U.S. Department of Energy

Office of Building Technology, State and Community Programs

Workshops on Next Generation Energy Tools (August 1995 and June 1996)

Introduction

Many building energy simulation programs developed around the world are reaching maturity. Many use simulation methods (and even code) that originated in the 1960s. Without substantial redesign and recoding, expanding their capabilities has become difficult, time-consuming, and expensive. However, recent advances in analysis and computational methods and power have increased the opportunity for significant improvements in these tools.

To inform planning activities for next-generation simulation tools, the U.S. Department of Energy held workshops in August 1995 and June 1996. Energy simulation developers and expert users were invited to the first workshop (developers workshop), held following *Building Simulation '95* in Madison, Wisconsin. Energy simulation users and other professionals attended the second workshop (users workshop), held in Washington, D.C. The structure and the results of the two workshops are described below.

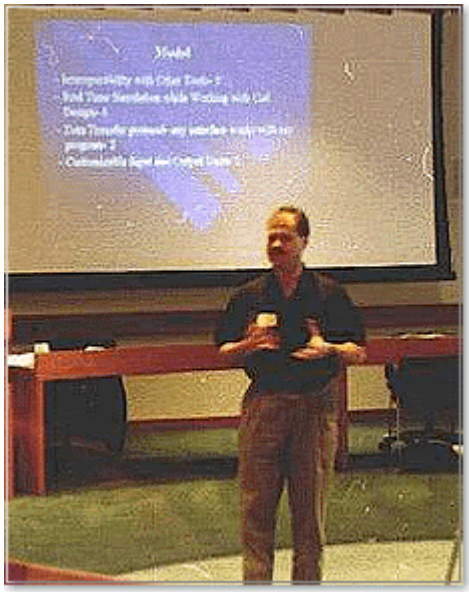
Structure of the Workshops

The goal of both workshops was to generate and prioritize ideas for next-generation simulation environments where the scope was simulation of building life-cycle processes that influence energy performance and environmental sustainability. The developers workshop focused on applications, capabilities, and methods and structures; the users workshop focused on applications, capabilities, and user interfaces. Participants were reminded that the workshops were not a forum to discuss pros and cons of any existing tool, or to decide who might perform any development work for any potential U.S. next-generation simulation tools.

Each workshop was organized in three breakout sessions: Applications, Capabilities, and Methods and Structures for the developers workshop: Applications, Capabilities, and User Interfaces for the users workshop. We divided the participants into groups each with a facilitator. The facilitators used a five-step process for each of the breakout sessions: brainwriting, grouping and eliminating duplicate ideas, brainstorming, prioritizing and Pareto voting, and summarizing.

At the beginning of each breakout session the facilitators described the general subject of the session. Then, the groups began brainwriting in which each workshop participant writes down one idea on a note card and passes that card to their right. As cards are passed, each person reviews the idea and continues to generate their own new ideas. Brainwriting encourages idea generating through individual creativity and brainpower. After 10-15 minutes the groups organized the cards/ideas into general groups and eliminated duplicate ideas. To make sure no important ideas were missed, the groups then spent 10-15 minutes brainstorming--working as a group to generate new ideas. After brainstorming, each group counted the number of cards/ideas and multiplied by 0.2. This was the number of votes each participant had when selecting their top 20% of the ideas (Pareto voting). Votes (using dots) were applied to the cards once all participants in a group had selected their top 20%. The groups then rank-ordered the cards from highest priority (most votes) to lowest priorities (fewest votes). Voting provided a relative ordering of the ideas within each group-all of the ideas generated would be useful to the group. Last, each facilitator prepared a summary that they presented to the entire workshop at the end of each breakout session.

Results



The following figures present summary grouping of the concepts and ideas generated in the two workshops. In total, the developers workshop generated 225 ideas for the Applications breakout session, 242 ideas for the Capabilities breakout session, and 201 ideas for the Methods and Structures breakout session. The users workshop (with more participants) generated 247 ideas for the Applications breakout session, 301 ideas for the Capabilities breakout session, and 213 ideas for the User Interface breakout session.

Figure 1 compares the application priorities of users and developers. The raw votes of software developers and users were normalized and plotted as percentages in the figure. The developers workshop included researchers in the field of building simulation and energy analysis. Predictably, users disagreed with developers on the importance of research. The significance placed on design by the user community was also not surprising. But although the expected bias of the two groups is discernible, there is remarkable agreement on program application priorities. This indicates that, for the most part, researchers and developers are cognizant of the needs of the user community.

A similar trend can be seen in Figure 2, which compares the capability priorities of users and developers. For the most part, developers seem to be aware of user concerns and priorities. The most serious disconnect occurs on the issue of input and output capabilities. This category was clearly a high priority for users but a lower priority for developers.

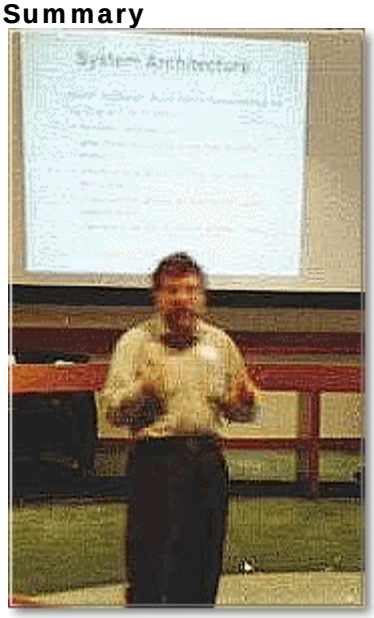
As shown in Figure 3, users' top priorities for software program interfaces were interoperability and integration with other building tools such as CAD and customizability. Still important but with less agreement was graphical input/output, defaults/error checking/help, and data storage. One of the fun concepts that came from one of the user teams was a TUI—similar to a GUI (Graphic User Interface) but instead a Telepathic User Interface-showing that some of the teams were willing to think 'outside the box'.

In Figure 4, the developers' topic priorities for program methods and structures are shown. By far the most important issue for the developers was pre- and post-processing methods-similar to the users' priorities of interoperability and integration. The other three

categories were considered important but of lessor priority. The authors conjecture that this occurs because the developers have these issues under control.

Tables 1, 2, 3, and 4 show the votes by topic within each category from the users and developers workshops. Tables 3 and 4 (as with Figures 3 and 4) show information only for the users and developers workshops respectively.

Summary



A surprising outcome of the workshops was that not many new or unusual ideas were brought up—even with a group of international building simulation developers and users. The hundreds of ideas generated during the workshops showed instead that the field of building energy simulation has many fundamental problems that are being addressed. Even the developers were not willing to stretch the boundaries and capabilities of simulation (even in their own minds) until more of these basic issues are resolved.

Note that participants in both workshops identified similar topics of concern and priority. Using simulation programs in design is high on both lists (though naturally a stronger issue for users). The main differences appear in the areas where we split the focus of the workshops-Interface, and Methods and Structures. The interface priorities identified in the user workshop are crucial to the success of any next-generation tool in the building simulation area.

For users, recurrent themes throughout were design, environment, economics, and occupant comfort and safety. Designers need tools that provide answers to very specific questions during design. They are less concerned with the mechanics of the Tools—although they want tools that provide the highest level of simulation accuracy and detail reasonably possible. The developers focused more on model and module development, and related issues. From the similar priorities identified, it is clear that the developers at least recognize the concerns of their users.

To obtain the complete list of concepts from the two workshops, click here.

Acknowledgments
DOE, LBNL, CERL, and University of Illinois staff participated as leaders and facilitators for the developers and users workshops. We wish to thank the participants for their contributions to the workshops and the long range planning efforts that will evolve from them. To view the list of participants in the developers workshop, click here; to view the list of participants in the users workshop, click here

Workshops on Next Generation Energy Tools

Figure 1

Program Application Priorities of Developers and Users

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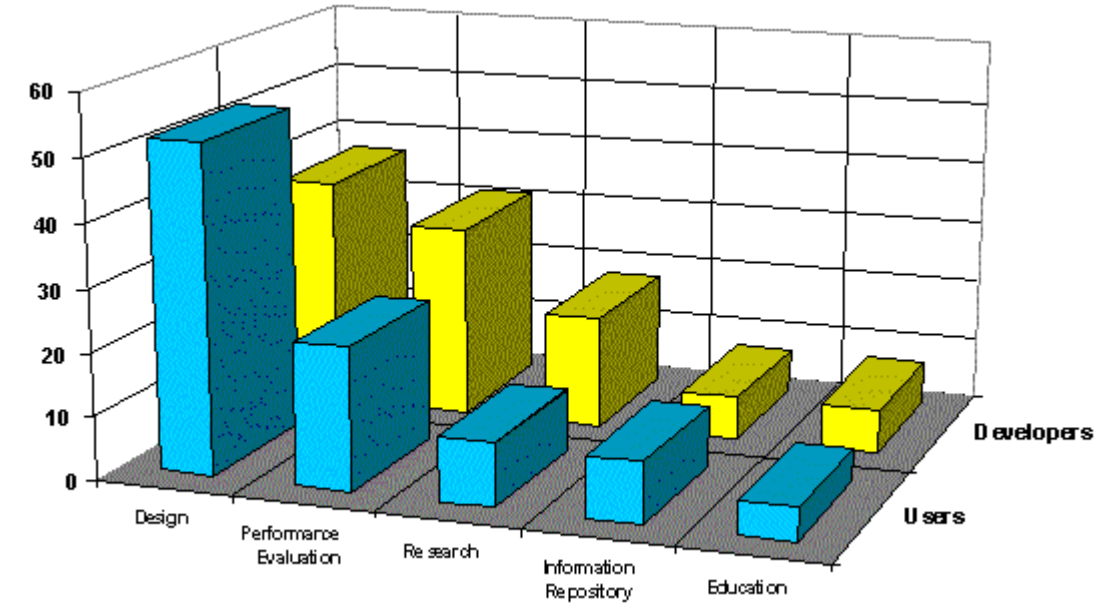

Figure 2

Program Capability Priorities of Developers and Users

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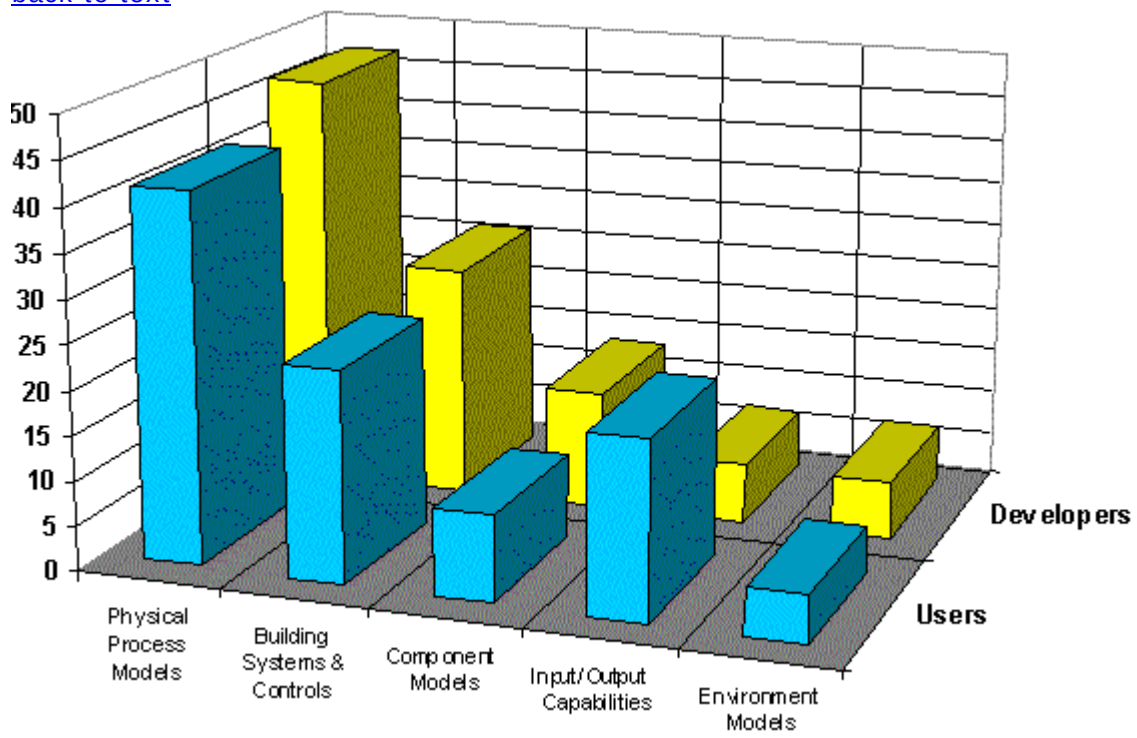

Figure 3

Program Interface Priorities of the Users Workshop

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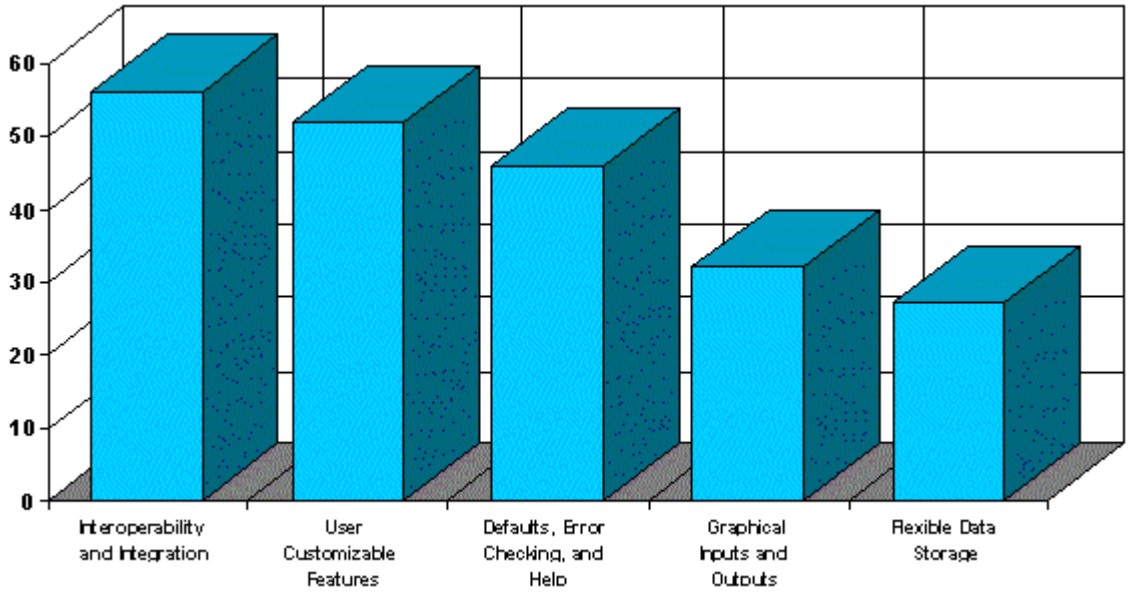

Figure 4

Program Methods and Structures Priorities of the Developers Workshop

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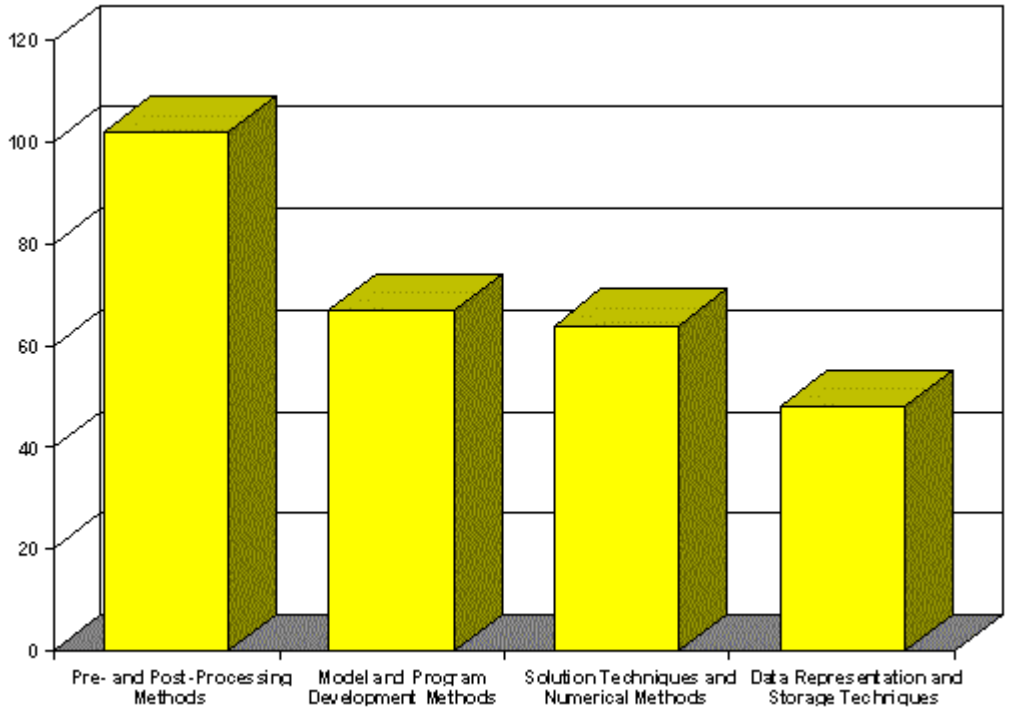

Workshops on Next Generation Energy Tools

Table 1.
Program Application Priorities of Developers and Users

Design			
Developers	**Votes**	**Users**	**Votes**
Collaborative, integrated, facilitated building design	39	Envelope design	37
Building code compliance—energy and environmental impact	18	Early analysis of design alternatives	25
System selection and equipment sizing wizards	16	Environmental impact and sustainability	24
Lighting/daylighting (selection of products, performance assessment)	7	Economic and cost analysis	15
Aid in selecting retrofit strategies	7	System design	14
		Occupant comfort and safety	11
		Retrofit design	3

Performance Evaluation			
Developers	**Votes**	**Users**	**Votes**
Comfort evaluation	21	Performance contracting	16
Economic, life cycle, and cost-benefit analysis	14	Code development and compliance	11
Optimal operation and control	14	Performance data acquisition and analysis	8
Control strategies/ optimization/ supervisory	13	Commissioning	7
Indoor air quality	12	Comfort- and energy-based controls	7
		Fault detection and diagnostics	7

Research			
Developers	**Votes**	**Users**	**Votes**
Policy formation code development	9	Emerging technologies and new processes	11
Solution of inverse problem to calibrate model for existing building	6	Occupant health and productivity	8
Basic research	5	Environmental impact	6
Sensitivity and error analysis	5		
Provide basis for simplified	4		

Information Repository			
Developers	**Votes**	**Users**	**Votes**
Electronic owner's manual (building life cycle)	9	Performance databases and libraries	12
Feed intelligent database for future designs	5	Design databases and libraries	8
Need for structural libraries of models, object-oriented programming	3	Expert systems	4
No gap between description and behavior; i.e. performance data immediate after object selection	2		
Use of historical data files, previous work/buildings	2		

Education			
Developers	**Votes**	**Users**	**Votes**
Student and practitioner education	23	Student education	13
Make it fun	2		

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Table 2.
Program Capability Priorities of Developers and Users

Physical Process Models			
Developers	**Votes**	**Users**	**Votes**
Air flow modeling	25	Envelope/environment interaction	47
Moisture absorption/desorption in building materials	17	Heat transfer models	37
1-, 2-, and 3-D transient conduction	15	Air infiltration and movement within spaces	22
Daylighting	14	Realistic simulation time steps	7
Full generality 3-dimension shading, lighting, and solar geometry	14	Moisture	7
		Indoor air quality	5

Building Systems and Controls			
Developers	**Votes**	**Users**	**Votes**
Flexible system and plant modeling	18	Integrated systems with modular component models	21
First principles system and plant models	14	Realistic building and HVAC simulation	18
Imperfect mixing of zone air	13	Process (e.g. moisture, daylighting) and component controls	12
Zones, systems, plants coupling	8	Performance, compliance and validation	10
Passive and active solar	6	Multiple building systems	7
		Human interaction models	3

Component Models			
Developers	**Votes**	**Users**	**Votes**
Advanced fenestration	11	Air delivery system component models	10
Energy storage in buildings including phase change	8	Central plant equipment models	10
Advanced lighting system modeling	4	Building envelope component models	7
Dynamic coil models	3	Multilevel component models	2
Duct losses	3		

Input and Output Capabilities			
Developers	**Votes**	**Users**	**Votes**
Variable time step	5	Flexible inputs and outputs	26
Uncertainty analysis	4	Life-cycle and real time cost analysis	11
Economic Analysis	3	Expert systems	7
Costs based on utility rate schedules modular interchangeable features	2	Optimization	7
Shell to facilitate the combining of components into a system	2	Access library and database information	4
		Design support	3
		Multi-platform, parallel processing	2

Environment Models			
Developers	**Votes**	**Users**	**Votes**
Occupant comfort	9	Pollution models and environmental impact	6
Typical, extreme and site-specific weather	5	Daylighting	6
Wind pressure distribution	4	Micro and macro weather data	4
Modeling of terrain and surrounding obstructions	2		
Long-term climates with special peak conditions and micro-climates	1		

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Table 3.
Program Interface Priorities of Users

Interoperability and Integration	
Users	**Votes**
Interoperable with other tools	22
Interoperable with CAD programs	20
Integration of components and analysis modules	10
Multi-platform applicability	4
User Customizable Features	
Users	**Votes**
Multilevel inputs	13
Simple input options	13
Clear separation of interface and computational engine	10
Customizable output and reports	7
Customizable interface	6
Adaptable to multiple uses	3
Defaults, Error Checking, and Help	
Users	**Votes**
Context sensitive and "smart" help	17
Knowledge-based analysis of inputs and output	10
Automated error and range checking	7
Tutorials and documentation	7
Online support	5
Graphical Input and Output	
Users	**Votes**
Graphical representation of inputs	12
Graphical output of results	10
Three dimensional spatial displays	10
Flexible Data Storage	
Users	**Votes**
Component libraries	16
External databases and manufacturer's catalogs	11

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Table 4.
Program Methods and Structures Priorities of Developers

Pre and Post Processing Methods	
Developers	**Votes**
Adaptable interface according to user type and stage of design process	21
Knowledge-based front end with intelligent defaults	15
Visualization of complex outputs, including virtual reality display	10
CAD integration	7
Validation by empirical, analytical, and comparative techniques	7

Model and Program Development Methods	
Developers	**Votes**
Object-oriented representation	12
Model reduction	6
Modularity of components	6
Equation-based models—NMF format	5
Tool able to be used by a team (concurrency)	5

Solution Techniques and Numerical Methods	
Developers	**Votes**
Simultaneous solution of loads plant and controls	5
Stochastic methods	5
Macroscopic air-flow modeling (non-CFD)	4
Numeric nodal approach for maximum future flexibility	4
Powerful differential-algebraic equation solvers	4

Data Representation and Storage	
Developers	**Votes**
Extensive and extensible libraries of building components and systems	13
Online documentation, structuring information	6
Flexible structure to allow quick change in systems configuration	5
Standardized data structures	5
Case studies database for decision-making	4

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Concepts, Workshops on Next Generation Energy Tools

Concepts

Click below to see tables of all the concepts generated at the two workshop. The concepts are arranged in alphabetical order by number of votes received within the group. Similar concepts have not been combined between groups.

Experts Workshop

- Applications
- Capabilities
- Methods and Structures

Users Workshop

- Applications
- Capabilities
- User Interface

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Workshops on Next Generation Energy Tools

Developers Workshop Participants
August 1996
Madison, Wisconsin

Participants

Marlin Addison	Energy Simulation Specialists, Inc.
Doug Balcomb	National Renewable Energy Laboratory
Chip Barnaby	WrightSoft
Vladimir Bazjanac	Lawrence Berkeley National Laboratory
Ian Beausoleil-Morrison	Natural Resources Canada
Bill Beckman	University of Wisconsin
Nathan Blair	University of Wisconsin
Jean-Pascal Bourdouxhe	Universite de Liege, Belgium
Rob Briggs	Pacific Northwest National Laboratory
Axel Bring	Royal Institute of Technology, Sweden
Bill Carroll	Lawrence Berkeley National Laboratory
Joe Clarke	University of Strathclyde, Scotland
Sten de Wit	Tech. University Delft, The Netherlands
Mike Donn	Victoria University, New Zealand
Helmut Feustel	Lawrence Berkeley National Laboratory
Jon Hand	University of Strathclyde, Scotland
Philip Haves	Loughborough Univ. of Technology, England
Doug Hittle	Colorado State University
Michael Holtz	Architectural Energy Corporation
Bob Howe	Carrier Corporation
Ron Judkoff	National Renewable Energy Laboratory
John Mitchell	University of Wisconsin
John Murphy	The Trane Company
Kosta Papamichael	Lawrence Berkeley National Laboratory
Roger Pelletret	Centre Scientifique et Tech.du Batiment, France
	Royal Institute of Technology, Sweden
Per Sahlin	Pacific Gas and Electric Company
Peter Schwartz	Johnson Controls, Inc.
John Seem	California State University, Fullerton
Ed Sowell	Oklahoma State University
Jeff Spitler	University of Strathclyde, Scotland
Paul Strachan	National Institute of Standards and Technology
George Walton	GARD Analytics
	EMPA, Switzerland
Mike Witte	
Gerhard Zweifel	

Workshop Leader

Dru Crawley	U.S. Department of Energy

Facilitators

Linda Lawrie	U.S. Army CERL
Curt Pedersen	University of Illinois
Fred Winkelmann	Lawrence Berkeley National Laboratory
Dan Fisher	University of Illinois
Rich Liesen	University of Illinois

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Workshops on Next Generation Energy Tools

Users Workshop Participants
June 1996
Washington, DC

Participants

Michael Andelman	Shooshanian Engineering Associates
Michael Anello	Florida Solar Energy Center
Doug Balcomb	National Renewable Energy Laboratory
Vlado Bazjanac	Lawrence Berkeley National Laboratory
Rob Briggs	Pacific Northwest National Laboratory
Martha Brook	California Energy Commission
John Castelvecchi	Virginia Power
Ted Collins	U.S. Department of Energy
Larry Degelman	Texas A&M University
Joe Deringer	The Deringer Group
K. Dean Devine	Engineering Analysis
Terry DuBois	U.S. Department of Energy
Gary Epstein	Energy & Resource Solutions
Jim Fireovid	SAIC
Rajinder Garg	U.S. Department of Veterans Affairs
Harry Gordon,	Burt Hill Kosar Rittelmann Associates
Christopher Gribbs	American Institute of Architects
Debra Haltrecht	Natural Resources Canada
Mary-Margaret Jenior	U.S. Department of Energy
Theresa Jenne	Honeywell, Inc.
Barry Jones	HOK Architects, Inc.
Ron Judkoff	National Renewable Energy Laboratory
Michael Kintner-Meyer	SAIC
Satish Kumar	Carnegie Mellon University
Malcolm Lewis	RBFW & Associates
Gail Lindsey	Design Harmony
Robert Mackie	U.S. Department of Energy
Ardeshir Mahdavi	Carnegie Mellon University
Paul Mathew	Carnegie Mellon University
Joe McCarty	U.S. Army Corps of Engineers
Daniel Nall	Roger Preston + Partners
Fred Roberts	Solaequis Software
Thomas R. Rutherford	U.S. Department of Defense
Muthusamy Swami	Florida Solar Energy Center
Michael Tinkleman	Electric Power Research Institute
Adrian Tuluca	Steven Winter Associates
Gren Yuill	Pennsylvania State University

Workshop Leader

Dru Crawley	U.S. Department of Energy

Facilitators

Curt Pedersen	University of Illinois
Mike Case	U.S. Army CERL
Fred Winkelmann	Lawrence Berkeley National Laboratory
Kosta Papamichael	Lawrence Berkeley National Laboratory
Dan Fisher	University of Illinois
Bill Carroll	Lawrence Berkeley National Laboratory
Rich Liesen	University of Illinois

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Experts Workshop
Program Applications Priorities

Original concepts arranged in alphabetical order by number of votes.
Similar concepts have not been combined between groups.

Item	Votes	Group
HVAC system design	8	1
Life-Cycle Costing	6	3
Size Equipment	6	2
Student Education	6	2
Thermal Comfort/productivity	6	4
Appraisal of overall building performance	5	5
Code compliance	5	4
Comfort Prediction	5	2
Control Strategies/optimization/supervisory	5	4
Education-Understanding Building Processes	5	3
IAQ	5	1
System Operation Optimization	5	2
A neat shell is necessary to manage the various modules	4	5
Allows energy design and simulation to be integrated with overall design process	4	5
Building code compliance - energy and environmental impact	4	3
Collaborative design	4	3
Comfort evaluation	4	1
Decision visualization from early design interaction	4	3
Design guideline development	4	3
Electronic owner's manual (all life cycle)	4	3
Energy Analysis	4	2
Energy consumption prediction	4	1
Gauged to each stage of the design process	4	5
Link to CAD packages for geometry input	4	5
Optimization	4	4
Solution of inverse problem to calibrate model for existing building	4	5
Thermal comfort	4	3
Aid in Selecting Retrofit Strategies	3	2
Air quality	3	3
Analysis of thermal/lighting/etc. cross effects	3	1
Basic Research	3	4
Building owner life-cycle calculations	3	1
Code compliance	3	1

Code compliance	3	3
Daylighting design	3	1
Design optimization (fine tuning of building energy systems)	3	5
Economic, life cycle, and cost benefit analysis	3	5
Educate Practitioners	3	2
Facilitate Architectural Design	3	2
Fault Diagnosis	3	2
Heating/Cooling Loads	3	4
IAQ	3	2
Integrate design analysis and intent with building operation	3	5
Integrate optimization with building simulation	3	3
Modular structure for easy additions of algorithms	3	5
Negotiation tool for designers (risk level and documentation)	3	3
Parameter Identification for Models	3	2
Reduce Time Required for Analysis	3	2
Sensitivity and error analysis	3	5
Simple analyses at conceptual stage	3	4
Student education	3	1
System Selection Wizard	3	2
Teaching tools	3	4
Training tool for building operators	3	3
Acoustical Performance	2	3
Algorithm Testbed	2	2
Allow Optimization of Systems/Design	2	2
Applications manual; check lists for program selection and applications	2	5
Building Controls	2	2
Building operators tools and representations of control system, etc. a final version of successively refined representation in design	2	3
Code development/standards	2	4
Coupled Processes	2	2
Cue on-line helps and on-line documentation	2	5
Daylighting	2	2
Design Wizards	2	2
Energy code/standard compliance analysis	2	5
Energy policy development (state/national) Environment (local/global)	2	4
Environmental design tool -- costs/benefits of window size/insulation/materials vis a vis comfort in aural, visual, thermal terms	2	3
Environmental Impact	2	2
Equipment selection	2	4
Equipment Sizing	2	3
Evaluation of new/speculative systems	2	4
Fault diagnosis	2	4

Feed intelligent database for future designs	2	3
Find at least one person who wants to apply energy analysis	2	2
HVAC component optimization	2	1
Lighting/Day lighting (selection of products, performance assessment)	2	4
Make it Fun	2	2
Natural ventilation/thermal mass	2	4
New/non-conventional systems	2	4
Object Based or Oriented	2	5
Optimal Control	2	3
Performance Contracting: Electronic Contract Generator	2	3
Retrofit design	2	1
Sharing of data or Integrated Data Model (IDM)	2	5
Simulate new innovative design concepts	2	3
Simulation-based EMS	2	4
System optimization	2	1
System Selection	2	2
Tools needed to capture product model and support inter-design transfers	2	5
Use of historical data files; previous work/buildings	2	5
Used in conjunction with dynamic building control	2	5
Visual Performance	2	3
“freeze-step” sizing capabilities	1	3
Active Solar	1	2
Adapted to Different Categories of Users (Architects, Consultants, etc.)	1	2
Air flow/contaminate movement	1	4
Application in all phases of design and building operation	1	5
Assessment of Retrofit Options via Calibrated Models	1	2
Building energy rating residential and commercial	1	5
Building operation decision making tool; "what if analysis"	1	5
Building performance maps for facility manager	1	3
Code Compliance	1	2
Comfort and Indoor air quality analysis for interior spaces	1	5
Communication tool within design team	1	1
Coupling between thermal and air flow models is needed	1	5
Default Values	1	2
Design Facilitator	1	3
Design teams using common building model	1	3
Develop Performance Standards	1	2
Development of Real Time Optimal Control Strategies	1	2

Energy use characteristics defining the energy problem of a facility	1	5
Envelop analysis for retrofit design	1	4
Equipment Sizing	1	4
Facilitate Integrated Design	1	2
Fault-detection algorithms	1	4
Fault detection	1	1
Federal Facility Manager's Guide to performance improvement	1	3
Floating Temperatures	1	2
Help architect with energy design	1	1
IAQ levels from HVAC systems	1	4
Information development tool for clients - risk of design decisions	1	3
Integration with other disciplines in design process	1	3
Life Cycle Cost	1	4
Manufacturer Support for research for new product development	1	3
Market research - Customers? Who are they?	1	3
Model documentation	1	5
Moisture Analysis	1	2
Multiple criteria decision support	1	3
Need for structural libraries of models, OOP	1	5
No gap between description and behavior; i.e. performance data immediate after object selection	1	5
On-line testing/commissioning of EMCS/DDS systems	1	4
Operating Costs	1	2
Optimal Real Time Energy Purchase	1	2
Optimization of control	1	1
Parametric Analyses	1	2
Peak demand analysis	1	1
Policy Formation Code Development	1	3
Post Mortem Analysis	1	2
Prototype Data Base	1	3
Provide basis for simplified tools	1	3
Quick estimates in early stages of design, based on scant info	1	3
Research	1	1
Sensitivity Analysis for Systems	1	2
Sizing of building Elements - architect's use, - design team negotiation	1	3
Sound/Acoustics	1	4
Standards generation	1	1
Tenant Billing	1	3
Tools should have embedded performance assessments methods (approved by professional bodies)	1	5

Tune Models to Fit Reality	1	2
Typical and Extreme Weather	1	3
Use Thermal Inertia for Equipment Downsizing	1	2
Used for industrial process comfort conditioning, human interaction, & environmental interaction	1	5
Used to develop energy standards and codes	1	5
Utility Rate Planning	1	2
Validation of control / real time controller design via interface	1	3
Ventilation Effectiveness	1	4
What-if scenarios	1	4
“Instant” feedback to building owner at early design & programming	0	3
Acoustic analysis	0	1
Acoustics	0	2
Baseline energy use for existing building consumption -- ESCO performance contracting	0	5
CFD Capability	0	2
Commissioning	0	1
Continuing professional development	0	1
Contract Document Automation	0	3
Cost Estimation Tools	0	3
Customizable graphic display of simulation results	0	5
Customizable GUI on multi-platforms	0	5
Data Analysis	0	2
Data must fit manufacturers data	0	5
Database of Federal Facilities projects by congressional district	0	3
Design analysis and solution of energy design strategies and systems	0	5
Design decision support tool	0	1
Design Load Calculation	0	2
Design/development	0	4
Different Design Process	0	2
Displacement ventilation vs. mixed	0	4
Documentation tool for simulations i.e. assumptions/risks changes due to stochastic processes (weather, users, etc).	0	3
Electrical System Design	0	2
Emissions	0	3
EMS Modeling	0	3
Energy analysis of Buildings and energy design	0	5
Energy bench marking	0	5
Energy optimization of buildings	0	5
External environmental impact	0	1
Fire Safety	0	2
Flexible enought to match assessment task	0	2
Forecasting energy use by country, utility, etc.	0	1

Generation of weather statistics	0	4
Ground loop heat exchanger	0	2
Have multiple ways of using or defining complex models rather than developing simplified models.	0	5
Impact evaluation of new or retrofit energy design	0	5
Integrate building simulation with CFD code	0	3
Integrate with tools from MatLab/Simulink such as ANN, Fuzzy Logic, Robust Control, Optimal Control	0	3
Introduction of error bands and uncertainties within modeling process	0	5
Lighting design	0	1
Loads calculations for buildings	0	5
Model tuning	0	4
Moisture and condensation	0	1
New Product analysis for manufacturers of energy related materials, components, and systems	0	5
On-line energy targeting	0	4
On a global network	0	5
Operator Training	0	4
Parameter estimation	0	5
Passive/active solar evaluation	0	4
Peak demand	0	4
Prediction of electrical demand/limiting strategies	0	4
Propose different system configurations	0	2
Retrofit alternatives with energy analysis tools	0	5
Safety Evaluation	0	3
Sales	0	4
Short-term effects/long-term performance	0	4
Simulation of specific equipment (by OEM)	0	4
Solar heat gain (windows/skylights)	0	4
Special air-distribution systems (e.g. floor panels)	0	4
Structural Design	0	2
Supply basis for online building operation	0	3
Tools needed to give balanced appraisals and uncertainty bands	0	5
Uncertainty analysis support	0	3
Uncertainty modeling	0	1
Use CAD tools with GUI	0	5
Users Groups	0	2
Utility Load Modeling	0	3
Visual Reality Designer	0	3

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Experts Workshop
Program Capabilities Priorities

Original concepts arranged in alphabetical order by number of votes.
Similar concepts have not been combined between groups.

Item	Votes	Group
Air flow modeling	8	3
Coupled Interzone Air Flow and Thermal Processes Incorporating Moisture/ Contaminant Transport and Infiltration.	8	2
Completely flexible system and plant modeling	7	5
Generalized 3-dimension radiation modeling with complex geometry's and deep penetration	7	5
Zones, Systems Plants Coupling	7	2
Bernoulli based air flow models linked to thermal models	6	5
Daylighting and artificial lighting simulation with multiple view points	6	5
First Principles System and Plant Models	6	2
Occupant interaction with interior environment	6	5
Adjustable N-Dimensional conduction with thermal buildings etc.	5	5
Full generality 3-Dimension shading, lighting, and solar geometry	5	5
Imperfect mixing	5	4
Intrazone air flow	5	4
Simultaneous heat and moisture processes with vapor adsorption and desorption	5	5
1, 2, and 3 D Transient Conduction	4	2
All physical processes modeled at most detailed level possible plus several simpler levels of models	4	5
Daylighting	4	2
Glazing systems	4	4
Ground coupling	4	1
occupant comfort	4	1
Passive/Active Solar	4	2
Room Air Heat Balance	4	2
Sky Radiation	4	5
Stratification/Non-uniform Zone Temperatures	4	2
Thermal stratification	4	1
wind pressure distribution	4	1
2 & 3-D heat transfer	3	3
All HVAC Systems	3	2

automatic optimization	3	1
Building-ground heat transfer	3	3
Building control systems	3	4
Detailed Interior Convection Heat Transfer Models	3	2
evaporative cooling	3	1
Integrated building information structures	3	3
Model any equipment or system configuration	3	3
moisture absorption/desorption	3	1
open window ventilation	3	1
Shading systems	3	4
single-sided ventilation	3	1
System Dynamic Response	3	2
Typical weather/extreme weather	3	3
ventilative cooling	3	1
water side economizer	3	1
Window + shade lw/sw/vis/thermal transfer	3	1
Advanced fenestration	2	3
Advanced lighting modeling	2	3
air flow patterns	2	1
Comfort Calculations	2	2
Complex daylighting options	2	3
Concurrent modeling of thermal, airflow, control, etc.	2	3
Contaminant modeling	2	4
Costs based on utility rate schedules modular interchangeable features	2	5
Daylighting (illuminance/luminance)	2	4
demand controlled ventilation	2	1
desiccant cooling	2	1
Duct losses	2	3
Dynamic coil models	2	3
Economic reporting concurrent with energy analysis (on screen)	2	5
energy content of materials	2	1
Energy Storage Equipment	2	2
Energy Storage in Buildings Including Phase Change	2	2
Frequency estimates for comfort	2	3
ground-to-building heat transfer	2	1
ground coupling	2	1
ground source heat pumps	2	1
Heat recovery	2	1
Infiltration	2	1
Internal load modeling - radiant/convective coupling	2	3
Internal loads (stochastic)	2	4

Internal radiant exchange	2	4
large opening air flow	2	1
Mix of Time Scales	2	2
Model time-dependent processes	2	3
Modeling lighting systems performance	2	4
Modeling of terrain and surrounding obstruction	2	5
Moisture & mass transport	2	3
Moisture absorption	2	4
Moisture modeling	2	4
Mycotoxins and air quality aspects	2	5
Natural ventilation	2	5
night radiative cooling	2	1
Occupant behavior use of electrical devices, windows and doors, presence in rooms	2	5
occupant effects on operation/performance	2	1
outside air film conductance	2	1
phase change materials	2	1
pollutant transport	2	1
radiant heating and cooling	2	1
radiative/convective heat from lights and equipment	2	1
Shell to facilitate the combining of components into a system	2	5
sky temperature	2	1
Stochastic modeling	2	4
Stochastic prediction	2	3
transparent insulation	2	1
Tuning to measured data	2	3
Uncertainty analysis	2	4
Variable time steps	2	3
Weather data modification (site-specific)	2	4
Zone Air Motion	2	2
zone to zone heat transfer	2	1
Acoustic analysis (sound trans., abs.)	1	4
Acoustics	1	2
Advanced Fenestration	1	2
Advanced Ventilation Control	1	2
Building Environmental Control Systems	1	2
Comfort assessment	1	3
Continuous shading calculations	1	5
Correct modeling of heat transfer in the ground	1	5
Coupled envelope systems plant	1	4
Critically evaluate resources - illumination, pollutants, etc.	1	3
Data sharing	1	4
Design load calcs w/o redescribing bldg	1	3

displacement ventilation	1	1
duct leakage	1	1
dynamic material properties	1	1
Economic Analysis	1	2
effect of furniture and internal mass	1	1
Effect of occupants/furniture on room air motion	1	4
Electrical power flow modeling	1	5
equipment malfunction	1	1
Explicit occupant and process modeling	1	5
Extensibility	1	4
exterior pollution production	1	1
Exterior Radiant Environment	1	2
Fault modeling	1	4
Furniture	1	4
Ground Heat Transfer	1	2
Ground heat transfer	1	4
Ground Source Heat Pump	1	2
heat and moisture transport and storage	1	1
Heat exchange models (detailed coil models)	1	4
Intelligent defaults	1	4
Intelligent manipulation, construction of operating schedules	1	5
Interior radiosity network	1	5
long-wave radiation from ground	1	1
Long term climates with special peak conditions and micro climates	1	5
Manufacturer Specific Models	1	2
Moisture Absorption/Desorption in Building Materials	1	2
Moisture impacts on insulation effectiveness	1	3
Multiple sunspaces	1	5
Natural ventilation of large spaces	1	3
Non-homogeneous walls	1	4
part load efficiencies	1	1
Photo Voltaic	1	2
photovoltaics	1	1
pollutant production and transport	1	1
propagation of uncertainties	1	1
Public domain	1	4
Range of models for glazed spaces	1	3
sky lw/sw/vis radiance	1	1
thermal bridging	1	1
Uncertainty assessment	1	3
Validation	1	4
Variable time step	1	4
Varying Levels of Model Complexity	1	2

Ventilative cooling	1	1
Visualization (interior/exterior)	1	4
Water-, air- coupled slabs (low-temp radiane/slabs	1	4
Ability to handle external factors i.e. reflected solar from neighboring buildings	0	5
Acoustics	0	3
Active solar	0	1
Advanced control system linking with occupants behavior	0	5
Air contaminant and moisture movement	0	5
All physical processes modeled at several levels of detail	0	5
Boundary layer processes	0	5
Building element cavity analysis; cavities with natural and forced convection	0	5
CFD coupling	0	3
cogeneration	0	1
Complex window algorithms i.e. Heat mirror, etc.	0	5
Contaminants (- transport, - production)	0	2
Control based on thermal comfort	0	3
crack flow	0	1
Daylight related lighting control systems modeling	0	5
Deal with random occupancy & use patterns	0	2
Design years	0	3
Detached shading; i.e. trees and surrounding buildings	0	5
Distribution + Components (including losses)	0	2
District Heating and Cooling	0	2
Easier representation of the environment and terrain	0	5
Evaporative cooling	0	4
External flow analysis; i.e. CFD exterior pressure fields	0	5
Fault detection within control system operation	0	5
Fully coupled equation-based	0	3
Graphic Output	0	4
Heated/cooled surfaces	0	3
HVAC systems dynamic models	0	5
Innovative systems, i.e. cogeneration, PV, Solar systems	0	5
inside surface film conductance	0	1
Integration of all processes at the time-stepping level	0	5
Internal distribution	0	4
Knowledge-based systems	0	4
life cycle costing	0	1

lighting	0	1
Lighting Fixtures/Energy Splits	0	2
Load shedding	0	1
Luminance virtual reality images	0	5
Macro and micro supply side (including renewables)	0	5
Mean radiant temperature calculations relative to human comfort	0	5
Methods for structure processes (e.g. occupant interactions)	0	5
Micro climate processes	0	5
mixing ventilation	0	1
moisture generation	0	1
multiple chiller operation	0	1
Non-linear	0	4
Non-linear programming (optimization)	0	3
Occupancy loading and population flow models	0	5
Occupant exposure	0	5
outdoor pollutant absorption by envelope	0	1
Parametric runs	0	4
Plenum Heat Transfer	0	2
Pollutant transport coupled with thermal modeling	0	5
Pressure coefficients	0	5
Pressures in hydraulic networks of flow with thermal behavior	0	5
product libraries	0	1
Radiant Convection Heat Transfer (i.e. Attics)	0	2
radiation exchange (lw/sw/vis)	0	1
Real time control of system and plants	0	5
Realistic color/reflectivity modeling	0	3
Refined nodal network air flow models	0	5
Reflection	0	4
Removable energy systems PV, Solar, DHW, etc..	0	5
roof ponds	0	1
Room Surface Temperature	0	2
RTP building control	0	1
Scheming based on historical templates	0	5
Selectable analysis focus	0	3
short time step controls	0	1
Simulation of air movement	0	5
Soil thermodynamics for ground heat transfer and underground surface modeling	0	5
Special feature capabilities e.g. PV, special glazings, etc.	0	5
switchable glazing	0	1
System and plant processes both component and		

non-component based	0	5
Template system and plant models for verified systems	0	5
Thermal and daylighting analysis in glazed spaces adjacent to atriums	0	5
Thermal capacitance effects	0	5
thermal storage	0	1
Thermal stratification	0	5
Thermophysical properties modeling (effects of moisture, etc.)	0	5
Time-dependent performance	0	4
Visual comfort model	0	3
Weather extrapolation and interpolation routines	0	5
Wind-driven ventilation	0	4
Wind effects on pressures and heat transfer	0	5

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Experts Workshop
Program Methods and Structures Priorities

Original concepts arranged in alphabetical order by number of votes.
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Item	Votes	Group
Shell to help sharing of data between simulation codes	6	5
CAD integration	5	1
Extensive and extensible libraries of building components and systems	5	4
Model reduction	5	2
Object oriented modeling and object oriented support	5	5
Simultaneous solution of loads plant and controls	5	4
Standardized data structures	5	2
Validation by empirical, analytical, and comparative techniques	5	5
Distributed Systems	4	2
Experiment planning theory (useful for sensitivity and error analysis)	4	5
Extensive post-simulation analysis (output)	4	2
Great shell is needed	4	5
Knowledge based front end with intelligent defaults	4	5
Man-Model interface	4	2
Modularity of components	4	4
Not C++	4	2
Numeric nodal approach for maximum future flexibility	4	5
Product Modeling	4	2
Standardization of objects Interoperability	4	5
Standardized interfaces and protocols between program modules	4	2
Stochastic modeling of behavior	4	5
Visualization of complex outputs, including virtual reality display	4	1
3-Dimension and time output visualization	3	5
Adaptable GUI	3	5
adaptable interface according to user type and stage of design process	3	1
Automatic solution of system equations at time scales appropriate to the subsystems	3	4
case studies database for decision making	3	1

Comprehensive graphical user interface	3	2
Convergence Enhancement Techniques	3	3
Expert Systems	3	2
Flexible structure to allow quick change in systems configuration	3	4
Intelligent Defaults and Value - Checking	3	3
Macroscopic air-flow modeling (non-CFD)	3	2
Object Oriented Environments	3	3
Online Help	3	2
Powerful differential-algebraic equation solvers	3	2
Raytracing combined with the energy flux associated with the "Ray"	3	5
Real-time radiation	3	5
Separation of models and solvers	3	4
uncertainty based output	3	1
Visualization software	3	2
Able to access NMF libraries	2	2
Built in example problems	2	5
design advisor modules for lighting, HVAC...	2	1
Different Data Views for different users	2	3
Dynamic defaults (conditions)	2	4
Dynamic links to other software packages	2	5
Equation based models - NMF format	2	3
Finite difference (not transfer functions)	2	4
Flexibility	2	2
Fluid links and units conversion	2	3
Generalized optimization routines	2	4
Inverse modeling	2	2
Multi-platform (not just Intel)	2	2
Network (Internet) distributed development	2	2
Object - oriented representation	2	4
Parallel processing techniques	2	2
Pre-simulation wizards	2	2
Smart data representation; add knowledge to results	2	5
Solve over/under determined systems of equations	2	2
Staged calculations (i.e. prepross and generate recursion equation for transient analysis)	2	2
Standardized communications between all object based modules and simulations	2	5
Step Express / ISO-NF	2	5
Stepwise “debugger” for simulation calcs	2	3
Tool able to be used by a team (concurrency)	2	2
Variable Time Step/Multiple Time Step	2	3
Virtual reality as post processing data system	2	5
Well-defined input/output data structures	2	4

What about model documentation?	2	2
1-D,2-D,3-D conduction transfer functions	1	2
Airflow and thermal networks	1	2
Benchmarking	1	4
Building products database management tools	1	2
CAD <==> analytic model	1	2
Case studies of existing buildings (library)	1	4
Connection to product manufacturers testing	1	5
Constant time unit with break down possible to include event scheduling	1	5
Data Visualization	1	3
Dictionary of Units to eliminate differentiation between current systems	1	5
Different models @ various models of detail	1	4
Dimensional Polymorphism for Component Linking	1	3
easily-modifiable modules	1	1
Easy Access to libraries	1	5
Efficient coupling of component models of fabric/envelope elements	1	4
Equation based modeling	1	2
Error propagation through analysis process	1	2
Finite Volume Technologies	1	2
flexible calculation modules dependent on user discipline and need	1	5
Fundamental Theory based technique	1	3
Fuzzy logic, use of	1	5
Generalized geometry engine for all radiation, shading, etc.	1	5
Hierarchical Modeling	1	3
Information exchange procedures/formats	1	4
Integrated Building data models (standardized)	1	3
integrated data structure for different programs	1	1
Intelligent warning system about underlying assumption	1	5
Interactive zoning design based on CAD, libraries, and schedules	1	5
Interchangeable input models and output results	1	5
Interfaces with multiple CAD systems	1	5
internal validation against standard results	1	1
lifetime tracking of building, design to demolition	1	1
Link CFD to thermal solution in each time step	1	5
Mix of Solvers to match mix of problems	1	2
Model documentation, structuring information	1	5
Model representation of relationships automatic update of all parameters affected by change	1	5
Model to facilitate parallel processes	1	5

Network (Internet) use for dispersed teams	1	2
Next generation codes need OOP techniques for all modules	1	5
Object oriented calculations	1	5
Open Architecture Platform	1	3
Open Program Structure	1	2
Operation on basis of volunteered information rather than requested information	1	5
Opportunity to hand check a heat balance at any time step	1	5
Parallax based digitized input from photos for existing buildings	1	5
Parametric analyses	1	4
portable to different machines	1	1
Possibility of hidden complexity for practitioners	1	2
Problem Decomposition	1	3
Problem Reduction	1	3
process models for controlling design process	1	1
program chooses appropriate modules to use	1	1
Propose default values	1	2
Ready estimation of parameters	1	4
Risk Analysis	1	5
Sharing data (IDM)	1	5
Should be easy to use!!!	1	3
Simulation environment with templates at different levels of modeling detail	1	5
Solution should be reached on the basis of information available from the manufacturers	1	2
solver for large sets of differential equations	1	1
Specific Tool Development Toolkit	1	2
Standard Utility Rate Database	1	3
Standardized theory exchange at equation level	1	5
Stochastic methods	1	4
Super Fast Simulations	1	3
Toolkits	1	2
Transfer functions for variable and arbitrary time steps	1	4
Translations from standard model documentation to simulation codes	1	5
Translators to export data in ISO-NF format	1	5
Uncertainty estimates of output results	1	4
User defined levels of detail	1	5
Advisors to help users choose and connect models	0	5
AIS data for context (weather, utility rates, codes, ...)	0	4
Block scheme technique	0	5
Built-in analytical empirical solutions	0	5

CFD	0	4
Communication between models as a basic feature	0	2
Component based HVAC modeling	0	3
computer platform cross-compatibility	0	2
Connection to physical scale models	0	5
Design Advisor	0	3
Design process modeling	0	2
Discrete time controllers	0	4
distributed calculations over Internet	0	1
Distributed execution	0	2
Dynamic modeling of everything	0	5
Dynamic System Modeling for User	0	3
Economic modeling tools	0	3
Equation-based	0	4
Experiential outputs	0	5
Expert systems	0	5
Explicit process modeling and inter-tool cooperation	0	5
Extensibility	0	4
Finite Methods	0	5
flexible system capabilities	0	1
Graphic linking of building components	0	4
Identify and track display dynamics interactions	0	5
Input/output free	0	4
Integrated CFD / BSIM / nodal networks / etc.	0	5
Integrating digitized photos and CAD designed buildings	0	5
intelligent defaulting	0	1
intelligent starting values for iterative solvers	0	1
Interface to real-time operations hardware	0	3
Man-Building data interface	0	2
Meters	0	2
Model Partitioning (grouping/blocking)	0	2
Modularity	0	2
Monitor resolution of simulation	0	5
Neural network	0	5
Neural networks	0	2
NMF Libraries	0	3
Non-linear solvers	0	4
Non-Microsoft	0	2
Non-numerical analysis	0	5
Object oriented databases for models, projects, and components	0	5
Objects, Objects, Objects!	0	3
On-line visualization of important output	0	4

Optimization Trade Offs (e.g. lighting vs. energy)	0	3
Partitioning of system	0	4
Rapid Calculation methods (run-time vs. accuracy)	0	3
Sharing of models with a standard neutral format	0	5
Single/Multiple Platform (hardware) Environments	0	3
State purpose of simulation model to ascertain the level of detail	0	5
Symbolic processing of equations	0	5
Symbolic solving in conjunction with numerical	0	3
User defined analysis shell	0	5
variable time steps	0	1
Video input parameter creation	0	5
Virtual Reality Feedback to users	0	3
Visual Programming Environments	0	3
Wizard to choose best calculation modules for problem at hand	0	1
Wizards --> on-line advice	0	2

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Users Workshop
Program User Interface Priorities

Original concepts arranged in alphabetical order by number of votes.
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Item	Votes	Group
Educational (understanding energy processes)	5	7
Energy efficient design	5	4
Energy, daylight, sustainability, recyclability, embodied energy in production and transport (holistic approach to environmental impact of built environment)	5	3
Interoperability of tools	5	2
Life cycle cost optimization	5	4
Stand-alone analysis (not whole-building analysis, e.g. lighting motors)	5	7
Tools that relate workplace quality and occupants productivity	5	3
Verification of energy savings (performance contracting)	5	7
Alternative or innovative system / plant design	4	4
Commissioning	4	4
Evaluating thermal comfort	4	5
Evaluation of passive building elements (mass, windows, insulation, etc.) on energy use	4	3
Fundamental analysis	4	1
Identify effectiveness of design strategies	4	5
Improved (less arcane) inputs	4	7
Research (examine new options)	4	4
Select and size equipment	4	5
Teaching themselves to understand buildings	4	4
Verify compliance with concept/standard/code	4	4
Better handling of baseline and parametric cases	3	7
Campus-wide	3	2
Commissioning (O & M)	3	7
Comparison of alternatives	3	4
Design	3	6
Energy evaluation of envelope, system and plan options for retrofit design	3	3
Evaluate implications of various massing and configurations	3	5
Evaluation of renewable energy alternatives	3	7
Fault detection in building operation	3	1
Generate new design alternatives	3	5

LCC	3	2
Libraries of typical buildings	3	7
Natural Energy	3	2
New techniques and controls	3	2
Performance metrics	3	2
Predesign	3	6
Simplified input capability	3	7
Standards	3	2
Tool to show building case studies—what worked—what didn't	3	7
User specification of new / emerging technology parameters	3	7
Ability of occupants to discuss (and publicize) quality of individual buildings, i.e., feedback performance to market	2	3
Access multiple existing files of actual buildings (photos) the energy and environmental data and tool inputs as starting points	2	5
Advanced building design	2	7
Allow incremental accumulation of data over life cycle	2	5
Assess occupant comfort (probability)	2	4
Assess pollution prevention benefits (societal costs)	2	4
Building energy code compliance, use a program to prove that a proposed building design meets or exceeds the 'standard energy budget'	2	3
Building energy management applications	2	3
Building energy rating	2	1
Building environmental rating	2	1
Building fault detection and diagnostics	2	4
Economic analysis (life cycle) of design	2	3
Education	2	3
Energy code compliance	2	7
Energy consumption evaluation; energy used, when and where	2	5
Evaluate implications of glazing options	2	5
Expert system to advise—path with greatest opportunity	2	7
Heuristic model for determining actual existing building thermal parameters	2	3
IAQ analysis	2	4
Implementation of performance-based standards	2	1
Improved methods for billing data reconciliation	2	7
Integrate with design process	2	5
Integration of metering data	2	7
Life-cycle analysis including ecological "cradle to cradle" considerations	2	1
Low energy residential housing	2	4

Model natural air movement in physical space	2	7
Modeling capability for other utilities (i.e., water)	2	7
Moisture analysis including adsorption and desorption	2	4
Need to include new electric technologies (e.g., microwave dryers, horizontal axis washers)	2	7
Need tool(s) that can effectively lay out energy efficiency options in a way that non-quantitative PMs can understand and will approve	2	7
Optimization	2	2
Optimizing performance-based design decision making in architectural studios	2	1
Productivity simulation analysis	2	7
Real-time optimization of controls in real time utility rate environment	2	3
Simplified (appropriate) analysis of measures	2	7
Simulation of user comfort – thermal, visual, acoustic, air quality	2	1
Thesaurus	2	2
Tool to assess time, $, quality for issues of sustainability	2	7
Tools and Guideline Development	2	6
Users should be able to utilize 'libraries' in order to quickly generate input	2	7
Whole-building energy design, analysis, optimization, systems integration	2	3
A&E design support	1	7
Allow comparison with monitored buildings (via web)	1	5
Allow input from 2-D and 3-D sketch software	1	5
Analysis of occupant behavior, impact on building energy use	1	3
Architectural design (linked to engineering design)	1	4
Assess embodied energy of alternative construction	1	4
Assess performance of buildings without mechanical systems	1	4
Assessment of environmental materials	1	4
Communicate impact of design concept	1	4
Deal with subject outside one's competency	1	4
District heating and cooling planning and evaluation	1	7
Early Design	1	2
Early direction setting during conceptual design	1	4
Energy consumption of existing systems	1	5
Energy use analysis	1	2
Evaluate impacts / benefits 'smart controllers'	1	7
Evaluation of new HVAC system technologies	1	3

Evaluation of systems interaction / integration in the design process	1	1
Fitting to measured data	1	2
Identify / define problems in the building / design	1	4
Impact analysis	1	2
Moisture transport analysis	1	1
Need to be able to asses impact of real time pricing on building system design	1	7
New tool should consider impact of utility deregulation	1	7
Obtain quantitative performance estimates	1	4
Operation / Diagnostics	1	6
Optimal building operation	1	1
Passive analysis - parametric studies	1	1
Performance contracting support—baseline and NAV(?)	1	7
Prioritizing future project options	1	4
Provide a basis for design decisions	1	5
Provide energy evaluation for other software	1	5
Provide guidance about what typically is used when and why	1	5
Provide self-calibrating feature for energy simulation program	1	5
Regional aspects of sustainability	1	7
Retrofit	1	2
Retrofit	1	6
Retrofit Screening	1	7
Simulation of lighting (luminous environment)	1	1
'Smart' default data based on other building characteristics	1	7
Speed up design analysis	1	4
System selection (LCCA, energy use, etc.)	1	4
System sizing	1	4
Teaching students fundamental physical processes	1	1
Thermal comfort of occupants	1	3
Tool (expert system) economic and environmental and productivity assessment	1	7
Tool that walks the user through the input, suggesting the 'correct' method of entering data	1	7
Accurate forecasting of energy budgets	0	1
Allow assessment of potential energy, cost, environmental impacts at predesign stage, from programming data	0	5
Allow search of data bases of existing input solutions to types of design strategies (e.g. airflow, windows, TES, etc.)	0	5
Analysis for basis / support for new / revised		

design criteria	0	4
Analysis of emerging technologies	0	3
Applications that learn about building behavior and accumulate data	0	3
Auditing	0	2
Building acoustics especially in open office environment	0	3
Building energy code development, massive parametrics including life cycle cost analysis of various energy efficiency measures	0	3
Building types, tools that match level of complexity: easy for residential, greater for high rise	0	3
Code compliance	0	1
Codes	0	6
Comfort with monitoring and verification of energy efficiency savings	0	7
Commissioning	0	2
Commissioning new buildings	0	3
Compare the performance of various HVAC systems	0	5
Cost benefit analysis	0	1
Creation of a database for various building types (offices, hospitals, schools, etc.)	0	3
Decision making – how to spend limited funds on energy efficient design	0	1
Demonstrate compliance with performance budgets	0	4
Design Architecture	0	4
Design HVAC	0	4
Determine the application of various systems	0	5
Development of building energy standards	0	1
Diagnosis of existing building energy problems	0	3
Eco-analysis environment based	0	3
Education	0	6
Electric and gas utility DSM evaluation	0	7
Evaluate building energy performance	0	5
Evaluate promising equipment technologies based on energy saving	0	1
Evaluate visual comfort	0	5
Evaluating noise emissions from HVAC	0	5
Evaluating special fitting of HVAC systems	0	5
Evaluation / optimization of control system methodology	0	7
Evaluation of building alternatives for new construction	0	7
Existing building retrofit analysis from energy efficiency / sustainability perspective	0	7
Failure analysis	0	1

Fault analysis	0	2
Gas air conditioning evaluation including desiccant	0	7
Healthy buildings, workplace that supports productivity	0	3
Identify retrofit opportunities	0	5
Identify space/building loads, energy, costs, environmental impacts	0	5
Identify various materials available for better design	0	5
Indoor air quality assessment	0	3
Indoor air quality, control and maintenance of HVAC systems	0	3
Justify design decisions after decisions have been made	0	4
Life of building analysis (fuel costs, embodied energy, sustainable development, life cycle, ...)	0	4
Link for LCC & LCA to energy, materials, IAQ, waste (C&D), and site (infrastructure)	0	7
Maintaining quality of workplace	0	3
Marketing	0	6
Match energy strategies with utility rate structure	0	4
Material costing	0	4
Material damage analysis	0	1
Monitoring day-to-day building performance by on-site staff	0	3
Optimization based on cost, building options, occupant's needs	0	7
Optimization of controls	0	3
Optimize energy / economics of designs	0	4
Parameter estimation and sensitivity analysis	0	4
Peak Demand	0	2
Performance contracting	0	2
Policy	0	6
Predictive control	0	3
Product/System Development	0	6
Project justification (LCCA, energy savings, etc.)	0	4
Provide data (costs, energy, etc.) for design reports/presentations	0	5
Provide expert analysis/critic to non-thermal disciplines	0	5
Provision of passive solar, thermal massing, natural ventilation	0	3
Public audience tools, simple tools that illustrate benefits to a public or client (on the web or CD)	0	3
Quick impact of renewables in design phase (or 'alternatives')	0	3
Real time feedback from occupants on workplace environment	0	3

Recommissioning existing buildings	0	3
Safety	0	2
Save on project / service cost	0	4
Simulation-based energy management system	0	3
Site-specific product analysis	0	1
Size systems	0	5
Software to help suggest better design alternatives	0	5
Test performance of a new energy system	0	7
Tool for connecting energy usage of material processing / manufacturing / & transportation (LCA)	0	7
Tool for 'embodied energy' (address renovation work)	0	7
Tool to adjust input based on user's background and data available	0	7
Tool to assess occupant productivity (personal 'energy')	0	7
Tool to link IAQ and energy efficiency / effectiveness (for life cycle costing)	0	7
Tools that vary depending on 'profession', e.g., interior designer, architect, mechanical engineer, etc.	0	3
Track hazardous materials	0	5
Training in building operation	0	1
User should be able to enter minimum data for desired output	0	7

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Users Workshop
Program Capabilities Priorities

Original concepts arranged in alphabetical order by number of votes.
Similar concepts have not been combined between groups.

Item	Votes	Group
Advanced optimization capabilities	6	7
Simulation of building controls	6	1
Building impact on productivity	5	2
Detailed simulation of occupant response	5	7
Dynamic (transient) simulation of interaction between building fabric's thermal behavior, energy systems / controls (HVAC), lighting (both daylighting and electric lighting), air flow (ducting, VAV), IAQ (pollutant flow through building, hydronics / fluid	5	2
To simulate actual operations and scheduling of buildings for all systems: HVAC, daylighting / lighting, waste, recyclables, air quality, recoverables	5	2
Building construction simulation à scheduling, construction, robotics	4	2
Building support systems and controls: HVAC, lighting / equipment, occupancy effect (density / schedules, etc.) , controls, plant / utility	4	2
Chiller prioritization	4	2
Coupled heat and mass transfer	4	1
Energy/Mass Flows	4	6
Ground coupling (transient) systems and foundation heat loss	4	4
Hour-by-hour analysis, msec / msec analysis for controls development, multi-time step simulation	4	2
Improved daylighting analysis	4	7
Interaction between HVAC operation (thermally controlled) and IAQ	4	4
Level—simple, detailed, empirical, network, user defined	4	1
Modeling of emerging technologies	4	7
Moisture transport through building elements including adsorption / desorption	4	4
Phenomena—heat, momentum(?), moisture, containment(?), airflow	4	1
Ability to choose appropriate level of modeling detail	3	3
Ability to model complex HVAC control systems	3	7
Air distribution / movement within spaces,		

airflow modeling	3	1
Computational fluid dynamics – air motion	3	7
Cost-effectiveness evaluation using real-time pricing rates	3	5
Detailed simulation of subsystem (i.e., distribution systems)	3	1
Evaluate luminous environment under a variety of solar conditions	3	5
Evaluation of indoor air quality transient analysis / out gassing of building materials	3	1
First principles modeling of conduction, radiation (short and long-wave), convection	3	1
Formal validation process for whole building simulation programs and individual models, subroutines, and algorithms	3	3
Fundamental processes of heat and mass transfer: conduction / convection / radiation, air flow, lighting, shading and light redirection, moisture migration, thermal comfort analysis, energy analysis	3	2
Fundamentally correct models of physical processes	3	3
Ground-coupled heat transfer	3	1
Integrated evaluation of daylight and electrical lighting	3	1
Intelligent integrated control of enclosure, HVAC, lighting systems	3	1
Interoperability / Flexibility / Modularity	3	6
Knowledge-based expert system support for both novice and expert users	3	3
Life-cycle costing	3	7
Lighting distribution (especially daylight, daylighting in multi-oriented spaces)	3	4
Modular approach to modeling HVAC systems and equipment	3	7
Modular HVAC and controls modeling capability for primary and secondary systems (build up 'new' systems and/or building constructions by merging / editing unique heat transfer modules from a library)	3	3
Occupant comfort	3	4
Plug in information basics about building, see alternative choices: advantages, disadvantages, ...	3	7
Short and variable Delta t and A simulation for control simulation	3	5
Stochastic modeling (incorporating random phenomena in simulation)	3	1
Take input of local utility's generation mix vs. time-of-day to evaluate real impacts on local area pollution	3	2
Tool Validation, Evaluation, Calibration	3	6

3-D heat transfer	2	7
Air flow inside buildings	2	4
Air movement, temperature, and pollutant concentration within a room	2	4
Calculate external pressure coefficients	2	5
Campus-wide modeling/simulation, district energy with typical buildings for modeling central plant, i.e., 2 dorms x SF each, 2 academic buildings	2	2
Daylighting control	2	2
Daylighting/thermal load interactions	2	5
Desiccant cooling	2	2
Ecological impact analysis/modeling: eco-balance analysis, life-cycle modeling	2	2
Emulate fundamental physical processes	2	1
End-use components equipment (pumps, chillers, etc.)	2	7
Estimate reliability of energy efficiency measures – controls vs. insulation, for example, to include / compare both in life-cycle cost analysis	2	3
Evaluate moisture absorption and desorption	2	5
Expert advice to improve performance	2	1
Impact of different retrofit (analysis and reporting): energy, cost, comfort, etc.	2	2
Integration of various modules in a seamless manner	2	3
Model heat pipes in HVAC systems	2	2
Natural infiltration	2	4
Natural ventilation	2	1
Numerical Scheme (lumped, FDM, FEM, WF, CTF, other?, variable DT?)	2	1
Pollutant production - on site and source	2	2
Pollutant transport and concentration	2	4
Probabilistic outcomes modeling (Bayesian analysis)	2	7
Reconciliation with actual meter readings (calibrated modeling)	2	4
Sophisticated / customized controls sequences of operation	2	2
Task controls (i.e., occupant controls lighting and ventilation)	2	4
Thermal ice-storage cogeneration systems	2	5
Utilize empirical data systems	2	1
Variable speed drives: cooling tower, fans, pumps, chillers	2	2
3-D air flow simulations	1	5
3-D thermal flow	1	4
Ability to run on various platforms (operating systems)	1	3
Access equipment performance data typically		

available from manufacturers	1	3
Account for local climate data (finer than solmet)	1	5
Acoustical impact: is privacy essential, what part of day	1	2
Active support in different domains for use to achieve performance goals	1	3
Advanced control systems (neural networks, fuzzy logic)	1	4
Air flow outside buildings (wind and terrain)	1	4
Annual simulation of periods other than Jan 1 through Dec 31	1	4
Building leakage based on weather	1	7
Building types: residential, commercial, industrial, health/hospitals, and? jails/prisons, airports	1	2
Calculation based on deterioration of materials	1	7
CFD (computational fluid dynamics) module for air movement and air quality analysis	1	3
Detailed radiation transfer modeling	1	7
District / multiple building systems – chilled water, steam, hot water	1	1
Duct leakage	1	7
Early design support	1	3
Electro-chromic glazing control of shading coefficient	1	2
Embodied energy, eco-balance analysis	1	1
Energy types: electrical, steam, chilled water, gas, oil, wood, coal, etc., hot water	1	2
Equipment operation: HVAC, desiccant cooling, chillers, etc.; optimization	1	4
Equipment reliability effects on performance	1	5
Evaluate comfort of indoor/outdoor spaces	1	5
Evaluate heat flow to-from ground connections	1	5
Evaluate space-to-space airflow and heat flow	1	5
Evaluation of different zoning configurations	1	1
Explicit plant modeling (e.g., combustion process)	1	4
Fire alarm, temperature control and security systems	1	5
Human control, fuzzy logic, how people influence	1	7
Impact – good and bad – of people being continuously informed as to building total status	1	2
Interrelated schedules of use	1	4
Libraries	1	6
Local (workspace) climate control strategies	1	5
Marginal utility analysis to determine source emissions impact	1	1
Micro weather data	1	4
Model air motion within space	1	7

Model impacts of actual construction variations on energy performance (to identify most important issues to control during construction and operations)	1	2
Modular (customizable) HVAC systems	1	4
Moisture control	1	7
Multiple levels of details for different components	1	1
Multiple models with different levels of detail: high level of detail (control analysis), low level of detail (quasi-steady-state energy analysis)	1	2
Natural ventilation	1	5
Operable windows	1	4
Optimization	1	6
Outputs must allow an energy balance check at various time intervals	1	3
Parallel processing software architectures	1	7
Part loads – HVAC, lighting, power	1	4
Passive solar technologies and active	1	4
Passive ventilation	1	4
Performance metrics post construction, monitoring of building performance	1	3
Performance of chillers, boilers, pumps, etc.	1	5
Performance of spaces with floating temperature	1	4
Profiles for energy efficiency office equipment	1	4
Profiles for occupancy sensors	1	4
Rapid Smart Input	1	6
Real time controls	1	4
Real time data acquisition of performance data by expert systems	1	3
Residential systems, HVAC and DHW	1	4
Shading (dynamic)	1	4
Simplify modeling of actual equipment – include default curves for variety of equipment types	1	7
Simulate air infiltration	1	5
Simulate ground source heat pump and other systems	1	5
Simulation (uncoupled, partially coupled, fully coupled)	1	1
Smoke control system operation	1	4
Sub-cooling using building thermal mass	1	5
System controls	1	4
Thermal bridging	1	1
Time increment less than hour	1	4
Time-dependence	1	6
Tools that look well beyond individual buildings: state, region, national, international impact	1	3
Use of advanced algorithms for accurate performance prediction	1	3

UV bleaching	1	4
Variable time steps	1	1
Variable time steps for controls modeling (variable time scale capabilities: < 1 h for systems, > 1 hour for massive elements)	1	3
Window management (multiple systems)	1	4
3-D general thermal network ground module that can plug into a whole building simulation program	0	3
Ability to do large number of parametrics	0	3
Active and passive solar system	0	5
Auto Design / Backward Engineering / Design Advice (context-dependent)	0	6
Automation of elimination parametrics	0	2
Better structuring of time of use and real time pricing analysis	0	7
Black sky radiation	0	4
Building interface issues with various services (collaborative design)	0	3
Capability of modeling massive building structures (e.g. historic buildings with large thermal mass)	0	7
City water distribution, sewer	0	2
Co2 concentration	0	5
Code Compliance	0	6
Design day simulation with mixed criteria	0	4
Design sizing of equipment: operating capability, bid select	0	2
De-superheating heat recovery	0	2
Dilution ventilation, fresh air, IAQ issues	0	1
Directional daylight devices	0	1
Duct – flow analysis / balancing	0	7
Duct insulation	0	7
Effect of ceiling fans	0	7
Enable modeling of diversity on stochastic basis (rather than just fiddling with schedules)	0	2
Environment	0	6
Flexible modeling of HVAC systems	0	7
Full multi-zone wind and stack natural ventilation, convection, and advection module	0	3
General thermal network 'building physics' module	0	3
Ground heat transfer	0	2
Heat recovery	0	4
Hierarchy or levels (1, 2, ,3) of choices – degree of difficulty or higher costs	0	7
Humidity in sensitive environments	0	4
Impact of alternative fueled vehicles: electric charging, natural gas filling station	0	2

Integrate CFD capability for air flow analysis	0	2
Integrated advanced models	0	7
Integration of information: HVAC, IAQ, costs, energy use	0	7
Interpret code compliance rules to generate building simulation inputs	0	3
Interpret SQL or other standard equation format to generate ultimate simulation parameters	0	3
Lighting impacts on productivity	0	1
Macro weather data	0	4
Maintenance of systems (impact on efficiency)	0	3
Measure human (manual) override of systems vs. programmed settings	0	3
Model impacts of O&M on predicted energy performance	0	2
Moisture balance	0	7
Multizone infiltration	0	7
Must no be so 'computationally intensive' to frustrate users, computational time	0	3
Optimization/parametric (first cut, operating cost, ROI, etc.)	0	1
Outside air film conductance vs. wind speed, direction	0	2
Parameter estimation (evaluate significance of simulation input parameters)	0	3
Peak load profiles by equipment, system / zone / building, fuel meter	0	3
Peak loads: HVAC, lighting, power	0	4
Peak sharing capabilities	0	5
Photovoltaic systems: standalone, building-integrated	0	2
Radiant cooling / heating	0	7
Radiant heat transfers using ray tracing	0	5
Radiant HVAC systems	0	1
Semi-conditioned buildings	0	5
Simplified specification of financial analysis of retrofit options	0	7
Simulate occupant loading	0	5
Simulating control schemes using solar PV and solar thermal units	0	5
Simulations – add / subtract items and see energy / environmental / $ impact results	0	7
Smart windows (dynamic)	0	4
Solar impact by orientation and glazing systems	0	2
Stratification in multi-story spaces	0	4
System psychrometrics, e.g., direct / indirect desiccant, etc.	0	7
System Simulation	0	6
Thermal storage (chilled water) system design		

(tanks, headers, etc.)	0	2
Time frame and occupant feedback	0	7
Type of utilities	0	5
Vapor diffusion and moisture transport module	0	3
Ventilation - cross and stack	0	1

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Users Workshop
Program User Interface Priorities

Original concepts arranged in alphabetical order by number of votes.
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Item	Votes	Group
Automatic acquisition of building geometry	5	4
Graphical libraries of building components and technologies	5	7
Interoperable with other tools	5	4
Shared intelligent, object-based representation of building and its systems: eliminate redundant input, gives consistent building model, concurrent simulation, allows multiple applications to work off same building model, consistent modeling throughout d	5	2
'Smart' help	5	7
Streamlined integration of I/O with database, spreadsheets, word processor, other programs	5	7
Automated error checking	4	4
Clear demarcation between required and optional values	4	3
Context-sensitive help	4	1
Interconnect program inputs	4	7
Interface from 3-D sketch visualization software for input	4	5
Real time simulation while operating CADD	4	4
Simplified, detailed, very detailed methods of input	4	4
Access to external databases	3	4
Automated generation of simulation models from CAD representation – "seamless integration"	3	1
Clear separation of interface and computational engine (no calculations in interface)	3	3
Common / Multiple Interfaces - input and output	3	6
Context-sensitive online help	3	3
Different levels of user input	3	7
'Expert' advice on inputs	3	7
Graphic Output	3	6
Interface with manufacturer's catalogs	3	1
Program modules that users can add or subtract to fit needs	3	7
Tutorials on how to use	3	7
User customizability	3	7
Automated graphical duct design	2	4

Built-in optimization	2	3
Clear mapping of interface inputs to simulation variables and parameters	2	3
Customizable input and output units (metric, English, mixed)	2	4
Customizable reports and graphs	2	4
Data transfer protocol – any interface works with any program (and with any CAD program)	2	4
Directly integrated within CAD environment	2	7
Documentation	2	6
Expert interactive quality control recommendations	2	7
Extensive libraries (building components, systems, space loads, whole building, codes/standards)	2	1
For operation of building interface to equipment maintenance programs	2	5
Geometry and non-geometric data input in formats intuitive to building designers	2	1
Graphic Input	2	6
Graphical object-oriented modular systems	2	4
HVAC component plug-ins where manufacturers can provide a disk of their equipment you could incorporate in your design and simulate performance	2	7
Input	2	3
Input Organization	2	6
Integration with industry standard CAD packages	2	3
Interactive error check and validation	2	1
Multi-platform applicability	2	1
Online help to include engineering info	2	4
Output compatibility with spreadsheet and other analytical tools	2	3
Simulation tool interface as a 'hook' to 3rd party GUIs (standardized building description format)	2	3
Tutorials, online help, solved examples, . . .	2	4
Use of web to provide up-to-date electronic documentation	2	1
Virtual reality	2	7
Wizards and other process-related checklists	2	5
3-D modeling of spaces, displaying thermal characteristics (like structural stress) diagrams	1	7
3-D spatial display air movement (like wind tunnels where smoke is introduced into the air system)	1	7
AutoCAD input interface	1	7
CAD, 3-D graphical interface, the building as 3-D object from start	1	3
Capabilities of detailed outputs (how answers are determined)	1	7

Code compliance forms	1	4
Customizable reports	1	3
Data Management	1	6
Display results on charts instead of numbers	1	3
Easily modifiable for different languages (i.e., English, French, ...)	1	4
Easy Customization of Reports	1	6
Easy parameter access for 'what ifs'	1	3
Extensible model	1	4
Extensive user-select default libraries and weather files	1	3
Globally usable model	1	4
Graphic output generation / editing	1	4
Graphical building walk-through	1	1
Graphical input and editing	1	7
Graphical input of site, adjacent building, vegetation	1	5
Graphical output of results	1	5
Graphical user interface for input and output	1	3
GUI	1	3
Help	1	3
Industry standard interoperability	1	5
Integrate with CAD (IFC compliance)	1	1
Integrate with next generation object-oriented component-based CAD systems	1	1
Integrated review capability	1	5
Integration Linking	1	3
Integration with design load calculation programs	1	1
Integration with other modules	1	1
Integration; graphics and other spreadsheets	1	1
Interface with building energy management systems	1	1
Interface with utility rate structure data in order to evaluate economics of peak shifting, shaving technologies	1	1
Internal databases for all libraries (building element, schedules, controls, materials, etc.)	1	4
Interpretation of functional relationships between user inputs to generate simulation parameters	1	3
Knowledge based outputs	1	4
Manufacturer databases (products directly incorporated into program)	1	7
Minimize input via building-function-driven defaults	1	5
Multimedia / Visual Output	1	6
Multi-media I/O	1	4

Multi-platform	1	4
Navigation for new users	1	3
Non-Microsoft GUI !!	1	4
Objectified model (to support behavior)	1	4
Output	1	3
Prototype building (with customizable defaults)	1	4
Range checking for input values	1	3
Removal of redundancy in user input	1	3
Representation and construction of equipment model using graphical components	1	5
Shared database with other tools (costing, structure, etc.)	1	5
Simple and easy to use	1	4
Simple input option (minimal user input with intelligent defaults)	1	1
Simple-to-detailed input mapping	1	1
Standard input procedure for new users	1	3
Structure IF logic	1	3
User capability to customize defaults	1	3
User group network	1	3
User profile sensitive help	1	5
User-defined output	1	4
Utilize distributed computing, parallel architect	1	4
'Visual' checks of building geometry	1	7
Visual drawing checks	1	4
Write the model in next generation software technology	1	4
3-D spatial display of lighting, visual filters to display excessive glare, contrast	0	7
Ability to allow different simulation capabilities to be plugged in, in a modular manner	0	1
Access to databases for equipment, schedules, weather, etc.	0	3
Activity and design phase - dependent help	0	5
Auto-checking building description consistency	0	5
Automatic sequencing for common evaluation steps (i.e. eliminate parametrics)	0	5
Backward compatibility	0	4
Built-in cost estimating	0	3
CAD-based input	0	7
'Checksum' output reports	0	7
Combination of canned (default) outputs and flexible (database) outputs	0	3
Common building component hierarchy	0	7
Common interface, i.e., Windows or DOS standard features	0	7
Comprehensive online documentation	0	7
Computer aided software engineering	0	2

Critical evaluation / selection of application platform	0	1
Customization of simulation interface	0	1
Customized output reports	0	7
Cut/Paste of Systems / Details (object/module tools)	0	6
Data visualization	0	7
Databases	0	7
Defaults and other advise	0	1
Design guidance: input error checking, compliance checking, wizards (interactive help), algorithm information, on-line, expert system support for input preparation and output interpretation, system design sizing, design options based on initial building	0	2
Develop applets for customizable user interface	0	4
Different timing (phases: PD, SD, DD, CD, CA) user options	0	7
Distributed Computing / Links	0	6
Ease of use – simple icons	0	3
Engine with multiple GUIs	0	4
Feedback to users when computation is in progress	0	3
Flexible coupling to data reduction, database, and graphing program	0	3
Functional interface—not necessarily glitzy	0	4
Generalized standard building and system descriptor protocol	0	1
Glossary	0	3
Glossary of keywords	0	3
Good on-line help	0	3
Graphic interface	0	3
Graphical building component toolboxes	0	5
Graphical inputs and outputs	0	1
GUI: intuitive; point, click, drag, drop; switchable between graphical and text; schematics of building, systems, components; voice activation; integrated with CAD interface; telepathic input	0	2
Input / output English / SI options	0	7
Interface to 3-D CAD programs	0	5
Interface with virtual reality program in order to evaluate design option (i.e., lighting schemes, etc.)	0	1
Interoperability between components	0	4
Intuitive geometry input	0	7
Knowledge based inputs	0	4
Libraries: materials, windows, walls, HVAC systems, HVAC components, whole building, schedules, control sequences, utility rates		

(including real time), costs (components, construction, maintenance, ...), geographic information system, weather	0	2
Libraries—characteristics: updateable from web / online, search engine, manufacturer's data, object-oriented	0	2
Link with other users to append simulation to libraries	0	1
Linked with all other design requirements (structural, etc.)	0	3
Multi-user/multi-project/multi-discipline	0	5
On-demand access to building overview	0	7
Online documentation	0	7
Online support	0	1
Open system code development, code public domain	0	2
Output as input to design tools	0	4
Output to common formats (.dB, .xls, etc.)	0	7
Parallax photo 3-D digitized input for existing buildings	0	3
Project data: case studies, modifications (history), alternative options tracking, comparison to regional energy use by building type, exemplary buildings	0	2
Public domain, availability issues	0	4
Pull-down menus of equipment types and performance characteristics	0	7
Readily accepted by design community	0	4
Real time or time step lighting changes during day and year, 3-D rendered space (shading / shadows)	0	7
Results interpretation: importable into spreadsheets, data reduction (monthly averages, peaks, etc.), selective output based on simulation objective (energy, comfort, cost, ...), out-of-range output flags, output templates, easy comparison of design alterternatives	0	2
Scaling of 'library' sample buildings	0	7
Seamless interface between analysis modules	0	3
Should support both SI and IP units	0	3
Simulated user can be placed in space and human comfort can be tested (mean radiant, glare, drafts, etc.)	0	7
Special user version, e.g., federal sector	0	7
Standard fixed format 'echo print' of inputs with 'what's different feature'	0	3
Tool flexibility: low—sales engineer, high—algorithm developer	0	2
Use of default values to aid in input	0	3
User built libraries – new product library update	0	1
User variable setups	0	3

Variable levels of detail and roll-up (abstraction)	0	5
VRML (virtual reality modeling language) and other WEB enabling	0	5

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