DOCET^{PRO}: Energy Certification and Diagnosis Software on Web Platform

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Abstract

DOCETPRO was born from the experience of national boards ITC-CNR and ENEA, which are in charge of the research activity related to the energy performance of buildings. The new tool aims at defining a national web platform with a calculation engine recognized at regional and ministerial level, that implements the Italian standard UNI TS 11300 concerning the energy performances of buildings, and acknowledges the European standard EPBD (Energy Performance of Buildings Directive) at national level. DOCETPRO is an energy certification software and as such it guarantees the reproducibility of results and the standardization of the calculation methodology. The software produces an XML file that allows the interchange with other software. The tool is based on the monthly balance method. Customers can define the building model, creating several dispersing surfaces with different physical and constructive characteristics: these may be horizontal or vertical, opaque or transparent surfaces. Customers can also define the heating system, with one or more traditional and non-traditional heating generation systems and domestic hot water generation system; it is also possible to define the thermal solar system and the photovoltaic system. The last part of the software is the cost/benefit analysis that allows the economic evaluation of several energy retrofit actions.

Keywords: DOCET^{PRO}, web platform, energy certification, UNI TS 11300

1. Application context

Since mid-2008 UNI TS 11300 part 1 and 2 were issued in accordance with standards developed by CEN under mandate M/343 in support of Directive 2002/91/EC on the energy performance of buildings; the need to define a single national instrument of calculation was generated in this context. The goal is to create an Italian Web portal, called Web Service Channel (WSC), that supports the calculation engine DOCET^{PRO} updated to UNI TS 11300 for energy certification of buildings.

UNI TS 11300 part 2 defines 3 different types of energy assessment:

- Design assessment: the calculation is made on the basis of design data; for the conditions of employment and use of the building and the system a continuous operating system is assumed;

- Standard assessment: the calculation is made on the basis of the data concerning both the building and the real system, as built; for the conditions of occupancy and use of the building and the system a continuous operating system is assumed;

- Assessment under actual use conditions: the calculation is made on the basis of the data concerning both the building and real plant, as built; for the conditions of occupancy and use of the building and the system actual operating values are assumed.

DOCET^{PRO}, as a software of energy certification, is consistent with the design and standard assessment. For the purpose of energy diagnosis it is advisable to carry out the third assessment, integrated with the measurement of consumptions.

2. Software architecture

The software is based on the monthly balance method, aimed at the energy certification of buildings, according to different uses.

The calculation of net energy for heating is carried out according to the UNI TS 11300 part 1, which defines the net energy as the balance of heat losses and heat gains.

The primary energy for heating is calculated according to the methodology laid down in UNI TS 11300 part 2, which defines the primary energy as the balance of heat loss and heat and electrical recovery for every subsystem of the heating and domestic hot water system.

The model building is user-defined as a single thermal zone, thus creating different opaque and transparent, horizontal and vertical scattering surfaces, as detailed as deemed appropriate by setting a minimum number of areas according to the differences between building, physical and exposure characteristics of the individual elements.

For existing buildings, where information retrieval is often an issue, the software gives tips based on the input data and qualitative input entered by the user and according to the abacus contained in the regulations.

DOCET^{PRO} evaluates one or more heating generators, choosing between traditional and non-traditional systems not taken into account in technical standards UNI TS 11300 part 1 and 2, such as thermal solar and photovoltaic systems, heat pumps and micro-cogeneration. The normative references for this type of evaluation are as follows:

- Heat pump: UNI EN 15316-4-2;
- Thermal solar system: UNI EN 15316-4-3;
- Micro-cogeneration: UNI EN 15316-4-4;
- Photovoltaic system : UNI EN 15316-4-6.

The evaluation of multi-heat generation systems is performed with the introduction of allocation factors allocating the thermal energy among the different generators.

The software also contains a cost/benefit analysis, called CBA, for specific types of energy retrofits; starting from a fuel price and a cost manually entered, the certifier can get some economic parameters to determine the specific financial indicators (e.g., payback time, NPV, etc.).

The cost/benefit analysis is therefore an objective tool to evaluate, to compare and to optimize the economic feasibility of possible energy-efficiency refurbishment works identified by the energy diagnosis and fits in the evaluation approach of a building as follows:

- Specific energy diagnosis made by the certifier;
- Identification of performance deficiencies of the building;
- Definition of targets for improvement in performance to be achieved;
- Study of possible alternative technological actions, on equal performances, to achieve the set targets;
- Assessment of the viability of alternative technologies through the CBA identified and definition of the solution allowing the aspects of performance to match at best the economic efficiency.

3. Performance indicators

The methods developed within CEN define three steps of calculation with related performance indicators:

- Net energy;
- Delivered energy;
- Primary energy.

The requirement of net energy is that necessary to meet criteria of comfort, taking into account the thermal losses and gains; this parameter varies depending on the thermal transmittance, orientation, shape factor, profiles of use, etc., and basically indicates that the architectural and construction solutions are fit for the building envelope.

The delivered energy is that actually measurable at the "power meter"; the calculation depends on the type of technological systems installed, their efficiency and the performance factor, and gives comprehensive information on the efficiency of the “building-plant system”.

The third indicator is the primary non-renewable energy, which indicates the actual consumption of non-renewable resources, depending on the fuel used and the actual use of renewable energy sources.

Only the evaluation of all performance indicators described provides comprehensive information on the strategies and the choices made to serve the purpose of increasing the energy efficiency of a building.

3.1 Net energy

The net energy for heating, $Q_{H,nd}$, and for cooling, $Q_{C,nd}$, expressed in kWh, is determined by the balance of losses (transmission and ventilation) and gains (internal and solar gains), according to the following formulas:

$$Q_{H,nd} = \left(Q_{H,tr} + Q_{H,ve}\right) - \eta_H \cdot \left(Q_{int} + Q_{sol}\right)$$

$$Q_{C,nd} = \left(Q_{int} + Q_{sol}\right) - \eta_C \cdot \left(Q_{C,tr} + Q_{C,ve}\right)$$

where:

$Q_{H,tr}$ is the total heat transfer by transmission for heating, expressed in kWh;

$Q_{C,tr}$ is the total heat transfer by transmission for cooling, expressed in kWh;

$Q_{H,ve}$ is the total heat transfer by ventilation for heating, expressed in kWh;

$Q_{C,ve}$ is the total heat transfer by transmission for cooling, expressed in kWh;

Q_{int} is the sum of internal heat gains over the given period, expressed in kWh;

Q_{sol} is the sum of solar heat gains over the given period, expressed in kWh;

η_H is the dimensionless gain utilization factor.

η_c is the dimensionless utilization factor for heat losses.

The net energy requirement depends on the characteristics of the building envelope, such as: geographical location (province, municipality, degrees/day, latitude, altitude, etc.); intended uses of the building; geometry of the building; thermo-physical features of opaque and transparent technical elements (thermal transmittance, surface coloring, solar factor, etc.).

3.2 Delivered energy

The energy delivered for heating and/or for the production of hot water for domestic use depends on the technological systems installed. The heat producing systems can be divided into the following subsystems:

- Heating: emission, regulation, distribution, stoke, generation;
- DHW production: emission; distribution; stoke; generation.

For each subsystem the following shall be determined:

- total amount of energy entering the subsystem;
- total auxiliary energy of the subsystem;
- losses;
- recovered losses.

The calculation is made from the downstream system (emission system) to the heat generator, as defined in figure 1.

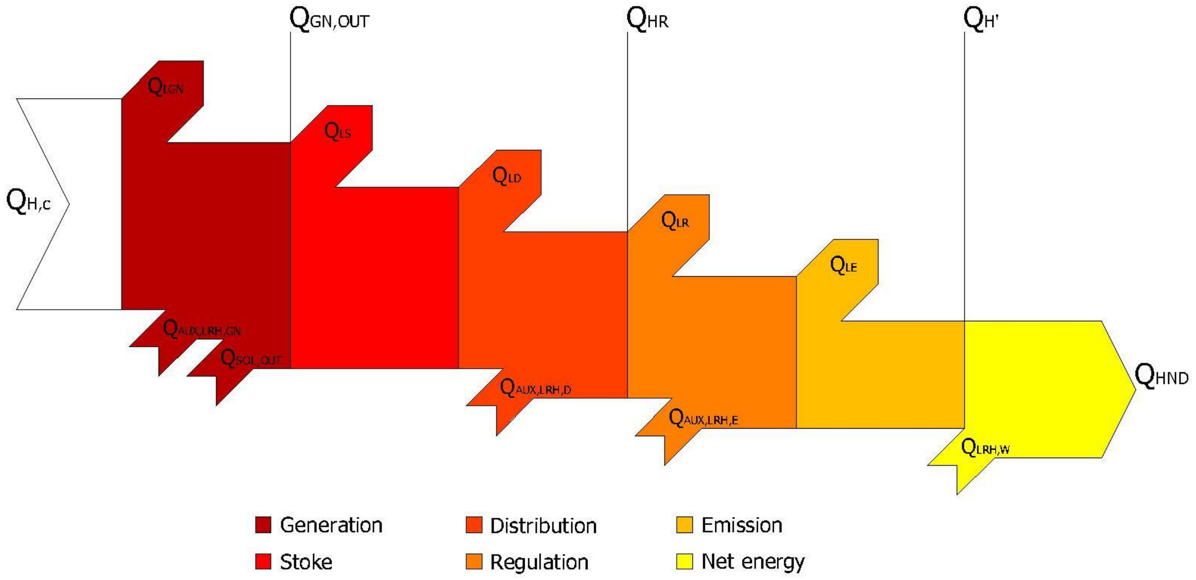

Figure 1: Heat flow of the heating

3.3 Primary energy

The primary energy is defined as the energy potential presented by carriers and energy sources in their natural form, i.e. energy that is not subject to any conversion or transformation process; the tool adds different forms of energy such as fuel (natural gas, oil, biomass, etc.), self-produced or purchased electric energy, derived from renewable sources (geothermal, hydroelectric, wind, etc.) or fossils.

For evaluation of the heating and/or DHW production, the primary energy factors allows the thermal and electrical energy used by the auxiliary systems to be added, according to the following formula:

$$Q_{p,H,W} = \sum Q_{H,c,i} \cdot f_{p,i} + \sum Q_{W,c,j} \cdot f_{p,j} + \left(Q_{H,aux} + Q_{W,aux} + Q_{INT,aux} - Q_{el,exp}\right) \cdot f_{p,el}$$

where:

$Q_{H,c,i}$ is the thermal energy requirement for heating obtained from each energy carrier, expressed in kWh;

fp,i/j is the conversion factor of the energy carrier into primary energy;

$Q_{W,c,j}$ is the thermal energy requirement for DHW production obtained from each carrier, expressed in kWh;

$Q_{H,aux}$ is the electricity requirement for the auxiliary heating system, expressed in kWh;

$Q_{W,aux}$ is the electricity requirement for the auxiliary DHW production system, expressed in kWh;

$Q_{INT,aux}$ is the electricity requirement for any auxiliary systems that use renewal energy sources, expressed in kWh;

$Q_{el,exp}$ is the electric energy exported from the system (photovoltaic, cogeneration), expressed in kWh;

$f_{p,el}$ is the conversion factor of auxiliary energy into primary energy.

4. Financial indicator

According to the European EPBD (Energy Performance of Buildings Directive) normative framework the energy certificate must be accompanied with recommendations for the improvement of the energy efficiency of the building. DOCET^{PRO} contains a section devoted to the cost-benefit analysis, in which possible energy-efficiency refurbishment actions are evaluated from the point of view of improving performance and the economic and financial impact; to this end, the simple payback time of investment is calculated.

4.1 Simple payback time of investment (SP)

The simple payback time is defined as the number of years necessary so that the cash flows (excluding debt payments) equal the total investment, according to the formula:

$$SP = \frac{\text{Initial investment}}{\text{Annual saving}}$$

The simple payback time is one of the most important financial indicators because it determines the time needed to recover the capital invested through the analysis of annual flows of each specific operation.

Since this method does not evaluate the cash flow after capital recovery time and does not take into account the possible currency floating over the time, the value calculated in years for the SP needs to be compared with the expected useful life of the refurbishment; in order for the solution to be economically feasible, the SP must be less than the useful life of the refurbishment.

In the event that the simple payback time is used as a tool to compare and choose the solution that, on equal achievement of energy targets, better meets the financial and economic needs, the solutions with the lower SP value will be preferred.

5. Conclusions

The goal is the realization of an energy platform, called Web Service Channel (WSC), in which DOCET^{PRO} is the tool for energy certification of buildings updated to UNI TS 11300.

WSC is an advanced environment where tools for energy certification are available. It is a user-friendly desktop interface represented by a centralized web-based browser usable operating system; this technology allows the updates to be always available.

References

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