VOLUME 27, NO. 4 -- APRIL 2006

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BUILDING ENERGY SIMULATION ★ USER NEWS

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Highlights

Software

Departments

The 🐝 *Buzz*

The newsletter features of [Ask an EnergyPlus Expert](#) and [DOE-2 Modeling Tips](#) have been compiled for 2005. Click on the active links above or go to our publications page at http://SimulationResearch.lbl.gov

🐝

A new version of ENERGY-10 (v.1.8) has been released. Turn to p. 18 or go to www.energy-10.com for details.

🐝

If you want to be listed as an EnergyPlus or DOE-2 consultant in this newsletter and on the Building Simulation web site, email klellington@lbl.gov.

Release of EnergyPlus 1.3.0

The tenth major version of EnergyPlus (1.3.0) was released on April 25, 2006 and is now available in versions for both the Windows and Linux operating systems. Download this newest release at no cost from the EnergyPlus web site: www.energyplus.gov.

What's New in Version 1.3.0

- UFAD (Under Floor Air Distribution) room air model for exterior zones is now available.

- Completely reworked airflow modeling -- the new AirflowNetwork model replaces both COMIS and ADS and has the combined capabilities. Calculation of infiltration, ventilation, mixing and cross mixing moved to system time step for future feature development of hybrid (mixed mode) ventilation control. Differences in results are usually minor.

- Outside air temperature is now varied as a function of zone or surface height above ground. Wind profile options can be set separately for the weather station and the building site. Includes new zone and surface report variables for height dependent properties. There will be differences in results, particularly in files with Ventilation or Infiltration.

- Simple earth tube model for preconditioning (heating/cooling) outside air.

- Tempering valve (3-way valve emulation) for effective and safe use of stored thermal energy.

- Variable and constant speed headered pumps.

- Detailed ice storage.

- New Compact HVAC models for fan powered VAV, fan coil, night cycle controls, outside air heat recovery, supply air temperature reset, chilled/hot water temperature reset, VAV supply fan part-load options, VAV fan blow through or draw through option, and zone supply and return plenums.

- Energy end-use subcategories are now user-definable.

- New report variable for Zone Operative Temperature (Operative Temperature Control planned for V 1.4 in October).

And many other enhancements and <u>significant speed improvements</u> throughout.

To EnergyPlus Documentation
http://www.eere.energy.gov/buildings/energyplus/documentation.html

Download Now!!!   **New IBPSA Newsletter is available at**
http://www.ibpsa.org/newsletter/ibpsanews-16-1.pdf

# DesignBuilder v.1.1 - New User Interface for EnergyPlus

DesignBuilder v.1.1 is based around an innovative OpenGL modeling tool, it allows even inexperienced users to access EnergyPlus' most powerful features: What the interface does:

Presents the most commonly used HVAC systems including VAV with terminal reheat with options for VAV box and outside air control, constant volume, DX unitary systems, packaged rooftop systems, fan coil units, hot water radiators and underfloor heating.

Provides a detailed simulation of air flow through cracks and openings from wind and buoyancy effects. You can control window/vent opening using timers and thermostats.

All significant EnergyPlus fabric, glazing, shading, natural ventilation and daylight control features are implemented.

Shading and reflection from architectural features; electrochromic glazing; transparent insulation; free cooling; night cooling; glazed cavities such as double facades and Trombe walls etc.
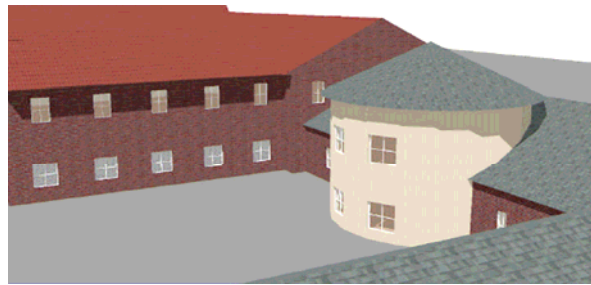
DesignBuilder allows rapid construction of building models. Buildings may be visualised in 3D to assess design / energy performance trade-offs.

Simulation data can be shown in annual, monthly, daily, hourly or sub-hourly intervals:
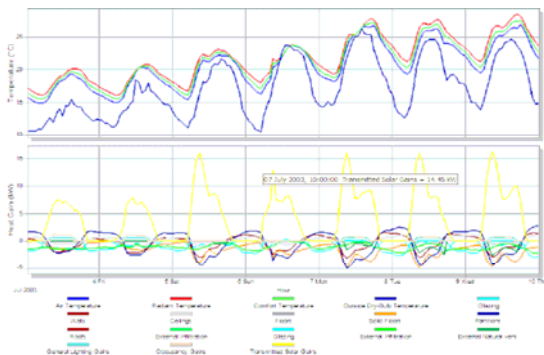
DesignBuilder uses the latest EnergyPlus simulation engine to calculate the energy performance of the building. Output data may be graphed or exported in table format for use in other applications.

- Energy consumption broken down by fuel and end-use.
- Heat input from heating and cooling coils.
- Internal air, mean radiant and operative temperatures and humidity
- Heat transmission through building fabric. including walls, roofs, infiltration, ventilation, etc.
- Heating and cooling loads.
- CO_2 generation.
- Site weather data.
- Comfort output including temperature distribution curves, ASHRAE 55 comfort criteria, Fanger PMV, Pierce PMV ET and PMV SET, Pierce Discomfort Index (DISC), Pierce Thermal Sens. Index (TSENS), Kansas Uni TSV.

The DesignBuilder user interface is the result of a considerable development effort over the last seven years. It has been designed from the ground up to be easy to use while retaining the flexibility to allow just about any building to be modelled. The most important features are:

- OpenGL building modeller allows building models to be assembled by positioning 'blocks' in 3-D space. Blocks can be cut, moved and stretched allowing you to work with just about any geometry.
- Easily generate stunning rendered images and movies of your building design including the effect of site shading for any day of the year. Explore the model using simple view controls.
- Data templates allow you to load common building constructions, activities, HVAC & lighting systems into your design by selecting from drop-down lists. You can also add your own templates if you often work on similar types of buildings.
- Data inheritance allows global changes to be made at building, block or zone level. This doesn't sound very impressive but it is the underlying basis for DesignBuilders' flexibility and ease of use!
- Control the level of detail in each building model allowing the tool to be used effectively at any stage of the design or evaluation process.

Interface features continued …

- Switch between Model Edit View and Environmental performance data with a single click - data is displayed without the need to run external modules and import data - any simulations required to generate the data are started automatically.
- Building geometry can be imported from CAD data and traced over within DesignBuilder to create blocks and to partition blocks into zones.
- Export IDF files and work with them outside DesignBuilder to access system functionality not provided by DesignBuilder.
- Heating and cooling plant sizes can be calculated using design weather data.
- ASHRAE worldwide design weather data and locations (4429 data sets) are included.
- Latest EnergyPlus hourly weather files are available (1258 data sets) free using the DesignBuilder 'Install on Demand' feature.

Cost:
The price for DesignBuilder version 1 is 1449 USD which includes EnergyPlus and Visualisation modules, all version 1.x updates and priority e-mail support. You can find out more about the various licensing options from the website:

Future:
We have exciting plans for future versions of DesignBuilder. Once the Version 1.x feature set is complete (summer 2006) we plan to start developing a detailed HVAC system modeller, a CFD simulation capability and advanced data management and reporting functions. We are currently testing our UK Part-L building regulations compliance modules and will start work very soon on providing certified building regulations compliance reports for Australia and New Zealand. We also expect to provide LEED reports later in the year.

You can also download a free 30-day evaluation version of the software. And if you have downloaded DesignBuilder in the past and would like us to extend your evaluation please contact Andy Tindale.

http://www.designbuilder.co.uk/

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2006 EnergyPlus Training

| June 15-16	**Atlanta, GA** Note that 2-day workshops are now structured so that Day 1 covers basics and Day 2 goes into more depth. Attendees may register for Day 1 or Day 2 or both.
August 01	**Cambridge, Massachusetts (at MIT)** Immediately before the IBPSA-USA SimBuild Conference at MIT Early registration deadline is June 28, 2006; Registration closes after July 24

http://www.gard.com/training.htm

Please visit our website at http://SimulationResearch.lbl.gov

xEsoView: Open Source File Viewer for EnergyPlus

Download from http://xesoview.sourceforge.net/

xEsoView, an open source file viewer for EnergyPlus eso files, gives the user a very fast overview of the simulation results. The program lists all reported variable names, which can then be sorted and filtered. At the same time, it shows the graphical representation of the selected variable. The time axis can be changed using predefined ranges but xEsoView also supports zooming. With a selection box you can switch between the available environments, e.g. summer design day and run-period. A simple CTRL+C copies the variable data to the clipboard so you can easily paste the data into your favorite spreadsheet program for further analysis.
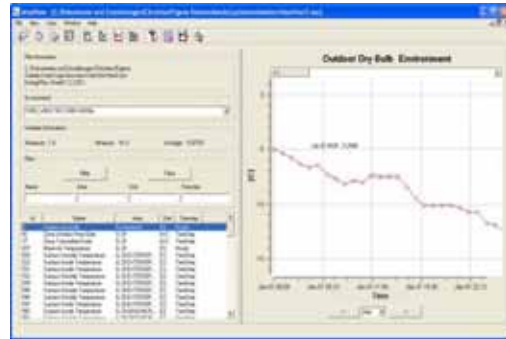
Features

- Switch between environments (summer design day, winter design day, run period)
- Sort variables (id, name, area, unit, timestep)
- Filter variables (name, area, unit, timestep)
- Show variable information (max, min, avg)
- Show file information
- Select time scale (total, month, week, day, hour)

- Zoom
- Grid
- Markers
- Copy graphic to clipboard (Ctrl-Shift-C)
- Copy variable data to clipboard (Ctrl-C) optionally with time/date
- Reload eso file
- Export graphic as PDF

xEsoView author: Christian Schiefer, Vienna, Austria

Ask an EnergyPlus Expert

WINDOW HEAT GAINS

I'm studying window heat gains. I want to put gains and losses together like this:

```
[(losses)*(-1)] + gains = window heat transfer
```

Then I want to separate the solar portion from this so that I can plot a window breakdown graph. To do so I assume I subtract the solar portion from this calculated value; is that correct? Or by doing so will I be subtracting the solar portion twice? I ask this because when I looked at the documentation I saw that the window heat gains are composed of several components, including transmitted solar energy. However, when I checked the heat losses it says *"absolute value of heat flow when the total heat flow is negative (see the definition of heat gains above)."* Does that mean that the transmitted solar portion is zero or different in this case and the balance is negative? I ask this question because I'm afraid I might be subtracting the solar portion twice.

Answer
The components of Window Heat Gain and Window Heat Loss are the same. The net heat flow of the window is computed, then positive values are reported as Gain and negative values are reported as Loss.

Ask an EnergyPlus Expert

MAIN BRANCH COOLING/HEATING COIL CONTROL NODES

I am getting max iterations on a loop and I'm trying to go through the file iteratively to locate the source of the problem (node connections, correct flow rates, etc.). A brief description of the system I am trying to emulate:

I have a fixed flow system. The AHU takes full fresh air before entering a cooling coil, a heating coil and a supply fan (no reheat). The temperature leaving the supply fan is varied according to zone temperature.

This is what I have done so far:
  I have two Controller:simple objects which both use the same control node (the supply fan outlet node). I have set this at 18C. However, I would prefer to let EnergyPlus decide what the setpoint should be.

Could this be the source of my problems?

Answer
EnergyPlus controllers all have a finite control tolerance (specified in the controller object), so the control is not perfect. Our guess is that the heating and cooling coil controllers are battling each other. If we understand your application correctly, SETPOINT MANAGER:SINGLE ZONE HEATING and SETPOINT MANAGER:SINGLE ZONE COOLING can be used to control your system.

Move the heating coil to be after the fan and place the SETPOINT MANAGER:SINGLE ZONE HEATING setpoint on the heating coil outlet node. Place the SETPOINT MANAGER:SINGLE ZONE COOLING setpoint on the fan outlet node and use a SETPOINT MANAGER:MIXED AIR to place a setopint minus fan heat correction on the cooling coil outlet node.

Question
Just so I know for future systems, do I have to use the SETPOINT MANAGER:MIXED AIR even though the system is set up to take 100% fresh air?

Answer
From the Engineering Reference Manual under Setpoint Managers:

MIXED AIR
The mixed air setpoint manager takes an already established setpoint (usually the supply air outlet node setpoint temperature), subtracts the supply fan heat gain, and applies the result as the setpoint temperature at the mixed air node (or any other node the user specifies).

So yes, if you want to control equipment to a setpoint and include fan heat, you will need to use the Setpoint Manager:Mixed Air object.

Find EnergyPlus Documentation At
http://www.eere.energy.gov/buildings/energyplus/documentation.html

Ask an EnergyPlus Expert

MINIMUM ENERGY USE

I want to predict the lowest amount of energy use that a building would require (in essence, a benchmark) in order to control adequate levels of thermal comfort in a space throughout a typical year. Would it be best to use purchased air or should I use a dummy HVAC system?

Answer
You should use an HVAC system that includes a full blown outdoor air system with economizer. Purchased air won't capture the free cooling. Because purchased air/heating/cooling is perfectly controlled and infinitely available, it's not the best way to accomplish your goal.

ASHRAE Standard 90.1-2004 Appendix G contains standard HVAC system configurations for various commercial building types along with the definitions of various parts of the systems. It is intended for evaluating 'above code' evaluations such as green building rating systems.

Also the 30% Guide for Small Offices from ASHRAE, IES, USGBC shows how to take small offices 30% beyond 90.1-2001 (or ~ 25% beyond 90.1-2004).

EXTRACT VENTILATION

I want to simulate a building with an extract ventilation system only, there is no supply air. I did this initially using ZONE EXHAUST FAN objects for each zone. Now I want to have a duct system connecting multiple zones, with a single extract fan. Can I set up an AIR PRIMARY LOOP without any supply ?

Answer
No; every AIR PRIMARY LOOP is a loop, with return air, outside air, mixed air, supply air. Also, the air flow must be balanced. Thus, whenever you exhaust air, it must be balanced by inlet outside air which is part of the supply air. So to use an AIR PRIMARY LOOP, you would need to set up the usual air loop but ensure there is no return air by setting the minimum outside air flow rate to the maximum in the OA Controller object.

AUTOSIZING – PLANT LOOP

When autosizing a plant loop, do you have to autosize everything on that loop and everything connected to that loop or can you just autosize specific things like flow rates, etc. The reason I ask is that I tried autosizing flowrates in a plant loop and I encountered numerous errors. Then I tried autosizing everything on the plant loop and got even more errors. What should be my next course of action?

Answer
The Plant Loops and associated components are generally able to mix and match autosizing with hard sizes. In the Input Output Reference, there is a section that discusses this issue. Search for "Mixing User-Specified and Autosized Inputs." If you have not seen that yet, it may help you solve this problem.

Free!!! **Subscribe to the ASHRAE newsletters at**
http://www.ashrae.org/template/enewsletterlanding

Ask an EnergyPlus Expert

WORK EFFICIENCY SCHEDULE

I am evaluating the thermal performance of a multi-family dwelling and I would like to know which value is recommended for the "work efficiency schedule" for summer and winter.

Answer
You should probably refer to the ASHRAE Handbooks and/or the Thermal Comfort Standard (55).

In the EnergyPlus datasets folder, there is a SCHEDULES.idf which contains example schedules for occupants, lighting, and equipment based on ASHRAE standards including multifamily dwellings.

The Building America benchmark also includes information on dwelling energy baselines and schedules, available at http://www.nrel.gov/docs/fy05osti/36429.pdf

UNDERFLOOR HEATING

What is the simplest method to model underfloor heating? I considered using a low temperature radiant system and, if this is a good choice, do I need to make another object. I don't see a link with any other objects (except for the nodes of course).

Answer
Reference ExampleFiles\RadLoHydrHeatCoolAuto.idf. The objects required to define a low temperature radiant floor are:

CONSTRUCTION WITH INTERNAL SOURCE and LOW TEMP RADIANT SYSTEM:HYDRONIC

In addition, the usual zone control objects are required for any HVAC systems (ZONE CONTROL:THERMOSTATIC, CONTROLLED ZONE EQUIP CONFIGURATION, ZONE EQUIPMENT LIST) along with plant loops and branches to connect it to the boiler.

LOW TEMP RADIANT SYSTEM:HYDRONIC requires specification of the "Hydronic tubing inside diameter" and the tubing length and water flow rate in order to autosize.

Andy Tindale, of DesignBuilder offers this alternative:
You could use a low temperature radiant System for modeling underfloor heating, but it isn't exactly simple. At DesignBuilder we have been experimenting with the high temperature radiant system which has a simpler definition.   You can set up the high temperature radiant system to emit all of its radiant heat into the floor surface and this seems to give believable results. Of course, the heat should really be injected within the floor construction, but provided the underfloor heating system you are trying to model has coils fairly close to the surface this method should provide good results.

The next version of DesignBuilder will have an option for high-temperature radiant systems using this mechanism. You can get a working prerelease from the DesignBuilder website www.designbuilder.co.uk/downloads .

Ask an EnergyPlus Expert

WINDOW-5

I am using WINDOW-5 to create a window. If I don't create exactly the same size window in .idf then EnergyPlus issues a warning. Is this simply a warning or will it affect the results as well. How does EnergyPlus handle size variations?

Answer
It depends on the window details. Some windows will scale well, others will not. See discussion in Input Output Reference titled "Importing Windows from WINDOW-5" beginning on p. 180 (pdf p. 216), especially the top of p. 180 (pdf p. 218).

Question
Thanks for the suggestion. I guess I am not still clear how EnergyPlus adjusts the dimensions. The text pdf p. 218 states "*If there is one glazing system, the glazing system height and width from the* WINDOW-5 *data file are not used.*" Let's say my window in the idf file (actual size in my building) is 1000 mm x 1600 mm but in WINDOW-5 I had modeled it as Fixed (picture) window 1200 mm x 1500 mm. Will EnegyPlus adjust these dimensions with reasonable accuracy?

Answer
In the I/O Reference Manual, beginning on p. 184 (pdf p. 220), there is a description of the contents of the WINDOW-5 Data file. The quantities used in EnergyPlus are shown in bold.

The glazing system properties are all for center of glass and do not change with the window dimensions. The window subsurface dimensions in the EnergyPlus input file are the glass dimensions, and the glazing properties from the WINDOW-5 data file are applied to this glass area (less any dividers, frames are outside the subsurface dimensions).

The only quantities that are dependent on actual window dimensions are the average frame and divider characteristics. If the frame is uniform on all sides, then the average properties will be the same no matter what the window dimensions are.

So, for a window with a uniform frame, EnergyPlus will adjust the dimensions just fine (using the geometry in the EnergyPlus surface input object). Strictly speaking, however, the WINDOW-5 model results for center of glass performance will vary with size of the product (because of how convection is modeled inside the gap). Although this subtle feature leads to including a disclaimer/warning on the dimension mismatch, most would agree that it can be safely ignored for annual energy modeling.   Matching the height dimension is more important than matching width. You could play with sizes in WINDOW-5 to see the magnitude of the impact on window performance levels.

Free! The 2005 Buildings Energy Data Book includes statistics on residential and commercial building energy consumption. Data tables contain statistics related to construction, building technologies, energy consumption, and building characteristics. Download book from:
http://buildingsdatabook.eere.energy.gov/

Please visit our website at http://SimulationResearch.lbl.gov

New Items from the ASHRAE Bookstore
http://www.ashrae.org/

Principles of Heating, Ventilating and Air-Conditioning provides broad and current coverage of the heating, ventilation, and air-conditioning field when combined with the 2005 ASHRAE Handbook—Fundamentals. There are four significant changes (from the 2001 Ed.) in this 2005 edition of Principles of HVAC. Click here for more information.

HVAC Simplified provides an understanding of fundamental HVAC concepts and how to extend these principles to the explanation of simple design tools used to create building systems that are efficient and provide comfortable and healthy environments. Includes CD with spreadsheet programs containing design and computation procedures. Click here for more information.

ASHRAE Standards and Guidelines on CD 2006 This CD includes a library of all new Standards and Guidelines that you can easily print, search, copy and paste text or graphics. All available on one CD, you can search across all Standards and Guidelines and have unlimited access to download these files via ASHRAE's website. Click here for more information.

HVAC&R Research is a quarterly journal reporting significant research from ASHRAE and the international HVAC&R research communities. Click here for more information

VisualDOE 4 and LEED Training for 2006

Architectural Energy Corporation is pleased to announce three VisualDOE training seminars in 2006, as follows:

May 18-19 in San Francisco
November 13-14 in Boulder, CO
July or August in New York City

Each seminar includes two days focused on DOE-2, the VisualDOE interface, new features of VisualDOE 4, general energy simulation skills, and LEED-NC 2.1 and 2.2 energy savings calculations for green buildings.

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Building Energy Software Tools Directory

This directory provides information on over 300 building software tools for evaluating energy efficiency, renewable energy, and sustainability in buildings. The energy tools listed in this directory include databases, spreadsheets, component and systems analyses, and whole-building energy performance simulation programs. Know of a tool (yours?) that isn't in the directory? Send email to Dru Crawley at Drury.Crawley@ee.doe.gov.

Visit **http://www.eere.energy.gov/buildings/tools_directory/about.cfm**

The Forecast Looks Favorable for …

(Free!) Weather Data on Demand

Access archived weather data from around the world through this U.S. DOE web interface:

www.eere.energy.gov/buildings/energyplus/cfm/weatherdata/weather_request.cfm

Hourly weather data is continuously collected and stored into a local database, available through this web interface. Most stations have information for dry bulb temperature, wet bulb temperature, wind speed/direction, atmospheric pressure, visibility, cloud conditions, and precipitation type.

Ask an EnergyPlus Expert

BACKWARD COMPATABILITY

Is EnergyPlus v.1.3.0 backward compatible? Can I run a v.1.2.3 file in v.1.3.0?
For the most part, the answer is yes. There are many changes that require you to transition to v.1.3.0. EP-Launch will now check the selected file (if there is a version object) and you can launch the Transition program from the EP-Launch "File" menu. You can also view the ObjectStatus spreadsheet in the root folder of the installed version. This file has detailed explanations of changes to the objects.

This is particularly important for existing input files with COMIS objects – they are both internally and externally transitioned but will not be internally transitioned in the next release. If you have both COMIS and ADS objects in your input file – please contact email support (EnergyPlus-Support@gard.com) for assistance.

EnergyPlus v.1.3.0

Free Download from http://www.energyplus.gov/

Support Tools
> Support software is listed on our website (http://SimulationResearch.lbl.gov/EP/ep_tools.html) and in Section 2 of this newsletter.

Weather Data from http://www.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm
> Weather data for more than 800 locations are now available in EnergyPlus weather format. See the write-up on how to create Meteonorm files for EnergyPlus.

Ask an EnergyPlus Expert
> Questions from EnergyPlus users are answered promptly via email by program developers. To submit questions, join the EnergyPlus User Group at http://groups.yahoo.com/group/EnergyPlus_Support/.
> A selection of questions/answers are compiled (yearly) into a downloadable PDF document: Q and A for 2002, Q and A for 2003, Q and A for 2004. Q and A for 2005

Are you an EnergyPlus Consultant ?
> If you are engaged in EnergyPlus consulting, and would like to be listed in the *Building Energy Simulation User News* and on our website (http://SimulationResearch.lbl.gov), please send details to klellington@lbl.gov.

Join the EnergyPlus User Group
> The developers of EnergyPlus have formed a support group to foster discussion and maintain an archive of information for program Users. We invite questions about program usage and suggestions for improvement to the code. Go to http://groups.yahoo.com/group/EnergyPlus_Support/

Testing and Validation http://www.eere.energy.gov/buildings/energyplus/testing.html.

Spotlight on SPARK – Part 3 of 5

Frequently Asked Questions about the Simulation Problem Analysis and Research Kernel Software

Download VisualSPARK 2.01 (Free!) from http://gundog.lbl.gov/VS/vs201_eula.html

This is a list of frequently asked questions (FAQ) for VisualSPARK users. If you need help for something that is not covered by the SPARK Reference Manual, the SPARK Atomic Class API, the SPARK Problem Driver API, or this FAQ, please email us.

This FAQ is intended to supplement, not replace, the SPARK documentation. Before emailing us a question, you should first check to see if the topic is covered in the various manuals.

SPARK Preference Settings
- **How to deal with bad numerics?**
- **How to deal with no convergence?**
- **How to prevent early convergence after the prediction step?**
- **How to relax the convergence test on the non-break variables?**

SPARK Preference Settings

The SPARK preference settings for the solution methods are specified in an ASCII file with extension *.prf using the so-called preference syntax. The preference syntax relies on set of parenthesis "( )" to identify the various tokens in a tree-like structure. See the SPARK Reference Manual for more information on the preference syntax. In this section we discuss issues pertaining to the preference settings only, independent of the file format.

How to deal with bad numerics?

When SPARK detects bad numerics (i.e., Not a Number or an infinite number) in a strongly-connected component, you can try to set the $CheckBadNumericsFlag$ in the component section of the preference settings file to 1 in order to activate a more robust numerical treatment that is likely to cure the problem. Essentially SPARK will check for bad numerics in the residual function at each iteration and halve the relaxation coefficient until the bad numerics situation is no longer detected in the resulting residuals. This mode of operation is very costly because it happens at the inner most level of the nonlinear solver. Therefore, it is not selected by default and you should only select it for the components that require it.

```
(
  ComponentSettings (
    0 ( …
      CheckBadNumericsFlag ( 1  ())
      …
    )
  )
)
```

For example, the previous code snippet sets the robust bad numerics checking mode on for the component 0. This setting might be required to solve highly nonlinear equation systems that are likely to produce bad numerics in the residuals if the full Newton step is applied.

How to deal with no convergence?

For each strongly-connected component SPARK solves a system of nonlinear equations for the set of break variables identified by the setup program during the graph-algorithmic analysis. By default the nonlinear solver uses the Newton method with a fixed relaxation coefficient, typically set to 1. The Newton method is locally q-quadratically convergent, which means that if the initial approximation is good enough then it will be improved rapidly until the desired precision is achieved.

However, applying the full Newton step at each iteration might be unsatisfactory when the initial approximation is not good enough. Such situations might lead to poor convergence or even divergence of the solution process. In order to ensure finding a solution of the system of nonlinear equations, *from almost any starting point*, SPARK implements globally convergent strategies derived from the Newton method. Such methods are usually referred to as **quasi-Newton** methods. They behave like the Newton method close to the solution, thus retaining its local convergence rate, whereas away from the solution they rely on a step dictated by a global method to ensure taking a *reasonable* step.

In SPARK these strategies are called the **step control methods**. They are responsible for determining the direction and the length of the step that the nonlinear solver makes at each iteration. In particular, they adapt the relaxation coefficient to ensure global convergence. SPARK implements the following step control methods, specified from the less robust and "cheapest" strategy to the most robust and most computationally expensive one:

- [0] Fixed relaxation coefficient strategy (default)
- [1] Basic halving strategy
- [2] Linesearch backtracking strategy
- [3] Affine invariant backtracking strategy

When the default step control method does not converge, you should try to use one of the more robust methods by specifying the corresponding value using the key SteplengthControlMethod in the component section of the preference settings file. For each strategy listed above we have included in square brackets the corresponding value used to identify it in the preference settings file.

```
(
  ComponentSettings (
    0 ( …
      SteplengthControlMethod  ( 2   ())
      RelaxationCoefficient ( 1.0 ())
      MinRelaxationCoefficient ( 1e-10 ())
      …
    )
  )
)
```

For example, setting the step control method to 2 in the previous code snippet will select the linesearch backtracking strategy for the component 0. Furthermore, this strategy will attempt to use a relaxation coefficient of 1.0 close to the solution, and otherwise will be allowed to adapt the relaxation coefficient up to a minimum value of 1.0e-10. Such settings are typical of highly nonlinear system of equations.

Finally, it is fundamental that the model equations are **continuously differentiable** otherwise the convergence assumptions underlying the Newton method will break down and SPARK will not be able to compute the solution of the nonlinear equations. The way the equations are formulated in the atomic classes is critical to guarantee the differentiability of the system. Also, the model writer should always

be aware of the possibility that the Jacobian matrix derived from the set of equations may be intrinsically or become singular or ill-conditioned. Most numerical problems can be avoided by paying enough attention to the formulation of the equations during the design phase. Typically it is good practice to avoid:

- possible divisions by zero,
- discontinuities in the return values,
- expressions that will generate partial derivatives likely to become infinite, and
- expressions that have a limited validity domain likely to generate a NaN.

The remaining pathological numerical problems arising at runtime are then dealt with algorithmically using a different solution method and the various recovery strategies implemented in SPARK.

How to prevent early convergence after the prediction step?

The nonlinear solver always checks for the convergence after the prediction phase, i.e. firing of the predict callbacks assigned to the break variables. This is accomplished by checking the residual functions associated with the break variables against the specified tolerance multiplied by the prediction safety factor. By default the prediction safety factor is set to 0.01 so that this prediction convergence test will only succeed when the residuals are significantly smaller than the prescribed tolerance.

However, this test does not ensure that the desired precision is achieved in all the unknown variables for the component in question since "small" residual functions do not imply a certain number of significant digits in the solution. Such an assumption is entirely dependent on the scaling of the residual functions. This is especially an issue with highly nonlinear system of equations. In order to prevent such early and unsatisfactory convergence from being detected, it is possible to set the value of the residual safety factor in the global settings section of the preference settings file using the key ResidualsSafetyFactor.

```
(
  GlobalSettings ( …
    ResidualsSafetyFactor ( 0.0 ())
    …
  )
)
```

For example, setting the residual safety factor to 0.0 will ensure that the nonlinear solver never detects convergence after the prediction phase unless all residuals are exactly equal to zero. When the "convergence" diagnostic level is set in the runtime controls file, the result of the prediction phase is indicated with the iteration count 0 in the run log file.

How to relax the convergence test on the non-break variables?

After each iteration the nonlinear solver checks for convergence by comparing the solution increments since the last iteration against the specified tolerance. The iterative process stops only when the increments of both the break variables and the non-break variables are smaller than the prescribed tolerance multiplied by some safety factor.

In some cases it is impossible to obtain the desired precision for some of the non-break variables because the error is amplified from the break variables in such way that the smallest change in the solution of a break variable causes the increments of a dependent non-break variable in the same component to be larger than the requested tolerance. Such unfortunate numerical situations are likely to occur with SPARK when solving highly nonlinear problems because of its solution methodology whereby only the break variables forming the cut set are solved iteratively a opposed to the entire set of unknowns in each strongly-connected component.

To deal with such situations we recommend that:

- either you make the cut set bigger by forcing some of the offending variables to become break variables using the BREAK_LEVEL language construct,
- or that you relax the convergence test on the non-break variables by specifying a safety factor larger than 1, the default value.

The latter is achieved using the key NormalUnknownSafetyFactor in the global settings section of the preference settings file.

```
(
  GlobalSettings ( …
    NormalUnknownSafetyFactor  ( 100.0  ())
    …
  )
)
```

For example, setting the safety factor for the non-break variables (also referred to as the normal unknowns) to 100 relaxes the convergence test by 2 orders of magnitude. If the requested tolerance is 1.0e-6, you should expect 6 significant digits in the solution of the break variables but only 4 significant digits in the solution of the non-break variables.
Such precision is of course only achieved for the variables whose values lie far away from their respective absolute tolerance. Consult the SPARK Reference Manual for more information on the convergence tests and the meaning of the various safety factors and tolerances involved.

More Frequently Asked Questions in the next Newsletter !!

Pacific Gas and Electric Company™
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May 2006 Educational Programs
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Building Performance (Cx)	
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H V A C	
May 4	Brown Bag HVAC Seminar - How to Measure Airflow
May 24	Optimizing Air-Side System Design

LIGHTING	
May 23	Lighting Fundamental

RENEWABLES	
May 25	Photovoltaic (PV) Site Analysis and System Sizing

TITLE 24 (CALIFORNIA ENERGY CODE)	
May 4	Brown Bag HVAC Seminar - How to Measure Airflow
May 11	Exceeding 2005 Title 24 for Offices
May 24	Optimizing Air-Side System Design

DOE-2

DOE-2.1E (version 121) 1,000-Zone version for Windows from ESTSC; other vendors of DOE-2 based programs are listed on our website: http://SimulationResearch.lbl.gov/.

Cost is as follows:
$ 300 U.S. Government/Non-Profits/Education
$ 575 U.S. Public, Mexico, Canada
$1129 to $1268 Other Foreign

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What is included on the CD?
DOE-2 Reference Manual (Part 1) and (Part 2)   DOE-2 BDL Summary (2.1E)
DOE-2 Engineers Manual (2.1A)   DOE-2 Supplement to the Reference Manual (2.1E)

Order Software and ESTSC Documentation

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NCI Information Systems, Inc.
Energy Science and Technology Software Center (ESTSC)
P.O. Box 1020
Oak Ridge, TN 37831

Phone: 865/576-1037
Fax: 865/576-6436
Email: estsc@adonis.osti.gov

Purchase DOE-2 Documentation

DOE-2 Sample Run Book (2.1E) -- The Sample Run book is the only DOE-2 manual not available electronically. It must be purchased separately from NTIS; ordering information may be found at http://SimulationResearch.lbl.gov > DOE-2 > Documentation

Free DOE-2 Documentation (http://simulationresearch.lbl.gov/> DOE-2 > Documentation)

DOE-2 Basics Manual (2.1E)

Update Packages: Update Packages are not cumulative; each one contains different information. Download all four packages then print and insert the pages into your existing DOE-2 manuals.

Update Package #1: DOE-2.1E Basics, the Supplement and BDL Summary

Update Package #2: BDL Summary and Supplement.

Update Package #3: Appendix A of the Supplement.

Update Package #4: (1000-zone DOE-2.1E) BDL Summary.

DOE-2 Modeling Tips (pdf files)   for 2005   for 2004   for 2003   for 2002
A compilation of all the "how to" and "DOE-2 Puzzler" articles from the newsletter.

Changes and Bug Fixes to DOE-2.1E (txt file)
Description of all changes and bug fixes in a text document.

From the Department of Time-Wasting Guilty Pleasures . . .

The Dialectizer takes text or other web pages and instantly creates parodies of them!

http://rinkworks.com/dialect/

Outlines of California's 16 Climate Zones have been overlaid on the aerial images of Google Earth. This is useful if you want to examine the boundary areas between two climate zones. The outlines are based on the GIS (Arcview) shapes.

Google Earth is a free broadband, 3D application.

Go to http://earth.google.com/

California Climate Zones on Google Earth™

Once you download, install and launch the application, download and open the Climate Zones CA-CZ.kmz 120 kb file.

The free version does not allow labeling on the map, climate zones can be selectively viewed by using the check box along side each layer. We suggest that you uncheck all the climate zones and then select only the one of interest at the time to view.

Free Building Energy Software from Lawrence Berkeley National Laboratory

BDA 3.1 *(Building Design Advisor)* gaia.lbl.gov/BDA
(building decision-making from design through completion)

COMIS www-epb.lbl.gov/comis (multi-zone air flow and contaminant transport model)

EnergyPlus 1.3.0 www.energyplus.gov/
(next-generation whole-building energy analysis program, based on BLAST and DOE-2)

GenOpt® 2.0 SimulationResearch.lbl.gov (generic optimization program)

Optics 5.2 windows.lbl.gov/materials/optics5/
(for analyzing optical properties of glazing systems)

RADIANCE 3.5 radsite.lbl.gov/radiance/ (analysis and visualization of lighting in design)

   Desktop Radiance 2.0β radsite.lbl.gov/deskrad/
     (integrates the Radiance Synthetic Imaging System with AutoCAD Release 14)

   Radiance Control Panel www.squ1.com/site.html
     (automates some Radiance tasks once the model has been created)

THERM 5.2 windows.lbl.gov/software/therm/therm.html (models two-dimensional heat-transfer effects in building components where thermal bridges are of concern)

VisualSPARK 2.0 SimulationResearch.lbl.gov
(Simulation Problem Analysis and Research Kernel) (connect component models to simulate innovative building envelope and HVAC systems)

WINDOW-5.2 windows.lbl.gov/software/window/window.html
(thermal analysis of window products)

Free Software / Request by Fax from 510.486.4089

RESFEN 3.1 windows.lbl.gov/software/resfen/resfen.html
(choose energy-efficient, cost-effective windows for a given residential application)

Web Based

Home Energy Saver hes.lbl.gov (quickly computes home energy use)

IBPSA-USA -- SimBuild 2006 -- August 2-4, 2006

To be held at the Massachussets Institute of Technology in Cambridge, MA, USA
For details, access the website: http://ceae.colorado.edu/ibpsa/SimBuild06/index.html

IBPSA-USA will hold its second national conference, August 2-4, 2006 on the campus of the Massachusetts Institute of Technology. Technical sessions over two days will feature presentations on a wide range of topics related to the simulation of HVAC equipment, airflow in buildings, energy usage, and the visual and acoustic environment in buildings, as well as demonstrations of simulation software and of hardware and software needed to emulate or measure the performance of buildings. Friday will be a practitioner day, offering case studies, hands-on software demonstrations and other presentations aimed at giving practicing architects and engineers the information they need to be more informed collaborators with simulation experts. The practitioner day will be coordinated with local US Green Building Council chapters and affiliates.

Free Membership for 2006 -- IBPSA-USA

The IBPSA-USA Board of Directors has voted unanimously to extend our policy of free membership. Those interested in renewing their membership or becoming new members may do so by expressing their desire to be IBPSA-USA members and providing updated contact information
(Affiliation, Mailing address, Phone number, Email address)

Establishing membership may be done on-site at any IBPSA-USA meeting or by sending an email to the IBPSA-USA Secretary, Peter Ellis, at peter_ellis@nrel.gov.
[P] 303.384.7443, [F] 303.384.7540

Meetings, Conferences, Symposia and Workshops

2006		
May 17–19	International Conference on Air Conditioning & Ventilation	www.acv2006.cz
May 21–24	5th International Conference HVAC+R Technologies	www.ttmd.org.tr
May 31– June 2	International Conference on Thermal Energy Storage	www.stockton.edu/ecostock

ENERGY-10™ Version 1.8 is now available for purchase online through SBIC at:

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- **Photovoltaic module** that provides the ability to model and simulate the performance of a PV system that is either stand-alone or integrated with the building.

- **Solar Domestic Hot Water module** provides a new solar domestic/service hot water modeling capability.

- **A new library** ("ASHRAELIB") is included with Version 1.8 defining constructions (wall, roof, window, etc.) as spelled out in ASHRAE 90.1-2004.