Required Features of Overall Systems Model Software for ESS and ED2S Design and Performance Evaluation

Introduction

A software platform, acceptable and useful to all the Testbed Program participants, is sought to assist in the design and evaluation of Energy Supply and Energy Delivery and Distribution Systems, the ESS and ED2S, for the Intelligent Workplace and the Building as Power Plant, the IW and BAPP. What follows is a draft description of the features desired in this platform for consideration and comment by all the program participants.

All the participants are asked to provide suggestions regarding this listing of desired platform features by 3 December 2004 and to identify preferences regarding the platform to be adopted prior to 23 December 2004. Tentatively, TrnSys and EnergyPlus have been suggested as candidate system model platforms.

Testbed Program Desired Modeling Platform Features

The platform should

- make available and/or accept models of ESS and ED2S components; and provide for their solution. These models might be
    - fundamental, steady state or dynamic, prepared in EES.
    - empirical, steady state, presented as an equation set or data tables. An empirical model may be based on measured data, information provided by the equipment supplier, calculations carried out by fundamental models.

ESS and ED2S components are listed in Appendix A below.

- make available or accept models of a building's power, cooling, heating, and ventilation energy loads, hourly, daily, and monthly throughout a year, based on the location, design, occupancy, and use of the structure; provide for the exercise of such models, for example, DOE-2, EnergyPlus, or E-20-II. The building load model may be steady state or dynamic, based on thermal energy storage by the thermal mass of the structure or added thermal storage features.
- make provision for the supply of weather data (air temperature and humidity, precipitation, wind) and of solar insolation data (direct and diffuse, direction, and intensity).
- make provision for the supply of property data and phase and chemical equilibria data needed for the solution of the various ESS and ED2S components.
- make provision for operation (a schedule, logical algorithms) and for control (feed back, feed forward, etc) of the ESS and ED2S components in the overall system involving the building and its occupants.

- provide for integrated solutions of the ESS and ED2S component and the building load models, steady state or dynamic at selected time intervals, with added input and computational programming to determine the performance of the overall system at peak loads on summer and winter design days and at intermediate loads on a spring/fall day. Performance involves
    - effectiveness, comfortable temperatures, air humidity, and air quality throughout the building;
    - efficiency, minimal use of energy;
    - economy, low capital and operating costs;
    - environmental acceptability, low overall impact on the surroundings.
- provide numerical, graphical, and pictorial information on the performance of the overall system at a design point, hourly throughout a design day, and also throughout a year.

Such solutions will be useful in design of optimal ESS and ED2S's, selecting and sizing components, and in setting up optimal operating and control measures for the BAPP and for buildings in general.

Supplementary requirements for the building systems model are provided in Appendix B.

Suggested Test Exercise for Overall Systems Model Selection, Evaluation, and Application

The scope of this exercise is indicated in Figure 1. The IWs is the building for this exercise. Information on this structure (a floor plan, a section drawing, and a DOE-2 model for the power, cooling, heating, and ventilation loads based on an occupancy schedule) will be posted on the Testbed website. The IWs might be considered either as a single structure or as a set of 10 bays; for the purposes of the exercise it will be considered as a single structure.

The exercise will focus solely on the cooling and heating loads of the IWs. (The power supply and the ventilation system, supplying adequate fresh air to the IWs at comfort levels of temperature and humidity, are considered in this exercise to be independent systems.) The cooling and heating loads will be met by an ESS and an ED2S comprising

- a high temperature solar thermal heat supply with a natural gas fired auxiliary heater. A flow diagram for this system is shown in Figure 2.
- a BCT 16 steam driven absorption chiller. A flow diagram for this system is shown in Figure 3.
- a hydronic chilled/heated water distribution system. A flow diagram for this system is shown in Figure 4.
- fan coils, radiant mullions, and operable windows in the IWs. A description of the fan coils is shown in Figure 5.

The MMCH chilled and heated water grids, as indicated in Figures 1 and 5, are available to accept or to supply hydronic water as may be involved in cooling and heating the IWs in the planned operation of the ESS.

An integrated model of the IWs, ESS, and ED2S as described above will be constructed and exercised to address the following questions.

How will the overall system operate for occupant thermal comfort (74 F in summer, 72 F in winter) at peak cooling and heating loads on the design days, 20 July and 20 January? How will it function at a peak cooling or heating load on characteristic days in the intermediate fall and spring seasons? How will the overall system operate hourly throughout these characteristic days? How will the overall system operate throughout a typical year? The question of operation includes determination of

- operating conditions within the various IWs, ESS, and ED2S models.
- the number of times throughout a day or a year comfort temperature levels are not achieved due to limitations of the ESS and ED2S.
- the energy consumption of the overall system.
- the economic and environmental aspects of the system, including capital and operating costs and the overall effects on occupant health and productivity, air quality, water consumption, etc.

These questions will be addressed based on

- IWs, ESS, and ED2S design data for component models to be supplied on the Testbed web site
- weather and insolation data from the modeling platform.
- occupancy schedules for the IWs , yet to be specified.
- operating and control algorithms yet to be considered, but including continued operation of the ESS at design levels, variable operation of the ESS at IWs load level.

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Appendix A: ESS and ED2S Components Proposed for Overall Systems Modeling

ESS components include those for

- power generation with heat recovery by an engine generator, fuel cell, or gas turbine; cooling by an absorption or vapor compression chiller;
- heating by hot water from heat recovery or solar thermal supply.
- solar energy supply, high temperature thermal or photovoltaic;
- ventilation based on desiccant, liquid or solid, dehumidification;

ED2S components include those for

- delivery of hot and cold water and ventilation air, piping and ducts to the space;
- distribution of space cooling and heating, convective elements such as fan coils, pem's; and/or radiative elements such as mullions, radiant panels.
- distribution of ventilation air such as diffusers, pem's.
- operable windows, automatic or manual, in the structure that introduce outside air for temperature adjustment and/or ventilation.

Appendix B: A Supplementary Statement of Requirements for a Simulation Platform

The requirements for the simulation platform:

- The platform should be well validated, for example, using BESTEST and HVAC BESTEST
- The platform should be able to deal with both building and mechanical system simulation
- The platform should be able to carry out annual energy simulation for 8760 hours
- User-definable simulation time step
- The non-conventional geometry and building envelop of IWs can be handled
- The non-conventional mechanical system of IWs can be implemented, either by using available modules integrated in the platform or by developing external modules
- External modules can be plugged in without too much extra work
- System control functions, such as on/off scheduling and economizer cycle, are available
- Weather data for Pittsburgh is provided, readable and editable
- Commercially available
- Technical support available from the software developer

Appendix C: The features of Energy Plus See PDF

Appendix D: The features of TRNSYS See PDF