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Supporting Integrated Design through Interlinked Tools: The Labs21 Toolkit

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1 INTRODUCTION

In this paper, we illustrate the use of the Laboratories for the 21st Century (Labs21) toolkit to support a team-based integrated design process for sustainability. Labs21 is a voluntary partnership program sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy to improve the environmental performance of U.S. laboratories. Although the Labs21 toolkit is focused on laboratories, the framework for this toolkit is more general and can be adapted for other building types as well.

First, a note on “design process”: There is a significant body of literature that addresses the descriptive and normative aspects of the design process, in both theoretical and empirical terms. A review of this literature is beyond the scope of this paper. Suffice it to say that there is no standard definition of the design process. We use the term design process in this paper as it is commonly used in the building industry to generally refer to the collection of activities that constitute the design of a building, from pre-design to occupancy and operation.

Table 1 lists the tools in the Labs21 toolkit. At the heart of this toolkit is a knowledge base of core information resources on sustainable design strategies and case studies of their implementation in laboratories. However, sustainable design is not just a matter of incorporating appropriate strategies, but following a process that supports their incorporation in a holistic manner to ensure whole building performance. Accordingly, the Labs21 toolkit also has tools that provide design process guidance. Finally, the toolkit also has some resources that provide overview information on sustainable design, for those unfamiliar with the concept of sustainable design (e.g. owners, financiers).

In the remainder of this paper, we describe the toolkit from the perspective of its use within the design process. We describe the tools sequentially, for convenience. Of course, design is an iterative process, and in actuality, the tools are to be used iteratively and simultaneously by various members of the design team. Also, the tools are interlinked, but not interdependent – they can each be used in a standalone manner, but the interlinked functionality increases their overall effectiveness. Finally, the toolkit does not prescribe a fixed process, and can accommodate the myriad variations of the design process.

Table 1: The Labs21 Toolkit

Tool	Purpose
Design process tools:	
Labs21 Process Manual	Guidance for sustainable design process.
Design Intent Tool	Documentation of design intent – objectives, strategies, metrics.
Environmental Performance Criteria	Point-based rating system for sustainability, based on LEED™.
Core information resources:	
Design Guide	Reference manual on energy efficiency features in laboratories.
Best Practice Guides	Information on design, construction and operation of specific technologies and strategies.
Case Studies	Whole building case studies of high-performance laboratories.
Energy Benchmarking	Energy use data for laboratory systems and buildings.
Overview resources:	
Intro to Low-Energy Design	Overview of key strategies for high performance labs.
Labs21 Video	Examples of high performance labs.

2 GETTING STARTED

While the Labs21 toolkit provides a rich set of information for sustainable design, its effectiveness is contingent on the appropriate use of the tools within the context of a process – both in terms of what the tool is used for, and when the tool is used.

The Labs21 Process Manual is designed to provide guidance on the design process to support sustainability goals, and serves as a "portal" to the toolkit. The Process Manual acts like a map in that it leads the user through the design process and indicates how to use the tools during the course of the design process. To those unfamiliar with the toolkit and/or a sustainable design process, the Process Manual is a good place to start.

It has two major components: a checklist of action items for each stage of the design process, and a checklist of sustainable design strategies. The *checklist of action items* specifically lists those process-related action items that impact sustainability (Figure 1). The checklist was based on similar checklists in other design guides [MSDG 2001, FEMP 2001], with adaptations based on Labs21 experience. While the items in the list are fairly obvious and common-sense, they are often overlooked or are acted upon too late to be effective – which is why this checklist can be useful to key stakeholders. This is especially true of action items in the early design stages i.e. pre-design and schematic design. Where appropriate, links to Labs21 tools and other resources are provided. Also indicated are the lead team members for each action item.

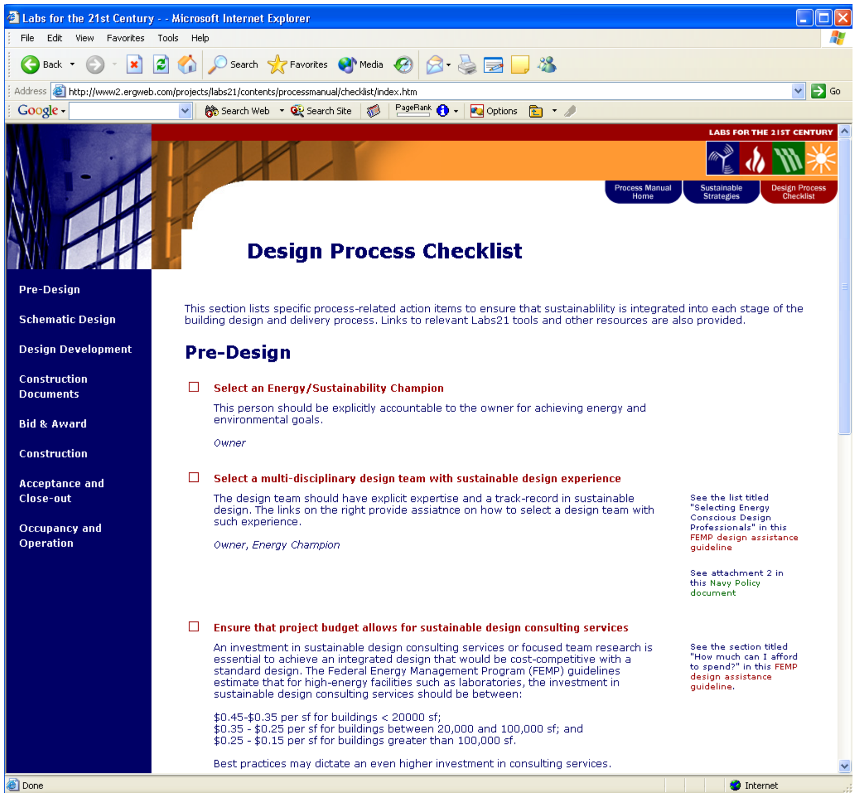

Figure 1: Design Process checklist in Labs21 Process Manual

The *checklist of sustainable design strategies* serves as a portal to detailed information on each of these strategies. The strategies are organized within a 3-tier hierarchy (Figure 2):

- Design areas – which correspond to the design areas in the USGBC's LEED™ rating system [USGBC 2002].
- Objectives for each design area.
- Strategies for each objective.

For each strategy, links are provided to the relevant information in the core resources i.e. Best Practice Guides, Design Guide, Case Studies and Benchmarking data (each of which are described in more detail later). Also, for each strategy, there is a link to the relevant credit or prerequisite in the Labs21 Environmental Performance Criteria (see again Figure 2). The EPC, which is described in more detail later, is essentially a rating system that is built on the LEED™ rating system, but adapted for laboratories. This allows designers to quickly map the strategies to the relevant credits and determine the number of points that they can obtain by adopting particular strategies.

With its links to core information resources and EPC credits, the strategies checklist is especially useful in the context of a design charrette.

Figure 2: Strategies checklist in Process Manual.

3 CREATING A (USEFUL) PAPER TRAIL

Often the weakest link in a typical design process is the lack of seamless, consistent and structured documentation of design intent. Proper documentation is essential to ensuring that sustainabilty goals are met and maintained during the course of the design process. Meaningful documentation:

- Communicates design intent and contractual obligation between the building owner, architects, engineers, builders, and commissioning agents;
- Allows the owner and the design team to track and assess sustainability goals during the course of the design process, especially during later stages, when value engineering occurs;
- Provides the basis of design decisions to new design team members;
- Provides the intended performance of various systems to commissioning service providers;
- Provides operations and maintenance personnel with an understanding of the intended operation and performance of systems

While few would argue with the need for and value of proper documentation, in practice it is more the exception than the rule. Thus, even though a lot of documents may be generated during the design process, if it is not structured and seamless, it is very difficult to usefully and effectively retrieve information from the document set, thereby defeating the purpose of documentation. This is primarily because of the time and effort required to do proper documentation, and no single stakeholder taking "ownership" of it.

The Design Intent Tool (DIT) is an MS Access™ database tool that facilitates seamless and structured documentation of design intent, and can thereby reduce the burden of creating and maintaining such documentation (Mills et al. 2002). Design intent is documented in terms of objectives, strategies, and metrics, for each design area. The Design Intent Tool uses the same 3-tier hierarchy as the Process Manual, so that a user can seamlessly navigate between these tools. The user can either start with a blank slate or use various built-in templates. For instance, Labs21 has developed a template that contains the design areas, objectives and strategies, consistent with the Process Manual and other Labs21 tools. Figure 3 shows a screen image of the DIT. An essential component of design intent is the documentation of metrics and their targets. These provide quantitative measures of the extent to which design intent is being met for each objective. Furthermore, the values for each metric can be documented as the design develops through each stage of the design process.

For each strategy, links are provided to the core information resources related to that strategy, just as they are in the Process Manual. For each metric, a link is provided to relevant data in the Labs21 benchmarking database, which can be used to help set targets for the metric.

One of the most valuable features of the DIT is automated report generation. Since the tool is essentially a database tool, reports in various formats, and various levels of detail can be generated at the click of a button. Some of the report options include:

- An MS Word™ documentation of all objectives, strategies and metrics
- An MS Excel™ file listing the metrics and their values at each stage of the design process.

While the DIT makes documentation easier, it still requires someone to play the role of design intent coordinator. This person will have overall responsibility to ensure that the design intent is documented, even if the documentation is actually carried out by several people on the design team. In the context of sustainable design practice, this role is best suited to the commissioning service provider (CSP). The CSP would update the design intent for each design stage and generate the reports for distribution and discussion with the team members.

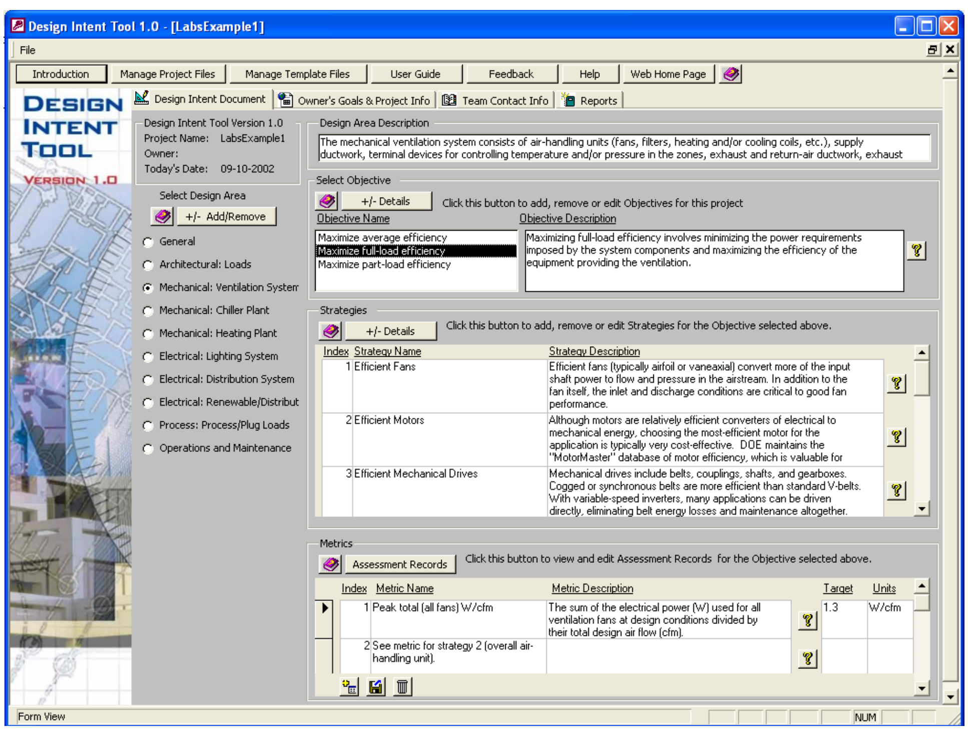

Figure 3: The Design Intent Tool, showing the hierarchical organization of design areas, objectives and strategies and metrics.

4 CONTEXT-SPECIFIC ACCESS TO THE LABS21 KNOWLEDGE-BASE

Over the past several years, Labs21 has developed and compiled a knowledge base on the design, construction, and operation of sustainable laboratories. Design information needs to be accessed in different ways, depending on the desired level of detail, the design context in which it is being used, and the background of the user. For instance, consider a strategy such as low-pressure drop air distribution system design. In the context of a pre-design goal setting charrette, the information required about this strategy centers on its key benefits (e.g. energy savings potential) and systems integration implications (e.g. plenum depth, mechanical room sizes). Further more, the users of this information will include a broad spectrum of the design team, many of whom will not have HVAC design expertise. On the other hand, during design development, the information required on this strategy will pertain to details on component design (e.g. coil design, filter pressure drop), and will typically be used by a design professional with expertise in this area. Consequently, there is no "universal" way to structure the breadth and depth of sustainable design information in a manner that makes it equally accessible to various needs. Accordingly, the Labs21 knowledge base allows designers to access the information in multiple ways. We briefly describe the four core resources in the knowledge base, and then discuss how a user can access the information in alternative ways.

4.1 Overview of Core Resources

The Design Guide for Laboratories is the largest and most comprehensive of the Labs21 core information resources. It is essentially a compendium of abstracts and references of publications, largely organized by system area (Bell et al. 2003). The information is hierarchically organized from general to specific. For example, Figure 4 shows a screen image of the guide displaying information on fume hood face velocity response time. The tree structure on the left indicates that this information is hierarchically nested as follows: Exhaust systems -> VAV fume hoods -> face velocity control -> response time. The guide also has search tools to find information based on keywords or questions.

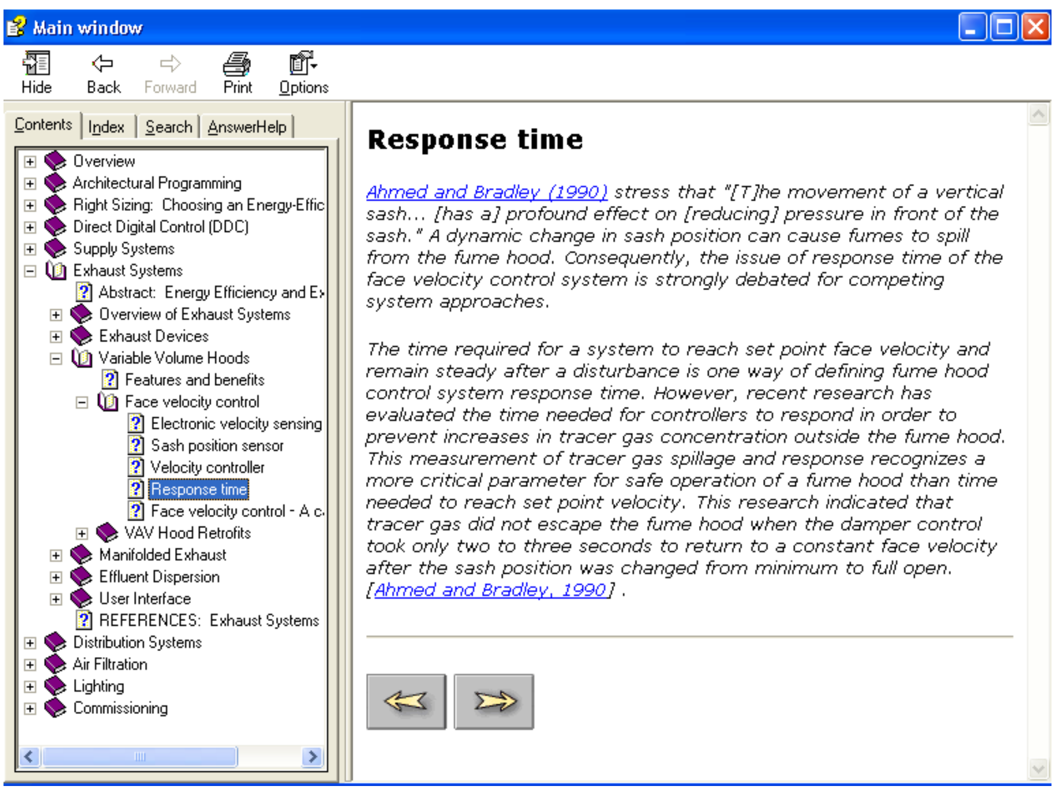

Figure 4: Screen image of the Design Guide, showing nested structure of information

The Best Practice Guides are a series of publications that provide information on the design, construction and operation of specific technologies that promote energy efficiency and sustainability in laboratories. The Guides include information from actual implementations of these technologies in various laboratory facilities, and highlight quantifiable performance goals and possible methods to achieve them. To date, three have been published. Over the next two years, it is anticipated that guides will be published on about 20 topics. For architects and engineers who may be unfamiliar or only minimally familiar with a certain strategy (e.g. high performance fume hoods), the best practice guide would be the most appropriate starting point.

Case Studies of laboratories that have incorporated sustainable design features are often the most popular and effective means of learning about these strategies, since they provide "real world" experience. Labs21 has published seven case studies on different types of laboratories.

The Energy Benchmarking tool is a web-based database tool that has been developed to collect, analyze and display energy use data for a wide variety of laboratories. The tool allows a user to input laboratory characteristics and energy use data via conventional web-forms (Figure 5a). In order to perform data analysis, the user specifies a metric of interest, and can set criteria to filter the data set by lab-area ratio, occupancy hours, and climate. The tool then presents the data analysis in graphical and tabular format, as shown in Figure 5b. As noted earlier, this information is especially useful when setting targets for various metrics as part of design intent documentation.

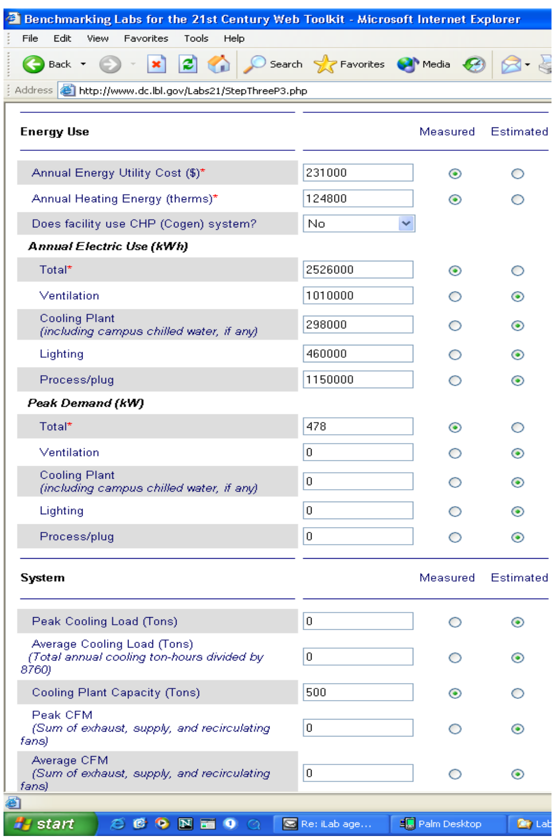

Figure 5a Benchmarking Data Input Form

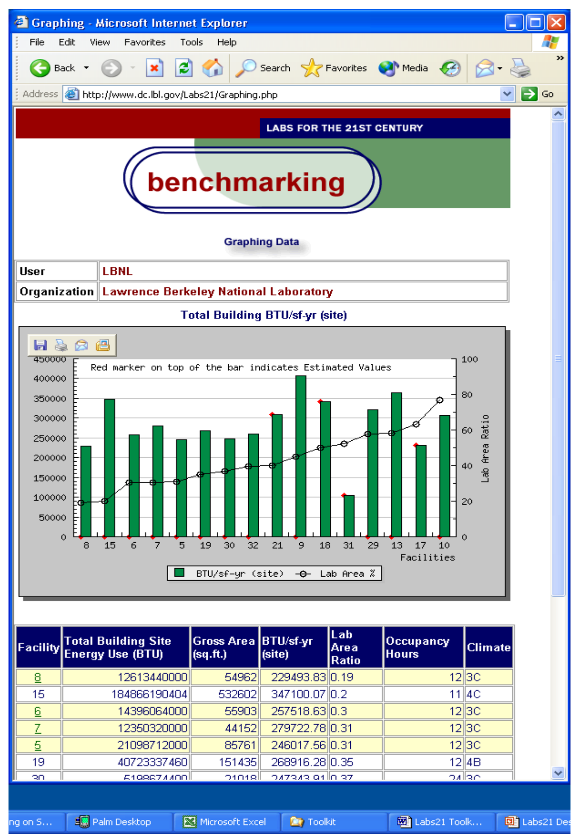

Figure 5b Benchmarking Data Analysis Output

4.2 Accessing the Knowledge Base

Collectively, these resources contain a significant amount of information. However, the effectiveness of these resources depends not just on their content, but on the ease with which their content can be accessed and navigated within the context of specific design process use-cases. Table 2 below indicates how the core resources can be accessed to support different use cases.

Table 2: Use cases for accessing information from the Labs21 knowledge-base

Use case	Access Modes
Access design information by strategies, categorized by LEED™ areas. *"Give me a list of sustainable design strategies for pre-design goal-setting"* *"How do I implement low pressure drop design in laboratories?"* *"Show me case studies where energy recovery wheels have been used in chemistry labs"*	1. In the Process Manual strategies checklist, click on the link for each strategy to get links to: Best practice guide (if available) Relevant information in Design Guide Case Studies that incorporate the strategy 2. In the Design Intent Tool Labs21 Template, click the "info" button for each strategy to get these same links
Access design information by system or component *"What are the key considerations pertaining to exhaust systems in labs?"* *"What are the issues concerning face-velocity response time in VAV fume hoods?"*	1. In the Design Guide, use the hierarchical tree structure to navigate and view information on related systems and components. 2. In the Design Guide, use the search engine to locate information on specific topic.
Access energy use metrics and data *"What are the efficiency metrics for ventilation systems in labs?"* *"What is the range of values for ventilation effectiveness in W/cfm?"*	1. In the Benchmarking tool, retrieve data for specific metrics. 2. In the Design Intent Tool, view the metrics for relevant design area and objective.

5 RATING YOUR LABORATORY

Rating sustainability is increasingly becoming an integral part of the green design process. This is especially due to the remarkable success of the LEED™ rating system. Rating systems provide a measurable means of evaluating sustainability, and also minimize "greenwashing".

The Labs21 Environmental Performance Criteria (EPC) is a point-based rating system for use by laboratory building project stakeholders to assess the environmental performance of laboratory facilities. It was developed by team of over 40 laboratory design and operation professionals. To facilitate widespread use and to avoid "re-inventing the wheel" the EPC builds on the existing LEED™ Rating System, by modifying and adding credits and prerequisites that are tailored to the unique attributes of laboratory facilities, as shown in Table 3 (Mathew et al. 2002).

Although Labs21 does not provide a certification process for the EPC, the EPC is useful as a document to help focus discussions during design charrettes - it provides an effective means for goal-setting, particularly in schematic design. It is being used as a basis for the LEED™ Application Guide for Laboratories, which is currently under development.

Table 3 Issues addressed in EPC credits for different LEED™ areas

Design area	Issues addressed in EPC Prerequisites and Credits
Sustainable Sites	Modeling of effluent dispersion
	Prevention of releases into sanitary sewer
Water efficiency	Documenting and reducing process water use
Energy & Atmosphere	Process for assessing minimum ventilation requirements
	Energy efficiency of laboratory HVAC and lighting systems
	Renewable energy use
	Source energy use reduction from use of on-site generation
	Energy efficient laboratory equipment selection
	Right-sizing of HVAC systems based on measured loads
Materials & Resources	Hazardous material handling and chemical resource management
Indoor Environmental Quality	Compliance with ANSI Z 9.5
	Laboratory airflow modeling
	Fume hood commissioning
	Laboratory alarm systems

6 CONCLUSION

We have shown that the Labs21 toolkit provides an effective means to support a sustainable design process in laboratories. Some of the key features that make it effective are:

- Scope: The toolkit has rich knowledge base in both breadth (range of topics covered) and depth (level of detail for each topic).
- Process support: The toolkit includes tools that are explicitly designed to support the design process and documentation of owner objectives for the laboratory.
- Context-specific linkages: The tools are interlinked, but not inter-independent. This provides flexibility in how the tools are used (i.e. it does not prescribe a particular path in the design process) while at the same time enhancing their effectiveness by providing content-specific links to other tools.

We should note that the integrated framework for the toolkit was not created *a priori*. The tools have been developed largely independently over the past several years as dictated by the needs of the Labs21 community. As more tools were developed, there was a need to provide guidance to a user on how to use the tools effectively during the course of a design process. This was the impetus to develop the integrated framework described in this paper, and was derived primarily based on design experience. Although this toolkit is specific to laboratory facilities, the underlying toolkit framework can be adapted for other building types as well.

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