OPEN COMPETITION

Energy Design of High Performance Buildings

Organised by EC-JRC and ESRU

Target group: under-graduate, postdoc, PhD students and researchers level

SUMMARY

The objective is to assess for a simplified high performance building (a cube), in a chosen climate and associated building energy regulations, the minimum primary energy consumption and GHG emissions for local boundary conditions by optimising thermal characteristics of the building envelop and the choice of building energy systems. The design freedom is in the building construction composition, the specific thermal parameters, the available energy resources and building system technologies. The energy design approach should follow three steps that deal with

1. building energy needs (envelope and its volume),
2. building system operational energy and
3. optimisation for available energy resources (feedback to step 1 and 2)

Beside the applied climate and building parameter settings, the results of primary energy consumption and GHG emission figures have to be reported.

INTRODUCTION

A **High Performance Building** is a building that consumes as little as possible energy during a whole year for heating, cooling, ventilation, light, hot water and copes with the presence of people and domestic appliances. Such a building is expected to have an optimised insulation of the envelope, profits from environmental energy resources and uses thermal mass to balance thermal energy flows. The energy building systems are high efficient and innovative technologies that optimise the use of the available energy resources, delivered to the building or available in the environment of the building.

Each Member State has its national and sometimes regional building codes and regulation. They differ for particular parameters based on specific conditions such as climate, energy-mix and calculation methodology. As an example, Member States differ for the dimensions used for floor area, e.g internal, external or heart to heart dimensions. This will affect the reporting of energy performance expressed in kWh/m^2 .In the scope of this competition it has been decided to apply the external dimensions which is limited to 10 by 10 meters. The minimum requirements set by the Member States in the building codes influence a lot the calculation methodology and results for reporting. The level of comfort that includes indoor temperature settings, temperature control regime, the air change rate etc. might differ even from one part of the country to another. It is important to take note of the boundary conditions and to report them

The aim is to study a particular simple construction (a cube) in a specific climate that is supposed to give insight in the energetic behaviour of the building in the climate chosen by the participant. The philosophy is to simplify the main characteristics of a building and to assess the important variables and parameters in the energy process for the purpose of energy performance assessment.
Through simplification the excluded phenomena might include: corner effects, thermal bridges, infiltration, stratification and multi-zoning however all these aspects could be a voluntary part of the study.
In relation to the annual energy consumption of this simplified high performance energy building, attention will be given to the **minimization** of the building energy needs (primary energy consumption), **maximizing** energy systems efficiency and the **optimization** of using the auxiliary gains, importantly the solar gains.

It is evident that dynamic calculation techniques have to be applied in order to take into account the variability of the climate, occupancy pattern and seasonal impact on building systems. It is advised to use hourly or daily intervals for the calculations. Apart from the requested annual primary energy consumption data, it is strongly encouraged to present monthly calculation results. Although not a specific request, the part of renewable energy resources in the annual primary energy might be welcomed.

Further information
A simplified representation of a multi-floor (-zone) construction is given. The aim of the competition is energy design and not necessarily architectural building design while the calculation step is recommended to be daily. The chosen form of the construction is a CUBE. Reference for hourly climate data (worldwide; the data resource will have to be reported) and could be:
http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm
For this particular resource the available data (.ZIP) is in EnergyPlus format; when necessary, convert all the data.

The climate data should contain hourly observations for a period of one year. Location as well as the applied heating and cooling period (e.g. duration) should be reported.

GEOMETRY
The object to be studied could be considered as a residential building with a number of parameters that can be freely chosen. However, the residential building is a 10 * 10 * 10 m external dimensioned construction, a cube, with little restrictions for energy design. This building consists of

more than one floor. These floors could be considered for thermal mass. It is up to the building designer to choose for that purpose the materials; wood, concrete, etc. Floor and roof should be considered opaque and could be treated in the same way in the energy design. The sum of the 4 wall surfaces needs to have a minimum window (glazing) area of 20%. The composition of the walls can be freely chosen, e.g. air gap brick wall or a fully glass façade, could be an option.

Remember that the external dimension is defined (10 x 10 m.) and should be used for the Primary Energy consumption report for the reason of comparison. There is no restriction on architectural (e.g. aesthetic) design including application of fixed external shading construction and devices and within the provided volume the use of thermal mass. Use your imagination but stick to the limited restrictions for energy design.

In particular ventilation technology is important. This will become clear when the below presented steps are followed.

RECOMMENDED APPROACH

The energy design proposed approach should follow three steps in order of priority and that deal with:

Step 1: **Minimisation** of energy consumption (e.g. saving). Calculate the energy needed for the construction in the chosen climate while applying the related building regulations for energy.

Step 2: **Maximisation** of energy use (e.g. efficiency). Fulfil the building energy needs by selecting appropriate building systems and calculate the operational energy consumption.

Step 3: **Optimisation** by seeking the energy technologies and resources available including auxiliary gains; feedback to step 1 and/or 2.

1 - Building energy needs

Depending on the chosen climate and therefore the requirements for building energy design, the design of freedom lay in the thermal parameters (do not consider building energy consuming systems yet). As an example this means that for a country as Sweden the geo-position is giving the climate as well as the minimum requirements for energy performance as stated by the regional or national regulations.

Heatloss of the opaque part of the building; one may decide to use one or more different heatloss coefficients; as a minimum: one for the walls and another one for the floor and roof, etc..

Heatloss of the window (glass) part of the building. An option for simplification: assume all walls having the same size and position of the window (glass). Report the specifications for all windows and if they can be opened (as an energy design feature).

Solar aperture of the whole building; one may decide to study the window size and the placement of the window, for example in a thick wall the position may influence the solar aperture, (in plane with external wall or towards internal wall, reducing the solar aperture). Further passive design is an option, like solar protection. Fixed shading devices can be added if required.

Thermal mass; one may decide to study the size and placement of thermal mass ranging from the external opaque walls, floor and roof to symmetrically placed inside the volume of the construction.

Ventilation rate in air change per hour (ACH). Note that mechanical ventilation and heat recovery systems as are all energy conversion systems and are considered under the building system section.

The choice of using the information that the building consist of more than one floor, can be made; this might give some freedom for ‘playing’ with thermal mass, etc. However you might want to consider the construction as one-zone for the internal temperature. Natural ventilation can be an important design feature and details of operation have to be reported and if necessary in relation to wind conditions.

For the reporting of the energy consumption figure, the external area has to be taken multiplied by the number of floors.

2 - Building system operational energy needs

System technologies

The choice of an energy system technology for heating, cooling, ventilation, air-conditioning, domestic hot water (DHW) and light systems can be selected freely depending on the available energy resources related to the selected location. Reported has to be the energy efficiency and coefficient of performance for each of the applied systems and installations while considering duration of operation during the year. Note the importance of working hours during heating or cooling period.

Energy consumption due to occupancy

Four people, a common family size, are assumed to live in the residential building. Assume a realistic occupancy and use of domestic hot water, appliances and light. For metabolic heat, a gain of 100 Watt/person could be used.

Note that all assumptions have to be reported and are importantly defining the final results.

Available energy resources

For this evaluation keep in mind step 3 and consider:

- Delivered energy carriers (behind the counter or under contract; local conditions)
  Electricity, Gas, Oil, Coal, Biomass, District heat
- Environmental energy (not measured and from climate or local data conditions)
  Solar radiation, wind, bio, geo- (air, water, soil) source.

3 - Optimisation of the energy design

When necessary, apply local data for the available national or regional energy mix and energy prices (year 2011; preferably from the Eurostat Yearbook KS-CD-12-001-EN).

As an example: for Sweden the energy mix may be importantly representing renewable energy resources. This will give feedback information to step 2 and in some cases to step 1 of the approach.

An important consideration is the technical evaluation of the assessed energy design. Note that the requested performance results will have to deal with a period of one year and should consider operational energy costs only. However try to focus on energy design, technology and available energy mix. Calculations using energy prices should include VAT.

Reporting requirements; see next page in Annex.

Minimum reported information:

Traceable data for chosen climate and associated building regulations (national or regional).

All data sources for minimum energy performance requirements as well as for available energy resources and energy prices.

Report anything that you consider as important for the final judgment, such as any energy gain or supply that will influence the final result.

According to the EPBD the primary energy consumption and GHG emissions (see EN 15603) have to be reported against external dimensions of the building. The use of conversion coefficient is accordingly. See annex.

Annex. Reporting template (minimum requested information)

To be completed by applicant (please inform DYNASTEE about your intention to participate)

Name and contact information :

Attached documentation (PDF and data) :

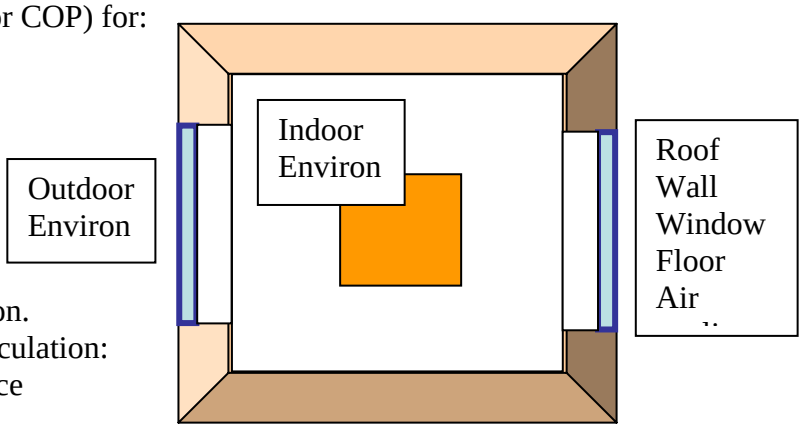
1. Geo-position (coordinates) and climate location that has been applied for the calculation

2. Building regulation or building codes (country or region)

Building energy needs: kWh /m^2
Applied Minimum requirements for:
U-values for Roof, Floor, Wall, Window or other
Ventilation: Air changes per hour
Applied indoor temperature settings for heating and/or cooling period

Operational energy: Primary Energy consumption: kWh /m^2
Applied technology (report efficiency and/or COP) for:

1. Heating
2. Cooling
3. Ventilation
4. DHWater
5. Light



Economic evaluation in € per kWh /m^2
Available energy mix for the applied location.
Energy prices (including VAT) used for calculation:
Remember to report the reference data source
(like: Eurostat 2012 Key Figures):
Reference year (20xx) :

1. Electricity
2. Gas
3. Oil
4. Coal
5. Others (district heat, biomass/pellets)

For the calculation of Primary Energy report the applied conversion factor(s).

For clarification you may decide to add a design of the construction.

IMPORTANT
The deadline for submission is yearly **1st of June** (please inform DYNASTEE about your intention to participate)
A jury will be composed of international acknowledge experts in the field of energy performance of buildings.

The **assessment criteria** will be based on

- The most realistic approach to achieve low primary energy consumption and GHG emission for the selected building in the provided climate.

Further Information

The philosophy that supports the reduction of energy consumption in buildings for a given climate is presented in three priority steps:

1. Minimisation: Energy saving (improve insulation; envelop related),
2. Maximisation: Increase energy efficiency (building installations, comfort related),
3. Optimisation: Use renewable energy resources (solar energy, etc., boundary related).

In general Energy Performance of Buildings can be classified in three consumption categories:

- **Building energy needs (savings).** This is directly related to indoor (comfort level of temperature, air quality and light) and outdoor climate conditions (temperature, solar radiation and wind) for working and living in buildings. The heat transfer through the building envelope and the ventilation define importantly the building energy needs. Minimum energy performance requirements are set for insulation levels of walls, roof, floor and windows, etc.
- **Building systems energy (efficiency).** The combined efficiency of the installations for heating, cooling, ventilation, hot water and electricity are the relevant factors in the end-use energy consumption. The EU harmonises national measures relating to the publication of information on the consumption of energy and of other essential resources by household appliances, thereby allowing consumers to choose appliances on the basis of their energy efficiency in relation to the available delivered energy carrier.
- **Occupancy energy consumption (behavioural).** The remaining use of energy depends on how the occupant makes use of the building. Household appliances, such as washing machines, refrigerators, etc. and entertainment apparatus, such as TV and computers, consume mainly electricity that is converted for a great part into auxiliary heat. Occupancy behaviour is covering also variable aspects as the opening of windows, temperature setting, etc.

This open competition for energy design focuses on the most important parts of building energy consumption, cq the building energy **needs** and the auxiliary gains due to climate boundary conditions and usage of the building. The use of renewable energy resources in the built environment, like solar radiation (passive design and thermal and electrical technologies) is considered an important factor in the whole design process. Included are aspects of **efficiency** of installations, defined **occupancy** behaviour, available energy-mix and available energy resources, etc.

High performance or low-energy consuming buildings can become reality when the design process takes into account the energy flows, in particular from passive solar and landscape design (orientation and immediate environment, including soil) integrated with architectural design. This design will have to incorporate technologies that are related to the envelope (ambient exposed surface area) and space (volume contained by the envelope).

New insulation products and techniques for construction materials, facades, windows and doors are available for new buildings and refurbishment. Air tightness and thermal bridges of the whole construction receives more attention than before to reduce overall energy consumption. The sun as source of our energy system could be utilised effectively in a passive solar and landscape design.