TITLE 24, PART 6 | 2028 CODE CYCLE

Compressed Air Dryers

Codes and Standards Enhancement (CASE) Proposal

M M Valmiki
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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Proposal Description

- Code Change Proposal
- Benefits
- Background Information

Proposed Code Change

1. **Trim air compressors** would have a dedicated air dryer.
2. Where plant compressed air dew point requirements are 35°F or greater, **refrigerated dryers** would be specified.
   - Cycling air dryers would be required for trim air compressors.
3. **Desiccant air dryers** would include dew point measurement, display, and **controls that reduce regeneration based on load**.
   - For systems with target compressed air dew point > -100°F and a desiccant air dryer, require a **heated desiccant dryer**.
4. **Field verification** to confirm dryers are scheduled with air compressors and that dew point controls are properly commissioned.

See Title24stakeholders.com for proposal description, justification, draft code language, and requested data

Who it applies to: buildings with compressed air systems currently covered by Title 24, Part 6 (those with a total combined air compressor power of 25hp and above) and with air dryers.

Benefits of the Proposed Change

Energy Savings

- Refrigerated air dryers use far less energy to condition plant air than desiccant dryers by avoiding inefficient, expensive use of compressed air.
- Cycling refrigerated dryers have much better part-load performance than non-cycling models; using these with trim compressors saves energy.
- When desiccant dryers are required, the use of heated models and load-following regeneration can both save significant compressed air energy.

Best Practices

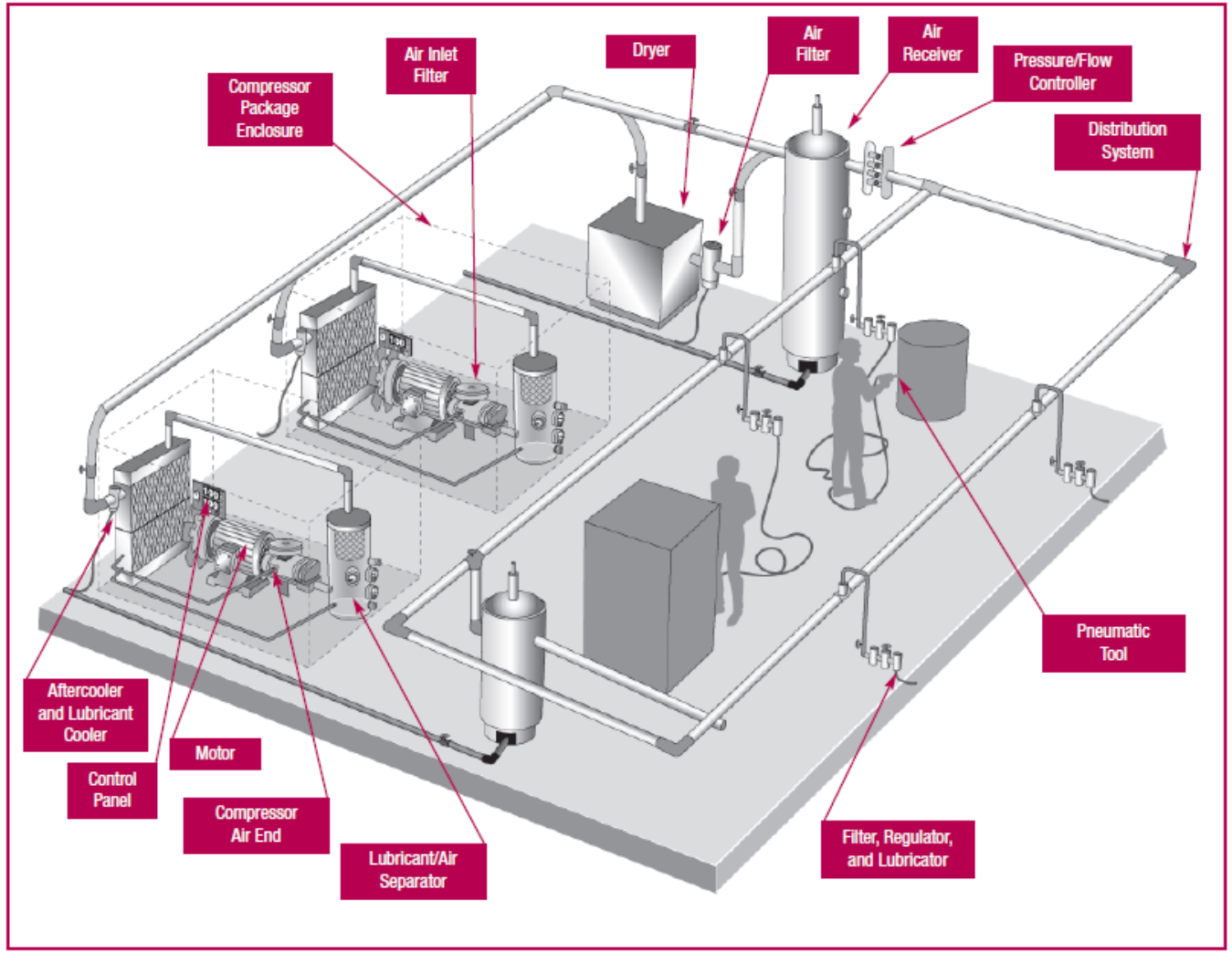
- Compressed air dryer language would ensure that well-accepted, proven best practices are followed in equipment selection.
- Field verification requirements would improve the commissioning practice of features that may otherwise go unused.

Background Information: Compressed Air Drying

- Air dryers **condition air after compression and before delivery** to storage or the plant.
- Moisture in the air needs to be removed to maintain dew point, determined based on plant needs.
- Generally, air is dried using **refrigerated or desiccant dryers:**
  - **Refrigerated dryers** use a refrigeration cycle to condense moisture from the air.
    - Cycling refrigerated dryers have better part-load efficiency than non-cycling options.
  - **Desiccant dryers** are typically dual tower.
    - Moisture is absorbed by the material in one tower while the second is regenerated using purge air, up to 20% of the rated flow. These dryers are often the largest air end-use in the plant!
    - Heating and load-following controls based on leaving air dew point can both reduce the energy consumption of this type of dryer.
- Deliquescent or membrane dryers are less common and not used for plant-level compressed air drying.

Background Information: Regulations and Standards

- Compressed Air systems were first regulated by Title 24, Part 6 in 2013 and updated in 2022, covering all major, ubiquitous components except dryers.
- Air dryers were considered as part of the 2022 cycle CASE Team measure selection but left out of the Compressed Air CASE Report because other measures were deemed higher priority.
- **No public standard for compressed air dryer specification** exists to the team's knowledge.
- Compressed Air Gas Institute's (CAGI's) Compressed Air & Gas Handbook and Compressed Air Challenge articles include some dryer guidelines but with ample room for engineering judgement and no hard recommendations for equipment selection.



Marked-up Code Language

See Title24stakeholders.com for marked-up code language

Title 24, Part 1

- No changes

Title 24, Part 6

- Section 100.1(b) – Definitions
- Section 120.6(e) – Mandatory Requirements for Compressed Air Systems
- Section 141.1 – Requirements for Covered Processes in Additions/Alterations

Reference Appendices

- NA7.13 – Compressed Air System Acceptance Tests
- NA9 – Compressed Air Dryer System Sizing (**TBD**)

Market and Technical Considerations

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

Current Market Conditions

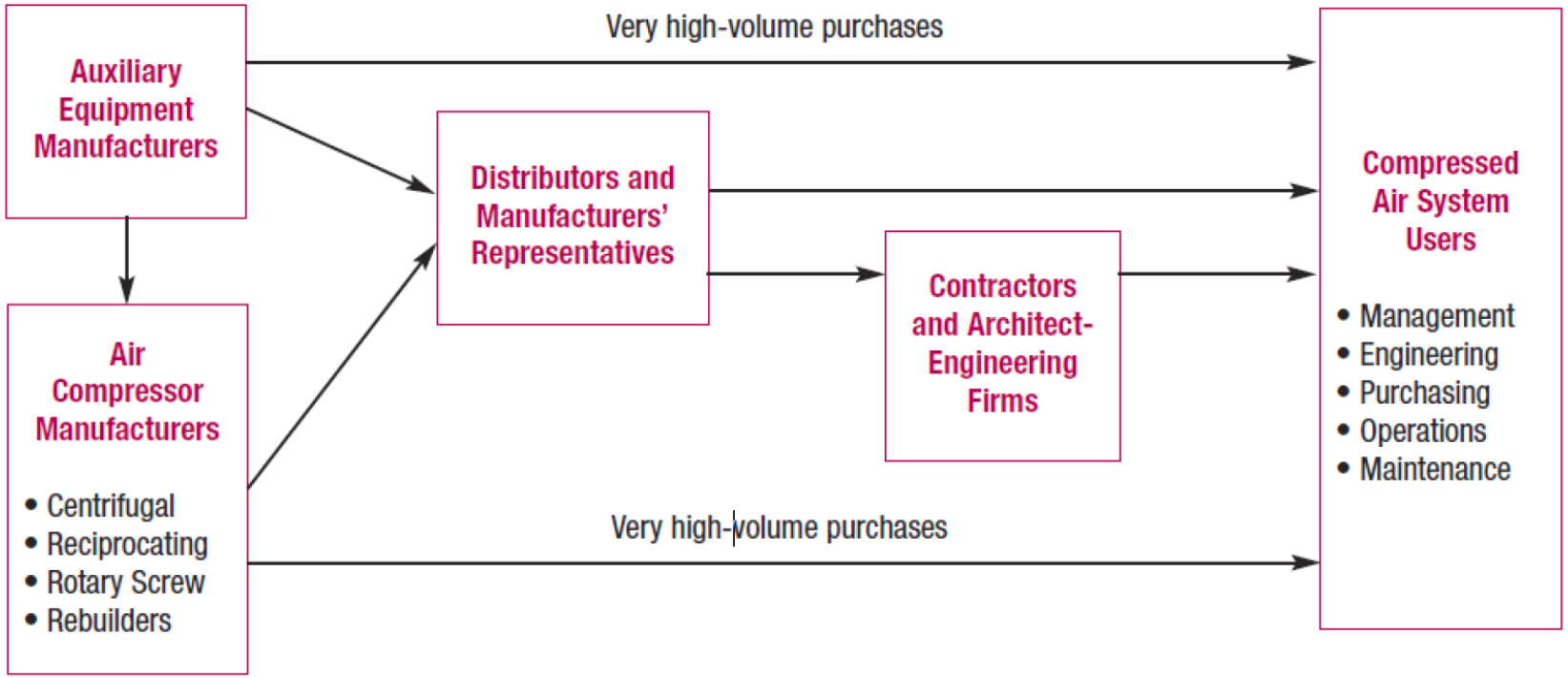
- Compressed air systems account for about 10 percent of industrial electrical energy use. Roughly 70 percent of manufacturing facilities have full compressed air systems, across all industries.
- Dryers are roughly a $1 Billion market in the United States.
- Proposed dryer technologies are mature, have widespread adoption, and are available from many providers and manufacturers.
- While the proposed code changes may be best practices, they are not ubiquitous according to interviews with subject matter experts. The proposed language will ensure adherence to efficient dryer selection.
- The team has found limited information and surveys on market share of various dryer technologies.

Market Barriers and Solutions

Market Barriers	Potential Solutions
1. Site practices for specifying dryer types may not align with best practices.	1. Conduct stakeholder outreach and share documentation of best practices.
2. Default specification of desiccant dryers as a safe option if dew point requirements are unknown.	2. Research causes of desiccant dryer overspecification and create sizing requirements.
3. Individual manufacturers may not offer load-following control options.	3. Confirm that there are no barriers to procuring cycling refrigerated dryers or desiccant dryers with dew point controls (factory option or add-on).
4. Lack of guidelines for dryer selection based on capacity sizing and air quality needs.	4. Consider Reference Appendix, compliance manual additions, or reference to industry group documentation.

Poll

When specifying an air dryer, who is the main driver for decision-making?



Current Market Share: Refrigerated Dryers

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

Current Market Share for Plants with Dew Point Requirement of 35°F or above

New Construction and Additions	**50%**	▪ Assumed adoption rate needs additional research
Alterations	**50%**	▪ Assumed adoption rate needs additional research

Source: Engineering judgement and subject matter expertise

Poll

When required dew points are 35°F or above, what percentage of dryers are specified as desiccant dryers?
(*results will not be shared live*)

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. >50+%

Current Market Share: Desiccant Dryer Regen Controls

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

Current Market Share of Desiccant Dryers with Load-Following Regeneration Controls

New Construction and Additions	**50%** ▪ Assumed adoption rate needs additional research	
Alterations	**50%** ▪ Assumed adoption rate needs additional research	

Source: Engineering judgement and subject matter expertise

Poll

What percentage of desiccant dryers are specified to include load-following regeneration controls? In other words, what percentage of desiccant dryers include dew point measurement to limit use of purge air during equipment selection?
(*results will not be shared live)*

a. 1% – 10%
b. 11% – 20%
c. 21% – 30%
d. 31% – 40%
e. 41% - 50%
f. >50+%

Technical Considerations

The applicability and effectiveness of the proposed code changes must consider the nuances of industrial buildings and their compressed air needs:

- Dew point and air quality requirements can vary significantly by plant. Dew point is assumed to be a sufficient parameter for defining measure coverage.
- Sizing practices of dryers depending on operating conditions and preferences for oversizing. Dryers may be sized to match the capacity of their upstream compressor.
- Cycling refrigerated dryers have higher part-load efficiency than non-cycling but non-cycling have higher full-load efficiency than cycling.
- Energy use of the desiccant drying equipment depends on efficiency of the air compressors.
- Medical air and other gas compression is not covered.

Dew point is the main driver for selection of dryer type. What else should we be considering as a design selection criterion?

Technical Barriers and Solutions

Technical Barriers	Potential Solutions
1. Possibility of conditions, other than dew point requirements, that necessitate the use of desiccant dryers. 2. Feasibility of add-on load matching controls and dew point measurement. 3. Cycling and non-cycling dryers have varying performance. 4. Alternating base load and trim compressor positions.	1. Conduct stakeholder outreach to identify possible exceptions or additional criteria. 2. Verify technical feasibility with survey of market offerings, manufacturers, and stakeholders. 3. Collect dryer specifications to characterize efficiency spectrum. 4. Study impacts of defaulting to cycling or non-cycling dryers.

Per Unit Energy and Cost Impacts

Methodology and Assumptions

- Energy and Energy Cost Savings
- Incremental Costs

Energy and Energy Cost Savings Methodology

Methodology will be founded on the work done in previous code cycles for compressed air measures.

- Compressed air profiles have been established for four prototype systems previously used in the 2013 and 2022 code cycles. Air dryer loads and compressed air efficiency will be based on these prototypes and load profiles, inclusive of all existing measures.
- Air dryer efficiency will be based on average performance as gathered from equipment specification sheets.
  - Refrigerated dryers: full- and part-load efficiencies with direct electrical energy consumption.
  - Desiccant dryers: heated and heatless purge rates with direct and indirect energy consumption from air compressors.
  - Dryers sized to match compressor capacities.
- Energy costs and greenhouse gas emissions will be based on CEC's hourly factors.
- Equipment costs to be based on equipment quotes or other available information to be gathered as part of the research process.

Energy Modeling Assumptions

- Simulating energy savings in Excel and AirMaster+ using the following prototypical systems
- Simulations include purge rates, efficiency, and load-following abilities of different dryer types
- Evaluate seasonality of select sub-industries

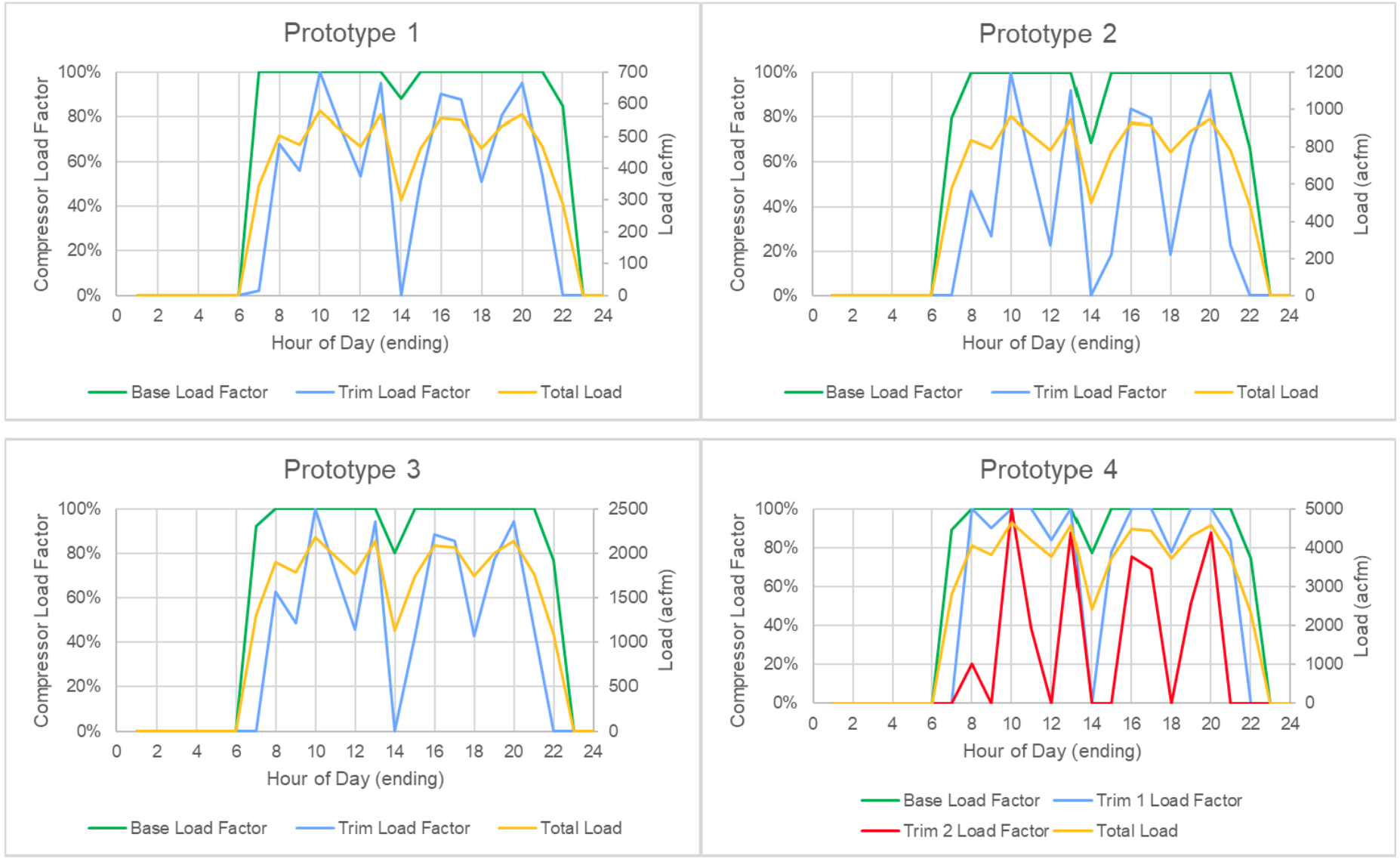
Prototypical Buildings

- Four established compressed air prototypes with varying capacity, trim, and baseload profiles:
  - 579 cfm
  - 966 cfm
  - 2,181 cfm
  - 4,666 cfm
- Load profiles based on empirical plant data aligned to previous code cycles.
- Two shift, 7-day operation

Climate Zones

- No impact on energy savings

Energy Modeling Assumptions



Key Modeling Assumptions

Standard Design	Proposed Design
1. Code-compliant air compressors, controls, and distribution	1. Code-compliant air compressors, controls, and distribution
2. Desiccant dryer selection for DP≥35°F	2. Refrigerated dryer
3. Non-cycling refrigerated dryer for trim loads	3. Cycling refrigerated dryer for trim loads
4. Desiccant dryer on timed regeneration	4. Desiccant dryer on load-following regeneration
5. Heatless desiccant dryer	5. Heated desiccant dryer

Incremental Cost Framework

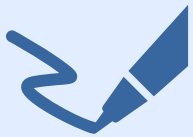
Baseline

First Cost

1. Equipment
2. Installation
3. Commissioning

30-Year Maintenance Costs

1. Equipment Replacement
2. Regular Maintenance



Proposed

First Cost

1. Equipment
2. Installation
3. Commissioning

30-Year Maintenance Costs

1. Equipment Replacement
2. Regular Maintenance

Approach for Gathering Costs

The team will gather measure costs through contractor and distributor interviews for different dryer technologies:

- First costs
- Installation costs
- Equipment useful life
- Maintenance costs and frequency

The team will also review existing program measure documentation and efficiency program participant data (if available).

RSMeans will be used as a supporting resource.

Look out for requests for interviews or reach out proactively!

Compliance Verification

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

Key Aspects of Compliance Verification

- AHJ plan checkers will review design documents to confirm stated design dew point corresponds to specified dryer technology.
- Updates to NRCC-PRC-E (Process Certificate of Compliance form)
- Updates to NRCI-PRC-E (Process Certificate of Installation form)
- Updates to NRCA-PRC-01-F (Process Certificate of Acceptance form)
- Installing field technician verifies dew point controls in addition to existing compressed air testing.
- No updates to compliance software.

Compliance Barriers and Solutions

Compliance Verification Barriers	Potential Solutions
1. Frequency of dew point specification in plans documents. 2. Varying processes for commissioning load-following controls.	1. Interview stakeholders and set expectations to enable compliance pathway and require dew point for desiccant dryers. 2. Interview stakeholders on commissioning practices and establish simple commissioning verification test.

Compliance Software Updates

No changes to compliance software.

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M M Valmiki
ASK Energy
valmiki@askenergyinc.com

Joe Vukovich
2050 Partners
joevukovich@2050partners.com

Please copy: info@title24stakeholders.com

More information on
CEC's 2028 proceeding website.

We want to hear from you!

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