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21 April 2004

California Energy Commission
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1516 Ninth Street, MS-26
Sacramento, CA 95814-5512

California Energy Commission
Attn.: Executive Director
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Sacramento, CA 95814-5512

Sirs:

This letter is to acknowledge the shipment of the updated application package for eQUEST and D2comply hereby submitted for full approval and certification as an Alternative Calculation Methods (ACM) to be used to demonstrate compliance with the Energy Efficiency Standards for nonresidential buildings as specified in Title 24, Part 1, Chapter 10, Sections 101-110 of the California Code of Regulations. This application package is updated, as requested by CEC staff, to reflect all comments that we have received relating to the requirements for approval.

James J. Hirsch & Associates (JJH), a sole proprietorship (DBA for James J. Hirsch), has assembled this package for your review and approval in accordance with the requirements set out in the publication "AB 970 NONRESIDENTIAL ALTERNATIVE CALCULATION METHOD APPROVAL MANUAL" with its various updates and references. The submitted package includes:

- ACM Vendor Certification Statement (in hardcopy and on CD in PDF format)
- Computer Runs (on CD for both reference program and ACM)
- Compliance Supplement and User's Manuals (on CD in PDF format with standard eQUEST User's Manual included as an on-line help document and D2comply DOE-2.2 six volume manual set)
- Copy of the ACM and Weather Data (on CD and as freeware downloadable from our website)
- CEC supplied Weather Data (included in ACM on CD and from website)

The eQUEST and D2comply programs, as submitted, are available to the public as freeware. They can be downloaded from our website (http://DOE2.com) at no charge. User training and support is also available. If, after eQUEST/D2comply is certified, the Commission desires to obtain the right to distribute the packages to the public at no charge we would be pleased to make that possible.

The JJH team looks forward to the completion of the certification process by the CEC. If any questions arise please contact us.

Cordially

James J. Hirsch

eQUEST® 3.55 AND D2COMPLY 3.55
(DOE-2.2 BASED PROGRAMS)
ACM Certification Application

Sections Contained in this Application

- ACM Vendor Certification Statement
- 1 - Summary of Application
- 2 - Modification Of Reference Program Input Files
- 3 - CEC DOE 2.1E Reference File Concerns
- 4 - CEC Defined Optional Capabilities
- 5 - ACM Certification Test Results

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CALIFORNIA ENERGY RESOURCES
CONSERVATION AND DEVELOPMENT COMMISSION

APPLICATION FOR APPROVAL OF A VENDOR-CERTIFIED ALTERNATIVE CALCULATION METHOD FOR USE IN DEMONSTRATING COMPLIANCE WITH THE NONRESIDENTIAL BUILDING ENERGY EFFICIENCY STANDARDS PER SECTION 141, TITLE 24 OF THE CALIFORNIA CODE OF REGULATIONS

Part I: General Information

1. Organization filing application:

   Name: James J. Hirsch & Associates Phone: (805) 553-9000
   Address: 12185 Presilla Road
   Camarillo, CA 93012-9243

2. Name of person responsible for completion of this application:

   Name: Kevin Madison Phone: (206) 834-0002
   Address: 543 NE 83rd Street
   Seattle, WA 98115

3. Name, Date, and Version of the Alternative Calculation Method (ACM):

   Name: eQuest and D2comply Date: April 19/20, 2005
   Version: 3.55 (eQUEST) and 3.55 (D2comply)

4. Has a previous version of this ACM ever been certified?

   [ ] YES [X] NO

5. Has this ACM been previously submitted for approval or certification?

   [ ] YES [X] NO

6. Has this ACM ever been used to analyze the energy use of a building in California?

   [X] YES [ ] NO

7. Has this ACM ever been used to determine compliance with the energy efficiency standards of California?

   [ ] YES [X] NO

VENDOR CERTIFICATION OF ALTERNATIVE CALCULATION METHOD

I/We, James J. Hirsch , certify that the alternative calculation method (ACM), herein designated
name

eQUEST ,version 3.55 , dated 4/19/2005 , occupying 2,678,838
name of alternative calculation method version last saved update exact memory size in bytes

and

D2comply ,version 3.55 , dated 4/20/2005 , occupying 36,864
name of alternative calculation method version last saved update exact memory size in bytes

conform to all of the requirements specified for an ACM for Commission approval listed in the Nonresidential ACM Approval Manual. I/We specifically certify that this ACM successfully conforms to the test criteria for each and every ACM capability test in Chapter 4 of the Alternative Calculation Method (ACM) Approval Manual for the Nonresidential building energy efficiency standards. Moreover, I/we certify that, to the best of my/our knowledge and belief, we have found no instances where this ACM would indicate compliance for a proposed building that the reference computer program using the reference method would indicate fails to comply with the building energy efficiency standards.

I/We also understand that all required inputs must be available in any approvable ACM but the ACM is not required to model the features described by a given set of inputs. I/We stipulate that this ACM gives the user access to the required inputs and that this ACM automatically warns the user when building inputs use features that the ACM cannot model with sufficient accuracy and automatically fails the proposed building by a margin sufficient to meet the test criteria for any test of that capability.

Signed: Date: 21 April 2005

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Section 1

Summary of Application

PRODUCTS SUBMITTED FOR CERTIFICATION

The team would like to have the following software packages certified for compliance:

1. **eQUEST:** This is a full Title 24 compliance analysis package including both Building Creation Wizard and Detailed User Interface, DOE-2 simulation and property defaulting, compliance analysis capabilities and compliance form production.

2. **D2Comply:** This includes a version of DOE-2 in the form of an executable (.DLL) files and a compliance ruleset in the form of an encrypted binary (.BIN) file that are supportable using an interface written Visual Basic® or other interface capable of interacting with a Component Object Model (COM). All simulation and compliance analysis components included in this package are compiled from the same source code files as similar components included with eQUEST. Within reasonable testing time constraints, this package yields identical results to eQUEST. The package includes all components necessary for simulation, defaulting , compliance analysis and compliance form production.

   The D2Comply package allows third parties to develop unique interfaces for creating DOE 2 input files and performing compliance analysis. Once these software combinations are certified by the Commission, any third party who uses one of the combinations in their ACM, would not need to perform the ACM tests to achieve certification of their ACM. (There are other requirements for certification such as user documentation, software support and compliance supplement that would have to be addressed by any third party ACM developer.)

PERIODIC UPDATES

The team makes periodic revisions to DOE-2 and the compliance analysis ruleset. Rarely do these revisions affect simulation results. Most are "bug-fixes" that improve the functionality and reliability of the program and do not impact results. Revisions of this type are usually denoted with a letter at the end of the version number (e.g.: DOE 2.2 Version 44c). The team proposes that these periodic revisions be made available to users, third party developers and the Commission as certified revisions without having to be completely re-certified. We will provide the Commission with advanced notice and copies of software revisions prior to any general releases.

The software version number (DOE-2 or compliance analysis ruleset) will be incremented if any software revisions cause significant changes in simulation or compliance analysis results. In these cases, the team will submit a new ACM Application for the streamlined approval as allowed in Section 1.2.2 of the ACM Manual.

OVERVIEW OF EQUEST COMPLIANCE ANALYSIS

The underlying concept of the eQuest/DOE 2.2 Title 24 compliance analysis feature is to enable users to generate performance compliance documentation for any building file created and analyzed using DOE 2.2. At this time, the team has submitted for approval only a portion of the DOE 2.2 simulation capabilities. The capabilities to be covered in the application include:

1) minimum capabilities of any ACM,

2) some pre-defined optional capabilities covered by the ACM Manual, and

3) a small number of "vendor-defined" optional capabilities that are submitted along with vendor-developed certification tests.

A critical issue to this ACM is how the ruleset handles features not explicitly addressed as part of our application, are not explicitly addressed in the ACM Manual, and are not being submitted as minimum or optional capabilities under this application. Equally critical to the team is being able to facilitate compliance analysis for nearly any user created DOE 2 input file. In many cases, the ruleset will automatically remove, replace or modify user-defined components and features that are not explicitly addressed in the application or the ACM Manual. In most cases, warning messages are posted so users are aware of building features that will not be considered in the compliance analysis. These "unavailable" features are documented in the eQUEST Compliance Supplement and the DOE 2.2 California Compliance Addenda, included with this application. Consistent with ACM Manual requirements, all DOE 2.2 inputs that are not necessary or inappropriate for simulation of capabilities included with this application are automatically set to DOE 2 defaults by the compliance analysis ruleset.

CEC DEFINED OPTIONAL CAPABILITIES

This application covers all optional capabilities defined in the ACM Manual **EXCEPT THOSE LISTED IN THE TABLE BELOW:**

ACM Section	Capabilities Excluded from this Application
3.1.1 Additions and Alterations	Alterations
3.1.2 Alteration or Addition Plus Altered Existing	All
3.5.2.1 Types of HVAC Systems and Central Plants	Renewable Energy Sources

ACM Section	Capabilities Excluded from this Application
3.5.2.6 Proposed System Types	• Convective/radiant • Constant volume perimeter systems
3.5.2.9 Equipment Efficiency	Performance curve inputs for heating and cooling equipment. The compliance analysis ruleset will reset any user inputs to DOE-2 default performance curves.
3.5.2.15 Water Economizer	• Strainer cycle • Evaporator pre-cooler
3.5.2.17 Renewables	No renewables included in this application. Components are removed by compliance analysis ruleset.

In some cases, the CEC's reference program is not capable of properly simulating certain optional capabilities defined in the ACM Manual. These capabilities are discussed in more detail in Section 3 and are listed below:

- Variable speed, centrifugal chillers
- Evaporative cooling

VENDOR DEFINED OPTIONAL CAPABILITES

In addition to the optional capabilities defined in the ACM Manual, this application includes a request for approval of the capability to simulate the benefits of daylighting controls in place of using prescriptive lighting control credits.

Section 2

DOE 2.1E Reference Input File Revisions

SUMMARY OF REFERENCE FILE REVISIONS

As part of any application to the California Energy Commission for approval of an Alternative Calculation Method (ACM), the applicant must submit a series of tests performed using the ACM that demonstrate the program yields nearly identical results, in terms of compliance with California's Efficiency Standards for New Buildings, as the Commission's reference program, DOE 2.1E.

The Commission provides DOE 2.1E input and output files for the reference tests. The eQuest development team has used the test descriptions in the ACM Approval Manual and the supplied DOE 2.1E input files to develop the comparable eQuest test files. While the team has tried to replicate the supplied DOE 2.1E files in eQuest format, there are many instances where the team believes that the supplied files are either incorrect or in need of revision due to differences in modeling approaches. The Commission allows for revisions to the supplied DOE 2.1E files in Section 5.1 of the ACM Approval Manual:

> "If the vendor believes that the reference program results presented in this manual and its supplement do not reflect the proper procedures described in Chapters 2 and 3 of this manual and (where not otherwise specified herein) the nonresidential energy efficiency standards, the vendor may also submit runs and results for the reference program, DOE 2.1E as an alternative to the results published in this manual. The vendor must thoroughly justify and document the reasons for the differences in the reference program inputs and results from the inputs and results presented in this Manual and the Supplement."

This document describes the modifications the eQuest team has made to the supplied DOE 2.1E reference program input files. Along with the description of each modification is a thorough justification for the modification. The table below summarizes the types of modifications and the justifications for each.

Command	Description of Modification	Justification for Modification
GLASS-TYPE	Update standard GLASS-TYPE properties to match 2001 prescriptive requirements	Supplied files had 1998 Standards values; 2001 Standards have different glazing performance requirements

Command	Description of Modification	Justification for Modification
EXTERIOR-WALL	Revise budget assemblies for buildings in Climate Zone 10	2001 envelope performance criteria for Climate Zone 10 are now the same as Climate Zones 11-13, which are more stringent than 1998 requirements
SPACE	Revise lighting, equipment and occupancy properties to match Table 2-2	Table 2-2 is allowed for "Area occupancy assumptions when lighting plans are submitted for portions or for the entire building or when lighting compliance is not performed."
SPACE	Revise internal mass keywords to utilize Custom Weighting Factors	Revised per Section 2.2.2.13, which REQUIRES the use of Custom Weighting Factor properties.
ZONE	Outside air ventilation rate revised per Table 2-2	Table 2-2 is allowed for "Area occupancy assumptions when lighting plans are submitted for portions or for the entire building or when lighting compliance is not performed."
ZONE	Minimum VAV box position revised to match standards by setting the following: • MIN-FLOW-RATIO = 0.30 • MIN-FLOW/AREA = 0.40	Section 2.4.2.29 requires that, even in the proposed building, the VAV minimum position be set no lower than the larger of: • 0.4 cfm/sf • 0.30 minimum flow ratio • minimum ventilation requirements
SYSTEM	Fan power inputs revised	Most fan power inputs were not consistent with the HVAC equipment database in the ACM Approval Manual Appendix.
SYSTEM	VAV fan types revised to minimum standards	Whenever total BHP was less than 25, the fan was revised to be a forward curved fan with discharge dampers.
SYSTEM	Heating, cooling and airflow capacities in the proposed design	Most capacities in the supplied files were not consistent with the HVAC equipment database in the ACM Approval Manual
SYSTEM	Heating, cooling and airflow capacities in the standard design	Capacities were revised to reflect the use of DOE 2.2 design day routines to perform sizing runs and determine maximum system capacities according to the Standards
SYSTEM	Curve-fits for packaged cooling equipment were revised to assume a Cd of 0.03.	Section 2.4.2.7 of the ACM Approval Manual requires that the degradation coefficient for DOE covered air conditioners be 0.03 for the proposed and standard designs.
SYSTEM	Supply temperatures revised to match default system assumptions.	Supply temperatures for heating and cooling varied between the proposed and standard designs. Values were revised to match defaults provided in Figures 2-2a-d

Command	Description of Modification	Justification for Modification
SYSTEM	Economizer set points revised to 70F in some climate zones	2001 Title 24 sets the minimum economizer lockout temperature to 70F for some climate zones. 1998 input files use 75F in all cases.
SYSTEM	Fan location revised to "DRAW-THROUGH"	Section 2.4.2.19 of the ACM Approval Manual requires all systems (except for fan coils) to have DRAW-THROUGH fans.
PLANT	Boiler and chiller capacities revised in proposed design files	Capacities revised to match equipment database in the ACM Approval Manual Appendix
PLANT	Boiler and chiller capacities revised in standard design files	Capacities were revised to reflect the use of DOE 2.2 design day routines to perform sizing runs and determine maximum system capacities according to the Standards

All changes are documented with comments within the DOE 2.1E input files. Section 2 provides detailed justification for each type of revision including examples where appropriate.

LOADS PORTION MODIFICATIONS

GLASS-TYPE Properties for the Proposed Design

For many tests, the ACM Approval Manual specifies that glazing in the proposed design building meets prescriptive requirements for a particular climate zone. The input files provided were created for certification with the 1998 Standards and therefore would have incorrect glazing performance characteristics. These properties, namely GLASS-CONDUCTANCE and SHADING-COEF have been updated to match 2001 Standards requirements.

GLASS-TYPE Properties for the Standard Design

Values for GLASS-CONDUCTANCE and SHADING-COEF for all standard design runs were revised (and noted in the DOE 2.1E input files) to reflect revised 2001 requirements.

EXTERIOR-WALL Properties for Tests in Climate Zone 10

In the 1998 Standards, Climate Zone 10 opaque envelope requirements were the same as Climate Zone 9. The 2001 requirements for Climate Zone 10 are the same as the more stringent requirements for Climate Zones 11-13. Standard design input files for all Climate Zone 10 certification files were revised by copying assemblies for tests in Climate Zones 11-13. These substitutions are noted with comments in the input files.

SPACE Properties for Lighting, Occupant Density and Miscellaneous Equipment

According to the caption accompanying Table 2-2 in the ACM Approval Manual, Table 2-2 may be used to determine default and budget light levels, occupant densities and cooling loads, miscellaneous equipment loads, water heating loads and ventilation rates "when lighting plans are submitted for portions or for the entire building or when lighting compliance is not performed." In other words, this table may be used for any building. Most of the supplied 2.1E reference files appear to utilize table 2-1 for determining values for the occupancy characteristics.

For example, below is a SPACE command from test B32D12 for a retail space. The values from Table 2-2 are the actual values, while the values from the supplied DOE 2.1E files (apparently taken from Table 2-1) are listed in the comments.

```
$ Retail 85% $
ZONE-1 = SPACE
   ZONE-TYPE        = CONDITIONED
   TEMPERATURE      = (72)
   FLOOR-MULTIPLIER =  1
   PEOPLE-SCHEDULE  = SCHED-71
   LIGHTING-SCHEDULE= SCHED-72
   EQUIP-SCHEDULE   = SCHED-73
   INF-SCHEDULE     = SCHED-75
   AREA/PERSON      = 30.3 $Old 100 rev per table 2-2
   PEOPLE-HG-SENS   = 250
   PEOPLE-HG-LAT    = 200  $Old 250 rev per table 2-2
   LIGHTING-TYPE    = REC-FLUOR-NV
   LIGHT-TO-SPACE   = 1.000
   LIGHTING-W/SQFT  = 2.0  $Old 2.200 rev per ACM test desc
   EQUIPMENT-W/SQFT = 1.0  $Old 0.50 rev per table 2-2
   EQUIP-SENSIBLE   = 1.0
   EQUIP-LATENT     = 0.0
   INF-METHOD       = AIR-CHANGE
   AIR-CHANGES/HR   = 0.0894
   SOURCE-TYPE      = ELECTRIC
   SOURCE-BTU/HR    = 0
   SOURCE-SENSIBLE  = 0.000
   SOURCE-LATENT    = 1.000
    FLOOR-WEIGHT     = 0   $Old 90 rev per ACM rqmts
    FURNITURE-TYPE   = HEAVY  $Added per ACM rqmts
    FURN-FRACTION    = 0.85   $Added per ACM rqmts
    FURN-WEIGHT      = 80     $Added per ACM rqmts
   AREA             = 1020
   VOLUME           = 12240 ..
```

All revisions of this type have been documented similarly throughout all supplied DOE 2.1E input files.

SPACE Properties for Mass Characteristics

Section 2.2.2.13 of the ACM Approval Manual specifies that lightweight mass shall be simulated using the furniture keywords of the SPACE command. In order for these inputs to be valid, FLOOR-WEIGHT must be set to zero so that Custom Weighting Factors may be generated by DOE 2. All of the supplied

DOE 2.1E input files had non-zero values for FLOOR-WEIGHT, meaning that ASHRAE standard weighting factors are used and any inputs to furniture keywords would be ignored. Every file has been modified to include the following keyword assignments:

```
FLOOR-WEIGHT     = 0
FURNITURE-TYPE   = HEAVY
FURN-FRACTION    = 0.85
FURN-WEIGHT      = 80
```

SYSTEMS PORTION MODIFICATIONS

ZONE Outside Air Flow Properties

Similar to the space keywords for lighting, occupant density and miscellaneous equipment, zone keywords specifying the amount of outside air have been revised to be consistent with Table 2-2.

ZONE Minimum VAV Box Position

Section 2.4.2.29 requires that ACMs:

> "… must not allow any minimum box position to be smaller than the air flow per square foot needed to meet the minimum occupancy ventilation rate."

The equipment database specifies minimum VAV box positions of 0.30, 0.35 or 0.40 for all zones in input files with VAV systems specified. In many cases, particularly north and core zones, these minimum positions allow the air flow rate to drop below the minimum needed to meet the minimum occupancy ventilation rate. This values have been revised based on inputs automatically generated by the eQuest rules processor (Values from eQuest generated DOE 2.2 input files have been copied to the DOE 2.1E reference input files.)

For the standard design, section 2.4.2.29 requires that the minimum VAV box position be set to the larger of:

(a) 30% of the peak supply volume for the zone; or

(b) The air flow needed to meet the minimum zone ventilation rate; or

(c) 0.4 cfm per square foot of conditioned floor area of the zone.

As with the proposed design, values for VAV minimum position have been input directly from the equipment database without ensuring that the proper budget value has been set. The eQuest rules processor automatically determines the correct budget VAV minimum position. Similar to the proposed buildings, values for VAV minimum position from the eQuest generated DOE 2.2 input files have been copied to the DOE 2.1E reference input files.

SYSTEM Properties for Fan Power

Section 2.4.2.17 of the ACM Approval Manual requires ACMs to require users to:

> "… input the full-load efficiency for all electric motors documented in the plans and specifications for the building as established in accordance with NEMA Standard MG1."

Additionally, section 2.4.2.24 of the ACM Approval Manual requires that total brake horsepower for a fan system be input by the user. If it is not input, this section requires that:

> "… the ACM shall assume that no mechanical compliance will be performed and shall model the default mechanical system according to the rules in Section 2.4.2.26 (modeling default heating and cooling systems)".

Unfortunately, the equipment database contained in the ACM Approval Manual Appendix does not include motor efficiency for smaller systems, nor does it include brake horsepower for any systems. Fan power for small and large systems are handled differently, in terms of modifying the DOE 2.1E input files, as described below.

Fan Power for Small Fan Systems

For smaller systems (those with names that begin with "ACS" and "HPS" in the equipment database) only watts per cfm is provided in the equipment database. In these cases, motor efficiency is only needed for reporting on the compliance forms. The eQuest rules processor will automatically calculate a brake horsepower based on the provided fan power index according to the following equation:

$$BHP = 746 \times fpi \times cfm$$

The result of the above equation is then used to determine the motor efficiency. The rules processor performs two additional iterations to refine the correct minimum motor efficiency using the following equation:

$$BHPnew = 746 \times fpi \times cfm \times motoreff$$

The rules processor will perform this series of calculations anytime the user has not input a value for brake horsepower, but has described the fan power using other keywords. These calculations are based on the following assumptions:

- drive efficiency = 1 (direct drive)
- CEC minimum motor efficiency

All ruleset determined motor efficiencies are output to the compliance forms as if they were input by the user.

Fan Power for Large Systems

For larger systems (those with names that begin with "ACL" in the equipment database) watts per cfm and motor efficiency have been provided. Brake horsepower can be easily calculated from the following equation:

$$BHPnew = 746 \times fpi \times cfm \times motoreff$$

If the motor efficiency provided exceeds the minimum requirements of the 2001 Standards, and the fan power index does not exceed allowable prescriptive levels, then the standard design fan power has been modified according to the following equation:

$$FPIstd = FPIppd \times \frac{Motor\,Effstd}{Motor\,Effppd}$$

System VAV Fan Type Properties

Figures 2-2b and 2-2c specify the default VAV fan types as:

- Forward curved fan with discharge dampers for fan systems not greater than 25hp
- Variable speed drive fan for fan systems greater than 25hp

Where the total fan system brake horsepower did not exceed 25hp, there were many inconsistencies between the standard and proposed DOE 2.1E files. To be consistent, all of these fan types were revised to be forward curved fans with discharge dampers.

System Heating, Cooling and Air Flow Capacities

Proposed design system capacities have been revised whenever the DOE 2.1E files contained values that were not consistent with the equipment database. All standard design files were revised to reflect different sizing run results due to the following:

- proposed and standard glazing performance properties have been revised to match prescriptive values from 2001 Standards
- internal gain values for lighting, occupant density and heat output and miscellaneous equipment have been revised to match Table 2-2
- standard design lighting levels have been revised to match prescriptive requirements of the 2001 Standards
- eQuest uses DOE 2.2 design day routines to perform sizing calculations instead of the proprietary method used for sizing calculations for the supplied DOE 2.1E files

System Curve-Fits for DOE-Covered Air Conditioners and Heat Pumps

Section 2.4.2.7 describes the required procedures for establishing part-load performance of DOE-covered air conditioners and heat pumps that are rated with SEER for cooling efficiency. The procedures establish custom part-load curves based on SEER, EER (if input by the user) and degradation coefficient (0.03 as fixed by this Section). It appears that the DOE 2.1E reference files have curves based on degradation coefficients other than 0.03. For the proposed design, curves from the eQuest generated DOE 2.2 input files have been copied to the DOE 2.1E reference program files.

For the standard design, the eQuest generated curves are based on the following assumptions:

- SEER of 9.9 for rooftop units and 10.0 for split systems
- EER of 8.6 for rooftop units and 8.7 for split systems
- degradation coefficient of 0.03

These curves have been copied from the eQuest generated DOE 2.2 input files to the DOE 2.1E reference input files.

SYSTEM Supply Air Temperatures

All supply air temperatures have been revised to match the defaults from figures 2-2a through 2-2d, and listed below:

- For VAV Systems: 105F heating supply, 55F cooling supply
- For all other systems: 100F heating supply, 55 cooling supply

SYSTEM Economizer Temperature Set Points

Section 2.4.2.24 requires the standard design economizer lock-out temperature to be set to 70F in Climate Zones 4, 6, 7, 8 , 9, 10 and 12. The economizer lock-out temperature (ECONO-LIMIT-T) is set to 75F in all of the DOE 2.1E reference files. This value has been revised to 70F for the files in the listed Climate Zones.

SYSTEM Fan Location

Section 2.4.2.19 requires the fan placement (FAN-PLACEMENT) to be "DRAW-THROUGH" for all systems except four-pipe fan coils. "DRAW-THROUGH" has been substituted for all instances of "BLOW-THROUGH" for all systems, other than four-pipe fan coils, found in the DOE 2.1E reference files. "BLOW-THROUGH" has been substituted for all instances of "DRAW-THROUGH" occurring in any four-pipe fan coils in the DOE 2.1E reference files.

PLANT PORTION MODIFICATIONS

CHILLER and BOILER Capacities

Proposed design chiller and boiler capacities have been revised whenever the DOE 2.1E files contained values that were not consistent with the equipment database. All standard design files were revised to reflect different sizing run results due to the following:

- proposed and standard glazing performance properties have been revised to match prescriptive values from 2001 Standards
- internal gain values for lighting, occupant density and heat output and miscellaneous equipment have been revised to match Table 2-2

- standard design lighting levels have been revised to match prescriptive requirements of the 2001 Standards

- eQuest uses DOE 2.2 design day routines to perform sizing calculations instead of the proprietary method used for sizing calculations for the supplied DOE 2.1E files

Section 3

CEC DOE 2.1E Reference File Concerns

Review of the DOE 2.1E reference files provided by the Commission has revealed many concerns about the inputs files in terms of their representation of ACM Manual requirements as well as good modeling techniques. These concerns are described in the following tables along with any proposed resolution.

STEEL STUD WALLS

In all buildings budget U-Factors are set as if steel stud walls (construction W1A and W1B) are wood stud assemblies. The modeling rules for the reference design in ACM Section 2.2.1.7 Steel Frame states:

> "ACMs must model standard design wall assemblies using the same **steel frame construction**, layers, and modeling technique as the proposed wall assembly. An ACM shall adjust the cavity insulation in order for the overall U-factor of the standard assembly to match the U-factor requirement listed in Table 1-H or 1-I of the Standards for steel-framed walls and the applicable climate zone."

This discrepancy has been resolved by setting CONSTRUCTION:C-WALL-TYPE to "non-metal framing" for all assemblies in eQUEST input files, even though some constructions represent steel framed assemblies. While inconsistent with the actual inputs, it was the quickest way, without adding steel framed assemblies to all DOE 2.1E reference budget building files, to create consistent results between eQUEST and the CEC's DOE 2.1E reference files.

VAV FAN AND ZONE AIR FLOW CAPACITIES

In many tests using the "B" prototype with a VAVS or PVAVS systems, the total of the zone air flows specified in the ACM Appendix table titled "ACM VAV BOX SELECTED" is less than the total supply flow for the unit specified in the equipment libraries. The main problem with this is that it causes the supply fan to operate at a lower point on its part load curve.

The larger problem, however, is that the CEC's DOE 2.1E reference input files have no flow rates input for zones on VAV systems. DOE 2 will therefore apportion zone airflow rates, according to load, so that the total of all zone airflow rates add up to the value input for SYSTEM:SUPPLY-FLOW. This is

consistent with ACM requirements for the standard design (Section 2.4.2.25.3 Sizing Procedures for Systems 1, 3, 4 and 5, Modeling Rules For Reference Design, Step 2) but not for the proposed design. Proposed air flows for zones and systems are as input by the user or increased as needed to avoid hours outside of the throttling range. The result is that CEC DOE 2.1E reference results yield much higher fan energy for the proposed design than eQUEST where zone air flow rates are input.

Test case O65B12 is provided as an example. The total of the zone air flow rates specified in the ACM Appendix is 17,300 cfm. The air flow specified for the central air handling system is 22,321. The DOE 2.1E input file will be simulated with 5,000 cfm more peak air flow than the eQUEST file, while the budget buildings will be roughly the same. In the case of O65B12 the difference in proposed building energy use between the reference and eQUEST file is so great that the eQUEST results fail the CEC's criteria for this certification test. Both buildings fail compliance, but the eQUEST file does not fail by a large enough margin.

To create reasonable consistency between eQUEST and DOE 2.1E proposed design results, design VAV box flow rates specified in the ACM Manual have been omitted from some eQUEST input files. As a result, eQUEST sizing methods perform in a similar fashion to the DOE 2.1E files, assigning flow rates to each zone, prorated by design load, so that the total of all zone flow rates equals the design flow rate for the system. This change has been implemented for the following test cases:

- C22C16
- O11B13
- O12B13
- O23B13
- O65B12

POWERED INDUCTION UNIT SYSTEMS (PIU)

The version of DOE 2.1E used to process the DOE 2.1E files provided by the CEC (JJH Version 136) has a programming bug that prohibits proper simulation of PIU systems. The DOE 2 simulation engine included with eQUEST properly simulates PIU systems and allows the selection of the same zone as the INDUCED-AIR-ZONE among other improvements. It is recommended that the CEC consider adopting the submitted eQUEST files for O11BO2 and O12BO2 as the reference cases for these tests.

INTERMITTENT FAN OPERATION

Section 2.4.2.20 of the ACM Manual requires that fan operation for systems serving residential and hotel guest room occupancies be simulated using INDOOR-FAN-MODE = INTERMITTENT. Unfortunately, the INDOOR-FAN-MODE keyword is not available for many systems in DOE 2.1E, four-pipe fan coil (FPFC) in particular. The ACM certification test that includes residential occupancies (C22C16) utilizes FPFC systems, therefore it is impossible for the CEC's reference program to simulate this test according to ACM Manual requirements.

EQUEST and DOE 2.2 have the capability to simulate intermittent fan operation in many systems including fan coils and other constant volume single zone systems. The eQUEST versions of test C22C16 uses intermittent fan operation in both the proposed and standard design simulations as required by the ACM Manual. While the eQUEST version of this test meets the ACM Manual criteria – it fails by an appropriate compliance margin – it is not reasonable to compare the results of the eQUEST and DOE 2.1E simulations as the annual fan energy consumption will be very different.

Section 4

CEC Defined Optional Capabilities

VARIABLE SPEED CHILLERS

Test O64B12 specifies an optional capability test for "Variable Speed Drive (VSD) Chiller modeled with an EIR of 0.2275. Review of the DOE 2.1 reference file provided by CEC staff, O64B12.DOE, showed that no input keywords were included in the file for the chillers, making simulation and comparison of the eQUEST/DOE 2.2 capabilities to the reference program impossible.

Variable Speed Drive chillers can be simulated in DOE 2.2 through the assignment of appropriate performance curves that account for the temperature difference between entering condenser temperature, ECWT, and leaving evaporator temperature, LChWT (also referred to as "lift"). This capability is only available for centrifugal chillers.

From the DOE 2.2 Dictionary:

> "Part-load capacity reduction in a variable-speed centrifugal chiller utilizes a combination of impeller speed and inlet vanes. To maximize the part-load efficiency of a variable-speed centrifugal chiller, some form of condenser temperature relief must be employed at part-load to reduce the temperature (and pressure) differential across the chiller. Otherwise, the performance of a variable-speed chiller may not be significantly different from that of a constant-speed chiller. This is because the pressure rise across the impeller is proportional to the square of the impeller's speed. If the condenser temperature never drops below the design value, then the pressure differential between the evaporator and condenser will remain almost constant, no significant impeller speed reduction will be possible, and most of the capacity reduction will be accomplished via the inlet vanes."

Given these considerations, below is a description of test provided for a variable-speed chiller:

- 10 zone B building prototype with the same features (except as noted) in test F14B13
- HVAC system features as described in the ACM Manual Appendix test O64B12
- Centrifugal chiller with capacity and efficiency as specified in the ACM Manual Appendix for test O64B12
- Chiller type in the Compliance subtab of the Chiller tabbed dialog set to "Centrifugal"

- DOE 2.2 chiller property, VARIABLE-SPEED, set to "YES"
- Temperature reset controls simulated on condenser water loop to enable chiller condenser temperature and pressure relief as discussed above
- Cooling tower setpoint of 65F to allow for condenser water temperature drop as wetbulb temperature decreases

The results from the test described above were compared against results from a test, O64B12S, using the same input file, except that the chiller is not variable-speed and the condenser water loop is controlled to maintain a fixed temperature. Summary of results from the BEPS reports for the proposed and standard simulations are provided below.

	Test:O64B12 - VSD Centrifugal Chiller w/ Load Reset Tower and CW Loop				Test:O64B12S - Fixed Speed Centrifugal Chiller w/ Fixed Temperature Tower and CW Loop			
	Proposed		Standard		Proposed		Standard	
Enduse	Elec	Gas	Elec	Gas	Elec	Gas	Elec	Gas
Lights	360,700	-	360,700	-	360,700	-	360,700	-
MiscEq	114,355	-	114,355	-	114,355	-	114,355	-
SpcHeat	-	441,690	-	364,957	-	441,690	-	364,957
SpcCool	213,175	-	324,468	-	264,401	-	324,468	-
HtReject	19,668	-	-	-	20,480	-	-	-
PumpsAux	228,953	-	45,575	-	228,888	-	45,575	-
VentFans	105,215	-	84,058	-	105,215	-	84,058	-
DHW	-	68,349	-	68,349	-	68,349	-	68,349
TOTAL	1,042,066	510,039	929,155	433,307	1,094,038	510,039	929,155	433,307

EVAPORATIVE COOLING

The version of DOE 2.1E used to process the DOE 2.1E files provided by the CEC (JJH Version 136) has a programming bug that prohibits the operation of add-on evaporative cooling with economizer operation. It is not known if this bug exists in the version of DOE 2.1E used by the CEC as the CEC only provided input files, not output files.

The DOE 2 simulation engine included with eQUEST properly simulates proper add-on evaporative cooler operation during economizer and mechanical cooling modes. Consequently, eQUEST certification tests O92A11, O93A12 and O94A13 show significantly more cooling energy savings than the same simulations using DOE 2.1E.

It is recommended that the CEC consider adopting the submitted eQUEST files for O91A13, O92A11, O93A12 and O94A13 as the reference cases for these tests.

Section 5

ACM Certification Test Results

Test	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITEr	RECPr	CR3	CR4
A11A09 OUT	132.8	132.6	0.3	134.4	133.4	1.0	0.4	n/a	42.5	15.3	1.00	1.00
A12A09 OUT	131.2	132.3	-1.1	134.0	136.3	-2.2	n/a	2.5	42.5	15.3	1.00	1.00
A13A09 OUT	174.3	162.5	11.7	176.8	163.8	13.0	1.7	n/a	42.5	15.3	1.00	1.00
A21B13 OUT	180.9	170.2	10.7	182.3	175.9	6.4	6.3	n/a	35.3	22.2	1.00	1.00
A22B13 OUT	187.6	169.1	18.6	173.8	176.1	-2.3	21.5	n/a	35.3	22.2	1.00	1.00
A23B06 OUT	181.3	164.2	17.1	173.8	201.2	-27.4	41.4	n/a	35.3	22.2	1.00	1.00
A24B16 OUT	158.5	127.6	30.9	161.5	153.2	8.4	24.8	n/a	35.3	22.2	1.00	1.00
A25B03 OUT	140.6	133.2	7.4	141.5	134.8	6.7	2.7	n/a	35.3	22.2	1.00	1.00
A26B13 OUT	163.1	163.4	-0.3	153.9	160.1	-6.1	n/a	7.7	35.3	22.2	1.00	1.00
A27B16 OUT	166.1	142.7	23.4	134.5	160.4	-25.9	46.5	n/a	35.3	22.2	1.00	1.00
B11B13 OUT	245.1	195.5	49.6	233.0	191.9	41.1	15.7	n/a	50.1	15.9	1.00	1.00
B12B13 OUT	261.7	199.1	62.7	231.8	192.1	39.7	30.0	n/a	50.1	15.9	1.00	1.00
B13B13 OUT	270.9	190.9	80.1	229.9	182.5	47.4	40.8	n/a	50.1	15.9	1.00	1.00
B14B06 OUT	246.9	203.3	43.5	230.3	209.5	20.8	26.8	n/a	50.1	15.9	1.00	1.00
B15B16 OUT	226.6	189.8	36.8	207.7	184.6	23.2	18.2	n/a	50.1	15.9	1.00	1.00
B21B12 OUT	244.6	202.8	41.8	227.0	200.4	26.6	20.2	n/a	50.1	15.9	1.00	1.00
B22B12 OUT	232.1	204.4	27.7	199.3	202.2	-3.0	31.2	n/a	50.1	15.9	1.00	1.00
B23B12 OUT	221.3	214.4	6.8	218.0	214.8	3.2	5.1	n/a	50.1	15.9	1.00	1.00
B24B03 OUT	203.3	194.1	9.2	185.7	198.3	-12.5	20.9	n/a	50.1	15.9	1.00	1.00
B31D12 OUT	182.2	142.8	39.4	180.1	152.0	28.1	16.6	n/a	52.5	14.8	1.00	1.01
B32D12 OUT	189.2	149.1	40.1	193.3	153.1	40.2	7.0	n/a	52.5	14.8	1.00	1.01
C11A10 OUT	183.1	152.6	30.6	185.1	154.2	30.9	5.3	n/a	42.5	15.3	1.00	1.00
C12A10 OUT	181.8	159.5	22.3	185.1	161.3	23.8	3.1	n/a	36.8	13.2	1.00	1.00
C13A10 OUT	241.8	222.1	19.8	245.2	225.2	20.0	3.8	n/a	40.4	9.1	1.00	1.00
C14A10 OUT	146.9	129.4	17.5	149.5	131.2	18.2	3.0	n/a	34.5	19.9	1.00	1.00
C15A10 OUT	125.9	108.0	18.0	126.4	108.0	18.4	3.4	n/a	17.6	16.9	1.00	1.00
C21B10 OUT	205.5	147.2	58.3	217.2	161.8	55.5	12.2	n/a	38.2	19.6	1.00	1.00
C22C16 OUT	156.5	115.4	41.1	187.7	147.5	40.1	8.0	n/a	30.0	14.9	0.98	0.99
D11D12 OUT	134.9	159.7	-24.8	141.8	165.7	-23.9	n/a	3.7	58.8	17.0	1.00	0.99
D12D12 OUT	163.3	151.2	12.2	153.8	158.2	-4.4	16.9	n/a	58.8	17.0	1.00	0.99
D13D07 OUT	132.0	149.0	-17.0	124.6	146.5	-21.9	n/a	9.2	58.8	17.0	1.00	0.99
D14D07 OUT	139.1	149.0	-9.9	131.8	146.5	-14.7	n/a	8.0	58.8	17.0	1.00	0.99
E11D16 OUT	81.5	68.5	13.0	91.9	83.6	8.3	6.9	n/a	21.0	7.0	1.01	1.02
E12D16 OUT	87.1	75.0	12.1	97.9	90.2	7.8	6.5	n/a	21.0	7.0	1.01	1.02
E13D16 OUT	107.1	96.9	10.3	117.3	111.1	6.2	6.0	n/a	21.0	7.0	1.01	1.02
E14D14 OUT	87.4	74.5	12.9	95.7	86.6	9.1	6.2	n/a	21.0	7.0	1.01	1.02

Test	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITEr	RECPr	CR3	CR4
E15D14 OUT	91.5	79.1	12.3	99.8	91.3	8.6	6.0	n/a	21.0	7.0	1.01	1.02
E16D14 OUT	115.9	96.9	19.0	124.4	108.8	15.7	6.7	n/a	21.0	7.0	1.01	1.02
E21B16 OUT	190.9	163.4	27.5	167.8	173.1	-5.3	33.0	n/a	38.2	33.8	1.00	1.00
E22B16 OUT	204.8	175.0	29.8	191.1	185.7	5.3	26.3	n/a	38.2	42.3	1.00	1.00
E23B16 OUT	223.1	192.8	30.3	204.8	198.9	6.0	26.3	n/a	38.2	59.1	1.00	1.00
E24B12 OUT	190.6	173.3	17.4	161.3	183.7	-22.4	37.4	n/a	38.2	33.8	1.00	1.00
E25B12 OUT	210.8	189.8	21.0	203.2	201.3	1.9	20.4	n/a	38.2	42.3	1.00	1.00
E26B12 OUT	229.1	211.9	17.3	216.9	221.2	-4.3	21.9	n/a	38.2	59.1	1.00	1.00
F11A07 OUT	120.8	116.4	4.4	120.8	117.3	3.5	2.4	n/a	37.7	22.1	1.00	1.00
F12A13 OUT	178.9	165.7	13.2	182.4	167.9	14.5	1.9	n/a	37.7	22.1	1.00	1.00
F13B12EP OUT	266.8	174.7	92.1	272.0	189.7	82.2	23.2	n/a	58.9	16.9	1.00	1.00
F14B12EP OUT	267.3	175.6	91.6	272.0	191.1	80.8	23.9	n/a	58.9	16.9	1.00	1.00
F15A01 OUT	124.7	68.8	56.0	125.5	66.9	58.5	7.2	n/a	17.7	3.3	0.99	1.01
G11A11 OUT	222.0	164.8	57.3	224.1	164.1	60.0	7.2	n/a	37.7	22.1	1.00	1.00
G12A11 OUT	172.5	148.6	24.0	173.8	148.0	25.8	3.0	n/a	37.7	22.1	1.00	1.00
G13A11 OUT	189.9	165.4	24.4	200.0	177.5	22.5	6.3	n/a	37.7	22.1	1.00	1.00
G14A11 OUT	172.4	152.2	20.1	172.5	148.7	23.9	0.8	n/a	37.7	22.1	1.00	1.00
G15B03 OUT	392.7	166.8	225.9	231.2	211.8	19.4	210.4	n/a	38.3	25.4	1.00	1.00
G16B16EP OUT	351.8	130.7	221.0	336.5	138.4	198.1	53.7	n/a	38.3	25.4	1.00	1.00
O11B02 OUT	232.1	166.6	65.5	217.4	171.2	46.2	27.3	n/a	50.1	15.9	1.00	1.00
O12B02 OUT	233.9	164.7	69.2	236.4	171.2	65.2	14.8	n/a	50.1	15.9	1.00	1.00
O21B13 OUT	276.3	173.9	102.4	290.0	176.4	113.6	6.8	n/a	50.1	15.9	1.00	1.00
O22B13 OUT	302.6	173.9	128.7	315.7	176.4	139.3	11.3	n/a	50.1	15.9	1.00	1.00
O23B13 OUT	257.5	173.8	83.7	240.9	176.4	64.5	29.9	n/a	50.1	15.9	1.00	1.00
O24B13 OUT	235.2	173.9	61.3	241.5	176.4	65.0	7.0	n/a	50.1	15.9	1.00	1.00
O31A12 OUT	213.4	180.8	32.6	187.5	155.8	31.7	6.6	n/a	42.5	15.3	1.00	1.00
O32A12 OUT	168.4	154.7	13.7	146.1	132.4	13.7	3.0	n/a	42.5	15.3	1.00	1.00
O33A12 OUT	166.2	154.7	11.5	144.8	132.4	12.4	2.0	n/a	42.5	15.3	1.00	1.00
O41B13 OUT	181.4	184.0	-2.6	159.1	181.0	-21.8	n/a	23.5	50.1	15.9	1.00	1.00
O61B12 OUT	343.6	189.2	154.4	330.6	183.3	147.3	30.2	n/a	50.1	15.9	1.00	1.00
O62B12 OUT	291.6	189.2	102.4	274.7	183.4	91.3	25.8	n/a	50.1	15.9	1.00	1.00
O63B12 OUT	248.8	189.2	59.6	225.1	183.4	41.6	25.2	n/a	50.1	15.9	1.00	1.00
O64B12 OUT	215.6	189.2	26.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
O64B12S OUT	222.8	189.2	33.6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
O65B12 OUT	222.2	186.8	35.4	226.1	184.3	41.7	0.9	n/a	50.1	15.9	1.00	1.00
O66B12 OUT	221.8	180.9	40.9	199.2	178.3	20.9	24.1	n/a	50.1	15.9	1.00	1.00

Test	PTa	STa	DTa	PTr	STr	DTr	CR1	CR2	LITEr	RECPr	CR3	CR4
O71B12 OUT	234.7	172.1	62.6	220.3	163.3	57.0	15.1	n/a	50.1	15.9	1.00	1.00
O81A11 OUT	217.4	195.1	22.2	189.7	165.3	24.4	2.5	n/a	42.5	15.3	1.00	1.00
O82A15 OUT	240.4	206.4	34.0	222.8	191.4	31.5	8.3	n/a	42.5	15.3	1.00	1.00
O91A13 OUT	210.2	196.5	13.7	184.4	169.6	14.8	2.1	n/a	42.5	15.3	1.00	1.00
O92A11 OUT	201.9	207.0	-5.2	172.8	177.6	-4.7	n/a	1.2	42.5	15.3	1.00	1.00
O93A12 OUT	198.6	196.9	1.7	168.3	167.5	0.8	2.0	n/a	42.5	15.3	1.00	1.00
O94A13 OUT	203.8	208.8	-5.0	176.6	181.9	-5.3	n/a	2.1	42.5	15.3	1.00	1.00