THE ENERGY INTENSITY AS A NEW PARAMETER FOR THE VALUE PERFORMANCE OF THE ENVELOPE OF BUILDING STOCK

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Summary: the energy of the existing building stock

In the general context of the impact evaluation of the building sector on the environmental systems, the energy parameter represents a fundamental factor for the inquiry a necessary indicator to give a quantitative evaluation to the environmental compatibility of a building technical system.

In this studies, the research are focalized on the building envelope, in particular the value of the "energy intensity" used in the production of materials and components.

The objectives derive from the necessity to define a methodology of intervention in this ambit and to associate it to systems that, since the production phase, have an energy behaviour in line with the necessity to guarantee interventions with low environmental impact. In addition, the choice of the technical solution to adopt in the actions on existing building, takes in consideration the "new" parameter of the energy intensity in production phase. The existing building stock already embodies a certain quantity of energy, defined as "latent energy". Such energy store should not undergo excessive increase in consequence of over-dimensioned actions for energy requalification.

Keywords: Building energy performance; Embodied energy; Building stock; Building envelope.

1 Our Approach: the role and evaluation of embodied energy

In recent years, the building and construction sector, as all others that are involved in the transformation dynamics of our planet, has undergone considerable changes. These changes to a great extent have been caused by the conceptual and operative consequences of themes regarding the sustainability of their actions.

In the context of international debate, consensus is commonly reached regarding the impact of the construction industry on the planet's carrying capacity, indicating how far materials are a determining factor in the increase of critical levels related to the said impact.

There is no doubt that the constantly increasing flows of energy required by production processes must now be considered as new "incorporated rates" which increase the environmental burden of any given product and which therefore constitute an additional quality to be taken into account in the decision-making procedure.

Furthermore, in the light of quite justified alarms regarding the high energy consumption of the building industry, it has become necessary to revise all related processes in order to contain the effects of this particular characteristic – from the quantity of material required to the energy needed for its transformation – in order to reconstruct the entire product lifecycle whilst keeping to the performance requirements and regulations required .

In this sense, studies which investigate the types and quantities of energy employed in order to obtain “one unit of product” identify *Energy Intensity* as a parameter for control, using it as a principal indicator in the most consolidated systems for the evaluation of energetic and environmental performance of production processes.

In particular, the principle factor for the understanding and evaluation of the quality, incidence and therefore the effects of energy intensity related to production processes and building materials is the value of *Embodied Energy* (Alcorn 1998).

Sustainable Development and Eco-Efficiency patterns have revealed how much activities connected to the building cycle, at both programming and operative stages (material acquisition, manufacturing, building, management, demolition, recycling, disposal), have a decisive impact on the resource calculation and on the planet’s load capacity, in relationship to the waste produced by the cycle itself. Energy flow, which is converted and downgraded during building activity, can be divided into five categories:

- 1: energy necessary for material acquisition processes and relative transportation;
- 2: energy necessary for component production and manufacturing and relative transportation;
- 3: energy necessary for construction processes and relative transportation;
- 4: energy necessary for management and use of the constructed product;
- 5: energy flows of emissions, demolition, reclaim, reuse and recycling processes.

In addition to that used in building, the energy required for the use and management of finished constructions makes up about 50 % of the energy consumption of the European Union; in this sector, low temperature applications account for 85 % of the entire demand. The resulting environmental impact of this consumption is significant: the building sector is responsible for 33 % (average value) of the total energy consumption of EU Member States, producing 30–40 % of total CO_2 and CFC emissions.

This approach can be considered correct if one considers that the construction of a building uses materials and energy, variable in quantity and quality, which are necessary for the transformation and assembly of different elements.

In the light of this, one can consider Intensity, understood as the quantity of a given resource, energetic or material, used to produce services or products, closely connected to the Resource from the moment in which the building product begins to be built (Bringezu, Stiller, Schmidt-Bleek 1996)

It is then possible to set indicators that can direct the investigation. These indicators relate to two associated aspects in the eco-efficiency sphere:

- material performance both in use and potential;
- natural emissions during the material’s life-cycle.

For the building sector this means that:

- buildings should have a lesser impact upon the material stock of the planet (influence in the *Resource* area);
- buildings must be “thermally” efficient, in order not to contribute to the increase of emissions provoked by primary energy consumption (influence in the *Emissions* area);
- building cycle processes must control their performance regarding balance between acquired/transformed material and emissions produced in the cycle (influence in the *Resource* and *Emissions* areas).

In this way, the identification and evaluation of new and different performance characteristics of material would appear to influence the creation of specific eco-efficiency indicators in the building sector.

The approach to energy decision-making remains one of the greatest challenges in addressing climate change. Technology experts tell us that there are many energy efficiency technologies available today that are cost-effective and in line with current energy prices, but which are not yet being fully deployed. Our incomplete understanding of why such technologies may or may not be adopted is a prime example of the type of challenge involved in decision-making in the efforts to mitigate climate change.

2 Methodology

The situation that has arisen, shows how the eco-efficiency theme includes three important problem areas, which involve some clear control lines, feasible in an "entire cycle":

- *Resource* use (defined as groups: energy, soil, water, material)
- The *Intensity* of the energy and material of the same;
- the *Emissions* produced by the transformation processes.

Debate literature and the results of several studies, have always placed emphasis on how these three areas should be understood, and how they should be considered within the perspective of the *entire cycle.*

The various requirements go from the reduction of greenhouse gases produced by fossil fuel use, to the "drastic" reduction of resource use, to a minor waste of energy and material "per product and service unit", to the increase of service intensity, to the product use and durability extension. A synthesis of these requirements can be represented by the WBCSD eco-efficiency concept definition studies: "… to improve their eco-efficiency the companies must: – reduce material intensity of goods and services, reduce toxic dispersions, increasing material recyclability, extend product durability, increase service intensity of goods and services (WBCSD 1999).

There is no doubt that the constantly increasing flows of energy required by production processes must now be considered as new "incorporated rates" which increase the environmental burden of any given product and which therefore constitute an additional element to be taken into account in the decision-making procedure.

Therefore, studies which investigate the types and quantities of energy employed, identify *embodied energy* as a parameter for control, using it as a principal indicator in the most consolidated systems for the evaluation of energetic and environmental performance of production processes.

The quantification of embodied energy in any particular material is an inexact science, requiring a "long view" look at the entire life-cycle, and filled with a large number of potentially significant variables. Consequently, obtaining accurate figures for the evaluation tool through embodied energy calculations, is highly complex (Atkinson 1999).

The embodied energy value is the energy per unit necessary for:

- quarrying the raw material;
- transportation to the manufacturing unit;
- manufacturing building material;
- transportation of finished material to the distribution outlet.

The assessment of embodied energy considers the energy required to extract raw materials plus the energy used in primary and secondary manufacturing activities to provide a finished product. There is embodied energy in any processed product, from a pen to a building.

In order to reduce the complexity of the evaluation process, the present study has been conceived on the basis of protocol evaluation models or models which reference the decision-making code. Further and more rigorous evaluation of acquired data that may be translated into software and databases may be carried out at a later point (Baird, Alcorn, Haslam 1997)

Drawing on a critical reading of the premises and of the most significant results of state-of-the-art and regulatory references, the present study has defined a procedure for research which has developed in concordance with three phases: analytical-cognitive, analytical-critical and critical-purposeful.

Of the range of performance values offered by the type of building subjects involved in the experiment, the thermophysical behaviour requirement seemed the most able to offer a thorough picture of the response to the needs highlighted earlier, inasmuch as that, depending on material and therefore on the material nature of the resources, it influences quality and emissions capacity.

Considering the particular “numerical” nature of the data and values which may influence the achievement of the objectives, the formulation of the results has been guided by a model which makes reference to the instrument for Protocols and Codes. The goal was to produce a Support Instrument for Decision-Making, split into various scales and phases in order to assist the different users in the different choosing processes.

In particular, the general objectives were to:

- Identify new efficiency solutions for materials, defining the relationship between their energy intensity and the possibility of reaching the standardized minimum base value.;
- Understand whether high energy intensity of material corresponds to high efficiency with regard to the heat control requirements;
- Establish whether (and in what way) high energy intensity of material corresponds to high environmental impact;
- Try to define percentages of energy intensity that may be added to the material’s unit of product separately from the aforementioned percentage of energy intensity.

The field of study has examined the following construction systems: 1. reinforced concrete 2. steel. All the sealing elements (horizontal and vertical) and their functional coatings have been considered with different material compositions. In particular the following materials have been considered traditional materials (cement, mortar, bricks e terracotta) and innovative building materials (cork and olive residues).

From these, the elements to have been taken as base parameters and parameters for comparison, elaboration and evaluation are those of Embodied Energy from the studies of A. Alcorn and G.J. Treloar (Treloar 1996).

3 Conclusions

The present research provides a contribution towards the identification of integrated strategies of requalification, developed according to local specifications, for a more efficient and more effective policy of intervention.

Therefore, the proposed tool enables the definition of a design criteria, based on the concept of the individuality of requalification actions. The tool should avoid rigid standardizations, but rather suggest approaches which unite the conformation of the building organism and the context in which the latter is localized.

The choice to simply consider the energy parameter as a prejudicial factor for strategies of intervention, could mislead users with little experience and limited technical and technological knowledge. It is also important to underline the experimental character of the proposed tool and to emphasize the possibility that it be implemented and improved through the addition of other parameters (for example durability and maintenance 1838of technical solutions).

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