

Instituto de Engenharia de Sistemas e Computadores de Coimbra
Institute of Systems Engineering and Computers
INESC - Coimbra

Denilson França Moreira*, Osvaldo Luiz Gonçalves Quelhas*, † and Valdir de
Jesus Lameira§

**Energy efficiency in Brazilian buildings: analysis of software to support
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Instituto de Engenharia de Sistemas e Computadores de Coimbra
INESC - Coimbra
Rua Antero de Quental, 199; 3000-033 Coimbra; Portugal
www.inescc.pt

* Federal Fluminense University, Rio de Janeiro, Brazil
*, † Federal Fluminense University, Rio de Janeiro, Brazil
§ INESC Coimbra, Coimbra, Portugal

Energy efficiency in Brazilian buildings: analysis of software to support energy assessment

Abstract: This research presents an overview of the concepts of energy efficiency against the principles of sustainable development. We stress the importance of optimization of energy consumption, particularly within the buildings. It highlights the government initiatives and the impacts to the environment by various sources of power generation. The research identifies as important the existence of computational resources to support designers and users in order to optimize the use of electric energy in buildings. In the case study evaluates the computational resource "PLUS MARK IV. Present proposals for updating of computer resource using a critical analysis by specialists. The result of consultation with experts confirmed the importance of computational resources in project development and use of electricity in a rational way in construction. One conclusion is that the computational resources for management of electric energy use in buildings, allows obtaining the energy diagnosis and induces rationality in design criteria and use of energy. In the end, were outlined to the possibilities of improving the computational resource "MARK IV PLUS".

Keywords: Quality in Construction, Energy Efficiency, Engineering Sustainability.

1. INTRODUCTION: THE CONTEXT WHERE TO FIND THE RESEARCH PROBLEM

Sustainability and Business Ethics, according to Barbosa (2007), is characterized as an interdisciplinary term. Public policies have been developed in the country and internationally in the construction industry, supporting practices aligned with sustainability presents the relevance of research and development into energy to enable economic, social and environmental sector in Brazil. The IPCC (2007) estimated that approximately 30% of CO₂ emissions from buildings, in 2020, can be avoided. For this, suggests heating, cooling, lighting and appliances more efficient. Exploiting this potential in construction industry contributes to global sustainability. According to the IPCC (2007), the main ways to modify the emission of greenhouse gases are: awareness of the need to establish criteria for energy consumption, replacing fossil fuels with renewable energy and increasing energy efficiency. Measures to improve energy efficiency in energy consumption are among the most important options to reduce emissions of greenhouse gases in the construction industry. In this context it is relevant

to perform diagnostics energy in buildings. It is identified as equally important, the use of computing resources that provide improvement in the effectiveness of projects and use of buildings, balancing the economic and environmental outcomes in buildings as in Lee *et al* (2003).

2. THE RESEARCH QUESTION

This research aims to answer the central question: What are the critical factors to use and update tool for computational energy diagnosis, in particular the "MARK IV PLUS"?

This research is an analysis of how computational tools can influence the energy efficiency of buildings. Study the concepts of optimization in the use of electricity in buildings in the Brazilian market. Its specific objectives are: To analyze the computational resource "MARK IV PLUS"; propose guidelines for the improvement of computer resources; present computational resources for evaluation of building energy performance. To answer the central research question and achieve the objectives proposed hypotheses are formulated: a) the use of energy diagnosis contributes to improving energy efficiency in construction; b) the use of diagnostic energy encourages the consumption of energy in a rational and sustainable; and c) the use of computational resources enables the application in the design stages, the concepts of energy efficiency in buildings.

3. METHODOLOGY

It is descriptive research that has as its object of study is the use of computational resources for improvement of performance improvement in energy efficiency in the Brazilian construction industry. For data collection were employed two questionnaires answered by experts in the use of computational resources and energy efficiency. The questionnaires were aimed at clarifying the research questions, assumptions and objectives. Issues questionnaire components were intended to collect critical to the performance of computer resources.

The preparation of the questionnaire was based on the use of analytical model of strategic management of energy second Sola (2006). For elaboration of the questionnaires were created five dimensions for analysis of the "MARK IV PLUS: Architectural Dimensions, Economic, Ecological, Social and Politics. Each specific objective has been observed using one or more questions, as can be seen in table 1.

Table 1: Composition of the questionnaire and links with the research objectives.

Questionnaire	RESEARCH GOALS
Architectural Dimension	Identify in which sector is being applied in the study program and how it presents the surroundings of the building analyzed, as well as whether the program helps create projects energy efficient.
Economic Dimension	Demonstrate savings in energy expenses, identify if there was investment in more efficient equipment and if there is an awareness that with the energy savings decrease the need for new investments for power generation.
Ecological Dimension	Note the recommendation of some system of generating energy from renewable sources and if there is awareness that energy efficiency reduces the environmental impact of sources of energy.
Social Dimension	Identify whether there was transfer of knowledge to form a critical mass in implementing the program, if there was the recommendation of administrative measures in managing the energy consumption and identify the MARK IV PLUS can be used by people without specific knowledge.
Political Dimension	See the construction of the company's partnership with some public institution, with the goal of energy efficiency, knowing the opinion of experts about the possibility of building a distribution network of intelligent energy and evaluate the participation of PROCEL as the body responsible for implementing public policy.

First questionnaire was sent to 20 and 29 according to experts (working in the area of energy efficiency and users of computer resources to diagnose energy). The expert group who answered the first questionnaire (Appendix A) consists of twenty professionals from public, private and educational institutions. The survey was conducted on 09.01.2010, in the 1st meeting of 2010, the ABNT/CCE-116 Energy Management - group of the Committee 242 - ISO 50001.

The meeting requested all members to answer the questionnaire. Respondents were twenty experts. Three were familiar with the computational tool MARK IV. They knew only the old version, said they could not continue to answer the questionnaire over the ignorance of the new version. In an attempt to find experts who could answer the survey was found to UNIFEI, institution responsible for developing the software for the purpose of nominating experts who could answer the questionnaire. The UNIFEI did not provide experts to participate in the study.

4. ENERGY EFFICIENCY IN BUILDINGS

The concept of energy efficiency is linked to the idea of minimizing the losses in converting primary energy into useful energy as Sola and Kovalski (2006). The regulation of energy efficiency measures and the dissemination of culture give rise to public policies that lead to the conservation of energy. According to Lee and Yik (2003), public policies in the area of energy efficiency for buildings, using various instruments: the creation of standards and

codes required, and provide certifications that may be voluntary in nature, such as agreements and the seals of efficiency. The list of policy measures used to improve the energy efficiency of buildings regulatory instruments includes: building codes (energy efficiency standards for buildings), economic instruments such as cooperative acquisition, fiscal measures (taxes and energy subsidies) and voluntary or informational instruments (Voluntary labeling of appliances). Mendes (2005) recommends the use of computational tools for simulation of thermal energy and light.

5. ENERGY MANAGEMENT: USE OF COMPUTER INSTRUMENTS

5.1 Energy Management: According to Sola (2006), energy management should include aspects of management (contracts, pricing system, uses of technology, quality monitoring, energy audit), strategy (scenario analysis, systems integration and IT management environmental indicators, projects and economic analysis) and issues facing the people (education and skill level, pay plan and career and professional recognition). The strategic management of energy means to manage energy use. The management process needs to be supported by a methodology as in Oliveira (2004).

Haddad (2006) reports that the Federal Government through the PROCEL issued technical guide, "Energy Management", with the aim of encouraging companies to reduce their costs energy. Some model proposed in this Guide is based on "audit energetic. Under the energy management, Lucon; Goldemberg (2009) examines the financial crisis, energy and sustainability in Brazil and suggests tips for investment in research, integrating universities, enterprises and government.

5.2 Energy diagnosis: As Alvez (1998) the energy diagnosis aims at determining the current condition of the facility, from the point of view of energy use, identifying problems and recommending solutions to it becomes. The completion of the Diagnostic Energy begins by understanding the energy situation of the installation: conditions of use of renewable energy consumption on the premises, electrical measurements in sectors with greater consumption.

5.3 Computational tools: Play a fundamental role in the development of analytical models that represent the energy performance of buildings, allowing the simulation and analysis of different scenarios. As Motta (1985) the use of computational tools allows flexibility to investigate the performance of a system during a specified time. Mendes (2005), presents historical evolution of software tools for energy simulation in buildings. The DOE-2 is a software which simulates the behavior of the building, demanding weather information, the description of the building,

the air conditioning system and tariff structure. According to Mathews (1998) DOE-2 is an internationally recognized program, however, its interface is not friendly to restrict what the consultants and research centers.

ESP-r is a general analysis program capable of performing thermal analysis of building air flow between zones, air movement within the zones, air conditioning and electrical systems. It is being developed for over 25 years. This product allows the user to increase the complexity of the simulation with project information, what makes the tool valuable resource for the milestone. It is a package of tools that can import CAD files and export files to Radiance. The program provides tutorials to help new users. It was developed for use by designers (Crawley *et al*, 2005). In the 90 research centers and companies invested in the development of interfaces for these programs are compatible with the Windows operating system is developing more modern and complex programs such as EnergyPlus, the FLUENT, CFX and the PHOENICS.

According to Melo (2009) the EnergyPlus is a computational tool, created from the programs BLAST and DOE-2 and distributed by the Department of Energy United States, for the prediction of heat load and energy analysis of buildings and their systems. It is a program endorsed by BEPAC Conduction Test, HVAC BESTEST, Furnace BESTEST and is being evaluated by the HVAC BESTEST as in Crawley (2005). The program is capable of simulating different, such as "time-step calculation less than an hour, modular system, the possibility of calculating air infiltration differed for each thermal zone, the calculation of thermal comfort indices and integration with other systems (photovoltaic, solar heating, etc. ...). The EnergyPlus program includes several modules that work together to calculate the energy required to heat or cool a building using a variety of systems and energy sources, it does so by simulating the building and associated systems in different environmental and operating conditions. The Energy Plus program was recognized as one of the top 100 tech products in 2003 at the 41th R & D 100 Awards, also received the award for Excellence in Technology Transfer in 2002 and 2004 and also awarded IT Quality for Technical Excellence.

As Sentelhas (2004) the computer system that allows the integrated energy planning model is the LEAP Environmenty Stockholm Institute of Boston and can be applied to determine the evolution of the energy system, both from industrialized countries and for countries via development in local planning. This tool allows computational modeling based on scenario analysis of energy development and environmental effects. These scenarios are based on the detailed presentation of how energy is consumed, converted and produced in a region, creating a scenario of how an energy system might evolve over time in a particular

socioeconomic system and a set of constraints on energy policy. For each scenario definition of the model determines power requirements, costs, benefits and associated environmental impact. Currently there are over 290 programs listed in the Building Energy Simulation Tools Directory (USDE, 2009).

A Brazilian program appears on the list: the UMIDUS, designed to simulate the flow of heat and moisture in building components. Some research groups in the country stood out, using existing software tools or developing their own codes and algorithms to promote the development of more efficient building designs. Through simulation can evaluate the thermal and energy performance of buildings for different design alternatives, be they architectural design options, building components, lighting or air conditioning systems. With computer simulation, we can estimate the energy consumption, the cost of consumption and even the environmental impact caused by the alternative project before its implementation. In 1993 Eletrobrás launched the computer resource MARK IV, developed in partnership with UNIFEM and Procel. Table 2 presents examples of software with their applications with a focus on energy efficiency.

Table 2: Computational resources available for development of energy efficiency in buildings

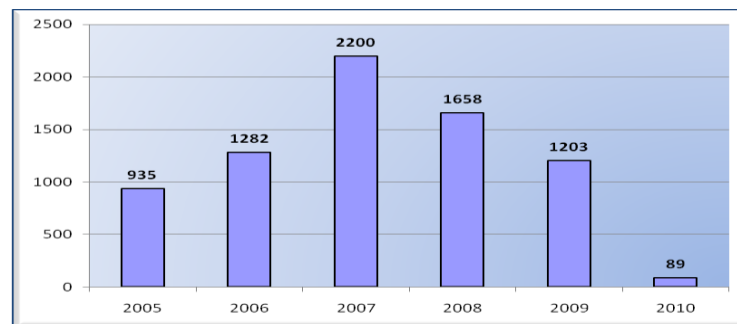
Institution	Software name	Utility
Procel – Ministério de Minas e Energia	Mark IV Plus http://www.procel.gov.br/procel/site/dols/index.asp	It analyzes data from different configurations of electric equipment installation, checking the feasibility of implementing conservation measures for the efficient use of energy.
SEI-Stockholm Environment Institute	LEAP http://www.seib.org	Energy Planning with aggregate consumption data.
EERE-Energy Efficiency and Renewable Energy – US Department of Energy	Energy Plus http://www.eere.energy.gov/buildings/energyplus	Modeling and simulation of energy flows in a building for environmental conditioning, lighting, ventilation, and other end uses. Ouvir
US Department of Energy	DOE-2 http://www.eere.energy.gov/buildings/tools_directory/doe_sponsored.cfm	Analysis of the energy performance of buildings and calculation of cost of operation.

5.3.1 MARK IV PLUS free software

As Perrone (2004), Eletrobrás is encouraging, through the Program of Conservation of Energy-Procel, shares of energy conservation nationwide, resulting in the Energy Optimization Program. Among his initial goals was to prioritize the preparation of studies for optimizing energy sector and individual, from a specific software that can analyze the data collected on diagnostic work. In view of the improvement project and the need to have a computational tool to expedite and standardize the diagnostic performance of energy in industrial facilities, we developed the software that became known as Mark IV.

PROCEL is a tool of analysis, generation of energy diagnosis and management of end uses of energy consumed, in which the user interacts directly with the program providing information on installing analyzed. The software is available for download at the Procel (MARK IV PLUS, 2009) and can be obtained by filling out a registry for Procel can communicate with users. The purpose of the register is to know how the program was used and what savings were generated. Eventually the user may receive a questionnaire to evaluate the performance of the program. This procedure also aims to provide grants to improve the MARK IV PLUS. In a survey by the PROCEL was obtained the number of downloads made between 2005 and 2010 as a graphic 1.

Graphic 1: Evolution of the downloads MARK IV PLUS,
Source: PROCEL (2010)



As Perrone (2004), the main goals aimed to developing this software are: to offer the user a flexible tool and easy to use analysis and energy diagnosis, cover a broad spectrum of approaches to energy analysis and optimization, expanding the number of users . The application is a diagnostic tool in energy that the user downloads the program information on an electrical installation, and then analyzes the data, providing results in a report with the energy consumption with suggested measures to be applicable norms software features feature

a modular and consists of the following modules: main, analysis of energy bills, economic analysis, central air conditioning, window air conditioners, boilers, cogeneration, water condensers, furnaces and stoves, lighting, motors, distribution boards, cooling, processing and pipeline..

6 ANALYSIS OF RESULTS

From the literature and results of the questionnaires, it is intended to elicit suggestions for improvement to the computational resource diagnostic energy performance of the construction. The problem analysis is done in the light of three hypotheses in "Formulation of the problem." This chapter presents the results of the survey of experts on computational resource MARK IV PLUS.

The three assumptions are: a) the use of energy diagnosis contributes to improving energy efficiency in construction; b) the use of diagnostic energy encourages the consumption of energy in a rational and sustainable, c) the use of computational resources enables the application in the design stages, the concepts of energy efficiency in buildings.

The field research revealed difficulties of obtaining questionnaire responses allow the conclusion that there are barriers to the use of computational resources for simulation energy in Brazil. As Gitahy (2006) these barriers are classified into three main categories: cultural, economic and technological. Cultural barriers arise mainly in the fact that the various parties involved in the energy efficiency theme are not aware or convinced of the advantages offered by the simulation.

The economic and cultural barriers are related to marketing question concerning the wages paid for the services of professionals and cost of continuous updating of a market software. The applicants are entrepreneurs and investors in construction who expect quick results with low cost of the project. However, designers do not have allocation of time to become acquainted with modeling and simulation. They have full knowledge that the use of simulation can result in design solutions more economical and energy efficient as in Chvatal (1998) and Dunovska, Drkal, Hensen (1999).

In Brazil, as in other developing countries, the barriers are not responsible for the dissemination of simulation software among professionals in civil engineering as Mathews, Richards (1990). As Mendes, Lamberts, Neto (2001) lack a model to be followed, including the lack of database of thermo-physical properties of national building materials, lack of data on the influence of vegetation, climate data, failure or inability of the tools national simulation to

go beyond the simulation of specific problems. It adds to the difficulty of using foreign tools depending on the language barrier.

It is important to generate the data obtained from the simulation quality information to be used by the company in accordance with the governmental policies in pursuit of energy efficiency. Consulted to Eletrobrás on the feasibility of application of research to users of MARK IV PLUS they had "downloaded" software. Eletrobrás informed about the term of confidentiality non-disclosure of your database.

Eletrobrás undertook to apply the research in partnership, but there was no time for its realization. Aiming to mitigate the fact that the first group of experts had no knowledge of the instrument computational MARK IV PLUS, sampling was increased from 20 to 49 specialists. The experts who responded to the questionnaire number two are working in the area of energy efficiency. Through e-mail the search was conducted with 49 experts including 20 experts who participated in the initial search. A total of eighteen respondents constituted the sample. The analysis of the responses provided by the experts: the eighteen experts surveyed, 33.3% belong to Eletrobrás. The concentration of specialists in Eletrobrás respondents underscores the difficulty of disseminating knowledge in the market of designers and builders. A view of the participants can be seen in table 3 bellow.

Tabela 3: Companies research participants

Company / Institution	Number of experts	Percentage
ELETROBRÁS	6	33.3%
EDP ESCELSA	2	11.1%
PETROBRAS	2	11.1%
ABNT	1	5.6%
ANDRADES E CANELAS	1	5.6%
CHEMTECH	1	5.6%
IMETRO	1	5.6%
NBS	1	5.6%
NITTOGUEN	1	5.6%
UFF	1	5.6%
UNIFEI	1	5.6%
Total	18	100.0%

Regarding the first issue of the second questionnaire showed that the total sample analyzed 61.1% working specifically with energy efficiency. The second issue is identified that 38.9% work with computational tools for simulation and data analysis. Regarding the use of computational MARK IV instrument (question 3) it found that only 11.1% use it. As the most used computational tool (question 4) found that the BD ENGINE has the preference of 16.7%, as shown in Table 4.

Table 4: Software used

Software used	number of specialists	Percentage (*)
BD MOTOR	3	16,7%
EXCEL	3	16,7%
MARK IV	2	11,1%
CALCULUX	1	5,6%
DIALUX	1	5,6%
ULYSSE	1	5,6%
Não responderam	9	50,0%

(*) – Base rate: 18 experts

The replies to Question 5 was evidenced most frequent use for systems analysis of motive power, and used the software and EXCEL MOTOR BD, followed by the lighting. In this case using Excel spreadsheets for data processing of energy efficiency as well as software: MARK IV PLUS, CALCALUX, DIALux, ULYSSE, as shown in table 5.

Table 5: Use final evaluated with computational tool

Use final applied	Application	Percentage (*)
Lighting	4	22,2%
Cooling	1	5,6%
Heating	2	11,1%
Motor	5	27,8%
No Information	1	5,6%
Not answered	9	50,0%

(*) – Base rate: 18 experts

The eight respondents said they employ computational tools that they are easy to use as you analyze the responses provided to question 6.

In analyzing the question 7 was evidenced by the experts that the ways of using the concept of energy diagnosis are: a) make suggestions according to the diagnostic energy deployments and the changes under the responsibility of the user; b) performing technical analysis of the economic payback time "payback"; c) transferring knowledge related to conservative measures, applying measures to retrofit, evaluating and adjusting the levels of illuminance associated with the quality and efficiency of equipment, simulating different types of configuration / topology of illumination; and d) applying Energy Efficiency Policy.

As for question 8 the difficulties of using computational tools indicate: a) non interchangeability between the software used, specific software only for a final use of energy; b) need to update the database of programs, lack of dependability. The eight respondents said they employ computational tools that recommend its implementation as we analyze the responses provided to question 9. When the possibility of computational tools to assist in the awareness of the need to employ processes that use less material and energy resources that pollute less and use cleaner technology (question 10), 38.9% of experts surveyed agreed with this statement.

In parallel with the interview was held research to assess the functioning of the instrument computational MARK IV PLUS, used for simulation and energy diagnosis. It was found that this software allows the user to analyze data of energy consumption in end uses: lighting, electrical panels, transformers, motors, boilers, furnaces, window air conditioner, central air conditioning, refrigeration systems, condenser water and pipes.

After entering data in the current situation of the building under consideration in the computational tool MARK IV, the system provides tips on improving facilities, proposing the use of efficient equipment. In the module of the electricity bill tariff analysis software runs simulating the hiring cheaper financially to be established between the user and dealer. In the simulation analysis of the final use of lighting, there was the need for registration of a greater number of types and models of luminaires and lamps to allow its use in buildings.

As the database is closed it is necessary to constantly update the information, we suggest the creation of the possibility of entering data and even perform methodology of calculation of energy efficiency. In economic analysis module suggests the inclusion of information generated in the economy size electric, and provide the details of the calculation methodology used. To use the MARK IV is necessary that the user is aware of the values relating to technical information of the equipment being replaced, otherwise the simulation can

not be done due to lack of data. Segatto-Mendes (2006) draws attention to the technological cooperation between universities and companies to develop technological solutions and management methods as well as energy audit, aimed at achieving higher levels of energy efficiency

7. CONCLUSION AND SUGGESTION OF NEW RESEARCH

Although research has been hampered by lack of computer resources and studied by the unavailability of government institutions and research, we can infer that the use of computational resources for simulation and diagnosis of energy efficiency in buildings is not very common in manufacturing enterprises Brazilian civil construction. That is, there was the finding of a gap between theory and practice in this research.

One of the hypotheses that guided this study was to clarify based on the use of energy diagnosis can contribute to improving energy efficiency in construction. The survey results confirm the importance of computational tools in achieving energy diagnoses contributing to awareness of the need to employ processes that use less material and energy resources that pollute less and use cleaner technology towards improving energy efficiency in building civil. A secondary result achieved was to understand / help to establish systematic project analysis and retrofit through suggestion for use of computing resources. It also investigated whether the diagnostic criteria for energy creates energy more consciously. The research has observed that create criteria for most energy-conscious.

Other questions in this study included: examining the possibility exists for improving the computational tool PLUS MARK IV to better assess the energy performance of buildings, whether it is possible to propose improvements to the tool MARK IV PLUS evaluating the concept of sustainability in relation to environmental aspects social and economic? Confirmed the importance of computational tools in achieving energy diagnosis, allowing to observe that the diagnostic criteria for energy creates more energy conscious. It was verified the possibility of improving the computational tool MARK IV PLUS, through critical analysis and its application in construction.

An important fact to improve the dissemination of culture and energy efficiency is the creation of a multimedia module of online courses for training for use of MARK IV PLUS, with the goal of having more users managing their energy consumption. This is due to the fact that we found the decline in the number of users. It is also suggested the creation of a residential application module, in order to disseminate such software in high schools, creating the possibility for adolescents to intervene not only in the household economy, but also in

energy savings and reduction in GHG emissions, enabling the allocation of the potential energy savings to another part of society, ensuring the effectiveness of public policy criteria.

With regard to the disclosure of the simulator PLUS MARK IV suggests that it be disclosed by electric utilities for their benefits are being used by society as a whole. Currently it is understood that companies and governments should not only think about enforcing environmental laws, they must take proactive actions and plan their activities in a sustainable manner. This should be accountable not only to shareholders and creditors, but also to a much greater range of stakeholders. These influence the governments in developing public policies that establish energy efficiency standards for buildings in Brazil.

There is not formed in the power market and the Universities contacted no training of technicians (architects and engineers) for use of computing resources in order simulation and diagnosis of energy efficiency in buildings, either at design or use.

Despite large investments in housing construction and the importance of technological innovation that is pressing to deploy the industry sector of construction, it was found in the sample that experts consulted and their companies have not made investments in skills development and acquisition of computational resource for simulation and diagnosis of energy efficiency. Furthermore, based on testimony, if this will happen in the future, it will surely be given preference to the purchase of "tools" (software ready) provided by the international market.

One of the objectives of this study and a survey of practices of simulation and diagnosis of energy efficiency in buildings, is to identify ways to spread the use of simulation and diagnosis of energy efficiency in design, use and building on reforms. In order to better structure a set of potential initiatives to achieve this end, consider that the introduction of computational resources to support simulation and diagnosis of energy in buildings results from three alternatives are not mutually exclusive, they are: a) its own initiative for professionals involved in designing, planning, execution and renovating buildings in acquiring knowledge about simulation and diagnostic energy; b) acquisition of market software; and c) development and deployment with the assistance of external consultants.

In the first alternative, the fundamental point refers to vocational training. For a professional feels encouraged that the contract activity on its own initiative, along with pressure for results, it is crucial that he has training in the areas of simulation, information technology, sustainability concepts, concepts of energy and energy efficiency.

Apart from technical knowledge, you need to provide skills that ensure success in this initiative. As the practice of using computing resources of simulation is not widespread in

companies, the first contact and experience must also occur during the undergraduate teaching experience or graduate courses. Besides the process of acquisition of theoretical knowledge, the remaining stages of a project of this nature also require some skills that only develop with practice. Thus, it is recommended that the undergraduate and postgraduate courses have a greater emphasis on simulation for the sustainable use of resources, among them energy and that provide students opportunities to develop practical work as a team under actual conditions of enterprises. If this initial experience is successful and if these professionals have access, in the process of continuing education, reference materials (not just textbooks) and professional support, you can gradually change the current reality frustrating.

Another way to facilitate the introduction of computational resources for simulation and diagnosis of energy is through software vendors. Currently, it is difficult to evaluate the models embedded in software, hidden by suppliers for commercial reasons. Cooperation between academia and these companies should contribute so much to enrich the products offered on the market, and provide opportunities for relevant research and, consequently, production of new knowledge. This cooperation also helps to open a new perspective for professional engineers and architects involved in construction, embodied in the activity of developing energy management systems. This partnership with software vendors is also considered strategic by Robinson and Dilts (1999).

Finally, the consulting activity, performed by professionals working for private companies or even in academia, is an important channel for spreading computational resources for simulation and diagnosis of energy resources. The rapprochement between research centers and companies should contribute to the development of research and generating new knowledge on energy efficiency in buildings. The university-enterprise integration through education and research, should contribute to the production of new knowledge and vocational training quality.

Due to the particularities of this research, then relate some suggestions for future work to expand knowledge of the use of computational tools in the management of energy efficiency: Find the reason for reducing the amount of "downloads" of the software MARK IV PLUS from 2007; evaluate the goals of the people who "download" program MARK IV PLUS, Expand the study to assess the applicability of computational tools LEAP PLUS ENERGY DOE-2 and the use of energetic diagnoses in residential and commercial buildings; Check the importance of computational tools; Find the current barriers for non-use of computational tools in energy audit

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APPENDICES

APPENDIX A - QUESTIONNAIRE I

DIMENSION ARCHITECTURAL / URBAN

1 - What kind of enterprise software was applied

Residential Industrial Commercial and Service

2 - The environment where the building is installed

Rural Urban Centre Industrial

3 - The results obtained with the program helped him to recommend the use of daylighting, natural ventilation in building reviewed?

Yes No

4 - The use of the program creates new opportunities for projects in architecture, influencing the creative process with a focus on energy efficiency?

Yes No

ECONOMIC DIMENSION

5 - The use of the system allows the user to achieve a more fuel efficient, reducing the need for new investment in power generation?

Yes No

6 - With the implementation of the measures suggested by the program showed a reduction in total energy consumption by using more efficient?

Yes No

7 - What is the value of energy savings (kWh / month) obtained with the measures?

Lower / same (15,000) less / equal 25,000 greater than 50,000

8 - What is the value (R \$) of the investment made?

Lower / same (15,000) less / equal 25,000 greater than 50,000

ECOLOGICAL DIMENSION

9 - It was recommended the application of any measure to reduce water consumption?

Yes No

10 - It was recommended the application of some system of generating energy from renewable sources?

Windmill Solar Biomass

11 - It was recommended the creation of green space?

Yes No

12 - The application of computational tool to help raise awareness of the need to employ processes that use less material and energy resources that pollute less and use cleaner technologies.

Agree Disagree

SOCIAL DIMENSION

13 - MARK IV contains the management measures focused on staff training in order to create an environment of awareness among employees?

Yes No

14 - It was recommended management measures directed to the staff training, aiming to create an awareness among employees?

Yes No

15 - are observed in the MARK IV, in producing its final report, recommendations to help improve awareness of the need to implement energy efficiency measures?

Yes No

16 - The use of MARK IV can help people without expertise in the application of energy efficiency measures.

Agree Disagree

POLITICAL DIMENSION

17 - considered to be positive PROCEL participation in spreading the culture of energy efficiency.

Agree Disagree

18 - What percentage of buildings considered part of environmental or social projects in partnership with Government Agencies?

Equal to 0% or less (25%) \leq 50% Or less (75%) equal to 100%

19 - It is conducive to establishing a network of intelligent power distribution, where there was the possibility of hiring an energy tariff of custom and off selected appliances during peak hours to reduce the demand of the electric system.

Agree Disagree

20 - What kind of guidelines for energy efficiency program do you suggest for Public Policy?

Encouraging the use of solar water heating Incentive coogeração and distributed generation Implementation of energy efficiency programs in higher education institutions (Other (Specify)

APPENDIX B - QUESTIONNAIRE II

1) You work with energy efficiency?

Yes No

2) You use a computational tool to implement energy efficiency measures?

Yes No

3) You use the MARK IV?

Yes No

4) What software do you use most?

5) To that end use you apply?

Lighting Cooling heating motor

6) Do you consider the software in use, easy to use?

7) How do you implement energy efficiency measures?

8) What (which) (s) increased (ers) difficulty (s) that identifies you to use the simulation tool?

9) Would you recommend the use of computational simulation tool energy? Comment.

10) The application of computational tool to help raise awareness of the need to employ processes that use less material and energy resources that pollute less and use cleaner technologies.

Agree Disagree