Evaporatively Cooled Condensing Units

Compliance Options Application

STAFF REPORT

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Governor Arnold Schwarzenegger

CALIFORNIA ENERGY COMMISSION

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EXECUTIVE SUMMARY

Staff has prepared this report evaluating an application for approval of a compliance option for evaporatively cooled condensing units used for low-rise residential buildings. This application was submitted by Freus Air Conditioning of Vinton, Texas. The proposed compliance option would provide compliance credit under the *2005 Building Energy Efficiency Standards* (Standards) for residential buildings when an evaporatively cooled condensing unit is installed.

An evaporatively cooled condensing unit is more efficient than an air-cooled unit, resulting in reduced energy usage especially during the peak periods when the cooling load is high. An evaporatively cooled condensing unit is similar to a conventional split system, air-cooled condensing unit except that water is sprayed on the condenser coils by a water pump. The condenser coil remains wet during the unit's operation. The condenser fan draws air through the wet coil, and the coil is evaporatively cooled. The compressor operates at lower temperature and pressure, which increases the efficiency of the unit. The water pump consumes some extra energy, but this is insignificant compared to the improvement in efficiency.

Staff supports approval of this compliance option on the condition that evaporatively cooled condensing units meet the acceptance testing and eligibility criteria specified in this report. Credit from approval of this compliance option would be applied to all evaporatively cooled condensing equipment that meet the acceptance requirements and eligibility criteria set forth in this compliance option. Compliance software could be updated to include this compliance option to model evaporatively cooled condensing units as specified in this report, and such software updates would need to be approved by the California Energy Commission.

SUMMARY OF APPLICANT'S REQUEST

The applicant proposed that compliance credit for evaporatively cooled condensing units be approved because it will reduce energy usage, particularly during hot periods. Building energy use for the 2005 Standards is calculated using Time Dependent Valuation (TDV) energy use, which places substantially higher value on saving energy during peak electricity periods. To calculate TDV energy use, hourly energy use is multiplied by a TDV multiplier. The TDV multiplier depends on the climate zone and on the hour of energy use. Based on TDV, the credit for this compliance option will be substantial.

The applicant presented eligibility criteria and acceptance requirements in the application to qualify evaporatively cooled condensing units for compliance credit. The eligibility criteria address the Home Energy Rating System (HERS) Rater verification of specific measures that impact the efficient performance of the equipment. The acceptance requirements call for installer verification of the proper operation of required controls and the presence of required features that protect against scale buildup and

corrosion of components of the unit. The eligibility criteria and acceptance requirements are discussed on page 8 of this report.

Evaluation of Proposal

Staff evaluated the proposal using a research version of MICROPAS, an Energy Commission certified compliance software program. Staff also visited a home where the system was installed to observe how the equipment is operated and maintained.

Staff observed that the system is reliable and simple to operate. Corrosion is minimized by use of cathodic protection and a nonmetallic cabinet. A flush pump, which runs periodically after a specified compressor run time, removes solids from the water that is reused in the evaporative process. As the unit cycles, the coils are subjected to high and low temperatures (thermal shock). As the coils expand and contract, solids are removed from the coil surfaces. The water sump at the bottom of the condensing unit is automatically flushed periodically to ensure good water quality for the water that is cycled through the evaporative process and less reintroduction of solids onto the coil surfaces.

To ensure that the condenser continues to reliably operate as an evaporatively cooled unit, if the water pump fails to operate, the pressure at the discharge of the compressor will rise due to higher temperature, and the compressor will trip off due to high head pressure. The high head pressure trip for the compressor is set at 285 psig (pounds per square inch gauge) for refrigerant R22.

To ensure good heat transfer, the condenser coils are made of copper. These coils are sprayed with a protective coating to reduce corrosion and accumulation of solids on the tube surface.

Compared to a conventional system, the condenser coils for this system will have longer life. The compressor runs at lower temperature and pressure. This increases compressor life and reduces maintenance and replacement costs.

Features that increase the reliability of the energy savings over the life of the equipment are included in the eligibility criteria. To ensure that the equipment performs as intended, the installer will complete acceptance testing and provide a signed CF-6R form that will be provided to the HERS Rater and the building department.

Compared to a conventional split system, air-cooled condensing unit, this system requires some additional routine simple maintenance checks (for example, visual inspection to check proper water level, proper drainage of water and the lack of solids in the sump).

Test Data Submission and Energy Commission Approval Process

In order to list evaporatively cooled condensing units that qualify for compliance credit, manufacturers shall submit the data using the form in Appendix D to the Energy Commission. This data shall include:

- Brand
- Manufacturer
- Model number
- EER_a (EER at 95^o F DB and 75^o F WB)
- EER_b (EER at 82^o F DB and 65^o F WB)
- Unit Capacity in Tons at ARI Test conditions
- Condenser air flow during the test at 95^o F DB and 75^o F WB
- Condenser inlet air moisture content (lbm of water per lbm of air) at 95^o F DB and 75^o F WB
- Condenser outlet air moisture content (lbm of water per lbm of air) at 95^o F DB and 75^o F WB
- Water capacity of the water tank (gallons)
- Compressor run time between each flush (hours)
- Total water use at 95^o F DB and 75^o F WB including evaporation, drift and flush (gallons per ton-hour) - The water use is based on published manufacturer test data determined in accordance with ARI test conditions (95^o F DB and 75^o F WB).

Approval of specific values for modeling input parameters for each model number will be made by the Executive Director for authorization of the extension of the compliance option to cover specific models. All the approved models will be posted on the Energy Commission website.

COMPLIANCE CREDIT ANALYSIS

Table 1 compares the Standards' energy budget (based on the Standard Design with all of the Package D measures including a minimally compliant air conditioner with an air-cooled condensing unit) for the base-case 1,761 square foot home for all the climate zones to a building with exactly the same features except it has an evaporatively cooled condensing unit.

TABLE 1
Energy use of a 1,761 square foot house with standard design features and an evaporatively cooled condensing unit compared to the same house with an air-cooled condensing unit

Climate Zone	Standard cooling energy TDV KBtu/sqft)	Proposed cooling energy (TDV KBtu/sqf)	Standard total energy (TDV KBtu/sqft)	Proposed total energy (TDV KBtu/sqft)	Reduction in cooling energy	Reduction in total energy
1	0.34	0.27	32.19	32.12	21%	0.2%
2	10.03	6.59	44.74	41.3	34%	8%
3	3.58	2.73	29.52	28.67	24%	3%
4	4.12	3.18	33.02	32.08	23%	3%
5	4.02	2.98	29.38	28.34	26%	4%
6	4.18	3.22	22.65	21.69	23%	4%
7	3.12	2.5	22	21.38	20%	3%
8	9.72	7.05	29.68	27.01	27%	9%
9	16.11	11.25	36.18	31.32	30%	13%
10	25.88	16.57	48.01	38.7	36%	19%
11	23.94	14.86	55.74	46.66	38%	16%
12	16.8	10.85	46.9	40.95	35%	13%
13	33.05	20.85	58.45	46.25	37%	21%
14	33.44	19.55	66	52.11	42%	21%
15	74.05	30.61	88.72	45.28	59%	49%
16	10.55	7.39	62.54	59.38	30%	5%

The reduction in energy shown in Table 1 represents the compliance credit resulting from installation of an evaporatively cooled condensing unit in this house. The amount of compliance credit depends on the climate zone and the evaporatively cooled condensing unit's Energy Efficiency Ratio (EER) at two wet bulb temperatures as certified by the Air-conditioning and Refrigeration Institute (ARI). The table above shows the amount of credit for an evaporatively cooled condensing unit with a 14.8 EER rating at 75^{o} F wet bulb and a 16.7 EER rating at 65^{o} F wet bulb. Compliance credits for climate zones 9 through 15 are substantial due to the large cooling loads in those hotter climates.

Table 2 compares the energy use for a 1,761 square foot home, if the credit for evaporatively cooled condensing units is traded off completely by increasing window area in the still complying building. In actual practice staff believes that the credit may often not be traded off completely. Most likely, some of the credit will be traded off to increase some fenestration area in some buildings. The energy impact of using an evaporatively cooled condensing unit on a larger, 2,698 square foot house is shown in Tables 6 and 7 in Appendix A.

TABLE 2
Cooling and heating energy use of a 1,761 square foot house when compliance credit is completely traded off by increasing window area

Climate Zone	Standard cooling energy (TDV KBtu/sf)	Standard heating energy (TDV KBtu/sqft)	Proposed cooling energy (TDV KBtu/sqft)	Proposed heating energy (TDV KBtu/sqft)	Square feet of added glass (equally distributed)	Cooling Load Increase (Btu/hr)	Heating Load Increase (BTU/hr)
1	0.34	19.07	0.27	19.1	3.8	2097	792
2	10.03	22.32	9.12	24.25	87.8	5520	3276
3	3.58	13.56	3.58	14.05	27.8	3506	1403
4	4.12	16.67	3.93	17.41	27.8	1936	1519
5	4.02	13	3.86	13.74	7.8	3374	1528
6	4.18	5.21	4.27	5.64	47.8	4495	1647
7	3.12	5.65	3.04	6.11	47.8	2479	1582
8	9.72	6.87	9.47	7.82	107.8	4736	3226
9	16.11	7.08	15.79	8.58	147.8	6281	3538
10	25.88	9.15	24.8	11.5	247.8	10269	4523
11	23.94	19.78	21.73	23.45	207.8	10867	6034
12	16.8	17.93	15.69	20.32	147.8	7588	3923
13	33.05	13.7	31.09	17.5	287.8	13671	7696
14	33.44	19.34	30.39	24.35	307.8	14703	10906
15	74.05	2.87	73.05	5.92	527.8	27305	13425
16	10.55	38.87	10.34	40.9	67.8	6289	3320

If all the compliance credit available for installing evaporatively cooled condensing units is traded off for increased window area, there will be a substantial increase in heating energy use in climate zones 10 through 15. It is possible that an increase in heating energy use could result in a significant environmental impact. Environmental impacts are addressed on page 9 of this report.

Staff believes that the performance of evaporatively cooled condensing units will degrade over time due to scaling of condenser coils and corrosion of unit components. Performance degradation will depend on water quality and operation and maintenance practices. To minimize performance degradation, some of the possible sources of scaling and corrosion are addressed by the acceptance requirements.

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 eligibility criteria include HERS-Rater verification of the Energy Efficiency Ratios (EERs) certified by ARI, required duct sealing for all installations, and verification of the presence of a Thermostatic Expansion Valve (TXV) when required to achieve the EERs. The Acceptance Requirements call for installer verification of the proper operation of required controls and the presence of required features that protect against scale buildup and corrosion of components of the unit.

Eligibility Criteria

The eligibility criteria require the measures listed below. These measures must be certified by the installer on the CF-6R and verified by a HERS rater and certified on the CF-4R.

- EER at 95^{o} F dry bulb and 75^{o} F wet bulb temperature is listed with ARI (generally called EER_a).
- EER at 82^{o} F dry bulb and 65^{o} F wet bulb temperature is submitted to ARI and published by the manufacturer in accordance with ARI guidelines (generally called EER_b).
- Presence of TXV is verified, if the EERs are based on equipment with TXVs.
- Ducts are tested and sealed in all installations of this equipment.
- Proper refrigerant charge is verified if compliance credit is taken for this measure.

Acceptance Testing

The installing contractor shall complete the following acceptance testing and document the results to the Building Department using the CF- 6R form shown in Appendix B.

1. Verify that there is water in the water casing.
2. Switch on the cooling system by setting the thermostat below the room temperature.
3. Verify that the water pump starts running when the system is turned on.
4. When the water pump is running, verify that all the condenser coils are wet.
5. Verify that the high pressure trip for the compressor is set (per manufacturer's specifications) at or below 300 psig for R22 Refrigerant and at or below the saturation pressure corresponding to a temperature of 131^{o} F for all other refrigerants.
6. Turn off the water supply to the water casing, drain the water from the sump, and verify that the water pump (if the pump is water cooled) and the compressor trip.
7. Verify that the condenser coils have a corrosion resistant coating and that the water casing is made up of corrosion-resistant material.
8. Verify that the electrolytic protection is installed as specified by the manufacturer.
9. Verify that a blow-down pump is installed for periodic blow-down to remove solids from the water casing. Verify that the operation of this pump is automatic based on compressor run time or the conductivity of the water in the casing.

10. Verify that the water casing is sloped downward toward the blow-down pump location to facilitate removal of solids.

The following eligibility criteria were added as additional mitigation of unit water usage:

11. Verify that drift elimination is in place and there is no mist of water exiting with the exhaust air.
12. Verify that condensate from the cooling coils is routed to water casing unless a document is submitted to the Building Department showing that doing so is not practical due to availability of space, health, or safety concerns.
13. Verify that there the manufacturer has documented that the water consumption is less than or equal to 5.0 gallons per ton-hour of capacity at ARI capacity test rating conditions.
14. Verify that the water connection is made with tubing not more than ¼" internal diameter at the unit. (A larger line may come up to the connection).
15. Verify that overflow from the unit is not connected to any piping, unless there is an alternate method of determining an overflow (such as an alarm) approved by the Executive Director. In case there is a water overflow situation, the water must fall on the ground, and the overflow condition must be clearly visible unless there is an alternate method of determining an overflow (such as an alarm) approved by the Executive Director.

Modified compliance forms for evaporatively cooled condensing units are included in appendices B and C.

ALTERNATIVE CALCULATION METHODS APPROVAL MANUAL SECTION

The following algorithms provide information for compliance software developers regarding the Energy Commission-approved modeling approach for evaporatively cooled condensing units. This information is provided in the format of an insert to Section 4.7.1 of the *2005 Standards Residential Alternative Calculation Methods Approval Manual*.

Cooling System Energy (4.7.1)

Evaporatively Cooled Condensing Units

The calculation of the hourly cooling electricity consumption shall be determined using equations R4-34 and R4-36 in Section 4.7.1 of the *Residential ACM Manual*. Equations R4-37(ec), R4-40(eca) and R4-40(ecb) shown below shall replace equations R4-37 and R4-40, respectively. Equations R4-35, R4-38 and R4-41 do not apply to evaporatively cooled condensing units.

Equation R4-40(eca) $EER_{nfa} = (1.0452*EER_a+0.0115*EER_a\text{^}2+0.000251*EER_a\text{^}3)*F_{txv}*F_{air}*F_{size}$

Equation R4-40(ecb) $EER_{nfb} = (1.0452*EER_b+0.0115*EER_b\text{^}2+0.000251*EER_b\text{^}3)*F_{txv}*F_{air}*F_{size}$

Where:

EER_a = EER at 75^o F wet bulb listed with ARI
EER_b = EER at 65^o F wet bulb published by the manufacturer in accordance with ARI guidelines
F_{txv} = TXV factor (Default value of F_{txv} is 0.96. If TXV installation is verified, F_{txv} = 1.0)
F_{air} = Air flow factor (Default value of F_{air} is 0.925. If air flow is verified, F_{air} = 1.0)
F_{size} = Sizing factor (Default value of F_{size} is 0.95. If the equipment is sized using the method in Appendix RF, F_{size} = 1.0)

Equation R4-37(ec) $$CE_t = EER_{nfa} - ((EER_{nfa}-EER_{nfb})*7.5) + ((EER_{nfa}-EER_{nfb})/10)xT_{wb}$$

Where

T_{wb} = Outdoor wet bulb temperature taken from the Energy Commission weather file.
CE_t = Energy efficiency ratio at a particular wet bulb temperature. EER_{nfa} and EER_{nfb} are calculated using equation R4-40(eca) and R4-40(ecb).

Other Requirements of ACM Developers

ACM developers must cause inputs to be linked between the credit for evaporatively cooled condensing units and duct sealing so that errors cannot be made by the program user. If the user chooses evaporatively cooled condensing units, the user must be notified that duct sealing is also required, and compliance results must not be determined until both measures are properly selected.

ACMs also must also automatically list “Evaporatively Cooled Condensing Unit” on page 2 of the CF-1R and provide both the EER_a (measured at outdoor wetbulb temperature of 75^o F) and EER_b (measured at outdoor wetbulb temperature of 65^o F). ACMs also must automatically list “Evaporatively Cooled Condensing Unit” and “Duct Sealing” on page 4 of the CF-1R in the list of “Special Features Requiring HERS Rater Verification when the user chooses to take compliance credit for evaporatively cooled condensing units.

ENVIRONMENTAL IMPACT

Air Quality

Approval of this compliance option for evaporatively cooled condensing units will provide substantial cooling compliance credit. The credit may be traded off to allow other less efficient equipment and building envelope features. This may result in increased building space heating and/or cooling loads. For example, this compliance credit may be traded off for measures such as more window area or reduced wall and ceiling insulation. 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 hard to predict the expected market penetration of evaporatively cooled condensing units. To assess air quality impacts that could occur as a result of Energy Commission 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 (SEER 13) in the base case building was replaced with an evaporatively cooled condensing unit, and the building window area was increased until the building became minimally compliant with the energy budget. The onsite heating energy usage of the proposed building was compared to the base case. The increase in natural gas energy usage was multiplied by emission factors that are applicable to natural gas furnaces for each primary pollutant to estimate the potential worst case incremental emissions that could result from approval of the compliance option.[1]

Table 3 shows the estimated worst case potential increase in emissions in comparison to total statewide emissions. The emission factors are based on California's statewide average furnace emissions factors developed by Energy Commission staff.

TABLE 3
Worst case increased emissions from approval of this compliance option

	NO_x	CO	PM_{10}
Statewide worst case increased emissions from this compliance option (Tons/yr)	**282.23**	**85.52**	**28.51**
Statewide total emissions (Tons/yr)	**1,244,449**	**6,376,204**	**1,174,229**
Worst case percent increase	**0.023%**	**0.00134%**	**0.0024%**

Table 4 shows the average emission factors for furnaces in California that were used in the analysis.

TABLE 4
Emission factors (Lbm per MMBtu)

Pollutant	**NO_X**	**CO**	**PM_{10}**
Emission factor	**0.05**	**0.03**	**0.01**

The emission data 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 evaporatively cooled condensing units is expected to be significantly lower (could be only 5 percent or less). Also, it is possible that compliance may occur without all of the energy savings being fully traded off.

[1] Note that reduced electricity consumption would reduce emissions at the power plant that generated the electricity (whether in California or at an out-of-state power plant that supplies electricity to California). These reduced emissions are not a negative environmental impact, and thus are outside this analysis. The location of the reduced emissions at the power plant is indeterminable.

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

Water Usage

Water usage is calculated for the worst case scenario (assuming that all new houses will have evaporatively cooled condensing units). Table 5 shows the estimated increased water usage based on 100 percent market penetration.

TABLE 5
Worst case water usage increase from the approval of this compliance option

Worst case increase in water use from this compliance option (Million acre-ft/yr)	**0.0036[2]**
Statewide water usage (Million acre-ft/yr)	**64.8**
Worst case percent increase	**0.0055 %**

Water consumption for evaporatively cooled condensing units is calculated by Energy Commission staff based on the information provided by the manufacturer. The statewide usage value is *California Water Plan Update 2005 Volume 1*. The value is based on year 2001, which had 72 percent of normal rainfall.

Staff finds that the incremental increase in water usage resulting from approval of this compliance option would be insignificant compared to the total water usage in the State.

In response to concerns from the California Urban Water Conservation Council (CUWCC) that installation of evaporatively cooled condensing units could lead to increased water usage at those residences, several eligibility criteria were added to further reduce water usage.

Table 6 shows the estimated water use due to evaporation minus the condensate from the cooling coils for all the climate zones for a three-ton unit. The data is calculated using a research version of MICROPAS, an Energy Commission-certified software for residential building modeling. The table shows total yearly usage, daily average usage based on yearly use, total for the month of July and for the peak (hottest) day in the month of July. The last column shows total water used in flushing. This data is for the applicant's unit.

[2] Value is based on 5 gallon per ton-hour performance requirement

TABLE 6

Water evaporation (in gallons) based on the model analyzed by the staff for a 1,761 square foot home[3]

Climate Zone	Yearly water Evaporation* minus condensate (gallons)**	Daily average water evaporation* minus condensate (gallons)**	Water evaporation* minus condensate for the month Of July (gallons)**	Daily peak water evaporation* minus condensate for the month of July (gallons)**	Daily average water evaporation* minus condensate for the month of July (gallons)**	Non consumptive flush (gallons per year)***
1	24	0	5	2	0	7
2	813	2	197	21	6	223
3	300	1	22	9	1	83
4	379	1	85	12	3	104
5	366	1	32	11	1	100
6	381	1	49	13	2	105
7	253	1	75	11	2	70
8	744	2	189	17	6	205
9	1,276	3	316	20	10	351
10	1,893	5	457	31	15	520
11	1,938	5	583	39	19	533
12	1,243	3	353	23	11	342
13	2,783	8	787	36	25	765
14	2,411	7	736	39	24	663
15	6,048	17	1,300	56	42	1,663
16	965	3	272	18	9	265

* Evaporation based on ETL tests during certification adjusted to 1.476 gallons/ 12,000 btuh.

** Recovery based on relatively dry California 75db/63wb indoor analysis @ 1.02 gallons per full load hour

***Flush based on 7.5 gallon flush every 8 hours of full load

[3] Water Use Values are derived from performance of Freus 3 ton model

Indoor Air Quality

Conditioned air in the house will never come in direct contact with water used in the evaporative process. There are no other potential indoor air quality impacts from installation of this equipment. Staff finds that this compliance option will not have a negative impact on indoor air quality.

STAFF CONCLUSIONS

Staff supports approval of this compliance option. Staff believes that this type of system will provide significant and reliable energy savings. Performance of evaporatively cooled condensing units is expected to degrade due to scaling of condenser coils. This may result in reduced savings over time. Reduction in savings will depend on operation and maintenance practices and water quality.

This product has water conservation features that reduce water consumption. These features include drift eliminators and water flushing operation control based on compressor operational hours.

During the public workshop the California Urban Water Conservation Council (CUWCC) raised concerns that installation of evaporatively cooled condensing units could lead to increased water usage at those residences. To address CUWCC's concerns, staff incorporated the following mitigation measures in the acceptance requirements:

- Requiring drift eliminators.
- Limiting water consumption to 5.0 gallons per ton-hour of capacity.
- Routing condensate from cooling coils to the water casing.
- Limiting the size of the water tubing at the unit to ¼-inch internal diameter.
- Making an overflow situation clearly visible (not allowing overflow connection to sewer drain).

APPENDIX A

COMPLIANCE CREDIT ANALYSIS FOR 2,698 SQUARE FOOT HOUSE

TABLE 7
Energy use of a 2,698 square foot house with standard design features and an evaporatively cooled condensing unit compared to the same house with an air-cooled condensing unit

Climate Zone	Standard cooling energy (TDV KBtu/sqft)	Proposed cooling energy (TDV KBtu/sqft)	Standard total energy (TDV KBtu/sqft)	Proposed total energy (TDV KBtu/sqft)	Reduction in cooling energy	Reduction in total energy
1	0.28	0.22	23.5	23.44	21.43%	0.26%
2	7.75	5.1	33.92	31.27	34.19%	7.81%
3	3.24	2.47	22.16	21.39	23.77%	3.47%
4	2.88	2.23	24.95	24.3	22.57%	2.61%
5	3.52	2.62	21.63	20.73	25.57%	4.16%
6	3.62	2.41	16.92	15.71	33.43%	7.15%
7	2.09	1.68	16.06	15.65	19.62%	2.55%
8	7.49	5.43	22.4	20.34	27.50%	9.20%
9	12.7	8.88	27.66	23.84	30.08%	13.81%
10	21.23	13.6	37.49	29.86	35.94%	20.35%
11	20.87	12.94	45.95	38.02	38.00%	17.26%
12	14.28	9.21	37.79	32.72	35.50%	13.42%
13	29.38	18.49	49.07	38.18	37.07%	22.19%
14	29.61	17.29	54.97	42.65	41.61%	22.41%
15	65.73	38.5	76.75	49.52	41.43%	35.48%
16	10.1	7.08	50.68	47.66	29.90%	5.96%

TABLE 8
Cooling and heating energy use of a 2,698 square foot house when compliance credits are completely traded off by increasing glass area

Climate Zone	Standard cooling energy (TDV KBtu/sqft)	Standard heating energy (TDV KBtu/sqft)	Proposed cooling energy (TDV KBtu/sqft)	Proposed heating energy (TDV KBtu/sqft)	Square feet of added glass (equally distributed)	Cooling Load Increase (Btu/hr)	Heating Load Increase (Btu/hr)
1	0.28	13.39	0.22	13.4	0.4	128	48
2	7.75	16.65	6.04	17.33	80.4	3,150	1,924
3	3.24	9.41	2.84	9.63	40.4	2,465	987
4	2.88	12.68	2.54	13	40.4	1,340	1,056
5	3.52	8.62	2.83	8.8	20.4	1,245	565
6	3.62	3.13	3.27	3.34	60.4	3,494	1,280
7	2.09	3.82	1.86	3.96	40.4	1,307	835
8	7.49	4.88	6.75	5.35	120.4	4,134	2,817
9	12.7	5	11.5	5.82	160.4	5,659	3,205
10	21.23	6.31	19.41	7.8	300.4	10,489	4,882
11	20.87	15.85	17.55	19.2	240.4	10,966	6,090
12	14.28	14.17	12.44	15.7	180.4	7,653	4,368
13	29.38	10.72	26.13	13.43	360.4	15,558	9,107
14	29.61	15.22	25.32	18.74	380.4	16,528	12,259
15	65.73	2.03	62.87	4.38	700.4	34,239	16,835
16	10.1	30.48	8.29	31.33	60.4	3,912	2,065

APPENDIX B

CERTIFICATE OF COMPLIANCE: FORM CF-6R

Note that staff proposes to change page 3A(ec) of the CF-6R as shown on the following page to direct the installer to enter the EER_a and EER_b for the evaporatively cooled condensing units and to complete the checkboxes for the eligibility criteria and acceptance requirements on page 3B(ec). Page 4 of the CF-6R also must be completed.

CERTIFICATE OF COMPLIANCE (FORM CF-6R)

INSTALLATION CERTIFICATE	**(Page 3A(ec) 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, per Section 10-103(a).

HVAC SYSTEMS:

Evaporatively Cooled Condensing Units

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

EER_a = EER at 75° F wetbulb and 95° F dry bulb
EER_b = EER at 65° F wetbulb and 82° F dry bulb

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

1.	EER at 95° F dry bulb and 75° F wet bulb temperature is listed with ARI	☐ Pass ☐ Fail
2.	EER at 82° F dry bulb and 65° F wet bulb temperature is submitted to ARI and published by the manufacturer in accordance with ARI guidelines.	☐ Pass ☐ Fail
3.	Presence of TXV is verified, if the ARI certified EERs are based on equipment with TXVs	☐ Pass ☐ Fail
4.	Ducts are tested and sealed in all installations of this equipment.	☐ Pass ☐ Fail
5.	Proper refrigerant charge is verified if compliance credit is taken for this measure when TXVs are not installed.	☐ 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 of Title 24), 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 COMPLIANCE (FORM CF-6R)

INSTALLATION CERTIFICATE	**(Page 3B(ec) 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, per Section 10-103(a).

HVAC SYSTEMS:

Evaporatively Cooled Condensing Units

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

1.	Water stays in the water casing.	☐ Pass ☐ Fail
2.	Water pump starts running when the system is turned on.	☐ Pass ☐ Fail
3.	When the water pump is running, verify that all the condenser coils are wet.	☐ Pass ☐ Fail
4.	High pressure trip for the compressor is set (per manufacturer's documents) at or below 300 psig for R22 Refrigerant and at or below the saturation pressure corresponding to a temperature of 131^0 F for all other refrigerants.	☐ Pass ☐ Fail
5.	When the water supply to the water casing is turned off and the casing is drained, the water pump (if the pump is water cooled) and the compressor trip off.	☐ Pass ☐ Fail
6.	Condenser coils have a corrosion-resistant coating.	☐ Pass ☐ Fail
7.	Electrolytic protection is installed, and the wiring of the protection circuit is intact.	☐ Pass ☐ Fail
8.	Water casing is made up of corrosion-resistant material	☐ Pass ☐ Fail
9.	A blow-down pump is installed for periodic blow-down in order to remove solids from the water casing. Operation of this pump is automatic and is linked to compressor run time or conductivity of the water in the casing.	☐ Pass ☐ Fail
10	Water casing is sloped downward toward the blow-down pump location.	☐ Pass ☐ Fail
11	Drift elimination is in place, there is not a mist of water exiting with the exhaust air.	☐ Pass ☐ Fail
12	Verify that condensate from the cooling coils is routed to water casing unless a document is submitted to the Building Department showing that doing so is not practical due to availability of space, health, or safety concerns.	☐ Pass ☐ Fail
13	Condenser has manufacturer's certification that water consumption is less than or equal to 5.0 gallons per ton-hour of capacity at ARI Rating conditions.	☐ Pass ☐ Fail
14	Water Connection is made with tubing not more than ¼" ID at the unit. Larger line may come up to the connection.	☐ Pass ☐ Fail
15	Overflow from the unit is not connected directly to the sewer drain (so that in the event of a water float failure, an overflow condition can be more easily detected) or another means of determining an overflow condition is provided.	☐ 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

CERTIFICATE OF FIELD VERIFICATION AND DIAGNOSTIC TESTING: FORM CF-4R

Note that the attached new page 5(ec) of the CF-4R must be completed for Evaporatively Cooled Condensing Units. The HERS Rater must verify that 1) the EER_a and EER_b on the CF-1R are no lower than the values listed with ARI and published by the manufacturers for the model that is installed, 2) a TXV is installed if the ARI and manufacturer's information indicates the EER_a and EER_b of the model is achieved through the installation of a TXV and/or if the CF-1R shows credit for a TXV, and 3) the requirements for duct leakage reduction compliance credit are met and page 1 of the CF-4R is completed.

CERTIFICATE OF FIELD VERIFICATION & DIAGNOSTIC TESTING (Page 5(ec) of 8) CF-4R

Project Address	Builder Name
Builder Contact Telephone	Plan Number
HERS Rater Telephone	Sample Group Number
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 installer has provided a copy of CF-6R (Installation Certificate).

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

1.	EER at 95° F dry bulb and 75° F wet bulb temperature is listed with ARI.	☐ Pass ☐ Fail
2.	EER at 82° F dry bulb and 65° F wet bulb temperature is submitted to ARI and published by the manufacturer in accordance with ARI guidelines.	☐ Pass ☐ Fail
3.	Presence of TXV is verified, if the ARI-certified EERs are based on equipment with TXVs.	☐ Pass ☐ Fail
4.	Ducts are tested and sealed in all installations of this equipment.	☐ Pass ☐ Fail
5.	Proper refrigerant charge is verified if compliance credit is taken for this measure when TXVs are not installed.	☐ Pass ☐ Fail

I, the undersigned, verify that equipment listed above my signature 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 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.

_____ _____

Signature, Date

Installing Subcontractor (Co. Name) OR
General Contractor (Co. Name) OR Owner

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

APPENDIX D

Data Form to be used by the manufacturers for submittal to the Energy Commission for listing evaporatively cooled condensing units that qualify for compliance credit.

Instructions: Provide the following measured efficiency and water use related data for the condenser model with the Highest Sales Volume Tested Coil Combination as submitted to ARI. The Maximum total water use allowed for compliance credit is 5 gallons per ton at 95° F DB and 75° F WB. The total water use for the condenser model is calculated from published manufacturer test data determined in accordance with ARI test conditions using the equations below. The total water use is the sum of the water evaporation plus drift plus the flush water minus the condensate recovery for the system.

Brand	
Manufacturer	
Model Number	
EER_a (EER at 95° F DB and 75° F WB)	
EER_b (EER at 82° F DB and 65° F WB)	
Unit Capacity (C) in Tons at ARI Test conditions This is capacity in Btu/h at EER_a divided by 12,000	
Condenser air flow (CFM) during the EER_a test at 95° F DB and 75° F WB	
Condenser inlet air moisture content (HR_1) in lbm of water per lbm of air during EER_a test at 95° F DB and 75° F WB	
Condenser outlet air moisture content (HR_2) in lbm of water per lbm of air during EER_a test at 95° F DB and 75° F WB	
Density at Condenser Outlet (D) in cubic feet per pound of dry air (in accordance with ASHRAE Psychrometric chart)	
Water Evaporation & Drift (E) in gallons per ton hour (Calculated using Equation 1 below and the measured data in this table)	
Water capacity of the water tank (in gallons)	
Gallons of Water Per Flush	
Compressor run time between each flush (hours)	
Flush (F) in gallons per Ton Hour (Calculated using Equation 2 below and the measured data in this table)	
Condensate Recovery (CR) - default 0.33 gallons/ ton hour. A measured amount may be substituted if it was recorded during the EER_a test	
Total Water Use (TWU) during EER_a test at 95° F DB and 75° F (Calculated using Equation 3 below and the calculated data in this table)	

Equation 1: E = Evaporation/Drift (gallons per ton hour) = CFM / C x 60 x (HR_2- HR_1) / D / 8.333

Note: 8.333 is a factor to convert pounds of water into gallons of water

Equation 2: F = Flush (gallons per ton hour) = Gallons per Flush / Run Hours between Flushes / C.

Note: If a conductivity meter is used to control the flush, instead of a timer, a default of 0.50 may be used as the default flush per ton hour.

Equation 3: TWU = E + F - CR

This form must be submitted to:

Rob Hudler
California Energy Commission
Buildings and Appliances Office
1516 9th Street, MS-25
Sacramento, CA 95814