

# ENERGYPLUS™ VERSION 9.6.0 DOCUMENTATION

## Acknowledgments and Copyright Notices

*U.S. Department of Energy*



September 23, 2021

Build: f420c06a69

COPYRIGHT (c) 1996-2021 THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS, THE REGENTS OF THE UNIVERSITY OF CALIFORNIA THROUGH THE ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY, OAK RIDGE NATIONAL LABORATORY, MANAGED BY UT-BATTELLE, ALLIANCE FOR SUSTAINABLE ENERGY, LLC, AND OTHER CONTRIBUTORS. ALL RIGHTS RESERVED. NO PART OF THIS MATERIAL MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS WITHOUT THE PRIOR WRITTEN PERMISSION OF THE UNIVERSITY OF ILLINOIS OR THE ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY. ENERGYPLUS IS A TRADEMARK OF THE US DEPARTMENT OF ENERGY.

# Contents

<b>1</b>	<b>Notices and Acknowledgments</b>	<b>3</b>
1.1	Copyright Notice . . . . .	3
1.2	Other Software included or referenced directly . . . . .	6
1.2.1	ZLIB DATA COMPRESSION LIBRARY . . . . .	6
1.2.2	ExPat Copying Notice . . . . .	8
1.2.3	FMU SDK license . . . . .	9
1.2.4	Minizip Notice . . . . .	9
1.2.5	MODELISAR Notice . . . . .	10
1.2.6	Functional Mock-up Unit for Co-Simulation Import Notice . . . . .	10
1.2.7	Functional Mock-up Unit Export of EnergyPlus Notice . . . . .	11
1.2.8	Kiva License . . . . .	13
1.3	Other Acknowledgments . . . . .	13

# Chapter 1

## Notices and Acknowledgments

### 1.1 Copyright Notice

Copyright (c) 1996-2015 The Board of Trustees of the University of Illinois and The Regents of the University of California through Ernest Orlando Lawrence Berkeley National Laboratory. All rights reserved.

Portions of the EnergyPlus<sup>TM</sup> software package have been developed and copyrighted by other individuals, companies and institutions. These portions have been incorporated into the EnergyPlus software package under license.

**In addition to the primary authorship of the LBNL Simulation Research Group (<http://simulationresearch.lbl.gov/>) and the UIUC Building Systems Laboratory, the following have contributed to EnergyPlus Versions (includes all minor revisions):**

Portions of the EnergyPlus weather processor were developed by US Department of Energy, Office of Building Technologies.

Portions of the input processing, output processing, weather processor, BLAST Translator were developed by US Army Corps of Engineers, Construction Engineering Research Laboratories, 2902 Newmark Drive, Champaign IL 61821. <http://www.erc.usace.army.mil/Locations/ConstructionEngineeringResearchLaboratory.aspx>

Portions of this software package were developed for Ernest Orlando Lawrence Berkeley National Laboratory and Florida Solar Energy Center by Linda Lawrie of DHL Consulting.

Portions of this software package were developed for Ernest Orlando Lawrence Berkeley National Laboratory and Florida Solar Energy Center by C.O. Pedersen Associates.

Portions of the EnergyPlus utility software (EP-Launch, IDFEditor, DOE2Translator, HVAC-Diagram, ExpandObjects, CSVProc, ParametricPreprocessor, AppGPostProcess, EP-Compare, and convertESOMTR) were developed by GARD Analytics, Inc. 115 S. Wilke Road, Suite 105, Arlington Heights, IL, USA, <info@gard.com>, [www.gard.com](http://www.gard.com). GARD Analytics performed independent verification and validation testing of the software after developing the testing strategy and plan. GARD Analytics was also responsible for gas absorption chiller, desiccant dehumidifier, ice storage (simple), table reports, economics and life cycle costing.

Portions of flow resolver, chiller models (absorption, electric, const cop, engine-driven, gas-turbine), generator models (diesel electric, gas turbine), furnace models, heat recovery loop, plant loop, plant condenser loop, air-change dependent inside film coefficients were developed by Oklahoma State University, 110 Engineering North, Stillwater, OK 74078.

Portions of EnergyPlus related to the models for EMPD moisture calculations, DX coils, furnace/unitary systems, air-to-air heat pumps, changeover-bypass VAV systems, packaged terminal heat pumps, cooling towers, AirflowNetwork, refrigerated cases, reformulated and electric EIR chillers, desuperheater air and water heating coils, heat pump water heaters, desiccant and generic air-to-air heat exchangers, window screens, and thermal comfort controls were developed by University of Central Florida, Florida Solar Energy Center (FSEC), 1679 Clearlake Road, Cocoa, FL 32922, [www.fsec.ucf.edu/](http://www.fsec.ucf.edu/).

Portions of the refrigeration model and the exhaust-fired absorption chiller model were developed by Oak Ridge National Laboratory, Bethel Valley Road, Oak Ridge, Tennessee 37831.

Portions of EnergyPlus were developed by the National Renewable Energy Laboratory (NREL), 1617 Cole Blvd, Golden, CO 80401.

Portions of EnergyPlus related to transformer losses model, autosizing calculations, life cycle costing and chemical battery storage model were developed by Pacific Northwest National Laboratory (PNNL), P.O. Box 999, Richland, WA 99352.

EnergyPlus v1.0.1, v1.0.2, v1.0.3, v1.1, v1.1.1 (Wintel platform) included a link to TRNSYS (The Transient Energy System Simulation Tool) for photovoltaic calculations developed by Thermal Energy System Specialists, 2916 Marketplace Drive, Suite 104, Madison, WI 53719; Tel: (608) 274-2577. EnergyPlus v1.2 and later includes Photovoltaic calculations implemented in EnergyPlus by Thermal Energy System Specialists. This model was originally developed by Oystein Ulleberg, Institute for Energy Technology, Norway – based on the Duffie and Beckman equivalent one-diode model.

Portions of this software package that convert certain stand-alone heat transfer models for slab-on-grade and basement foundations were developed by William Bahnfleth, Cynthia Cogil, and Edward Clements, Department of Architectural Engineering, Pennsylvania State University, 224 Engineering Unit A, University Park, Pennsylvania 16802-1416, (814) 863-2076.

The concept and initial implementation for the EnergyPlus COM/DLL version (Wintel platform) was made possible through cooperation with DesignBuilder Software, Ltd, Andy Tindale – an EnergyPlus collaborative developer.

The thickness, conductivity, density and specific heat values of the material layers for the constructions in the Composite Wall Construction reference data set have been taken from the ASHRAE report “Modeling Two- and Three-Dimensional Heat Transfer through Composite Wall and Roof Assemblies in Hourly Energy Simulation Programs (1145-TRP),” by Enermodal Engineering Limited, Oak Ridge National Laboratory, and the Polish Academy of Sciences, January 2001.

EnergyPlus v1.2 and later versions contains DELight2, a simulation engine for daylighting and electric lighting system analysis developed at Ernest Orlando Lawrence Berkeley National Laboratory.

EnergyPlus v1.2.2 through v3.1 contained links to SPARK, a simulation engine for detailed system modeling developed at Ernest Orlando Lawrence Berkeley National Laboratory in conjunction with Ayres Sowell Associates, Inc.

The airflow calculation portion of the EnergyPlus AirflowNetwork model was based on AIRNET written by George Walton of the National Institute for Standards and Technology (NIST), 100 Bureau Drive, Gaithersburg, MD 20899. The EnergyPlus AirflowNetwork model also includes portions of stack effect and detailed large opening from an early version of COMIS (Conjunction Of Multizone Infiltration Specialists) developed by a multinational, multi-institutional effort under the auspices of the International Energy Agency’s Buildings and Community Systems Agreement work-

ing group focusing on multizone air flow modeling (Annex 23) and now administered by the Swiss Federal Laboratories for Materials Testing and Research (EMPA), Division 175, Ueberlandstrasse 129, CH-8600 Dübendorf, Switzerland.

The EnergyPlus model for displacement ventilation and cross-ventilation (version v1.2 and later) was developed by Guilherme Carrilho da Graca (Department of Mechanical and Aerospace Engineering, University of California, San Diego and NaturalWorks) and Paul Linden (Department of Mechanical and Aerospace Engineering, University of California, San Diego).

The EnergyPlus models for UFAD served zones were developed by Anna Liu and Paul Linden at the Department of Mechanical and Aerospace Engineering, University of California, San Diego.

ASHRAE research project 1254-RP supported the development of the following features first added in EnergyPlus v1.2.2:

- DXSystem:AirLoop enhancements (valid as OA system equipment, new humidity control options)
- New set point managers: SET POINT MANAGER:SINGLE ZONE HEATING, SET POINT MANAGER:SINGLE ZONE COOLING, and SET POINT MANAGER:OUTSIDE AIR PRE-TREAT
- New 2-stage DX coil with enhanced dehumidification option:
  - COIL:DX:MultiMode:CoolingEmpirical
- Additional DESICCANT DEHUMIDIFIER:SOLID setpoint control option

American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329<sup>1</sup>. Work performed by GARD Analytics, Inc., 115 S. Wilke Road, Suite 105, Arlington Heights, IL, USA<sup>2</sup>, November 2004. These items were renamed in V3.0 to:

- SetpointManager:SingleZone:Heating
- SetpointManager:SingleZone:Cooling
- SetpointManager:OutdoorAirPretreat
- Coil:Cooling:DX:TwoStageWithHumidityControlMode
- Dehumidifier:Desiccant:NoFans

The Ecoroof (Green Roof) model, first introduced in EnergyPlus v2.0, was developed at Portland State University, by David Sailor and his students. It is based on the FASST vegetation models developed by Frankenstein and Koenig for the US Army Corps of Engineers.

The HAMT (Heat And Moisture Transfer) model, first introduced in EnergyPlus v3.0.0 was developed by Phillip Biddulph, Complex Built Environment Systems, The Bartlett School of Graduate Studies, University College London, Gower Street, London WC1E 6BT, United Kingdom. <http://www.cbes.ucl.ac.uk/>.

---

<sup>1</sup><http://www.ashrae.org/>

<sup>2</sup>[urinfo@gard.com](mailto:urinfo@gard.com); <http://www.gard.com/>

The SQLite output module, first introduced in EnergyPlus v3.0.0, was developed by Gregory B. Stark, P.E., Building Synergies, LLC, 1860 Washington Street, Suite 208, Denver, Colorado 80203, United States.

Refrigeration compressor performance data and refrigeration practices were provided by CDH Energy, Cazenovia, NY 12035.

The external interface was developed by Michael Wetter and Philip Haves (Lawrence Berkeley National Laboratory) and by Rui Zhang (Carnegie Mellon University). An earlier upgrade to a development version of EnergyPlus 3.0 was implemented by Charles Corbin, Anthony Florita, Gregor Henze and Peter May-Ostendorf (University of Colorado at Boulder).

Various suggestions for time reduction, improved documentation and other items have been incorporated from Autodesk, Inc., Bentley Systems, and others.

Particular recognition goes to Noel Keen (LBNL Computational Research Division) and Geof Sawaya (Oak Ridge National Laboratory fellow) who have done extensive profiling and creation of time reduction features that have gone into the code.

Second Law modified the WaterToAirHeatPump:EquationFit module to include the variable “WaterCyclingMode”. This variable determines whether the heat pump water flow is constant, whether it cycles with the compressor, or whether it is constant when the heat pump is active. WaterFlowMode is set by the HVAC wrapper object; either ZoneHVAC:WaterToAirHeatPump or AirLoopHVAC:UnitaryHeatPump:WaterToAir. Second Law, Burlington, VT, Karen Walkerman.

**NOTICE:** The U.S. Government is granted for itself and others acting on its behalf a paid-up, nonexclusive, irrevocable, worldwide license in this data to reproduce, prepare derivative works, and perform publicly and display publicly. Beginning five (5) years after permission to assert copyright is granted, subject to two possible five year renewals, the U.S. Government is granted for itself and others acting on its behalf a paid-up, non-exclusive, irrevocable worldwide license in this data to reproduce, prepare derivative works, distribute copies to the public, perform publicly and display publicly, and to permit others to do so.

**TRADEMARKS:** EnergyPlus is a trademark of the US Department of Energy.

## 1.2 Other Software included or referenced directly

The following notices apply to those EnergyPlus distributions which include the interface to BCVTB or Functional Mock-up Units.

### 1.2.1 ZLIB DATA COMPRESSION LIBRARY

zlib 1.2.5 is a general purpose data compression library. All the code is thread safe. The data format used by the zlib library is described by RFCs (Request for Comments) 1950 to 1952 in the files <http://www.ietf.org/rfc/rfc1950.txt> (zlib format), rfc1951.txt (deflate format) and rfc1952.txt (gzip format).

All functions of the compression library are documented in the file zlib.h (volunteer to write man pages welcome, contact [zlib@gzip.org](mailto:zlib@gzip.org)). A usage example of the library is given in the file example.c which also tests that the library is working correctly. Another example is given in the file minigzip.c. The compression library itself is composed of all source files except example.c and minigzip.c.

To compile all files and run the test program, follow the instructions given at the top of Makefile.in. In short “./configure; make test”, and if that goes well, “make install” should work for most flavors of Unix. For Windows, use one of the special makefiles in win32/ or contrib/vstudio/. For VMS, use make\_vms.com. Questions about zlib should be sent to <zlib@gzip.org>, or to Gilles Vollant <info@winimage.com> for the Windows DLL version. The zlib home page is <http://zlib.net/>. Before reporting a problem, please check this site to verify that you have the latest version of zlib; otherwise get the latest version and check whether the problem still exists or not.

PLEASE read the zlib FAQ [http://zlib.net/zlib\\_faq.html](http://zlib.net/zlib_faq.html) before asking for help.

Mark Nelson <markn@ieee.org> wrote an article about zlib for the Jan. 1997 issue of Dr. Dobbs’s Journal; a copy of the article is available online<sup>3</sup>.

The changes made in version 1.2.5 are documented in the file ChangeLog.

Unsupported third party contributions are provided in directory contrib/.

zlib is available in Java using the java.util.zip package, documented online<sup>4</sup>.

A Perl interface to zlib written by Paul Marquess <pmqs@cpan.org> is available at CPAN (Comprehensive Perl Archive Network) sites, including <http://search.cpan.org/pmqs/IO-Compress-Zlib/>.

A Python interface to zlib written by A.M. Kuchling <amk@amk.ca> is available in Python 1.5 and later versions, see <http://www.python.org/doc/lib/module-zlib.html>.

zlib is built into tcl: <http://wiki.tcl.tk/4610>.

An experimental package to read and write files in .zip format, written on top of zlib by Gilles Vollant <info@winimage.com>, is available in the contrib/minizip directory of zlib.

Notes for some targets:

- For Windows DLL versions, please see win32/DLL\_FAQ.txt
- For 64-bit Irix, deflate.c must be compiled without any optimization. With -O, one libpng test fails. The test works in 32 bit mode (with the -n32 compiler flag). The compiler bug has been reported to SGI.
- zlib doesn’t work with gcc 2.6.3 on a DEC 3000/300LX under OSF/1 2.1 it works when compiled with cc.
- On Digital Unix 4.0D (formerly OSF/1) on AlphaServer, the cc option -std1 is necessary to get gzprintf working correctly. This is done by configure.
- zlib doesn’t work on HP-UX 9.05 with some versions of /bin/cc. It works with other compilers. Use “make test” to check your compiler.
- gzdopen is not supported on RISCOS or BEOS.
- For PalmOs, see <http://palmzlib.sourceforge.net/>

Acknowledgments:

---

<sup>3</sup><http://marknelson.us/1997/01/01/zlib-engine/>

<sup>4</sup><http://java.sun.com/developer/technicalArticles/Programming/compression/>

The deflate format used by zlib was defined by Phil Katz. The deflate and zlib specifications were written by L. Peter Deutsch. Thanks to all the people who reported problems and suggested various improvements in zlib; they are too numerous to cite here.

Copyright notice:

(C) 1995-2010 Jean-loup Gailly and Mark Adler

This software is provided ‘as-is’, without any express or implied warranty. In no event will the authors be held liable for any damages arising from the use of this software.

Permission is granted to anyone to use this software for any purpose, including commercial applications, and to alter it and redistribute it freely, subject to the following restrictions:

1. The origin of this software must not be misrepresented; you must not claim that you wrote the original software. If you use this software in a product, an acknowledgment in the product documentation would be appreciated but is not required.
2. Altered source versions must be plainly marked as such, and must not be misrepresented as being the original software.
3. This notice may not be removed or altered from any source distribution.

Jean-loup Gailly  
jloup@gzip.org

Mark Adler  
madler@alumni.caltech.edu

If you use the zlib library in a product, we would appreciate \*not\* receiving lengthy legal documents to sign. The sources are provided for free but without warranty of any kind. The library has been entirely written by Jean-loup Gailly and Mark Adler; it does not include third-party code.

If you redistribute modified sources, we would appreciate that you include in the file ChangeLog history information documenting your changes. Please read the FAQ for more information on the distribution of modified source versions.

### 1.2.2 ExPat Copying Notice

Copyright (c) 1998, 1999, 2000 Thai Open Source Software Center Ltd

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the “Software”), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED “AS IS”, WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.



### 1.2.3 FMU SDK license

Copyright (c) 2008-2011, QTronic GmbH. All rights reserved.

The FmuSdk is licensed by the copyright holder under the BSD License<sup>5</sup>: Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY QTRONIC GMBH “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL QTRONIC GMBH BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

### 1.2.4 Minizip Notice

Condition of use and distribution are the same than zlib :

This software is provided ‘as-is’, without any express or implied warranty. In no event will the authors be held liable for any damages arising from the use of this software.

Permission is granted to anyone to use this software for any purpose, including commercial applications, and to alter it and redistribute it freely, subject to the following restrictions:

1. The origin of this software must not be misrepresented; you must not claim that you wrote the original software. If you use this software in a product, an acknowledgment in the product documentation would be appreciated but is not required.
2. Altered source versions must be plainly marked as such, and must not be misrepresented as being the original software.
3. This notice may not be removed or altered from any source distribution.

---

<sup>5</sup><http://www.opensource.org/licenses/bsd-license.html>

### 1.2.5 MODELISAR Notice

Copyright (c) 2008-2010, MODELISAR consortium. All rights reserved.

This file is licensed by the copyright holders under the BSD License<sup>6</sup>:

---

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- Neither the name of the copyright holders nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

### 1.2.6 Functional Mock-up Unit for Co-Simulation Import Notice

Functional Mock-up Unit for Co-Simulation Import in EnergyPlus Copyright (c) 2012, The Regents of the University of California, through Lawrence Berkeley National Laboratory (subject to receipt of any required approvals from the U.S. Dept. of Energy). All rights reserved.

If you have questions about your rights to use or distribute this software, please contact Berkeley Lab’s Technology Transfer Department at <TTD@lbl.gov>.

NOTICE. This software was developed under partial funding from the U.S. Department of Energy. As such, the U.S. Government has been granted for itself and others acting on its behalf a paid-up, nonexclusive, irrevocable, worldwide license in the Software to reproduce, prepare derivative works, and perform publicly and display publicly. Beginning five (5) years after the date permission to assert copyright is obtained from the U.S. Department of Energy, and subject to any subsequent five (5) year renewals, the U.S. Government is granted for itself and others acting

---

<sup>6</sup><http://www.opensource.org/licenses/bsd-license.html> \TU\textgreater

on its behalf a paid-up, nonexclusive, irrevocable, worldwide license in the Software to reproduce, prepare derivative works, distribute copies to the public, perform publicly and display publicly, and to permit others to do so.

Modified BSD License agreement

Functional Mock-up Unit for Co-Simulation Import in EnergyPlus Copyright (c) 2012, The Regents of the University of California, through Lawrence Berkeley National Laboratory (subject to receipt of any required approvals from the U.S. Dept. of Energy). All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.

Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

Neither the name of the University of California, Lawrence Berkeley National Laboratory, U.S. Dept. of Energy nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

You are under no obligation whatsoever to provide any bug fixes, patches, or upgrades to the features, functionality or performance of the source code (“Enhancements”) to anyone; however, if you choose to make your Enhancements available either publicly, or directly to Lawrence Berkeley National Laboratory, without imposing a separate written license agreement for such Enhancements, then you hereby grant the following license: a non-exclusive, royalty-free perpetual license to install, use, modify, prepare derivative works, incorporate into other computer software, distribute, and sublicense such enhancements or derivative works thereof, in binary and source code form.

### 1.2.7 Functional Mock-up Unit Export of EnergyPlus Notice

Functional Mock-up Unit Export of EnergyPlus (c)2013, The Regents of the University of California, through Lawrence Berkeley National Laboratory (subject to receipt of any required approvals from the U.S. Department of Energy). All rights reserved.

If you have questions about your rights to use or distribute this software, please contact Berkeley Lab’s Technology Transfer Department at <TTD@lbl.gov>.referring to “Functional Mock-up Unit Export of EnergyPlus (LBNL Ref 2013-088)”.

NOTICE: This software was produced by The Regents of the University of California under Contract No. DE-AC02-05CH11231 with the Department of Energy.

For 5 years from November 1, 2012, the Government is granted for itself and others acting on its behalf a nonexclusive, paid-up, irrevocable worldwide license in this data to reproduce, prepare derivative works, and perform publicly and display publicly, by or on behalf of the Government. There is provision for the possible extension of the term of this license.

Subsequent to that period or any extension granted, the Government is granted for itself and others acting on its behalf a nonexclusive, paid-up, irrevocable worldwide license in this data to reproduce, prepare derivative works, distribute copies to the public, perform publicly and display publicly, and to permit others to do so. The specific term of the license can be identified by inquiry made to Lawrence Berkeley National Laboratory or DOE. Neither the United States nor the United States Department of Energy, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any data, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Copyright (c) 2013, The Regents of the University of California, Department of Energy contract-operators of the Lawrence Berkeley National Laboratory.

All rights reserved.

1. Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:
  - (1) Redistributions of source code must retain the copyright notice, this list of conditions and the following disclaimer.
  - (2) Redistributions in binary form must reproduce the copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
  - (3) Neither the name of the University of California, Lawrence Berkeley National Laboratory, U.S. Dept. of Energy nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission.
2. THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS"

AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

3. You are under no obligation whatsoever to provide any bug fixes, patches, or upgrades to the features, functionality or performance of the source code ("Enhancements") to anyone;

however, if you choose to make your Enhancements available either publicly, or directly to Lawrence Berkeley National Laboratory, without imposing a separate written license agreement for such Enhancements, then you hereby grant the following license: a non-exclusive, royalty-free perpetual license to install, use, modify, prepare derivative works, incorporate into other computer software, distribute, and sublicense such enhancements or derivative works thereof, in binary and source code form.

NOTE: This license corresponds to the “revised BSD” or “3-clause BSD” License and includes the following modification: Paragraph 3. has been added.

### 1.2.8 Kiva License

Copyright (c) 2012-2018 Big Ladder Software LLC. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

- (1) Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
- (2) Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
- (3) Neither the name of the copyright holder nor the names of its contributors may be used to endorse or promote products derived from this software without specific prior written permission from the copyright holders.

THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDER AND CONTRIBUTORS “AS IS” AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT HOLDER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

## 1.3 Other Acknowledgments

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technologies of the US Department of Energy – under the guidance of Dru Crawley from inception through March 2010.

Additional support was provided by the Gas Technology Institute and the California Energy Commission.

The ice thermal storage module development was supported by the U.S. Department of Energy Office of Electricity Delivery and Energy Reliability.

The HAMT (Heat And Moisture Transfer) model was supported by the Engineering and Physical Sciences Research Council (EPSRC), the UK government agency for funding research and training in engineering and the physical sciences.

The SQLite output module was funded by Building Synergies, LLC and was made possible by inclusion of software code from the SQLite project (<http://www.sqlite.org/>).