Guidelines for economical construction 2009

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Contents

Purpose and applicability

The purpose of these guidelines is to take a lifecycle approach to minimizing annual total costs (total capital costs, operating costs, and environmental follow-up costs) over the period of use under consideration. This approach ensures better quality for users and sustainability for the environment.

Additional goals include creating a „barrier–free" Frankfurt to the greatest extent possible, making a local contribution to global climate protection (50% reduction in CO_2 emissions in Frankfurt am Main by 2010), and planning for the coming climate change (hotter summers, stronger storms, more frequent heavy rains) already evident today.

These guidelines apply to all new construction and renovation projects for city government buildings, city facilities and establishments, as well as for any new buildings constructed for the City of Frankfurt in the framework of PPP activities (StVVB-§2443). However, the guidelines do not imply any obligation to upgrade existing buildings, as long as such an upgrade is not required by law (e.g. in energy conservation legislation).

Types of guidelines

In accordance with the above-mentioned statement of purpose, there are three types of guidelines:

Type A: Municipal resolutions, city council resolutions, standards

Type A guidelines include only the municipal resolutions, city council resolutions, and standards that pertain directly to the above-mentioned statement of purpose. These resolutions and standards must always be adhered to. This list, however, is not exhaustive.

Example: DIN 18024 Barrierefreies Bauen (Barrier-free built environment).

Type B: Guidelines for minimizing investment costs

A section of the guidelines aims to reduce both investment costs and follow-up costs. In the interests of cost-effectiveness, these guidelines are to be adhered to even when it conflicts with the interests of the planners (reducing their fees, for instance).

Example: limiting or reducing the installed load in lighting systems.

Type C: Guidelines for minimizing operating costs

Some measures for minimizing operating costs require increased investment costs. In type C guidelines, however, these additional costs generally amortize over the service life.

Example: use of a condensation boiler.

It is permissible to deviate from the Type B and C guidelines if an economic advantage can be demonstrated in the total cost calculation
www.stadt-frankfurt.de/energiemanagement -> Rechenverfahren.

In preparing the calculation, environmental impact costs of 50 €/t CO_2 are to be added (climate protection contribution). Any deviation from the guidelines must be justified in writing on the accompanying checklist.

In construction projects of the same type, the economic comparison should be performed initially as a fundamental analysis. These results are then applied to the follow-up measures.

Implementing the guidelines

The following guidelines shall serve as the basis for all architectural and engineering tasks. The project management shall ensure adherence to this guideline using a checklist at three milestones (once pre-planning is complete, once the building specifications are complete, and following hand-over of the completed project). The guidelines reflect the current state of the art and will be updated annually (www.stadt-frankfurt.de/energiemanagement). They expand upon existing standards and codes, but are not a substitute for professional, project-based planning.

Careful, coordinated planning developed among a team of specialist planners is critical to achieving economical construction. To this end, the architect/project lead gets both users and specialist planners involved as early as the pre-planning stage, in order to develop an economically optimized total building concept based on user requirements (defined with the help of the users) and local conditions that fits the budget of the financing entity. Whenever possible, the fee should not be linked to the actual costs, but rather agreed upon as a lump sum. A bonus shall be awarded if final costs come in lower than the initial estimate and a penalty shall be levied if the estimate is exceeded.

The planning targets (key values, building and services concepts, and project costs) should be stated in a target agreement, which shall be updated over the course of the planning process. The current status of the project shall be documented in the IPASS software in a timely manner.

Project management must ensure that the building and building services planners prepare user and operator instructions that are comprehensive and easily understandable for all building systems to ensure that projected cost targets are met once the building is put into operation. Furthermore, users should receive comprehensive instruction. All of the documents should be generated in standard file formats (.dxf, .dwg, .doc, .xls, .pdf, .jpg). The documentation must adhere to the City of Frankfurt's *Hochbauamt* documentation specifications (www.stadt-frankfurt.de/energiemanagement/dok.htm).

1 Building materials

A. Municipal resolutions, city council resolutions, standards

The following materials may not be used:

a) Components made of non-FSC-certified tropical woods (Forest Stewardship Council, www.fsc-deutschland.de, MB 2561 of 12/8/1989)

b) The following building components made of polyvinyl chloride (PVC): Water supply and drainage pipes, flooring, wallpaper, window and door moldings, electric wiring, and ducting. As a rule, halogen-free cable shall be used, except in the case of partial renovation of existing facilities containing PVC cables or buried cables (MB 525 of 2/16/1990).

c) Only construction materials that have a high degree of health and environmental compatibility should be used. Examples of materials that should not be used are those containing asbestos or PCBs and materials manufactured using chlorofluorocarbons (e.g. CFC-foamed panels).

d) Synthetic mineral fibers must be completely isolated from interior air and must be in compliance with bio-solubility approval criteria.

C. Guidelines for minimizing operating costs

a) If external insulation is not possible (e.g. on historic buildings) mineral building materials should be used for interior insulation whenever possible. 120 mm mineral foam panels with an R-value of 045 are standard. A structural engineer shall plan and calculate the mounting details.

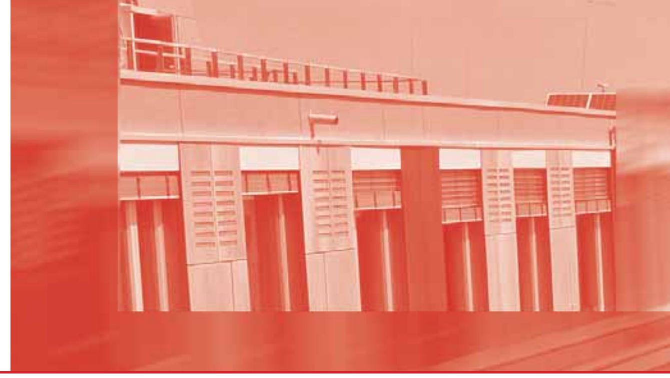
b) Building materials manufactured with the least possible use and content of formaldehyde.

c) All structural measures possible should be used to protect wood. Chemical wood treatments are to be limited solely to what is necessary. Chemical wood treatments are to be avoided in interiors.

d) Solvent-free surface treatments, finishes, and adhesives are to be used whenever possible. If substances containing small amounts of solvents have to be used, they should carry the "*schadstoffarm*" (low toxicity) environmental seal (see also 3.2 Ventilation).

e) To reduce maintenance costs, wooden windows with aluminum exterior cladding should be used.

f) Easily disassembled and recyclable assemblies should be used if they are available at competitive prices. This applies to tubing, ducts, and pipes in particular. Disassembly and disposal costs shall be taken into account when comparing the economic viability of different solutions.



2 Construction

A. Municipal resolutions, city council resolutions, standards

a) New city buildings shall be built to the passive house standard and shall be designed as such (among other things, buildings shall have an annual heating demand of < 15 kWh/m²a, www.passiv.de). Justification is required if this standard cannot be achieved. In every case, the applicable minimum standard is 30% better energy efficiency than the EnEV 2007 requirement.

b) In the renovation of city buildings, passive house components are to be used (insulation, windows, ventilation with heat recovery >75 %). The passive house standard shall be the goal. Justification is required if this standard cannot be achieved. In every case, the applicable minimum standard is 30% better energy efficiency than the EnEV requirement. This should also be the goal for protected historic buildings, while observing historic preservation requirements (StVVB §2443 of 9/6/2007). The following key values generally apply: exterior wall U <= 0.2 W/m²K, roof U <= 0.15 W/m²K, floor/cellar ceiling U <= 0.3 W/m²K, interior insulation U <= 0.3 W/m²K, windows and doors U <= 0.8 W/m²K, glazing U <= 0.7 W/m²K. This yields the following minimum insulation thicknesses at an R-value of 035: exterior wall >= 16 cm, roof >= 25 cm, floor/cellar ceiling >= 10 cm, interior insulation >= 10 cm.

c) *DIN 18024 Barrierefreies Bauen – speziell Teil 2 Planungsgrundlagen für öffentlich zugängige Gebäude* (Barrier-free built environment, Part 2 Planning Basics for Public Buildings) shall be adhered to (current version: DIN 18030). Furthermore, the *Hessische Behinderten-Gleichstellungsgesetz* (Act on Equal Access for the Disabled, HessBGG) must be observed. Any limited, individual exceptions to these regulations should be outlined in the construction and financing documentation.

d) In new construction and additions to existing buildings, lavatory facilities are to be equipped for people with physical disabilities in accordance with AMEV directive *Sanitärbau 95*, Annex 4.

e) In keeping with EnEV, summer thermal protection in accordance with DIN 4108 T2 must always be demonstrable.

f) In new construction and roof renovation, the construction of photovoltaic systems should always be taken into consideration. If the building owner decides against installing a photovoltaic system, the roof area should be made available to investors (StVVB § 1491 of 3/1/2007). All roof surfaces suitable for solar energy exploitation (based on geographic orientation) should be structurally designed to be able to accommodate a solar or photovoltaic array (slanted roof: additional 25 kg/m² of load bearing capacity, flat roof: additional point load bearing capacity of 30 kg on a gravel roofs, otherwise an additional surface load bearing capacity of 60 kg/m².) This static reserve is not necessary for photovoltaic systems integrated into the roof membrane. Shafts/hollow pipes should be provided for wiring.

g) Major school and day care center renovations, as well as fire safety renovations should include an analysis of whether necessary energy-saving measures can be performed at the same time. For example, when replacing windows, uninsulated façades must be renovated at the same time (*Energiespar-Offensive, 12 Punkte-Plan für Kitas und Schulen*).

h) Rooms should adhere to the target reverberation times specified in DIN 18041 no. 4.3.2 without disconnecting the storage mass of the ceilings. This can usually be achieved in classrooms by applying rear-ventilated sound absorbing materials to the edges of the ceiling. Furthermore, to prevent flutter echoes, walls should be fitted with noise-dissipating bulletin boards or perforated panels – at least the wall opposite the blackboard and, if possible, the walls adjacent to the hallways.

B. Guidelines for minimizing investment costs

a) Economical key values based on GIA/NIA and GIV/NIA should be used. The goal should be the target values specified in the *Dienstanweisung Bau des Landes Hessen* (e.g. for schools, GIA<= 1.75 x HNF, BRI <= 6 x HNF).

b) Construction should be carried out such that the impact of thermal bridges on U values is a maximum of 0.05 W/m²K, in accordance with EnEV.

c) Rooms should be naturally lighted and ventilated to the greatest extent possible. This also applies to passive houses outside of the heating season.

d) For natural ventilation in classrooms, window casements of at least 0.1 m² per seat should be used when cross ventilation is available, and at least 0.3 m² per seat should be used when there is no cross ventilation, even when a mechanical ventilation system is in use (passive house).

e) Window surfaces should be optimized with respect to lighting, ventilation, safety, solar protection, and glass cleaning. Costs saved for certain windows must be balanced against possible increased cleaning costs, such as those incurred when lifts are required for cleaning.

f) The following minimum reflection coefficients apply to interior surfaces: ceiling > 0.8, walls > 0.5, floor > 0.3 (calculated according to DIN 5036 Part 4, AMEV-Beleuchtung 2000).

g) To avoid overheating in the summer, adequate heat-storing mass should be coupled to the rooms (for instance, suspended ceilings should not be used, massive interior walls and latent heat storage structures should be built) and should be designed to allow cooling (night cooling). Acoustics should also be taken into consideration. Any acoustic elements required can be rear-ventilated.

h) Rooms with high internal loads (e.g. computer rooms, server rooms, or kitchens) should be located on the north side of the building whenever possible or in naturally ventilated basement rooms.

i) Due to potentially high costs, preventive fire protection should be considered early on in the planning process. Clever designs can help to avoid costly smoke and heat control systems, fire flaps, overpressure ventilated elevator lobbies, and motor driven fire doors, which are especially prone to break down in schools.

j) Planning concepts that minimize building services and their controls should be preferred (low-tech to minimize operation and maintenance costs).

C. Guidelines for minimizing operating costs

a) New construction and additions to existing structures should include adequately large unheated vestibules. Doors should be equipped with automatic closing mechanisms (without stops). However, especially in day care centers and elementary schools, children must be able to open the doors unassisted. Motor-driven doors should be avoided wherever possible.

b) Blower door tests to establish the air-tightness of the building envelope in accordance with EnEV shall be performed in new buildings and total renovations (for buildings built to the passive house standard, N50 <= 0.6/h, otherwise n50 <= 1.0/h). Leaks should be located using thermographic images whenever possible.

c) Radiators should not be put behind glazed surfaces – even windows that extend all the way to the floor; use triple glazed solar glass instead.

d) The daylight quotient (the relationship between inside and outside light intensity calculated according to DIN 18599-4) should be at least 5 % in all locations where 300 lux or more is required and at least 3 % in corridors and stairwells. This can usually be accomplished when the surface area of the windows exceeds the surface area of the floor by 15 %, room depth is not greater than 7 m, lintels are minimized, and windows are placed above doors to the corridor.

e) As a general rule, effective external solar protection for useful area should be used (permeability factor b < 0.2 according to VDI 2078). Solar protection equipment must be adjustable, so that artificial light is not needed, even when it is set to provide maximum protection. This can usually be accomplished with two-part, tiltable, reflective external blinds that adjust to the position of the sun.

f) Necessary solar protection systems must be motor-controlled via a weather station (temperature sensor, irradiation sensor, and wind monitor) and designed to withstand wind speeds of at least 13 m/s (using rigid tracks). Solar protection should not be used when heating is in use (to maximize passive solar energy yield). Adequate rear ventilation should always be used, and it should also function at times when the facility is not in use. The systems have to be able to be cleaned.

g) In addition, adequately large night ventilation flaps with suitable tamper-resistance and screens should be installed to prevent overheating in classrooms and group rooms in the summer.

h) Flat roofs have to have a minimum slope of 2%.

i) Large-scale construction projects (> 100,000 €) should use their own electricity and water-consumption meters. In general contractor projects at least, the contractor shall cover the cost of power and water consumed during construction and calculate these costs into the bid.

j) Due to more frequent heavy rainfall events expected in the future, doors and windows should be installed at least 20 cm above street level (ramps shall be provided for wheelchair accessibility).

3 Building services

3.1 Heating systems

A. Municipal resolutions, city council resolutions, standards

a) Heating distribution and hot water lines as well as fittings are to be insulated in accordance with Annex 5, Table 1 of the *Energiesparverordnung* (EnEV 2007).

b) When heating plants are being built or renovated, the possibility of using a cogeneration unit or wood-fired furnace should be examined. The contracted cogeneration plant planners should have a copy of the reference planning documents (*Energiespar-Offensive, 12 Punkte-Plan für Kitas und Schulen*).

B. Guidelines for minimizing investment costs

When heating systems are installed in existing buildings, the reference power at design temperature (-12°C), either measured or determined through regression, shall serve as a basis. For new installations, the conditions in DIN 4701 (no pre-heating reserve, less air exchange) should be used rather than those in DIN EN 12831. The derived value should not be exceeded in order to minimize the investment costs, demand charge, and stand-by losses.

C. Guidelines for minimizing operating costs

For all technical systems that require maintenance (especially cogeneration units), maintenance contracts covering the projected service life of the system (min. 10 years) should be procured as well to determine which tender is the most economical when the operating phase is also taken into consideration. A price escalation clause for labor and material costs shall also be included.

3.1.1 Heat supply

a) When gas is used for heating, condensation boilers should be used (or condensation water heaters).

b) In wood-fired heating systems, the *Blauer Engel* emission threshold values shall be adhered to (www.blauer-engel.de, soot emission value of 20-25 mg/m³ exhaust gas). The goal should be to cut this value in half. In large plants, an emission value of less than 15 mg/m³ should be adhered to.

c) In outdoor swimming pools, the pool water is to be heated (to the extent necessary) with solar collectors.

d) The feasibility of using solar heating for water in gyms and sports facilities must be assessed. Solar heating allows boilers to be switched off in the summer (saving standby losses, electricity for pumps, and heat losses in the mains connection.

e) Cogeneration units, geothermal probes, wood-fired systems, and solar collectors should, as a rule, be equipped with heat meters.

f) Electric coil heaters are usually uneconomical, even in temporary facilities (such as temporary container units) due to the high power requirements (heating during peak rate

hours). Thus, generally gas heating should be used or, if gas is not economical, an off-peak electric heating system.

3.1.2 Heat distribution

a) There should be a string regulator for every individual building. They should be divided into two heating circuits (N-E and S-W). For reasons of economy, each group should have an output of at least 30 kW.
b) Depending on demand, additional heating circuits should be installed (such as administration facilities, gyms with showers and locker rooms, auditoriums).
c) New radiators should be designed to a maximum of 60°C/40°C. A low return temperature is especially important to utilize the calorific value to the fullest. To ease cleaning, radiators should be installed on walls, and the connection should run through the wall.
d) In new buildings, radiators should not be placed in front of glass surfaces; in renovations, radiators positioned near glass should be fitted with effective radiation shielding. In buildings constructed to the passive house standard, radiators do not have to be placed under windows, but they may (if needed at all) be placed on inside walls of rooms (see 2.C.c).
e) In general, passive house school buildings and daycare centers that have a temperature requirement greater than 17 degrees must have one radiator per room (generally only on when users are not in the room).
f) Controllers should include a user-friendly night, weekend, and holiday heat reduction system. Outside of use periods boilers and heat circuit pumps should be switched off at outdoor temperatures of greater than 5°C.
g) The controller shall be equipped with an optimization program to ensure the most energy-saving adjustment of the control characteristics, heating-up moment, and the cooling-down moment.
h) As a rule, energy efficiency class A pumps (eff1) should be used. All pumps subject to changes in demand should be equipped with a timer switch and a speed regulator (pumps must be protected against frost). The appropriate setting for the site must be checked during final inspection and handover. If a controller is used, the error reporting function of the pump controller can be overridden.
i) For rooms used differently at different times (such as classrooms in schools), each room is required to have its own controls (except passive house schools). They should also be divided into two heating circuits (N-E and S-W).
j) Generally, all individually adjustable radiators must be equipped in advance with lockable reverse-flow fittings and a valve adjustment knob with a readable preset position.
k) When individual room controls are used, open windows should be detected by the sudden temperature drop, causing a drop in heating. If a window that has been open for some time triggers the frost protection system, the caretaker should receive an alert. Temperature sensors are to be placed at an adequate distance (> 1m) from doors and windows.
l) If individual room controls are not used, preset thermostat valves should be installed (preset values: max = target temperature, min = frost protection = 5°C). Maximum and minimum settings should only be adjustable by custodial personnel. The radiator has to be able to be switched off or adjusted using the thermostat valve or the return flow fitting.
m) A heating system should only be accepted from the contractor when it is accompanied by a detailed record of proper hydraulic adjustment. While the above point is an ancillary service in the VOB, it must still be explicitly listed as a position in the project specifications.
n) While heating systems are being adjusted, the target heating temperature specifications in the *AMEV-Richtlinie Heizbetrieb 2001* are to be set (e.g. offices and classrooms 20°C, connecting corridors and stairwells 12°C, lavatories 15°C, gyms 18°C, locker and shower rooms 22°C).
o) The heating controls must be set only to allow heating when outside temperatures are less than 15°C (*AMEV-Heizbetrieb 2001*).

3.2 Ventilation

A. Municipal resolutions, city council resolutions, standards

a) Concentrations of hazardous substances must be kept below legal limits, especially in classrooms and labs. Ventilation concepts should be developed to keep concentrations below these limits. Generally, ventilation systems should be "simple ventilation systems" (THM-C0 according to DIN 13779).
b) In the renovation of city buildings, passive house components are to be used (ventilation with heat recovery, heat recovery rate of for dry air >75 %, StVVB §2443 of 9/6/2007). A heat recovery rate of > 80% is recommended.

B. Guidelines for minimizing investment costs

a) The volume of air and the portion of outside air are to be limited to the minimum amount necessary (usually RAL 4 according to DIN EN 13779; i.e., 5.5 l/Ps or 20 m³/Ph). The design should be based on a standard/average number of occupants. Temporary additional/peak emissions shall be extracted via window ventilation. A bypass for the heat recovery system is to be used to handle high thermal loads. Extract air from other rooms, such as classrooms, locker rooms, etc., should be used – to the extent that good hygiene permits – to ventilate storage areas, hallways, showers, and toilets, where CO_2 concentrations in the air play a secondary role.
b) Fire protection flaps shall be avoided wherever possible with a well planned ducting system. Thus, the fire protection concept should be developed in the preliminary design phase.

C. Guidelines for minimizing operating costs

a) According to the DIN 13779 standard, ventilation systems should generally be built to the requirement lower threshold *üblich* (regular), *normal* (normal), or *standard* (standard). In other words, systems in their operational status have to comply with efficiency class SFP 1 or SFP 2 (standard), and corresponding pressure loss values according to tables A4 and A5 (normal to low) have to be preset. Usually, the specific consumption rate has to be < 0.45 Wh/m³ (required in the passive house standard).

b) Controllers are usually RAL-C3-compliant, DIN 13779-compliant (timed) or better. User-operated switches should be limited to a maximum duration of 3 hours (special classrooms: 45 minutes).

c) The limit values specified in *Leitfaden elektrische Energie im Hochbau des Landes Hessen* (LEE, July 2000 edition) must be adhered to; the target values should serve as goals (such as ventilation in a non-smoking office with normal equipment; limit value 3 kWh/m²a, target value 1.5 kWh/m²a).

d) Ventilation motors of more than 200 W should generally be fitted with speed controllers and a direct drive.

e) In ventilation systems subject to significantly varying use requirements (such as auditoriums), the user has to be able to easily adjust the system to the actual conditions (number of occupants, room temperature, etc.) via speed regulators for the motors and by adjusting the amount of outside air. Generally, the system should be controlled based on air quality (CO_2). For pools and shower rooms, humidistats or timers should be used to control the ventilation.

f) For heating, the system must be able to be pre-warmed prior to use in circulation mode.

g) For hygienic reasons, regenerative heat recovery in which there is a danger of transferring toxic substances between fresh air and exhaust air should not be used in schools and kindergartens.

h) Compact filters must not be used if possible due to their small filter surface area, which causes higher pressure losses and shorter maintenance intervals.

i) The thermal insulation [U] / thermal bridge factor [Kb] for indoor ventilation equipment should be at least T3/TB3 and for outdoor equipment at least T2/TB2 (see *RLT Richtlinie 01*).

j) Ventilation in passive house buildings is to be controlled according to the occupancy plan. During operation fresh air is generally only to be heated via the heat recovery unit.

k) Rooms shall be pre-ventilated approximately one hour prior to use to meet the ventilation requirement during periods of non-use in accordance with DIN 13779 (p.20).

3.3 Air conditioning

A. Municipal resolutions, city council resolutions, standards

a) If active cooling is necessary, renewable energy should be used, such as photovoltaics or ground probes (StVVB §2443 on 09/06/2007).

B. Guidelines for minimizing investment costs

a) Air conditioning devices should be avoided (by reducing glazed areas, solar protection, arrangement of heat-storing mass, night ventilation, placement of areas that require cooling on the north side of the building or in the cellar.

b) When air conditioning is necessary, the first options that should be considered are night ventilation and adiabatic cooling (of extract air). Drinking water shall not be used for air conditioning.

c) Air conditioning controls are to be set so that they cannot be switched on until the room temperature reaches 26°C (target temperature for computer rooms: 27°C).

C. Guidelines for minimizing operating costs

a) If active air conditioning is necessary and piped heating from a cogeneration plant is available, the use of absorption refrigeration should be assessed.

b) For air conditioning, the target indoor temperature should be adjusted on a sliding scale that tracks outdoor temperature (above 29°C: indoor target temperature = outdoor temperature – 3 K).

c) Air conditioning should only be possible when solar protection is activated in the area to be cooled.

d) For conservational applications (such as museums) target humidity and temperature should be adjusted seasonally. The rate of change of temperature and humidity should be limited depending on use requirements (e.g. Δ F < 1 %/day).

3.4 Sanitary services

B. Guidelines for minimizing investment costs

a) Sinks for hand washing should only have cold water taps, especially in cleaning rooms.

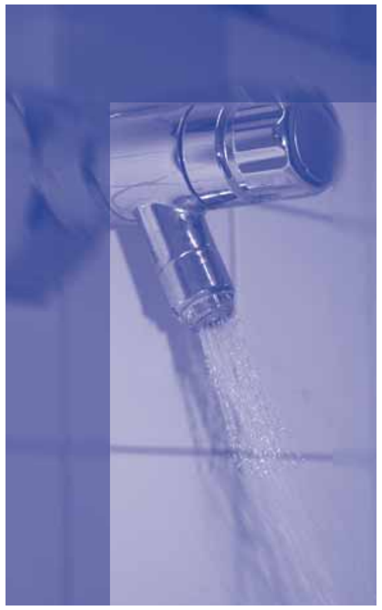
b) Hot water tanks should only be installed if need is demonstrated (no reserve; if possible, only small systems with a maximum of 400 l capacity in accordance with *DVGW-Arbeitsblatt W 551*) and should be installed as close to the point of use as possible. In existing buildings, measurements must be taken beforehand to determine hot water demand.

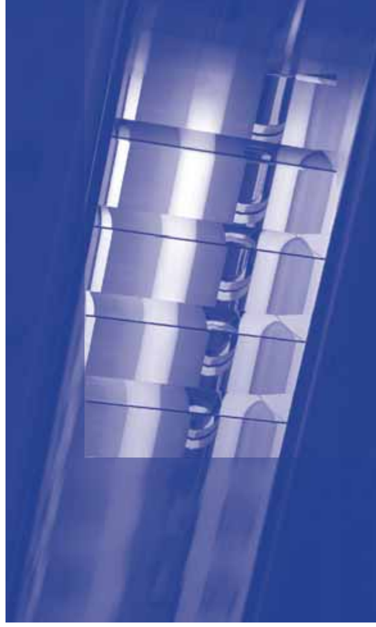
C. Guidelines for minimizing operating costs

a) Drinking water pipes should generally be made of stainless steel (taking fire load into account, exception for plumbing installed over the walls).

b) Toilets should be wall-mounted to lower cleaning costs.

c) Toilet seats are to be installed with stable fittings (fully penetrating shaft-hinges).
d) Only flushing tanks with stop buttons or separate buttons for small-quantity flushes and user instructions are to be used.
e) Flushing tanks may only have a 4.5 liter capacity (except in existing buildings).
f) In buildings with more than five urinals and more than 30 uses per day, all of the urinals must be individual dry-flush urinals, unless users provide an adequate justification not to use them.
g) Aerators are to be installed on sinks (max. 5 l/min).
h) Only shower heads with a maximum of 7 l/min and a full stream are to be installed.
i) Sinks and showers should be fitted with self-closing taps. Sinks should have a running time of 5 seconds and showers 40 seconds. The taps must be fitted with filters to eliminate any foreign objects.
j) To prevent legionnaire's disease only "fresh water" stations are to be installed (see DST note 17). In isolated, seldom-used showers (common areas, kitchens, and daycare centers) small flow heaters (4-5 kW) are often economical.
k) Electric hot water tanks should be avoided due to the high stand-by losses. Instead, the smallest flow-through heaters (3.5 kW) should be used.
l) For large boilers or long hot water pipes and low hot water demand, a separate heating system for the hot water tank should be considered (such as a condensation heater).
m) The hot water heater pump and the circulation pumps must meet energy efficiency class A and be controlled by a timer (and possibly a contact thermostat). *DVGW-Arbeitsblatt 551* should be observed.
n) The water supply line from the manifold to the toilets and, if necessary, the urinals must be laid separately to make it easier to switch to rainwater.
o) If high potable water demand is great (>60 m³/a), a study of economical rainwater and potable water use must be carried out. For outdoor watering (sports and park facilities, etc.), rainwater use is usually economical if sufficiently large roof areas are available.
p) Pipes and special rainwater pipes must be installed for easy access to simplify maintenance and subsequent replacement. In passive house buildings with external insulation, these water pipes must be mounted on the building façade.
q) Due to more frequent heavy rainfall events in the future, a check valve must be installed at least 20 cm above street level.





3.5 Electrical system, electric appliances

A. Municipal resolutions, city council resolutions, standards

In schools and daycare centers, conventional light bulbs can no longer be used. In large renovation projects, old fluorescent bulbs have to be replaced in accordance with 3.5.B.b) (*Energiespar-Offensive, 12 Punkte-Plan für Kitas und Schulen*).

B. Guidelines for minimizing investment costs

a) When equipping rooms with lighting, care should be taken not to exceed the required lighting intensity according to DIN EN 12464. For each room type, compliance must be provided by a certified computer program (such as Dialux). The result should be verified after the lighting is installed in spot checks.
b) The limit values specified in *Leitfaden elektrische Energie im Hochbau des Landes Hessen* (LEE, July 1996 edition) should be used as targets. The installed lighting capacity should reflect the required nominal lighting intensity according to DIN 18599 (note: programs such as Dialux comply with the standard with respect to Em). The limit value including the ballast box is 2.5 W/m²100lx, and the target value is 2 W/m²100lx. These values apply to the sum of basic and effect lighting (if it is present at all), yielding a limit value of 7.5 W/m² and a target value of 6 W/m² for a classroom with 300 lux. A standard classroom can usually be adequately lighted with eight single-element, efficient, wide dispersion 36-watt lamps (two of them for the blackboard). In a special classroom, usually six 2 x 36 watt lamps and two 36 watt lamps for the board are adequate. Experience shows that a maintenance factor of 0.8 is adequate for design purposes.
c) Computer servers that generate high levels of heat or need to be cooled should usually be installed on the north side of the building or in basement rooms (as long as the rooms are dry).
d) Before expanding a transformer station or an electrical connection, an assessment should be made to determine whether cost-neutral savings can be made with the existing system to avoid having to increase capacity.

C. Guidelines for minimizing operating costs

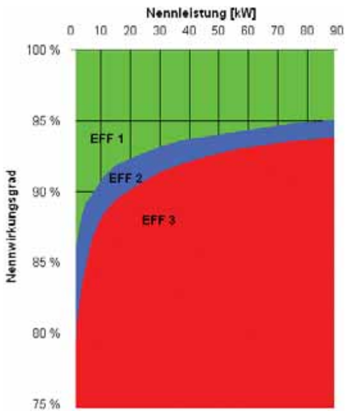
a) The light yield of the lamps should be at least 50 lm/W including the ballast box (fluorescent bulbs or compact fluorescent bulbs should be used instead of light bulbs).
b) At greater than 300 h/a, electronic ballast boxes are to be used.
c) The lighting efficiency should be at least 80 % (mirror screen fittings, etc.).
d) In large rooms (such as classrooms), lighting should be arranged in rows that can be switched on separately to permit lamps to be switched on or off to adjust to need, daylighting conditions, etc.
e) Large lighting groups (> 1 kW, such as in gymnasiums) should generally be equipped with motion detectors (or a light sensor in daylighted areas).

f) Rarely used rooms (such as hallways, stairwells, storage rooms, and basements) should be equipped either with time relays (with adjustable time delay: standard value 3 min.) or motion detectors. If daylighting is used, the motion detectors should be supplemented by light sensors.
g) For indoor toilets, locker rooms, etc., motion sensors at the entrance combined with acoustic sensors should be used.
h) Newly installed classrooms should be equipped with central lighting cut-off switches set to switch off the lights 5 minutes after every class period. For other applications, planners should consider using a central cut-off switch activated when adequate daylighting is present and at the end of periods of use.
i) Exterior lighting should be switched on with a daylight control and timer (as long as this does not conflict with a safety requirement) or with an additional motion detector.
j) Electric heating should be avoided. Kitchen appliances, such as stoves and convection ovens, should be gas-operated, which is usually economically feasible.
k) Office appliances should meet the criteria of the GED label (www.energielabel.de). Household appliances should be efficiency class A+ or A++ (www.spargeraete.de /Frankfurt).
l) If it is economical (in kitchens, etc.), a load shedding should be installed.
m) Reactive power should be limited to the load power factor (cos phi) authorized by local power company. If necessary, a compensation system can be installed (as an individual, group or central compensator).
n) If UPS systems are needed, they should have an efficiency class of 3 in accordance with EN 62040-3.
o) For computer equipment, an adequate number of separate designated power outlets with special fuses should be installed (see 3.8).
p) LEDs should generally be used for emergency lighting.

3.6 Mechanical systems

C. Guidelines for minimizing operating costs

a) All electrical drives should be equipped with energy-saving motors (more than 500 h/yr, eff2 motors, more than 1,000 h/yr eff1 motors or DC motors).
b) If elevators are needed, they should comply with efficiency class A according to VDI 4707.
c) If an emergency generator is needed, it should be a cogeneration unit whenever possible, unless economic or operational reasons demand otherwise.



3.7 Measurement, control, and regulating systems

C. Guidelines for minimizing operating costs

3.7.1 Basics

a) For economic reasons, the management and the operational monitoring personnel should provide an open control system. Therefore, all of the building services should be planned such that they can be operated from a common process visualization system (Wonderware's IAS/InTouch View). The common visualization system makes central operational control and system optimization possible, while simplifying training for operational personnel. The precise default settings for the system should be included in the required building operators' manual (www.stadt-frankfurt.de/energiemanagement/dok.htm).
b) Integral planning is necessary for measurement, control, and regulating systems.
c) During planning, building automation function list and, for each system, an automation sketch according to DIN EN ISO 16484-3 should be generated.

3.7.2. Field plane

a) In the SPS/DDC and in all of the documentation, all data points should be labelled as follows according to a unified 28-digit general designation system (see building control system operator manual.)

Position 1-4:	Street identification code
Position 5-7:	House number
Position 8-9:	Building
Position 10-11:	Floor
Position 12-14:	Cost group
Position 15-17:	System number
Position 18-24:	Machinery
Position 25:	Physical descriptor
Position 26:	Street address
Position 27-28:	Consec. no.

Keys are available for the individual fields under www.stadt-frankfurt.de/energiemanagement.
b) For every complete building (gymnasium, etc.) and for every user-group within a building, a separate demand meter for electricity, heating energy, and water should be installed. That includes temporary container facilities. All of the demand meters (utility company meters and supplementary meters) should be equipped with isolated pulse outputs (and possibly and M bus) for central data logging. The pulse value should not exceed the following values:
Power: 0.01 kWh/pulse, gas: 0.1 m³/pulse, heat: 1 kWh/pulse, water: 1 l/pulse
c) All power, heating energy, and water consumers (building, building parts, devices) expected to exceed 2,500 € in costs annually should be fitted with supplementary meters (equipment energy and media logging measures specified in FKGB/AMEV apply). In

particular, the cold water intake for central hot water installation should be logged (to prevent legionnaire's disease).

d) In facilities that have annual power and water costs in excess of 15,000 €, all of the usage meters should be connected to a data logger (for automatic consumption logging) and/or to the process visualization system (see management level). A data socket or modem connection should be available on the low voltage main distribution board for the logger connection.

e) To the extent economically justifiable (additional costs < 10 %), all of the sensors and actuators on the field plane should be connected to a universally compatible bus, for data transfer from all of the connected equipment. If there is already a bus system for one of the building service subsystems (individual room controls, blinds controls, etc.), compatibility of the bus with the other systems should be checked and a unified bus system installed, if it is economical.

f) When a bus installation is performed, the cost-effectiveness of also installing motion detectors for switching off lights, individual room controls, break-in alarms should also be reviewed.

g) Room sensors should have an accuracy of <= 2 % of the typical use measurement range for a period of at least 10 years (temperature <= 0.5 °C, humidity <= 2 %, CO_2 concentration <= 20 ppm). The sensors should be placed in an undisturbed location in the room (at least 2 m from windows, doors, air vents, heat sources, etc.)

3.7.3 Automationsebene

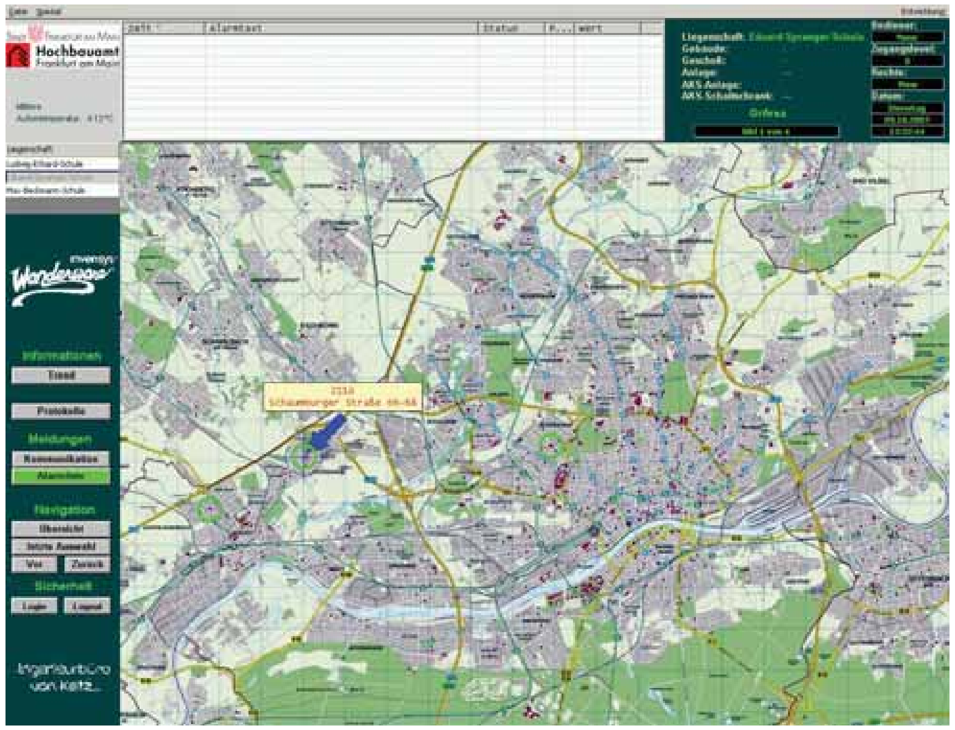
a) Generally, autonomous digital regulators for each system should be used (DDCs in decentralized systems)

b) The DDC substations should all have a common type of universal interface, so that they can all be connected on the automation plane (e.g. Modbus, LONtalk (LONMark certified))

3.7.4 Management plane

a) In facilities with annual energy costs in excess of 30,000 €, a management plane consisting of a universal process visualization system (PVS) using Wonderware's IAS/InTouch View is to be set up either on site or at a remote control room. At the facility, the PVS replaces the central control computer of a manufacturer-specific building control system. The main PVS computer displays a complete process visualization of all the building services systems and their data points. Wonderware DA, DI or I/O server based protocols and driver software must be used for data transfer between the automation stations and the PV system. OPC servers are only approved if one of the above-named servers is unavailable and the contractor can provide proof of compatibility with the Factory Suite Gateway and an OPC foundation compliance test.

b) The monitor layout will adhere to a prescribed standard, so that all facilities will have a user-friendly, common interface from which to operate the building control system. Access is obtained via a common selection window with an aerial map and floor plans



(including room labels) or images of the property including information on areas of the building or groups of rooms and/or systems.

c) In a status window, the current status of the user, login name, access level, and date / time of the client computer is displayed.

d) At the lowest level of the system diagram (control diagram), all of the actuators and sensors in the corresponding systems and room groups along with their technical systems – such as heating systems and boilers, pumps, mixers, target and actual temperatures, as well as meter readings or room groups with their heating, window blinds, and lighting systems – are displayed. The current values and system dispositions are shown, as are possible actions.

e) All of the system diagrams must be fully editable for those with write-access.

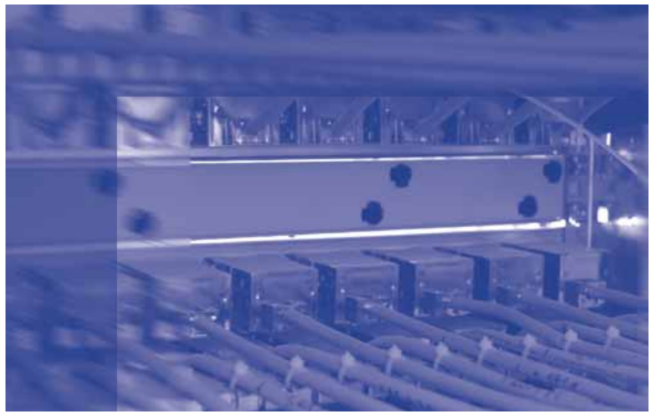
f) In an error alert window, current error messages are displayed from top to bottom from the perspective of the observer. In other words, all of the error messages are visible from the very first screen. From the current system view, only the error messages pertaining to that system are visible.

g) Occupancy plans have to be assignable for every room (at least weekly and yearly plans). In schools, class schedules can be imported into the software. The vacation/holiday calendars have to be accessible centrally for every room. Subsequent modifications for individual rooms have to be possible. The occupancy schedules have to be able to be copied into every room. In addition, it has to be possible to enter irregularly occurring events without having to change the occupancy plans.

h) Additional components of the PVS are: A data point list with copy and paste functions in system schematics, function descriptions, linking to additional object files and measurement value processing.

i) Users have to be able at any time to graphically assess all data points (such as use statistics, room temperatures) via monthly values and 1/4h load profiles (trend curves) on the PVS.
j) All central control systems and alerts have to be arranged at a central location, such as in the caretaker's office. It should be possible to transfer the control system at any time via a modem, Internet or intranet to the central facility management office.
k) Deviations from target temperatures and targets for consumption values should be programmed to trigger error messages.
To alert on-call personnel, high-priority error messages from the building control system/PVS should be delivered via text message on a D1/D2/E-Plus mobile telephone.

3.8 Communications equipment



a) In all offices and classrooms, a common cable topology for telecommunications (ISDN) and data network (100BT) should be planned to make subsequent upgrades easy. A logically separated building services network should be created within the data network for building automation.
b) Rooms that have a single workspace should be equipped with 2 telephone connections (ISDN) and 2 data connections (10BT). For each additional workspace in the room, an additional telephone connection and data connection are added.
c) Computer cabling should be installed in conformity with the Amt 16 directive "*Grundsätzliches zur Verkabelungstechnik*" in its current edition (the directive can be downloaded over the Internet on the Amt 16 website in the downloads area).
d) For computer and office equipment, the current GED label values should be adhered to (www.energielabel.de). To allow equipment to be properly taken off the mains, all PC workstations must be equipped with power strips that can be switched off.

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Stadt Frankfurt am Main