WHOLE BUILDING ENERGY SIM. FOR ACCESS TO INCENTIVE FUNDING:
LESSONS LEARNED FROM CANADA'S COMMERCIAL BUILDINGS INCENTIVE PROGRAM.

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ABSTRACT
The Commercial Buildings Incentive Program was launched in 1996 by the Canadian federal department of Natural Resources Canada (NRCan). The intent is to curtail greenhouse gas emissions resulting from the use of energy in commercial buildings, and the objective of the program is to lead industry into designing more energy efficient buildings (new or retrofit). Monetary incentives are awarded, based on the amount of energy saved above the Model National Energy Code for Buildings (MNECB) level [NRC, 1997].

To demonstrate compliance with the Commercial Buildings Incentive Program (CBIP) requirements, in particular regarding minimum energy savings and compliance with the MNECB mandatory requirements, applicants most often simulate the energy consumption of the proposed building design. The EE4 software was developed to support this performance approach, and is essentially a custom shell for the DOE-2 engine. In addition to allowing for an accurate evaluation of the energy performance of the proposed design, EE4 automatically generates the MNECB compliant reference building, against which the proposed building is compared and the incremental energy savings calculated.

The Buildings Group of Natural Resources Canada provides the technical support to CBIP. This paper discusses our experience with the use by industry of whole building modelling for the purpose of assessing design energy efficiency. Although the discussion is based on the use of the EE4 software within the CBIP context, emphasis is placed on the generic issues and barriers related to the adoption by the building design and construction community of whole building simulation. Software development, users' issues including training, common design practices and commitment to energy efficient design, and program issues including modelling guidelines and rules, and distinction between modelling for program compliance and energy efficient design, are addressed.

INTRODUCTION
The Commercial Buildings Incentive Program (CBIP) was launched in 1996 by Natural Resources Canada, and continues until 31 March 2004. Its aim is to promote the adoption of the Model National Energy Code for Buildings, encourage increased energy efficiency in commercial buildings, and assist the reduction of greenhouse gas production from the commercial buildings sector.

CBIP provides a monetary incentive to the building owner where the design can be shown to have operating energy performance 25% better than that of the same building constructed to the MNECB minimum requirements. The incentive amount currently is two times the value of energy savings predicted for the first year of operations. The incentive provided was intended to take the risk out of learning new design methods by covering the cost of additional time required for advanced energy efficient design, or to cover the costs of an additional design team member, the building energy simulator. In parallel with the monetary incentive, the program attempts to initiate lasting changes in industry design practices and adoption of energy efficiency.

Potential CBIP participants submit an expression of interest to Natural Resources Canada, which identifies their willingness to follow the terms of the program and makes them eligible for technical assistance with the preparation of CBIP submissions, in particular compliance simulations. Typical CBIP submissions include a simulation of the whole building annual energy performance, which is then reviewed against the building permit documents to confirm the simulation was based on the built version of the project. Once a satisfactory assessment of the performance claim is completed, the incentive amount is calculated based on the energy savings. An agreement is then prepared to provide 80% of the value of the calculated incentive with the final 20% delivered on submission of a copy of the occupancy permit for the completed project.

WHOLE BUILDING SIMULATION FOR INCENTIVE PROGRAMS

The financial incentive programme is based upon a reference building approach, wherein the performance of the proposed design is contrasted against a reference building constructed with representative envelope, lighting, and HVAC systems. A whole-building performance philosophy is used to give designers maximum flexibility. As such, the designer can opt for any solution, within set limits, in terms of HVAC, lighting, and envelope design as long as the overall energy consumption of the building is no more than 75% of the level it would consume had it been built according to the Canadian Model National Energy Code for Buildings (NRC 1997), Figure 1. Conceptually, this reference building approach is very similar to that employed in other energy efficiency standards, codes, and incentive programmes [CEC 1999, ASHRAE 90.1 - 1999].

As an example of the whole-building performance approach, a designer may choose to focus on finding efficiencies in the areas of lighting and HVAC while using conventional envelope construction. Similarly, a conventional HVAC system may be sufficient if high-performance windows and high levels of roof and wall insulation are used in conjunction with reduced lighting power.

The simulation of the proposed building is conducted with standard weather data to estimate the building's annual consumption of electricity, natural gas, oil, and other fuels. A reference building is automatically constructed by the building simulation software, without any input from the user. It has the same size, shape, occupancy, temperature set points, equipment, operating schedules, and orientation as the proposed design. The energy consumption of that reference building is then computed and contrasted against that for the proposed building. It should be noted that the user is specifically prevented from being able to modify or affect the reference building definition process.

Customized simulation software was developed specifically to allow applicants to follow this process within the context of tight design schedules, budgets and limited knowledge of whole building simulation [IBPSA 2001].

COMPLIANCE CHECKING versus DESIGN APPROACH

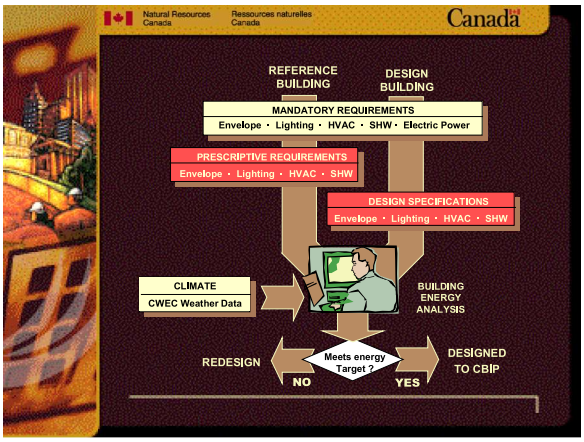


Figure 1: MNECB / CBIP Compliance Path

Energy simulation for CBIP was intended to standardize the process of compliance without sacrificing design flexibility. HVAC designers are used to building energy simulation software in the context of design tools. Many designers found it difficult to adapt to a compliance checking approach which requires a specific characterization of equipment.

It is commonly understood that the core of the CBIP software is in compliance verification rather than design, and that simulators are therefore required to know the base requirements of the MNECB. For instance, this implies that simulators should have a general idea of the plant size required for the building, or at least as an operative first guess. It has been observed that mechanical designers prefer software that self-size, given the presence of information that would first allow an understanding of exterior loads.

This conflict between the design approach and a compliance checker approach has been debated since the initiation of the MNECB software development work. It was hoped that training for software users would mitigate these issues by providing appropriate methodologies for file creation and review.

Even though these two approaches might seem divergent, both require a fundamental understanding of the building performance along with a high level of input details for successful simulation. It should be noted that the level of effort requires significant time investment from designers.

There are different levels of detail in energy simulation: simulations that are as close to reality as can be made with current tools; and simulations that are intended to show the relative merits of a proposal with respect to a standardized base line building. The first type of simulation is used for accurate predictions of energy bills, which requires an accurate description of yearly weather and operating conditions. The second type is concerned with a more generalized performance characterization. This latter approach was selected for the MNECB to identify changes in applications of code requirements. Accordingly, the software design for the MNECB allows for fair and consistent evaluations of the effects of deviations from MNECB prescriptive requirements.

EE4.CBIP is the software used for verifying compliance to CBIP. It is directly derived from a software developed to demonstrate compliance with the MNECB, which took advantage of the EnergyPro experience. EnergyPro is a DOE-2.1E interface prepared to assist building designers show compliance to the California "Title 24" energy legislation.

SOFTWARE AND INDUSTRY SIMULATION CAPACITY

At the time CBIP started, whole building energy simulation was a small niche in the larger discipline of mechanical design, with consequently few experts available having in-depth knowledge of, and on-going exposure to, whole building simulation. A smooth compliance path for CBIP depended on knowledge of the priorities of the MNECB, a quick integration of whole building energy simulation into design practice, and a rapid expansion of the industry capacity for energy simulation in Canada.

As a result of CBIP, many junior engineers in larger firms have had experience with EE4, but that experience has generally not progressed beyond an introduction to the software and a test of its "user friendliness." In many cases the junior staff were assigned because of the labour intensive character of doing drawing take-offs and data entry, not because of their interest or ability with energy simulation. To date, although a wider group of building designers has been exposed to whole building energy simulation, a small core of practitioners seems to be involved in the majority of the CBIP simulations.

Interestingly, these most experienced simulators tend not use the compliance path outlined above. They are closer to the design approach because they use simulation to optimize the HVAC design. They produce a file that can actually be used in the compliance process however it does not follow the compliance methodology. The most senior simulators are highly proficient in DOE-2, which they use for design optimization. Under CBIP, DOE-2 files are accepted for compliance verification (EE4 uses DOE-2 as its calculation engine).

During the initial phases of CBIP, the need for a simplified compliance-checking tool became quickly apparent. Many developers and designers interested in CBIP desired a preliminary indication of whether the energy performance of their conceptual design was close to meeting the programme target. Using EE4 was an investment difficult to justify at that early design stage, and a quick and easily accessible tool was required. The CBIP Screening Tool was developed as a web-based application to rapidly assess whether a design is likely to comply, and for estimating the energy impact of major design decisions, e.g., type of HVAC system or heating fuel, with limited building information. This software is particularly useful for a quick estimate of the impact of design alternatives at the conceptual design stage when insufficient data are available for performing detailed simulations. The latter feature is popular with designers pitching alternative, i.e., more energy efficient, design concepts to their clients.

The screening tool enables quick exploratory analyses by defaulting a significant number of parameters that affect energy usage. In total, 28 data inputs are required to describe a building. A combination of pick lists, default values, and numerical inputs are used to speed data entry enabling analyses within a two-hour time frame. The screening tool provides results on operational energy consumption and cost and greenhouse gas emissions. Figure 2 illustrates a typical output screen. The screening tool enables a rapid assessment of a building's energy performance with minimal data input. However, this does come at a cost. Only the seven most common building types can be examined and a limited number of HVAC configurations can be considered for each.

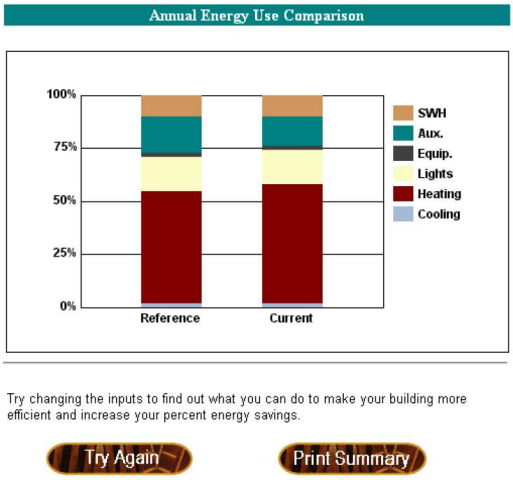


Figure 2. A typical Screening Tool output screen

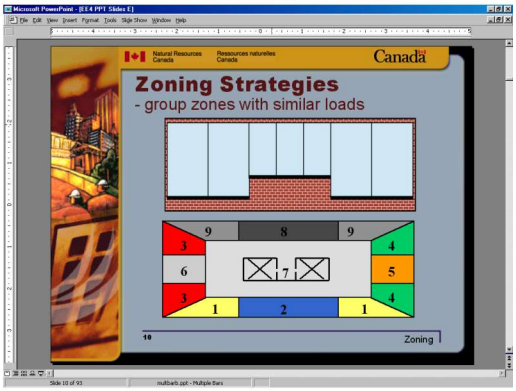
TRAINING IS CRITICAL

The development of compliance-checking software tools was not sufficient in itself to support the incentive programme. A key programme objective was to have the design teams perform their own simulation work. Consequently, as many designers currently use software to size HVAC systems, but not to analyze whole building energy consumption, a substantial effort was placed upon training.

Two courses were developed to train voluntary participants from industry, an introductory course and a specialized modelling course. The introductory course describes the intent and scope of the incentive programme and provides an overview of the technical requirements for compliance. It also includes an overview of the principles of simulating buildings and a demonstration of the EE4 software. This one-day course serves the dual purpose of providing sufficient information to building developers and owners for decision-making purposes while giving designers the introductory information required to start modelling using EE4. This course has proven to be critical in raising awareness of the programme.

The second course is the next logical step in providing CBIP training. It is specifically targeted at the technical staff tasked with performing the EE4 simulations. The objectives of the course are to enhance general building simulation knowledge, to develop modelling skills using EE4, and to encourage standardized procedures that can streamline compliance checking and verification. A combination of lectures, case studies, and hands-on exercises are used throughout the one-day course. Figure 3 illustrates the zoning of an office floor.

Figure 3. A zoning exercise



A complementary building modelling guide has also been created. This document acts as a repository for modelling rules and guidelines that are continuously added and developed as new cases are processed. For ease of access of the latest information, the guide is available directly off the web.

A computer based training course (CBT) was developed to complement the training workshops and manuals discussed in the previous section. This CBT serves two purposes: it replaces the workshop for users who are unable to attend a training course due to geographical constraints; and, as it provides in-depth information on specific topics, it acts as a source of reference material for all users. The CBT's total run time is about four hours.

CHANGING DESIGN PRACTICES

The CBIP program is aggressively marketed to generate changes in the marketplace. In addition to a strong presence of CBIP in the building design press, a number of high profile CBIP buildings were opened, and national events covering the subject of building energy efficiency featured design charrettes and awards.

In addition to CBIP being a new programme requiring the use of a new custom software, a number of barriers related to whole building simulation were faced:

- Availability, maintenance and upgrade of the simulation tools and modelling guidelines;
- Availability of energy consultants or mechanical designers familiar with whole building simulation, i.e., industry capacity to perform whole building simulation;

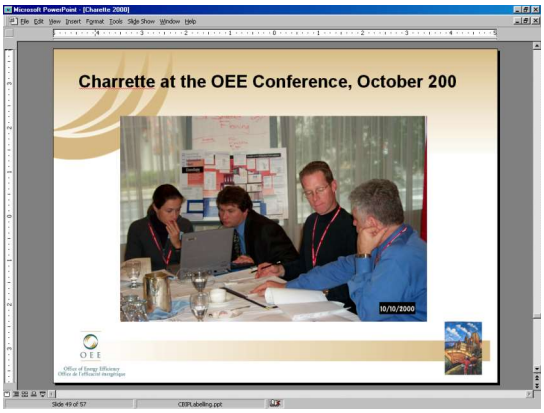
- Recognition of the character of the new tasks and an appreciation that they required an adjustment to working methods;
- Willingness to adopt new working methods, or modify existing methods to accommodate new tasks;
- Lack of perception within the design community at large that whole building energy simulation could be a value added component of design, as opposed to solely a means to recover costs or allow discounted design fees.

Solutions to the technical barriers encompass targeted training, the development of a pool of experts within industry, the use of simplified tools that feed into the sophisticated EE4 software, and a submission framework that allows industry to readily purchase targeted expert simulation assistance when required while minimizing the additional costs to the parties involved.

At the time of publication of this paper, a new strategy was being developed for establishing a technical assistance framework for the purpose of CBIP submission. The strategy reflects the acknowledgement that it is unrealistic to expect most building designers to become sufficiently proficient with EE4 modelling, and become able to readily prepare an EE4 plan take-off acceptable under CBIP. It is proposed that a qualification program be put in place to establish a pool of expert simulators, from which companies preparing submissions could draw expert resources, whether for specific consultations or the entire building take-off. This would assist companies not willing or able to develop internal EE4 expert knowledge to optimize resource usage for the purpose of preparing a CBIP submission. Although fees would be charged for such design assistance, it is precisely the aim of CBIP incentive to cover these additional design costs. From NRCan's perspective, that would ensure a satisfactory and consistent level of quality of the simulation, and would clearly develop industry's simulation capacity. It is hoped that such capacity would then be used beyond the bounds of CBIP.

The CBIP programme benefited indirectly from another federal program, the C-2000 Program for Advanced Commercial Buildings, a demonstration program for high performance building also run through NRCan. A feature of C-2000 is the promotion of an integrated design process where all design disciplines work together in a workshop, or charrette setting, Figure 4. C-2000 design teams take the familiar architectural, structural, mechanical, and electrical disciplines and add an energy simulator, cost consultant, and client and builder representatives to the team. Whole building energy simulations of options discussed around the table are performed on real time, providing checks for the assumptions made throughout the integrated design process. As a result, designs run through the C-2000 process would almost automatically be examined by the design team for submission under CBIP.

Figure 4. An integrated design process session.



As the CBIP programme matures, there is an increasing interest in emphasizing this type of design process both for its ability to deliver high performance with little added capital cost, and as a quality control strategy that ensures the simulator has an influence on the design. It is clear that such synergy created at these early design stages has enormous potential for influencing the paying clients, and was proven to be one of the most successful way of influencing current design practices.

CONCLUSIONS

Initiating and launching a programme of the technical scope of CBIP was a formidable challenge. The development of the software, technical guidelines and training modules in support of the incentive programme required significant resources in the initial phase of CBIP.

CBIP has completed its early growth phase, and now has the training and tools in place to support an increased use of whole building energy simulation. Both a push from trained consultants and a pull from increasingly interested building owners and developers have contributed towards an accelerated rate of submissions.

One of the main challenges in developing compliance software is to achieve a balance between the needs of novice users and those of experience simulators, while ensuring that the overall technical requirements were respected. In addition to assessing the proposed building performance, EE4 automatically creates the reference building, and generates a compliance report. These steps are critical for code compliance, or for providing financial incentives for energy efficient designs.

Considerable effort has been invested in training and supporting users. The availability of comprehensive on-line help and access to training (either classroom or computer-based) is critical, both in maximizing programme adoption and in minimizing one-on-one support costs.

Training and user support are key elements that should not be overlooked in programme design. In addition to raising awareness of the program and use of its custom software, it is critical to acknowledge that, while a large number of designers may acquire the basis for use of the compliance software, training and qualification of a pool of expert simulators should be performed. These experts will provide support to industry at all stages of the preparation of the CBIP submissions. Simulations performed by professionals would result in faster processing of quality building simulations.

A new element in the CBIP programme, the use of the integrated design process, has shown extraordinary potential. The benefits were made evident by whole building simulation for a number of real projects. The challenge will be to promote the process beyond the small number of firms interested in high performance buildings.

The usual time lines for changes in the building design community are very long. Through CBIP and other programs, whole building energy simulation has demonstrated its value, and requires continued efforts in promotion before it can be said to be part of mainstream design activities.

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