THE EUROPEAN
GREEN BUILDING PROGRAMME

Air-Conditioning Technical Module

Contents

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1. Introduction

The GreenBuilding Programme is a European Commission voluntary programme through which non-residential building owners and occupiers private and public organisations are aided in improving the energy efficiency and to introduce renewable energy sources in their building stock. Any enterprise, company or organisation (hereinafter defined as “organisation”) planning to contribute to the GreenBuilding Programme objectives can participate.

By becoming a GreenBuilding Partner, your company can demonstrate its commitment to significantly reduce the energy consumption in its non-residential buildings that are participating in this effort.

This document is subsidiary to the GreenBuilding “Partner Guidelines”. It defines what a GREENBUILDING Partner Action Plan should cover, if the Partner company's commitment includes an A/C system. In particular, it explains what a Partner does for each of the following steps:

- **Inventory** of A/C components and system functioning
- **Assessment** of the applicability of possible energy savings measures
- **Action Plan**, which defines what the Partner has decided to do to reduce operating costs by improving energy efficiency
- **Annual report** of progress on the Action Plan.

Note that documents relating to the Inventory and the Assessment are in house, confidential documents, while the action plan and annual report are reported to GREENBUILDING.

2. Inventory of the System

Used by the auditor to describe the existing system/structure in a systematic way. A template for an Audit form should be included in the Annex.

a. Fundamentals

How A/C works

A/C uses the same operating principles and basic components as refrigerators. They cool rooms with one or more cold coils called evaporator(s). The condenser, a hot coil, releases the collected heat outside. A compressor moves a heat transfer fluid (or refrigerant) between the evaporator and the condenser. The liquid refrigerant evaporates in the indoor evaporator coil, pulling heat out of indoor air and thereby cooling the room. The hot refrigerant gas is pumped outdoors into the condenser where it reverts back to a liquid giving up its heat by the condenser. In commercial and industrial sites, installations are far more complex, even if they follow the same principles.

In most cases, these equipments use the “vapour compression cycle” like refrigerators. The other process, called “absorption cycle”, uses a refrigerant/solvent mix (water/ammonium or lithium bromide/water) and requires a heat source. This kind of installation is however more expensive and less efficient but uses a less expensive energy source (CHP heat).

Reversible equipments can produce heat and cold alternatively or simultaneously. Technically, the vapour compression cycle is always reversible but it is not always the case in reality for example when the installation is equipped with a cooling tower: Although the absorption cycle is also technically reversible, there is no interest because it is more efficient to use directly the heat source to heat the building.

The conditioning of the air

There are 3 families of cold generating equipments on the market: “packaged units” (all in one), “split systems” (one outdoor unit with the condenser and the compressor connected to one or more indoor units composed of evaporators and fans) and “chillers” (water cooling equipment). The main difference between the 3 is the carrier by which the “cold” is transported in cooled areas. Indeed, this carrier can be water for chillers, the refrigerant for split systems or directly air for packaged units.

Whatever the carrier used, at the end of the pipe, air will have to be cooled in order to be introduced in areas. Air-cooling can be done either locally (in each area) or centrally (before distribution in each area) with an air handling unit (AHU). The first way needs an extra-ventilation system whereas the second way allows to control the renewal of the air with fresh air.

The heat rejection

The heat of the condenser can be extracted either by air or by water. Air-cooled condensers can either be included or excluded from the equipment and then located elsewhere in order to increase flexibility. An air-cooled condenser is an air/refrigerant heat exchanger associated to one or more fans. A water-cooled condenser is a water/refrigerant heat exchanger that is fed either by a natural source or by the water network. The cooling water is however usually recycled into a cooling tower.

b. System description

Some building owners or facility managers have a well-documented description of their plants. The inventory is then simple and can be summed-up by the following table.

Cold generating system	**Description**
Packaged unit	All in one equipment that is installed directly into the area to treat. Ducts allow to feed with fresh air and then cool the condenser. The condenser can also be located outside or be water-cooled. The unit can manage the renewal of the air by blowing fresh air. Air supply can be ducted.
Window unit	Small all in one equipment that is installed “through” a wall or a window. The condenser is on the outside panel whereas the evaporator is on the inside panel.
Rooftop	A type of packaged unit located on the roof. The air supply is made by ducts. In most cases, the condenser is air-cooled. The unit can manage the renewal of the air by blowing fresh air.
Split-system	The installation is split into one outdoor unit (compressor and condenser) and one or more indoor units (evaporator and fan). Each indoor unit is linked with the condensing unit by two copper pipes and can be managed independently. Sometimes, it is associated to an AHU in order to manage the renewal of the air.
VRF (variable refrigerant flow)	An evolved split-system that allows longer networks, more indoor units, heat-recovery by carrying the refrigerant in liquid phase and expanding it locally. Each indoor unit is then fed in refrigerant by a loop.
Chiller	It is a water-cooling equipment. Typically the cold water is supplied into a loop at 6°C and returned at 12°C. It can be used either locally by FCUs or centrally with AHUs that can manage the renewal of the air. It can use the absorption cycle.
Water Loop Heat Pump System	Several reversible and small capacity heat pumps are located into each treated area and operate on a water loop. That process allows heat-recovery. The temperature of the loop is controlled by a heat source (boiler, heat exchanger) in winter and heat extractor (cooling tower, cold generating system) in summer.

3. Assessment of performances

a. Measurement of parameters

Electric power or consumption of the A/C installation

The electric power (or consumption) of the A/C installation is useful for comparisons or for improvement evaluations from one year to another. That measurement can be done for each cold generating system but also for auxiliaries (pumping, ventilating, etc…). Auxiliaries represent a huge part of the energy bill of an A/C installation. The difficulty of that measurement depends on the electrical structure of the building but is often simple.

The aim of GBP is to decrease the electricity consumption of A/C installations in the building by improving the equipment EE, controls or management.

Cooling power or energy of the A/C installation

As for the electric power, the cooling power (or energy) of the A/C installation is useful for benchmarking. However, that measurement is far more difficult than the previous one for certain systems (direct expansion) but allows to have details about the cooling needs of the building and about the load of the A/C installation.

The aim of GBP is to decrease the cooling requirements of the building by improving the building shell, lighting or ITs. Therefore, that measurement is a good indicator for the evaluation of some other modules of GBP.

b. Indicators of system performance

Ratios are not the ultimate solution and must be used carefully. Indeed, conclusions from comparisons of two different buildings without knowing their precise technical characteristics has no real meaning and can be totally false. However, they can be really useful if the building owner want to compare situations from one year to another or in two similar buildings of the same sector.

The Energy Efficiency Ratio

The Energy Efficiency Ratio (EER) measures the amount of electricity required by an A/C unit to provide the desired cooling level in the “standard” conditions. In fact, it is the ratio between the two previous measurement obtained during the same period of time. The higher the EER, the more energy efficient the unit is. That ratio is called seasonal (SEER) when the full period (cooling) is considered. One would like to know the average SEER of the plant but is usually aware of the EER only. News are expected on the EUROVENT website (www.eurovent-certification.com)

$$EER = \frac{P_{cooling}}{P_{electric}}$$

$$SEER = \frac{E_{cooling}}{E_{electric}}$$

$P_{cooling}$: cooling power provided by the unit (W)
$P_{electric}$: electrical power absorbed by the unit (W)
$E_{cooling}$: cooling energy provided by the unit during a period (J or kWh)
$E_{electric}$: electricity consumption of the unit during a period (J or kWh)

That data is necessary stipulated for each product by any manufacturer but only in certain conditions[1] (full load). The EER depends however on the load of the system so that the same equipment can have different performances depending on the cooling requirements of the building (insulation, occupation, climate). It can be measured either continuously (power) or calculated at the end of a period (energy).

It is possible to extend that definition to the entire installation including auxiliaries in order to create an “overall” SEER. The aim of GBP would in theory be to increase the overall SEER of the A/C installation by decreasing cooling requirements and electricity consumption and auxiliaries. The first one is achieved by applying other associated technical modules whereas the last ones are achieved by using more efficient technologies and better controls.

The electrical consumption per square-meter

Direct measurements have no signification unless they are translated into ratios that can be comparable from one year to another or between two buildings. For example, for an office building, the occupation is approximately constant from one year to another and cooling needs are not really dependant from the activity. Hence, the relevant ratio could be the electrical consumption per square meters but corrected with cooling degree-day (CDD). That ratio is very widespread so that it is possible to have a lot of references.

The other energy indicators

A lot of energy indicators can also be used in order to compare the A/C consumption (only without ventilation) from one year to another and between buildings from the same sector. In order to be correct, these energy indicators should be corrected with CDDs.

Building sector	**Relevant energy indicator**
General	kWh/m^2/year
Hotel	kWh/room/year
School	kWh/student/year
Museum, concert-hall or any payable activity	kWh/seat/year
Hospital	kWh/bed/year

Source: Energy audit of building systems: An engineering Approach[2]

4. Energy saving technical measures

Guide the module user on what to pay attention to (sizing, positioning, maintaining…), which alternatives exist to reduce energy waste and if possible energy typically saved by a different improvements.

[1] International Organization for Standardization, “ISO 5151 – Non-ducted air conditioners and heat pumps – Testing and rating for performance”, 1994
[2] Krarti, M., “Energy audit of building systems: An engineering Approach”, CRC press, 2000

a. Building design

As for heating, the building shell is really important and has huge consequences on energy consumptions of A/C installation. Special care must be taken on the reduction of the Sun exposure (by lowering glazing surfaces or improving glazing efficiency), the increase of the thermal insulation (increase of the thermal inertia) and the decrease of the air infiltration (reduction of thermal loads).

b. Internal loads

Cooling requirements depend on the climate (sun, temperature, humidity), the occupation rate, the building envelope, the air renewal rate, artificial lighting and included electrical appliances. Internal loads are difficult to treat because most of actions towards the reduction of cooling consumptions in summer have opposite effects on heating consumptions (see heating module) in winter. Indeed, it is important to increase lighting and IT efficiency in order to reduce loads that can be useful in winter!

c. Sizing of the A/C installation

The EER of an A/C system operating at part load is necessary lower than the nominal (full load) one. That is why it is not interesting to oversize systems. Main reasons to oversizing are the need for comfort (acceptable temperature and humidity with quick response) even during peak load and possible future activity growth leading to an increase of cooling requirements.

d. Choice of the cold generating system

Manufacturers give the EER of their A/C system. When choosing the system, privilege the equipment with the highest EER. However, as said previously, part load efficiency is often quite different from the nominal (full load) efficiency provided in usual documentations. If part load efficiencies are available, choose the equipment that minimizes the energy consumption.

e. Sizing of networks and choice of auxiliaries

For some installation, auxiliaries (fans, pumps) can represent an important part (more than 50%[3]) of the energy bill. It is then important to size correctly air, water or refrigerant networks in order to reduce pressure drops and hence consumption of auxiliaries. Auxiliaries must be chosen in accordance to networks and requirements of the system. It is recommended to choose the equipment with the highest efficiency at nominal operation.

f. Operation and maintenance

Technical improvements at one time cannot allow by itself high performances in the long term. O&M is indispensable because it allows to increase or at least maintain performances, availability, reliability and then operating costs of the installation.

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[3] Adnot, J. et al., "Energy Efficiency and Certification of Central Air Conditioners" (EECCAC) for the Directorate General Transportation-Energy of the Commission of the European Union, May 2003

g. Continuous follow-up of performances

The follow-up of performances based on a good metering is essential on an installation because it allows to detect technical defaults or energy drifts much quicker. Indeed, without measurement, problems are discovered far too late when a breakdown occurs. That follow-up can be included in a whole control system called “building energy management system” (BEMS) that allows to manage lighting, heating, A/C and combined heat and power (CHP) units for example.

5. Action plan

This section intends to help you to establish an action plan to study carefully the proposed actions, set a timetable to implement the actions and estimate the expected savings. A template for an Action Plan form is included in the Annex.

The action plan is to be used as a start point to study the technical and economical viability of a new cogeneration system or to improve the performance of an existing one. It comprises the following four stages.

1. Energy audit

An energy audit is a systematic gathering and analysis of energy use information and can be used to determine energy efficiency improvements of an A/C installation. The energy audit can include the following parts.

Building needs and owner constraints

Collect information about the needs of the building and constraints of its owner. It can be composed of occupation rates, characteristics of the building, internal loads, operation constraints, climate, activity, etc.

Technical information and operating conditions of the plant

Collect technical information and operating conditions of the existing A/C plant. The sources of information for this task can be the technical documents, walkthrough inspection, information on the equipment plates, BEMS, operation and maintenance (O&M) logbooks, etc.

Cooling load profile

Prepare the building’s cooling load profile and adjust it to the climate as accurately as possible to optimise the sizing of the installation. The load profile can be done thanks to previous indicators, relevant counters, CDD, etc. A table provided in annex 1 can help to evaluate internal loads in order to size the cold generating system or to consider possible other technical solutions.

2. Selection of measures to be implemented

A table provided in annex 2 can help to sum up the results of the energy audit of the building and to consider possible technical measures on the existing A/C installation.

Reduction of internal loads

Before any improvements or replacement of the existing installation and in order to optimise the sizing, it is essential to think about possible ways to reduce internal loads of the building. Other GBP technical modules provide additional information for achieving such objectives (office equipment, lighting and IT modules).

Privilege opportunities and passive technologies

Before investing in a new A/C installation, check the possible opportunities of your building. Maybe there is a CHP unit on site so that the heat can be used in summer in order to produce cold by the absorption cycle as described in the GBP combined heat and power (CHP) technical module. Maybe, your building can be connected to district cooling avoiding the installation of a new cold generating system. Finally, it is possible to cool a building using passive technologies as stipulated in the considered technical module.

Equipment selection and sizing (for new system only)

The selection and sizing should be made using the following criteria: performance, capacity and spatial requirements, first cost, operating cost, reliability, flexibility and maintainability. Performances must be considered at the same time than capacity because a bad choice of that couple can increase strongly operating costs. Actually, the choice of an A/C system must be based on total costs (investment + operation) and not only on investment costs as shown[4] in the following table.

[4] For an hypothetical 2000m^2 building, 800 hours equivalent, optimised SSEER. Sizing ratios are 120W/m^2 for CACs and 240W/m^2 for RACs

			Hypothetical SSEER	Cost		ALCC
				Invest.	Energy	
				€/15 y	€/15yr	€/m²/yr
Room Air Conditioning system	**Without primary air**	Multi-split	2,25	220000	128000	16,69
		Packaged unit	2,25	160000	128000	13,30
	With primary air	Multi-split	2,25	248000	128000	20,75
		Packaged unit	2,25	188000	128000	16,77
Central Air Conditioning system	**Without primary air**	Multi-split	2,25	186000	128000	14,77
		FCU - 2 pipes	2,00	220000	144000	17,23
		FCU - 4 pipes	2,00	228000	144000	17,68
		WLHPS	2,40	100000	120000	9,65
		VRF	2,80	260000	102857	22,01
	With primary air	Packaged unit	2,25	130000	128000	12,91
		Multi-split	2,25	274000	128000	22,48
		CAV	1,30	336000	221538	34,76
		VAV	1,70	352000	169412	34,33
		FCU - 2 pipes	2,00	318000	144000	27,53
		FCU - 4 pipes	2,00	326000	144000	28,10
		WLHPS	2,40	200000	120000	17,30
		VRF	2,80	348000	102857	31,78

Source: Energy Efficiency and Certification of Central Air Conditioners[5] (EECCAC)

However, A/C systems are more and more flexible and it is now better to get several small capacity units than only one large system sized on the annual peak load and operating at part load most of the time. Moreover, using cold storage can ensure the supply at peak load even if the system capacity seems not high enough. If these two options are not feasible, it is recommended to invest in variable capacity equipments using variable speeds as often as possible.

Upgrade of an existing A/C systems

The energy audit will reveal the opportunities for the efficiency improvement of existing equipments. The whole replacement can be a solution but in case of complex installations, a lot of improvements can be implemented individually such as:

- The replacement of motors by more efficient ones
- The variable speed of pumps, compressor or fans
- The improvement of controls and periods of operation
- The replacement of any obsolete part
- Network insulations
- Etc…

An informative list, as exhaustive as possible, on possible upgrade of an existing A/C installation is provided in annex 3.

[5] Adnot, J. et al., "Energy Efficiency and Certification of Central Air Conditioners" (EECCAC) for the Directorate General Transportation-Energy of the Commission of the European Union, May 2003

3. Improving the follow-up

As stipulated in the energy performance of building directive[6] (EPBD) article 9, the inspection of A/C installation becomes mandatory for any building with an effective rated cooling output higher than 12kW. It is then advised to include regular inspection procedures (similar to what the CEN standard[7] defines) in O&M in order to be able to provide the relevant information to inspectors and to get the best from them. That is why future follow-up of the A/C installation must be thought as early as possible in a GBP project. A good-follow-up is based on two points:

- The measurement of performances of the installation
- The operation and maintenance (O&M) of the installation

Continuous performance measurement

Only few parameters need to be metered for an energy follow-up, for example the electric power (global or individual), the cold supply. Although more precise, it can be more complex if sub-meters are used. After that, ratios can be established and then checked regularly. However, continuous diagnoses require a lot of measurements which can be done by installing several meters or by using a building energy management system (BEMS) that allow to manage, control and visualise processes and performances in real-time.

Operation & maintenance

O&M can be done by the building owner himself or can be delegated to a specialised third party. It is recommended to opt for an O&M contract of results that imposes a strong responsibility on the operator that must successfully fulfil the mission defined by the contract. Indeed, an O&M contract of means defines only frequencies of visits, the nature of services to be carried out, labour and material means.

In a contract of results, the third-party gives its estimate on operational budgets, its guarantee of well-being in the buildings, of the maintenance of the materials and implements the means that it judges necessary to obtain the contracted result. The duration of that contract is necessary longer because the guarantee implies a perfect knowledge of the process but also, significant investments in time for the knowledge, commissioning and adjustments. Thus, such a contract requires the use of relevant indicators to define objectives and possible penalties that can exist only if performances are measured continuously.

[6] European Parliament, "Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings", Official Journal of the European Communities, L 1/65, Vol. 46, 4 January 2003

[7] European Committee for Standardization (CEN), "Ventilation for buildings – Energy performance of buildings – Guidelines for inspection of air-conditioning systems", 2005

6. Reporting

Provide assistance for the building user to periodically report to the Commission on the improvements undertaken and the degree of completion and maybe on what is planned for the future. It is important to know the effect of improvements on energy consumption/ indicators, as well as the resulting money savings.

The report should include the following:

- Description of the building: date, shell, climate, internal loads, occupation, activity
- Description of the existing A/C installation: date, main problems that occurred, main corrections done and date
- Energy and economic performance of the existing installation in the existing building (using recommended indicators)
- Measures to reduce internal loads
- Description of the improvements on the A/C installation
- Energy and economic performance of the new installation in the new building (using recommended indicators)

That report can be based on the table provided in annex 4. That table sums up the savings generated by the improvements carried out in terms of energy and money.

Annex 1: Average thermal loads of the building for sizing new equipements

External loads due to
- The local climate (kWh)
- Air infiltration (m3 and kWh)

Internal loads due to
- Occupancy (number or percentage and kWh)
- The renewal of the air (m3 and kWh, depends on occupancy)
- Lighting (kWh)
- Electrical appliances (kWh)

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
0 – 2												
2 – 4												
4 – 6												
6 – 8												
8 – 10												
10 – 12												
12 – 14												
14 – 16												
16 – 18												
18 – 20												
20 – 22												
22 – 24												
TOTAL (kWh)												

Annex 2: the energy audit of the building

Energy Audit
Summary of results
Description of measures considered
Measure 1
Description
Reason for being selected or rejected
Measure 2
Description
Reason for being selected or rejected
Measure 3
Description
Reason for being selected or rejected
Detailed description of the selected measures
Working plan and time table for implementation of the selected measures

Annex 3: Technical measures that could increase the efficiency of CAC systems

There are a large range of technical measures that can lower the energy demand of CAC systems without changing the systems themselves as listed by type below. That list is extracted from the EECCAC[8] study.

Chiller circuit and control

CH1 Optimisation of cost/efficiency at full load (some threshold on accepted EER)
CH2 Optimisation of cost/efficiency at part load (some threshold on accepted IPLV)
CH3 Stable cold source at good temperature (river, aquifer)
CH4 Multi-speed strategies & swept volume control
CH5 Variable speed strategies
CH6 Improved effectiveness of the tower, selection of fillings flow rates
CH7 Optimal loading of stages
CH8 Sharing of load among chillers & loading of chillers (when various)
CH9 Optimal control of cooling tower for low auxiliaries and lowest cost effective condensing temperature
CH10 Free cooling integrated into the chiller
CH11 Reduction of power of cooling tower under a simpler form than CH9

Motors and fans

V1 Motor Eff. 2
V2 Motor Eff. 1
V3 Selection of fans characteristic curves and the pressure control
V4 Improved local tangential ventilator
V5 Improved fans on condensers, AHU
V6 Better filters, Classic option in design
V7 Less pressure drop in all parts
V8 Variable speed
V9 Feasibility of local stopping of each electrical motor
V10 Feasibility of central stopping of each electrical motor by BEMS

Design & Sizing

DS1 Decentralised system banned over a certain limit
DS2 Over-sizing banned, some under-sizing acceptable
DS3 Quality of the service of "sizing" (for example search for alternatives, sizing of fans, minimum LCC design)
DS4 Optimisation of multi-zone sizing & prohibition of cold & hot mixing
DS5 Sizing by full plant simulation
DS6 Regulation threshold is in primary energy, giving to electricity a weight close to its price
DS7 Regulation is expressed in terms of carbon intensity, giving to electricity a weight close to its global warming impact
DS8 Careful organisation of set points and control dead bands since design
DS9 Automatic adjustment of pressures planned from design

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[8] Adnot, J. et al., "Energy Efficiency and Certification of Central Air Conditioners" (EECCAC) for the Directorate General Transportation-Energy of the Commission of the European Union, May 2003

Operation & Maintenance

OM1 Recording energy consumption
OM2 Monitoring energy consumption with a BEMS
OM3 Obligation to install a device allowing to measure temperature in each zone
OM4 Optimisation of the change of the filters
OM5 Cleaning of condensing coils
OM6 Cleaning of evaporating coils
OM7 Optimal scheduling of M4-M6
OM8 Fine tuning of controls, namely through BEMS
OM9 Fault detection systematic thanks to BEMS
OM10 Contract of controlled service (which criterion?)
OM11 Performance Contracting
OM12 Balancing planned in design
OM13 Operation manual written by designer and transferred to operator

Decentralised system: Packages, rooftops, RAC, etc. used for homogeneous zones

PACK1 Local Free cooling
PACK2 Changing control setpoints (temperature, humidity)
PACK3 Reversibility (local heat pump)
PACK4 Optimisation of cost/efficiency at full load (some threshold on accepted EER)

System based on water distribution

WS1 Control on the returns at 7/12
WS2 Moving to 8/14 on departure
WS3 Moving to 8/16 on departure
WS4 Variable temperature on departures
WS5 Variable temperature on returns
WS6 Circuiting of chillers, “decoupling”, variable speed in distribution
WS7 Improved pumps
WS8 Pipes insulation reinforced
WS9 Less head losses, use of surfactants
WS10 Better control of FCU
WS11 Cold ceilings/ Beams/ Slabs
WS12 Reversibility
WS13 Water side free cooling

System with circulation of refrigerant SCR

SCR 1 Optimisation of cost/efficiency at full load (some threshold on accepted EER)
SCR2 Local free cooling
SCR3 Reversible MS
SCR4 Moving to the VRF (compression benefits) in MS
SCR5 Optimal distribution of flows by electronic unit in VRF
SCR6 Reversible behaviour of the VRF 2 pipes
SCR7 Reversible behaviour of the VRF 3 pipes
SCR8 Changing control setpoints (temperature, humidity)

Equipment for air handling

AS1 Central Free cooling
AS2 Smaller percentage of outside air
AS3 Variable air volume (VAV)
AS4 Better fans in AHU
AS5 Application of EUROVENT specifications for AHUs (less leakage, more insulation)
AS6 Cost effective AHU
AS7 Optimised blowing temperature (10-16 °C)
AS8 Quality of the moisture control system (critical for energy consumption)
AS9 Correction of the poor multi-zone efficiency of air systems
AS10 Sensor of occupancy and other "demand controlled" ventilation
AS11 Central heat/cold Recovery within the HVAC system
AS12 "Displacement" strategy by use of stratification of the rooms (low inlet speeds) or by other displacement strategies
AS13 The air flow follows the hygienic demand and has not a minimum value over the minimal hygienic demand
AS14 Prohibition and successive cooling & reheating
AS15 Ducts insulation and leakage limitation
AS16 Existence of an A/C stopping & controlling possibility in each zone
AS17 Ventilation should be in cascade among rooms
AS18 Reversibility by use of the same chiller as a heat pump
AS19 Recovery of heat for DHW

Systems with water and air

AWS1 Improved control of classic system
AWS2 Ejector improved allowing blowing temperature at 18°C
AWS3 Cold ceilings/Beams/Slabs + additional system by air
AWS4 "Displacement" equipment
AWS5 Reversibility

Systems with water loop

WL1 Optimisation of cost/efficiency at full load (some threshold on accepted EER)

Building envelope improvement

B1 Better insulation of building for winter purposes
B2 Threshold on maximum size of cooling zone in building codes
B3 Access doors (automatic closing after passage)
B4 Control of solar input through openings
B5 Shading of facades
B6 Lower electricity for lighting
B7 Lower electricity for office equipment
B8 Night time over-ventilation
B9 Ventilation requirements closer to minimum

Comfort conditions: changing the rules of the game

C1 Better adaptation to occupation of zones
C2 Adapted cooling, depending on outside temperature
C3 Occupation sensors, like CO2
C4 Ventilation sensors, like window opening
C5 Quality level

Alternative Equipment strategies

E1 District or block cooling
E2 Absorption or mixed strategies
E3 Cool storage
E4 Use of condenser to heat domestic hot water (DHW)
E5 "Double dividend strategies" based on a higher efficiency of office equipment and lighting leading to lower AC loads
E6 Evaporative cooling
E7 Desiccant cooling
E8 Natural cooling from cooling tower (free-chilling)

Annex 4: assessment of the measures carried out

		Before the action (kWh/yr - €/yr)		**After the action (kWh/yr - €/yr)**	
Energy costs	Electricity				
	Fuel				
	Other energy				
	TOTAL				
Investment costs	Equipment 1				
	Equipment 2				
	...				
	TOTAL				
O&M costs	Task 1				
	Task 2				
	…				
	TOTAL				
Other costs	Cost 1				
	Cost 2				
	…				
	TOTAL				
TOTAL					
Economic annual savings					
Payback period					