Ice Storage Air Conditioners

Compliance Options Application

STAFF REPORT

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Arnold Schwarzenegger, Governor

STATE OF CALIFORNIA
ENERGY COMMISSION

CALIFORNIA ENERGY COMMISSION

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EXECUTIVE SUMMARY

This draft report evaluates an application from Architectural Energy Corporation of San Francisco (AEC) and Ice Energy, Inc., of Windsor, Colorado, for approval of a compliance option for Ice Storage Air Conditioning (ISAC) systems, for use in residential and nonresidential buildings. The proposed compliance option would provide credit under the 2005 Building Energy Efficiency Standards for residential and nonresidential buildings when an ISAC system is installed. The 2005 Standards introduced Time Dependent Valuation (TDV), which accounts for the differential value of saving energy during hourly and seasonal peak periods. Properly designed and sized energy storage systems will potentially be highly valued under the TDV methodology. To deliver on the promise of the TDV benefits, energy storage systems must be well-designed and matched to the building's air conditioning load and manufactured to be reliable over the system's useful life.

ISAC systems produce ice at night and use it during peak periods for cooling. This reduces energy usage during the peak periods. Air conditioning (AC) units operate at higher efficiency at night when the ambient temperature is lower. As the charging of the ice tank progresses, the efficiency drops due to lower heat transfer. There are some standby energy losses from the surface of the tank, and additional energy is consumed by the pumps and controls. Depending on the climate zone, an ISAC system may use more, less, or the same total annual energy as a standard AC unit.

Credit from approval of this compliance option would be applied to all ice storage systems that meet acceptance requirements and eligibility criteria set forth in this compliance option. Compliance software may be updated to include this compliance option to model ISAC systems as specified in this report, and such software updates may be approved by the Energy Commission.

Staff is requesting review and comments from the public and Standards stakeholders regarding this compliance option.

Description of Applicant's Product

The ISAC system consists of a water tank containing refrigerant coils that cool the water and convert it into ice. To ensure good heat transfer, the ice tank coils are made of copper. These Helical copper coils can accommodate expansion and contraction resulting from the change in the water/ice tank temperature. The refrigerant is compressed in a compressor and then cooled in an air-cooled condenser. The liquid refrigerant then is directed through the coils in the water tank to make ice or to the air handler coils to cool the building. The compressor runs continuously as long as there is demand for cooling and/or demand for making ice. During peak periods, if there is enough ice capacity, the compressor remains turned off. At night, the compressor usually runs to make ice. However, if there is a cooling load on the building at night, which can occur in the hot central valley or inland regions and the deserts of Southern California, the compressor can alternate between ice making and cooling the building.

A valve in the refrigeration management system is the only other moving part. The ice tank is insulated and this compliance option takes into account the energy losses from the tank surface. The tank is made of corrosion resistant material. Water quality in the ice tank does not change with the operation of the system.

Summary of Applicant's Request

Prior to the introduction of TDV, the Standards were based on annual source energy and did not recognize energy storage as an energy efficiency measure because such systems commonly increased annual source energy. The applicant proposes that credit for ISAC systems be approved because of the reduced energy usage during peak periods. Building energy use for the 2005 Building Energy Efficiency Standards is calculated using TDV energy use in place of source energy use. To calculate TDV energy use, hourly site energy use is multiplied by a TDV multiplier. The TDV multiplier depends on the climate zone and the hour of energy use. Based on TDV, the credit for this compliance option will be substantial.

The applicant and staff developed eligibility criteria and acceptance requirements in the application to qualify ISAC systems for compliance credit. The low rise residential building eligibility criteria call for third-party field verification by a Home Energy Rating System (HERS) Rater of specific measures that are critical to the efficient performance of the ISAC system. The acceptance requirements call for installer verification of the proper model and operation of required controls, and the presence of required features to ensure that the system functions as modeled in the compliance software. The eligibility criteria and acceptance requirements are discussed on page 12 of this report.

In conjunction with this application, the applicant requests approval of five models to be used with this compliance approach. A listing of these models in included in Appendix F.

Evaluation of Proposal

With the assistance of the applicant’s energy consultants, staff evaluated the proposal using a research version of Micropas, an Energy Commission-certified compliance software program for residential buildings, and a research version of EnergyPro, an Energy Commission-certified compliance software program for nonresidential buildings.

Staff also visited a site where the applicant had installed an ISAC system to observe how the equipment is operated and maintained. Staff observed that if the system fails to perform as designed, the system will operate to provide mechanical cooling as a regular air conditioner during the peak period. The building owners and operators will notice this change from a comfort standpoint only if the compressor is not sized to meet the cooling load at that time.

Test Data Submission and Energy Commission Approval Process

The applicant submitted energy efficiency ratio (EER) and capacity test data for Ice Energy model numbers B600 LRL1CXX, B600 LT159LT, B600 LTL1CFT, B600 LRL1CXX-R and B600 GTG1CXX-R that the applicant reported receiving from an Energy Commission-approved test laboratory. This test data includes the capacity and the EER of the condensing unit for a minimum of 10 percent increments of ice storage ranging from zero percent to 100 percent of total storage and at 10°F temperature increments ranging from 55°F to 95°F. This test information, along with the controls approach that establishes the hour of the day when ice melting and ice making begins, determines the energy performance of the system and the compliance credit that is applicable to that model. This information is unique to each model. This compliance option once approved by the Energy Commission will establish the fundamental algorithms to be installed in Standards compliance software to enable proper and accurate modeling of ISAC systems based on the test information for each unique model. As new models are introduced into the market (with unique capacities, tested EERs for each ice storage increment, and specific controls for beginning ice melting and ice making), separate values of input parameters, certified by an Energy Commission-certified test laboratory, must be submitted to the Energy Commission. This staff report proposes that approval of these specific values for the modeling input parameters for each model be delegated to the Executive Director for authorization of the extension of the compliance option to cover the new models. To submit a model for the Energy Commission's approval, the applicant must provide the data specified in Appendix E.

Compliance Credit Analysis

Table 1 compares the energy usage of the standard design (which includes all of the Package D measures) for a 1,761 square foot home for all the climate zones, using a standard air cooled condensing unit, to a building with the same features except it has an ISAC system (based on test data for model number B600 ABOL). The reduction in total TDV energy use shown in the table represents the compliance credit. Compliance credits for climate zones 8 through 15 are substantial due to large cooling loads.

TABLE 1

Energy use of a 1,761 square foot house with ISAC system and standard design features, compared to the same house with a conventional air conditioning unit

Climate Zone	Standard cooling energy (TDV KBtu/sqft-yr)	ISAC cooling energy (TDV Kbtu/sqft-yr)	Standard total energy (TDV KBtu/sqft-yr)	ISAC Total energy (TDV Kbtu/sqft-yr)	Reduction in cooling energy	Reduction in total energy
1	0.15	1.19	31.91	32.95	-693%	-3%
2	7.89	4.59	42.7	39.4	42%	8%
3	2.8	2.42	28.11	27.73	14%	1%
4	2.68	2.58	31.62	31.52	4%	0%
5	3.22	2.69	27.21	26.68	16%	2%
6	3.06	3.11	20.53	20.58	-2%	0%
7	2.04	2.63	20.33	20.92	-29%	-3%
8	7.68	5.21	27.12	24.65	32%	9%
9	13.45	7.81	32.77	27.13	42%	17%
10	23.23	11.36	44.47	32.6	51%	27%
11	22.09	10.68	54.18	42.77	52%	21%
12	14.33	6.9	44.75	37.32	52%	17%
13	31.93	15.77	57.35	41.19	51%	28%
14	32.07	15.63	64.68	48.24	51%	25%
15	74.25	37.89	88.27	51.91	49%	41%
16	9.36	5.32	61.74	57.7	43%	7%

Table 2 compares the energy use for a 1,761 square foot home if the compliance credit for ISAC systems is completely traded off by increasing window area in the building. The values in Table 2 represent a worst-case scenario, and most likely only some of the credit will be traded off in order to increase window area.

Table 2 shows that in a worse case scenario two concerns may occur. Large tradeoffs are available in climate zones 8 through 15. The potential exists for significant reduction in the building envelope measures. The most dramatic case is in climate zone 15 where the building envelope could be degraded to the point that the cooling load would be increased by 22,810 Btu/hr if all of the credit were traded off. In this situation it becomes very important that the ISAC system is reliable, and the homeowner is satisfied with it. If the ISAC system is abandoned and replaced by a conventional air conditioner, the increased cooling load would result in an air conditioner that is almost 2 tons larger than an air conditioner sized to meet the standard design cooling load. This significantly larger air conditioner would add to the electricity system peak load. Also, the reduction in the building envelope measures would increase the home's heating energy use. It is possible that an increase in heating energy use could result in a significant environmental impact. Environmental impacts are addressed on page 10 of this report.

TABLE 2

Energy use in a residential building when compliance credits are completely traded off by increasing window area

Climate Zone	Standard cooling energy (TDV KBtu/sqft-yr)	Standard heating energy (TDV KBtu/sqft-yr)	Proposed cooling energy (TDV KBtu/sqft-yr)	Proposed heating energy (TDV KBtu/sqft-yr)	Square feet of added glass (equally distributed)	Cooling Load Increase Btu/hr	Heating Load Increase BTU/hr
1	0.15	18.98	1.19	18.98	0	0	0
2	7.89	22.42	6.05	24.22	147.8	5827	3460
3	2.8	12.93	2.6	13.08	27.8	1624	650
4	2.68	16.57	2.58	16.75	3.8	122	103
5	3.22	11.63	2.9	11.85	27.8	1559	708
6	3.06	4.21	3.11	4.21	0	0	0
7	2.04	5.06	3.36	5.83	0	0	0
8	7.68	6.35	6.57	7.15	147.8	5000	3407
9	13.45	6.33	11.42	8.13	247.8	7881	5049
10	23.23	8.26	19.72	11.71	447.8	18066	9947
11	22.09	20.07	16.73	25.12	347.8	15747	8736
12	14.33	18.25	10.87	21.61	267.8	11248	6428
13	31.93	13.72	25.89	19.52	507.8	21694	12213
14	32.07	19.39	25.01	26.23	487.8	21254	14598
15	74.25	2.22	71.87	4.35	467.8	22810	11215
16	9.36	39.26	7	41.23	107.8	6780	3578

Table 3 compares the energy usage of a 1,500 square foot single-story nonresidential retail building with a conventional air conditioner and features that minimally comply with the prescriptive standards, to a building where the conventional air conditioner is replaced with an ISAC system.

Table 3

Energy usage of a 1,500 square foot, single-story, nonresidential retail building with an ISAC system and standard design features, compared to the same building with a conventional air conditioning unit

Climate Zone	Standard cooling energy (TDV KBtu/sqft-yr)	ISAC cooling energy (TDV Kbtu/sqft-yr)	Standard total energy (TDV KBtu/sqft-yr)	ISAC Total energy (TDV Kbtu/sqft-yr)	Reduction in cooling energy	Reduction in total energy
1	88.69	70.74	402.93	385.73	20%	4%
2	149.6	112.88	474.55	438.68	25%	8%
3	122.74	100.24	443.28	416.03	18%	6%
4	159.14	129.11	477.16	447.26	19%	6%
5	129.26	110.61	439.3	420.73	14%	4%
6	171.04	151.6	520.86	496.01	11%	5%
7	179.26	156.93	496.28	474.07	12%	4%
8	215.18	187.61	569.1	541.57	13%	5%
9	231.57	186.65	588.9	537.29	19%	9%
10	248.45	201.53	608.73	562.41	19%	8%
11	185.66	142.02	515.3	472.54	24%	8%
12	173.63	131.57	494.32	453.03	24%	8%
13	233.13	189.32	554.05	510.88	19%	8%
14	231.85	182.72	600.96	552.69	21%	8%
15	409.85	351.51	767.97	710.14	14%	8%
16	107.97	79.3	458.68	431.85	27%	6%

Table 3 shows that compliance credits for commercial buildings are similar across climate zones. This is due to high internal loads in the nonresidential buildings. Climate zone 15 has a very high cooling load. The reduction in savings is because the storage capacity is not sufficient to meet the load during the peak periods.

When comparing the results of residential versus nonresidential in climate zones 1, 6, and 7, whereas residential buildings showed no savings, there are substantial savings in nonresidential buildings due to high internal loads.

Table 4

Energy impacts in a nonresidential building when compliance credits are completely traded off by increasing lighting levels

	Standard cooling energy (TDV KBtu/sqft-yr)	Proposed cooling energy (TDV KBtu/sqft-yr)	Lighting power Increase Watts/sq ft.	Cooling Load Increase Btu/hr
1	88.69	70.74	0.146	822
2	149.6	112.88	0.3	1689
3	122.74	100.24	0.215	1209
4	159.14	129.11	0.24	1350
5	129.26	110.61	0.148	832
6	171.04	151.6	0.16	899
7	179.26	156.93	0.187	1053
8	215.18	187.61	0.187	1052
9	231.57	186.65	0.345	1940
10	248.45	201.53	0.315	1773
11	185.66	142.02	0.352	1979
12	173.63	131.57	0.339	1906
13	233.13	189.32	0.335	1865
14	231.85	182.72	0.335	1884
15	409.85	351.51	0.36	2024
16	107.97	79.3	0.253	1423

The increase in lighting power and the resulting cooling load increases are relatively similar across all climate zones. In addition, the increased cooling load impacts are substantially lower compared to residential buildings. This is due to the features used in trading off the credit. In the residential building analysis, window area is increased as a trade-off for the compliance credits. In the nonresidential building analysis, lighting power is increased as a trade-off for the compliance credits. The increase in lighting power results in much smaller TDV energy use.

ENVIRONMENTAL IMPACT

Air Quality

Approval of this compliance option for ISAC systems will provide substantial compliance credit. The credit may be traded off to allow reductions in other energy efficiency measures, such as inefficient lighting equipment in nonresidential buildings and reduced building envelope measures in residential buildings (such as more window area or reduced wall and ceiling insulation). This may result in increased heating and/or cooling loads. Reduction in envelope efficiency may increase space heating energy, resulting in increased emissions of NO_x, CO and PM_{10} at the building site.

It is difficult to predict the expected market penetration of ISAC systems. To assess air quality impacts that could occur as a result of the Energy Commission's approval of the compliance option, staff evaluated a worst-case scenario assuming 100 percent statewide market penetration. Minimally compliant buildings with standard design features in all the climate zones were used as the base case. For the proposed case, the minimally compliant air conditioning unit (SEER13) in the base case building was replaced with an ISAC system. For residential buildings the window area was increased, and for nonresidential buildings the lighting power density was increased until the buildings became minimally compliant with the energy budget. In residential buildings the onsite heating energy usage of the proposed building was compared to the base case. To calculate the worst-case emission increase, the increase in natural gas energy usage was multiplied by emission factors that are applicable to natural gas furnaces. For nonresidential buildings, the increase in lighting levels decreased the heating load but increased the cooling load. To calculate the worst-case emission increase, the increase in cooling energy use was multiplied by emission factors that are based on California's electric generation emission factors.

Table 5A and 5B show estimated worst-case potential increases in emissions in comparison to total statewide emissions for residential buildings and nonresidential buildings, respectively. The emission factors are based on California's statewide averages developed by Energy Commission staff (see Table 6).

TABLE 5A

Worst case increase in emissions from approval of this compliance option for residential buildings

	NO_x	**CO**	**PM10**
Statewide worst case increased emissions from this compliance option (Tons/yr)	**323**	**98**	**32**
Statewide total emissions (Tons/yr)	**1,244,449**	**6,376,204**	**1,174,229**
Worst case percent increase	**0.026%**	**0.0015%**	**0.0027%**

The emission analysis for residential buildings is based on the 108,468 single-family housing starts in California for the year 2003. This housing starts data was used by the Energy Commission in developing the 2005 Building Energy Efficiency Standards (note that the single-family housing starts in California have been substantially higher in subsequent years). The actual market penetration of ISAC systems is expected to be significantly lower (could be only five percent or less). Also, the credits may not be completely traded off.

TABLE 5B

Worst-case increased emissions from approval of this compliance option for nonresidential buildings

	NO_x	CO	PM10
Statewide worst case increased emissions from this compliance option (Tons/yr)	**79**	**24**	**8**
Statewide total emissions (Tons/yr)	**1,244,449**	**6,376,204**	**1,174,229**
Worst case percent increase	**0.006%**	**0.00037%**	**0.0005%**

The emission analysis for nonresidential buildings is based on 159 million square feet of annual nonresidential new construction in California for 2003. This data was used by the Energy Commission in developing the 2005 Building Energy Efficiency Standards. The actual market penetration of ISAC systems is expected to be significantly lower (could be 5 percent or less). Additionally, the credits may not be completely traded off.

Table 6 shows the average emission factors for California that were used in the analysis.

Table 6
Emission factors (Lbm per MMBtu)

Pollutants	NO_X	**CO**	PM_{10}
Factors for Electric Generation Lbs/Mwhr	**0.38**	**0.23**	**0.06**
Factors for Use of Furnaces lbs/mmbtu	**0.05**	**0.03**	**0.01**

Staff finds no significant increase in emissions resulting from the approval of this compliance option.

Water Use

The system does not consume any water except for one time filling of the water tank. Approval of this compliance option will not result in any significant increase in water consumption.

Indoor Air Quality

Conditioned air in the building will never come in direct contact with water or ice. There is no impact on indoor air quality.

Eligibility Criteria and Acceptance Testing

To ensure reliable energy savings and proper operation and control, the applicant worked with the staff to develop eligibility criteria and acceptance testing requirements. The low rise residential building eligibility criteria include third-party field verification of the ISAC's model number by a certified HERS rater and the requirement that duct sealing be completed for all low-rise residential building installations. The Acceptance Requirements call for installer verification of the presence and proper operation of required controls.

Low-Rise Residential Buildings

Eligibility Criteria

The builder or installer provides a CF-1R form showing the system that was used for determining performance standards compliance, and that duct sealing was specified for compliance.

The following eligibility criteria must be certified on the CF-6R form and verified by a HERS rater on the CF-4R form for residential buildings (See Appendix A).

1. The model number of the installed unit is for a unit that the Energy Commission has approved for compliance credit and matches the model number used for compliance credit.
2. The duct system has been sealed and tested as required by the Residential ACM Manuals.
3. No Thermostatic Expansion Valve (TXV) credit is taken if applicable.

The installing contractor shall complete the following acceptance testing and document the results to the Building Department using the CF-6R form (See Appendix A).

1. Verify that building cooling is controlled by a standard indoor HVAC thermostat and not by factory-installed controls.
2. Verify that ice making is not controlled by the thermostat.
3. Verify that the water tank is filled to the proper level as specified by the manufacturer.
4. Verify that the correct model number is installed as indicated in compliance documents (including ice melt start time). Certify the installed model number on the CF-1R form.
5. Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period, and simulate that the tank is not full with ice. Verify that the system operates properly in the ice-making mode (in other , it starts charging the tank and does not provide cooling to the building).
6. Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period, and simulate the tank being full of ice. Verify that the system operates properly in the idle mode (i.e., the compressor is off, and no cooling is provided by the system).

7. Force the controls to indicate a demand for cooling and set the time to be within the daytime time period. Verify that the system operates properly in the ice melt mode (i.e., it starts discharging and that the compressor is off).
8. Force the controls to indicate a demand for cooling and set the time to be within the morning shoulder time period. Verify that the system operates properly in the direct cooling mode (i.e., the system is providing cooling with the compressor).
9. Force the controls to indicate no cooling load, and set the time to be within the daytime time period. Verify that the system operates properly in the idle mode (i.e., it does not provide cooling to the building and the compressor is off).
10. Force the controls to indicate a demand for cooling and set the time to be within the nighttime period. Verify that the cooling is provided by the compressor.

Nonresidential Buildings

Acceptance Testing

The installing contractor shall complete the following acceptance testing and document the results to the Building Department using the Mech-9A form (See Appendix B).

1. Verify that building cooling is controlled by a standard indoor HVAC thermostat and not by factory installed controls.
2. Verify that ice making is not controlled by the thermostat.
3. Verify that the water tank is filled to the proper level as specified by the manufacturer.
4. Verify that the correct model number is installed as indicated in compliance documents (including ice melt start time). Certify the installed model number on the CF-1R form for residential buildings and on the Mech-1 form for nonresidential buildings.
5. Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period, and simulate that the tank is not full with ice. Verify that the system operates properly in the ice-making mode (i.e., it starts charging the tank and does not provide cooling to the building).
6. Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period, and simulate the tank being full of ice. Verify that the system operates properly in the idle mode (i.e., the compressor is off, and no cooling is provided by the system).
7. Force the controls to indicate a demand for cooling and set the time to be within the daytime time period. Verify that the system operates properly in the ice melt mode (i.e., it starts discharging, and that the compressor is off).
8. Force the controls to indicate a demand for cooling and set the time to be within the morning shoulder time period. Verify that the system operates properly in the direct cooling mode (i.e., the system is providing cooling with the compressor).
9. Force the controls to indicate no cooling load, and set the time to be within the daytime time period. Verify that the system operates properly in the idle mode (i.e., it does not provide cooling to the building and the compressor is off).
10. Force the controls to indicate a demand for cooling and set the time to be within the nighttime period. Verify that the cooling is provided by the compressor.

Modeling Procedure and Proposed Alternative Calculation Method (ACM) Manual Amendments

The algorithms that were originally drafted by the applicant for both residential and nonresidential calculations are included in the appendices for review. The residential algorithms are located in Appendix C, and the nonresidential algorithms are located in Appendix D. The applicant is working on a more precise description of changes to the ACM Manual that will be necessary to guide compliance software developers.

For low-rise residential buildings only

Compliance software developers must cause inputs to be linked between the credit for ISAC systems and duct sealing and no credit for Thermostatic Expansion Valve so that errors can not be made by the program user. If the user chooses ISAC systems, the user must be notified that duct sealing is also required, and compliance results must not be determined until both measures are properly selected.

Compliance software also must automatically list “Ice Storage Air Conditioning Systems” on page 2 of the CF-1R form. Compliance software also must automatically generate the CF-6R form. Samples of the modified forms are in Appendix A.

For nonresidential buildings only

Compliance software developers must cause inputs to be linked between the credit for ISAC systems and no credit for Thermostatic Expansion Valve so that errors can not be made by the program user.

Compliance software also must automatically list “Ice Storage Air Conditioning Systems” on part 4 of the Mech-1-C form. Compliance software also must automatically generate the Mech-5-A-ISAC form. Samples of the modified forms are in Appendix B.

Staff Conclusions

Staff’s findings support approval of this compliance option. Staff believes that this type of system will reduce electric demand during peak periods. The peak demand shifting capability of ISAC systems will depend on initial commissioning, proper operation, and maintenance. This technology is relatively new. Long-term performance and reliability data is not available.

The algorithms as proposed for this compliance option properly account for the energy consequences of installing a ISAC system. In cases where the system is undersized relative to the cooling load, either because the building envelope has been substantially degraded through compliance credit trade-offs or because the building is too large and/or the climate is too severe for the fixed size of the ISAC systems, the modeling assumes the operation of a backup conventional air conditioner at minimum efficiency to meet the excess load. The energy savings are reduced substantially when the system is undersized for the cooling load.

APPENDIX A

Residential Compliance Forms

Note that staff proposes to add new pages 3C (ISAC) and 3D (ISAC) to the CF-6R forms as shown below to direct the installer to complete the checkboxes for the eligibility criteria and acceptance requirements.

CERTIFICATE OF COMPLIANCE

INSTALLATION CERTIFICATE	**(Page 3C(ISAC) of 12) CF-6R**
Site Address	Permit Number

An installation certificate is required to be posted at the building site or made available for all appropriate inspections. (The information provided on this form is required.) After completion of final inspection, a copy must be provided to the building department (upon request) and the building owner at occupancy, as required by Title 24, Part 1, Section 10-103 (a).

HVAC SYSTEMS:

Ice Storage Air Conditioning (ISAC) Units

CEC Certified Mfr. Name and ISAC Model Number	# of Identical Systems	EER	Duct Location (attic, etc.)	Duct R-value	Cooling Load (Btu/hr)	Cooling Capacity (Btu/hr)

The model number of the installed unit matches the model number used for compliance credit.	☐ Pass ☐ Fail
Ducts are tested and sealed as specified by Title 24, Part 6, Section 151 (f) 10 or 152 (b) 1 E	☐ Pass ☐ Fail

The system complies with all eligibility criteria✓ ☐ System Qualifies

✓ ☐ I, the undersigned, certify that the equipment listed above is: 1) the actual equipment installed, 2) equivalent to or more efficient than that specified in the certificate of compliance (Form CF-1R) submitted for compliance with the *Energy Efficiency Standards* for low rise residential buildings.

Installing Subcontractor (Co. Name) OR General Contractor (Co. Name) OR Owner	
Signature:	Date:

COPY TO: Building Department
HERS Rater (if applicable)
Building Owner at Occupancy

* Duct testing section must be completed on pages 4-5 of the Standard CF-6R form.

CERTIFICATE OF COMPLIANCE

INSTALLATION CERTIFICATE	**(Page 3D(ISAC) of 12) CF-6R**
Site Address	Permit Number

An installation certificate is required to be posted at the building site or made available for all appropriate inspections. (The information provided on this form is required.) After completion of final inspection, a copy must be provided to the building department (upon request) and the building owner at occupancy, as required by Title 24, Part 1, Section 10-103 (a).

HVAC SYSTEMS:

Ice Storage Air Conditioning System Acceptance Criteria

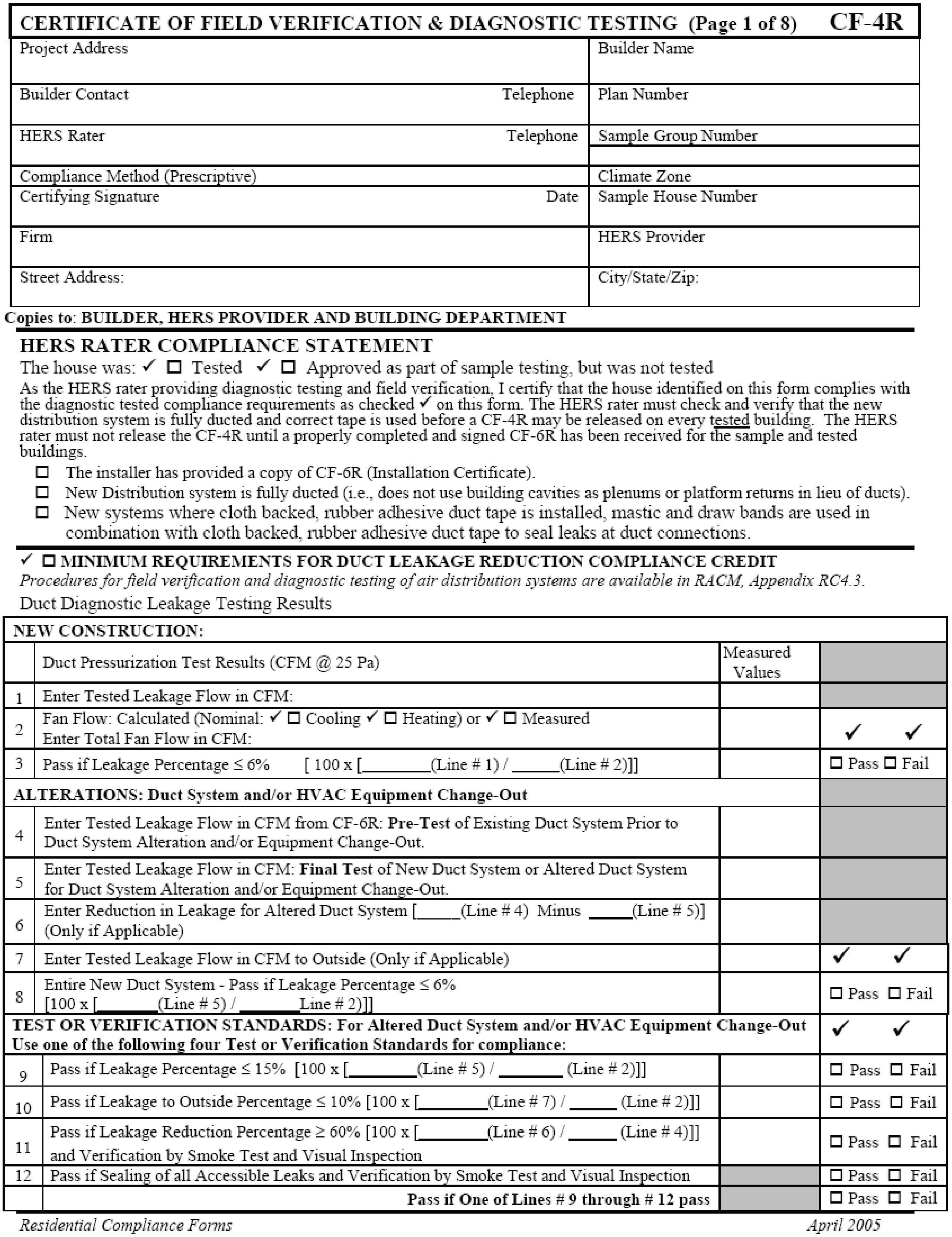
1. *Verify that building cooling is controlled by a standard indoor HVAC thermostat and not by factory installed controls.* ☐ *Pass* ☐ *Fail*
2. *Verify that ice Making is not controlled by the thermostat.* ☐ *Pass* ☐ *Fail*
3. *Verify that the water tank is filled to the proper level as specified by the manufacturer.* ☐ *Pass* ☐ *Fail*
4. *Verify that the correct model number (as indicated in compliance documents including) time is installed. Certify the installed model number on the CF-1R form for residential buildings and on Mech-1 form for nonresidential buildings.* ☐ *Pass* ☐ *Fai*
5. *Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period and simulate that the tank is not full with ice. Verify that the system operates properly in the Ice-Making mode (i.e., it starts charging the tank and does not provide cooling to the building).* ☐ *Pass* ☐ *Fail*
6. *Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period, and simulate the tank being full of ice. Verify that the system is operates properly in the Idle mode (i.e., the compressor is off, and no cooling via the system is provided).* ☐ *Pass* ☐ *Fail*
7. *Force the controls to indicate a demand for cooling and set the time to be within the daytime time period. Verify that the system operates properly in the Ice Melt mode (i.e., it starts discharging and that the compressor is off).* ☐ *Pass* ☐ *Fail*
8. *Force the controls to indicate a demand for cooling and set the time to be within the morning shoulder time period. Verify that the system operates properly in the Direct Cooling mode (i.e., the system is providing cooling with the compressor).* ☐ *Pass* ☐ *Fail*
9. *Force the controls to indicate no cooling load, and set the time to be within the daytime time period. Verify that the system operates properly in the Idle mode (i.e., it does not provide cooling to the building, and the compressor is off).* ☐ *Pass* ☐ *Fail*
10. *Force the controls to indicate a demand for cooling and set the time to be within the night time period. Verify that the cooling is provided by the compressor.* ☐ *Pass* ☐ *Fail*

The system complies with all acceptance criteria: ✓ ☐ System Qualifies

✓ ☐ I, the undersigned, verify that equipment listed above is: 1) is the actual equipment installed, 2) equivalent to or more efficient than that specified in the certificate of compliance (Form CF-1R) submitted for compliance with the *Energy Efficiency Standards* for residential buildings, and 3) equipment that meets or exceeds the appropriate requirements for manufactured devices (from the *Appliance Efficiency Regulations* or Part 6), where applicable.

Installing Subcontractor (Co. Name) OR General Contractor (Co. Name) OR Owner	
Signature:	Date:

COPY TO: Building Department
HERS Rater (if applicable)
Building Owner at Occupancy



CERTIFICATE OF FIELD VERIFICATION & DIAGNOSTIC TESTING (Page 1 of 8) CF-4R

Project Address	Builder Name
Builder Contact Telephone	Plan Number
HERS Rater Telephone	Sample Group Number
Compliance Method (Prescriptive)	Climate Zone
Certifying Signature Date	Sample House Number
Firm	HERS Provider
Street Address:	City/State/Zip:

Copies to: BUILDER, HERS PROVIDER AND BUILDING DEPARTMENT

HERS RATER COMPLIANCE STATEMENT

The house was: ✓ ☐ Tested ✓ ☐ Approved as part of sample testing, but was not tested

As the HERS rater providing diagnostic testing and field verification, I certify that the house identified on this form complies with the diagnostic tested compliance requirements as checked ✓ on this form. The HERS rater must check and verify that the new distribution system is fully ducted and correct tape is used before a CF-4R may be released on every tested building. The HERS rater must not release the CF-4R until a properly completed and signed CF-6R has been received for the sample and tested buildings.

- ☐ The installer has provided a copy of CF-6R (Installation Certificate).
- ☐ New Distribution system is fully ducted (i.e., does not use building cavities as plenums or platform returns in lieu of ducts).
- ☐ New systems where cloth backed, rubber adhesive duct tape is installed, mastic and draw bands are used in combination with cloth backed, rubber adhesive duct tape to seal leaks at duct connections.

✓ ☐ MINIMUM REQUIREMENTS FOR DUCT LEAKAGE REDUCTION COMPLIANCE CREDIT

Procedures for field verification and diagnostic testing of air distribution systems are available in RACM, Appendix RC4.3.

Duct Diagnostic Leakage Testing Results

NEW CONSTRUCTION:			
	Duct Pressurization Test Results (CFM @ 25 Pa)	Measured Values	
1	Enter Tested Leakage Flow in CFM:		
2	Fan Flow: Calculated (Nominal: ✓ ☐ Cooling ✓ ☐ Heating) or ✓ ☐ Measured Enter Total Fan Flow in CFM:		✓ ✓
3	Pass if Leakage Percentage ≤ 6% [100 x [________(Line # 1) / _____(Line # 2)]]		☐ Pass ☐ Fail
ALTERATIONS: Duct System and/or HVAC Equipment Change-Out			
4	Enter Tested Leakage Flow in CFM from CF-6R: **Pre-Test** of Existing Duct System Prior to Duct System Alteration and/or Equipment Change-Out.		
5	Enter Tested Leakage Flow in CFM: **Final Test** of New Duct System or Altered Duct System for Duct System Alteration and/or Equipment Change-Out.		
6	Enter Reduction in Leakage for Altered Duct System [_____(Line # 4) Minus _____(Line # 5)] (Only if Applicable)		
7	Enter Tested Leakage Flow in CFM to Outside (Only if Applicable)		✓ ✓
8	Entire New Duct System - Pass if Leakage Percentage ≤ 6% [100 x [_______(Line # 5) / _______Line # 2)]]		☐ Pass ☐ Fail
TEST OR VERIFICATION STANDARDS: For Altered Duct System and/or HVAC Equipment Change-Out Use one of the following four Test or Verification Standards for compliance:			✓ ✓
9	Pass if Leakage Percentage ≤ 15% [100 x [________(Line # 5) / ________ (Line # 2)]]		☐ Pass ☐ Fail
10	Pass if Leakage to Outside Percentage ≤ 10% [100 x [________(Line # 7) / _____ (Line # 2)]]		☐ Pass ☐ Fail
11	Pass if Leakage Reduction Percentage ≥ 60% [100 x [________(Line # 6) / _____ (Line # 4)]] and Verification by Smoke Test and Visual Inspection		☐ Pass ☐ Fail
12	Pass if Sealing of all Accessible Leaks and Verification by Smoke Test and Visual Inspection		☐ Pass ☐ Fail
	Pass if One of Lines # 9 through # 12 pass		☐ Pass ☐ Fail

Residential Compliance Forms *April 2005*

APPENDIX B

Nonresidential Compliance Forms

2005 ACCEPTANCE REQUIREMENTS FOR CODE COMPLIANCE	**MECH-5-A(ISAC)**
Ice Storage Air Conditioning (ISAC) system Acceptance Document	
Project Name	Date

.1 *Verify that building cooling is controlled by a standard indoor HVAC thermostat and not by factory installed controls.* *☐ Pass ☐ Fail*

2\. *Verify that ice Making is not controlled by the thermostat.* *☐ Pass ☐ Fail*

3\. *Verify that the water tank is filled to the proper level as specified by the manufacturer.* *☐ Pass ☐ Fail*

4\. *Verify that the correct model number (as indicated in compliance documents including) time is installed. Certify the installed model number on the CF-1R form for residential buildings and on Mech-1 form for nonresidential buildings.* *☐ Pass ☐ Fai*

5\. *Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period and simulate that the tank is not full with ice. Verify that the system operates properly in the Ice-Making mode (i.e., it starts charging the tank and does not provide cooling to the building).* *☐ Pass ☐ Fail*

6\. *Force the controls to indicate no demand for cooling, set the time to be within the nighttime time period, and simulate the tank being full of ice. Verify that the system is operates properly in the Idle mode (i.e., the compressor is off, and no cooling via the system is provided).* *☐ Pass ☐ Fail*

7\. *Force the controls to indicate a demand for cooling and set the time to be within the daytime time period. Verify that the system operates properly in the Ice Melt mode (i.e., it starts discharging and that the compressor is off).* *☐ Pass ☐ Fail*

8\. *Force the controls to indicate a demand for cooling and set the time to be within the morning shoulder time period. Verify that the system operates properly in the Direct Cooling mode (i.e., the system is providing cooling with the compressor).* *☐ Pass ☐ Fail*

9\. *Force the controls to indicate no cooling load, and set the time to be within the daytime time period. Verify that the system operates properly in the Idle mode (i.e., it does not provide cooling to the building, and the compressor is off).* *☐ Pass ☐ Fail*

10\. *Force the controls to indicate a demand for cooling and set the time to be within the night time period. Verify that the cooling is provided by the compressor.* *☐ Pass ☐ Fail*

✓ ☐ I, the undersigned, verify that equipment listed above is: 1) is the actual equipment installed, 2) equivalent to or more efficient than that specified in the certificate of compliance (Form CF-1R) submitted for compliance with the *Energy Efficiency Standards* for residential buildings, and 3) equipment that meets or exceeds the appropriate requirements for manufactured devices (from the *Appliance Efficiency Regulations* or Part 6), where applicable.

Installing Subcontractor (Co. Name) OR General Contractor (Co. Name) OR Owner	
Signature:	Date:

COPY TO: Building Department
HERS Rater (if applicable)
Building Owner at Occupancy

APPENDIX C

Nonresidential Algorithms

Proposed ACM Amendments

There are two proposed amendments to the Nonresidential ACM Manual. A new Section 3.3.16 DES/DXAC is added to the Optional Capabilities chapter. A new section NJ.11 DES/DXAC Acceptance is added to the NACM Appendix NJ.

Acceptance Requirements

Refer to the Nonresidential Acceptance Requirements section of this document for details.

Optional Capability

3.3.16 Ice Storage Air Conditioner

Description: ACMs may model DES/DXAC systems using the DOE-2 function listed in Appendix A for the following proposed system types:

1. PSZ: Packaged Single Zone System
2. PVAVS: Packaged Variable Air Volume System
3. PMZS: Packaged Multi-Zone System
4. PVVT: Packaged Variable Volume Variable Temperature System

DOE Keyword: FUNCTION = (*NONE*, *ISACFunc*). This keyword should be inserted right after the SYSTEM-TYPE keyword for each system that uses DES/DXAC. This keyword basically means the ISACFunc routine which calculates the cooling energy use of a DES/DXAC system will be called after DOE-2 completes calculation for a system.

Input Type: Required

Tradeoffs: Yes

DES/DXAC DOE-2 Function: The ISAC DOE-2 function written in FORTRAN code is listed in Appendix A. The ISAC function should be inserted between the system "END .." line and the "COMPUTE SYSTEMS .." line. This can also be done by inserting an include statement "##INCLUDE ISAC.func", and put the actual DOE-2 function file ISAC.func at the DOE-2 executable files folder.

Modeling Rules for Proposed Design:

Optional proposed systems shall be modeled as input by the user, according to the plans and specifications for the building, subject to all of the restrictions specified in the Required Systems and Plant Capabilities. User inputs for a DES/DXAC system include –

1. Change Condenser Type to DES/DXAC from Air-Cooled for the four packaged system types
2. Specify cooling capacity of the system

The makeup system cooling efficiency will be based on Title 24-2005 rules. There is no credit or penalty for the makeup system compared with the Standard Design.

Modeling Rules for Standard Design (New):

Standard system types and applicable system parameters are chosen according to Table N2-10. The air flow and supply air temperature for the standard design will be optimally controlled in the reference method. All efficiency descriptors shall be determined according to the requirements of the Required Systems and Plant Capabilities.

Modeling Rules for Standard Design (Existing Unchanged & Altered Existing):

ACMs shall model the existing system as it occurs in the existing building using DOE-2 default performance curves. If the permit involves alterations, ACMs shall model the system before alterations

Modeling Procedures

DOE-2 cannot directly model the DES/DXAC, but a DOE-2 system function is developed to calculate the DES/DXAC cooling energy use. The DOE-2 function takes inputs of the DES/DXAC performance data, the DES/DXAC control algorithm, hourly outdoor air temperature, and hourly system cooling load to calculate the hourly system cooling energy use using the DES/DXAC. Basically the function overwrites the way DOE-2 calculates the cooling energy use.

The DES/DXAC DOE-2 function is called by each HVAC system that uses the DES/DXAC during the simulation runs. The DES/DXAC function does not change any other energy use by a system, for example, heating and fan energy uses stay untouched. This section details the modeling procedures in the DES/DXAC DOE-2 function which is listed in Appendix A.

When there is system cooling demand, the DES/DXAC may run to meet the cooling demand, either in Direct Cooling mode or Ice-Melt cooling mode, based on the DES/DXAC control strategy. When DES/DXAC is not available to provide cooling or cannot meet 100% of the cooling loads, a default standard makeup conventional DX unit is assumed to operate to meet either 100% or part of the unmet system cooling demand. The performance of the makeup DX system is minimally compliant according to California and Federal standards, and is programmed into the DES/DXAC model.

Ice Bear B600 ABOL Specification

This DES/DXAC specification is based on Ice Bear Unit from Ice Energy, Inc.
Maximum discharging rate: IBMaxCl = 7.5 tons (90,000 Btu/h)
Maximum discharging capacity: IBClCAP = 40 ton-hours
Storage tank cool loss: TANKUA = 15 Btu/h-°F (insulated with R-18)
Parasitic electrical loss during discharging: ParaCool= 301 Watt (for pumps, controls, etc.)
Parasitic electrical loss during charging: ParaStore = 14 Watt (for pumps, controls, etc.)
Parasitic electrical loss during idle: ParaIdle = 2.6 Watt (for controls, etc.)
Size of storage tank: 6’9”L x 5’9”W x 5’6” H (500 gallons of water)
Nominal cooling capacity of the DES/DXAC condensing unit: 5 Tons (60,000 Btu/hr, ± 5%)
Efficiency of condensing unit: SEER 13, EER 11
Control parameters:
Charging offset. sngChgOffset = 6. One of the two variables to calculate optimal charging time.
Charging multiplier. sngChgMult = 1.5. One of the two variables to calculate optimal charging time.
Time charging must stop = 12. Ice make must stop by 12:00 noon.
Time charging can start = 19. Ice make cannot start before 7:00 pm.
Summer months = 5 - 9. May through September are peak cooling demand months.
Time discharging can start during peak months = 12. Discharging can start from 12:00 noon during peak months.
Time discharging can start during non-peak months = 9. Discharging can start from 9:00 am during non-peak months.
Cooling enabled. Hour of day when Ice Bear unit cooling (either Ice-Melt or Direct Cooling mode) becomes enabled. It is set to 12:00 pm for peak months and 9:00 am for off-peak months
Cooling disabled = 19. Hour of day when Ice Bear cooling becomes disabled (7:00 pm).
Ice Bear unit Condensing Unit Performance Data
Table 1 and **Table 2** shows the charging capacity and efficiency of a SEER 13 condensing unit for the Ice Bear DES/DXAC system as functions of outdoor air temperature and the Ice Bear DES/DXAC storage tank cooling capacity. The 15.8% is the transition point from sensible to latent storage.

Table 1 – Ice Bear Condensing Unit Capacity (tons) at Various Conditions
Charging Capacity vs. Outdoor Air Temperature and Tank Cooling Capacity with a SEER 13 5-ton Condensing Unit

Ice Bank Fraction Full	Outdoor Air Temp (°F) 55	65	75	85	95
0.00%	4.43	4.08	3.60	3.39	3.64
3.21%	3.65	3.47	3.15	3.05	3.15
11.09%	3.20	3.09	2.85	2.80	2.77
15.77%	2.77	2.72	2.54	2.55	2.38
25.13%	2.77	2.70	2.54	2.55	2.38
34.49%	2.77	2.70	2.54	2.55	2.38
43.85%	2.77	2.70	2.54	2.55	2.38
53.21%	2.77	2.70	2.54	2.55	2.38
62.56%	2.77	2.70	2.54	2.55	2.38
71.92%	2.77	2.70	2.54	2.55	2.38
81.28%	2.77	2.70	2.54	2.55	2.38
90.64%	2.77	2.70	2.54	2.55	2.38
100.00%	2.77	2.70	2.54	2.55	2.38

Table 2 – Ice Bear Condensing Unit Efficiency (Btu/h-W) at Various Conditions
Charging Efficiency vs Outdoor Air Temperature and Tank Cooling Capacity with a SEER 13 5-ton Condensing Unit

Ice Bank Fraction Full	Outdoor Air Temp (°F)				
	55	65	75	85	95
0.00%	21.10	17.83	14.55	12.61	11.95
3.21%	18.45	15.66	12.87	11.31	10.14
11.09%	16.57	14.12	11.67	10.38	8.84
15.77%	14.69	12.58	10.47	9.46	7.55
25.13%	14.62	12.79	10.97	9.51	7.59
34.49%	14.63	12.74	10.84	9.43	7.78
43.85%	14.64	12.77	10.89	9.47	7.74
53.21%	14.65	12.85	11.04	9.53	7.77
62.56%	14.68	12.86	11.03	9.61	7.81
71.92%	14.72	12.82	10.92	9.56	7.77
81.28%	14.65	12.71	10.76	9.54	7.72
90.64%	14.65	12.71	10.77	9.46	7.73
100.00%	14.57	12.68	10.79	9.51	7.75

The above two data tables can be represented by two bi-quadratic performance curves -
The Ice Bear unit Charging Capacity curve

$$\text{QCHG (ton)} = a0 + a1 \times OAT + a2 \times OAT^2 + a3 \times CAPR + a4 \times CAPR^2 + a5 \times OAT \times CAPR$$

The Ice Bear unit Charging Efficiency curve

$$\text{EER (Btu/h-W)} = b0 + b1 \times OAT + b2 \times OAT^2 + b3 \times CAPR + b4 \times CAPR^2 + b5 \times OAT \times CAPR$$

Where, OAT is the hourly outdoor air temperature (°F), and CAPR is the ratio of the tank remaining cooling capacity (unitless).

	Ice Bear unit Charging Capacity	
Coefficient	*CAPR <= 15.8%*	*CAPR > 15.8%*
a0	*7.0674911*	*3.1799690*
a1	*- 0.072931326*	*-0.0060738487*
a2	*0.00036214535*	*-0.0000224896*
a3	*-13.736024*	*-0.016667649*
a4	*15.715263*	*0.011038597*
a5	*0.058073656*	*0.0000409288*

	Ice Bear unit Charging Efficiency	
Coefficient	*CAPR <= 15.8%*	*CAPR > 15.8%*
b0	*44.540456*	*26.902775*
b1	*-0.57579463*	*-0.258017*
b2	*0.00237323*	*0.000562538*
b3	*-52.2722*	*0.731743*
b4	*47.510746*	*-0.880715*
b5	*0.2479852*	*0.00465355*

The Ice Bear unit Direct Cooling curves and the Standard Makeup DX Cooling curves
These performance curves are derived according to the SEER, EER, and rules defined in 2005 Title 24

Nonresidential ACM Manual pages 2-55 to 2-62.

	Ice Bear unit Direct Cooling *(SEER 13, EER11)*		*Standard Makeup DX Cooling* *(SEER 10, EER 8.755)*	
Coefficient	*COOL-CAP-FT*	*COOL-EIR-FT*	*COOL-CAP-FT*	*COOL-EIR-FT*
a	*0.053815799*	*0.991169621*	*0.053815799*	*3.21470461*
b	*0.02044874*	*-0.02958748*	*0.02044874*	*-0.0284561*
c	*-1.45568E-5*	*0.00023957*	*-1.45568E-5*	*0.00023938*
d	*-8.91816E-4*	*0.016367154*	*-8.91816E-4*	*-0.0316742*
e	*-1.22969E-5*	*5.03703E-05*	*-1.22969E-5*	*0.000309505*
f	*-2.61616E-5*	*-1.71866E-04*	*-2.61616E-5*	*-0.000183448*

$\text{COOL-CAP-FT} = a + b * \text{EWB} + c * \text{EWB}^2 + d * \text{OAT} + e * \text{OAT}^2 + f * \text{EWB} * \text{OAT}$
$\text{COOL-EIR-FT} = a + b * \text{EWB} + c * \text{EWB}^2 + d * \text{OAT} + e * \text{OAT}^2 + f * \text{EWB} * \text{OAT}$
Where, OAT is the hourly outdoor air temperature (°F), and EWB is the hourly wet-bulb temperature (°F) of the air entering the coil.

Verification of Software Model

To verify the accuracy of a new software model, the total kWh for the system (compressor, condensing unit, parasitic losses) for a complete make (from 0% capacity to 100% capacity) at 55°F, 65°F, 75°F, 85°F, and 95°F, as simulated by the bi-quadratic formulas, should match the raw data from the 3rd party tests within 5%.

Calculation Algorithms

Depending on the hourly system cooling demand, outside air temperature, the DES/DXAC Ice Storage Unit remaining cooling capacity, and the DES/DXAC operation controls, there are five operation modes of the DES/DXAC system –

Table 3 – Five Operation Modes of the DES/DXAC System

System Operation Mode	System Operation Description	DES/DXAC Operation	Makeup DX Unit Operation
1A	With cooling demand	Discharging. The tank has cooling capacity. Ice-melt cooling mode.	If DES/DXAC ice-melt meets 100% of the cooling load, the default makeup DX unit does not run; otherwise it runs to meet the remaining cooling load.
1B	With cooling demand	Direct cooling. Ice-melt is not scheduled to provide cooling but direct cooling is enabled.	If DES/DXAC direct cooling meets 100% of the cooling load, the default makeup DX unit does not run; otherwise it runs to meet the remaining cooling load.
1C	With cooling demand	Idle. Not scheduled to provide cooling. DES/DXAC cooling is disabled.	The makeup DX unit runs to meet 100% of the cooling load.
2A	Without cooling demand	Charging based on the DES/DXAC control strategy.	Idle
2B	Without cooling demand	Idle	Idle

Operation Mode 1A – DES/DXAC Ice-Melt Cooling

System has cooling demand. The DES/DXAC discharges to meet the cooling load. If cooling load is more than the DES/DXAC can handle, the makeup DX unit also operates to meet the remaining load.

Energy use by the DES/DXAC during discharging is the parasitic electrical loss, mainly the pump power –

Equation N3-4 IBCOOLKW = ParaCool / 1000

If the system hourly cooling demand QC is more than what the DES/DXAC can handle, either more than the maximum cooling rate of 90,000 Btu/h or the maximum available from the storage tank, the standard makeup DX system will operate to meet the remaining load.

Equation N3-5 QCDXstd = QC – QCIB

Energy use by the makeup DX unit is calculated according to DOE-2.1E formula and 2005 Title 24 equipment performance curves or default DOE-2 curves –

Equation N3-6

```
PLRC = QCDXstd/(QCT*CFMCYC+0.001)
PLRCC = AMAX(PLRC,MinUnloadRatio)
EIRM2 = CVAL(CEIRFPLR,PLRCC,PLRCC)
CLPLR = CFMCYC*AMIN(PLRC/(hgbmin+0.001),1)
CLPLRM = AMAX(CLPLR,CLOSSMIN)
CLCOR = CVAL(CLOSSFPLR,CLPLRM,CLPLRM)
PCTON = AMIN(CLPLR/(CLCOR+0.001),1)
DXCLKWstd = QCT*PCTON*(EIRstd*EIRM1*EIRM2)/3413
```

Where

QC = The hourly system cooling demand counting the air duct losses in Btu/h
QCIB = The cooling load on the DES/DXAC
QCDXstd = The cooling load on the makeup DX unit
QCT = The total cooling capacity with temperature correction of the makeup DX unit
PLRC = The cooling part load ratio
PLRCC = The cooling part load ratio the compressor sees
PCTON = The percent of time when the makeup unit compressor is on
EIRstd = The cooling efficiency (Energy Input Ratio) of the makeup DX unit
EIRM1, EIRM2 = Two adjusting factors to the EIRstd
hgbmin = The compressor minimum hot gas bypass
CLOSSMIN = The cooling cycle loss minimum part-load ratio
MinUnloadRatio = The minimum unloading ratio of compressor
CLOSSFPLR, CEIRFPLR = Pointers to curve blocks

The total cooling energy use (kWh) is calculated as,

Equation N3-7 TotCOOLKW = DXCLKWstd + IBCOOLKW

Operation Mode 1B – DES/DXAC Direct Cooling

System has cooling demand. The DES/DXAC operates in direct cooling mode. Energy use by the DES/DXAC during idle mode is the parasitic electrical loss –

Equation N3-8 IBCOOLKW = ParaIdle / 1000

Energy use by the DES/DXAC direct cooling is calculated according to DOE-2.1E formula and 2005 Title 24 equipment performance curves or default DOE-2 curves, similar to the calculation of the standard makeup DX in Operation Mode 1A –

Equation N3-9

```
QCTib = IBCondCap
PLRCib = QCDX/(QCTib*CFMCYC+0.001)
PLRCCib = AMAX(PLRCib,MinUnloadRatio)
IBEIRM2 = PLRCCib
CLPLRib = CFMCYC*AMIN(PLRCib/(hgbmin+0.001),1)
CLPLRMib = AMAX(CLPLRib,CLOSSMIN)
CLCORib = CVAL(CLOSSFPLR,CLPLRMib,CLPLRMib)
PCTONib = AMIN(CLPLRib/(CLCORib+0.001),1)
DXCLKWIB = QCTib*PCTONib*(EIRib*IBEIRM1*IBEIRM2)/3413
```

If the system hourly cooling demand QC is more than what the DES/DXAC direct cooling can handle, the standard makeup DX system will operate to meet the remaining load.

Equation N3-10 QCDXstd = QC – QCDX

Energy use by the standard makeup DX, DXCLKWstd, is calculated using the same formula as in Operation Mode 1A.

Total cooling energy use (kWh) is calculated as,

Equation N3-11 TotCOOLKW = DXCLKWIB + IBCOOLKW + DXCLKWstd

Operation Mode 1C – Standard Makeup DX Cooling

System has cooling demand but DES/DXAC is not available (either disabled by controls or runs out of ice) to provide cooling. DES/DXAC stands by, the standard makeup DX operates to meet 100% of the cooling demand,

Equation N3-12 $IBCOOLKW = ParaIdle$

Equation N3-13 $QCDXstd = QC$

DXCLKWstd is calculated using the same formula as in Operation Mode 1A.

The total cooling energy use (kWh) is calculated as,

Equation N3-14 $TotCOOLKW = DXCLKWstd + IBCOOLKW$

Operation Mode 2A – DES/DXAC Ice-Make

System does not have cooling demand. The makeup DX unit is in idle mode.

Energy use by the makeup DX unit is assumed to be 0. DXCLKWstd = 0.

The DES/DXAC controller determines whether or not to charge the storage tank.

The optimal time to start charging is from hour –

Equation N3-15 $sngChgStartHour = sngChgOffset - DAYCLHR1 \times sngChgMult$

Where

sngChgOffset, sngChgMult = Two control parameters

DAYCLHR1 = The total discharging hours on the previous day

If the current hour >= sngChgStartHour and is between the other two control parameters – the Time charging must stop and the Time charging can start, the DES/DXAC charges the storage tank. Otherwise, the DES/DXAC delays charging and is in idle mode.

Energy use by the DES/DXAC during charging mode includes the parasitic electrical loss ParaStore and condensing unit power use, it can be calculated as –

Equation N3-16 $IBCOOLKW = ParaStore / 1000 + QCHG / EER / 1000$

Where

QCHG = The condensing unit charging capacity in Btu/h

EER = The charging efficiency

Equation N3-17

$QCHG (ton) = 12000 \times (a0 + a1 \times OAT + a2 \times OAT^2 + a3 \times CAPR + a4 \times CAPR^2 + a5 \times OAT \times CAPR)$

$EER (Btu/h-W) = b0 + b1 \times OAT + b2 \times OAT^2 + b3 \times CAPR + b4 \times CAPR^2 + b5 \times OAT \times CAPR$

Where

CAPR = Ratio of the DES/DXAC remaining cooling capacity

Equation N3-18

$CAPR = TANKCAP / FULLCAP$

$FULLCAP = IBClCAP \times 12000 = 40 \times 12000 = 480{,}000$ Btu

$TANKCAP = TANKCAP + QCHG – QCIB – TANKUA \times (OAT – 32)$

Total cooling energy use (kWh) is calculated as,

Equation N3-19 $TotCOOLKW = IBCOOLKW$

Operation Mode 2B – Idle

System does not have cooling demand. The DES/DXAC is in idle mode. The makeup DX unit is also in idle mode.

Energy use by the DES/DXAC during the idle mode is the parasitic electrical loss –

Equation N3-20 $IBCOOLKW = ParaIdle / 1000$

Total cooling energy use (kWh) is calculated as,

Equation N3-21 $TotCOOLKW = IBCOOLKW$

APPENDIX D

Residential Algorithms

To include this optional capability, ACMs must allow the user to specify the ISAC system model number which is linked to the information contained in the approved model performance description file. The ACM must report the use of a ISAC system in the *Special Features and Modeling Assumptions* section of the reports. The ACM user shall also attach manufacturer's equipment specifications describing the performance of the ISAC system.

Algorithms and Modeling Assumptions

The hourly electricity consumption in kWh for ISAC systems shall be calculated using the algorithms described in this section. This section is a supplement to the air conditioning system calculations detailed in Section 4.7.
Since the initial application, several modifications have been made to the residential model.

- The ability to specify the peak months and a peak melting start time has been added. The algorithm now reads and uses the peak month specifications (see fPeakMonth to OpStMeltHour below) from the nonresidential portion of the description file to determine the melt start hour
- The model can now model a backup (second) compressor. If the variable IBBackup is set to true, the system is assumed to have a second compressor, allowing the primary compressor to provide the maximum possible ice make cycle.
- The model can now default to the ACM SEER 13 model when there is no ice stored. If the variable IBSEER13 is set to true, the model uses the EER passed through from the ACM algorithm for air conditioners for the zero ice stored case instead of the zero row case from the description file.
- Several changes were made to enable the algorithm to account for the tank losses when the tank is empty during the operating season and to remove the double counting of the 0.88 sensible heat multiplier on the gross cooling output that is already accounted for in the calling program.

Ice Storage Air Conditioning System

The ACM calculates the hourly cooling electricity consumption for ice storage air conditioning systems using Equation R6-8. This equation is of the same form as Equation R4-34 used to calculate the electricity consumption of standard air conditioners.

Equation R6-8 $$AC_{kWh} = (Fan_{Wh} + Comp_{Wh} + PPC_{Wh}) / 1,000$$

Where

AC_{kWh} = Air conditioning kWh of electricity consumption for a particular hour of the simulation. This value is calculated for each hour, combined with the TDV multipliers, and summed for the year.

Fan_{Wh}= Fan watt-hours for a particular hour of the simulation. This is calculated using Equation R4-38.

$Comp_{Wh}$= Compressor watt-hours for a particular hour of the simulation. This is calculated using Equation R6-9.

PPC_{Wh}= Parasitic Power watt-hours for a particular hour of the simulation. This is calculated using Equation R6-10.

Model Performance Description File

As many parameters and tables are needed to describe the performance of an ice storage air conditioning system, a standardized model performance description file has been created and is shown in Figure R6-6. Each approved ice storage system will have a separate description file. ACMs shall be able to read the model performance description file, which is stored in a comma separated file (.csv) that is viewable in spreadsheets or with other programs. Not all values in the file are used in the residential model.

Since the initial application, this data file has been updated to use performance data measured by ETL.

Figure R6-6 – Ice Storage Model Performance Description File

===== DES/DX-AC Energy Performance Data File =====

Value	**Name**	**Units**	**Description**
2	FileFormat	none	File format version
ETL data, 40 ton-hours, 8am start	Model	25 Characters	Model number that software user sees
Description	Description	25 Characters	Short description of model features. Additional text may be added at end of file
40	ClCAP	ton-hr	Cooling capacity
15	TankUA	Btu/hr-F	Tank UA
301	ParaCool	W	Power during ice melting (cooling)
14	ParaStore	W	Power during ice making (storage)
2.6	ParaIdle	W	Power during standby (idle)
22	sngChgEarliestStart	hour (1-24)	Earliest start time for ice making
7	sngChgLatestStop	hour (1-24)	Latest end time for ice making
6	sngChgOffset	hour (1-24)	Target time to end ice making (Start time = SngChgOffset - (Run Hours * sngChgMult))
1.5	sngChgMult	none	Multiplier for run time to calculate start time for ice making
4	fStoreMonth	month (1-12)	First month of year that ice making (storage) is enabled
10	lStoreMonth	month (1-12)	Last month of year that ice making (storage) is enabled
===== Nonresidential Model Values =====			
7.5	MaxClTon	ton	Maximum cooling rate
60000	RIBCondCap	Btu/h	ARI rated direct cooling capacity of an DES/DXAC outdoor unit
0.1	sngMinCapRatio	none	If no discharging on previous day and tank cap still more than this, don't charge
0.995	sngMaxCapRatio	none	Don't charge tank when tank capacity is more than this
5	fPeakMonth	month (1-12)	First Peak Month
9	lPeakMonth	month (1-12)	Last Peak Month
12	PStMeltHour	hour (1-24)	Peak Month StartMelt Hour
9	OpStMeltHour	hour (1-24)	Off-Peak StartMelt Hour
12	sngCoolingEnabled	hour (1-24)	Hour of day when DES/DXAC (either ice-melt or direct) cooling becomes enabled
19	CoolingDisabled	hour (1-24)	Hour of day when DES/DXAC cooling becomes disabled
0.2592	EIRib	none	DOE-2 input. Energy Input Ratio of ISAC in direct cooling mode under ARI rated conditions
0.1577	sngCAPR	none	Fraction of sensible cooling capacity when ice tank is full
===== Nonresidential Performance Values =====			
7.067491	sngCap10		DES/DX-AC performance curve for condensing unit capacity in charging mode as a bi-quardratic equations of
-0.072931	sngCap11		outside air temperature and charging completion ratio
0.000362	sngCap12		
-13.736024	sngCap13		
15.715263	sngCap14		
0.058074	sngCap15		
3.179969	sngCap20		
-0.006074	sngCap21		
-0.000022	sngCap22		
-0.016668	sngCap23		
0.011039	sngCap24		
0.000041	sngCap25		
44.540456	sngEER10		DES/DX-AC performance curve for condensing unit EER in charging mode as a bi-quardratic equations of
-0.575795	sngEER11		outside air temperature and charging completion ratio
0.002373	sngEER12		
-52.272205	sngEER13		
47.510746	sngEER14		
0.247985	sngEER15		
26.902775	sngEER20		
-0.258017	sngEER21		
0.000563	sngEER22		
0.731743	sngEER23		
-0.880715	sngEER24		
0.004654	sngEER25		
0.053816	sCapFT0		DES/DXAC performance curves COOL-CAP-FT and COOL-EIR-FT in direct DX cooling mode (SEER 13, EER 11
0.020449	sCapFT1		
-0.000015	sCapFT2		
-0.000892	sCapFT3		
-0.000012	sCapFT4		
-0.000026	sCapFT5		
0.991170	sEIRFT0		
-0.029587	sEIRFT1		
0.000240	sEIRFT2		
0.016367	sEIRFT3		
0.000050	sEIRFT4		
-0.000172	sEIRFT5		
===== Residential Performace Values =====			
13	Number of Rows		
6	Number of Columns		

Cond Unit Capacity (tons)	Outdoor Air Temp				
Ice Bank Fraction Full	55	65	75	85	95
0.00%	4.43	4.08	3.6	3.39	3.64
3.21%	3.65	3.47	3.15	3.05	3.15
11.09%	3.2	3.09	2.85	2.8	2.77
15.77%	2.77	2.72	2.54	2.55	2.38
25.13%	2.77	2.7	2.54	2.55	2.38
34.49%	2.77	2.7	2.54	2.55	2.38
43.85%	2.77	2.7	2.54	2.55	2.38
53.21%	2.77	2.7	2.54	2.55	2.38
62.56%	2.77	2.7	2.54	2.55	2.38
71.92%	2.77	2.7	2.54	2.55	2.38
81.28%	2.77	2.7	2.54	2.55	2.38
90.64%	2.77	2.7	2.54	2.55	2.38
100.00%	2.77	2.7	2.54	2.55	2.38

Cond Unit EER (Btu/h-W)	Outdoor Air Temp				
Ice Bank Fraction Full	55	65	75	85	95
0.00%	21.1	17.83	14.55	12.61	11.95
3.21%	18.45	15.66	12.87	11.31	10.14
11.09%	16.57	14.12	11.67	10.38	8.84
15.77%	14.69	12.58	10.47	9.46	7.55
25.13%	14.62	12.79	10.97	9.51	7.59
34.49%	14.63	12.74	10.84	9.43	7.78
43.85%	14.64	12.77	10.89	9.47	7.74
53.21%	14.65	12.85	11.04	9.53	7.77
62.56%	14.68	12.86	11.03	9.61	7.81
71.92%	14.72	12.82	10.92	9.56	7.77
81.28%	14.65	12.71	10.76	9.54	7.72
90.64%	14.65	12.71	10.77	9.46	7.73
100.00%	14.57	12.68	10.79	9.51	7.75

===== Additional Description =====

Format 2 has 13 rows of data, not 12. Added number of rows

Additional Line 2

Add as many lines as desired here

Not intended to be read by software

In addition to the performance maps shown near the end of this file, other values used by the residential model include:

ClCAP = Cooling capacity, ton-hr
TankUA = Tank UA, Btu/hr-F
ParaCool = Power during ice melting (cooling), W
ParaStore = Power during ice making (storage), W
ParaIdle = Power during standby (idle), W
sngChgEarliestStart = Earliest start time for ice making, hour (1-24)
sngChgLatestStop = Latest end time for ice making, hour (1-24)
sngChgOffset = Target time to end ice making, hour (1-24)
sngChgMult = Multiplier for run time to calculate start time for ice making,
fStoreMonth = First month of year that ice making (storage) is enabled, month (1-12)
lStoreMonth = Last month of year that ice making (storage) is enabled, month (1-12)
fPeakMonth = First month of peak period, month (1-12)
LPeakMonth = Last month of peak period, month (1-12)
PStMeltHour = Peak month starting melt hour (1-24)
OpStMeltHour= Off -peak month starting melt hour (1-24)
IBBackup = When true, the algorithm assumes that a backup system is in use
IBSEER13 = When true, the algorithm uses the EER passed from the calling program when storage is zero

The Capacity and EER are interpolated from the performance maps as a function of the current ice storage and the current outdoor temperature.

Capacity = Capacity(InStorage, $T_{outdoor}$) double interpolated from performance maps
EER = EER(InStorage, $T_{outdoor}$) double interpolated from performance maps

The SensibleCoilCap is equal to the Design Cooling Capacity calculated in accordance with Residential ACM Appendix RF.

Initialization

Unlike standard air conditioners, the performance of the ice storage system depends on conditions from previous hours of the simulation. Therefore, certain parameters must be initialized at the beginning of the simulation.

```
SUB ICEBEARINIT(ZONE%)
    ' Initialize InStorage = Ice stored at beginning of hour, kBtu
    InStorage(ZONE%) = 0
    ' Initialize DailySumHoursMelting = The total hours of melting for the day, hours
    DailySumHoursMelting(ZONE%) = 0
END SUB
```

Hourly Calculations

The following loop is executed for each hour of the year. The algorithm assumes that cooling loads are negative.

```
SUB ICEBEARHOURLY(ZONE%,SensibleCoilCap,CoolingLoad,Toutdoor,_
            Hour%,Day%,Month%,FanWh,CompWh,PPCWh,IBEER,IBZERO)

    ' IBEER should be set to value for CEC SEER 13 Equipment
    ' by calling routine

    IBZERO = 0 ' to count hours where ice storage is zero

    ' if not an operating month, assume no storage
    OperatingMonth% = TRUE
    IF (Month% < fStoreMonth(ZONE%) OR Month% > lStoreMonth(ZONE%))
THEN
      ' make sure an operating month
      OperatingMonth% = FALSE
      InStorage(ZONE%) = 0 ' throw away remaining ice
    END IF

    ' Calculate StorageDeficit = Amount that needs to be added to fill
    ' the ice tank to capacity, kBtu
    StorageDeficit = IBCICAP(ZONE%) * 12.0 - InStorage(ZONE%)
    IF (StorageDeficit < 0) THEN
      StorageDeficit = 0
    END IF

    ' Calculate GrossCoolingOutput = Total cooling delivered
    ' including fan heat, kBtu
    GrossCoolingOutput = (-CoolingLoad + 3.413 * FanWh) / 1000.0

    ' Calculate MeltHours = Fractional number of hours of ice
    ' melting during current hour
    MeltHours = 0
    IF (InStorage(ZONE%) > 0 AND CoolingLoad < 0) THEN
      MeltHours = -CoolingLoad / SensibleCoilCap
    END IF

    ' Calculate DailySumHours Melting = Hours of melting for
    ' the current day
    DailySumHoursMelting(ZONE%) = DailySumHoursMelting(ZONE%) +
MeltHours
    IF hour% = sngChgLatestStop(ZONE%) + 1 THEN
      DailySumHoursMelting(ZONE%) = 0
    END IF

    ' Calculate RefHr = Reference hour used to determine when
    ' to start ice build, hour
    RefHr = hour%
    IF (hour% > 12) THEN
```

```
  RefHr = hour% - 24
END IF

' Calculate BuildStartRefHr = Starting reference hour
BuildStartRefHr = sngChgOffset(ZONE%) - _
            DailySumHoursMelting(ZONE%) * sngChgMult(ZONE%) - 1

' Calculate BuildingThisHour = flag to see if building
' this hour, true/false
BuildingThisHour% = FALSE
IF OperatingMonth% THEN
  ' make sure an operating month
  IF (RefHr > BuildStartRefHr) THEN
    ' make sure refhr after building start hour
    IF (hour% <= sngChgLatestStop(ZONE%) OR_
      hour% >= SngChgEarliestStart(ZONE%)) THEN
      BuildingThisHour% = TRUE
    END IF
    END IF
END IF

' Calculate TankLoss = tank loss, kBtu
TankLoss = 0

' Only calculate tank losses if system is allowed to operate
IF OperatingMonth% THEN
  TankLoss = (Toutdoor - 32.0) * TankUA(ZONE%) / 1000.0
END IF

' Conservative model of tank losses as it assumes
' that tank remains at 32F rather than calculating tank
' temperature in liquid state. Actual losses lower.
DXOnly% = FALSE
' Accumlate tank losses in storage tank
IF InStorage(ZONE%) < 0 THEN
  DXOnly% = TRUE
  ' Enables accumlation of tank losses when the system is
  ' operating, but it is out of ice.
  ' Losses must be made up during next make cycle
END IF

' set melt starting hour based on peak months
MeltHourStart = OpStMeltHour(ZONE%)
IF (Month% >= fPeakMonth(ZONE%) AND_
  Month% <= lPeakMonth(ZONE%)) THEN ' make sure a peak month
  MeltHourStart = PStMeltHour(ZONE%)
END IF
IF hour% < MeltHourStart THEN
  DXOnly% = TRUE
```

```
END IF

' Calculate TotalOutput = compressor output, kBtu
TotalOutput = GrossCoolingOutput - InStorage(ZONE%)
IF DXOnly% THEN
  TotalOutput = GrossCoolingOutput
END IF
IF TotalOutput < 0 THEN
  TotalOutput = 0
END IF

Capacity = INTERPXY(IBCAP(),ZONE%,IBMROW%,IBMCOL%,_
            InStorage(ZONE%),Toutdoor)

IF BuildingThisHour% THEN
  TotalOutput = GrossCoolingOutput + StorageDeficit
  IF NOT IBBackup%(ZONE%) THEN
    IF TotalOutput > Capacity THEN
      TotalOutput = Capacity
    END IF
  END IF
END IF

' Calculate BuildHours = fractional number of build hours
BuildHours = 0
IF BuildingThisHour% THEN
  BuildHours = TotalOutput / Capacity
END IF

' Calculate DeltaIce = change in ice storage, kBtu
DeltaIce = TotalOutput - GrossCoolingOutput - TankLoss
IF IBCICAP(ZONE%) = 0 THEN
  DeltaIce = 0 ' if no capacity, no change in ice storage
END IF

IF NOT FirstCharge% AND BuildingThisHour% THEN
  FirstCharge% = TRUE ' for special report
END IF

' Calculate Compressor and parasitic energy use, Wh
EER = INTERPXY(IBEER(),ZONE%,IBMROW%,IBMCOL%,InStorage(ZONE%),Toutdoor)

IF IBSEER13%(ZONE%) AND InStorage(ZONE%) = 0 AND IBEER <> 0 THEN
  EER = IBEER ' IBEER set to CEC SEER 13 value before call
END IF
IBEER = EER
```

```
    CompWh = TotalOutput / EER * 1000.0
    PPCWh = MeltHours * ParaCool(ZONE%) + BuildHours * ParaStore(ZONE%)
+ _
      (1 - MeltHours - BuildHours) * ParaIdle(ZONE%)

    ' Calculate InStorage for next hour.
    ' Negative means tanklosses need to be made up
    InStorage(ZONE%) = InStorage(ZONE%) + DeltaIce
                                                  END SUB
```

APPENDIX E

Third Party Data Submittal Forms

Testing Laboratory	
Address	
Phone Number	
Contact Person	
Date Tested	
Tracking Number	
Model Number	
Manufacturer	

Parameter	**Value**
Max Cooling Capacity (Btu/hr)	
Direct Cooling Capacity (Btu/hr)	
Direct Cooling EIR	
Storage Capacity (Ton-Hours)	
Tank UA (Btu/(hr.F))	
Parasitic losses during discharge (KW)	
Parasitic losses during charge (KW)	
Parasitic losses while idle (KW)	

Cooling capacity (Tons)of the AC Units for making Ice					
Ambient Temperature	**55**	**65**	**75**	**85**	**95**
Tank Ice Capacity (% charge)					
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity
Cap	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity	Cooling Capacity

EER of the AC Units for making Ice					
Ambient Temperature	**55**	**65**	**75**	**85**	**95**
Tank Ice Capacity (% charge)					
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER
Cap	EER	EER	EER	EER	EER

Bi-quadratic performance coefficients

Bi-quadratic breakpoint =

Bi-quad Capacity Coefs < Breakpoint
sngCap10 =
sngCap11 =
sngCap12 =
sngCap13 =
sngCap14 =
sngCap15 =

Bi-quad EER Coefs < Breakpoint
sngEER10 =
sngEER11 =
sngEER12 =
sngEER13 =
sngEER14 =
sngEER15 =

Bi-quad Capacity Coefs >= Breakpoint
sngCap20 =
sngCap21 =
sngCap22 =
sngCap23 =
sngCap24 =
sngCap25 =

Bi-quad EER Coefs >= Breakpoint
sngEER20 =
sngEER21 =
sngEER22 =
sngEER23 =
sngEER24 =
sngEER25 =

Direct Cooling Capacity Coefs, if verified
sCapFT0 =
sCapFT1 =
sCapFT2 =
sCapFT3 =
sCapFT4 =
sCapFT5 =

Direct Cooling EIR Coefs, if verified
sEIRFT0 =
sEIRFT1 =
sEIRFT2 =
sEIRFT3 =
sEIRFT4 =
sEIRFT5 =

Control Parameters	
Parameter	**Value**
Min Cap Ratio	
Max Cap Ratio	
Charging Hr Offset	
Charging Hr Multiplier	
Latest Charge Stop	
Earliest Charge Start	
First Peak Month	
Last Peak Month	
Peak Start Melt Hr	
Off Peak Start Melt HR	
Cooling Enabled	
Cooling Disabled	
First Operating Month	
Last Operating Month	

APPENDIX F

Approved Ice Storage Air Conditioners

Ice Energy Inc.

Nonresidential Units	**Equipment Approval Date**
B600 LRL1CXX	Approved April 26, 2006
B600 LT159LT	Approved April 26, 2006
B600 LTL1CFT	Approved April 26, 2006

Residential Units	
B600 LRL1CXX-R	Approved April 26, 2006
B600 GTG1CXX-R	Approved April 26, 2006