

# GridLAB-D Technical Support Document: Commercial Module Version 1.0

DP Chassin

May 2008

Prepared for the U.S. Department of Energy  
under Contract DE-AC05-76RL01830

## DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, 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 information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.** Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST NATIONAL LABORATORY

*operated by*

BATTELLE

*for the*

UNITED STATES DEPARTMENT OF ENERGY

*under Contract DE-AC05-76RL01830*

Printed in the United States of America

Available to DOE and DOE contractors from the  
Office of Scientific and Technical Information,  
P.O. Box 62, Oak Ridge, TN 37831-0062;  
ph: (865) 576-8401  
fax: (865) 576-5728  
email: [reports@adonis.osti.gov](mailto:reports@adonis.osti.gov)

Available to the public from the National Technical Information Service,  
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161  
ph: (800) 553-6847  
fax: (703) 605-6900  
email: [orders@ntis.fedworld.gov](mailto:orders@ntis.fedworld.gov)  
online ordering: <http://www.ntis.gov/ordering.htm>



This document was printed on recycled paper.

(9/2003)

**GridLAB-D Technical Support Document:  
Commercial Module Version 1.0**

DP Chassin

May 2008

Prepared for  
the U.S. Department of Energy  
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory  
Richland, Washington 99352



## **Acronyms and Abbreviations**

ODE	ordinary differential equation
ETP	equivalent thermal parameters
UA	thermal conductance (surface area x thermal conductivity)

# Contents

Acronyms and Abbreviations .....	iii
1.0 Introduction .....	1
2.0 Single-Zone Office Building .....	1
3.0 References .....	2

## 1.0 Introduction

The Commercial Module implements commercial building models. Version 1.0 of this module only supports single-zone office buildings. Support for additional commercial buildings types is planned, including multi-zone office, schools, stores, and refrigerated warehouses.

## 2.0 Single-Zone Office Building

The Commercial Module uses a simple Equivalent Thermal Parameters (ETP) model (Taylor and Pratt 1988) with first-order ordinary differential equations (ODEs):

$$\dot{T}_i = \frac{1}{c_a} [T_m h_m - T_i(UA - h_m) + \Sigma Q_i + T_o UA] \quad (2.1)$$

$$\dot{T}_m = \frac{h_m}{c_m} [T_i - T_m] \quad (2.2)$$

where

$T_i$  = the temperature of the air inside the building

$$\dot{T}_i = \frac{dT_i}{dt}$$

$T_m$  = the temperature of the mass inside the building (for example, furniture, inside walls)

$$\dot{T}_m = \frac{dT_m}{dt}$$

$T_o$  = the ambient temperature outside air

$UA$  = the UA of the building envelope

$h_m$  = the UA of the mass of the furniture, inside walls, etc.

$c_m$  = the heat capacity of the mass of the furniture inside the walls, etc.

$c_a$  = the heat capacity of the air inside the building

$Q_i$  = the heat rate from internal heat gains of the building (for example, plugs, lights, people)

$Q_h$  = the heat rate from heating, ventilating, and air conditioning unit

$Q_s$  = the heat rate from the sun (solar heating through windows, etc.)

The general first order ODEs ( $C_1$ - $C_5$  defined by inspection above) is

$$\dot{T}_i = T_o C_1 + T_m C_2 + C_3 \dot{T}_m = T_o C_4 + T_m C_5 \quad (2.3)$$

The general form of the second-order ODE is

$$p_1 = p_1 \dot{T}_i + p_2 \dot{T}_m + p_3 T_i \quad (2.4)$$

The solutions to second-order ODE for indoor and mass temperatures are

$$T_i(t) = K_1 e^{r_1 t} + K_2 e^{r_2 t} + \frac{p_3}{p_1} \quad (2.5)$$

$$T_m(t) = \frac{T_i(t) - C_1 T_o(t) - C_2}{C_3} \quad (2.6)$$

where:

$$r_1, r_2 = \text{roots}(p_1, p_2, p_3)$$

$$K_1 = \frac{(r_2 T_o - r_1 \frac{p_3}{p_1} - T_o)}{r_2 - r_1}$$

$$K_2 = \frac{T_o - r_2 K_1}{r_1}$$

$$P_1 = \frac{1}{C_2}$$

$$P_2 = -\frac{C_3}{C_2} - \frac{C_1}{C_2}$$

$$P_3 = C_3 \frac{C_1}{C_2} - C_4$$

$$P_4 = -C_3 \frac{C_3}{C_2}$$

$t$  = the elapsed time

$T(t)$  = the temperature of the air inside the building at time  $t$

$T_o = T(t=0)$ , for example, the initial temperature of the air inside the building

$T_o' = T'(t=0)$ , for example, the initial temperature gradient of the air inside the building

### 3.0 References

Taylor, ZT and RG Pratt. 1988 "The effects of model simplifications on equivalent thermal parameters calculated from hourly building performance data." In *Proc. 1988 ACEEE Summer Study on Energy Efficiency in Buildings*, pp. 10.268-10.285.