)			
Rooftop factory packaged system			
Chillers (air/water) < 400 kW			
Chillers (air/water) > 400 kW			
Chillers (water/water) < 400 kW			
Chillers (water/water) > 400 kW			
Mobile			

Multiply the data in each cell in Table 6 (step 2.5) with the corresponding renewable energy share (Table 7) for the specific cooling system technology

The figures of each cell of Table 8 should be summed up.

Step 2.6b: Calculate the renewable cooling energy quantity $E_{RES\text{-}C}$ using own values for $SPF_{p,RE}$ distribution for cooling systems with local renewable energy input to the cooling generator

This step 2.6b is an alternative to step 2.6a, which can be used where Member States will calculate the share based on data on the $SPF_{p,RE}$ distribution for cooling systems.

Table 6 should be split up by relevant intervals of $SPF_{p,RE}$ values, where $SPF_{p,RE}$ is defined as $SPF_p/(1-\tau_{RE})$, τ_{RE} is calculated as shown in step 2.5 and SPF_p is calculated as:

- Space cooling: $SPF_p = \frac{SEER}{\frac{1}{\eta}} - F(1) - F(2)$
- Process cooling: $SPF_p = \frac{SEPR}{\frac{1}{\eta}} - F(1) - F(2)$

η is the average ratio of total gross production of electricity to the primary energy consumption for electricity production. At EU level, 1/η is 2.1[7].

$s_{SPF_{p,RE}}$ should be calculated with the following formula:

If $SPF_{p,RE} < SPF_{p\_LOW}$, $s_{SPF_{p,RE}} = 0$ %.

If $SPF_{p\_LOW} \leq SPF_{p,RE} \leq SPF_{p\_HIGH}$,

$s_{SPF_{p,RE}} = \frac{SPF\mathrm{p,RE} - SPF\mathrm{p}_{\_LIM\_PROG1\_LOW}}{SPF\mathrm{p}_{\_LIM\_PROG1\_HIGH} - SPF\mathrm{p}_{\_LIM\_PROG1\_LOW}}$ %.

If $SPF_{p,RE} > SPF_{p\_HIGH}$, $s_{SPF_{p,RE}} = 100$ %.

Where $SPF\mathrm{p}_{\_LIM\_PROG1\_LOW}$=2.8 and $SPF\mathrm{p}_{\_LIM\_PROG1\_HIGH}$= 9.5

Calculate the renewable cooling energy quantity $E_{RES\text{-}C}$ by multiplying the cooling supply for each cooling system technology group, usage category (residential and tertiary space cooling, process cooling) and $SPF_{p,RE}$ interval (adapted Table 26) with the calculated $s_{SPF_{p,RE}}$ values for each $SPF_{p,RE}$ interval. The results will be an adapted Table 8, where the figures of each cell in should be summed up.

[7] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency, OJ L 328, 21.12.2018, p. 210–230.

6. Step 3: Calculation for cooling generators with cooling capacity above or equal to 1.5 MW using site data

This calculation method is used for calculating the amount of renewable cooling energy for specific sites with cooling capacity above or equal to 1.5 MW. It requires the following input from each specific site in scope:

- Measured total energy input
- Measured renewable energy input to the cooling generator
- Measured cooling energy supply

The measurements need to be carried out for the specific year to be reported i.e. all energy input and all cooling energy supply for the whole year. If renewable energy input is considered as well, the measurement time step needs to be at least hourly in order to evaluate the concomitance of the renewable energy input.

For cooling systems, which also use waste heat for cooling, the renewable cooling quantity should be adjusted as described under step 4.

The resulting data for renewable cooling energy quantity in this step is to be added to step 1 or step 2.

Step 3.1: Collect measured data for each relevant cooling system

Collected the following data from each relevant cooling system:

- Measured energy input: The measured energy input includes all energy sources for the cooling system i.e. electricity, gas, heat etc. for cooling generator. It includes also auxiliary pumps and fans for the cooling system but not for the distribution of cooling to a building or a process. In case of air-based cooling with ventilation function, only the additional energy input due to cooling should be included in the energy input of the cooling system.
- Measured renewable energy input to the cooling generator: This includes local and concomitant renewable electricity or renewable fuel, gas or heat energy input by the cooling system. Hereby, local renewable energy generation can be one of the following:
    - Renewable heat generation
    - Off-grid renewable electricity or gas generation
    - Local renewable energy generation supplied under the same interconnection between the transportation and distribution grid as the cooling system in the case of grid electricity and gas, or a renewable electricity or gas generation source located nearby the cooling system, where the distance corresponding to the term “nearby” as used in the EPBD[5] is to be defined by each Member State.
    - Renewable fuel generation not already accounted for in the gross consumption of renewable energy sources in the transportation sector.
- The renewable energy input is determined by the local renewable energy generation at a certain time slot, subtracted by other electric load of the building, or – in case of district cooling – of the system in the same time slot. If this is equal or lower than the energy input in this time slot, this is the renewable energy input. If it is higher, the total energy input of this time slot is considered as renewable. Summing up all time slots results in the annual renewable energy input.

- Measured cooling energy supply: The cooling energy supply should be measured as the output from the cooling system and subtracted any cold losses in order to estimate the net cooling energy supply to the building or process that is the end-user of the cooling. The cold losses include losses in a district cooling system and in the cooling distribution system in a building or an industrial site. In case of air-based cooling with ventilation function, the cooling energy supply should be net of the effect of fresh air introduction for ventilation purposes.

If the cooling system uses several cooling generators or free cooling systems, the renewable energy quantity for cooling E_{RES-C} can be either be estimated for the complete cooling system or be estimated for each cooling generator or free cooling system considered as an individual subsystem. If the Member States (or the operator of the system reporting to the authorities) decides to calculate for each subsystem, the calculations need to be carried out at the subsystem level and the results should be summed up.

A cooling subsystem is a physical part of the cooling system, which comprises at least either one cooling generator or a free cooling system. Cold losses of the cooling system should be shared amongst cooling subsystems in proportion of the cooling energy supplied by each of the cooling systems. When dividing a cooling system into subsystems, the auxiliaries (e.g. controls, pumps and fans) of the cooling generator(s) and/or free cooling system(s) must be included in the same subsystem(s). For auxiliaries, which cannot be allocated to a specific subsystem, as for instance district cooling network pumps, their energy consumption should be allocated to each cooling subsystem in the proportion of the cooling energy supplied by the cooling generators and/or the free cooling systems of each subsystem.

Step 3.2: Calculate the Seasonal Performance Factor, SPF_p, and the share of renewable energy input to the cooling generator τ_{RE}

For each cooling system, where data is collected for under step 3.1, calculate the seasonal Performance Factor, SPF_p, with this formula:

SPF_p = Measured cooling net energy supply (i.e. gross energy supply after subtracting losses, in particular distribution losses (Q_{C_Supply}) divided by measured energy input (E_{INPUT}))

For each cooling system with renewable energy input to the cooling generator, where data is collected for under step 3.1, calculate the share of renewable energy input to the cooling generator τ_{RE} with this formula:

τ_{RE} = Sum of the measured renewable energy input to the cooling generator divided with the total energy input

The renewable energy input is determined by the local renewable energy generation at a certain time slot, subtracted by other electric load of the building, or – in case of district cooling – of the system in the same time slot. If this is equal or lower than the energy input in this time slot, this is the renewable energy input. If it is higher, the total energy input of this time slot is considered as renewable. Summing up all time slots results in the annual renewable energy input.

Step 3.3: Calculate the share of the cooling supply to be considered as renewable energy input

Based on the SPF_p for each cooling system**Error! Bookmark not defined.** from step 3.2, calculate the share of the cooling supply, which can be considered as renewable (s_{SPF_p}).

For cooling systems with no renewable energy input to the cooling generator:

- If SPF_p is less than 2.8, the share is 0, i.e. none of the cooling supply can be considered as renewable.

- If SPF_p is 2.8 or higher and less than 9.5, the s_{SPF_p} = (SPF_p-2.8)/(9.5-2.8) %
- If SPF_p is 9.5 or higher, the s_{SPF_p} is 1.

For cooling systems with renewable energy input to the cooling generator, partly or fully:

- If $SPF_p/(1–\tau_{RE})$ is less than 2.8, the share is 0, i.e. none of the cooling supply can be considered as renewable.
- If $SPF_p/(1–\tau_{RE})$ is 2.8 or higher, the $S_{SPF_p\_RE}$ = ($SPF_p/(1-\tau_{RE})$)/(9.5-2.8) %
- If $SPF_p/(1–\tau_{RE})$ is 9.5 or higher, the $s_{SPF_p\_RE}$ is 1.

Step 3.4: Calculate the renewable cooling energy quantity E_{RES-C}

For each cooling system calculate the renewable energy quantity E_{RES-C} with these equations and based on S_{SPF_p} and S_{SPF_pRE} from step 3.3:

For cooling systems with no renewable energy input to the cooling generator:

- Renewable cooling energy quantity E_{RES-C} = Measured cooling energy supply * S_{SPF_p}

For cooling systems with renewable energy input to the cooling generator, partly or fully:

- Renewable cooling energy quantity E_{RES-C} = Measured cooling energy supply * S_{SPF_pRE}

Sum up the renewable cooling energy quantity for all the cooling systems.

7. Step 4: Calculation of waste heat and cold contribution

Waste heat and cold does not count as renewable energy, but it can contribute to fulfil up to 40% of the renewable heating and cooling target (Article 23 of the Renewable Energy Directive) and up to 100% of the renewable district heating and cooling target (Article 24 of the Renewable Energy Directive).

These can only be included if they are calculated including the SPF_p according to the method for large cooling systems using measured data for energy input and for cooling energy supply (step 3).

Step 4.1: Collect measured data for each relevant cooling system

Collect the following data from each relevant cooling system:

- Waste heat contribution for each cooling system (E_{WHC})
- Waste cold contribution for each cooling system (E_{WC})

Step 4.2: Calculate the total waste heat contribution

Calculate waste heat contribution E_{WHC} for each cooling system following the same procedure as in step 3, where $E_{RES\text{-}C}$ is replaced by E_{WHC_RE} (the quantity of cooling supply based on waste heat and renewable energy) and E_{INPUT_RE} is replaced by the sum of E_{INPUT_RE} and E_{INPUT_WH} (waste heat energy input to the cooling system).Calculate the waste heat contribution to the renewable heating and cooling and district heating and cooling targets according to the share of waste heat energy input to the sum of waste heat and renewable energy input.

$$E_{WHC} = E_{WHC\_RE} \frac{E_{INPUT\_WH}}{(E_{INPUT_{WH}} + E_{INPUT_{RE}})}$$

For cooling systems using waste heat, the renewable cooling energy (calculated as under step 3) should be adjusted accordingly:

$$E_{RES-C} = E_{WHC\_RE} \frac{E_{INPUT\_RE}}{(E_{INPUT_{WH}} + E_{INPUT_{RE}})}$$

Step 4.2: Calculate the total waste cold contribution

Calculation of the total waste cold contribution ($E_{WC\text{-}MS}$) for a Member State is the sum of waste cold contribution for each cooling system (E_{WC}) using waste cold for cooling in the Member State.

Calculate waste cold contribution E_{WC} for each cooling system following the same procedure as in step 3, where the waste cold energy should be added to the cooling energy supplied by the cooling system.

Energy consumption related to supply of the waste cold (pumps, fans etc.) should be added to the measured energy input.

However, if the waste cold is the result of a heat pump simultaneously generating cooling and heating to the district heating and cooling system, only part of the heat pump energy input and of the energy input of the auxiliaries allowing the heat transfer to both sides of the cooling generator (heating and cooling sides) should be included in the energy supply of the cooling system. This part should be calculated as the ratio between the cooling supply and the sum of the heating and cooling supply.

8. Step 5: Sum up the total renewable cooling energy

The individual contributions calculated in step 1 to step 3 should be summed up to one figure for the total renewable cooling energy contribution and together with the figures from step 4 be included in the reporting to the European Commission.

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