



**TITLE 24, PART 6**

**2028 CODE CYCLE**



# Welcome to the Statewide CASE Team's Utility Sponsored Stakeholder Meeting



Topics: Updates to Hydronic Heat Pump Requirements:  
AWHP Glycol Concentration Limits



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# Agenda

Proposal Description

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Market and Technical Consideration

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Technical Barriers and Solutions

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Per Unit Energy and Cost Methodology

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Compliance and Enforcement

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Discussion and Next Steps



# Proposal Description

- Code Change Proposal
- Benefits
- Background Information



Photo credit: Red Car Analytics

# Proposed Code Change

1. Establish a maximum concentration of glycol (propylene or ethylene) for AWHPs to ensure high efficiency while protecting against freezing in cold weather
2. Concentration limits scale based on heating median of extremes temperature for the location
3. Exceptions for certain design situations (e.g. heating only, process loads, systems integrated with more complex HVAC systems, WWHPs)

**See [Title24stakeholders.com](https://Title24stakeholders.com)**  
for proposal description,  
justification, draft code  
language, and requested data

# Benefits of the Proposed Change

The proposed recommendations will

- Reduce unnecessary inefficiencies of excessive glycol use in climates where freezing is less of a concern
- Take the first step toward inclusion of the energy impacts of glycol concentration as a performance path trade-off
- Intervene before poor design practices become difficult to change as the market rapidly grows in the coming years

# Background Information

- Published heat exchanger and pump deratings for high glycol concentrations are significant
- General guidance provided by equipment and glycol manufacturers
- Stakeholder input that indicates glycol concentrations are usually carefully specified and monitored, but there are currently no mandatory limits in the code

Glycol Concentration	Pump Power Increase <sup>1</sup>	Heat Exchanger Film Coefficient <sup>2</sup>
0%	0.0%	0%
10%	65.2%	-22.0%
30%	192.0%	-58.5%
50%	465.5%	-79.9%

<sup>1</sup> Fluid properties from Dow Chemical sizing tool . <https://www.dow.com/en-us/market/mkt-building-construction/sub-build-heating-cooling-refrigeration/heat-transfer-fluids-calculators.html#tabs-2d02c53560-item-1cd173deb3-tab>

<sup>2</sup> Average of lowest power draw Grundfos and Taco pump curves that met head for 100 ft. of 1 inch PEX pipe at 50F and 12.2gpm.

# Background Information, cont

- Lab testing underway at Frontier's laboratory to quantify system efficiency impacts of glycol concentration

## ***Laboratory Test Results for 50% Propylene Glycol Compared to Pure Water in Cooling Mode***

	<b>95°F Chamber Temperature</b>		
	<b>0% PG</b>	<b>50% PG</b>	<b>% Change</b>
AWHP EER (kBtu/hour/kW)	9.39	8.63	-7.01
AWHP Capacity (kBtu/hour)	19.1	17.5	-8.60
AWHP Flow Rate (gpm)	5.92	5.51	-6.95
W2W HX Effectiveness (%)	63.6	52.5	-17.4
Secondary Loop Pump Power (W)	30.4	38.6	+27.0

# Background Information, cont

- Glycol manufacturers specify concentrations and fluid temperatures where freezing and bursting are possible
- As glycol freezes, it becomes slushy and has a strong negative effect on system performance
- At the burst protection temperature, complete freezing is possible and the pipes may rupture
- Proposed glycol concentration was based on burst protection with a 5°F safety margin in the Draft CASE Report, but will be changed to the freeze protection limit based on stakeholder feedback

## ***Proposed Glycol Concentration Limits Based on Burst Protection***

<b>Heating Median of Extremes (From JA2-4)</b>	<b>Maximum Glycol Concentration</b>
Above 37°F	0
25°F to 37°F	13%
15°F to 24°F	21%
5°F to 14°F	25%
-5°F to 4°F	29%
-15°F to -6°F	31%
Below -15°F	35%

# Marked-up Code Language

See [Title24stakeholders.com](http://Title24stakeholders.com) for marked-up code language

The following sections would be modified

## Title 24, Part 1

- No changes

## Title 24, Part 6

- Adds Section 110.2(g) under Mandatory Requirements for Space-Conditioning Equipment, limiting glycol concentration under most circumstances
- Adds glycol concentration limits based on heating median of extremes in JA2
- Exempts Occupancy Group R buildings

## Reference Appendices

- No changes



# Market and Technical Considerations

- Current Conditions and Trends
- Potential Barriers and Solutions
- Technical feasibility

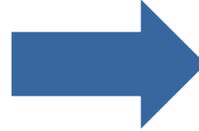
# Current Market Conditions

- In California, the number of installed AWHPs is small, probably under 10%
- Market penetration is likely to grow to at least 20% for all building types in the coming years, and 30% for small and medium offices and schools, given that about 60% of non-residential buildings nationwide currently use hydronic heating (primarily boilers)
- Low global warming potential refrigerants like propane are expected to become more common in future years as market barriers are addressed

# Market Barriers and Solutions

## Market Barriers

1. Risk of freezing
2. Lack of published studies of system efficiency effects of glycol concentration
3. Lack of training and tools for glycol concentration selection



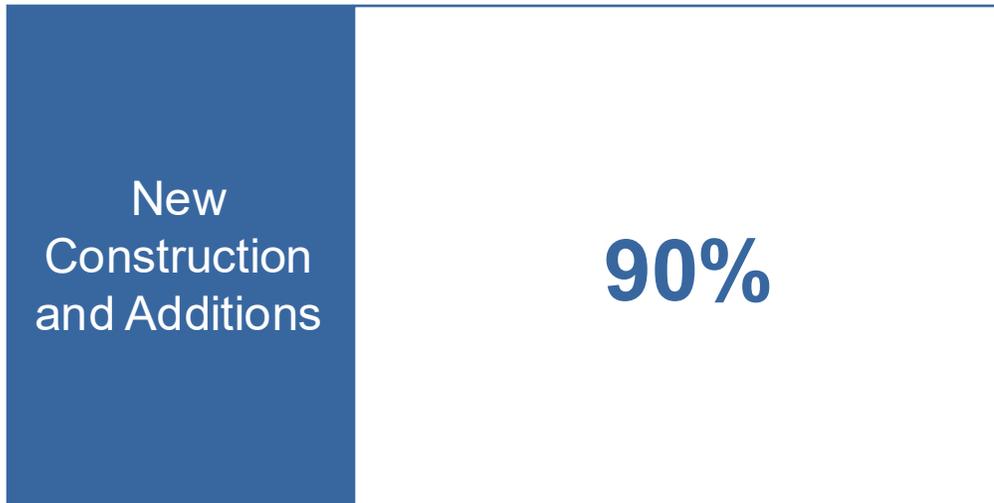
## Potential Solutions

1. Conservative approach to concentration limits to manage risk
2. Careful lab testing of impacts to heat exchanger effectiveness and pump efficiency
3. New tools and training resources to give designers and installers greater confidence to reduce concentrations

# Current Market Share

**Market share:** percentage of buildings that already use the proposed technology or design practice (at or above the proposed stringency level)

**Current Market Share: Percent of non-residential buildings with AWHPs that already meet the requirements of the proposed measure, based on stakeholder interviews**



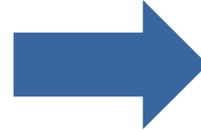
# Technical Considerations

- Consequences of high glycol concentrations on AWHP system efficiency have not been clearly quantified
- Specific concentration required to prevent freezing with adequate safety margin is difficult to establish
- Code requirements for glycol concentration are complicated by local climate and system design dependence

# Technical Barrers and Solutions

## Technical Barrers

1. Unquantified effect of glycol concentration on efficiency
2. Difficult to calculate required concentration to ensure freezing doesn't occur
3. Concentration over time may be difficult to control
4. Need for relatively simple rules in code



## Potential Solutions

1. Lab testing using different glycol concentration, extrapolation using simulations
2. Fluid system modeling under realistic weather and operating conditions, exceptions for more complex systems and process loads where freezing risk is difficult to predict
3. Require label on AWHP indicating design concentration and consequences if deviated from
4. Reasonably sized safety margins, analysis based on extreme local weather

## Poll

**Does the following assumption seem realistic?**

- **90% of AWHP systems have glycol concentrations that are already minimized by the designer to maintain efficiency while providing freeze protection**
  - a. Yes
  - b. Should assume higher than 90%
  - c. Should assume less than 90%
  - d. I do not know or not relevant to my role

# Per Unit Energy and Cost Impacts

## *Methodology and Assumptions*

- Energy and Energy Cost Savings
- Incremental Costs



# Energy and Energy Cost Savings Methodology

- Using CEC's methodology and metrics
- Model New Construction with default standard design
- Model Alterations with modified standard design
- Standard design uses conservative values of 30% or 50% for glycol concentration in colder climates
- Proposed design imposes concentration limits based on the proposed measure

# Energy Modeling Assumptions

- Simulating energy savings in EnergyPlus with CBECC rulesets
- Simulating using the following prototypical buildings and climate zones

## Prototypical Buildings

- For the Draft CASE Report, only the large school prototype
- For the Final CASE Report, all non-residential building types with established prototypes except hotels and mixed-use retail
- Existing HVAC replaced with multi-unit AWHPs for heating and cooling, but not hot water

## Climate Zones

- All climate zones except CZ 7, which has a winter median of extremes above 37°F and no glycol is assumed for either the base case or proposed case

# Key Modeling Assumptions

**Prototype:** All non-residential building types likely to have AWHP systems except hotels and mixed-use retail



## Standard Design

1. Typical standard practice glycol concentration as a function of Climate Zone

Heating Median of Extremes (From JA2-4)	Common Practice Glycol Concentration
Above 37°F	0
25°F to 37°F	30%
15°F to 24°F	30%
5°F to 14°F	30%
-5°F to 4°F	50%
-15°F to -6°F	50%
Below -15°F	50%



## Proposed Design

1. Maximum allowable glycol concentration specified in proposed measure

Heating Median of Extremes (From JA2-4)	Maximum Glycol Concentration
Above 37°F	0
25°F to 37°F	13%
15°F to 24°F	21%
5°F to 14°F	25%
-5°F to 4°F	29%
-15°F to -6°F	31%
Below -15°F	35%

# Incremental Cost Framework

**Prototype(s):** All non-residential building types likely to have AWHP systems except hotels and mixed-use retail



## Baseline

### First Cost

1. Installation costs for glycol based on current practice

### 30-Year Maintenance Costs

1. Regular Maintenance costs using current practices



## Proposed

### First Cost

1. No incremental installation costs for glycol based on lower concentrations under proposed code change (potentially lower cost for glycol, smaller pumps due to lower pressure drop)

### 30-Year Maintenance Costs

1. Regular Maintenance costs using proposed glycol limits are expected to be the same as baseline

# Approach for Gathering Costs

- Estimated incremental first cost is zero or slightly negative for reduced glycol concentration based
- Estimated cost of glycol is \$7,128 for a 30% concentration in the large school prototype building
- Model energy cost savings resulting from more efficient system operation in EnergyPlus

# Initial Cost-Effectiveness Estimates

Based on best estimates of cost and energy savings, measure is cost-effective (benefit-cost ratio >1) in all Climate Zones except CZ 7 where it doesn't apply

Climate Zone	Benefits LSC Savings + Other PV Savings (2029 PV\$)	Costs Total Incremental PV Costs (2029 PV\$)	Benefit-to-Cost Ratio
1	0.14	\$0	Infinite
2	0.18	\$0	Infinite
3	0.34	\$0	Infinite
4	0.49	\$0	Infinite
5	0.43	\$0	Infinite
6	0.64	\$0	Infinite
7	0.00	\$0	N/A
8	0.77	\$0	Infinite
9	0.71	\$0	Infinite
10	0.73	\$0	Infinite
11	0.31	\$0	Infinite
12	0.53	\$0	Infinite
13	0.36	\$0	Infinite
14	0.15	\$0	Infinite
15	1.03	\$0	Infinite
16	0.07	\$0	Infinite



# Compliance Verification

- Key Aspects of Compliance Verification
- Barriers and Solutions
- Revisions to Compliance Software

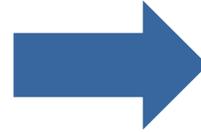
# Key Aspects of Compliance Verification

- Design concentration should be specified in the plan set for review by building department.
- There may be additional entries for AWHPs on Compliance Forms NRCC-MCH-E and NRCI-MCH-E to document actual concentration and mandatory limits, or basis for an exception.
- Educational material is needed for code officials, plan reviewers, and others involved with compliance to explain the effects of glycol concentration on freezing risk and system performance and how the proposed measure should be enforced

# Compliance Barriers and Solutions

## Compliance Verification Barriers

1. Evidence that concentration limits were met
2. Lack of awareness of glycol concentration effects on freeze potential and system efficiency



## Potential Solutions

1. Documentation from designers on NRCC form indicating specified glycol concentration complies with established limits, and documentation on NRCI form that the installer has complied with the specified design value
2. Educational materials targeted to market actors enforcing compliance

# Compliance Software Updates

- Compliance software may include a library and lookup table to determine maximum glycol concentration and demonstrate compliance with the mandatory requirement
- Longer-term compliance software updates may be needed to model energy effects accurately if a performance path component is added in a future measure

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More information on

[CEC's 2028 proceeding website.](#)

**We want to  
hear from you!**