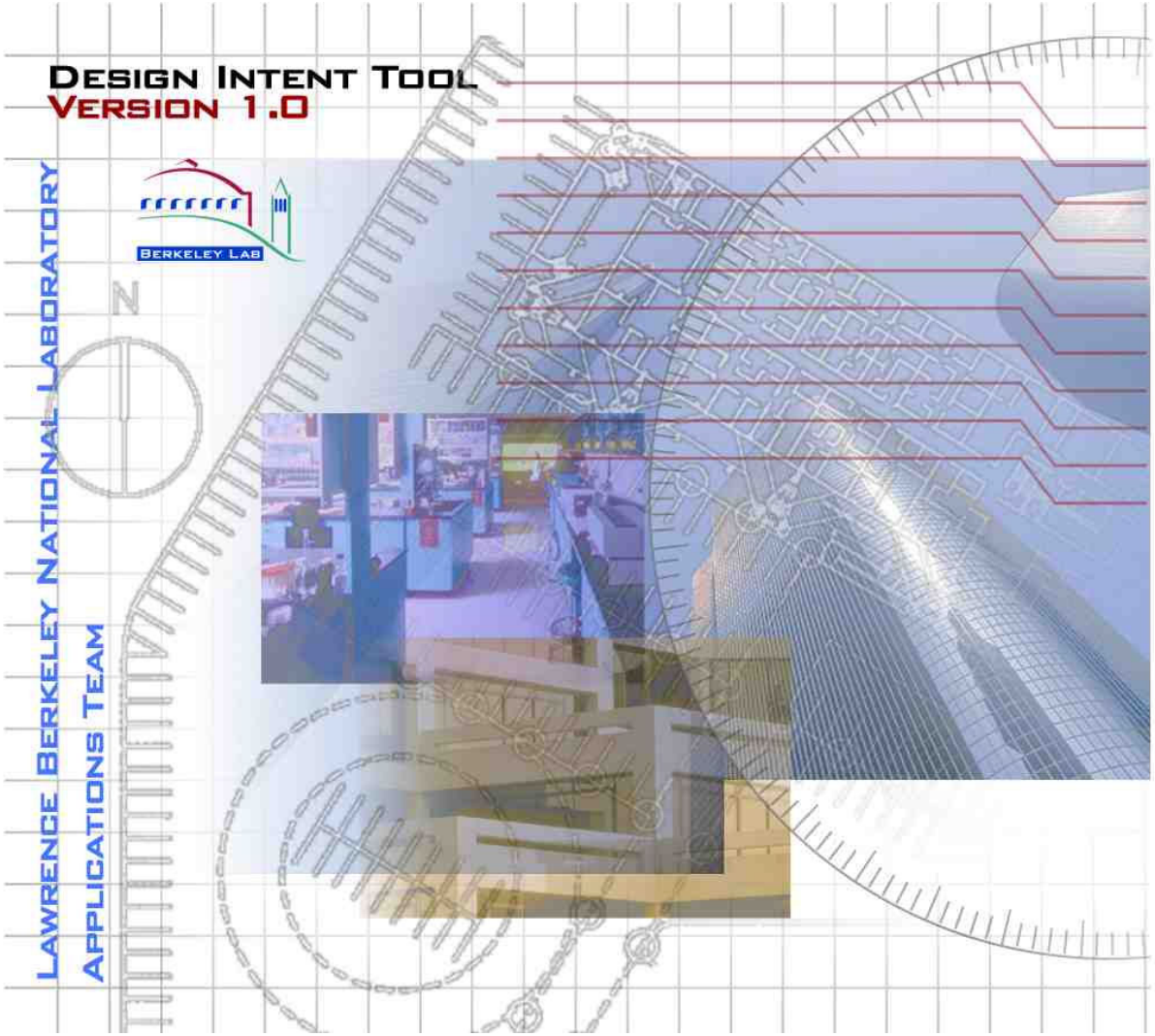
User Guide

Beta Test V.1



This database tool provides a structured approach to recording design decisions that impact a facility's performance in areas such as energy efficiency. Using the tool, owners and designers alike can plan, monitor, and verify that a facility's design intent is being met during each stage of the design process. Additionally, the Tool gives commissioning agents, facility operators and future owners and renovators an understanding of how the building and its subsystems are intended to operate, and thus track and benchmark performance. On-line at *http://ateam.lbl.gov/DesignIntent/home.html*

Contents

Introduction…….. 1

Documenting Design Intent ……...…… 2

Benefits – Why Document Design Intent? ……..…….. 3

Getting Started……...…..…… 4

Tour of the Tool……..……...…… 5

Navigation Bar…….…… 6

Design Intent Document Tab…… 7

Owner's Goals & Project Info Tab……8

Team Contact Info Tab…….… 9

Reports Tab…….…… 10

Design Areas……..… 11

Objectives Record…….…… 12

Strategies Record…….…… 13

Assessment Record…… 14

Manage Project Files & Templates…… 15

Exporting Projects & File Sharing……..…… 16

Web Home Page……..…… 17

Help…….…… 18

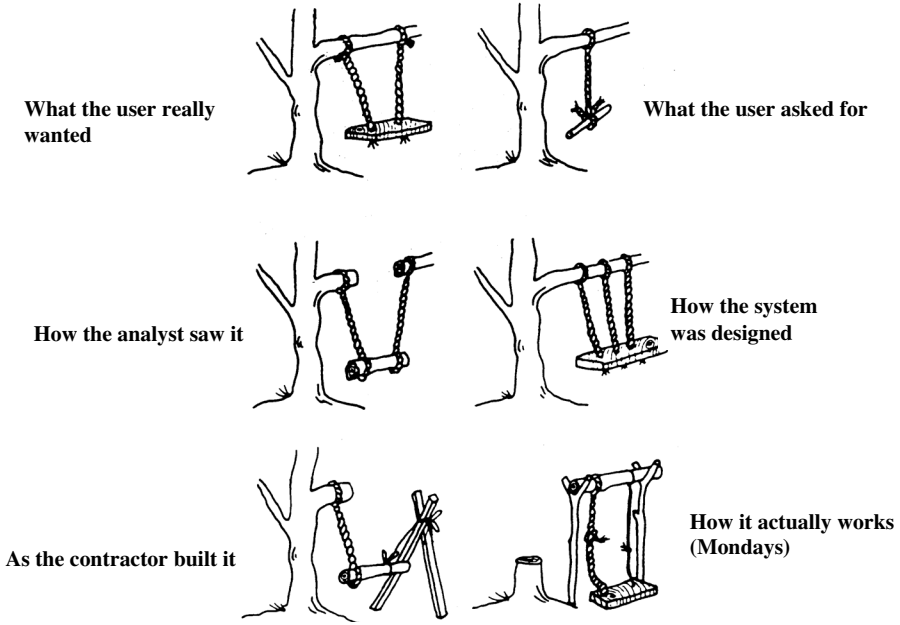
Further Reading……...…… 19

Credits……..…… 21

Introduction

Welcome to the Design Intent Tool. The Tool helps building owners, architects, and engineers develop a Design Intent Document (DID) to facilitate record keeping and ensure that the owner's and designer's up-front vision and goals (with a focus on energy-efficiency, but applicable to any aspect of design) are achieved and periodically verified through performance measurement. The tool is available at no charge via http://ateam.lbl.gov/DesignIntent/home.html.

As the fields of facility design and management mature, there is an increasing understanding that it is necessary but not sufficient to simply specify "good" technologies or design features in order to achieve desired performance. Efforts to do so are often thwarted by the absence of explicit direction from the owner, misunderstandings and different visions among members of the design team, and ambiguities imposed by the lack of measurable performance targets. The lack of clarity created by these problems in turn hampers the post-construction commissioning and measurement & verification processes. A more comprehensive and holistic approach can be described as "Design Intent Documentation". At the heart of the Design Intent Tool is a framework in which design solutions can be described in terms of Objectives (overall goals), with subordinate Strategies (specific means of achieving the goals), and Metrics (measurable performance targets). The result is an improved likelihood of attaining desired energy savings targets.



Documenting Design Intent

Design documents evolve as the project moves through the milestones of programming, design, and construction, into building occupancy and potential future renovations and retrofits.

Design intent documentation is crucial to the post-construction commissioning process (verifying the proper installation, operation, and performance of energy-efficiency features), and it is the essence of communication and contractual obligation between the building owner, architects, engineers, builders, and commissioning agents. And, when buildings change hands new owners can benefit tremendously from prior design intent documentation.

Developing a project's DID is a team effort. Many stakeholders need to be involved, including the building owner, occupants, design team members, facility operator(s), construction manager, and commissioning agents. Typically, one of the team members (e.g. the commissioning agent) takes the lead (on behalf of the owner) on seeing the DID process through to completion.

This Tool helps the user create a DID and a series of derivative reports (in MS-Word and MS-Excel format). Information entered by the user is gathered and organized using an MS-Access database. The Tool comes with importable default design suggestions (called Template Files), but users are encouraged to tailor it to their needs. The Template for energy management in laboratory-type facilities is supported by the Lawrence Berkeley National Laboratory *Design Guide for Energy-Efficient Laboratories* (http://ateam.lbl.gov/Design-Guide/index.html). Viewing links to the Design Guide requires a web browser (but not an active web connection). A Template for defining projects for conventional buildings according to the LEED "green buildings" criterion is also packaged with the Tool.

The Tool works in conjunction with a web site to provide links that efficiently bring the user to more in-depth design assistance resources, provides the most recent version for download, etc.

The Design Intent Tool was developed by the Applications Team at Lawrence Berkeley National Laboratory, with primary sponsorship from the California Energy Commission. The California Institute for Energy Efficiency sponsored initial conceptual development of the Tool. Portland Energy Conservation Inc. collaborated on an earlier version of the tool.

Benefits -- Why document design intent?

Buildings often fail to perform in practice as expected during design. In the case of energy-efficiency, actual savings often fall short of predictions. A building design process devoid of quantitative feedback does not detect or correct problems. One cause of this is the lack of a consistent method for documenting and communicating information about intended performance.

A facility's design intent is expressed as a set of qualitative Objectives that are developed into focused Strategies and then into quantitative Metrics. A Design Intent Document is intended to capture and preserve this information across the building's life-cycle, helping to ensure that:

- Participants in the project are able to clearly document their desired performance objectives during initial planning phases.
- Evaluations of proposed design options are better supported and the resulting decisions (including rejection of preliminary recommendations) are better documented and shared among design team members.
- Assessment of design changes during construction and operations and maintenance (O&M) is improved.
- The commissioning process is more comprehensive and cost-effective when supported by access to clearly specified performance targets.
- O&M evaluation of the day-to-day performance of systems and the early detection and diagnosis of maintenance problems are enhanced through performance benchmarking.
- Performance contracting and measurement and verification are supported in a structured and proactive manner.
- Post-occupancy evaluation is more easily performed.

Getting Started

1. **Please note that the DIT file is over 11.6 Mb:** If you are using a 56k modem, download times will exceed 12 minutes. If you prefer to receive a copy by mail, send email to MAJohnson@lbl.gov

2. **Minimum Hardware/Software Requirements:**

   - Operating System: Windows 95, 98, ME, NT 4.0, Windows 2000, or XP
   - Processor: Pentium II 200 Mhz; RAM: 64 MB
   - Software: > MS Access 2000
     > MS Word 2000 (allows viewing and printing of Text reports)
     > MS Excel 2000 (allows viewing and printing of DataTracker report)
   - Recommended screen resolution: 1024x768 or higher

   Functionality will be enhanced if an active Internet connection is established while the Tool is in use.

3. **Installation Instructions:** Download the DIT (DITInstall.exe) to your MS Windows™ desktop. Double-click DITInstall.exe on your desktop and follow the prompts. Program icons will be created for launching the tool from the desktop or from the Program files directory.

4. **Using the Tool:**

   - First, the owner selects a "Design Intent Coordinator" to orchestrate input to the Tool by all stakeholders. The Owner or Coordinator completes the "Owner's Goals & Project Info" and "Team Contact Info" Tabs, and, if desired, selects an appropriate Template File.* These steps provide the design team with a conceptual framework and guideposts.

   - The design team then develops the project's Design Intent Document Tab by adding/deleting/modifying the Design Areas, Objectives, Strategies, and Metrics (including "+/- Details" and "Assessment Records" sub-pages).

   - The Design Intent document is finalized, with input from all stakeholders. Reports generated in MS-Word and MS-Excel can be fed into the design program, specs, and other documents for easy modification.

---

* To save users' time, we have prepared optional default "Template Files" that users can begin with and modify as they see fit. These may be imported from the "Manage Project Files" button. The initial Release includes one Template File applicable to laboratory-type facilities (with links to the Laboratory Design Guide) and another for LEED's green-buildings measures (http://www.usgbc.org/programs/leed.htm) for common building types. Design Areas for LEED and Laboratories can be combined in either template. Users can also develop their own templates.

Tour of The Tool

The following pages offer annotated screen shots of key parts of the Design Intent Tool.

Navigation Bar

- Introduction, Manage Project Files, Manage Template Files, User Guide, Feedback, Help, Web Home Page – Helpful tools, background info, etc.

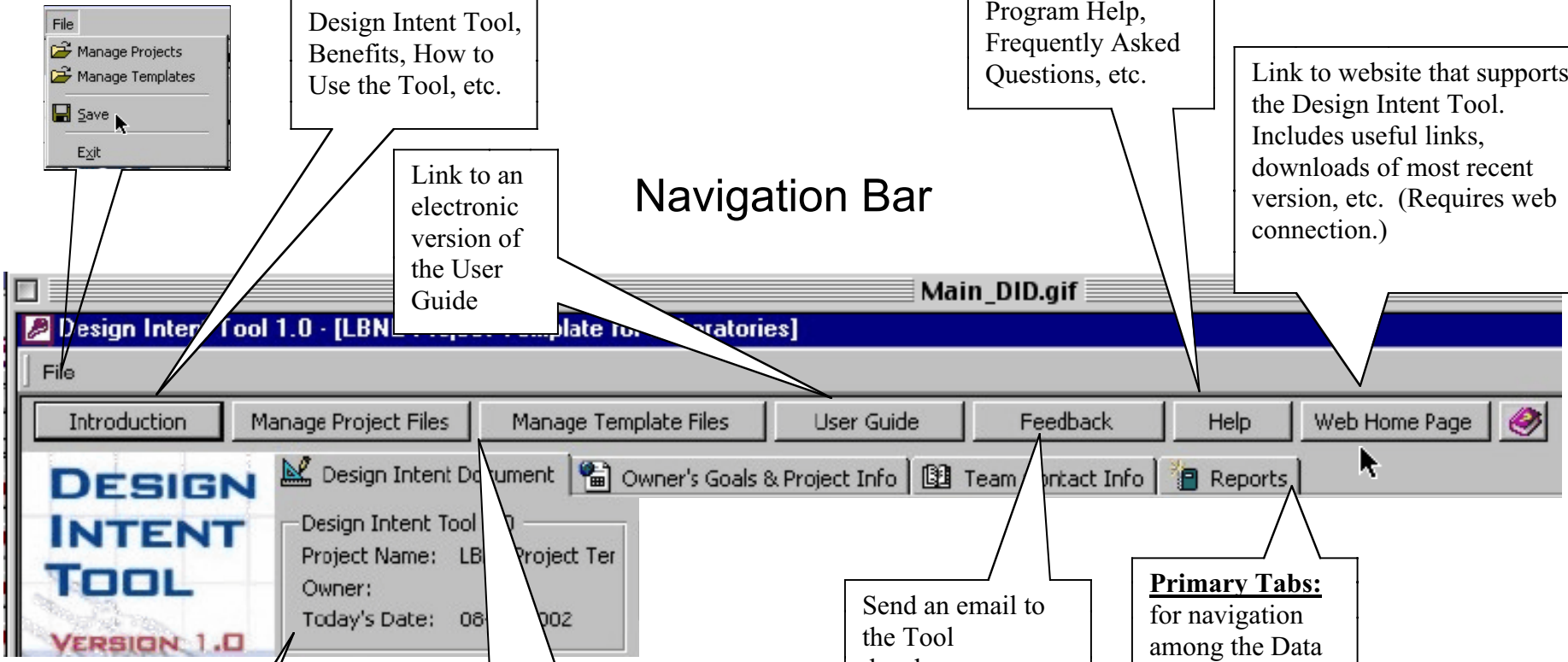
Primary Tabs

- Design Intent Document Tab – Most of the work is done here. This page allows the user to create/edit Design Areas, Objectives, Strategies, and Metrics.
- Owner's Goals & Project Info Tab– This tab contains a high-level description of the owner's goals, criterion for selecting the design team, and various project and building details.
- Team Contact Info Tab – This tab contains the names, addresses, email for project team members.
- Reports Tab – This tab allows users to generate six different reports, each composed of a set of information from the Design Intent Document and associated screens. The Data Tracker report (Excel format) can be imported into the *Metracker* tool (http://buildings.lbl.gov/hpcbs/Year_01/Element_2/01_E2_P2_1_2.html) for more comprehensive analysis.

Detailed Screens

- Detailed Design Areas, Objectives, and Strategies Records – Pop-up screens providing greater detail.
- Assessment Records – Detailed information about metrics, and a template for recording and verifying measurements to ensure that the target values are attained and maintained.
- Manage, Export, or Import Projects and Templates – Managing "Project Files".

Navigation Bar



Overview of the Design Intent Tool, Benefits, How to Use the Tool, etc.

Link to an electronic version of the User Guide

Program Help, Frequently Asked Questions, etc.

Link to website that supports the Design Intent Tool. Includes useful links, downloads of most recent version, etc. (Requires web connection.)

Send an email to the Tool developers. (Requires web connection.)

Primary Tabs: for navigation among the Data Entry screens.

"Fingerprint" of Project File currently in use, including project name, \owner, and current date.

Manage Project & Template files. Allows user to create, open, and modify Project Files, as well as Templates provided by the Tool authors at LBNL, export Project Files for distribution to others, etc.

Your data saved automatically as you go.

Design Intent Document Tab

DESIGN INTENT DOCUMENT:

Most of the data entry is done here. This page allows the user to create/modify Design Areas, Objectives, Strategies, and Metrics.

Navigation Bar (p. 6)

OBJECTIVES:
(see p. 12 for details)

Objectives are overall goals for the project, organized by Design Area.

STRATEGIES:
(see p. 13 for details)

Strategies are methods for achieving the Objectives, organized by Design Area.

METRICS:
(see p. 14 for details)

Metrics are quantitative measures of performance corresponding to the Objectives. The Assessment Records provide a framework for recording and tracking Target and actual performance. The data can be exported to an Excel file using the Reports Tab

DESIGN AREAS:
(see p. 11 for details)

Design Areas are the highest-level structure for organizing design intent information. Design Areas (and all other levels of information on the Design Intent Document) can be created, modified, or deleted. The remaining information displayed on this Tab depends on which Design Area is selected.

Program Help:

"Red Book" icons throughout the Tool will bring you to relevant sections of the User Guide.

Create/delete metric

Metrics can be created/deleted/saved via these icons

Content Help:

Links the user to background information about material provided in Template files, including web links (internet connection required).

Owner's Goals & Project Info Tab

OWNER'S GOALS & PROJECT INFO:

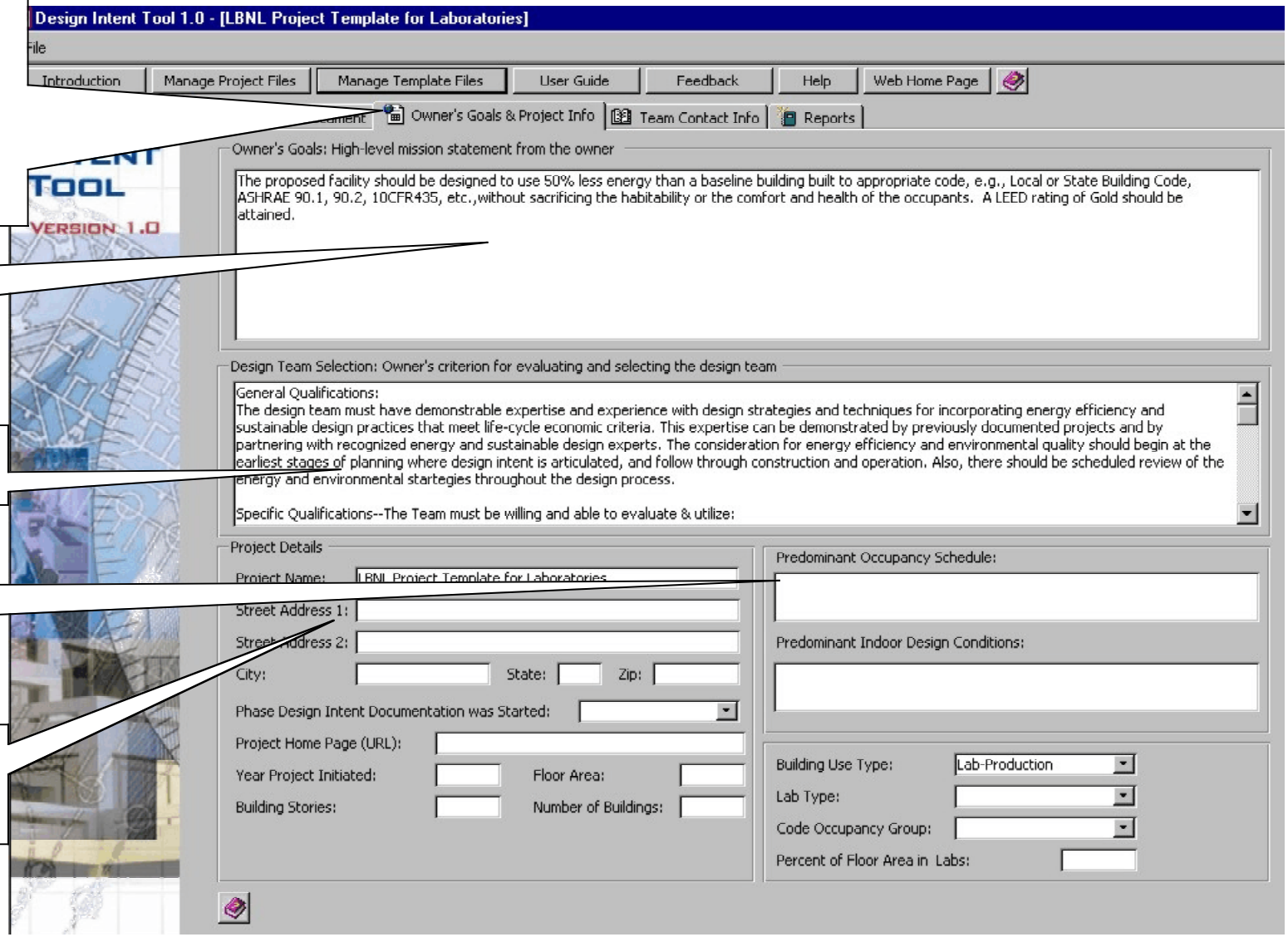
This tab is the critical starting point, where project Owners set the stage for the design and establish direction for the completion of the Design Intent Document.

A very brief, high-level description of the owner's goals for the project.

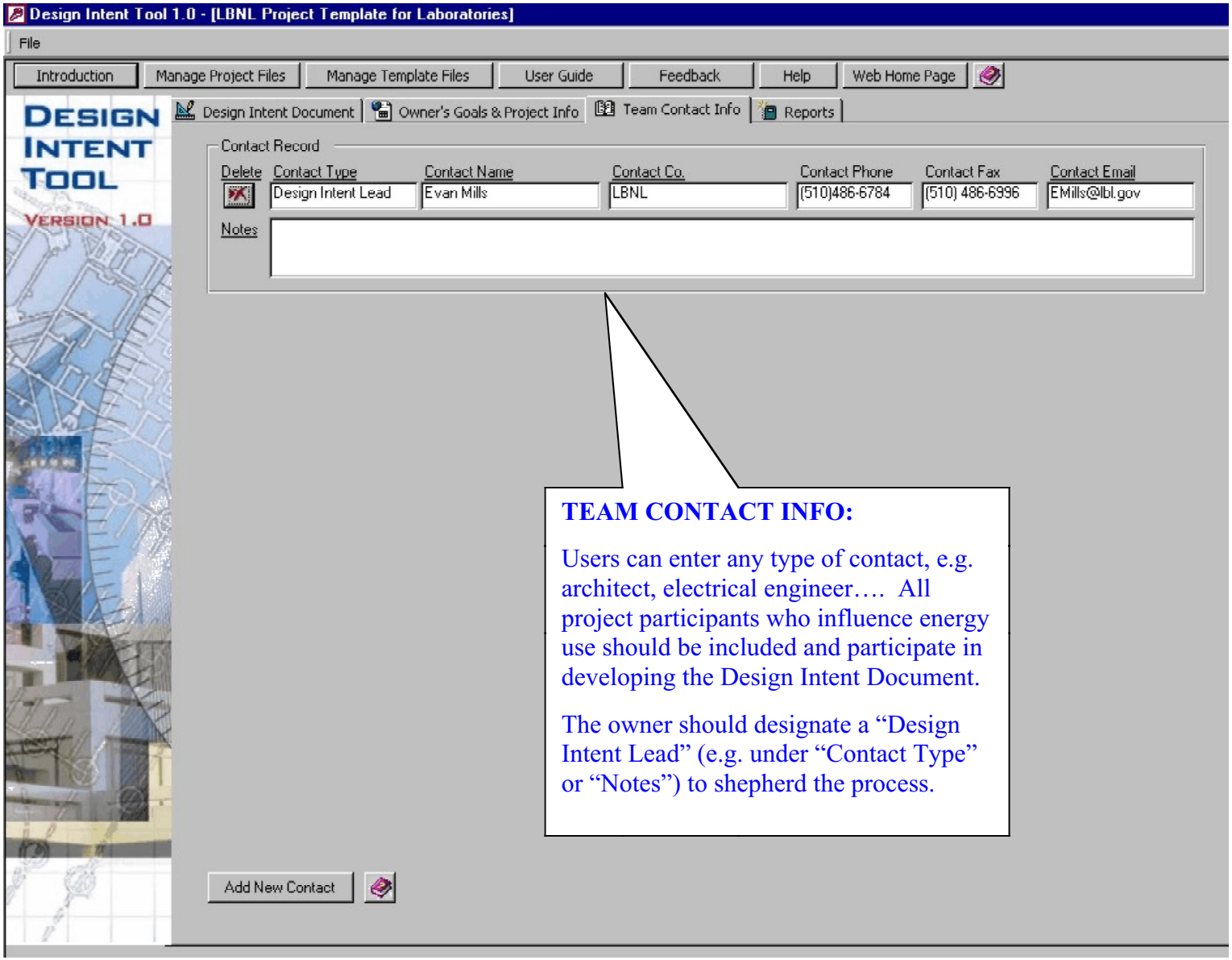
Owner's criteria for selecting the Design Team.

Building operating details, such as schedule, design conditions, and use.

Project details, such as name, address, project website address, and basic building characteristics.



Team Contact Info Tab

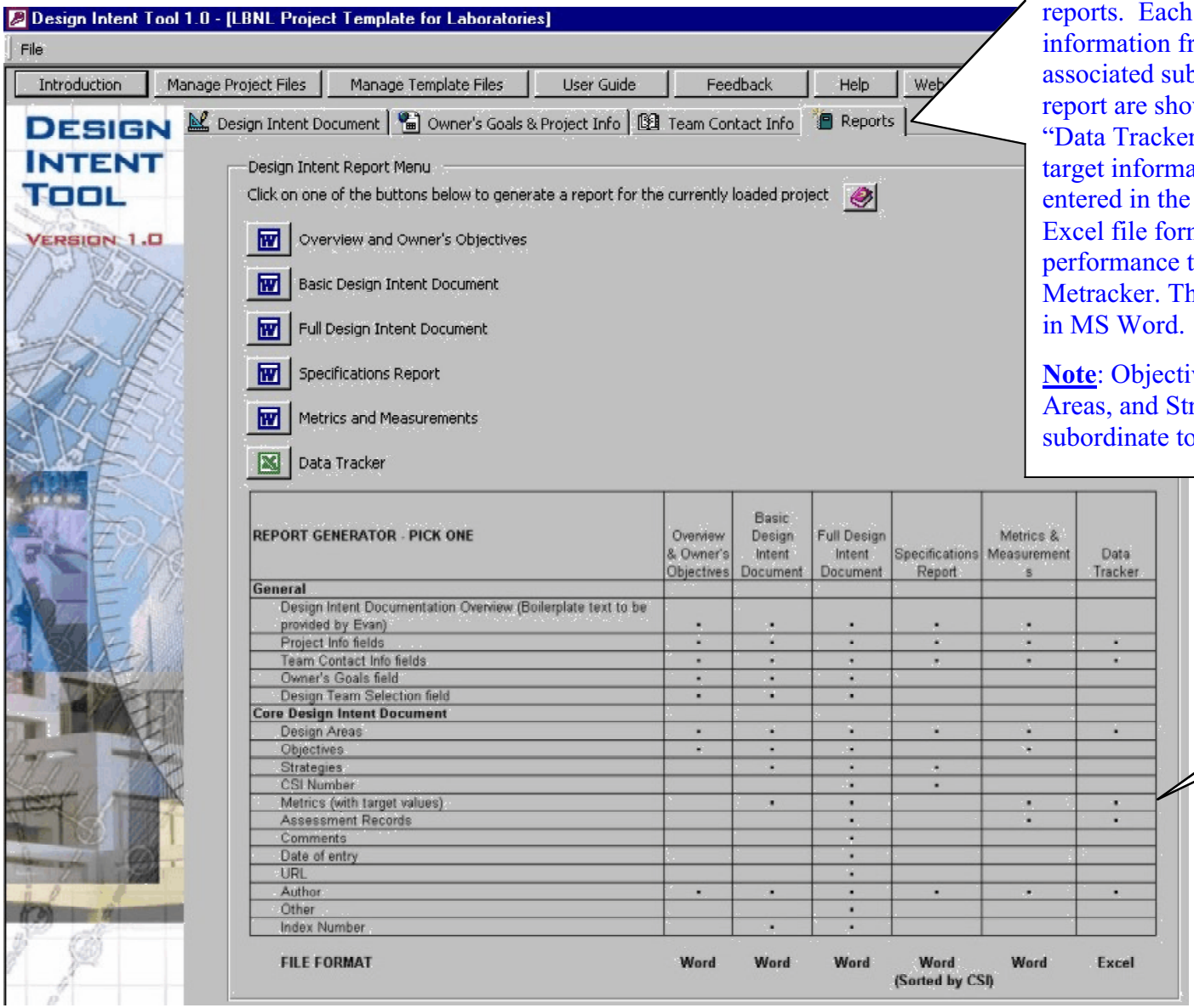


TEAM CONTACT INFO:

Users can enter any type of contact, e.g. architect, electrical engineer…. All project participants who influence energy use should be included and participate in developing the Design Intent Document.

The owner should designate a "Design Intent Lead" (e.g. under "Contact Type" or "Notes") to shepherd the process.

Reports Tab



REPORT GENERATOR - PICK ONE	Overview & Owner's Objectives	Basic Design Intent Document	Full Design Intent Document	Specifications Report	Metrics & Measurements	Data Tracker
General						
Design Intent Documentation Overview (Boilerplate text to be provided by Evan)	•	•	•	•	•	
Project Info fields	•	•	•	•	•	•
Team Contact Info fields	•	•	•	•	•	•
Owner's Goals field	•	•	•			
Design Team Selection field	•	•	•			
Core Design Intent Document						
Design Areas	•	•	•	•	•	•
Objectives	•	•	•		•	
Strategies		•	•	•		
CSI Number			•	•		
Metrics (with target values)		•	•		•	•
Assessment Records			•		•	•
Comments			•			
Date of entry			•			
URL			•			
Author	•	•	•	•	•	•
Other			•			
Index Number		•	•			
FILE FORMAT	**Word**	**Word**	**Word**	**Word (Sorted by CSI)**	**Word**	**Excel**

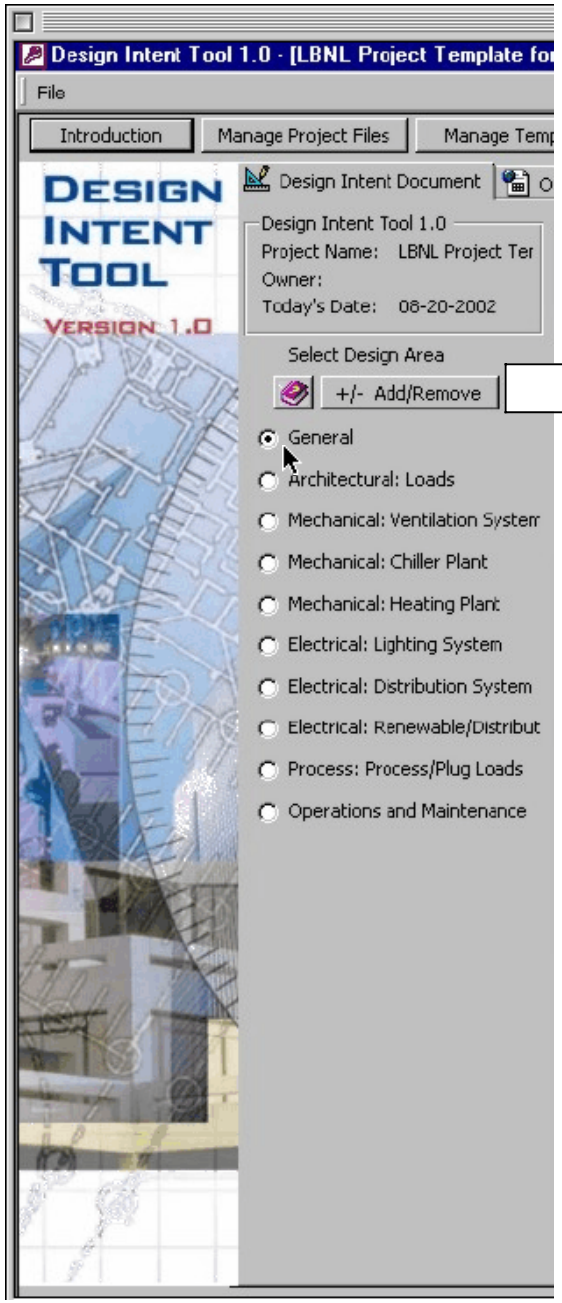
REPORTS TAB:

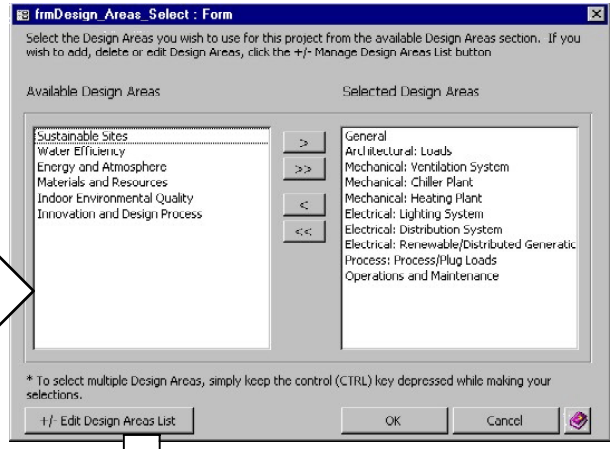
This tab allows users to generate six different reports. Each report is composed of a set of information from the other three Tabs and associated sub-screens. The contents of each report are shown in the table below. The "Data Tracker" report provides performance target information and (other Metrics values entered in the Assessment Records) in an Excel file format. This can be imported into performance tracking tools such as Metracker. The other five reports are created in MS Word.

Note: Objectives are subordinate to Design Areas, and Strategies and Metrics are subordinate to Objectives.

Matrix shows which database fields are included in each report.

Design Areas

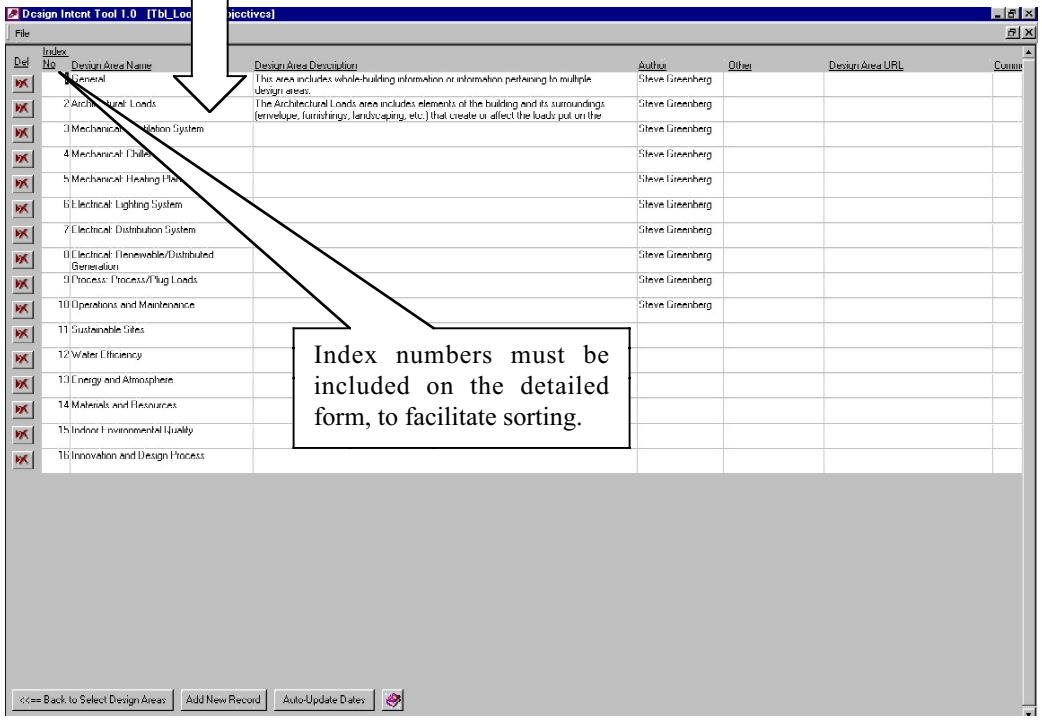




DESIGN AREAS DETAILS:

From the Design Intent Document Tab, the "+/- Add/Remove" button allows for customization of the available Design Areas. Design Areas can be defined/modified from the "+/- Edit Design Area" button.

Note: To select non-sequential Design Areas, keep the "CTRL" key depressed while selecting.



Index numbers must be included on the detailed form, to facilitate sorting.

Objectives Record

DETAILED OBJECTIVES:

Pop-up screen from the main Design Intent Document provides greater detail on Strategies.

Design Intent Tool 1.0 - [Tbl_Lookup_Objectives]

File

Objective Record

Del	Index No	Objective Name	Objective Description
	1	Minimize Ventilation Loads	Apply architectural solutions to minimize the amount of ventilation air while meeting all fresh air, exhaust, heating, and cooling requirements.

Author	Other	Objective URL	Update Date	Comments
			6/27/02	

Objective Record

Del	Index No	Objective Name	Objective Description
	2	Minimize Heating and Cooling Loads	

Author	Other	Objective URL	Update Date	Comments

Objective Record

Del	Index No	Objective Name	Objective Description
	3	Minimize Lighting Load	

Author	Other	Objective URL	Update Date	Comments
			6/27/02	

<<== Back to Main Design Intent Document | Add New Objective | Auto-Update Dates

Objective Name and Objective Description are migrated from the main Design Intent Document, and needn't be re-entered here.

User-defined ID number

Free field for additional information

Supplemental Comments

Elements in the Detailed Record screens can be added or deleted.

Users can enter any web address (URL) that provides more information, etc. If a browser is running, clicking on the URL will bring up the corresponding web page.

The current date will be auto-entered if the user clicks on the "Auto-Update Dates" button (bottom of screen) while the pointer is located in the record of interest.

Strategy Record

DETAILED STRATEGIES:

This pop-up screen from the main Design Intent Document provides greater detail on Strategies.

Design Intent Tool 1.0 - [Tbl_Lookup_Objectives]

File

Strategy Record

Del	Index No	Strategy Name	Strategy Description
	1	Exceed Title 24 requirement by factor of 2.5 (energy use 40% of Title 24 budget)	Energy code requirements can typically be easily outperformed. Such requ... baseline against which simulated performance can be compared. Title 24 is California's State Energy Code. Buildings can comply with the Code either by the prescriptive or performance method. The prescriptive method means meeting specific requirements for different end-uses (e.g. lighting and ventilation) and construction

Author	CSI Number	Other	Strategy URL	Update Date	Comments

Strategy Record

Del	Index No	Strategy Name	Strategy Description
	2	Achieve LEED Platinum rating	The Leadership in Energy and Environmental Design (LEED) system ... the U.S. Green Building Council to comprehensively rate buildings for their environmental impact ... Platinum is the highest rating.

Author	CSI Number	Other	Strategy URL	Update Date	Comments

Strategy Record

Del	Index No	Strategy Name	Strategy Description
	3	Minimize life-cycle cost	The life-cycle cost of a building is its total cost over its entire life, including design, construction, operation, maintenance, renovation, and decommissioning; future costs are discounted to present value for comparison. Minimizing life-cycle costs usually results in higher first costs and lower operating costs than are common for typical buildings.

Author	CSI Number	Other	Strategy URL	Update Date	Comments

Strategy Record

Del	Index No	Strategy Name	Strategy Description
	4	Commission	Commissioning is the process of ensuring that building elements and systems are designed, installed, programmed, and adjusted to operate as intended. Ideally, the commissioing begins early in the design process, and continues throughout the life of the building.

Author	CSI Number	Other	Strategy URL	Update Date	Comments
				6/21/02	

<<== Back to Main Design Intent Document | Add New Strategy | Auto-Update Dates

Strategy Name and Strategy Description are migrated from the main Design Intent Document, and needn't be re-entered here.

Free space for additional information.

User-defined ID number

Users can enter any web address (URL) that provides more information, etc. If a browser is running, clicking on the URL will bring up the corresponding web page. No ancillary characters can be added to this field beyond the URL itself.

Option to assign Construction Specifications Institute (CSI) numbers to Strategies.

Free field for additional information

The current date will be auto-entered if the user clicks on the "Auto-Update Dates" button (bottom of screen) while the pointer is located in the record of interest.

Elements in the Detailed Record screens can be deleted.

Assessment Record

ASSESSMENT RECORD:

Provide detailed information about metrics, and a matrix for recording and verifying measurements to ensure that the target values are attained and maintained over the project lifecycle.

Metric name, Target Value, and Author are carried forward from the main metrics entry page.

Technique(s) used to obtain the Value.

Name of individual conducting the assessment

Various "checkpoints" for the design and construction process. Values for Metrics are recorded here and verified against initial Target

Quantitative value of the given Metric.

Design Intent Tool 1.0 - [frmAssessmentRecord : Form]

File

Assessment Record

Metric Name: Total annual kWh/sf | Target Value: | Target Unit: | Author:

Metric Description: Whole-building electric energy use per gross square foot of building. From building electric meter.

General Assessment Method | Notes:

Measurement/Verification	Value	Assessor	Date	Verification Method
Pre-Design				
Schematic Design:				
Design Development				
Contract (final design):				
Bidding				
Construction (as built):				
Project Closeout:				

Assessment Record

Metric Name: Annual source BTU/sf (combined gas and el | Target Value: | Target Unit: | Author:

Metric Description: Whole-building total energy use per gross square foot of building. Source BTU/sf is calculated using XXXX BTU/kWh of electricity and a multiplier of 1.Y for natural gas to account for transmission and

General Assessment Method | Notes:

Measurement/Verification	Value	Assessor	Date	Verification Method
Pre-Design				
Schematic Design:				
Design Development				
Contract (final design):				
Bidding:				
Construction (as built):				
Project Closeout:				

Assessment Record

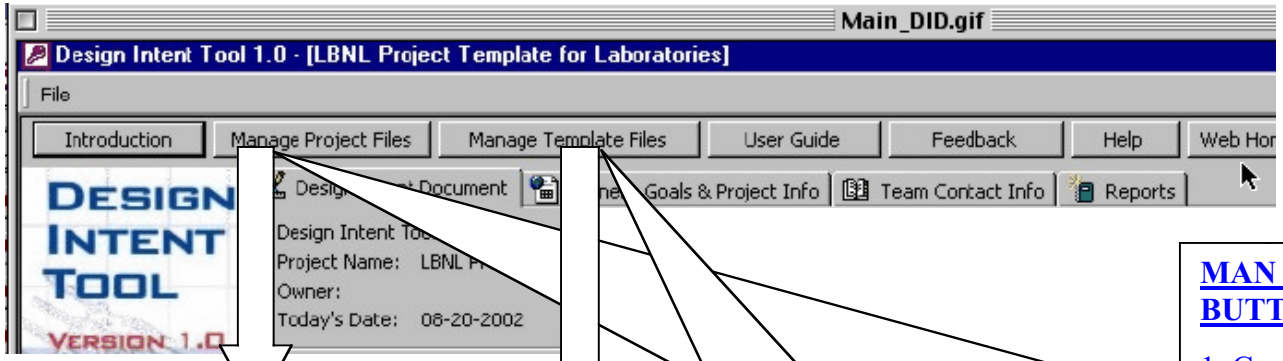
Metric Name: Annual peak W/sf | Target Value: | Target Unit: | Author:

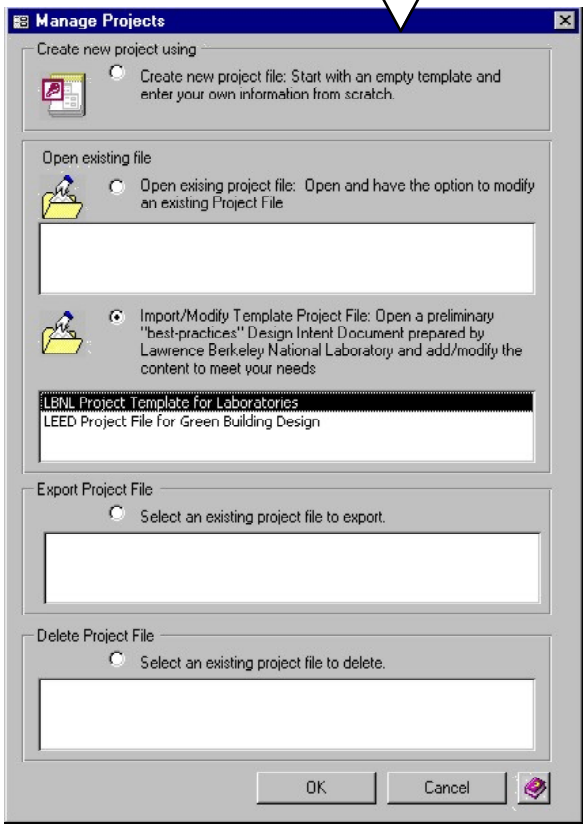
Metric Description: Highest annual whole-building peak power in Watts per gross square foot of building. From building electric meter.

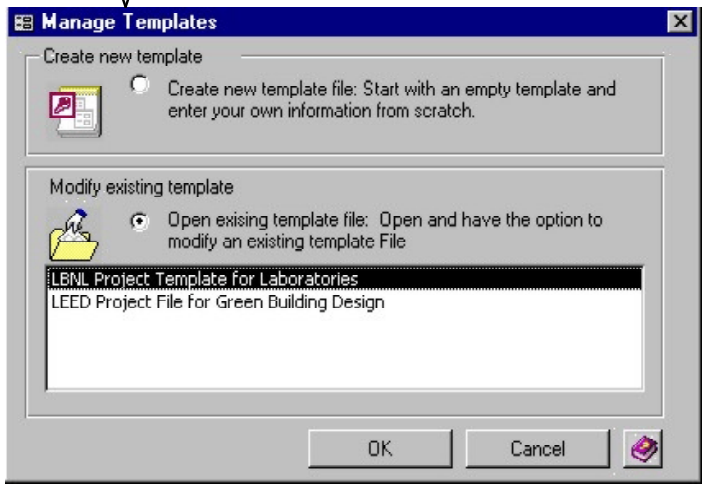
General Assessment Method | Notes:

<<== Back to Main Design Intent Document | Auto-Update Dates

Manage Project Files & Templates







MANAGE TEMPLATE FILES BUTTON:

Create new Template or import and modify the Templates provided with the Tool. Modifications to the Templates are irreversible.

MAN AGE PROJECTS FILES BUTTON:

1. Create a new project file.
2. Open and modify (or delete) an existing project (e.g. from a prior session or received from another member of the design team).
3. Import pre-defined "Template Project Files" prepared by Lawrence Berkeley National Laboratory. The content provided therein offers a starting point for tailoring a Design Intent Document for a particular project.
4, On occasion, users will have multiple Project Files in their version of the Design Intent Tool and want to share a single one with someone else. To do so, use the Export Project File feature to create a separate version of the Tool containing the desired Project File.

Exporting Projects & File Sharing

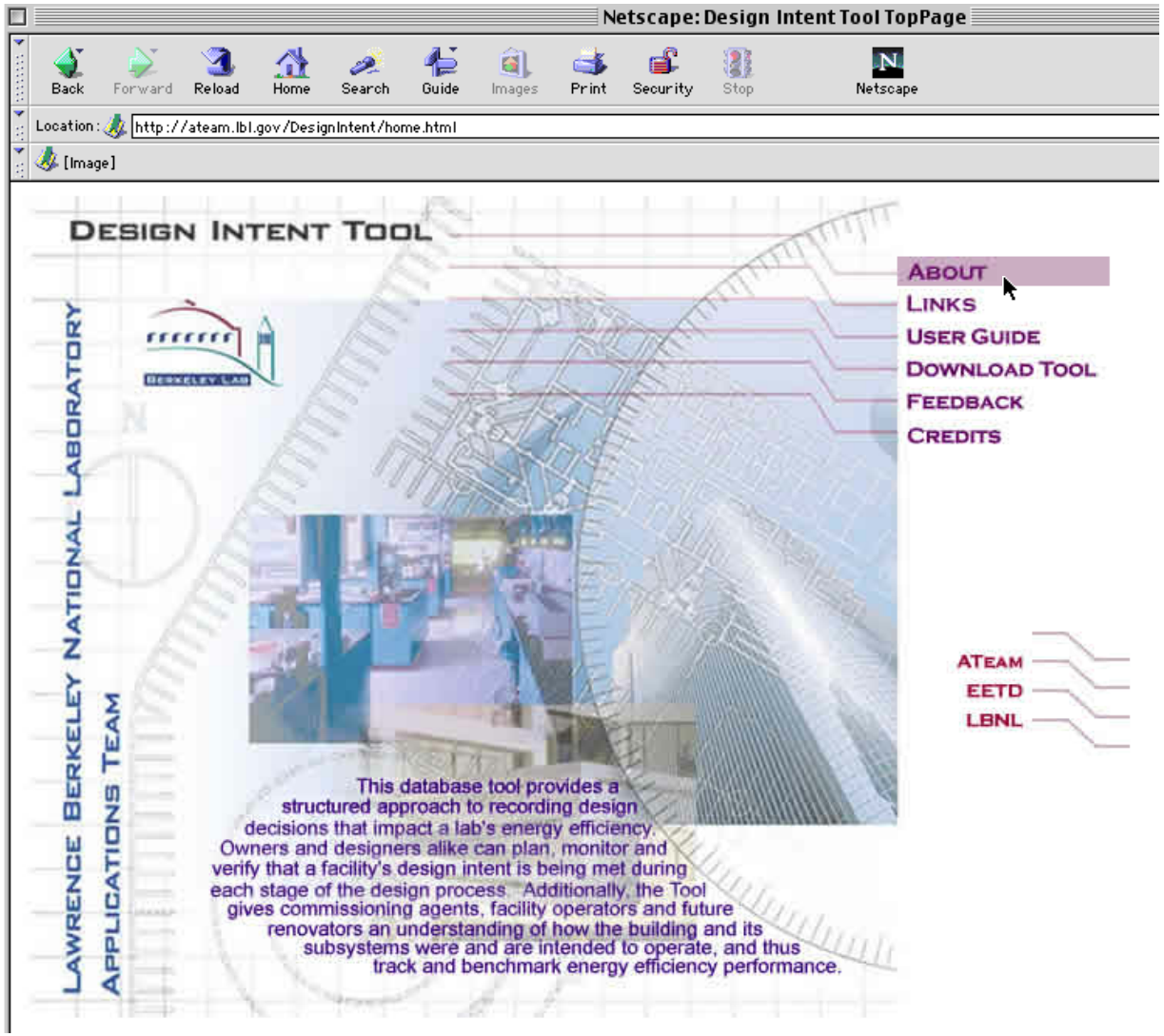
The Design Intent Tool provides the option for users to export a particular project file into a single database file, which can be shared with other users. To export a project file, click on the Manage Projects button, then click on the option to Export a project. After selecting which project to export, click the OK button. A new Access database file containing only the exported project will be created in the C:\Program Files\LBNL\DIT\Export directory. This new database file will function in much the same manner as the Design Intent Tool but with the following limitations:

1. The Manage Projects screen will only list one option: Open Existing File. The options to Create New Project File, Import/Modify Template Project File, Delete Project File and Export Project File are not supported.
2. The Manage Templates button has been disabled.

While the Design Intent Tool application will contain all project files as well as template project files, the exported database will only contain the exported project file. The exported project file can be emailed to other users and updated sequentially. When the exported database file is shared between users, only one user at a time may update the file before passing it on to another user.

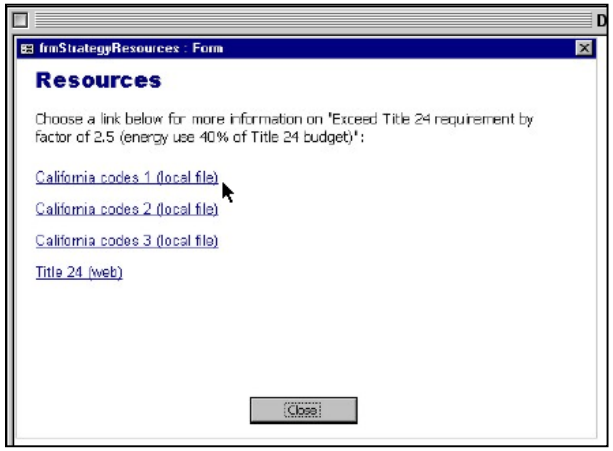
Note: As of Version 1.0, the ability to import an exported project file back into the Design Intent Tool application is currently not supported. In addition, an exported project file may not be imported into another user's Design Intent Tool application. The exported project file is self-contained and sealed in its own database file. The original project file in the Design Intent Tool is still available for modifications and further exports.

Web Home Page



HELP

Program and Content Help



Links (red-book icons) are provided throughout the tool to context-sensitive "Program Help" (how to use the tool). Question-mark icons to the right of Objectives, Strategies, and Metrics imported via the Template Files offer "Content Help" (right) and useful links for more information. The "Help" button on the Navigation Bar links to this page. For additional assistance, the "Feedback" button on the Navigation Bar will generate an email to the Tool developers.

Frequently Asked Questions

Q. Why bother? What are the benefits of design intent documentation?

A. See "Benefits: Why Document Design Intent?"

Q. How do I get the most current version of the Tool or new Template Files?

A. Download free copies at http://ateam.lbl.gov/DesignIntent/index.html.

Q. Who developed the Design Intent Tool?

A. See "Credits"

Q. How do I get rid of the paperclip-shaped "Wizard" that automatically pops up when I start Access?

A. Control Panel → Add/Remove Programs → Microsoft Office 2000 → Add/Remove → Add or Remove Features → Microsoft Access Tree → Typical Wizards → "Not Available" → Additional Wizards → "Not Available"-- an X should appear → Update Now

Further Readings

Friedman, H. and M.A. Piette. 2001. High Performance Commercial Building Systems: Comparative Guide to Emerging Diagnostic Tools for Large Commercial HVAC Systems. Lawrence Berkeley National Laboratory Report No. 48629. http://eande.lbl.gov/btp/papers/48629.pdf

This guide compares emerging diagnostic software tools that aid detection and diagnosis of operational problems for large HVAC systems. The authors have evaluated six tools for use with energy management control system (EMCS) or other monitoring data. The diagnostic tools summarize relevant performance metrics, display plots for manual analysis, and perform automated diagnostic procedures. The comparative analysis presents nine summary tables with supporting explanatory text and includes sample diagnostic screens for each tool.

PECI. 2001. "Summary Report on Design Intent Research and Design Intent Database Tool Development Recommendations." Prepared for Pacific Gas and Electric Company. Portland Energy Conservation Inc., Portland, OR.

Presents one view of definitions and concepts to use in design intent documentation—focusing on Basis of Design and Owner's Project Requirements—and proposes the development of a design intent tool, potentially building upon an earlier version of the LBNL/PECI tool. Presents detailed results of surveys of potential users of such a tool (including Owners, Designers, and Providers). Not available for general distribution.

PECI and Marinsoft, Inc. 2001. "Identification and Preservation of Building Design Information for Use in Commissioning and Operations". Draft. Final Report (October 1) for ASHRAE TC 1.5 (Computer Applications) and 9.9 (Building Commissioning). TRP-1032. Prepared for American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), TC 1.5 and 9.9. Other useful PECI resources and publications can be found at http://www.peci.org/cx/index.html

Discusses the insufficient availability and organization of building system equipment selection, performance and operation, and the need for standard methods and procedures for gathering and documenting data, with a focus on commissioning. Illustrates how highly detailed design information can be. For example, the report identifies over 150 data points for chilled water systems and over 100 for VAV systems. Report presents a detailed data schema for use in a computer-based tool for classification. Reviews related research, industry initiatives, and existing software.

Stum, K. 2002. "Design Intent and Basis of Design: Clarification of Terms, Structure and Use. (Draft)

Discusses the frequent confusion and controversy about definitions and usage terms for describing design intent documentation, design narrative, design programming, owner's project requirements, basis of design, design rationale, performance criteria, etc.

Tschudi, K. Benschine, S. Fok, P. Rumsey. 2001. Cleanroom Energy Benchmarking in High-tech and Bio-tech Industries. Lawrence Berkeley National Laboratory Report No. 47729. http://eetd.lbl.gov/btp/papers/47729.pdf

To understand the opportunities and potential impact energy savings strategies in "high-tech" buildings, Pacific Gas and Electric Company sponsored a project to benchmark energy use in cleanrooms in the electronics (high-tech) and biotechnology industries. Both of these industries are heavily dependent intensive cleanroom environments for research and manufacturing. In California these two industries account for approximately 3.6 million sq. ft. of cleanroom and 4349 GWh/yr. Little comparative energy information on cleanroom environmental systems was previously available. Benchmarking energy use allows direct comparisons leading to identification of best practices, efficiency innovations, an highlighting previously masked design or operational problems.

Wilkinson, R.J. 1999. "The Commissioning Design Intent Narrative". ASHRAE Journal, pp. 31-35 (April).

Early work defining the uses of design intent documentation, with emphasis on the applications for commissioning. Discusses how design intent documentation fits into the broader design, construction, and operation phases of a building's life-cycle. Articulates many of the benefits of design intent documentation, including an important discussion of how it can reduce liabilities of various parties involved (rather than increasing it, a concern that is sometimes voiced).

Credits

Prepared by:

Lawrence Berkeley National Laboratory
Environmental Energy Technology Division
Applications Team
University of California
Berkeley, California 94720 USA

Development Team:

Evan Mills
Daniel Abell
Geoffrey Bell
Jeremy Faludi (via Spark Factor Design)
Steve Greenberg
Rob Hitchcock
Mary Ann Piette
Dale Sartor
Karl Stum (via PECI)

Sponsored by:

The California Energy Commission
California Institute for Energy Efficiency

Disclaimer: This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or The Regents of the University of California. Ernest Orlando Lawrence Berkeley National Laboratory is an equal opportunity employer. Contract No. DE-AC03-76SF00098 with the U.S. Department of Energy. LBNL/PUB-3167.