OVERVIEW OF PROVISIONS FOR VENTILATIVE COOLING WITHIN 8 EUROPEAN BUILDING ENERGY PERFORMANCE REGULATIONS

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ABSTRACT

Ventilative cooling (VC) is a way to cool or to prevent overheating in a building by means of ventilation rates higher than hygienic ventilation rates. To this end, natural (such as windows, vents, louvers) as well mechanical (extract or supply fans) ventilation devices can be used. Taking into account the reported realised energy savings of this technology, this study aims to focus on regulatory measures taken or missing regarding ventilative cooling in several countries, which could either inspire developments in other countries or point out specific problems for the market uptake of this technology; it gives an overview of provisions for ventilative cooling within 8 European building energy performance regulations.
Information has been collected through a questionnaire prepared jointly by venticool, the international platform for ventilative cooling and IEA Annex 62. Representatives from 8 countries (Belgium- Flanders, Denmark, Finland, France, Greece, Ireland, Italy and United Kingdom) provided their feedback to the questionnaire. The responses to the survey confirm that energy performance regulations usually consider ventilative cooling in a rather simplified manner (when considered). However, Belgium, Denmark, France, Finland and Greece consider ventilative cooling in their regulation using various features: assessment of overheating risks (BE, DK), use of dynamic hourly tools (FI, FR), use of performance characteristics of ventilative cooling devices, specific requirements for ventilative cooling products (BE) and benefits of automated systems (FI, FR, GR). 6 of the 8 surveyed countries have thermal comfort criteria in their regulation, which is a pre-requisite to consider ventilative cooling. Nevertheless, these methods do not seem to have been carefully evaluated. Further evaluation and research is needed to address the complexities of ventilative cooling in Energy performance regulations in a pragmatic way.

KEYWORDS

Ventilative cooling, energy performance regulations, venticool, IEA Annex 62

1 INTRODUCTION

With the trend towards Nearly Zero-Energy Buildings, specific attention should be paid to maintain acceptable indoor environmental quality (including thermal, visual and acoustical comfort, and indoor air quality) while reducing buildings' energy use. Unbalanced focus on drastic reduction of heating energy use often leads to overheating in summer and shoulder seasons, and a significant risk of installing active cooling in practice. It is commonly accepted that designers should consider strategies such as ventilative cooling, adequate solar control, and thermal mass utilisation to overcome this problem; however, evidence shows that most building professionals have not properly integrated these options in design practice.
Ventilative cooling (VC) is a way to cool or to prevent overheating in a building by means of ventilation rates higher than hygienic ventilation rates. To this end, natural (such as windows, vents, louvers) as well mechanical (extract or supply fans) ventilation devices can be used.

There are a number of theoretical and field studies that have shown the energy savings that can be realised with ventilative cooling, using readily available products. Nevertheless, there are active debates about how regulations—which are known to be major market drivers in the construction sector—should account for ventilative cooling strategies. This is the reason why this report focuses more specifically on regulatory measures taken or missing regarding ventilative cooling in several countries, which could either inspire developments in other countries or point out specific problems for the market uptake of this technology.

2 APPROACH

This report presents the results of a questionnaire prepared jointly by venticool, the international platform for ventilative cooling and IEA Annex 62. The questionnaire dealt with ventilative cooling within building energy performance regulations and its primary objective was to compare approaches to account for ventilative cooling in regulations.
Because regulations have complex country- or region-specific sets of rules, we had to let some degree of interpretation of the questions to adapt to all contexts. Representatives from 8 countries (Belgium- Flanders, Denmark, Finland, France, Greece, Ireland, Italy and United Kingdom) kindly answered the questionnaire. We have not crossed-checked their answers. This document summarising the survey results has been reviewed by the respondents.

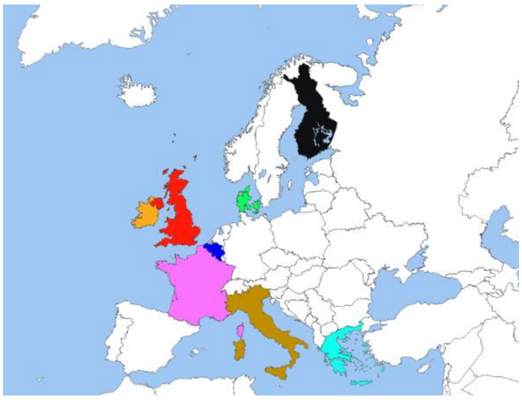

Figure 1: 8 countries represented in survey results.

3 GENERAL FEATURES OF ENERGY PERFORMANCE REGULATIONS RELEVANT TO VENTILATIVE COOLING

3.1 Building Energy performance regulations and calculation time-steps

Table 1 summarises the existing building energy performance regulations and their calculation time-step.

Table 1: Energy Performance calculation and time-step

Country	Energy Performance (EP) Regulation	EP calculation time step
Belgium (Flanders)	EPB	Monthly
Denmark	BR2010	Monthly
Finland	National Building Code of Finland	Monthly (hourly for summer comfort calculation)
France	RT 2012	Hourly
Greece	KENAK	Monthly
Ireland	Irish Building Regulations Part L & F	Monthly
Italy	D.Lgs. 311/2006	Monthly
UK	Building Regulations Part L & F	(Hourly/monthly)*

For most countries the calculation method is monthly, with the exceptions of France and the UK. In France, the calculation time step is hourly. In the UK, the monthly calculation method can be used (by a certified assessor) for all types of buildings but there is also an hourly method—a dynamic simulation approach for non-residential buildings or more complex new buildings which involve technologies that are difficult to represent satisfactorily in the monthly procedure. The National Building Code of Finland uses a monthly calculation for energy use estimates and an hourly calculation for summer comfort calculations.

3.2 Thermal comfort and overheating

The Energy Performance regulations of most of the countries surveyed include summer comfort criteria with the exception of Italy (Table 2).

Table 2: Thermal comfort and overheating risk

Country	Are there a thermal comfort criteria for summer in the EP regulation?	Is there a penalty on the calculated energy use depending on the overheating risk?
Belgium (Flanders)	Yes already	Yes
Denmark	Yes in the future	Yes
Finland	Yes already	Yes
France	Yes already	No
Greece	Yes already	No
Ireland	Yes already	No
Italy	No	No
UK	Yes already	No

More specifically, the Energy Performance regulation of the Flemish region of Belgium includes summer comfort criteria but only for residential buildings where the overheating risk is calculated based on monthly averaged heat losses and gains.

In Denmark, thermal comfort criteria are currently voluntary and limited to low-energy buildings design but will be mandatory for all types of buildings in the course of 2015. For residences, it should be proved by calculation that the temperature does not exceed 27°C for more than 100 hours and 28°C for more than 25 hours. For other buildings, the building owner sets the maximum number of hours the temperature can be above 26°C and 27°C.

In Finland, all buildings have to be designed and built to avoid overheating. Between June 1 and August 31, it is obligatory to calculate the summer room temperature; the calculation must be carried out with a dynamic calculation tool (commercially available) with given hourly weather data, internal loads and design air flow rates. Room temperature is not allowed to exceed cooling limit for more than 150 degree hours (based on 27°C for residential buildings and 25 °C for other buildings). To meet this requirement (to avoid overheating), structural and other passive means as well as night time ventilation has to be used primarily. If passive means are not enough to meet this requirement mechanical cooling is used.

In France, the Indoor Comfort Temperature ("Tic", a conventional indoor building temperature) has to be under a reference value (called “Tic reference”). The Tic is determined as the maximum indoor temperature reached at the end of the month of June. The calculation is performed on 4 weeks with conventional hot weather data specific to the region.

In Ireland, summer comfort criteria apply for naturally ventilated buildings: internal air temperature must not exceed 28°C for an acceptable portion of the total annual occupied hours— 20 hours for office spaces (this proportion of the occupied hours is subject to the nature of the building and activities), and mechanically ventilated energy use should be minimised. Alternatively, maintaining solar gains to below 25 W/m^2 is another way to demonstrate compliance with the national building regulations.

The United Kingdom Energy Performance regulation includes summer comfort criteria that apply to non-residential naturally-ventilated buildings, in terms of a percentage of hours exceeding certain temperatures.
EP regulations in France, Greece, Ireland, Italy and UK do not include penalties on the calculated energy use depending on the overheating risk. However, the EP regulations of Belgium, Denmark and Finland have such penalties. In particular, the Danish BR2010 includes an additional energy use based the cooling need necessary to overcome the overheating risk and a COP of 2 even if mechanical cooling is not installed. Therefore, the penalty is not based on an assessment of the overheating risk per day, but on a predicted cooling need. In the Flemish EPB, the risk is assessed based the probability to use active cooling which is assumed to be a linear function of overheating degree-hours (0 below 1000 $K \cdot h$, 1 above 6500 $K \cdot h$. The cooling need is then multiplied by that probability and added to the building's energy use.

4 SPECIFIC FEATURES OF ENERGY PERFORMANCE REGULATIONS TO ACCOUNT FOR VENTILATIVE COOLING

4.1 Provisions to account for ventilative cooling

Five countries out of eight already take into account at least one form of ventilative cooling in their Energy Performance regulation for residential buildings (Table 3). For non-residential buildings, ventilative cooling is taken into account in the energy performance regulations of Belgium, Denmark, France and Finland, while this is not the case for Greece, Ireland, Italy and UK.

Table 3: Ventilative cooling in the national EPBD

Country	Residential buildings		Non- residential buildings		
	Yes already	No	Yes already	Yes in the future	No
Belgium (Flanders)	✓		✓		
Denmark	✓		✓		
Finland	✓		✓		
France	✓		✓		
Greece	✓				✓
Ireland		✓			✓
Italy		✓			✓
UK		✓			✓

In Belgium, opening of windows during the day is considered for residential buildings; it will be considered for non-residential buildings with the implementation of night cooling strategies. Earth-to-air heat exchangers (which usually operate at high flow rates) are already considered both for residential and non-residential buildings.
In Denmark, venting by natural ventilation can be specified both during and outside occupied hours and differs from winter to summer.
In Finland, summer room temperature calculation between June 1 and August 31 must be carried out with an hourly dynamic calculation tool with given weather data and internal loads and design air flow rates and thus ventilative cooling can be taken into account in simulations.
In Ireland, the designer must demonstrate a low risk of overheating using a simulation tool but there is no direct allowance for ventilative cooling in the national EP regulation. In other words ventilative cooling contribution is not calculated based on a set of variable inputs. A separate calculation must be done and this is primarily based on reducing solar gains and does not take into account any contribution from ventilation components.
In the UK, ventilative cooling is integrated in the target values of Target Emission Rate (TER) and Target Fabric Energy Efficiency (TFEE).

Table 4 summarises the different ways by which the effect of ventilative cooling is taken into account in the EP calculations of the countries represented in the survey. It shows that the effect of ventilative cooling is expressed by different means in the different countries.
Ventilative cooling with natural ventilation is considered in all 5 countries.
Overall, various features have been implemented to consider ventilative cooling in several regulations, but, to our knowledge, they have been carefully evaluated with comparative analysis of different methods or with field data.

Table 4: Ventilative cooling effect considerations. (Countries where there is no provision for ventilative cooling in the EP regulation are excluded from this table)

	Belgium	**Denmark**	**Finland**	**France**	**Greece**
Ventilative cooling modifies the calculated thermal comfort index	✓			✓	
Ventilative cooling modifies the calculated energy performance		✓		✓	
"Free cooling" mechanical airflow rates are considered		✓	✓	✓	
Natural ventilation airflow rates are considered	✓	✓	✓	✓	✓
Hybrid ventilation is considered			✓	✓	
Single sided ventilation is considered				✓	
Cross ventilation is considered				✓	
Stack effect is considered				✓	
Other			✓		

4.2 Limitations to the impact of ventilative cooling on the calculated energy performance

2 countries (DK, FI) have limitations to the impact of ventilative cooling on the calculated energy performance.
In Denmark, there is a maximum flow rate which can be used without additional documentation of system performance. Similarly, in Finland, the energy demand for cooling and the energy consumption of the building must be calculated with the default internal loads and ventilation rates reported in the building code.

Table 5: Limitations to the impact of ventilative cooling on the calculated energy performance

Country	**Is there a limitation to the impact of ventilative cooling on the calculated energy performance (e.g. max wind velocity, max. airflow rate)?**
Denmark	Yes
Finland	Yes
France	No
Greece	Yes

4.3 Ventilative cooling devices

Table 6 summarises the types of ventilative cooling devices taken into account and their product characteristics. Respondents default choices included ten different types of devices: openable facade and roof windows, vents integrated in/around windows (window grills), wall louvers, natural extract ducts/chimneys, other natural systems or components, heat recovery bypass, whole house fan, active cooling system with air-side economizer and other mechanical extract and/or supply systems or components; default choices for the product characteristics were limited to air flow rate, component properties and other. Additional information provided by respondents is integrated in the table. Answers from Ireland, Italy and UK are not integrated in the table since no system information is applicable in the calculation for these countries; in the case of Denmark, a flow rate is provided in the calculations.

Table 6: Types of ventilative cooling devices and product characteristics

	Belgium		Finland		France		Greece	
Openable facade windows	✓	burglary resistance/type of window opening	✓	other	✓	component properties (net surface area, size etc.)	✓	air flow rate
Openable roof windows	✓	burglary resistance/type of window opening	✓	other	✓	component properties (net surface area, size etc.)	✓	air flow rate
Vents integrated in/around windows (~ window grills)			✓	other	✓	flowrate at 20Pa is entered in the calculation tool to be integrated in the pressure code		other
Wall louvers			✓	other				other
Natural extract ducts/chimneys			✓	other	✓	component properties (net surface area, size etc.)		other
Other natural systems or components			✓	other		component properties (net surface area, size etc.)		other
Heat recovery bypass	✓	full or partly bypassed	✓	other	✓	other	✓	component properties (net surface area, size etc.)
Whole house fan			✓	other	✓	air flow rate	✓	air flow rate
Active cooling system with air-side economizer	✓	nominal cooling capacity for free-chilling	✓	other			✓	component properties (net surface area, size etc.)
Other mechanical extract and/or supply systems or components			✓	other	✓	air flow rate	✓	air flow rate

4.4 Requirements set on natural ventilative cooling systems

Participants to the survey were asked whether specific requirements set on natural ventilative cooling systems exist. Based on their feedback, it appears that only Belgium and Denmark have specific requirements set on natural ventilative cooling systems. In the case of Belgium burglary resistance and controllability requirements exist for openable façade and roof windows. In Denmark there are requirements for all devices but wall louvers; however, these requirements are not derived from a ventilative cooling potential. More specifically, controllability, rain tightness, burglary resistance and insect proof requirements are set on openable façade and roof windows; insect-proof, outdoor noise, cleaning and controllability requirements exist for vents integrated in/around windows; controllability requirements are also set on heat recovery bypass. In France, there are requirements in standards on natural ventilative cooling systems but these requirements are not part of the regulation. In the UK, the requirements are not within the regulations but included in professional guidelines and considered by designers.

4.5 Input parameters used to characterise mechanical ventilative cooling systems

Figures 2, 3 and 4 show the input parameters used to characterise mechanical ventilative cooling systems for each country surveyed. These answers include those from countries where ventilative cooling is not considered in the Energy Performance regulation, in which case, they reflect how the systems are considered regardless of their ability to provide ventilative cooling. From Figures 2 and 3 it is clear that for the whole house fan system and the active cooling system with air-side economizer, energy use is taken into account in most cases followed by control options, the specific fan power (SFP) and the peak power demand. For other mechanical extract and/or supply systems the energy use is taken into account in most countries followed by the specific fan power (SFP), the control options, and the peak power demand.

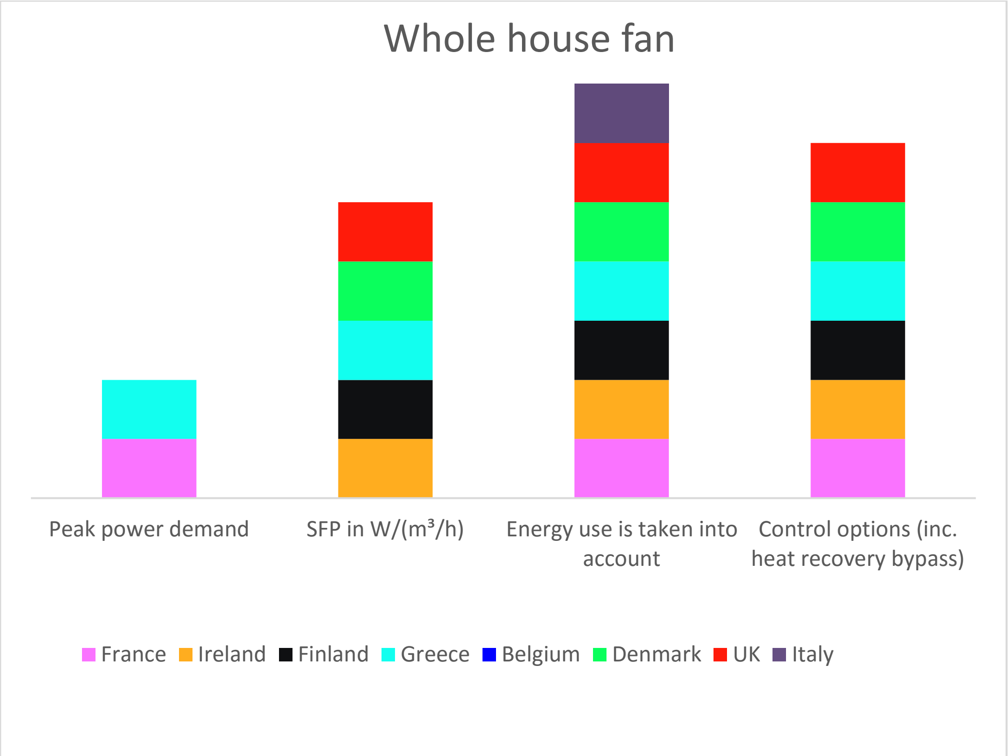

Figure 2: Whole house input parameters.

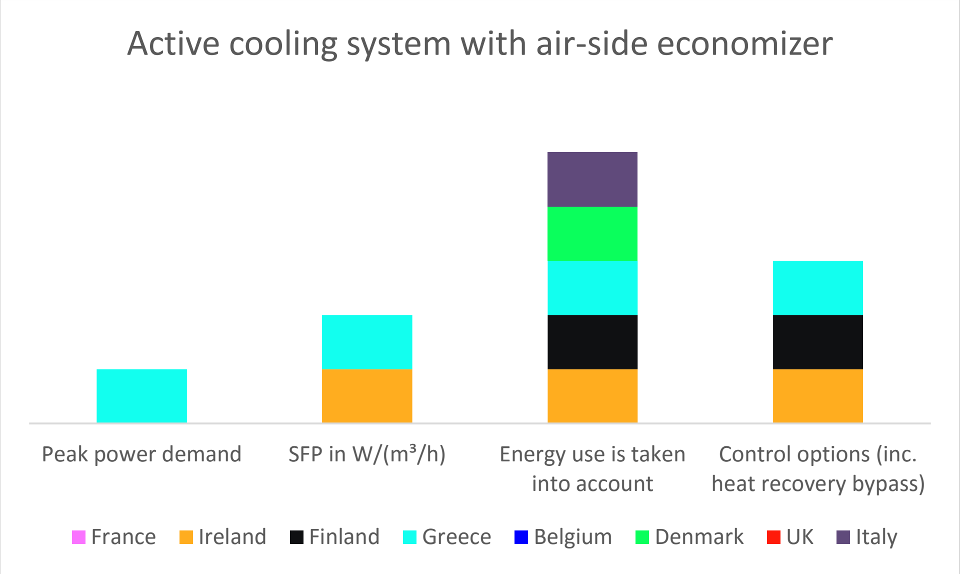

Figure 3: Active cooling system with air-side economiser input parameters

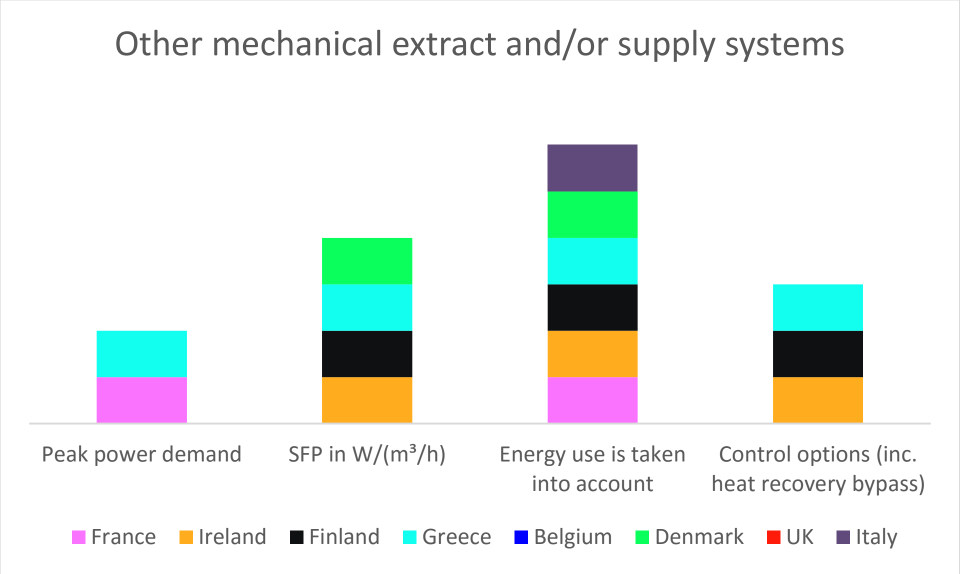

Figure 4: Other mechanical extract and/or supply systems input parameters.

4.6 Automated ventilative cooling systems versus manually-driven systems

Table 7 summarises the answers of the persons surveyed when questioned about the benefits of automated ventilative cooling systems compared to manually-driven systems. In the French regulation, heat recovery bypass is not supposed to be manually-driven. Manually-driven openings are assumed to be closed when external temperature is 2°C greater than the indoor temperature whereas automated systems are closed when external temperature is 6 °C less than indoor temperature. Automatic systems can work when the building is unoccupied and at night. In Ireland, there is no energy performance benefit allowance for including controls in the ventilative cooling system; if controls are included an advisory report is updated to advise the building owner.

Table 7: Have automated ventilative cooling systems a benefit compared to manually driven systems?

	France			Ireland	Finland	Greece	Belgium		Denmark	UK	Italy
	Yes	No	**I don't know**	**No**	**Yes**	**Yes**	**No**	**I don't know**	**No**	**No**	**No**
Openable facade windows	✓			✓	✓	✓	✓		✓	✓	✓
Openable roof windows	✓			✓	✓	✓	✓		✓	✓	✓
Vents integrated in/around windows (~ window grills)		✓		✓	✓	✓		✓	✓	✓	✓
Wall louvers			✓	✓	✓	✓		✓	✓	✓	✓
Natural extract ducts/chimneys			✓	✓	✓	✓		✓	✓	✓	✓
Other natural systems or components			✓	✓	✓	✓		✓	✓	✓	✓
Heat recovery bypass		✓		✓	✓	✓	✓		✓	✓	✓
Whole house fan			✓	✓	✓	✓		✓	✓	✓	✓
Active cooling system with air-side economizer			✓	✓	✓	✓		✓	✓	✓	✓
Other mechanical extract and/or supply systems or components		✓		✓	✓	✓		✓	✓	✓	✓

5 CONCLUSIONS

Energy performance regulations have become key market drivers because of their increasing weight on building design options. Therefore, to grasp the potential of ventilative cooling in practice, this technology must be fairly rewarded in these regulations. This survey confirms that energy performance regulations usually consider ventilative cooling in a rather simplified manner if they do. On the other hand, this survey shows there are interesting attempts in Belgium, Denmark, France, Finland and Greece to consider ventilative cooling in their regulation. This includes assessments of overheating risks (BE, DK), use of dynamic hourly tools (FI, FR), use of performance characteristics of ventilative cooling devices in the calculation, specific requirements for ventilative cooling products (BE), benefits of automated systems (FI, FR, GR). Note also that 6 of the 8 surveyed countries have thermal comfort criteria—which are a pre-requisite to consider ventilative cooling—in their regulation. There seems to be insufficient hindsight from these methods, calling for further evaluation and research to address the complexities of ventilative cooling in Energy performance regulations in a pragmatic way.

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