sustainability

MDPI

Article

Potential Evolution of the Cooling Market in the EU27+UK: An Outlook until 2030

Simon Pezzutto [1,*], Giulio Quaglini [1], Andrea Zambito [1], Antonio Novelli [2], Philippe Riviere [3,4], Lukas Kranzl [5] and Eric Wilczynski [1]

1 Institute for Renewable Energy, European Academy of Bolzano (EURAC Research), Viale Druso 1, 39100 Bolzano, Italy; giulio.quaglini@eurac.edu (G.Q.); andrea.zambito@eurac.edu (A.Z.); eric.wilczynski@eurac.edu (E.W.)
2 Planetek Italia, Via Massaua 12, 70132 Bari, Italy; antonio.novelli87@gmail.com
3 Directorate-General for Energy (DG Energy), European Commission, Unit B3—Buildings and Products, 1049 Brussel, Belgium; philippe.riviere@ec.europa.eu
4 Center for Energy Efficient Systems (CES), Department of Energy and Processes (DEP), Mines ParisTech, PSL University, 60 Boulevard Saint-Michel, CEDEX 06, 75272 Paris, France
5 Energy Economics Group, Institute of Energy Systems and Electric Drives, TU Wien, Gusshausstrasse 25-29/370-3, 1040 Vienna, Austria; kranzl@eeg.tuwien.ac.at
* Correspondence: simon.pezzutto@eurac.edu; Tel.: +39-0471-055-622

Abstract: This study investigates insights concerning the future of the cooling market of the European Union (plus the United Kingdom) and its possible development for the upcoming decade (until 2030). In this manuscript, a qualitative model—Porter's five forces analysis (PFFA)—and a quantitative tool—multi-criteria decision analysis (MCDA)—have been applied to produce a forecast and a corresponding validation technique. It has been observed that the MCDA tool came to a similar conclusion as the PFFA methodology, highlighting that, presumably, the cooling market will continue to grow moderately, mainly thanks to research and development (R&D) as the central driving force. Moreover, the latter is strictly connected with R&D developments, economic crises, and the welfare of the European population. Additionally, in this study, an extensive survey conducted on interviews of experts throughout each European country confirmed the slightly positive future developments forecast up to 2030 from the quantitative and qualitative methods mentioned above. The results of the study describe a steady growth of the cooling market in Europe until 2030 of about 1–2% annual increase, for a total gain of 24%.

Keywords: Porter's five forces analysis; multi-criteria decision analysis; Europe; outlook; market; 2030

check for updates

Citation: Pezzutto, S.; Quaglini, G.; Zambito, A.; Novelli, A.; Riviere, P.; Kranzl, L.; Wilczynski, E. Potential Evolution of the Cooling Market in the EU27+UK: An Outlook until 2030. *Sustainability* **2022**, *14*, 4461. https://doi.org/10.3390/su14084461

Academic Editor: Grigorios L. Kyriakopoulos

Received: 24 February 2022
Accepted: 22 March 2022
Published: 8 April 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

In the past few decades, the European Union (EU) has urgently supported the transition to renewable energy sources (RES) from fossil fuel technologies. Significant effort has been put into the aforementioned transition by revising the policies and regulations which coordinate the EU energy and climate framework. Initially, the central goals were written into legislation by the Renewable Energy Directive (RED-2009/28/EC) and recently revised in 2018 in the resulting REDII from 2021 to 2030 [1]. In 2018, the EU's greenhouse gas emissions (GHG) dropped by 23% compared to 1990 levels. According to the carbon-free policy, the EU points to reducing its emissions by at least 55% by 2030 and aims to be the first continent to reach carbon-neutrality by 2050 [2,3].

In addition to RES, energy efficiency has been a central focus of the EU's attention toward climate change resilience. As in the case of the RED II, the Energy Efficiency Directive II (EED II) was revised in 2018 by setting a target of 32.5% energy efficiency increase throughout the EU27+UK zone by 2030. Energy efficiency targets need to be set and pursued by each EU27+UK country [2,3].

In 2018, the EU27+UK primary energy consumption (PEC) was about 1600 Mtoe/y, 22% above the 2030 target [4,5]. Moreover, end-users' total energy, or final energy consumption (FEC), was about 1124 Mtoe/y, 22% above the 2030 mark [4,5]. The most significant contributor to the PEC is the heating and cooling (H+C) sector with a value of around 800 Mtoe/y, which includes different sectors such as space heating (SH), space cooling (SC), domestic hot water (DHW), and industrial heat [6,7]. The EU member states (MSs) have turned their attention to energy consumption quantification to align with the goals mentioned above. Significant data reliability, availability, and accessibility issues have been encountered regarding the H+C sector, especially for SC, which has barely been explored in the scientific literature [8,9].

Regarding the second law of thermodynamics, "cooling" is considered the effort of removing heat. This requires an external energy input, since the heat naturally flows from a hotter object or space to a colder one. Cooling accounts for a small share of the EU's FEC, around 4%, including SC and process cooling (PC) [10]. Notably, the term "space cooling" refers to the exclusion of heat from the enclosed air of a confined space (e.g., buildings) causing a decrease in the temperature and/or a phase change for the thermal comfort of the tenants, while the term "process cooling" refers to removing heat from products, processes, or an industrial space that needs to maintain a specific temperature. District cooling (DC) is also included in the share mentioned above, although it has not been explored in any depth in the scientific literature. Mainly, DC refers to the deployment of cold thermal energy in chilled liquid forms to multiple buildings or sites for SC and PC purposes [11,12]. District cooling primarily involves commercial and public buildings and the industrial and residential sectors [13,14].

It is worth mentioning that, in this study, the term "cooling" refers to both SC and PC and that the specific term is used when differentiation between them is necessary.

A constant increment in the total FEC has been observed in the past thirty years regarding both the sales volume of cooling equipment and the cooled floor area, and it is expected to increase substantially between 2030 and 2050 [10,12,15]. Several notable factors contribute to cooling needs, such as population growth, global warming, weather events, urbanization, digitalization, and modern building design which involves wide glazing areas [8].

The novelty of the current work is related to presenting insights concerning the past, present, and future cooling market (SC and PC—including DC) of the EU27+UK zone. Remarkably, it is worth stating that the subject of "cooling" is scarcely investigated in the scientific literature. Hence, knowledge and data are restricted for the SC sector, both in the residential and tertiary sectors, while the SH sector has been widely studied.

The current study aims to understand the possible developments of the EU's cooling market for the upcoming decade (until 2030). The objectives of the work are in complete accordance with the previous study of Pezzutto et al., 2016, in which the research team conducted expert interviews to collect information and input data to inform Porter's five forces analysis (PFFA) and a multiple criteria decision analysis (MCDA) tool [16]. Overall, a pool of around 56 experts (two from each country) have been contacted to feed the model and the tool. The expert pool was interviewed, and answers were collated regarding the entire EU27+UK. By combining the aforementioned model and tool, we generated an outlook until 2020 (starting from 2016), which this study aims to actualize until 2030 [16].

The present paper is structured as follows: Section 1, which introduces the work, locating it in a broad context; Section 2, which explains the materials and methods employed, including the model and tool; Section 3, which presents the outcomes by facts and figures; Section 4, which provides a discussion and critical evaluation of the main results; and finally, Section 5, which indicates the conclusions and potential future implications of the study.

2. Materials and Methods

The current section explains the model (PFFA) and tool (MCDA) introduced in Section 1. The PFFA and MCDA tools have been applied to generate a forecast and a respective validation method (consistency analysis). It is worth mentioning that the PFFA can be considered as a quantitative model, while the MCDA is recognised as a quantitative tool. Both methods have been compared to understand the cooling market's potential future development in the EU27+UK until 2030.

2.1. Porter's Five Forces Analysis (PFFA)

Generally, the market's status quo is individualized by the PFFA model. Moreover, the model can predict its potential future development based on the starting point. The present model considers the "de facto" market structure [17]. A better-elaborated tool has been developed from a traditional PFFA to generate a clearer evaluation of each force in the current study. Notably, a scale for weighing and a scheme for grading have been revised. Moreover, to properly evaluate the model's results, a calculation system has been provided.

Five competitive forces have been taken into consideration in the developed model:

- Force 1—market new entrant threat;
- Force 2—the service or product substitute threat;
- Force 3—the bargaining ability of suppliers;
- Force 4—the bargaining capacity of buyers;
- Force 5—the rivalry of the market's existing competitors.

The respective factors characterized the forces mentioned in the bullet points above. In particular, the influence of each factor on the EU27+UK trade (positive: + or negative: −), and its importance (from 10+ to 10−, with 0 specifying no influence) had to be indicated.

Concerning Forces 1 to 4, it should be said that by summing each factor characterizing the individual force, the results were obtained. Additionally, Force 5 was individualized by contrasting Forces 1 to 4.

The outcome of Force 5 was characterized by a rating scale. The latter was the sum of the parameters utilized to determinate Forces 1 to 4, and eventually multiplied by the values 10+ and 10− (upper and lower limits) as presented in Equation (1) below.

$$\text{Force } 5 = F_1 + F_2 + F_3 + F_4 \quad (1)$$

where F_1, F_2, F_3, F_4 are the results of each aforementioned force obtained by summing each factor.

Lastly, Force 5 was converted to a percentage by dividing the result by the cut-off value of the related rating scale. The previously mentioned ranking, in turn, was ultimately converted per centum: 100%+ and 100%.

Figure 1 below visually highlights the whole process.

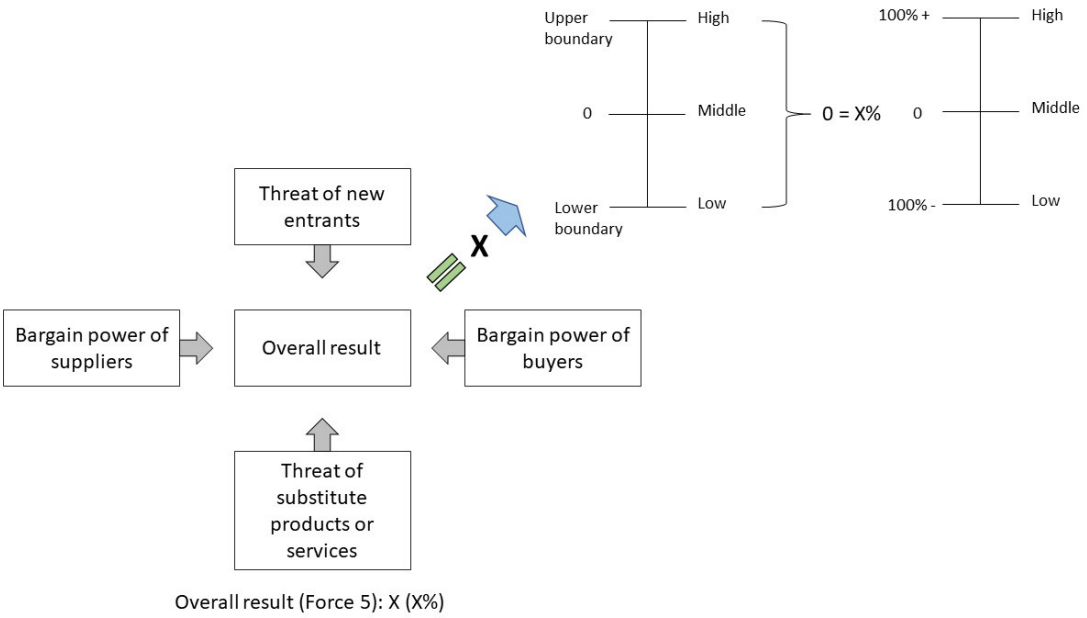

Figure 1. Porter's five forces analysis diagram [18].

In this study, the extended PFFA model was assigned to the current cooling market of the EU27+UK zone. In particular, the term "cooling market" refers to vapour compression (VC) as the dominant technology within the European cooling market, while fans, thermally driven heat pumps (TDHP), natural ventilation, etc., were considered as substitutes as they compete with the technologies of VC [19].

A consistency analysis was performed to determine the extent to which scientists agreed on the criticality of the factor. In more detail, the level of agreement was quantified by the interquartile range (IQR) of the weight distribution [20].

The above-mentioned system of measurement gives the difference between the 75th percentile and the 25th percentile of the data. The 75th percentile is the weight below which 75% of all weights per sub-goal or sub-factor fall. It has been observed that among scientists, the low agreement is determined by a high IQR [14–17].

2.2. Multi-Criteria Decision Analysis (MCDA)

The current section is focused on the MCDA form, which has been applied to generate reliable predictions of the EU27+UK cooling market development.

The above-mentioned tool entails both the objectives of the EU27+UK market actors and the external factors that will shape the market evolution until 2030.

Overall, the objectives and factors are divided into sub-objectives and sub-factors. Experts weighed the objectives, factors, and importance of each sub-factor. For this purpose, 28 experts were selected, one for each EU27+UK country. It is important to note that all experts differed from the previous PFFA.

The weighting of each sub-objective and sub-factor again ranges from 10− to 10+, depending on their grandness and impact (positive: + or negative: −) on market evolution. As with PFFA, 1 represents minimum importance, 10 represents maximum significance. The number 0 represents no significance at all. Once more, the symbol "+" represents an optimistic influence and the symbol "−" represents a pessimistic influence. The tool followed the indicated method. Essentially, the objectives, factors, and respective sub-items were ordered vertically and horizontally to form the edges of a matrix. Moreover, the influence of each sub-factor on each sub-goal is indicated. Thus, the influence of the external sub-factors on the respective sub-goals of the market participants is measured by multiplying the weights of the sub-factors by the weights of the corresponding sub-goals. It has to be said that, whenever a negative value is multiplied by a positive one, the outcome

is necessarily negative. Additionally, the negative sign is retained whenever two negative values are multiplied.

By summing up the resulting terms, a value per sub-factor is then obtained, indicating the measured influence and importance of the sub-factor on the market participants' sub-goals.

In addition, the results of the sub-factors were characterized by a rating scale (from low to medium to high). The limit above the rating range was determined by multiplying the highest possible weight (value: 10) by the number of sub-objectives indicated (upper limit indicated by + and lower limit by −).

Lastly, the checked influences and importance of the outer sub-factors on the sub-goals of the market participants were compared with each other to discuss result indications. The essence of the computation was estimating the influence of the individual external factors on the market participants' goals to provide personal predictions for possible future market development [21–23].

Figure 2 visually clarifies the MCDA calculation scheme.

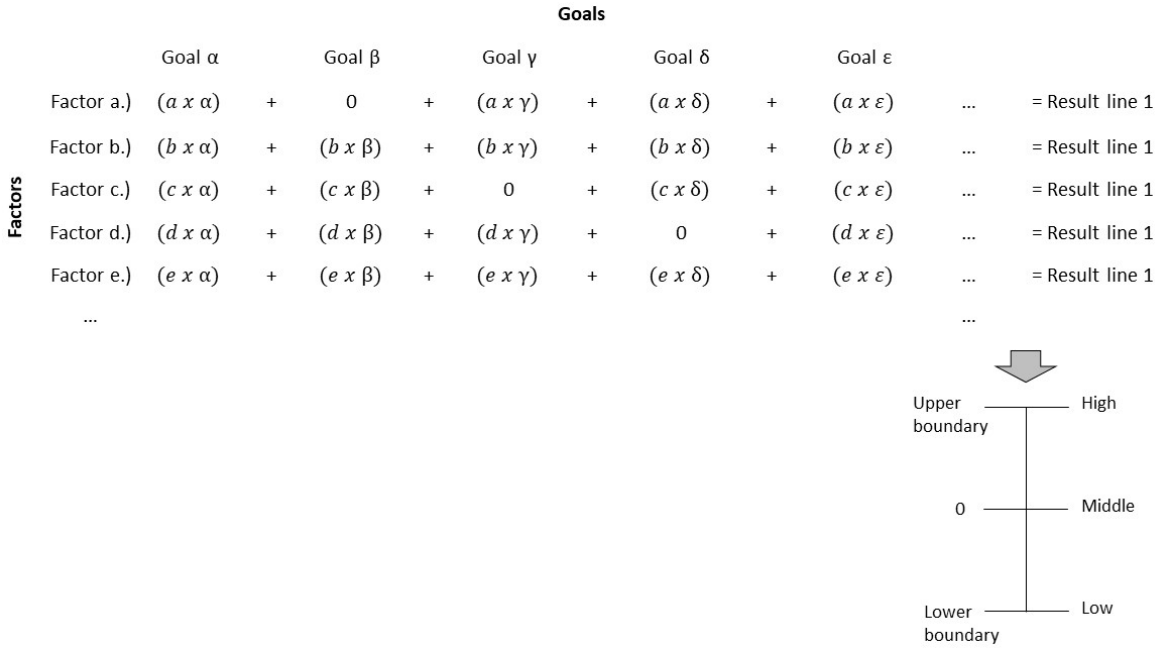

Figure 2. Multiple-criteria decision analysis scheme [18].

The results of each sub-factor were compared to provide clues to the outcome of the study.

After conducting the consistency analysis, the critical factor was how much significance the experts placed on the sub-objectives and sub-factors.

As with PFFA, the IQR of weight sharing was created to quantify the level of agreement among scientists. The experts' statements were taken into account when selecting the market participants, objectives, factors, and their relative sub-objectives appropriate to the possible evolution of the EU27+UK cooling market under study.

As with the PFFA for factors, the following ratings of the objectives, factors, and associated sub-items were taken from the weights of the experts consulted (averaging).

The various expert weights per objective, factor, and related sub-item were averaged and rounded to whole numbers.

The following descriptions of the goals, factors, and associated sub-items were taken from respondents' statements and cross-checked with scholarly sources. Respondents' answers were summed, and unchecked information was discarded. For both methods used, per factor, sub-objective, and sub-factor, all experts assigned either + or − signs only [13,15,16].

3. Results

3.1. Porter's Five Forces Analysis

Table 1 provides an outline of the factors with the relative relevance and influence of the PFFA indicated by experts.

Table 1. Factors with their respective importance and influence in Porter's five forces analysis regarding cooling in Europe until 2030.

	Force 4—Bargaining Power of Buyers		**Force 3—Bargaining Power of Suppliers**		**Force 2—Threat of Substitute Products or Services**		**Force 1—Threat of New Entrants**
6−	Sale price reduction	1−	Competitiveness	1−	Ventilators	7+	Economics of scale
3−	Concentration of customers	8+	Size and concentration of suppliers relative to the industry participants	2−	Thermally driven heat pumps	8+	Costs of market entrance
3−	Differentiation of technologies	6+	Possibility to forward integration of suppliers	1−	Natural ventilation	7+	Legislations
5+	Risk of failure	1+	Fragmentation of customers	4+	Renouncement	6+	Technology protection
		4+	Market support	2+	District cooling	6−	Market saturation
		5+	Investors' interest	3+	Other technologies *	5−	Market Image
		9+	Climate change	1−	Energy efficiency of buildings	4−	Market importance
		3+	Multifunctionalities			7+	Substitution of services
		3+	Customer loyalty measures			3+	Transportation costs
		9+	Comfort			5+	Export duties
7−	Result Force 4	48+	Result Force 3	4+	Result Force 2	28+	Result Force 1

Note: * "other technologies" refers to membrane heat pumps, magnetocaloric cooling, acoustic cooling, and building-integrated cooling.

As shown in Table 1, most of the factors mentioned relate to the danger of new competitors (Force 1) and the bargaining power of furnishers (Force 3). In the supplier categories, the most favourable items are also found.

In contrast, most negatively marked items are set up in the threat from new competitors and the bargaining power of consumers (Force 4), followed by the threat from exchange commodities or facilities (Force 2). The bargaining power of suppliers leads to only one negative item (competitiveness), marked with very low importance: 1−.

The threat of replacement commodities or facilities and the bargaining power of clients result in a restricted number of factors set against the additional two existing forces. The majority of the negative points characterize the two previously mentioned factors.

In the case of the treatment of new entrants, the experts mention one-third more points than their counterparts. Moreover, there are more than twice as many points in the bargaining power of suppliers than in the bargaining power of customers. Therefore, the bargaining power of suppliers turns out to be the major significant force with a favourable influence on the treated market. In contrast, the bargaining power of buyers records the bulk of negative influences.

In fact, the bargaining power of the buyer's category is characterized by only one positive point (risk of failure: 5+).

Moreover, Table 2 highlights the completed factors' evaluations obtained from the expert interviews.

Table 2. Porter's five forces analysis of the cooling market: evaluation of the treated factors and related calculations, EU27+UK.

											Results	Evaluation's Scale Range (+/−)
Force 1—Threat of new entrants	7+	8+	7+	6+	6−	5−	4−	7+	3+	5+	28+	
Force 2—Threat of substitute products or services	1−	2−	1−	4+	2+	3+	1−				4+	
Force 3—Bargaining power of suppliers	1−	8+	7+	1+	4+	5+	9+	3+	3+	9+	48+	
Force 4—Bargaining power of buyers	6−	3−	3−	5+							7−	
Force 5—Rivarly among existing competitors											73+	310
Force 5—Rivarly among existing competitors (%)											24%+	100% +/−

The computations concerning Force 5 resulted in 73+ for the greatest value of 310 (31 factors).

The above-mentioned result matches to about 24%+ (maximum: 100%+). Thus, the competitiveness among current rivals is moderately positive. Several scientists indicated that global warming and rising comfort expectations are the main drivers of the market under study. Another factor mentioned in this context is the energy efficiency of buildings, which has a low value (1−) due to the low renovation rates of the building stock in Europe and low new construction activities [24].

According to what has been stated above, an agreement analysis has been utilized to determine how the most important experts of the EU27+UK cooling sector agreed on the significance of the factors. The IQR per factor is less than three, which is relatively low. Therefore, it is assumed that the accordance of the scientists' weights is safe.

The respondents' answers for each factor can be found in Table A1 in the Appendix A.

3.2. Multiple Criteria Decision Analysis

In the current study of the EU27+UK cooling market, the cooling equipment manufacturers and the customers have been identified as essential market players. Therefore, their objectives and sub-objectives have been considered:

- EU27+UK: Currently, the cooling sector is regulated by European legislation, which involves great attention to the environmental impact, energy efficiency specifications, and RES energy generation. Particularly, relevant EU directives, regulations, and standards mark the cooling sector and its sub-sectors indirectly;
- Cooling equipment promoters: The potential development of the cooling sector is deeply influenced by the desire of equipment manufacturers to optimize their revenue. The ability of a company to create a profit that exceeds costs and other expenditures incurred in a certain time is defined as profitability [21,25];
- Cooling equipment clients: The future EU27+UK cooling market is controlled by the interest of potential customers to buy equipment with the leading cost–benefit ratio. The cost–benefit proportion defines the relationship between the current profit of a transaction and its opening price. Moreover, it defines parameters such as the quality and lifetime of a good [21,25,26].

Tables 3 and 4 visualize the goals, factors, and their sub-items, with significance and influence pointed out by scientists.

Table 3. Goals and sub-goals of the future cooling market participants, EU27+UK.

			Weights
Goals	EU Directives	2010/31 EU: EPBD	6+
		2018/2001EU: REDII	5+
		2009/125 Ecodesign Dir.	3+
		EU—EED 2018/2002	4+
	EU Regulations	66/2010: EU Ecolabel	6+
		EU Reg. N° 517/2014	4+
	EU Standards	Test requirements	6+
	Income Max.	Earnings generation	8+
		Expenses reduction	8+
	Benefit to Cost Max.	Gain Max.	8+
		Cost Min.	8+

Table 4. External factors and sub-factors influencing the future cooling market development, EU27+UK.

			Weights
Factors	Market potential	Number of installed units	6+
		Energy Efficiency	7+
	R&D	R&D funding	7+
	Habits	Energy consumption for cooling purposes	6+
	Weather	Climate change	9+
	Costs	Costumer's investemt costs	5−
		Running costs	4−
		Disposal costs	3−
		Transportation costs	2−
	Replacement	Life span of cooling equipment	3+
	Comfort	Comfort requests	8+
	Competition	Size and concentration of the cooling market	4+
		Costumer loyality measures	1+
	Building	Buildings efficiency increase	2−

Table 5 follows, which provides information concerning which sub-factors influence which sub-goals (marks suggest a link between specific sub-goals and sub-factors, while blank spaces suggest a non-relation).

Next, Table 6 shows the calculations' results, measuring the single external sub-factors' influence on the market participants' sub-goals.

Many external factors point to an optimistic influence on the future evolution of the cooling EU27+UK market.

First of all, it is noted that climate change again has an optimistic influence on the development of the cooling EU27+UK market. Climate change is influencing the revenue growth of refrigeration equipment manufacturers. By selling more appliances due to climate change, manufacturers of refrigeration appliances also experience a reduction in costs due to economies of scale.

Moreover, the habits of the European population will significantly increase the cooling market in the future. In turn, the habits of the European population primarily affect the increase in the income of cooling manufacturers, which in turn leads to lower expenses for manufacturers. Interviewees emphasised that the habits of Europeans would extend, particularly the final cooling consumption in the family sector, while a particular share of the service part is already screened by cooling [27,28].

Regarding households, the experts mentioned that portable appliances (portable appliances) would be purchased, especially in warm summers, particularly concerning the bedrooms of apartments.

Table 5. Related external sub-factors and market participants' sub-goals of the future cooling market, EU27+UK.

			Goals										
			EU Directives				EU Regulations		EU Standards	Income Max.		Benefit to Cost Max.	
			2010/31 EU: EPBD	2018/2001EU: REDII	2009/125 Ecodesign Dir.	EU—EED 2018/2002	66/2010: EU Ecolabel	EU Reg. N° 517/2014	Test Requirements	Earnings Generation	Expenses Reduction	Gain Max.	Cost Min.
Factors	Market potential	Number of installed units			x	x	x			x	x		
		Energy Efficiency		x	x	x	x			x	x	x	x
	R&D	R&D funding	x	x	x	x	x	x	x	x	x	x	x
	Habits	Energy consumption for cooling purposes								x	x	x	
	Weather	Climate change	x	x	x	x	x	x		x	x		
	Costs	Costumer's investemt costs								x	x	x	x
		Running costs								x	x	x	x
		Disposal costs								x	x	x	x
		Transportation costs								x	x	x	x
	Replacement	Life span of cooling equipment								x	x	x	x
	Comfort	Comfort requests	x	x	x	x	x	x		x	x		
	Competition	Size and concentration of the cooling market								x			
		Costumer loyality measures								x	x		x
	Building	Buildings efficiency increase	x	x		x		x		x	x	x	

Table 6. Influence of the single external sub-factors on the sub-goals of the market participants and respective results, EU27+UK.

			Goals														
				EU Directives				EU Regulations		EU Standards	Income Max.		Benefit to Cost Max.			
				2010/31 EU: EPBD	2018/2001EU: REDII	2009/125 Ecodesign Dir.	EU—EED 2018/2002	66/2010: EU Ecolabel	EU Reg. N° 517/2014	Test Require-ments	Earnings Generation	Expenses Reduction	Gain Max.	Cost Min.	Results	
			Weights	6+	5+	3+	4+	6+	4+	6+	8+	8+	8+	8+	Sum	%
Factors	Market potential	Number of installed units	6+			18+	24+	36+			48+	48+			174+	35+
		Energy Efficiency	7+		35+	21+	28+	42+			56+	56+	56+	56+	350+	44+
	R&D	R&D funding	7+	42+	35+	21+	28+	42+	28+	42+	56+	56+	56+	56+	462+	42+
	Habits	Energy consumption for cooling purposes	6+								48+	48+	48+		144+	48+
	Weather	Climate change	9+	54+	45+	28+	36+	54+	36+		72+	72+			396+	50+
	Costs	Costumer's investemt costs	5−								40−	40−	40−	40−	160−	40−
		Running costs	4−								32−	32−	32−	32−	128−	32−
		Disposal costs	3−								24−	24−	24−	24−	96−	24−
		Transportation costs	2−								16−	16−	16−	16−	64−	16−
	Replacement	Life span of cooling equipment	3+								24+	24+	24+	24+	96+	24+
	Comfort	Comfort requests	8+	48+	40+	24+	32+	48+	32+		64+	64+			352+	44+
	Competition	Size and concentration of the cooling market	4+								32+				32+	32+
		Costumer loyality measures	1+								8+	8+		8+	24+	8+
	Building	Buildings efficiency increase	2−	12−	10−		8−		8−		16−	16−	16−		86−	12−

This factor is closely related to the higher wellbeing preferences of the EU27+UK population.

Moreover, the energy efficiency of cooling appliances seems to present a relatively tough impact on the future EU27+UK cooling market. Increasing the energy efficiency of cooling appliances will encourage customers to purchase such appliances due to lower operating costs.

Besides that, other external factors show less influence on the studied market.

In contrast, many outer factors show a negative influence on the future development of the cooling market. All the primary external factors that harm the future cooling market are associated with the cost.

As mentioned by several scientists, the escalation in interest for cooling equipment will drive customer prices higher. Thus, the customer's investment cost is the primary external factor that negatively affects the analysed market.

The running prices are the second most negative influencing factor. Regarding the running costs, it should be emphasised that electricity costs have boosted significantly in the last few decades within Europe, which is expected to continue in the future [29,30]. In third place among the negative influencing factors are the disposal costs. As a guideline for disposal costs, a common cost of about EUR 33 is quoted (for devices weighing up to 100 kg) [31,32].

Other external factors show little influence on the market under investigation. As in PFFA, climate change was found to be the incentive of the treated market. The stronger comfort desires of the European population are also in second place. In addition, within the PFFA, market-entry costs are in third place, while in the MCDA, the energy efficiency of the cooling appliances can be found in the previously mentioned position.

Table 6 features the achieved objectives, factors, and individual sub-items' assessment and computations, driving the analysed market outlook's overall result.

The solutions of the MCDA contained in Figure 3 can also be shown graphically, as reported below.

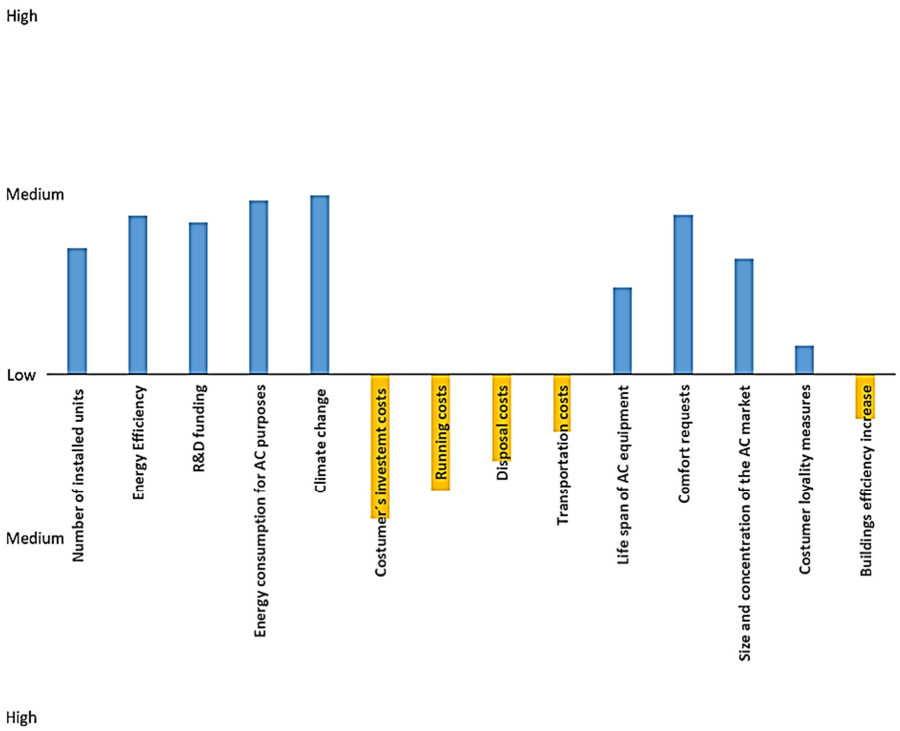

Figure 3. Results of the MCDA analysis—the influence of the external factors on the goals of the most relevant market players (external sub-factors with a negative influence are under the low line—marked in yellow; external sub-factors with a positive influence are over the low line—marked in blue).

As can be seen in Figure 3, nine factors positively influence future market development.

In contrast, five factors negatively influence the market under study. Thus, the positive factors are almost twice as significant.

Moreover, the optimistic elements are characterized by greater relevance. More than one-third of the factors, five specifically, are positive.

Considering the above indications, referring to Figure 3, the European cooling market seems to be distinguished by moderate growth.

A consistency analysis was again performed to determine how much the scientists agree on the concern of the sub-objectives and sub-factors.

The resulting IQRs per sub-goal and sub-factor are shown in Table A2 (Appendix A). The rate of four, which is relatively low, is not surpassed by any IQR per sub-goal or sub-factor.

Therefore, a safe correspondence of the scientists' weights is again believed to be designated.

4. Discussion

In this study, the future of the EU27+UK cooling market and its possible evolution until 2030 have been investigated using the PFFA and MCDA tools. Overall, it has been observed that an FEC of more than 105 TWh/year has been identified for the whole EU27+UK, where SC shares a large part of the building energy consumption [4,5]. In addition, in the EU27+UK market, FEC has marked a persistent boost over the past twenty years for SC, proven by the fact that from 1990 onwards, SC cooling equipment and chilled floor areas have increased significantly in both the residential and service sectors [32].

In this paper, PFFA has highlighted that the expansion of the EU27+UK SC is forecast to be moderately positive. The aforementioned finding has been proven in different studies which point to EU27+UK SC as a flourishing industry [15].

It is worth mentioning that, since 2008, electricity costs have risen by almost 30%, and customer purchasing power is depressed in parts of the EU27+UK due to the economic crisis triggered by the COVID-19 pandemic [18]. Again, it should be remembered that in most cases, the facilities of SC are not considered as a commodity of basic needs. Therefore, the market of SC has suffered significantly, attributable to the economic crisis, and the results of business models indicating a fairly enlarging market seem to be credible.

It has been observed that throughout this study, PFFA stated that research, development, and innovation are the driving strengths of the EU27+UK SC industry. Moreover, an SC market forecast prepared by an MCDA also shows a reasonably optimistic trend and a high dependence on research, development, and innovation activities. Particularly, research has the most considerable optimistic impact on the market. Therefore, in this study, both applied economic approaches, quantitative and qualitative, ultimately show the same result.

Again, in both PFFA and MCDA, energy efficiency turns out to be one of the three central drivers. The latter is significantly supported by European laws such as the revised EED II. Within the applied quantitative model, environmental impact is the third most important influencing factor for the market SC in the EU27+UK, which is mainly supported by EU decisions. Regarding the qualitative model outcomes, the change in comfort requirements resulted as the third most significant element.

The extent of the wellbeing requirements of the EU27+UK population in terms of climate comfort in homes and offices is undoubtedly one of the most critical factors of the SC market in the EU27+UK. Another research proposal considers a deeper dissection of climate change and the influence of severe weather events on the market development of SC, as the mentioned case has a significant impact. It can be clearly stated that the aggregation of rising heat, developing building layout, and expanding predilection for thermal comfort, due to an increase in wellbeing by the EU27+UK population, has led to a rise in SC energy needs. Following statistics, as previously mentioned, SC is no longer a small consumer of energy.

However, the authors found a lack of precise information on this topic. The latter might be related to the limited data availability and reliability emanating from market participants. Consequently, more open data and information gathering from the companies in the cooling industry will be beneficial for the future of the cooling market, leading to more synergy between R&D and cooling market players.

Overall, to conclude, the EU27+UK market seems to be characterized by moderate future growth.

5. Conclusions

Concerning the current economic situation, the expansion of space cooling does not look as great as in previous decades, as it is unnecessary in most cases.

In the current study, the space cooling forecast for the coming decade (2030), produced via multi-criteria decision analysis and Porter's five forces analysis tools, showed a moderate development with a high dependence on research and development activities, leading to a positive future development of the European space cooling market.

Overall, Porter's five forces tool registered a moderate market growth of around 1–2% per year, leading to a total of +24% by 2030.

As potential further research, it could be stimulating to understand the extent to which the market for space cooling in Europe affects the employment rate, how it contributes to the European Union's GDP, and how this market will develop after overcoming the economic crisis.

Finally, whether the space cooling market in Europe will continue to be receptive to research and development funding is crucial for future discoveries and data and information processes.

Author Contributions: Conceptualization, S.P., P.R., L.K. and G.Q.; data curation, S.P., A.Z. and G.Q.; writing, G.Q. and S.P.; supervision, L.K. and P.R.; validation, P.R., L.K., A.N. and E.W. All authors have read and agreed to the published version of the manuscript.

Funding: The Directorate-General financed this research for the European Commission's Energy, service contract number ENER/C1/2018-493/SI2.813961.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Acknowledgments: The authors thank the Department of Innovation and Research at the University of the Autonomous Province of Bozen/Bolzano for covering the Open Access publication costs.

Conflicts of Interest: The information and views set out in this article are those of the author and do not necessarily reflect the official opinion of the European Commission.

Appendix A

The following tables detail the contacted experts' answers during the 56 interviews for data/information collection. The interquartile range (IQR) of each factor is provided at the bottom of the following tables.

Table A1. Porter's five forces analysis—marks for factors.

	Force 1										Force 2						
	Treat of New Entrants										Threat of Substitute Products and Services						
	Economics of Scale	Costs of Market Entrance	Legislations	Technology Protection	Market Saturation	Market Image	Market Importance	Substitution of Services	Transportation Costs	Export Duties	Ventilators	Thermally Driven Heat Pumps	Natural Ventilation	Renouncement	District Cooling	Other Technologies	Energy Efficiency of Buildings
1	8+	8+	6+	5+	6−	7.5−	5−	9+	3+	3+	1−	3−	1−	3+	3+	3+	2−
2	8+	9+	7+	6+	6−	5−	4−	6+	3+	4.5+	1−		2−	4+	3+	1+	2−
3	7+	9+	8+	6+	7−	5−	2−	7+	4+	4+	2−	1−	0	5+	2+	4+	1−
4	2+		7+		8−	6−		2+	1+	4+	3−	1−	0	3+	1+	3+	1−
5	9+	8+	5+	7+	4−	3.5−	6−	8+	2+	3+	1−	2.5−	1−	2+		4+	2−
6	7+	7+	3+	5+	5−	4−	5−	9+	5+	5+	2−	5−	2.5−	4+	0	2+	
7	4+	9+	7+		6−	7−	3−	6+	6+	7+	0		1−	6+	0	2+	0
8		8+	8+	4+	8−	2−	5−	7+	4+	4+	4−	1−		5+	4.5+	1+	1−
9	8+		6+		4−		4−	8+	1.5+	5.5+			0	3+	1.5+		2−
10	9+	7+	4+	7+		4.5−	2−	9+	3+	5+	0	4−	2−	4+	0	0	1−
11	8+	7+		8+		4−	5−		4+	4.5+	2−	3−	0	7+	6+	3.5+	
12	9+	9+	9+			3−	6−	8+	9+	6+	3−	4−	3−	6+		2+	0
13	7+	9+	7+		6−	7.5−	4−	6+	5+	4+	1−	3−	2−	4+	3+	5+	0
14	4+				6−	5−	3−	5+	2+	5+	0	0		5+	1.5+	1+	1.5−
15	8+		9+	7+	5−	7−	2−	7+	3+	5.5+	2−	3−	0	3+	1+		3−
16	8+	8+	8+		7−			9+	5+		1−	2−	o	5+		0	2−
17	9+	9+	7+	5+	6−	4−	2−	9+	o	3+	0−	2−	3−	4+	0	0	3−
18	7+	5+	9+		7−		4−	6+	4+	5+	0−	3−	2−	5+	2+	3+	1.5−
19	5+	7+		6+	5−		3−	8+	6.5+	9+	0−	o	2.5−	4+	1.5+	2.5+	0
20	9+	9+	8+			4−		5+	0	4+		5−	2−	3+	o	3+	1−
21	10+		10+	8+	7−	6−	5−		3+	3+	0−	3.5−	1−	4+		6+	0
22	6+	9+			5−	3−	4−	1+	1+	4+	2−			4+	2+		
23	7+		9+	6+		4.5−	3−	7+	3+		1−	2−	o		1+	4+	o

Table A1. *Cont.*

	Force 1										**Force 2**					
	Treat of New Entrants										**Threat of Substitute Products and Services**					
	Economics of Scale	**Costs of Market Entrance**	**Legislations**	**Technology Protection**	**Market Saturation**	**Market Image**	**Market Importance**	**Substitution of Services**	**Transportation Costs**	**Export Duties**	**Ventilators**	**Thermally Driven Heat Pumps**	**Natural Ventilation**	**Renouncement**	**District Cooling**	**Other Technologies**	**Energy Efficiency of Buildings**
24	8+	9+	7+	8+	7−		5−		4+	1+	3−	2−	4−	4+	5+	5+	1−
25	9+	8+	8+	7+		4−	6−	8+	5.5+	4+	1.5−	3−	o	5+	0	5+	1−
26	6+	8+	7+		5−	6−	3−	9+		7+	1−		2−	3+	1.5+	1.5+	
27	6+	7+		8+	4−	7.5−	5−		1+	6+	o	1.5−	1.5−		1+	2+	1.5−
28	7+	4+	8+	2+	2−	2−	2.5−	2.5+	2.5+	5+	2−	2−	2−	2.5+	1+	1+	4−
Number of answers	27	22	23	17	22	23	25	24	27	26	26	23	25	26	24	25	24

	Force 1										Force 2					
	Treat of new entrants										Threat of substitute products and services					
Evaluated forces	Economics of scale	Costs of market entrance	Legislations	Technology protection	Market saturation	Market Image	Market importance	Substitution of services	Transportation costs	Export duties	Ventilators	Thermally driven heat pumps	Natural ventilation	Renouncement	District cooling	Other technologies	Energy efficiency of buildings
First Quartile	7	7	7	5	5	4	3	6	2	4	0	2	0	3	1	1	1
Third Quartile	9	9	8	7	7	6	5	8	4.5	5	2	3	2	5	2	4	2
Interquartile Range	2	2	1	2	2	2	2	2	2.5	1	2	1	2	2	1.5	3	1
Final result	7+	8+	7+	6+	6−	5−	4−	7+	3+	5+	1−	2−	1−	4+	2+	3+	1−

Table A1. *Cont.*

	Force 1										**Force 2**						
	Treat of New Entrants										**Threat of Substitute Products and Services**						
	Economics of Scale	**Costs of Market Entrance**	**Legislations**	**Technology Protection**	**Market Saturation**	**Market Image**	**Market Importance**	**Substitution of Services**	**Transportation Costs**	**Export Duties**	**Ventilators**	**Thermally Driven Heat Pumps**	**Natural Ventilation**	**Renouncement**	**District Cooling**	**Other Technologies**	**Energy Efficiency of Buildings**
	Force 3 Bargain power of suppliers										Force 4 Bargain power of buyers						
	Competitiveness	Size and concentration relative to the industry partecipants	Possibility to forward integration of suppliers	Fragmentation of customers	Market support	Investor's interest	Climate change	Multifunctionalities	Customer loyalty measures	Comfort	Sale price reduction	Concentration of customers	Differentiation of technologies	Risk of failure			
1	3−	7+	7+	1+	6+	6+	8.5+	4+	3+	7+	6−	3−	3−	4+			
2	0	9+	5+	1+	5+	7+	7.5	2+	2+	4+	4−			7+			
3	1−	9.5+	6+	2+		6+	8+	4+	3+	9+	6−	2−	2−	4.5+			
4	2−	9+	7+	1+	4+	10+	3+	5+	7+	9−	1−	5+					
5	2−	6.5+	5+	3+	3+	3.5+	5+	10+	1+	4+	6+	2−	5−2−	2.5+			
6	3−		6+	2+	2.5+	1.5+	9+	4+	1+	10+	4−	4−	3−				
7	1−	8+	4+		6+	6+	9+	5+	3+	9+	5−		6−	7+			
8	0	7+	5+	0	7.5+		8.5+	6.5+	2+		6−		0	6.5+			

Table A1. *Cont.*

	Force 1											Force 2					
	Treat of New Entrants											Threat of Substitute Products and Services					
	Economics of Scale	**Costs of Market Entrance**	**Legislations**	**Technology Protection**	**Market Saturation**	**Market Image**	**Market Importance**	**Substitution of Services**	**Transportation Costs**	**Export Duties**	**Ventilators**	**Thermally Driven Heat Pumps**	**Natural Ventilation**	**Renouncement**	**District Cooling**	**Other Technologies**	**Energy Efficiency of Buildings**
9	0	10+	8+		5+	3+	10+	4+		8.5+	8−	0	8−	2+			
10	2−	7.5+	7+	2+	4+	5+	9+	3+	5+	9+	7−	2−	3−	3+			
11	1−	9+	9+	3+		4+	9+		3+	10+	9−	4−	4−	7+			
12	1−	3+	+	1+		9+		4+	2+	9.5+		1−	2−	4+			
13			7+		7+	6+	8+	1.5+	5+		4−	2−	5−	8+			
14	1−	8+	2.5+	1+	5.5+		9+	3+	3+	10+	5−		1−	5+			
15	2−	9+	6+	1+	6+	2.5+	10+	4+	5+	9+		5−		2+			
16	0	4.5+	5+	1+	0+	5+	10+	2+	3+	8+	7−		0				
17	2−	7+	6+	0	3+	7+	8+	0	2+	8.5+	8−	6−	6−	5+			
18	1−	6+	7+			4.5+	8.5+		3+	10+		7−	3−	3+			
19		8+	8+	1+	5+		9+	5+	4+	10+	7−		4−				
20			7+	3+		7+		5.5+		7+	5−	2−	0	6+			
21	1−	8+	1.5+	0+	0+	5+	9+	4+	3+	9+	2−		2−	3.5+			
22	0	10+	5+	0+	2+	7.5+	9+			8+	4−	2−					
23	0	3.5+			3+	5+		4+	2+	9+		1−	2−	6+			
24	0		5+	2+		+	10+	4+		9+				3+			
25	6−	9+	7+	3+	5+	5+	9+	1.5+	3+		7−	3−	5−	+			
26	1−	7+	8+	1+	4.5+		9+	2+	4+	9+	4−	5−	5−	6+			
27	2−	8.5+	9+	2+	6+	4+	9.5+	5+	5+	10+	6−		6+				
28				2+		6+	8+		2+	+6	7−		3−	3+			
Number of answers	24	23	25	23	21	22	25	24	24	25	23	19	24	22			

Table A1. *Cont.*

	Force 1									**Force 2**						
	Treat of New Entrants									**Threat of Substitute Products and Services**						
	Economics of Scale	**Costs of Market Entrance**	**Legislations**	**Technology Protection**	**Market Saturation**	**Market Image**	**Market Importance**	**Substitution of Services**	**Transportation Costs**	**Export Duties**	**Ventilators**	**Thermally Driven Heat Pumps**	**Natural Ventilation**	**Renouncement**	**District Cooling**	**Other Technologies**	**Energy Efficiency of Buildings**
	Force 3 Bargain power of suppliers									Force 4 Bargain power of buyers						
Evaluated forces	Competitiveness	Size and concentration relative to the industry participants	Possibility to forward integration of suppliers	Fragmentation of customers	Market support	Investor's interest	Climate change	Multifunctionalities	Customer loyalty measures	Comfort	Sale price reduction	Concentration of customers	Differentiation of technologies	Risk of failure			
First Quartile	0	7	5	1	3	5	8.5	2	2	8	4	2	2	3			
Third Quartile	2	9	7	2	6	6	9.5	4	4	10	7	5	5	6			
Interquartile Range	2	2	2	1	3	1	1	2	2	2	3	3	3	3			
Final result	1−	8+	6+	1+	4+	5+	9+	3+	3+	9+	6−	3−	3−	5+			

Table A2. Multiple criteria decision analysis—marks for goals and sub-goals.

Goals											
	EU Directives				EU Regulations		EU Standards	Income Max.		Benefit to Cost Max.	
N°	2010/31 EU: EPBD	2018/2001EU: REDII	2009/125 Ecodesign Dir.	EU—EED 2018/2002	66/2010: EU Ecolabel	EU Reg. N° 517/2014	Test Requirements	Earnings Generation	Expenses Reduction	Gain Max.	Cost Min.
1	3+	7+	2.5+	5.5+	7+	4+	6+	9+	8+	7+	7+
2	3+	6+	1+	7+	6+	2.5+	7+	7+	7.5+	8+	8+
3		4+	6+		7+	9+	8+	8+	10+	8+	10+
4	8+	1+	2+	5+	6+	0		9+		9.5+	8+
5	7+	5+	3+	3+	5+	4+	8+		9+	6+	7+
6		6+		4+	6+		2.5+	9+	8+	7+	9+
7	2+	3+	2+	2+	7+	6+	7+	8+	7.5+	8+	7+
8	6+	4+	4+	6+	3+	7+	7+	8+	7+	9+	6.5+
9	5+	4+	5.5+	3.5+	4+	4+	3.5+	7+	9.5+	8+	8+
10	8+	6+	1.5+	1+	5+	5+	7+	7+	10+	7+	7+
11		8+	3+	5+		2.5+	5+	5.5+	8+	8+	9+
12	9+	6+	4+	6+	5.5+	5+	7+	9+		9.5+	4+
13	6+	2+	5+	3.5+	7.5+	3.5+		3+	8+		
14		4.5+	3+	6+	6+	6+	6+	8+	8+	7+	6+
15	5+	7+	6+	4+	7+	4+	9+	9+	6+	8+	7+
16	5+	5.5+	2.5+	3.5+		7+	8+	9.5+	7+	7+	9.5+
17	4+		7+	6+	7.5+	7.5+	3+	8+	8+	8+	7+
18	2.5+	6+	5+	2.5+	3+	2.5+	7+	8+	+	9+	9+
19	5+	3+	1+		9+	4+	7+	6.5+	9+	8+	7+
20	6+		5+	5+	4+	5+		7.5+	8+	0+	9.5+
21	5+	6+	4+	6+	6+	0		10+	3+		
22	8+	8+	0+	4.5+	3.5+	7+	7+	9+	9+	9+	7+
23	7.5+		6+				6+	7+	8+	8+	9+
24	9+	6+	3+	1.5+	5+	3+	7+	2.5+	7+	7+	6.5+
25	4.5+	7+	4+	2+	8+	4+	8+	9+	5.5+		9+

Table A2. *Cont.*

Goals											
	EU Directives				EU Regulations		EU Standards	Income Max.		Benefit to Cost Max.	
N°	**2010/31 EU: EPBD**	**2018/2001EU: REDII**	**2009/125 Ecodesign Dir.**	**EU—EED 2018/2002**	**66/2010: EU Ecolabel**	**EU Reg. N° 517/2014**	**Test Requirements**	**Earnings Generation**	**Expenses Reduction**	**Gain Max.**	**Cost Min.**
26	6+	5+	1+	4+	3+	5+	4+	5+	9.5+	7+	7+
27		4+		6+	6+		7+	9+	8+	8+	8+
28	7+	7+	3+	5+	6+	4+		7+	7+	6.5+	6.5+
Number of answers	23	25	26	25	25	25	23	27	25	25	26
Evaluated goals & factors	EU Directives				EU Regulations		EU Standards	Income Max.		Benefit to Cost Max.	
	2010/31 EU: EPBD	2018/2001EU: REDII	2009/125 Ecodesign Dir.	EU—EED 2018/2002	66/2010: EU Ecolabel	EU Reg. N° 517/2014	Test requirements	Earnings generation	Expenses reduction	Gain Max.	Cost Min.
First Quartile	5	4	2	4	5	3.5	6	7	7	7	7
Third Quartile	7	6	5	6	7	6	7	9	9	8	9
Interquartile Range	3	2	3	3	2	3	1	2	2	1	2
Final result	6+	5+	3+	4+	6+	4+	6+	8+	8+	8+	8+

Table A2. *Cont.*

	Goals													
	EU Directives				**EU Regulations**		**EU Standards**	**Income Max.**		**Benefit to Cost Max.**				
N°	**2010/31 EU: EPBD**	**2018/2001EU: REDII**	**2009/125 Ecodesign Dir.**	**EU—EED 2018/2002**	**66/2010: EU Ecolabel**	**EU Reg. N° 517/2014**	**Test Requirements**	**Earnings Generation**	**Expenses Reduction**	**Gain Max.**	**Cost Min.**			
	Market potential		R&D	Habits	Weather	Factors Costs				Replacement	Comfort	Competition		Building
N°	Number of installed units	Energy Efficiency	R&D funding	Energy consumption for cooling purposes	Climate change	Costumer's investemt costs	Running costs	Disposal costs	Transportation costs	Life span of cooling equipment	Comfort requests	Size and concentration of the cooling market	Costumer loyality measures	Buildings efficiency increase
1	6+	7+	7+	4+	8.5+	3−	4−	1.5−	1−	2+	8+	4+	1+	2−
2	7+	6+	6+	5+	7.5+	2−	2−			3+	7+	3+	1+	4−
3	5+	7+		7+	8+	5−	4−	5−	2−	4+	6+	2+	0	3−
4	4+	8+	8+	3+	10+	4−	5−	1.5−	5−	1+	4+	4+	0	5−
5	8+	8+		6+	10+	4.5−	6−	4−	1−	2+	8+	5+		1−
6	6+	7+	5+	6+		1−	4−	4−	1−	3+	9+	3+	3+	o

Table A2. *Cont.*

Goals														
	EU Directives				EU Regulations		EU Standards	Income Max.		Benefit to Cost Max.				
N°	2010/31 EU: EPBD	2018/2001EU: REDII	2009/125 Ecodesign Dir.	EU—EED 2018/2002	66/2010: EU Ecolabel	EU Reg. N° 517/2014	Test Requirements	Earnings Generation	Expenses Reduction	Gain Max.	Cost Min.			
7	6+	6+	8+	4+	9+	8−	5−	2−	2−	4+	9+	4+	2+	
8	5+	7+	9+	7+	8.5+	7−	1−	3−	3−	2+	9+	6+	1+	o
9	7+	8+	10+	5+	10+	8.5−	0	2−	4−		9+	5+	3+	
10	7+	6+	8+	6+	9+	5−	7−	2−	2−	2+	6+	3+	3+	2.5−
11	7+	7+	8+	3+	9+	4.5−	6−	7−	3−	3+	7+	4+	0	3−
12	5+	6+	7+	4+		4−	7−	2−	1−	4+	8+	2+	0	1.5−
13	7+	7+	7+	6+	9+	2−	4−	4−	0	4+	6+	2+		1−
14		8+	6+	3+	7.5+	7.5−	5−	3−	0	5+		1+	0+	
15	8+	7+	3+	7+		3−				3+	8+			1−
16		6+	8+	9+	8+					4+	6+	4+	1+	3−
17	7+		8+		9+	7.5−	3−	3−	0		7+		2+	0
18	7+	8+	7.5+	7+		4−	4−	2−	2−	2+	9+	5+	1+	
19	6+	8+	6+	8+	8.5+	3−	5−	3.5−	1−	4+	9+	4+	3+	o
20	8+	7+	7+	8+	8+	6.5−	4−	5−	3−	2+	8+	3+	2+	1−
21	7+	6+	9+	5+	9+	1−	3−	6−	2−	3+	7+	4+	1+	2.5−
22	6+	7+	9.5+	3+	10+					5+	8+	5+	1+	
23		6+	6+	6+		7−	2−	3−	1−	3+	9+	4+		5−
24		7+	7+	6+	7.5+	6.5−	3−	2−	0	5+	9+	3+	0	3−
25	6+	7+	4.5+	5+	9+	7−	2−	7−	0		6+	5+	0	2−
26	6+	7+	7+	6+	9+	4.5−	5−	2−	0	1+		3+	0	2−
27	7+	8+	10+	6+		3−	4−	3−	1−	3+	7+	5+	2+	
28					8+	7−	7−	3−	2−	1+	7.5+	4+	1+	3−
Number of answers	23	26	25	26	22	26	25	24	24	25	26	26	24	22

Table A2. *Cont.*

	Goals													
	EU Directives				EU Regulations		EU Standards	Income Max.		Benefit to Cost Max.				
N°	2010/31 EU: EPBD	2018/2001EU: REDII	2009/125 Ecodesign Dir.	EU—EED 2018/2002	66/2010: EU Ecolabel	EU Reg. N° 517/2014	Test Requirements	Earnings Generation	Expenses Reduction	Gain Max.	Cost Min.			
	Market potential		R&D	Habits	Weather		Costs			Replacement	Comfort	Competition		Building
Evaluated goals & factors	Number of installed units	Energy Efficiency	R&D funding	Energy consumption for cooling purposes	Climate change	Costumer's investemt costs	Running costs	Disposal costs	Transportation costs	Life span of cooling equipment	Comfort requests	Size and concentration of the cooling market	Costumer loyality measures	Buildings efficiency increase
First Quartile	6	6	6	4	8	3	3	2	1	2	7	3	0	1
Third Quartile	7	8	8	7	9	7	5	4	2	4	9	5	2	3
Interquartile Range	1	1.5	2	2.5	1	4	2	2	1	2	2	2	2	2
Final result	6+	7+	7+	6+	9+	5−	4−	3−	2−	3+	8+	4+	1+	2−

References

1. European Commission. 2020 Climate & Energy Package. Available online: https://ec.europa.eu/clima/policies/strategies/2020_en (accessed on 8 February 2022).
2. European Commission. *Impact Assessment, Accompanying Communication 'Stepping up Europe's 2030 Climate Ambition—Investing in a Climate-Neutral Future for the Benefit of Our People*; SWD—STAFF Working Document European Commission, No. 176 Final; European Commission: Brussels, Belgium, 2020.
3. European Commission. *Proposal for a Regulation of the European Parliament and of the Council Establishing the Framework for Achieving Climate Neutrality and Amending REGULATION (EU) 2018/1999 (European Climate Law)*; EN 2020, 2020/0036; European Commission: Brussels, Belgium, 2020.
4. Energy Savings Statistics. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_saving_statistics#Final_energy_consumption_and_distance_to_2020_and_2030_targets (accessed on 13 October 2020).
5. Eurostat. Table on EU Policy-Europe 2020 Indicators-Headline Indicators-Climate Change and Energy-Primary Energy Consumption. Available online: https://ec.europa.eu/eurostat/databrowser/view/t2020_33/default/table?lang=en (accessed on 8 February 2022).
6. Pezzutto, S.; Croce, S.; ZambottI, S.; Kranzl, L.; Novelli, A.; Zambelli, P. Assessment of the Space Heating and Domestic Hot Water Market in Europe—Open Data and Results. *Energies* **2019**, *12*, 1760. [CrossRef]
7. Pezzutto, S.; De Felice, M.; Fazeli, R.; Kranzl, L.; ZambottI, S. Status Quo of the Air-Conditioning Market in Europe: Assessment of the Building Stock. *Energies* **2017**, *10*, 1253. [CrossRef]
8. Rehfeldt, M.; Fleiter, T.; Toro, F. A bottom-up estimation of the heating and cooling demand in European industry. *Energy Effic.* **2018**, *11*, 1057–1082. [CrossRef]
9. European Commission. JRC-IDEES 2015. Available online: https://data.jrc.ec.europa.eu/dataset/jrc-10110-10001 (accessed on 7 February 2022).
10. EU. Directive (EU) 2018/2001 of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources. *Off. J. Eur. Union* **2018**, *2018*, 82–209.
11. Gang, W.; Wang, S.; Xiao, F.; Gao, D.-C. District cooling systems: Technology integration, system optimization, challenges and opportunities for applications. *Renew. Sustain. Energy Rev.* **2016**, *53*, 253–264. [CrossRef]
12. Possibilities with more district cooling in Europe. Available online: https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/ecoheatcool_more_district_cooling_in_europe.pdf (accessed on 26 February 2021).
13. Eveloy, V.; Ayou, D.S. Sustainable District Cooling Systems: Status, Challenges, and Future Opportunities, with Emphasis on Cooling-Dominated Regions. *Energies* **2019**, *12*, 235. [CrossRef]
14. International Energy Agency (IEA). *The Future of Cooling: Opportunities for Energy-Efficient Air Conditioning*; Future Cooling; International Energy Agency: Paris, France, 2018. [CrossRef]
15. Pezzutto, S.; Fazeli, R.; De Felice, M.; Sparber, W. Future development of the air-conditioning market in Europe: An outlook until 2020. *WIREs Energy Environ.* **2016**, *5*, 649–669. [CrossRef]
16. Porter, M.E. How Competitive Forces Shape Strategy. *Readings in Strategic Management* **1989**, 133–143. [CrossRef]
17. Pezzutto, S.; Grilli, G.; ZambottI, S.; Dunjic, S. Forecasting Electricity Market Price for End Users in EU28 until 2020—Main Factors of Influence. *Energies* **2018**, *11*, 1460. [CrossRef]
18. Deng, J.; Wang, R.; Han, G. A review of thermally activated cooling technologies for combined cooling, heating and power systems. *Prog. Energy Combust. Sci.* **2011**, *37*, 172–203. [CrossRef]
19. Wan, X.; Wang, W.; Liu, J.; Tong, T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med. Res. Methodol.* **2014**, *14*, 135. [CrossRef] [PubMed]
20. Li, Y.; Wang, J.; Zhao, D.; Li, G.; Chen, C. A two-stage approach for combined heat and power economic emission dispatch: Combining multi-objective optimization with integrated decision making. *Energy* **2018**, *162*, 237–254. [CrossRef]
21. Li, Y.; Li, Y.; Li, G.; Zhao, D.; Chen, C. Two-stage multi-objective OPF for AC/DC grids with VSC-HVDC: Incorporating decisions analysis into optimization process. *Energy* **2018**, *147*, 286–296. [CrossRef]
22. Pezzutto, S.; Sparber, W.; Fedrizzi, R. Analysis of the space heating and cooling market in Europe. In Proceedings of the 3rd International PhD-Day of the AAEE Student Chapter, Linz, Austria, 12–14 February 2014. [CrossRef]
23. Lechner, N. *Heating, Cooling, Lighting: Sustainable Design Methods for Architects*; John Wiley & Sons: Hoboken, NJ, USA, 2014; p. 720.
24. Song, Y.; Cui, C.; Li, M.; Cao, F. Investigation on the effects of the optimal medium-temperature on the system performance in a transcritical CO_2 system with a dedicated transcritical CO_2 subcooler. *Appl. Therm. Eng.* **2020**, *168*, 114846. [CrossRef]
25. Liu, Z.; Zhang, L.; Gong, G.; Li, H.; Tang, G. Review of solar thermoelectric cooling technologies for use in zero energy buildings. *Energy Build.* **2015**, *102*, 207–216. [CrossRef]
26. Goetzler, W.; Shandross, R.; Young, J.; Petritchenko, O.; Ringo, D.; McClive, S. *Energy Savings Potential and RD&D Opportunities for Commercial Building HVAC Systems*; United States Department of Energy: Washington, DC, USA, 2017. [CrossRef]
27. Bill, G.; Matt, G.; Theo, K.; Jim, Y.; Tim, S.; Antonio, B.; Monica, N.; Sawyer, K. *Grid-Interactive Efficient Buildings Technical Report Series: Lighting and Electronics*; United States Department of Energy: Washington, DC, USA, 2019. [CrossRef]
28. De Negri, J.F.; Pezzutto, S.; Gantioler, S.; Moser, D.; Sparber, W. A Comprehensive Analysis of Public and Private Funding for Photovoltaics Research and Development in the European Union, Norway, and Turkey. *Energies* **2020**, *13*, 2743. [CrossRef]

29. Moreno, B.; López, A.J.; García-Álvarez, M.T. The electricity prices in the European Union. The role of renewable energies and regulatory electric market reforms. *Energy* **2012**, *48*, 307–313. [CrossRef]
30. Murthy, P.S.; Naidu, M.M. Sustainable management of coffee industry by-products and value addition—A review. *Resour. Conserv. Recycl.* **2012**, *66*, 45–58. [CrossRef]
31. Fleiter, T.; Steinbach, J.; Ragwitz, M.; Arens, M.; Aydemir, A.; Elsland, R.; Frassine, C.; Herbst, A.; Hirzel, S. *Mapping and Analyses of the Current and Future (2020–2030) Heating/Cooling Fuel Deployment (Fossil/Renewables) Work Package 1: Final Energy Consumption for the Year 2012 Final Report*; European Commission: Brussels, Belgium, 2016. [CrossRef]
32. Brown, J.S.; Domanski, P. Review of alternative cooling technologies. *Appl. Therm. Eng.* **2014**, *64*, 252–262. [CrossRef]