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Ventilation and IEQ requirements in energy regulation – results of JRC assessment

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Background

Indoor Environmental Quality (IEQ) requirements in EU:

- A coordinated and coherent implementation of IEQ related requirements in building related policies in EU is still missing
- From a regulatory point of view this remains under the competencies and responsibilities of the EU Member States
- Currently there are no binding requirements at EU level

Healthy and highly energy efficient buildings:

- Because of strong links between energy and IEQ, the need of indoor environment levels has been discussed to ensure that highly energy efficient buildings will be healthy to occupants
- JRC has assessed the implementation status of the EPBD by the EU MS in terms of ventilation and indoor air quality criteria – an important input to EPBD review process

IEQ in EPBD

- Article 4 of the EPBD recast requires Member States to set and ensure minimum energy performance requirements which:

  "*shall take account of **general indoor climate conditions**, in order to **avoid possible negative effects such as inadequate ventilation**, as well as local climatic and surrounding environment conditions and the designated function and the age of the building*".

- Recital 9 of the EPBD recast states that: *The energy performance of buildings should be calculated on the basis of a methodology, which may be differentiated at national and regional level. That includes, in addition to thermal characteristics, other factors that play an increasingly important role such as heating and air-conditioning installations, application of energy from renewable sources, passive heating and cooling elements, shading, **indoor air-quality**, adequate natural light and design of the building……This methodology should take into account existing European standards.*

- In paragraph 6 of Annex I (2) to the Commission Delegated Regulation (EU) No 244/2012 establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings it is stated that:

  The selected energy efficiency measures and measures based on renewable energy sources, and packages/variants, shall be compatible with the basic requirements for construction works as listed in Annex I to the Construction Products Regulation (EU) No 305/2011 and specified by Member States. They shall also be compatible with ***air quality and indoor comfort levels according to CEN standard 15251 on indoor air quality or equivalent national standards****.*

- The cost-optimal calculation exercise has to be designed in such a way that differences in **air quality and comfort are made transparent**. In case of a serious **violation of indoor air quality or other aspects, a measure might also be excluded** from the national calculation exercise and requirement

Ventilation rates and IAQ in energy performance assessment

- Energy calculation needs input data – IEQ parameters of ventilation rates, temperatures etc.
- More detailed IEQ criteria is needed in design of buildings (HVAC, passive measures, overheating etc.)

- IEQ input parameters are specified in prEN 16798-1 (will replace EN 15251) + more detailed requirements for ventilation system in prEN_16798-3 (will replace EN 13779)

- However, despite of the EPBD statement that indoor climate cannot be compromised, most of MS have so far implemented EPBD without paying attention to indoor environmental quality – many national approaches exists for IEQ requirements

Some examples: Energy calculation input data

Multifamily buildings in energy regulation (building codes)

	Finland	Sweden	Norway	Denmark
Lighting, kWh/(m^2 a)	9.6	21	11.4	34.9
Appliances, kWh/(m^2 a)	21		17.5/10.5[1]	
Occupants, kWh/(m^2 a)	15.8	8.8	13.1	14.9
Energy need of domestic hot water, kWh/(m^2 a)	35.0	25	29.8	14.9
Outdoor air flow rate, L/(s m^2)	0,5	0,35	0,33	0,34
Heating set point,˚C	21	21	21/19	20
Cooling set point,˚C	27	-	-	25
Annual heat recovery efficiency, %				
SFP, kW/(m^3/s)	2	2	2,5	
g-value of windows, -				
Thermal bridges of the building envelope, W/K	191			

[1]Electricity use 17.5 and heat gain 10.5

Country or region	Room type	Lighting ($\frac{W}{m^2}$)	Appliances ($\frac{W}{m^2}$)	Occupants ($\frac{W}{m^2}$)	Operation time of ventilation system (h)	Outdoor air flow rate ($\frac{l}{s \cdot m^2}$)	Heating setpoint ($°C$)	Cooling setpoint ($°C$)
Belgium	No room types specified	(1)			24h/24h, 7d/7d (2)	1 [het16c]	Not specified	23 [Goua] [De a] [Gouc]
Estonia	Single family dwelling Apartment building	8 8 [oeac14c]	2,4 3 [oeac14c]	2 3 [oeac14c]	24h/24h, 7d/7d [oeac14c]	0,42 0,5	21 [gov14]	27 [gov14]
Finland	Single family dwelling Apartment building	8 11(4) [Min10a]	3 4	2 (4) 3 (4) [Min10a]	24h/24h, 7d/7d [Min10a]	0,4 0,5 [ME10]	21 [ME10]	27 [ME10]
France	Single family dwelling and apartment building	14 [le 12c]	1,14 [le 12c]	5,7 [le 12c]	24h/24h, 7d/7d, except for 2 weeks in august and one in December [le 12c]	(6)	21 [le 12c]	27 [le 12c]

(1) Belgian regulations estimate internal heat gains with a standard value depending on building volume [De 10b].
(2) Belgian regions define a factor that indicates the fraction of the time the ventilation system is running. For the residential reference buildings t constantly running [De 10a].
(3) Belgian calculation for DHW is done by estimating the DHW use of a specific bath/shower or sink, based on the volume of (part of) the building is made (equation 4.12 and 4.13).
(4)Only includes sensible but not latent heat. To incorporate this the value must be divided by 0,6.
(5) The latter value assumes the measurement of water per flat [Min10b].
(6) The value is dependant upon the specific room types that are part of the residential building [Edi15].
(7)the weekly DHW use at 40 $°C$ is calculated for a number of equivalent adults, see equations 4.37.

DG ENER – JRC project to EED and EPBD assessment (Task 13.3)

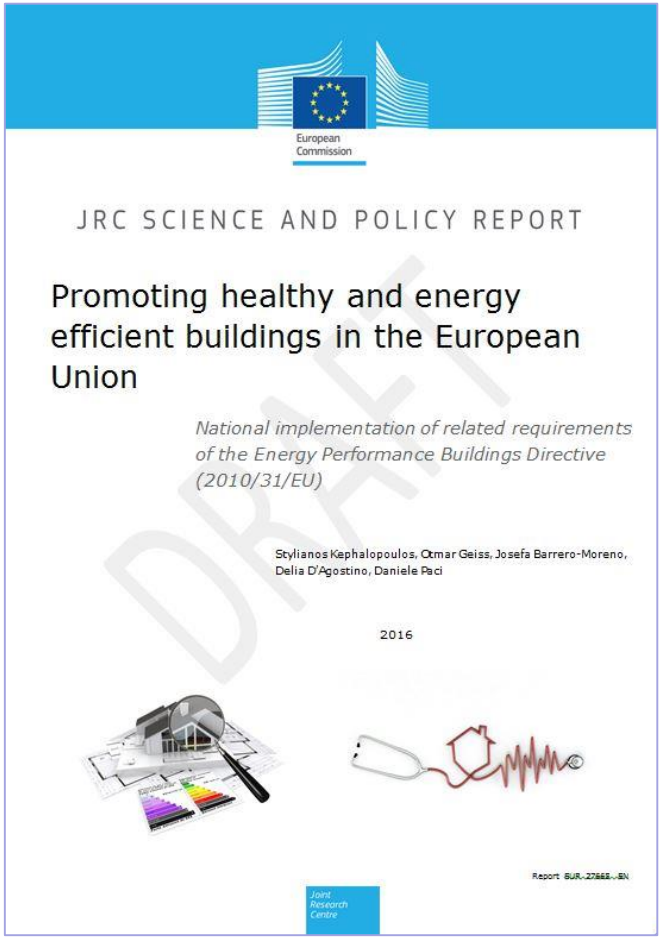
Task 13.3.1:
Assess the implementation status of the **EPBD** by the **EU MS** have in terms of **ventilation and indoor air quality criteria** and requirements and whether these are enough to guarantee that existing or future high energy-efficient buildings will be also healthy for their occupants

Task 13.3.2:
Literature review and **data collection** on the **consequences of high energy performance buildings to IAQ** and the monitoring of indoor air quality before and after improvement of energy efficiency of buildings

Task 13.3.3:
Recommendations on effective **implementation** of **healthy** and **energy efficient buildings** in the EU

European Commission

.....JRC report coming soon



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Joint Research Centre

JRC Overview of literature studies

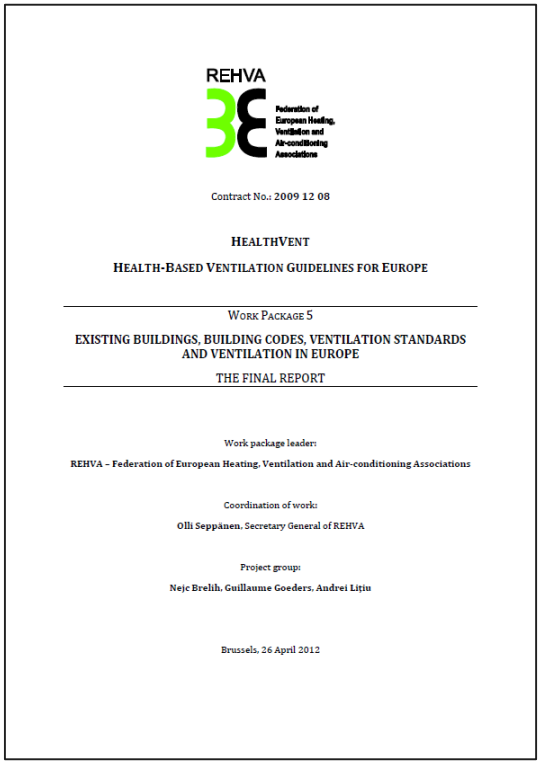
- **23 studies (2004-2015)** of which 18 in the period (2014-2015), in Europe but also in USA

- **Type of studies**
  - IEQ during pre-occupancy, occupancy (summer, winter)
  - IEQ post-occupancy (3 years)
  - IEQ in conventional and passive houses
  - IEQ in greenhouses and health related questionnaires
  - Energy performance and perceived IEQ
  - Effect of retrofitting buildings on IEQ
  - IEQ and comfort in deep and conventional energy efficiency renovation
  - Health outcomes after green renovation
  - Meta analysis of health impacts of energy efficiency measures

HEALTHVENT WP 5 Report (2012)

EXISTING BUILDINGS, BUILDING CODES, VENTILATION STANDARDS AND VENTILATION IN EUROPE

- Analysis of existing ventilation and IAQ requirements in building codes of 16 EU MS (survey, 2011 status)
- Expert views on trends and impact of the EPBD (survey)
- Review of related EN standards
- Development of test cases representing real-world situations, enabling the comparison of values of key parameters (ventilation rate, air pollutants, thermal environment, acoustic environment) on the basis of common metrics
- Building types: dwellings, office buildings, schools, kindergartens



REHVA

Federation of European Heating, Ventilation and Air-conditioning Associations

Contract No.: 2009 12 08

HEALTHVENT

HEALTH-BASED VENTILATION GUIDELINES FOR EUROPE

WORK PACKAGE 5

EXISTING BUILDINGS, BUILDING CODES, VENTILATION STANDARDS AND VENTILATION IN EUROPE

THE FINAL REPORT

Work package leader:

REHVA – Federation of European Heating, Ventilation and Air-conditioning Associations

Coordination of work:

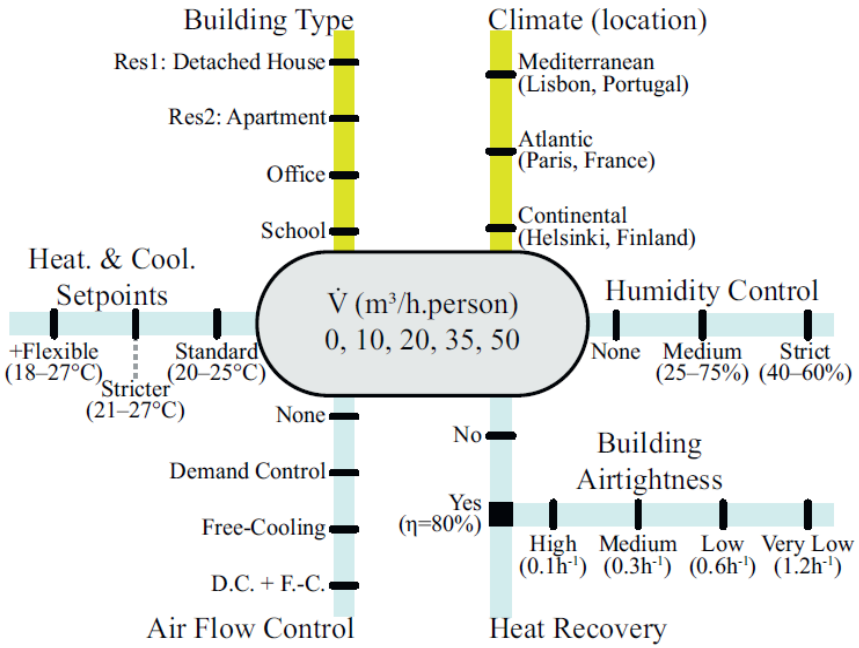
Olli Seppänen, Secretary General of REHVA

Project group:

Nejc Brelih, Guillaume Goeders, Andrei Litiu

Brussels, 26 April 2012

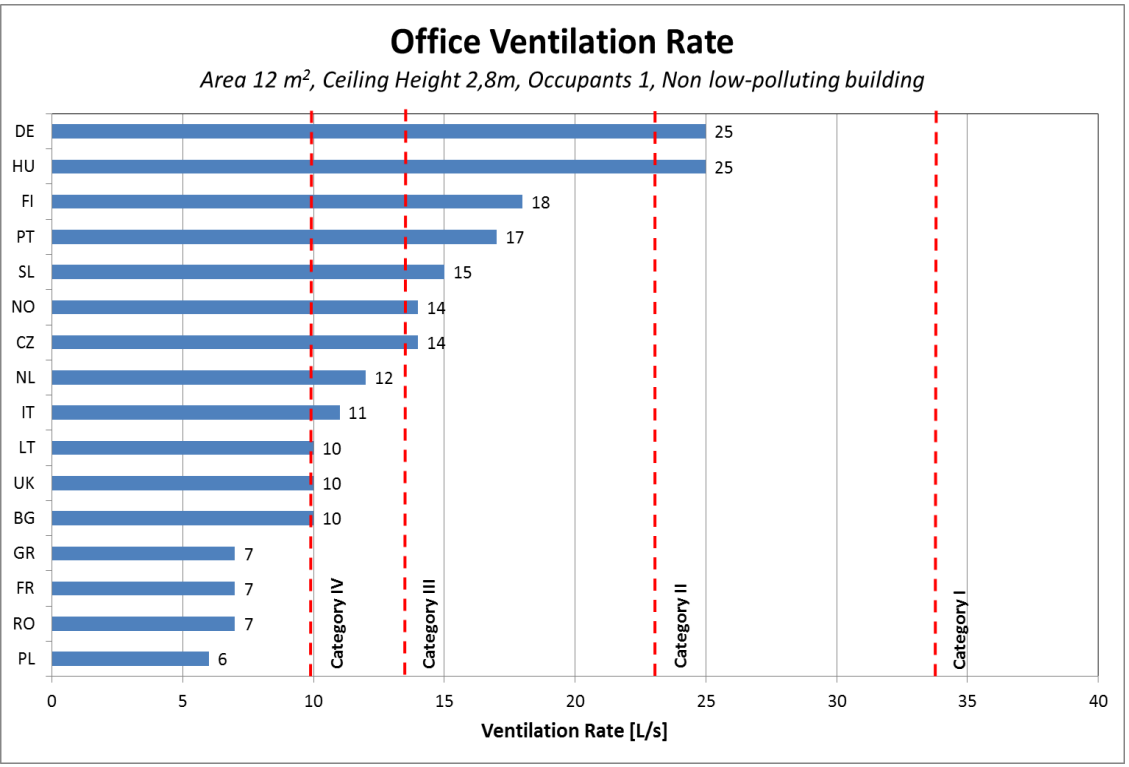
Health-based ventilation needs vs impact on energy use



(Source: Santos, H. and Leal, V., 2012; HEALTHVENT WP 6 final report, 2012)

- The use of any or both of demand control ventilation and heat recovery strategies enables meeting health-based ventilation needs without necessarily having a negative impact on the energy consumption…..BUT
- The benefits from the use of heat recovery may be offset in scenarios of low building airtightness which might be a technical and especially a cultural challenge in countries in which natural ventilation practices prevail and buildings mostly have low airtightness
- Health-based ventilation rates are implemented in prEN 16798-1

Ventilation rates versus standard pr16798-1

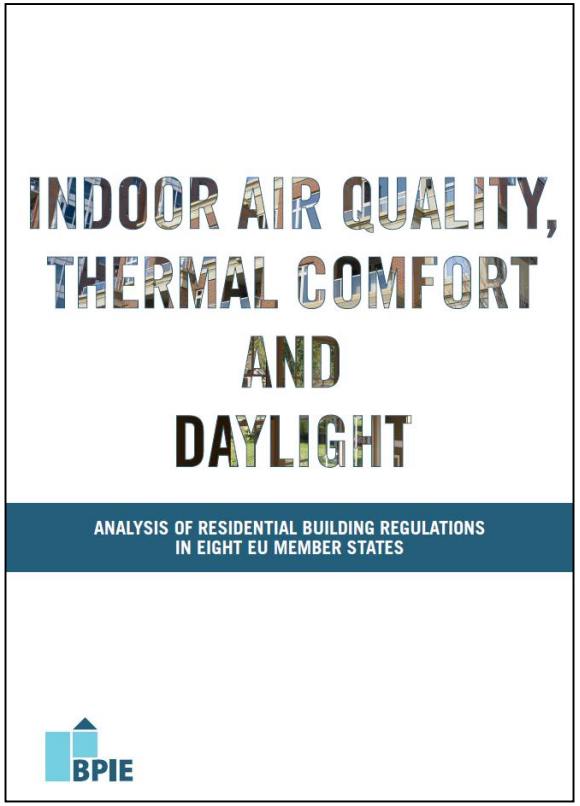


- Considerable discrepancies exist between national regulations and European standards
- The same also applies to other IEQ parameters (thermal comfort, lighting, noise and indoor air pollution levels)

BPIE 2015 Report

ANALYSIS OF RESIDENTIAL BUILDING REGULATIONS IN EIGHT EU MEMBER STATES

- The most recent review of national regulations related to indoor air quality, thermal comfort and daylight for both new and existing residential buildings
- Limited in eight EU countries and regions (i.e. Denmark, France, Sweden, Germany, Italy, Poland, UK and Brussels-Capital Region of Belgium) (BPIE, 2015).



Ventilation requirements

- Ventilation is included in all surveyed EU MS building regulations but **minimum requirements are set only for half of the countries** while for the other half there are only recommended minimum ventilation rates

⇒ Energy calculation may be done with ventilation, but building designed without ventilation if no binding ventilation requirements exist

Country and Standard Reference	Whole Building Ventilation Rates	Living Room	Bedroom	Kitchen	Bathroom + WC	WC only
Brussels (NBN D 50-001)	3.6 $m^3/(h \cdot m^2)$ floor surface area	Minimum 75 m^3/h (limited to 150 m^3/h	Minimum 25m^3/h (limited to 72m^3/h)	Open kitchen Minimum 75 m^3/h (exhaust)	Minimum 50 m^3/hour (limited to 75 m^3/h	Minimum 25 m^3/h
Denmark (BR10)	Min. 0.3 $l/s \cdot m^2$ (supply)	Min. 0.3 $l/(s \cdot m^2)$ (supply)		20 l/s (exhaust)	15 l/s (exhaust)	10 l/s (exhaust)
France (Arrêté 24.03.82)	10-135 m^3/h (depending on room number and ventilation system)			Continuous: 20 – 45 m^3/h		Minimum 15 m^3/h
Germany (DIN 1946-6)	15-285 m^3/h (details see chapter)			45m^3/h (nominal exhaust flow)	45 m^3/h (nominal exhaust flow)	25 m^3/h (nominal exhaust flow)
Italy (Legislative Decree 192/2005, UNI EN 15251)	Naturally ventilated: 0.3 – 0.6 vol/h	0.011 m^3/s per person for an occupancy level of 0.04 persons/m^2			4 vol/h	
Poland (Art 149 (1) – Journal of Laws 2002 No. 75, item. 690, as amended and PN-B-03430:1983/ Az3:2000)	20 m^3/h for each permanent occupant should be calculated according to the Polish standard but not less than 20 m^3/h	20 -30 m^3/h for each permanent occupant (for public buildings) For flats, it is a summary of flow from all rooms		30 m^3/h to 70 m^3/h without windows	50 m^3/h	30 m^3/h
Sweden (BFS2014:13 – BBR21)	Supply: min 0.35 $l/(s \cdot m^2)$ floor area					
UK (Approved Document F)	13-29 l/s (depending on bedrooms)			13-60 l/s (extract)	8-15 l/s (extract)	6 l/s (extract)
EN 15251	0.35 – 0.49 $l/(s \cdot m^2)$	0.6 – 1.4 $l/(s \cdot m^2)$		14-28 l/s	10-20 l/s	7-14 l/s

Requirement | Recommendation | European standard

Ventilation vs. energy requirements – new buildings

Three possible options how ventilation requirements have been set (or have not been set) can be found across EU:

1. Averaged (i.e. L/s m^2 –type) ventilation requirements specified in energy regulation as input data for energy calculation AND detailed ventilation requirements (per room, per person etc.) specified in ventilation/IEQ regulation
2. Binding ventilation requirements specified first time in energy regulation + more detailed recommended values in standards and guidelines
3. No specific mandatory ventilation requirements specified, only recommended values in standards and guidelines

JRC Literature review – conclusions (1/2)

- Limited number of studies investigating IEQ, health and comfort in low-energy buildings
- Limited evidence about the impact of energy efficiency strategy and retrofits on IEQ, comfort and health
- Caution in generalising the findings (limited sample size of buildings and occupants, diverse climate conditions, cultures and economic status)
- **Substantial performance gap is emerging between the design expectations and the measured performance in terms of energy consumption and IAQ in both new and refurbished buildings.**

JRC Literature review – conclusions (2/2)

- **Improving buildings' energy efficiency generally improves the IEQ. However, if energy sufficiency and energy efficiency measures are implemented incorrectly then the health-based ventilation conditions may not be fulfilled.**
- If the building itself and its systems and components are not adequately designed, installed and maintained, negative impacts on IAQ and consequently on the occupants' health, comfort and performance might be expected.
- Many studies focussed primarily on measuring CO_2 concentration (as a 'proxy' of IAQ) and general comfort parameters (i.e. relative humidity and temperature). Only a few studies have also included measurements of IAQ parameters known to be associated to health risks (i.e. according to WHO IAQ guidelines)

JRC Highlighted recommendations (1/3)

- A co-ordinated and coherent implementation of IEQ related requirements in building related policies in EU is still missing as from a regulatory point of view this remains under the competencies and responsibilities of the EU Member States with no binding requirements at EU level. This creates obstacles for the implementation of an integrated performance-based approach for buildings' related energy and IEQ issues in Europe.

- **There is a need to provide common health-based ventilation guidance in Europe, that will reinforce the definition and setting of ventilation requirements and metrics based on health criteria** to be applied after all possible control strategies of indoor and outdoor pollution sources have been exploited.

JRC Highlighted recommendations (2/3)

- With the increasing energy performance requirements towards NZEB, the **compliance checking** of the energy performance of new buildings becomes increasingly important and should be seen within the overall building's "efficiency" concept and implementation perspective (i.e. exploring the potential of energy efficiency in relation to the climate conditions and performance requirements, optimising over energy performance and costs without compromising the enforcement of the health-based ventilation concept).

JRC Highlighted recommendations (3/3)

- There is a need to provide guidance at EU level on **proper design, construction, installation, maintenance and inspections of ventilation systems**.

- Inspection and compliance checks of ventilation systems are recommended to become part of energy and IAQ auditing under the EPBD.

Conclusions

- EPBD "***avoid possible negative effects such as inadequate ventilation***" has revealed to be too soft formulation without expected effect. To ensure adequate IEQ one step more concrete statement would be needed:
  - In order not to compromise indoor climate Member States shall define minimum ventilation and Indoor Environmental Quality requirements (proposal from REHVA position paper)
- Minimum ventilation requirements are well supported by JRC recommendation on providing common health-based ventilation guidance in Europe, that will reinforce the definition and setting of ventilation requirements and metrics based on health criteria
- More widely, IAQ and thermal comfort are well addressed in environmental performance assessment of buildings as being two out of six core life cycle environmental performance, quality and value indicators identified by JRC, which are expected to be used as performance metrics for future buildings