Simulations without Experts: ECOnirman - a Whole Building Code Compliance Tool for India

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ABSTRACT

The ECOnirman Whole Building Performance tool was funded by the United States Agency for International Development (USAID) under the Energy Conservation and Commercialization Project - Phase-III (ECO-III). This tool is the first of its kind, an online simulation-based code compliance tool, made available through the Bureau of Energy Efficiency. It eliminates or minimizes the requirements for special software, building science or simulation expertise. It assists developers and building designers in demonstrating performance-based compliance with the Energy Conservation Building Code.

With a minimal learning curve, a user with knowledge equivalent to that of a final-year architecture student, having access to about one hour of an HVAC engineer's time, can use the tool to demonstrate compliance with ECBC. The tool runs energy simulations in the cloud using parallel computing, and DOE-2 as the simulation engine. A total of 1,294 city locations in India are currently supported.

ECOnirman WBP shows great promise for the future in India: it enables developers to meet code by installing only those measures that benefit their building; it promotes innovation in design and technologies; with validation of inputs, it enables a large user base to do energy simulations and results in true capacity building; and the database of inputs and results enables easier policy analysis.

Introduction

Benchmarking and labeling buildings helps building owners, operators and policy makers understand building energy performance and increases accountability. At a minimum, measurement of building energy performance needs to account for objectively, transparently and in a replicable manner: 1) the services a building provides; 2) the efficiency of the building in terms of its design and technologies installed (asset rating); 3) how well the building is operated (operational rating). Asset rating is most cost effectively done with energy simulations (Goldstein, 2012). Simulations allow the user to compare the building to an appropriate reference building like Appendix G to ASHRAE 90.1 or COMNET baseline, or an aspirational goal like the Reach Codes recommended in the CA Energy Efficiency Strategic Plan (Engage 360, 2010). Energy simulation models are also the basis for the Calibrated Operations and Maintenance Index proposed by Goldstein and Eley (Goldstein, 2012), which is a metric for the quality of energy management in building operations.

Software tools that are based on standardized protocols such as COMNET Modeling Guidelines and Procedures (MGP) help overcome the biggest barriers for using energy simulations extensively for benchmarking and labeling buildings; specifically these tools reduce or eliminate the large potential for user error by validating modeling inputs or holding them fixed and by automating the modeling of the reference building. This automation process reduces the engineering time for providing inputs to the models.

An example of this approach and its potential value has been demonstrated in ECOnirman WBP [1] a whole building simulation tool for performance based code compliance in India (USAID-ECO-III, 2012). ECOnirman WBP tool is a web-based energy simulation application made available to the Indian audience without the need for any software installation, and requires no building science or simulation expertise. This tool enables trade-offs between building systems, promotes innovation in design and technologies and makes building energy simulations more accessible and reliable. Users do not need to manage upgrades to the software, the database of standard inputs, the energy modeling protocols or even revisions to ECBC itself. Being web-based, the application also allows design teams to collaborate remotely.

ECOnirman's simplified input approach enables a user with no prior simulation experience to demonstrate code compliance in about one hour. A similar approach may also be developed for the United States or other countries.

Background

The Energy Conservation Building Code (ECBC) was launched in India by the Bureau of Energy Efficiency (BEE), Ministry of Power, in May 2007. ECBC allows compliance with the code using a Prescriptive or Whole Building Performance (WBP) method. In 2009, USAID-ECO-III Project undertook development of the ECOnirman tool to assess the prescriptive compliance of buildings. The Energy Conservation (EC) Act of 2001 in India however, requires energy code compliance through an Energy Performance Index (EPI) [2] expressed as the annual site energy normalized to the building area. The prescriptive compliance approach does not meet this requirement of the EC Act since it does not directly relate to performance of the building in terms of its EPI in annual kWh/m^2. The WBP method, using simulations, predicts the annual energy use of the building and can report the EPI of the building, thus complying with the EC Act. However, energy simulations require significant expertise and knowledge of building science. Most developers, architects and engineers do not have the skills, ability, time or access to simulation programs to perform energy simulations for compliance with ECBC using the WBP method. Additionally, since energy simulations are not done consistently even in markets where simulations have been used for decades, this method will result in unreliable code compliance submittals in India. This was a significant potential challenge to local governments in India trying to enforce code compliance.

In order to encourage compliance via the WBP method and to overcome the barriers mentioned above, the ECOnirman WBP tool was developed under the leadership of the ECO-III project.

[1] http://econirmanwbp.eetools.in/

[2] The EPI is similar to the Energy Use Index (EUI) used in the USA, expressed as the annual kWh/m^2.

Methodology

ECOnirman WBP runs in a standard Internet browser and communicates with a web service, where the building model is created, and simulations are run in the cloud. ECOnirman is designed to have a minimal learning curve. It is targeted to a user audience that has an architecture student's level of knowledge of buildings. The user is also expected to have access to about 1 hour of a mechanical engineer's time to confirm engineering inputs.

Users set up their login profile that gives them access to the projects they are working on. Users can create and save their projects. For each project, the user progresses through the interface specifying the inputs required by the tool, including building geometry, orientation, envelope, building use information, and salient aspects of HVAC systems. Screenshots of some of the user interface are included in figures 1 through 6. Prior to commencing a compliance check, the user is required to answer questions about mandatory requirements of ECBC. When the user requests a compliance check, the application develops a model of the reference building (Standard Design as per Appendix B of ECBC). The application then invokes the required sizing and annual simulations. The user is able to see the EPI results for both the ECBC Standard Design and Proposed Building. The user can download a compliance report that can be submitted to the code enforcement authority to demonstrate compliance with ECBC. Figure 7 shows an excerpt of the summary page of the compliance report.

A total of 1,294 city locations in five climate zones in India are included in version 1.0. Research indicated that in India, circulation spaces, storage rooms and restrooms are often left as unconditioned spaces and buildings are sometimes designed with additional unconditioned spaces. In ECOnirman WBP, unconditioned zones are modeled identically in the Standard Design and the Proposed Building. Since buildings in India do not have cooling and heating enabled for the entire year, it is not reasonable to run simulation models with heating and cooling available indiscriminately. This would result in EPI predictions that are higher than real values. However, it is also not reasonable to let the user edit the schedule for cooling and heating availability, since that may allow users to game the inputs to suit their desired outcomes, and it would lead to a lack of consistency across projects leading to problems in the compliance checking process. ECOnirman WBP therefore uses an algorithm based on the monthly average dry-bulb temperature and total enthalpy content of the outside air to establish heating and cooling availability, and this schedule is identical for the Standard Design and Proposed Building models[3].

The development of ECOnirman WBP included a peer review by simulation experts in India, and a usability review by a group of building industry professionals. The feedback from these reviews was used in modifications during the development of version 1.0 and led to a list of desired features for future development.

The tool has outputs and a database that is made available based on permissions. Table 1 shows the current permissions and those envisioned for future versions.

[3] The user can select heating and cooling availability for the entire year or on a seasonal basis. The seasonal availability schedule is based on weather data for the building location. Heating is made available for the months when the monthly average dry-bulb temperature is below 15°C. Cooling is made available when the monthly average dry-bulb temperature is above 26°C or when the monthly average enthalpy is above 60 kJ/kg.

Table 1. (Permissions for Viewing ECOnirman WBP Outputs and Database)

Output	Project Level User	Compliance Checker/ Local Government	Bureau of Energy Efficiency	Public (after Right to Information request)
Compliance Report (single project)	Yes	Future	No	No
Summary of Inputs (single project)	Yes	Future	No	No
Building characteristics database (all projects)	No	No	Future	Future
Simulation files (all projects)	No	No	Future	Future

Figure 1. Project Information Screen

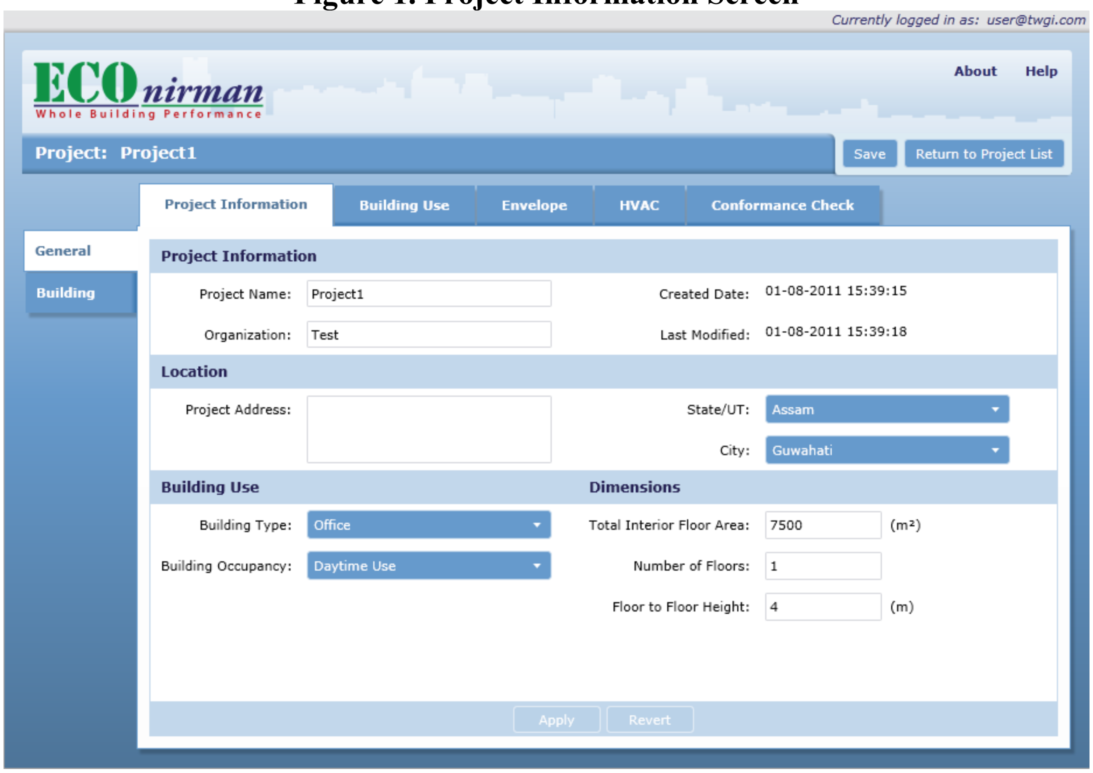

Figure 2. Building Shape and Orientation

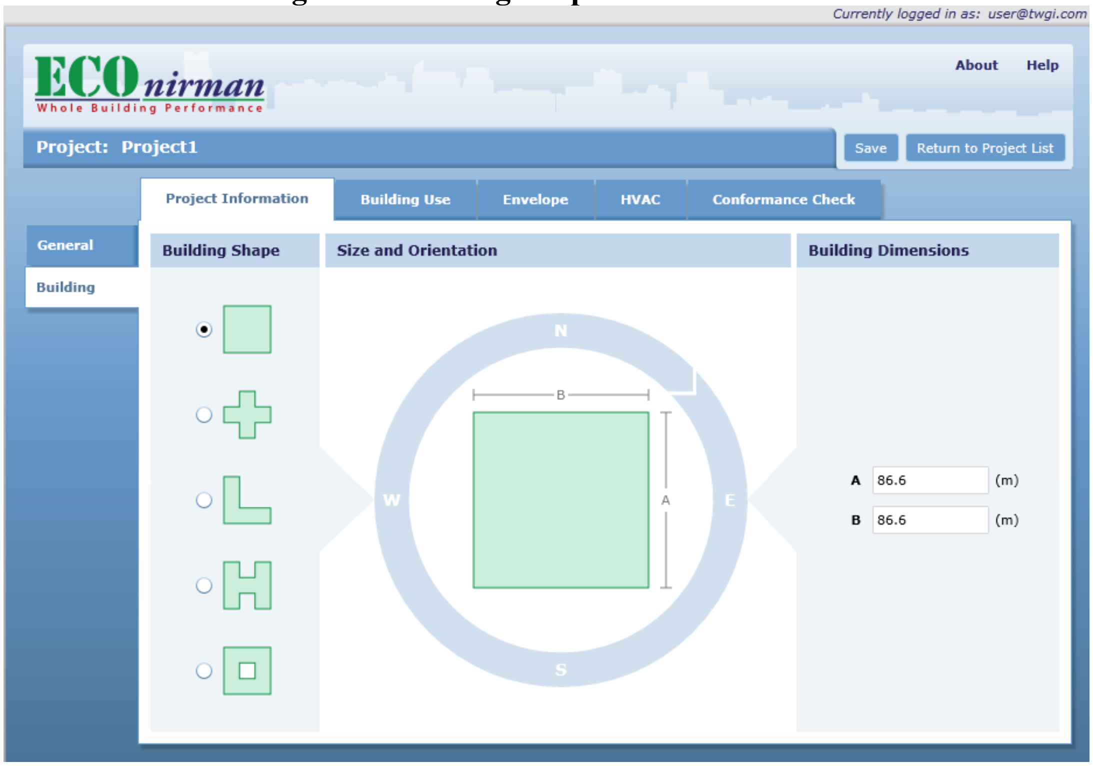

Figure 3. Building Use Screen

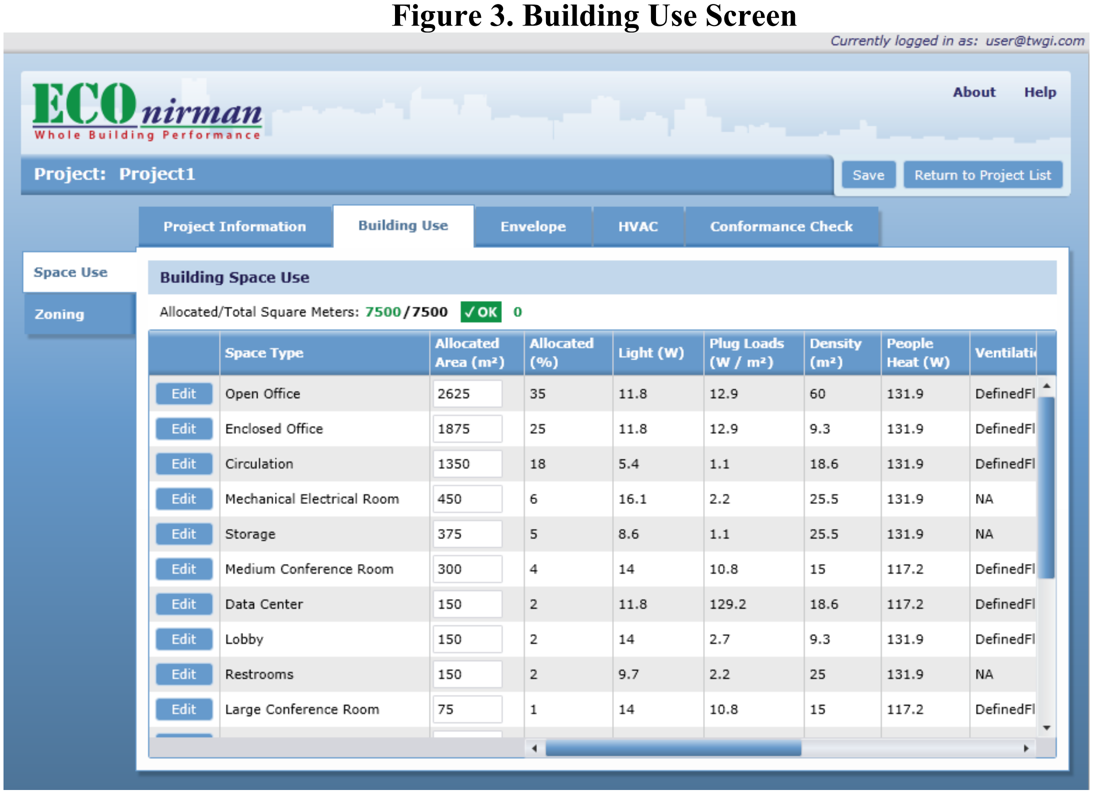

Figure 4. Schedules Tab of the Building Use Screen

Figure 5. Air System Definition Screen of HVAC Tab of ECOnirman WBP

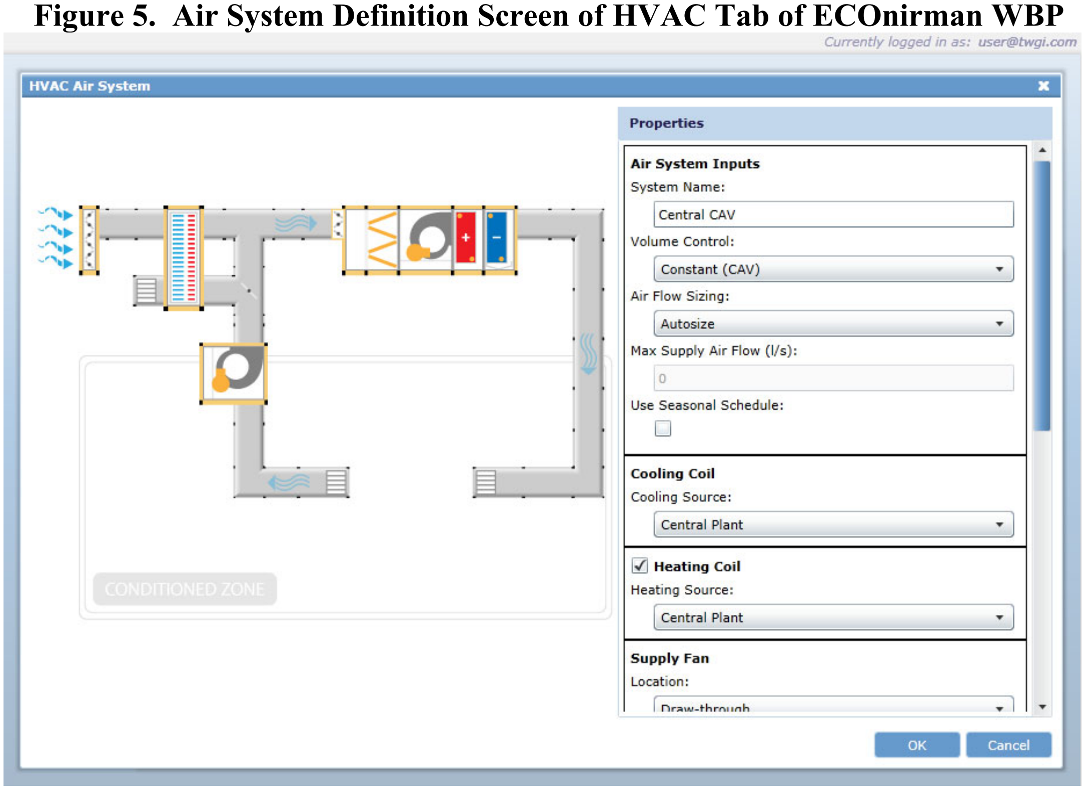

Figure 6. Conformance Check Summary Screen of the of ECOnirman WBP

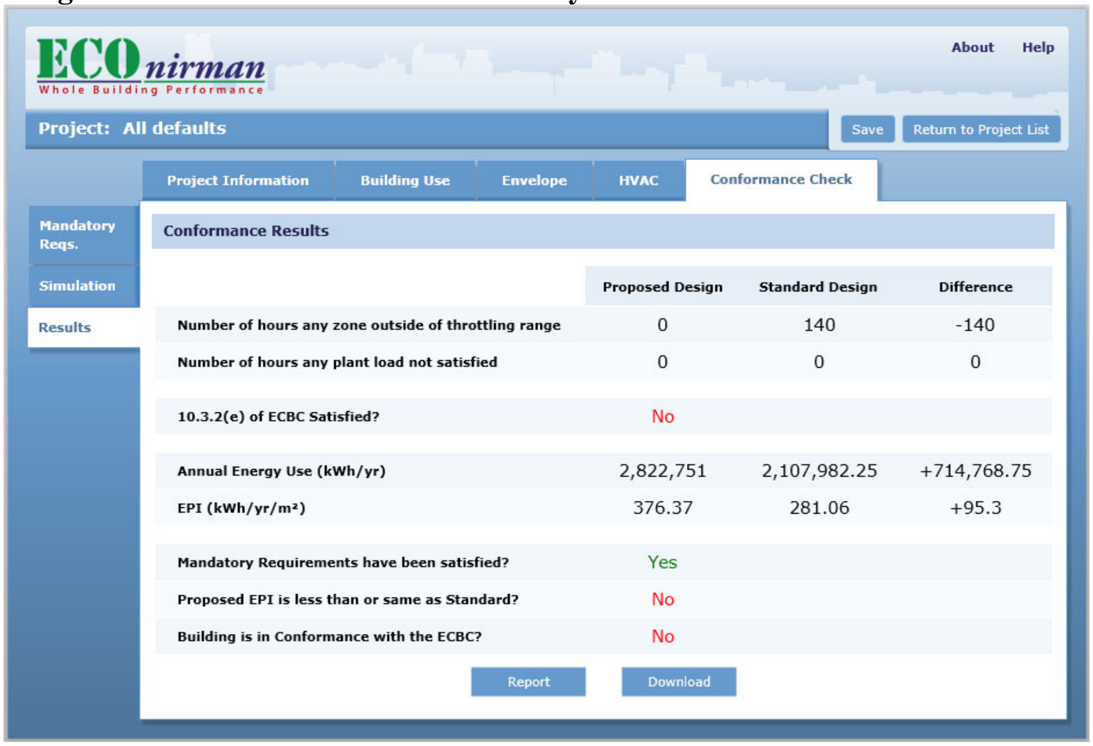

Figure 7. Conformance Summary of the Compliance Report of ECOnirman WBP

Building Conformance Summary		
Proposed Design Electricity Use per year (kWh/year)	Standard Design Electricity Use per year (kWh/year)	Percent Savings: Electricity Use per year
21,46,120	21,41,058	-0.2%
Proposed Design EPI (kWh/m²/year)	Standard Design EPI (kWh/m²/year)	Percent Savings: EPI
286	285	-0.2%
10.3.2(e) of ECBC Satisfied (Y/N)?		Y
Mandatory Requirements Met (Y/N)?		Y
Building Conformance as per the ECBC		NON-CONFORMING

Discussion

Energy conservation in buildings is achieved by recognizing the building asset efficiency separately from operational efficiency. Typically energy codes address building asset efficiency and the operational efficiency is addressed by other rating programs like Energy STAR. Energy simulations provide the standard test conditions under which the building asset can be rated. Software tools that are based on standardized protocols such as COMNET Modeling Guidelines and Procedures (MGP) help overcome the biggest barriers for using energy simulations extensively for benchmarking and labeling buildings; they reduce time and effort to generate the rating, increase consistency of the method and provide replicable. Energy code is a policy mechanism that requires minimum asset efficiency. Easy to use software tools for building energy simulation are badly needed in emerging economies, where new construction is growing at breakneck speed and building codes are just being introduced; however, these tools are also needed in economies where the construction growth has slowed down and the focus is on existing building retrofits, where rating, labeling and disclosure laws are being adopted.

ECOnirman WBP was developed as a code compliance tool that uses the standardized modeling protocol of Appendix B to ECBC. Its approach and the functionality it provides has potential beyond code compliance such that it can be further developed as a broader asset rating tool.

ECOnirman WBP populates a centralized database as users provide building inputs during their code compliance process. BEE intends to use this data in the future to do impact analysis of ECBC to determine the savings that have been acquired through the energy code; this impact analysis can be further broken down by geographical regions, building types etc. The database of building information can be used in the future to tie each building in to a benchmarking system that collects utility data, resulting in a high quality database that contains information on the entire building stock instead of just a statistical sample. This will lead to better informed policy decisions in the future.

Version 1.0 of ECOnirman WBP is available for use. BEE intends to fund further development of the tool to incorporate modifications and enhancements requested by various stakeholders, and to enable the impact assessment capability. Training programs for ECBC compliance tools are currently being conducted under the guidance of BEE. As states adopt ECBC for mandatory compliance, the first version of tools required to help implementation and enforcement are already in place.

Conclusions

The ECOnirman WBP tool is available as ECBC is adopted as a mandatory code by the states. The intent behind conceiving and developing this tool has been to provide a reasonably easy-to-use and widely accessible means for complying with ECBC and the EPI requirements of the EC Act, whereas the only method available hitherto was to engage a simulation expert for demonstrating compliance. The impact on compliance rates can be studied in future by comparing the state-level efforts to officially adopt these tools and provide awareness and training to the various stakeholders.

ECOnirman WBP tool shows great promise for the future of building energy efficiency in India by allowing developers and designers to do trade-offs between building systems and use new innovative building materials to comply with the energy code. This is the first online simulation-based energy code compliance tool. Tools like the ECOnirman WBP have the potential to propel India onto the world stage as a leader in code compliance, leap-frogging the USA in terms of ease and quality of implementation and enforcement. With the ability to collect data on the building stock and provide accurate and easy policy analysis, future versions of this tool will complete a virtuous circle between policy design, implementation and enforcement (Goldstein 2011). This code compliance tool can be extended to create a broader asset rating tool and can be tied to a benchmarking system in India.

Easy to use software tools for building energy simulation are badly needed in emerging economies, where new construction grows at breakneck speed and building codes are just being introduced; however, these tools are also needed in economies where the construction growth has slowed down and the focus is on existing building retrofits, and rating, labeling and disclosure laws are being adopted.

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