

Creating California's Online Commissioning Case Study Database: Case Studies Go High Tech

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ABSTRACT

Through the California Commissioning Collaborative (CCC) and Energy Design Resources, a new online Commissioning Case Study Database is now available. The goal of the database is to collect a detailed set of standardized information about commissioning projects in California, allowing for clear comparison of projects and articulation of their costs and benefits.

The project began in 2002 with the development of a case study protocol through a workshop with leaders in the commissioning field. The finalized protocol was then applied as an online database and made available for commissioning providers and building owners to complete surveys detailing their commissioning project's scope, costs, benefits, and findings. As projects are inputted into the database, summary information is compiled into case study datasheets that can be searched and viewed by all users. These datasheets will help owners and commissioning providers estimate the potential costs and benefits of a project by making data for comparable buildings readily available.

In May 2004, there were 35 registered case study database accounts, 9 surveys in progress and 8 surveys completed. Once the database is sufficiently populated, the commissioning information will be analyzed across all buildings. This analysis will be useful in providing commissioning cost-effectiveness metrics to owners and to regulators interested in commissioning as an energy saving measure. In addition, the CCC intends to publish and distribute detailed case studies on selected buildings in the database.

This paper describes the reasons the case study protocol was created, how it was created, and how it is intended to be used. Also, this paper details the definition of costs and benefits from commissioning tackled in the development of the case study protocol. Lastly, the paper discusses plans and proposals for populating the database.

Introduction

More and more owners are turning to commissioning as a building performance quality assurance strategy. As the commissioning industry grows, the need to demonstrate commissioning's viability through documented costs and benefits has become increasingly apparent. If commissioning is to become a mainstream practice, a sound case for its cost-effectiveness must be made. To do this, the California Commissioning Collaborative (CCC) developed a case study protocol and online commissioning case study database.

The case study protocol is a detailed survey that captures a range of information about commissioning projects, from basic inputs about the type of facility and commissioning process employed, to more detailed inputs about costs, findings, and benefits. The protocol has recently been implemented through an online database to collect standardized data about commissioning activities in California. The California Energy Commission and Pacific Gas & Electric

Company via Energy Design Resources¹ provided funding to develop the protocol and online database. Numerous members of the CCC contributed to its completion.

The California Commissioning Collaborative

First convened in 2000, the CCC seeks to transform the commissioning market in California by educating owners and policymakers that commissioning, as a quality assurance process, leads to lasting reductions in building operating costs. CCC members include representatives from commissioning firms, utilities, government agencies, and research organizations, and are directly engaged in a number commissioning activities, from actual hands-on commissioning of buildings in California, to developing commissioning related tools and educational materials, to research into specific commissioning issues, to offering incentives to promote commissioning. As a whole, these activities hold greater potential to increase commissioning in California if they are leveraged toward common goals and if results are shared. Information on CCC activities can be found at www.cacx.org. The creation of the CCC marks a strong effort to develop the commissioning industry in California (Duhon et al, 2004).

Why Create a Commissioning Case Study Protocol and Online Database?

Commissioning providers are often asked by owners to prove that the benefits of commissioning justify its costs. In responding, commissioning providers can draw from a vast number of case studies and anecdotal evidence to show that the cost-benefit analysis is favorable; however, the lack of consistency in reporting makes it very difficult to compare the results across these case studies. Research has shown that many times appropriate commissioning documentation is not available, or the level of detail is so limited that little knowledge about the as-found or final operation of the systems can be gained (Friedman et al, 2003). Furthermore, commissioning providers report their findings differently, verify measures differently, and do not rigorously collect cost-benefit data. Indeed, a critical challenge in making the case for commissioning has been that an industry-wide, standardized cost-benefit study does not exist.

The new construction commissioning industry has not typically attempted to quantify commissioning benefits. One commissioning firm routinely provides avoided cost calculations to justify the commissioning expense, making the case that avoided costs almost always outweigh their fee (Altweis and McIntosh, 2001). The only third-party analysis of industry-wide benefits of new construction commissioning is a California market characterization study that estimated a 10-year payback based on energy savings alone (PECI, 2000). However, many benefits from new construction commissioning stem from avoided costs other than energy.

The most complete analysis for retrocommissioning cost-effectiveness is a survey of four commissioning providers reporting the costs and benefits of 44 commissioning projects. An average simple payback of 0.9 years was calculated across all projects, with an average energy savings of 5-15% (Gregerson, 1997). Retrocommissioning costs and benefits are significantly easier to quantify and more often documented than new construction commissioning costs and benefits. Even so, retrocommissioning can benefit from a standardized protocol for reporting costs and benefits, as well as more commissioning providers contributing to the analysis.

¹ Energy Design Resources is a statewide public goods funded energy efficiency program under the auspices of the California Public Utilities Commission.

The case study protocol provides a standard way for commissioning providers to pool their project information so that data can be easily compared across many projects. The resulting cost-benefit information will help to increase an owner's ability to make informed decisions about commissioning their facility, and will also be useful to commissioning providers, building operators and facilities staff, and policy makers.

Developing the Case Study Protocol

The process of creating the case study protocol began with defining a standard set of information to gather and a methodology for quantifying costs and benefits. In November 2002, a workshop with eleven CCC members convened to work out these issues. Participants included commissioning experts from a variety of sectors, including private consulting companies, utilities, research institutions, and government. The goals for the protocol were set forth at the beginning of the workshop, and are listed below:

- **Reasonable:** The protocol will ask for information that requires a reasonable amount of additional effort by the commissioning provider. Analysis may be supported by incentives.
- **Clear:** The protocol will use a clear and open analysis methodology.
- **Flexible:** The protocol will guide the gathering of information during a commissioning process, but the protocol can also accommodate looking back on a completed project.
- **Standardizing:** The protocol must create a framework for gathering standard information in a consistent format.

Literature Review

In creating a methodology for the case study database inputs, a literature review on the costs and benefits of commissioning was performed. Only a few publications presented a methodology for quantifying the costs and benefits, and no publication reported results of implementing their methodology in more than eight buildings.

Altweis and McIntosh (2001) from the Farnsworth Group set forth a cost-benefit methodology that focused on calculating avoided costs. They identified two main cost types: issue resolution costs which include repair, replacement, installation, and professional costs; and issue effect costs which include energy cost, depreciation, maintenance cost, revenue loss, and cost of productivity loss. They used this framework to evaluate the estimated range of avoided costs associated with each issue; the range was applied to situations in which there was a “most likely” or high cost scenario or an alternative “least cost solution”. Their company applies this methodology to new construction commissioning projects to prove that commissioning savings greatly exceed the cost of commissioning.

Tso (2002) described the methodology they used for an engineering economic analysis of eight commissioning projects in public buildings in Oregon. In their study, the entire project team (project managers, O&M staff, designers, contractors, and commissioning providers) was required to submit ongoing documentation of time spent on commissioning activities and issues identified, break out fixed and variable costs, provide an issues log, and identify qualitative benefits. This analysis emphasized the need to identify commissioning scope. The researchers calculated savings from each measure rather than asking the project team to calculate savings.

One case study by Cox and Williams (2000) quantified energy and non-energy benefits and evaluated accumulation of project benefits over time.

These papers helped to formulate preliminary definitions of costs and benefits, as well as identify the critical discussion topics for the CCC workshop.

Case Study Protocol Workshop

To create the case study protocol, the workshop participants weighed in on a number of issues. Informational inputs that characterized the building, its management, the type of commissioning project, the systems commissioned, and the drivers for commissioning were straightforward and easily agreed upon. In all, there are six sections in the case study protocol, plus one separate survey for owner feedback on the commissioning process. These sections are listed below and shown in Figure 2 as they appear in the online database application.

- Project information
- Commissioning overview
- Costs & Scope
- Findings
- Benefits
- Contact Info/Upload photo
- Owner's Survey

The most interesting discussions revolved around defining cost of commissioning, quantifying its benefits, and calculating its cost-effectiveness, each summarized below. Coming to a consensus on these issues was critical to the development of the case study protocol.

Defining and reporting commissioning costs. For a clear and standardized protocol, workshop participants needed to define exactly what costs should be attributed to the commissioning process. Providing a framework for assessing costs was important so that the protocol could gather cost information in a standardized way. The following questions were raised in creating the cost framework:

- How should the costs of commissioning be described?
- Should the cost to resolve problems identified by the commissioning provider be counted as a cost of commissioning?
- Should the commissioning-related costs of designers, contractors, and operating staff be counted as costs of commissioning?
- Are tasks performed by a commissioning provider that are out of the scope of commissioning counted as a cost of commissioning?

The issues related to cost had to be examined separately for commissioning and retrocommissioning. The following paragraphs present the resolutions to these questions, as agreed upon at the workshop.

How should the costs of commissioning be described? Two main categories cover commissioning costs for both new and existing buildings: fixed costs and resolution costs. Fixed

costs are incurred as a part of the commissioning process and would have been incurred no matter what issues were encountered at the building. Examples include the cost to review design documents, write and perform functional tests, and coordinate activities. On the other hand, resolution costs are variable costs that are directly related to resolving issues identified during the commissioning process. The time the commissioning provider and contractors spend troubleshooting chilled water system instability is an example of a resolution cost.

Tracking fixed and resolution costs separately provides an understanding of the commissioning process cost (fixed cost) independent from how well the building was designed, constructed, and controlled. Workshop participants agreed that all fixed costs are costs of commissioning. However, assigning resolution costs as a cost of commissioning is more complicated, and led to the next question.

Should the resolution costs of issues identified by the commissioning provider be counted as a cost of commissioning? This question must be approached differently for new construction commissioning and retrocommissioning, since the processes are so different. New building commissioning is a quality assurance process that holds contractors to meeting the requirements of the contract documents. Additionally, there are opportunities within new building commissioning for improving the design or controls beyond the specification, which will be called “opportunities”. The opportunities may decrease the risk of the system not working properly, and they may improve performance and maintainability.

Workshop participants felt that the resolution costs for issues identified by the commissioning provider in a “quality assurance” mode should not be allocated as costs of commissioning. The cost to construct per the contract documents should be counted a cost to the contractors and designers, not the commissioning process. Through understanding the true cost of design and construction, owners can avoid promoting the low bid environment and perpetuating the cycle of buildings that are not constructed as specified. Saddling commissioning with the resolution costs for quality assurance fixes leads to perceived high commissioning costs, burdening commissioning with costs that should be borne by the parties that did not fulfill their obligations to the owner. Consider a case in which the contractor forgets to install an air handler for a whole wing of office space. Is the cost to install that system counted as a cost of commissioning simply because the commissioning provider identified that the specification had not being met?

Resolution costs for “opportunities” identified by the commissioning provider may be considered additional costs of commissioning, depending on the severity of the problem. This type of resolution cost is not clear-cut since one may argue that the system would not have operated correctly without the resolution of these “opportunities” – that the original design results in a high risk to the owner. Should the commissioning process be assigned the cost to resolve a poor design, or should those costs be attributed to the designer? If the system clearly does not or would not operate under the original design, then it seems appropriate that this category of resolution costs should not be attributed to commissioning. In instances where the commissioning provider identifies opportunities improve the design a system that will operate sufficiently, the resolution costs are attributed to commissioning. This situation is similar to retrocommissioning since the cost-benefit of the individual measure drives implementation.

In the retrocommissioning environment, measures are generally implemented based on a cost-benefit analysis. Retrocommissioning involves improving operations long after the warranty period, when contractors can no longer be held to the contract documents. Since the

decision to resolve issues is based on cost-benefit analyses, this cost is counted as a cost of retrocommissioning. Retrocommissioning is focused on low cost operations and maintenance measures rather than capital improvements. However, the cost of minor capital improvements undertaken as a direct result of retrocommissioning recommendations are still included as costs of retrocommissioning. Major capital improvements (i.e., those that require financing) are considered retrofit project costs, and are not costs of commissioning.

Should the commissioning-related fixed costs of contractors and operating staff be counted as costs of commissioning or retrocommissioning? The workshop participants agreed that it does not matter who performs the fixed costs of commissioning – it is still a cost of commissioning. Many times commissioning providers perform the functional tests for large or complex systems themselves, and spot check functional testing by the contractors of other subsystems. If contractors perform parts of the commissioning process, their costs are a portion of the fixed cost of commissioning. The cost of operations staff involvement in commissioning or retrocommissioning is both a cost to the owner and a benefit in the training received. To resolve this issue, the case study protocol simply asks, “Do you consider the staff’s participation in commissioning mostly an additional cost of commissioning or mostly training (a benefit)?”

Are tasks performed by a commissioning provider that are out of their commissioning scope counted as a cost of commissioning? Workshop participants agreed that any out-of-scope costs are not costs of commissioning, but are considered additional project costs to the owner. For example, the designer is responsible for creating the design intent and basis of design documentation, but often the commissioning provider ends up spending a significant amount of time developing this documentation. To add perspective to the commissioning provider’s cost, the protocol uses a checklist of tasks to capture the commissioning provider’s scope of work in each project.

For the purposes of the case study protocol, costs are summarized as in Table 1. This is a basic framework proposed, and the CCC is open to suggestions to improve this framework.

Table 1. Assigning Commissioning Costs

Type of Cost	Assigned as Cost of Cx?
All Commissioning Projects	
Cx provider’s fixed costs of cx	Yes
Other contractor’s fixed costs of cx	Yes
Operations staff fixed costs of cx	Ask owner
Cx provider’s out-of-scope costs	No
New Construction Commissioning	
Resolution costs related to opportunities for system optimization	Yes
Resolution costs related to holding contractors to the contract documents through quality assurance	No
Resolution costs related to improving the design or installation of a system beyond the contract documents, if critical to system operation.	No
Retrocommissioning	
Resolution costs related to operations and maintenance	Yes
Minor capital improvements to resolve RCx issues	Yes
Major capital improvements to resolve RCx issues	No

Defining, reporting, and quantifying commissioning benefits. In the case study protocol framework, not all costs related to commissioning are assigned as costs of commissioning, yet all benefits of commissioning are appropriate to count. If the costs to fix a problem are not counted as costs of commissioning, then why count the benefits? These benefits are counted because the commissioning provider identified the issue as a problem through the quality assurance process. Benefits of commissioning are generally classified as “energy” and “non-energy” benefits. Energy benefits are difficult to quantify for new construction since there is no baseline. Non-energy benefits are difficult to quantify in all cases since they often require tracking methods or estimation of avoided costs.

Quantifying avoided costs, by definition, requires that the commissioning provider and owner estimate what would have happened in a given circumstance. Most often, quantifying avoided costs is not even attempted by commissioning providers. However, ignoring this significant area of benefits underestimates the total benefits of commissioning. For the case study protocol, all assumptions behind avoided cost calculations will be gathered. Eventually the protocol may include standardized calculations for each type of avoided cost. Avoided cost categories in the case study protocol include:

- Avoided O&M costs
- Avoided retrofit costs and avoided change order costs (for design-phase resolutions)
- Avoided cost of premature equipment failure
- Reduced system or facility downtime and the cost implications of estimated downtime
- Avoided cost of reduced complaints and reduced operator time responding to complaints; if applicable, include assumptions for occupant salary, cost of lost productivity, and cost of maintenance time in responding to complaints.

Benefits are collected by the case study protocol first by providing details on specific findings that were resolved. The protocol allows an unlimited number of findings to be entered into the database, but only requires that three significant findings be entered. Quantifying non-energy benefits is a particularly thorny issue, and users are required to enter their assumptions regarding any quantification that they perform.

For each finding, the following inputs are *required*:

- Phase of commissioning found, systems involved
- Issue type (energy, IAQ, operational, maintenance, comfort, other)
- Significance/severity of finding
- Description of finding and resolution
- Who recommended the solution? Who implemented the solution?

For each finding, the following inputs are *optional*:

- What would have happened had the issue not been identified?
- Describe the energy and non-energy benefits related to this specific measure.
- How long do you expect the resolutions of this finding to persist?
- Avoided Cost: Estimate the cost of this finding to the owner without commissioning

An alternate way to capture all energy benefits is to monitor energy use before and after commissioning. However, this method only can be applied for retrocommissioning, since there is no pre-commissioning energy data for a new construction project. New construction projects may use modeling to determine energy savings from commissioning, but this is costly. Furthermore, these methods only account for energy savings, not other operational savings. In addition to gathering benefits for each finding, the case study protocol collects quantification of overall energy benefits and uses a checklist of non-energy benefits for the whole project.

Calculating cost-effectiveness. Once costs and benefits are defined and data is gathered, the next step is to put this information together to create cost-effectiveness metrics. The main problem with calculating cost-effectiveness is that gathering data on costs is much easier than gathering data on benefits and quantifying these benefits. If only three of a total of fifty findings are entered and cost savings are calculated for only these three findings, then comparing this small subset of quantitative benefits to the full commissioning cost is not a relevant metric. Currently, the “bottom-up” analysis of individual findings was determined to be the most effective and reasonable way to calculate all the benefits – energy and non-energy – for a commissioning project. To ensure that the metric is valid, it is intended that cost-effectiveness will only be calculated for projects when all major findings are quantified.

Online Case Study Database

An online version of the case study protocol was clearly needed to facilitate population of the paper-based case study protocol. At this time, only California commissioning projects are allowed in the online database. The main goal of the online database is to create a simple way for commissioning providers and owners to enter project information as the project progresses. Users are able to manage multiple projects under a single login profile and quickly find the percent complete of each project and each section of the survey. Figure 1 shows the “manage surveys” screen with these features. A sample screen of the online case study database interface is shown in Figure 2, highlighting the protocol navigation bar on the left side.

In addition to streamlining data collection, the online database allows confidentiality of inputs between the owner and the commissioning provider. Once the commissioning provider has completed the survey, the owner is automatically sent an email with a password to enter the site and answer the owner survey. The commissioning provider is not able to access these answers, which allows the owner to be open about the commissioning process outcomes.

How Is the Online Case Study Database Expected to Be Used?

There are four main ways that the commissioning case study database can be used. The most immediate avenue for use is identifying project summaries (called case study datasheets) for similar projects using the search engine. Through these case study datasheets, owners can understand building type, management structure, size, scope, cost (metrics include \$/square foot and % of project cost), and benefit information about other projects to help guide them on their own commissioning projects.

Figure 1. Managing Surveys in the Online Case Study Database

The screenshot shows the 'Manage Surveys' interface for user 'hfriedman'. It includes a sidebar with navigation options (MANAGE SURVEYS, SEARCH, LOGOUT, HELP) and resource tools (Mail, Print, Save to My EDR). The main area displays a table of surveys with columns for Facility Name, Type, Survey Status, Building Owner, Modified date, % Complete, and Export Data. Two surveys are listed: 'Existing bldg test' (65% complete) and 'New Cx Test' (100% complete). A red arrow points from the 'Existing bldg test' row to a separate window titled 'Survey Statistics - Existing bldg test'. This window contains a table with 6 sections and their respective completion percentages.

Section:	Percent Complete:
1	100%
2	57%
3	80%
4	0%
5	100%
6	100%

Source: www.cxdatabase.com

Figure 2. Case Study Protocol Interface

The screenshot shows the 'Case Study Protocol Interface' for 'Section #1 | New Cx Test, test'. It features a sidebar with navigation options and resource tools. The main area is divided into sections for project information and data entry. A red circle highlights the sidebar navigation menu, which includes links for Section 1 (Project Info), Section 2 (Commissioning Overview), Section 3 (Costs & Scope), Section 4 (Findings), Section 5 (Benefits), Section 6 (Contact Info), and Upload Photo. The main content area includes fields for Project Location (test, California), Electric and Gas Utility selection, Project Type (New building, Major renovation, Major addition, Other), Procurement (Design-build, Plan & spec, Other), and Facility Type (Office, Retail, Laboratory, Hospital, Apartment, College or University, K-12 School, Grocery, Manufacturing, Other).

Source: www.cxdatabase.com

Database users can search for these case study datasheets using any of the fields in the datasheet as search criteria. Figure 3 below shows this search criteria interface. For example, an owner might want to find all of the projects in the database that are offices with a total project cost of greater than \$1 million to better understand the cost per square foot that they might expect.

Figure 3. Search Criteria Interface

Search the Commissioning Case Study Database

Please search the database by selecting search criteria below. You can limit your search by choosing multiple criteria to search on.

<input type="button" value="Search"/> <input type="button" value="Reset"/>	
Project Type	- Select -
Building Type	- Select - Cx - New Building
Management Structure	Cx - Major Renovation (gut rehab) Cx - Major Addition
Total Floor Area	RCx - Major Capital Improvement RCx - O&M Improvement
Location	Other
Systems Commissioned	- Select -
Goals of commissioning	- Select -
Commissioning performed by	- Select -
Categories of significant findings	- Select -
Total project cost	- Select -
Commissioning provider's fee	- Select -
Commissioning provider's fee as a % of the construction costs	- Select -
Non-energy benefits of highest importance	- Select -
<input type="button" value="Search"/> <input type="button" value="Reset"/>	

Source: www.cxdatabase.com

The second way the case study database is intended to be used is by a third-party to create short “marketing-type” case studies using the information in the database. The standard case study information is gathered through the database, with the need for only a limited amount of additional information collection to perform a customized analysis and narrative about the project. With the standard set of information collected for each project, these case studies can be produced in a common format for simple comparison. Projects entered into the database will have varying levels of detail depending on which optional inputs are filled out. The most complete entries are to be selected for creation of these case studies.

Third, once many projects are entered into the database, commissioning costs and benefits can be analyzed across all projects. It is important to analyze the cost of commissioning and its benefits while taking into account the scope of each project. In this way, we can better understand how variations in the rigor of implementation of the commissioning process affect both costs and benefits. This analysis is expected to look at commissioning metrics such as:

- Types of buildings commissioned
- Scope of commissioning typically undertaken
- Types of problems most often found
- *Quantified* benefits and cost savings based on building size and type

- Range of qualitative benefits
- Cost-effectiveness (simple payback)

Finally, once the case study database is populated with a robust set of data, it will serve as a sound basis for studying persistence of new and existing building commissioning. Understanding how long the benefits of commissioning last helps to better quantify the cost-effectiveness of commissioning. Using the data entered as the baseline for commissioning-related benefits, the energy use and operations of the building can be tracked periodically to identify improvements or degradation in building operations.

Populating the Online Database and Analyzing the Data

Now that the CCC has created a case study protocol and implemented it as an online database application, there is work to be done to populate the database with commissioning projects, analyze the data, and create case studies from the data. In May 2004, there were 35 registered case study database accounts, 9 surveys in progress and 8 surveys completed. To create a case study database account, users go to www.cxdatabase.com and set up a login and password. Immediately, the user has access to enter projects and search the database for project datasheets. Depending on the complexity of the project and the organization of project findings, entering a project into the database is estimated to take 4-8 hours.

The CCC has a number of project ideas to help populate the database and analyze the data. It is possible that incentives to commissioning provider/owner teams could be provided to help fund entering projects into the database. Another avenue for entering commissioning projects into the database is through persistence of commissioning studies. Lawrence Berkeley National Laboratory (LBNL) is completing a persistence study in which past projects were examined and the case study protocol was used as a framework for gathering data. Six to eight of these buildings will be entered into the database. In the LBNL study, the process of looking through old commissioning reports and filling out the surveys emphasized entering projects retroactively is difficult because documentation often does not have enough detail.

In the previous section on quantifying benefits, standardized energy calculations were discussed as desirable to create a consistent way to look at energy benefits across projects. As projects are entered into the database, it will be determined how realistic this goal may be. The level of analysis required by a third-party may be too costly. Therefore, the CCC may decide to require that the commissioning provider do the energy calculations, potentially for a higher incentive.

Entering California building commissioning projects into the database is most likely to occur through requirements of other programs. Through Southern California Edison funding, a number of commissioning projects from the California High Performance Schools (CHPS) program will be entered into the database. The California Public Utilities Commission has funded two retrocommissioning programs in the state, and the CCC will request that these buildings be entered into the database as well.

To facilitate this high level analysis, there is a need to create a front end to the database to run queries on the raw data. Creating this interface, determining the quality of data collected, and calculating industry-level metrics is the most immediate avenue for development of the database and analysis methods.

Conclusions

The data collected from the case study protocol will help to clarify our understanding of the costs and benefits of commissioning using a standardized set of data. Implementing the case study protocol as an online database gives commissioning providers, owners and the CCC the ability to estimate the potential costs and benefits of a project by examining case studies of comparable buildings. The data can also serve as content for the creation of detailed case studies on specific buildings, building sectors, and analysis of the commissioning industry as a whole.

To those owners with positive experiences using the commissioning or retrocommissioning process, it may be intuitively clear that the benefits far outweigh the costs. Other owners need their decision to commission to be supported by the cost-benefit analysis that the CCC's online case study database can bring to the commissioning industry. If these owners decide to implement commissioning, then commissioning will begin to be viewed as a viable part of the mainstream buildings market.

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