Checklist for Energy Efficiency in Buildings

(Note: **P** = planning; **D** = design; **C** = construction; **M** = maintenance and management.)

1. Architecture

Item	Key points	P	D	C	M
Siting and surroundings	• Thermal environment of surroundings	X	X		
	- sunshade, sunlight, wind, reflecting surfaces				
Thermal design of outdoor environment	• Effect of plants	X	X		
	- shading by trees and plants				
	- wind shielding by trees and plants				
	• Cooling effects by ponds and fountains	X			X
	• Reflection from road or floor surfaces and plants	X	X		
Shape of the building	• Ratio of envelope surface area to total floor area	X	X		
	- usually the smaller the better				
	• Aspect ratio of floor plan	X	X		
	- usually the smaller the better				
	• Number of floors and building height	X	X		
	- floor-to-floor height, light well's height				
Orientation of facades	• Desirable orientation from thermal viewpoint	X			
	• Optimal strategy of orientation	X	X		
	- for the same floor plan, east-west axis is better than north-south one				
	- main wall openings to face south	X			
Design of building plan and section to enhance thermal performance	• Zoning and location of air-conditioned and non-air-conditioned spaces	X	X		
	- non-air-conditioned spaces and spaces without occupants may have more exterior walls				
	- plant rooms to be placed on the topmost floor				
	• Appropriate provision for different building functions	X	X		
	- hours of using the space				
	- moving of heavy objects by occupants				
	- provision of smoking lounge				
	- provision of store room				
	- spaces with high internal loads (lights, people and equipment) may compensate heat loss at the building envelope				
	• Use of transit areas for thermal buffer zones	X	X		
	• Design of wind-shielded area under openings	X	X		
Thermal insulation and thermal storage of the roof	• Thermal insulation	X	X		
	- material selection				
	- thickness				
	- thermal properties (and moisture barrier)				
	• Construction of the roof	X	X	X	
	- double slab				
	- thermal bridge prevention				
	• Treatment on the roof	X	X		X
	- soil and planting				
	- drainage of rainwater				
	• Sunshade provision	X	X		X
	• Glare control	X	X		
	• Thermal storage	X	X		
	- heavy structure (thermal mass)				
	- interaction with thermal insulation				

1. Architecture (continued)

Item	Key points	P	D	C	M
Thermal insulation and thermal storage of the exterior walls	• Thermal insulation - material selection - thickness - thermal properties (and moisture barrier)	X	X		
	• Construction of the walls - use of air cavity - ventilation of air cavity - location of thermal insulation - thermal bridge prevention	X	X	X	X
	• Sunshade provision - louvres and shading devices	X	X		X
	• Reduce radiant heat - use of trees for shading and shielding - select materials for glare control - provision of ventilated cavity	X	X		X
	• Thermal storage - heavy structure (thermal mass) - interaction with thermal insulation	X	X		
Thermal insulation, air tightness, ventilation properties and daylight properties of windows and doors	• Thermal insulation - Type and construction of window glass: plain glass, insulating glass, reflective glass, tinted glass, double glazing, low-e glass, etc. - window-to-wall ratio - shading coefficient - use of trees, sidewalls, louvres and balcony for shading - use of internal shading devices like blinds and curtains - orientation (south facing is preferable, and if in other directions, the facing angle of window glass may be adjusted)	X	X		
	• Air tightness - air leakage properties - shape and design of door openings: double door, automatic door and rotating door	X	X	X	X
	• Ventilation (natural) - possibility of windows being opened - openings and path have less resistance to air flow	X	X		X
	• Daylight penetration - reflective louvre - skylight - design of light wells - light transmission properties of window glass - array of window openings	X	X		
Glare control of exterior and interior walls	• Solar absorptivity, control of glare from sunlight and artificial lighting	X	X		

2. Heating, Ventilating and Air-conditioning (HVAC)

Item	Key points	P	D	C	M
Overall planning	• Suitable zoning strategy to prevent unnecessary losses - zoning of air-conditioned and non-air-conditioned spaces - zoning for spaces with different air change rates - zoning for spaces with different air-conditioning hours	X	X		
	• High efficient operation of system equipment	X	X		X
	• Zoning for spaces with different conditions: temperature and humidity, lighting density, air cleanliness, occupant density and equipment used	X	X		
	• Zoning for spaces with different load characteristics - peak hour, load lagging	X	X		
	• Balance of building air pressure - positive and negative air pressure	X	X		X
	• Sources of energy - consider local energy structure and form of energy available	X	X		X
Indoor environment	• Design indoor temperature and humidity - setting of design conditions - use of thermal comfort index - reset conditions at night, before and after occupying hours - reset according to actual outdoor conditions - setting of control tolerance bands	X	X		X
	• Outdoor fresh air rate - minimum outdoor air requirement - primary fresh air cooling	X	X		X
	• Lighting power density - setting of design maintained illuminance	X	X		X
	• Changeover of heating and cooling, and period of air-conditioning - optimize the design and review the necessity				X
	• Distribution of air (and temperature) - air supply method and location, return air location	X	X		
System and equipment	• Reduce energy losses from inappropriate mixing - setting of perimeter and interior zones - effective air supply method (avoid cooling and reheat)	X	X		
	• Matching of load characteristics - for design of cooling and heating plants - heat recovery method	X	X		
	• Correct use of multiplying factors - safety factor of climatic conditions (in load calculation), equipment and systems; diversity factor	X	X		
Heat/cold source system	• High efficient operation of equipment (by good management) - efficient part load operation - number and division of multiple equipment - use of thermal storage method - setting of chilled and condensing water temperatures	X	X		X
	• Heat recovery from waste heat and exhaust air - utilization of heat sources: exhaust air, transformers, motors, lighting, gas burning, warm discharged water	X	X		
	• Use of heat pumps	X	X		
	• Total (and sensible) heat exchanger	X	X		
	• Waste heat and condensing boilers	X	X		
	• Use of natural energy sources - primary fresh air unit to use night ventilation - solar thermal utilization - use of river or sea water for cooling	X	X		X
	• Thermal storage to cut down peak load and increase efficiency of heat recovery equipment - water or ice thermal storage - use of latent heat - thermal storage by system equipment	X	X		X
	• Cogeneration system				

2. Heating, Ventilating and Air-conditioning (HVAC) (continued)

Item	Key points	P	D	C	M
Load distribution and transmission systems	• Prevent losses during transmission - thermal insulation of piping and ducting - minimize air leakage - decrease local flow resistance	X	X	X	X
	• Reduce space loads - water-cooled lighting fixture (if needed) - reduce energy losses from inappropriate mixing - better control of latent loads	X	X		X
	• Decrease of running power - use variable air volume (VAV) method - use variable water volume flow (VWV) method - use larger temperature difference - use low-temperature air supply system - use of booster fans and pumps - fans and pumps specific to part load operation - straightening and shortening of air ducts - alternate energy transmission method - close loop for water distribution systems - lowering of water or air flow velocities - better thermal insulation for pipes and ducts	X	X	X	
Ventilation systems	• Reduce transmission energy - prevent excessive ventilation - shut down ventilation when not needed - control of ventilation rate at part load conditions - use of localized ventilation method - use of air-conditioning to replace high volume ventilation (e.g. for transformer and plant rooms) - utilization of natural ventilation - use air cleaners - multiple fans to handle a large flow capacity	X	X	X	X
	• Reduce ventilation load - decrease outside air when preheat or pre-cool is needed - control of fresh air (from number of people or use CO_2 analysis) - use of primary fresh air unit - use of night ventilation - use of total heat exchanger - transfer of exhaust air from plant room to car park - use of exhaust air from cooling tower - decrease of ventilation rate during peak load	X	X		X
Control systems	• Control of indoor environment (computer automatic control) - setting of temperature and humidity control (response to outdoor) - control of outdoor fresh air	X	X		X
	• Control of the operation of equipment - optimal start-stop - capacity control on the number of equipment running - control of water and air flow rates - operation forecast control - demand control - peak-cutting control	X	X		X
Use of natural energy	• solar energy	X	X		
	• geothermal energy	X	X		
	• wind energy	X	X		
	• use of energy in soil (temperature and underground water)	X	X		
Use of energy from waste heat and exhaust	• heat recovery from exhaust air	X	X		
	• heat recovery from waste products	X	X		
	• heat recovery from discharged water	X	X		

3. Electrical Services

Item	Key points	P	D	C	M
Overall planning	• Reduce losses in electrical circuits	X	X	X	X
	- with a low voltage system, use a supply method with less losses				
	- consider to use high voltage supply				
	- shortening of electrical cable and wiring network				
	• Improvement of power factor	X	X		X
	- use power factor correction equipment (demand or supply sides)				
	• Correct capacity and power ratings	X	X		
	- correct use of multiplying factors				
	- control of a number of equipment				
	• Reduce power consumption of control equipment	X	X		
	- use of instantaneous magnetic contactors				
	• Consider a total energy approach	X	X		
	- cogeneration, photovoltaics, reduction of harmonics				
Power transformation and distribution	• Location of the installations	X	X		
	- entry/connection point and the load centres				
	• Capacity	X	X		
	- relationship between average load factor and transformer efficiency				
	- number of equipment and division				
	• Transformer planning and design	X	X		
	- economic analysis and system zoning				
	- operation and distribution during no-load condition				
	• Electric voltage and wiring	X	X		
	- study of economics and security				
	• Power distribution	X	X		
	- use of tree-type distribution				
	- raising of voltage				
	• Group management (by computer automatic control)	X	X		X
	- control of the number of equipment in operation				
	- peak-cutting strategy				
	- demand control				
	• Energy efficient equipment	X	X		X
	- check the economics and security				

4. Lighting Installations

Item	Key points	P	D	C	M
Lighting installations	• Design of illumination levels	X	X		
	- suitable zoning and appropriate level for each zone				
	• Lighting system	X	X	X	X
	- general lighting and localized (task) lighting				
	- direct and indirect lighting methods				
	- on-off method and circuitry design				
	• Lighting control (by computer methods)	X	X		X
	- manual control				
	- occupant-sensing control				
	- lighting level sensing control				
	- time-schedule control				
	• Energy-saving equipment (and their cleaning and maintenance)	X	X		X
	- energy efficient lighting system and luminaires				
	• Light-sensing control	X	X		X
	- daylight-activated lighting control				
	- control system to maintain appropriate illumination level				

5. Lifts and Escalators

Item	Key points	P	D	C	M
Lifts and escalators	• Method and capacity suitable to meet the demand	X	X		
	- traffic analysis (number of equipment, waiting time, speed)				
	- reduce the number of equipment by centralized design				
	- correct combination of lifts and escalators				
	- automatic stopping or standby mode of lifts and escalators				
	• Group management of equipment	X	X		
	- "double-deck" lift system				
	- operation control				
	- better braking control				
	- lights automatic turn off when not in use				
	- escalators turn to standby when not in use				

6. Plumbing and Drainage

Item	Key points	P	D	C	M
Cold water supply and drainage	• Necessity of cold water supply	X	X		
	- selection of rooms and locations for cold water supply				
	• Load estimation and equipment capacity sizing	X	X		
	- correct and accurate loads				
	- suitable capacity (with safety and diversity factors)				
	• Reduce pumping energy	X	X	X	
	- shortening of piping network and system				
	- open loop and close loop systems				
	- booster method				
	• Maintenance of appropriate water pressure	X	X		
	• Equipment	X	X	X	
	- energy-saving (water-saving) equipment and system				
	- correct type and size				
	• Water recycling systems	X	X		
	- feasibility of using them, their economics and reliability				
	• Rainwater utilization	X	X		
Hot water supply	• Necessity of hot water supply	X	X		
	- selection of rooms and locations for hot water supply				
	• Conditions of hot water supply	X	X		X
	- flow rate of hot water supply				
	- temperature of the hot water				
	• Hot water supply system	X	X	X	
	- design of storage tank or pond				
	- specific boiler				
	- central supply method and local supply method				
	- thermal insulation properties				
	- use of solar thermal energy				
	- shortening of water piping network				
	- heating method				
	- thermo-siphon for circulation				
	• Heat recovery from waste water	X	X		

7. Building Management

Item	Key points	P	D	C	M
Building management system	• Management of indoor environment	X			X
	• Management of equipment operation	X			X
	• Energy demand and consumption management	X			X
	• Preventive maintenance	X			X
	• Educational and training	X			X