



DGENTR LOT 6: AC & V systems

ARMINES, BRE, VHK

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Functions

1) Air conditioning system (EN 15240: 2007)

- ✓ combination of all components required to provide a form of air treatment in which temperature is controlled, possibly in combination with the control of ventilation, humidity and air cleanliness
- ✓ Focus on air conditioning systems for human comfort in buildings

2) Primary functions

- ✓ Ventilation
- ✓ Cooling (includes dehumidification provided by cooling systems)
- ✓ Sometimes also heating (reversibility and heat recovery)

3) Secondary functions

- ✓ Humidification (associated to heating in general)



Cooling basics

1) Cooling process

- In general, convective or convective + radiative heat transfer from a cold fluid via a heat exchanger
 - ✓ Refrigeration cycle
 - ✓ Vapor compression
 - ✓ Absorption cycle
 - ✓ Direct use of cold water
- Evaporative and desiccant cooling
 - ✓ Evaporative cooling (direct, indirect + direct)
 - ✓ Desiccant cooling
 - ✓ Association of desiccant and evaporative

2) Main type = refrigeration cycle but alternatives to be studied in Task 5



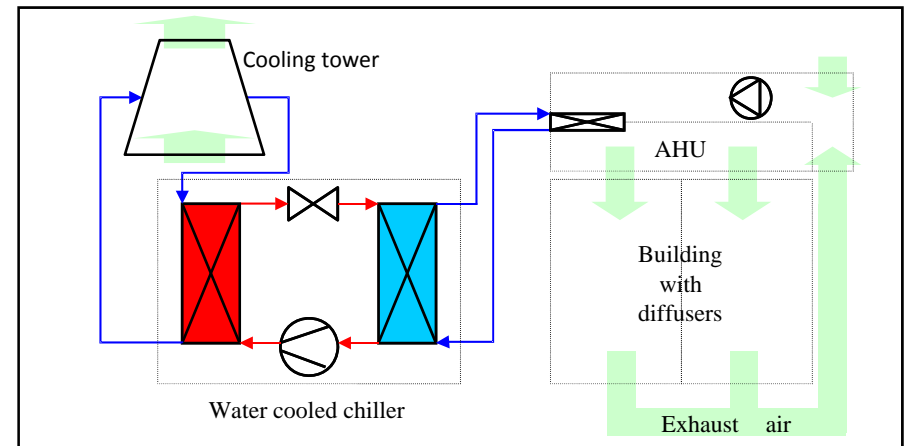
Systems and products

All air systems, made of

- ✓ a chilled water plant, an AHU, the water loop that feeds the cooling coil of the AHU, ducts for air distribution, terminal units that can supply complementary heating/cooling and possibly additional functions.

LEGEND

<i>Water</i>	<i>Air</i>	<i>Refrigerant</i>
<i>Expansion valve</i>	<i>Fan</i>	<i>Compressor</i>
<i>Condenser</i>	<i>Evaporator</i>	<i>Cooling tower</i>



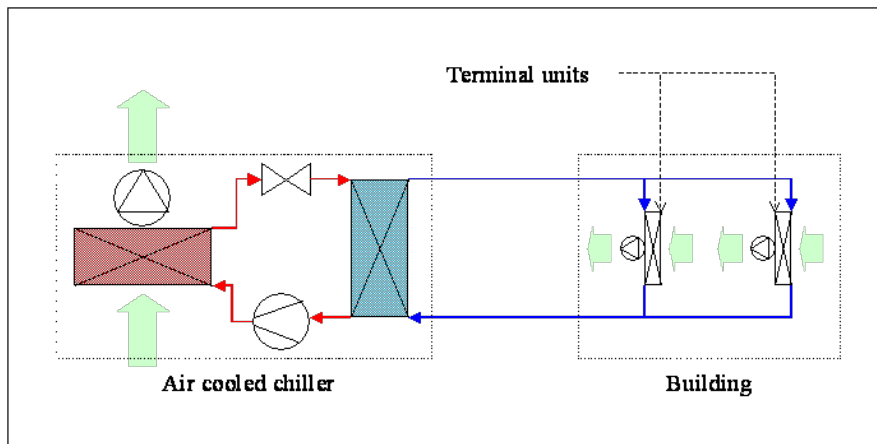
- ✓ Constant air volume (CAV) Vs Variable air volume (VAV)
- ✓ Zoning (terminal reheat, dual duct, ...)



Systems and products: main system types

Water based systems, made of

- ✓ a chilled water plant, an AHU for ventilation, the water loop that feeds the terminal units (and potentially the cooling coil of the AHU), ducts for air distribution, terminal water to air units that can supply heating/cooling and possibly additional functions (like dehumidification and air filtration).



Differences depending on terminal unit type

- Fan coil
- Cold beams
- Cooled surfaces (radiative)
- Water to air package air conditioners



Systems and products: main system types

DX systems

- ✓ Direct expansion air conditioners, no secondary fluid as water for water based units between the refrigerant and the cooled air. Package (includes rooftops), split, multi-split, VRF systems

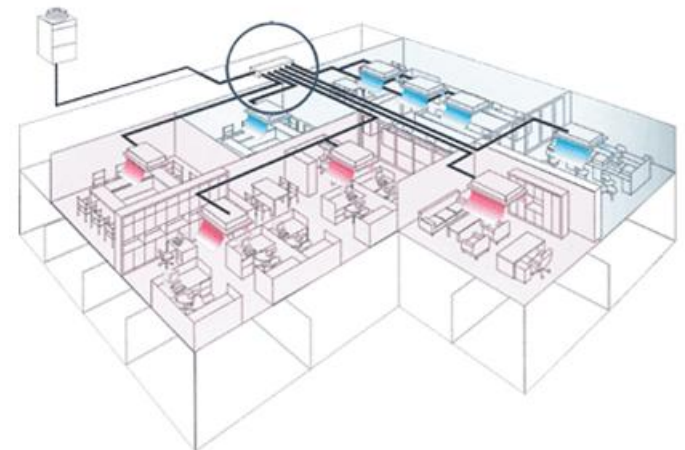
Rooftop



Split / multisplit system



VRF system with heat recovery





Products in systems

Cooling generators Package, split and multi split air conditioner [air-to-air > 12 kW, water-to-air, evaporatively cooled], Roof tops [air-to-air], VRF systems, Chillers for air conditioning applications [air-to-water, water-to-water, evaporatively-cooled], Renewable cooling: evaporative and desiccant cooling, solar cooling (*)

Air circulation and air treatment: Air Handling Units including energy consuming subsystems as air to air heat recovery air conditioning units, all sections, filters
...

Water circulation: Circulators, pipes

Terminal units: to extract heat from the space to be conditioned, Fan coils, active ceiling beams, water-to-air air conditioners.

Heat rejection: Cooling towers, Dry coolers

Controls to minimize energy consumption of air conditioning systems including Building Energy Management Systems (BEMS)



Categories and performance parameters

1) Cooling generators

○ Categories

Heat transfer medium		Classification
Outdoor heat exchanger	Indoor heat exchanger	
Air	Air	Air/air heat pump or air cooled air conditioner
Water	Air	Water/air heat pump cooled air conditioner
Brine	Air	Brine/air heat pump or brine cooled air conditioner
Air	Water	Air/water heat pump or air cooled liquid chilling package
Water	Water	Water/water heat pump or water cooled liquid chilling package
Brine	Water	Brine/water heat pump or brine cooled chilling package

○ Performance parameters:

- ✓ cooling (heating) capacity and SHR
- ✓ EER, SEER, COP, SCOP ...
- ✓ TEWI
- ✓ Noise
- ✓ Specificity: rooftop cumulates also the ventilation function



Categories and performance parameters

2) AHU

- ✓ Treated in the ventilation study

3) Circulators

- ✓ Treated in the circulator study (DG ENER Lot 11)

4) Heat rejection

- Performance parameters
 - ✓ Cooling capacity
 - ✓ Electricity consumption or EER
 - ✓ Noise

5) Terminal units (Active)

- Performance parameters
 - ✓ Cooling capacity
 - ✓ Electricity consumption or EER
 - ✓ Noise



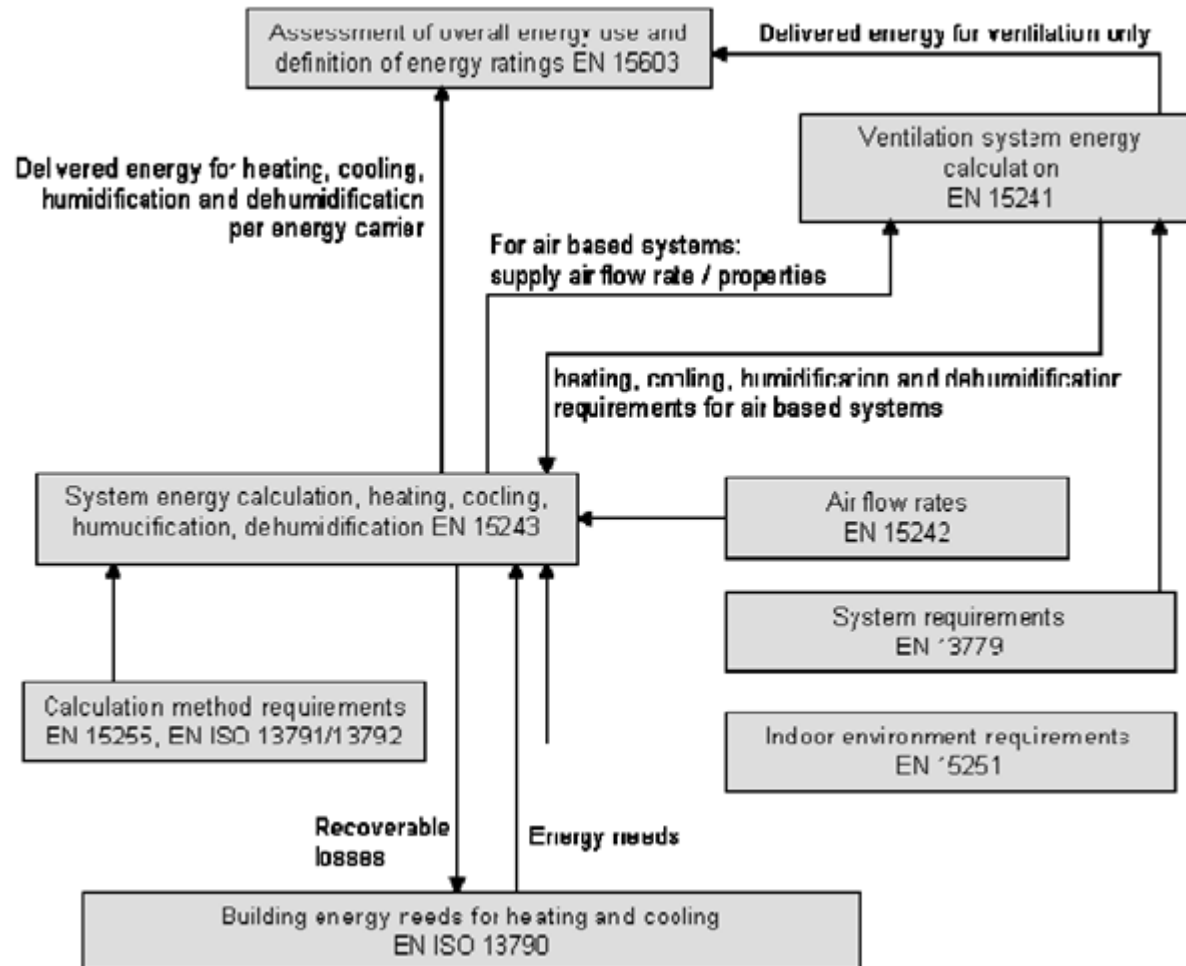
1) DIRECTIVE 2002/91/EC

- ✓ Requirements that apply to the overall energy performance of buildings and their building technical systems
- ✓ Inspection of air conditioning systems

2) Directive 2010/31/EU of 19 May 2010 on the energy performance of buildings

- ✓ Minimum performance requirements shall be set for new, replacement and upgraded building technical systems installed in existing buildings. These are to cover energy performance, installation, sizing, adjustment and control.
- ✓ Inspection of air conditioning systems made more explicit, no more needs for sizing check except in case of system modification, report is required
- ✓ Inspection quality insurance from third party (certified reporting)
- ✓ Entering into force at the end of 2012

EPBD standards





EPBD standards

Purpose of EN standard	EN Standard
System level	
Criteria for Indoor Environment	EN 15251: 2007
Design and dimensioning of air conditioning systems	Further standard planned under ISO/TC 205/WG9
Calculation of energy consumption & presentation of performances	<p>EN ISO 13790:2008 - Energy performance of buildings - Calculation of energy use for space heating and cooling</p> <p>EN 15255:2007 - Thermal performance of buildings – Sensible room cooling load calculation – General criteria and validation procedures</p> <p>EN 15265:2007 - Energy performance of buildings - Calculation of energy needs for space heating and cooling using dynamic methods - General criteria and validation procedures</p> <p>EN 15243:2007 - Ventilation for buildings - Calculation of room temperatures and of load and energy for buildings with room conditioning systems</p> <p>EN 13779 : 2007 - Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems</p> <p>EN 15241 : 2007 - Ventilation for buildings - Calculation methods for energy losses due to ventilation and infiltration in commercial buildings</p> <p>EN 15242 : 2007 - Calculation methods for the determination of air flow rates in buildings including infiltration</p> <p>EN 15603 : Energy performance of buildings — Overall energy use and definition of energy ratings</p>
Inspection of installed systems	<p>- <i>Systems and generators</i></p> <p>EN 15240:2007 - Ventilation for buildings - Energy performance of buildings - Guidelines for inspection of air-conditioning systems</p> <p>- <i>AHU and air terminal devices</i></p> <p>EN 12599:2000 /AC:2002 - Ventilation for buildings - Test procedures and measuring methods for handing over installed ventilation and air conditioning systems</p>
Control functions	EN 15232:2007 - Energy performance of buildings - Impact of Building Automation, Controls and Building Management

- Nothing on system system sizing yet
- HVAC system description in Annex of EN 15243 standard
- Humidity normally uncontrolled with high limit to 12 g/kg



Product standards

Cooling production	
Rating and performance	<p>EN 14511:2007 (and prEN14511:2009) Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling</p> <ul style="list-style-type: none"> - Part 1: Terms and definitions - Part 2: Test conditions - Part 3: Test methods - Part 4: Requirements <p>prEN14825 :2009 - Air conditioners, liquid chilling packages and heat pumps, with electrically compressors, for space heating and cooling- Testing and rating at part load conditions and calculation of seasonal performance</p> <p>EN 12309 - Gas-fired absorption and adsorption air-conditioning and/or heat pump appliances with a net heat input not exceeding 70 kW</p> <ul style="list-style-type: none"> - Part 1: Safety (1999) - Part 2: Rational use of energy (2000) <p>EN 15218:2006 Air conditioners and liquid chilling packages with evaporatively cooled condenser and with electrically driven compressors for space cooling - Terms, definitions, test conditions, test methods and requirements</p>
Noise	<p>EN 12102:2008 - Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling - Measurement of airborne noise - Determination of the sound power level</p>
Safety	<p>EN 378-1:2008 Refrigerating systems and heat pumps - Safety and environmental requirements</p> <ul style="list-style-type: none"> - Part 1: Basic requirements, definitions, classification and selection criteria - Part 2: Design, construction, testing, marking and documentation - Part 3: Installation site and personal protection - Part 4: Operation, maintenance, repair and recovery



Product standards

Air Handling unit	
Rating and performance	<ul style="list-style-type: none"> - <i>Air handling units</i> EN 13053:2006 Ventilation for buildings - Air handling units - Rating and performance for units, components and sections - <i>Cooling coils</i> EN 1216: 1998 - Heat exchangers – Forced circulation air-cooling and air-heating coils – Test procedures for establishing the performance

Circulators	
Rating and performance, noise, safety	<ul style="list-style-type: none"> EN 1151-1:2006 Pumps - Rotodynamic pumps - Circulation pumps having a rated power input not exceeding 200 W for heating installations and domestic hot water installations - Part 1: Non-automatic circulation pumps, requirements, testing, marking EN 1151-2:2006 Pumps - Rotodynamic pumps - Circulation pumps having a rated power input not exceeding 200 W for heating installations and domestic hot water installations - Part 2: Noise test code (vibro-acoustics) for measuring structure- and fluid-borne noise



Product standards

Terminal units	
Rating and performance	- <i>Fan coils</i> EN 1397:1998 Heat exchangers - Hydronic room fan coil units - Test procedures for establishing the performance
	- <i>Chilled ceilings</i> EN 14240:2004, Ventilation for buildings — Chilled ceilings — Testing and rating
	- <i>Chilled beams</i> EN 14518:2005 Ventilation for buildings - Chilled beams - Testing and rating of passive chilled beams
	EN 15116:2008 Ventilation in buildings - Chilled beams - Testing and rating of active chilled beams
	- <i>Floor cooling</i> EN 1264:2009 - Floor heating - Systems and components Part 1: Definitions and symbols Part 3: Dimensioning Part 4: Installation Part 5: Heating and cooling surfaces embedded in floors, ceilings and walls - Determination of the thermal output
	EN 15377-1:2008 - Heating systems in buildings - Design of embedded water based surface heating and cooling systems Part 1: Determination of the design heating and cooling capacity Part 2: Design, dimensioning and installation Part 3: Optimising for use of renewable energy sources



Product standards

Heat rejection	
Rating and performance	<ul style="list-style-type: none"> - <i>Dry cooler</i> EN 1048:1998 - Heat exchangers - Air-cooled liquid coolers "dry coolers" - Test procedure for establishing the performance - <i>Cooling towers</i> EN 14705:2005 - Heat exchangers - Method of measurement and evaluation of thermal performances of wet cooling towers EN 13741:2004 - Thermal performance acceptance testing of mechanical draught series wet cooling towers

Controls	
Technical characteristics	<ul style="list-style-type: none"> EN ISO 16484 - Building automation and control systems (BACS) Part 1: Overview and Vocabulary (PrEN 2009) Part 2: Hardware (2005) Part 3: Functions (2007) Part 4: Applications (No draft available) Part 5: Data communication - Protocol (2010) Part 6: Data communication - Conformance testing (2009) Part 7: Project specification and implementation (No draft available)



Product standards

Cooling production	
Rating and performance	<p>International ISO 5151, 2005, Non-ducted air conditioners and heat pumps — Testing and rating for performance. ISO 13253, 2005, Ducted air-conditioners and air-to-air heat pumps — Testing and rating for performance, revision of the 1995 version approved on Dec 12 2005.</p> <p>USA (Canada also if CSA is indicated) ANSI/AHRI 210/240-2008: Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment ANSI/AHRI/CSA 310/380-2004: Standard for Packaged Terminal Air-Conditioners and Heat Pumps (CSA-C744-04) ANSI/AHRI 340/360-2007: Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment AHRI 550/590-2003: Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle ANSI/AHRI 560-2000: Absorption Water Chilling and Water Heating Packages AHRI 1230 - 2010: Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment</p> <p>Japan Standards JRA: 4046 (JRA, 2004) - "Calculating method of annual power consumption for room air conditioners" and JRA: 4048 (JRA, 2006) - "Annual Performance Factor of Package Air Conditioners"</p>
Heat rejection	
Rating and performance	USA - CTI standard STD-201 – cooling towers



EU legislation

- 1) 89/106/EC relating to Construction Product
- 2) 98/37/EC relating to machinery
- 3) 2004/108/EC relating to electromagnetic compatibility
- 4) 94/9/EC relating to explosive atmospheres
- 5) 2006/95/EC relating to low voltage
- 6) EuP measures and EU energy labels
- 7) ROHS, WEEE
- 8) Directives regarding health
- 9) Fgas (– to be revised in 2011)



EU legislation: Labelling and EuP

1) Existing measures

- ✓ Energy Labelling Directive 2010/30/EU
- ✓ Directive 2002/31/EC, Energy labelling of air conditioners
- ✓ Regulation on circulation pumps EC regulation No 641/2009

2) Coming measures

- ✓ Fans
- ✓ Air conditioners (below 12 kW)
- ✓ Boilers (reversible chillers)

3) On going studies

- ✓ ENTR Lot 1 : chillers (coordination)
- ✓ ENTR Lot 21: Central heating products using hot air to distribute heat (coordination)



Agreements at EU level

1) No agreement

2) Eurovent Certification Company

- Certification programs

- ✓ Comfort air conditioners (AC1, AC2, AC3)
- ✓ Rooftops
- ✓ Liquid chilling packages
- ✓ Fan coil units (and ducted fan coil units)
- ✓ Air handling units and air to air plate and rotary heat exchangers
- ✓ Cooling coils
- ✓ Chilled beams
- ✓ Air filters

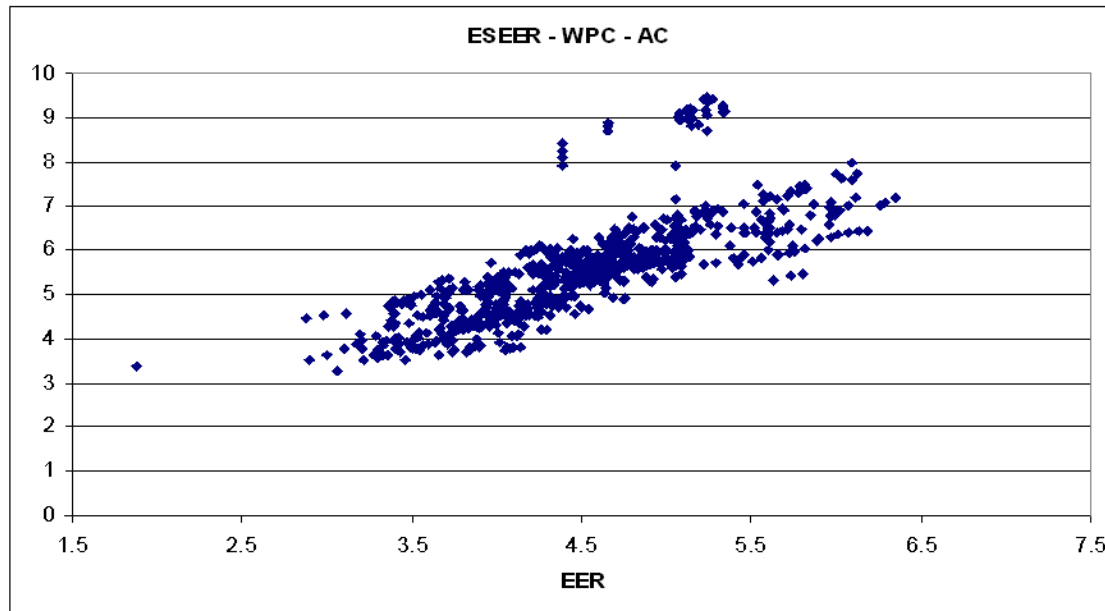
- Products not yet covered

- ✓ Cooling towers (under construction)
- ✓ VRF systems (under construction)



Agreements at EU levels: ECC

- Main source of data on efficiency of products & system components
- Already existing voluntary labels
- Information to be used for base case assessment
 - ✓ Ex: chillers, EER, SEER values for water cooled package chillers





Member States' legislation

- 1) Building regulation and cooling
- 2) Cooling generators
- 3) Air distribution systems
- 4) Water distribution systems
- 5) Terminal units & Heat rejection
- 6) HVAC system control, monitoring, maintenance



Member States' legislation

1) Building regulation and cooling

- Mandatory requirements per module / Comparative index / Global performance requirement
- Cooling is not explicitly covered by all regulations or methods are missing
- Max summer temperature with proper envelope design (limiting solar gains, nocturnal ventilation ...)
- Global target for building consumption is becoming the standard Vs previous regulations with mandatory requirements or prescriptions by module
- There still remains mandatory requirements at national levels



Member States' legislation

2) Cooling generation

- ✓ **Minimum EER, SEER** requirements (UK, France) for generators
- ✓ Number of **capacity steps** Vs cooling power (Spain, Portugal)
- ✓ **Information required on part load** (Spain, UK)
- ✓ **Centralized system** over 25 kW and 100 kW per building (Portugal)
- ✓ **Max split capacity** allowed 12 kW (Portugal)
- ✓ Optimal **generator loading** (Spain, UK)
- ✓ Mandatory **free cooling** (air or water) > 70 kW (Spain)
- ✓ Provisions on water free cooling if applied (to be done with a parallel supplementary coil – Spain, controls integrated within the chiller - UK)

Potência (kilowatt)	Escalões
Inferior a 100	1
De 100 a 500	2
De 500 a 1000	4
Superior a 1000	Modulante



Member States' legislation

3) Air distribution systems

- ✓ **Mandatory free cooling** (Air side - Portugal if air flow > 10.000 m³/h, Air or water side - Spain, above 70 kW)
- ✓ **Motor and drive efficiency**, full load : Motor EFF2 fans (Portugal), part load : SFP at 25 % flow = SFP at 100 % (UK), VSD above 1.1 kW (UK)
- ✓ **Airtight** ductworks and components (UK national rules and AHU leakage class 2, Poland)
- ✓ **Insulated ductworks** (Spain)
- ✓ **Specific fan power limits** with supp allowance for (HE, filters ...) (Germany, Ireland, Spain, UK)
- ✓ **Pressure drop** limitations (Spain - duct pressure loss, UK by subcomponent)
- ✓ **Filtration** (Spain - Prefilter mandatory, Max RH of 90 % for filters except fresh air)
- ✓ **Controls** (zone requirements, timer, variable supply air temperature)
- ✓ **Monitoring**



Member States' legislation

4) Water distribution systems

- ✓ **Constant leaving chilled water** temperature (Spain)
- ✓ **Reduced flow rate at part load** (Spain)
- ✓ Pipe insulation (Spain, Portugal, UK)
- ✓ Motor EFF2 pumps (Portugal)
- ✓ Controls for pumps (can be stopped – France)



Member States' legislation

5) Terminal units and heat rejection

- Terminal units
 - ✓ Valves for capacity control (UK)
 - ✓ Max SFP (UK) and pressure drop
 - ✓ Interlock to prevent simultaneous cooling / heating

System type	Maximum SFP, W/l/s New and existing bldg	Maximum external system pressure drop, Pa New building only
Fan assisted terminal VAV unit	1.2	30
Fan coil units (rating weighted average*)	0.6	30

- Heat rejection
 - ✓ Well defined design conditions (Spain) and advise on heat rejection system depending on these conditions
 - ✓ Control to minimize water inlet temperature of the chilling plant (Spain)
 - ✓ Strict authorization / control for open cooling towers (several MS)



Member States' legislation

6) HVAC system control, monitoring, maintenance

- Control
 - ✓ Max and min zone temperature setpoint – deadband (Portugal)
 - ✓ Maximum cooling operative temperature = 26 °C (comfort AC) (France)
 - ✓ Mandatory BEMS (Portugal– for each subsystem above 25 kW, above 100 kW – centralized)
 - ✓ Possibility to limit power by zone (Portugal)
- Monitoring (Spain, Portugal, France), audit (Portugal), maintenance (Portugal, Spain), performance assesment (Spain)

Air conditioning systems

Standards

Legislation



International legislation

- 1) USA
- 2) Japan
- 3) Australia / New Zealand
- 4) China



International legislation

1) USA (mandatory requirements)

- Minimum efficiency for cooling generators
 - ✓ EER, IPLV (chillers), SEER (package air conditioners [12 , 19 kW]), EER, IPLV and IEER (larger package air conditioners)
- Load calculation
- Controls
 - ✓ (i) Zone heating or cooling is controlled thermostatically. (ii) "dead band" of at least 5 F (2.8 C) (iii) intermittent of low capacity HVAC systems shall be equipped with "off-hour" controls, (iv) motorized dampers (v) Fans with motors greater than 0.75 hp (0.5 kW) shall be shut off when not required.
- Ducts and pipes
 - ✓ (i) Ducts and plenums thermally insulated and sealed. (ii) Piping shall be thermally insulated. (iii) Duct with working static pressures in excess of 3 inches water column shall be leak tested.



International legislation

2) Japan

- Non residential AC 4 kW < CC < 28 kW (50.4 Multisplit)
- VRF HR excluded
- Targets differentiated for residential non residential use, depending on capacity, type of indoor unit, single or multisplit, ducted non ducted
- Seasonal performance indicator APF (residential) and E (equivalent to APF but may include variation with capacity)
 - ✓ Japanese Industrial Standards C 9612: 2005 (Room Air Conditioner)
 - ✓ Japan Industrial Standards B 8616: 2006 (Package Air Conditioner).



International legislation

3) Australia / New Zealand

- Air cooled air conditioners
 - ✓ MEPS varying depending on capacity, product category (unitary, split, ducted), phase (single or three) (up to 65 kW)
 - ✓ Exemption for water cooled, multisplit
 - ✓ 2011 integrated values (with low power modes – an annual use profile is available)
 - ✓ Grid : Load control integrated design mandatory
- Chillers
 - ✓ Acknowledgement of ARI and Eurovent certifications
 - ✓ Based on USA COP (SI EER) and IPLV MEPS without distinction of the compressor technology and more capacity classes
 - ✓ More ambitious values published / with specific higher IPLV targets for chillers mainly designed for part load operation



International legislation

4) China

- Minimum EER requirements for air cooled air conditioners small size
 - ✓ Split < 14 kW, EER ≥ 3
 - ✓ Multisplit air conditioners IPLV(C), MEPS 2008 ? And 2012 ?
- Labelling for chillers with distinction for condensation type and capacity (slightly higher grades (5) than Eurovent classes A to E)
- Local (Taipei) minimum requirements for water cooled chillers
 - ✓ Min COP (SI EER)
 - ✓ Requirements close to ASHRAE 2001 standard

Source for chillers (Yu and Chan, 2007)



International legislation conclusion

Input from stakeholders is required

1) Missing legislation

2) International comparison

- Chillers: comparison of IPLV, ESEER, prEN14825(2009)
 - ✓ Either by giving (ESEER, IPLV, prEN14825) values for a large number of chillers
 - ✓ Either by supplying set of performance curves covering main chiller types (including different part load controls)
- Air conditioners : comparison of USA ESEER, IPLV, IEER, prEN14825(2009)
 - ✓ The same two methods as above can be used



Scope proposal

Air conditioning of buildings Energy Related Products

ENER Lot 10
Air-to-air AC P ≤ 12 kW

AC products:

- Single ducts
- Double ducts
- Window / wall units
- Split systems
- Multi-split systems

ENTR Lot 6

Air-to-air AC P > 12 kW

Air-to-water, water-to-air, water-to-water AC

ENER Lot 11: Fans 125 W < P < 500 kW

Reg. 640/2009/EC: Motors 0.75 kW < P < 375 kW

Reg. 641/2009/EC: Circulators 1 W < P < 2.5 kW

1. **Cooling generators (*) : Package, split and multi split AC, (> 12 kW), Roof top, VRF systems, Chillers for AC**
2. **Air distribution : AHUs (**)**
3. **Water circulation: circulators (***)**
4. **Terminal units: Fan coils, active ceiling beams, water-to-air air conditioners (all sizes)**
5. **Heat extraction : cooling towers, dry coolers**
6. **Controls of AC systems**

(*) Heating function included in ENER Lot 1, 20 and 21

(**) Other than dedicated ventilation AHUs

(***) For those not included in reg. 641/2009/EC



Main comments received on scope

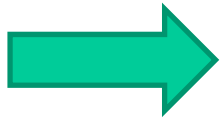
- 1) Chillers ENTR Lot 1 and Lot 6
 - ✓ Link with ENTR lot 1
- 2) Cooling function includes dehumidification
- 3) Dehumidification/humidification to be included at least for desiccant cooling
- 4) How to deal with reversible products without including the heating function ?
 - ✓ Link with ENER Lot 21
- 5) Heat recovery capability (of VRF systems)



Performance assessment

1) Cooling function

- ✓ Stand alone generators
- ✓ System embedded generators (eg chillers)



System comparison is required

2) Conditions of comparison

- ✓ To be developed in task 3 (calculation tool)
- ✓ Task 3 core partly developed already in task 1 (EPBD standards regarding cooling systems)