High-Performance Measure Details

Measure Name
Ground Source Heat Pumps

Use Category
HVAC – Space Heating Electrification

Effective Date
February 20, 2026

Version
1.2

Measure Code
LM401

Measure Stage
Early Adoption

Table of Contents

Technology Summary

Ground source heat pumps (GSHPs), sometimes referred to as geothermal heat pumps or ground-coupled heat pumps, use the earth as a stable heat source in winter and a heat sink in summer to provide space heating, cooling, and in some cases domestic hot water. In commercial applications, they are typically deployed as closed-loop systems (e.g., vertical boreholes, horizontal loops, or surface water heat exchangers) and are most often considered for larger facilities such as hospitals and other buildings with substantial and continuous thermal loads. Within the context of CEDA, GSHPs represent a pathway to deliver high-efficiency, all-electric space conditioning aligned with electrification, decarbonization, and grid resilience objectives, while informing future Title 24 compliance pathways.

For California, GSHPs matter because they decouple heating and cooling performance from outdoor air temperature swings. By exchanging heat with the ground rather than ambient air, these systems can maintain higher efficiency and lower peak electrical demand during extreme weather compared to many air-source systems. This operational stability has implications for winter and summer peak management, annual energy use, and load flexibility—key issues for a grid with increasing renewable penetration and declining gas infrastructure. Field data on peak demand reduction, annual thermal contribution, and hybrid configurations can directly inform cost-effective electrification strategies in large commercial buildings.

However, real-world performance has not always matched modeled expectations. Common gaps include: (1) over- or under-sizing of ground heat exchangers due to limited site-specific geological data; (2) incomplete commissioning and control integration, particularly in hybrid systems; (3) insufficient metering of ground temperature and loop performance, limiting validation of design assumptions; (4) higher-than-anticipated installation costs driven by drilling and site constraints; and (5) performance degradation over time from ground thermal imbalance or inadequate loop field design. The HPM is intended to close these gaps by pairing targeted deployment with robust operational monitoring.

Relevant industry standards and rating frameworks include ISO 13256-1, ISO 13256-2, AHRI/ASHRAE 13256, and the 2025 California Title 24, Part 6.

Alignment with CEDA Program Goals

The CEDA program supports the implementation of energy efficiency measures that support Code Readiness' Long Term Tactical Plan (LTTP) to drive the goals of electrification, decarbonization, and load reduction.

Projects must meet the CEDA Inducement Requirements identified in the next section to receive an inducement on the equipment and will be evaluated for level of interest in metering to support Code Readiness Objectives.

This measure meets the CEDA program goals as follows:

- **Building partnerships with market stakeholders** by consulting on innovative technologies and best practices in energy efficiency which can lead to the development of more effective solutions and accelerate the adoption of new technologies. As teams adopt the measure, this increases the volume of engineers able to design the equipment, contractors capable of installing the equipment, and owners able to operate the equipment.
- **Increasing the supply of high-performance measures and all-electric buildings** by combining electrification with energy efficiency that can result in projects implementing measures to achieve greater energy savings, reduced emissions, and overall improved building performance. As more buildings specify and install ground source heat pumps, this helps to increase the overall supply of GSHPs in the market for others to use, including beyond new construction.
- **Increasing the demand for high-performance measures and all-electric buildings** by pushing for electrification that drives the need for technological advancements, supporting economic growth opportunities through innovation, and raising awareness of the benefits of electrification to increase consumer adoption. As demand in the market increases for newer technologies, the long-term benefit is increased demand for manufacturers and suppliers to provide additional options available in the market.
- **Advancing new high-performance measure technology** by raising public awareness about new technologies and their benefits, helping build acceptance and demand through market support advocacy efforts that can influence stakeholder decisions that enables technological innovation.
- **Providing Codes & Standards with projects of interest** to collect metered data that will inform future California energy codes.

CEDA Inducement Requirements

Ground source heat pump systems have historically faced higher first costs than conventional air-source heat pumps or gas boiler systems, particularly due to drilling, ground loop installation, and site-specific engineering requirements. While GSHPs are widely recognized for high operational efficiency and reduced peak energy demand under extreme conditions, market adoption in large commercial buildings remains limited by cost uncertainty, perceived geological risk, and limited contractor experience. The CEDA inducement is intended to help bridge this gap by reducing incremental cost risk while advancing field data to inform future code pathways.

Inducement eligibility is determined based on a project's demonstrated contribution to electrification and decarbonization objectives, including avoided on-site natural gas use (therms avoided), projected annual and peak electric energy impacts, and estimated greenhouse gas (CO_2e) emissions reductions relative to baseline systems. Additional considerations may include the proportion of building heating and cooling load served by the GSHP system, total conditioned floor area or gross square footage, and the system's role in reducing winter and summer peak demand. By linking financial support to measurable performance and load contribution metrics, the inducement structure aligns near-term project feasibility with longer-term grid and code readiness goals.

Product and Plant Size

- Projects are required to utilize GSHP(s) to achieve at least 25% of the peak heating load for the site.
- Primary heating and cooling provided by heat pump(s).
- Additional heating and additional capacity for redundancy or backup heating are allowed.
- Additional cooling and additional capacity for redundancy or backup cooling are allowed.
- Ability to monitor the ground temperature.

Documentation

- Documentation of the GSHP system(s) including efficiency and ground heat exchanger dimensions (ground loop design details: length, depth, configuration).
- Equipment specifications (capacity, model, manufacturer).
- Heat pump and heat exchanger sizing method (heating/cooling, target % of peak).
- Geological data for heat exchanger location (soil reports/ type).
- Equipment costs
- Costs of installation, including a breakdown of costs (drilling, ground loop installation, etc.)

Efficiency

Efficiency shall meet or exceed requirements in 2025 Title 24 from Table 110.2-B shown below in

Table 1.

Table 1. Table 110.2-B Heat Pumps, Minimum Efficiency Requirements from 2025 Title 24

Equipment Type	Size Category	Rating Condition	Efficiency	Test Procedure
Ground Source (Cooling Mode)	< 135,000 Btu/h	77°F Entering Water	14.1 EER	ISO-13256-1
Ground Source Brine-to-Water (Cooling Mode)	< 135,000 Btu/h	77°F Entering Water	12.1 EER	ISO-13256-2
Ground Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	32°F Entering Water	3.2 COP	ISO-13256-1
Ground Source Brine-to-Water (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	32°F Entering Water	2.5 COP	ISO-13256-2

Incremental Measure Cost

The Incremental Measure Cost (IMC) represents a standardized program calibration input used to estimate the typical first-cost premium associated with implementing the GSHP HPM relative to a Title 24–compliant baseline HVAC system. The IMC supports CEDA portfolio planning, inducement calibration, and cross-measure comparison. It reflects representative new construction market conditions and commercial-scale applications.

The IMC is not a bid estimator, contractor quote substitute, or project reconciliation tool. Actual project costs vary based on geology, drilling depth, site access, hybrid system design, distribution temperatures, labor conditions, and avoided infrastructure (e.g., boiler or cooling tower reductions). The IMC excludes extraordinary site conditions and project-specific structural or civil work.

Base Case

The Base Case represents a conventional, code-minimum commercial HVAC configuration without ground heat exchange. Typical systems include:

- Air-source heat pumps (ASHP), VRF, or chiller + boiler plants meeting Title 24 efficiency requirements;
- Conventional heat rejection (cooling tower or air-cooled condenser);
- No borefield, drilling, or geothermal loop installation;
- Standard design, controls, and commissioning scope.

Heating is typically provided by high-efficiency condensing gas boilers or ASHP systems; cooling by air- or water-cooled chillers.

Measure Case

The Measure Case replaces or supplements the Base Case with a closed-loop Ground Source Heat Pump (GSHP) system meeting HPM requirements. The system includes:

- Vertical borehole ground heat exchanger field (assumed for normalization);
- Water-to-water or water-to-air GSHP units;
- Loop circulation pumps, headers, and integration controls;
- Borefield design, thermal modeling, and drilling;
- Commissioning and monitoring of loop performance.

Hybrid systems are permitted; IMC applies only to the GSHP-served portion of plant capacity.

Primary incremental cost drivers include:

- Borefield drilling and loop installation;
- Additional engineering and thermal analysis;
- Controls integration and commissioning scope.

Avoided costs may include reduced boiler capacity, eliminated cooling tower equipment, or reduced gas infrastructure, but these are not netted out of the standardized IMC value.

IMC Values & Normalization

Recommended normalization: **$/ton of GSHP-served nominal cooling capacity**

Rationale:

- Central plant HVAC systems are typically estimated and documented in tons.
- Consistent with other central plant HPMs in the CEDA IMC reference sheet (e.g., Heat Recovery Chillers, chillers, ccVRF)
- Scales proportionally with plant size and borefield scope.
- Although borefield sizing is often influenced by heating load and annual thermal balance, ton-based normalization maintains consistency and administrative clarity.

Representative Size Class & Pricing Anchors

For commercial-scale GSHP systems (≥100,000 sf), publicly reported and industry benchmark data indicate:

- Installed GSHP central plant systems: approximately $4,000–$7,000 per ton (including borefield and equipment).
- Comparable conventional chiller + boiler systems: approximately $3,000–$5,000 per ton installed.

Representative mid-range differential:

- GSHP system: $6,000/ton
- Baseline HVAC: $4,800/ton
- Incremental delta: $1,200 per ton

This anchor reflects economies of scale typical of large commercial or institutional buildings (e.g., hospitals, civic facilities), consistent with anticipated GSHP use cases.

Proposed Singular IMC Value

- **IMC** = $1,200 per ton of GSHP-served nominal cooling capacity

Example Calculation

Project with 350 tons of GSHP-served nominal cooling capacity:

350 tons × $1,200/ton = $420,000 Incremental Measure Cost

Sources

IMC values are informed by a combination of publicly available market pricing, industry cost references, and program experience, and are intended to reflect typical market conditions rather than project-specific pricing, including:

The IMC reflects 2024–2025 commercial new construction cost conditions based on:

- U.S. Department of Energy (DOE), Cost and Performance Analysis of Geothermal Heat Pump Systems (commercial/district-scale case studies).
- ASHRAE Journal (2023), Expanded Field Data to Validate Ground Source Heat Pump Design Models.
- RSMeans 2024–2025 Mechanical Cost Data (central plant HVAC benchmarks).
- decarbHEALTHCARE, Ground Source Heat Pumps / Geothermal Guidebook.
- UMass Amherst (2021), Ground Source Heat Pumps: Considerations for Large Facilities.
- Industry vendor pricing discussions and California commercial program experience (2023–2025).
- CEDA HPM Estimated Incremental Cost Reference Sheet normalization methodology

These sources represent publicly available market pricing, industry cost references, and recent program experience and are intended to reflect typical commercial new construction conditions rather than project-specific pricing.

Code Readiness Objectives

The primary objective is to identify commercial building use cases where ground-coupled heat pumps could be used as a compliance option in 2028 and 2031. To support future code cycles, the measure aims to gather the following information:

- Information on the cost-effective use of ground-coupled heat pumps for heating and cooling in commercial buildings.
- Identify operational efficiencies of specific GSHP configurations or control systems.
- Identify details of distribution systems installed adjacent to the heat pumps, including any additional information or efficiency requirements that should be incorporated into energy codes.
- Determine efficiency criteria that can be established in building codes and equipment ratings.
- Identify the contributions of GSHPs to peak and annual energy demands for heating and cooling.
- Identify product availability, market readiness of contractors and equipment vendors, and first cost information.
- Identify any potential enhancements to the criteria used in equipment test procedures for GSHPs, beyond current requirements, that are beneficial for the specific building heating and cooling applications.

Code Readiness Site Monitoring

If selected for Code Readiness monitoring, equipment energy consumption and mechanical system performance may be monitored on-site for a period of up to 24 months. To support performance evaluation and data collection, projects shall provide reasonable access for the installation and operation of metering, sensors, and communication equipment.

Projects equipped with a Building Automation System (BAS), Energy Management System (EMS), or equivalent platform should enable integration of advanced metering devices through the existing system to facilitate data collection and remote access. For projects without a BAS or EMS, the Code Readiness team may install temporary stand-alone data loggers, sensors, and communication equipment as needed to monitor system performance for the duration of the monitoring period.

Instrumentation may be installed or supplemented, where necessary, to measure key system and equipment parameters sufficient to evaluate system performance and operational characteristics. All monitoring equipment will be temporary and installed in a manner that minimizes disruption to normal building operations.

Data Benefits

Collected data will help support the following:

- Verify real-world COP/EER performance in commercial applications across heating and cooling modes under California climate conditions
- Quantify winter and summer peak demand reduction and contribution to annual heating/cooling loads, including hybrid configurations
- Obtain insights into optimal GSHP sizing strategies (e.g., partial peak coverage) and implications for redundancy, cost control, and system resilience
- Support Title 24 prescriptive criteria for GSHPs in future code cycles

Sample Data Points

A sample set of data points that would ideally be collected is provided below for reference. This list will be re-developed for each project based on the infrastructure and need of the monitoring effort:

Data Points to Meter	Unit	Additional Specifications
HP Power	kW	Maximum and minimum values
Thermal Load Provided	BTU	Average and Peak values
Operational Efficiency	COP	Efficiency measured at each instance
Operational Efficiency	TMCOP	Efficiency of temperature maintenance
Supply Water Flow	GPM	Average
Supply Water Supply Temp	°F	Average
Supply Water Return Temp	°F	Average
Supply Water Load	BTU	Average
Secondary Water Flow	GPM	Average
Secondary Water Supply Temp	°F	Average
Secondary Water Return Temp	°F	Average
Secondary Water Load	BTU	Average
Pump(s) Power	kW	Average
Outdoor Temperature	°F	Measured at heat pump or site
Outdoor Air Dewpoint	°F	Measured at heat pump or site
Indoor Air Temperature	°F	Average
Building Mode (Occupied Unoccupied)	-	Flag indicating status

Code Reference

2025 CA Title 24, Part 6, Section 110.2– Mandatory Requirements for Space-Conditioning Equipment

110.2(b) Controls for heat pumps with supplementary heaters*:*

Control requirements for heat pumps with supplementary heaters in single-family residential buildings are specified in Section 150.0(h)7 and Section 150.0(i)2. Heat pumps with supplementary heaters in nonresidential and multifamily buildings shall have controls:

1. *That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and*
2. *In which the cut-on temperature for heat pump heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for heat pump heating is higher than the cut-off temperature for supplementary heating.*

Exception 1 to Section 110.2(b): *The controls may allow supplementary heater operation during:*

A. Defrost; and
B. Transient periods such as start-ups and following room thermostat setpoint advance, if the controls provide preferential rate control, intelligent recovery, staging, ramping or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

Exception 2 to Section 110.2(b): *Room air-conditioner heat pumps.*

110.2(c) Thermostats*:*

All heating or cooling systems not controlled by a central energy management control system (EMCS) shall have a setback thermostat.

1. *Setback capabilities. All thermostats shall have a clock mechanism that allows the building occupant to program the temperature setpoints for at least four periods within 24 hours. Thermostats for heat pumps shall meet the requirements of Section 110.2(b).*

Exception 1 to Section 110.2(c): *Gravity gas wall heaters, gravity floor heaters, gravity room heaters, noncentral electric heaters, fireplaces or decorative gas appliances, wood stoves, room air conditioners and room air conditioner heat pumps.*

2025 CA Title 24, Part 6, Section 110.12– Mandatory Requirements for Demand Management

110.12(a) Demand responsive controls*:*

1. *All demand responsive controls shall be either:*
   A. *A certified OpenADR 2.0a or OpenADR 2.0b Virtual End Node (VEN), as specified under Clause 11, Conformance, in the applicable OpenADR 2.0 Specification; or a certified Baseline Profile OpenADR 3.0 Virtual End Node; or*
   B. *Certified to the Energy Commission as being capable of responding to a demand response signal from a certified OpenADR 2.0b or a certified Baseline Profile OpenADR 3.0 Virtual End Node by automatically implementing the control functions requested by the Virtual End Node for the equipment it controls.*

2. *All demand responsive controls shall be capable of communicating with the VEN using a wired or wireless bidirectional communication protocol.*
3. *RESERVED*
4. *When the demand response signal is disabled or unavailable, all demand responsive controls shall continue to perform all other control functions provided by the control.*
5. *Demand responsive control thermostats shall comply with Reference Joint Appendix 5 (JA5), Technical Specifications for Occupant Controlled Smart Thermostats.*

110.12(b) Demand responsive zonal HVAC controls*:*

Nonresidential HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for noncritical zones as follows:

6. *The controls shall have a capability to remotely increase the operating cooling temperature set points by 4 degrees or more in all noncritical zones on signal from a centralized contact or software point within an Energy Management Control System (EMCS).*
7. *The controls shall have a capability to remotely decrease the operating heating temperature set points by 4 degrees or more in all noncritical zones on signal from a centralized contact or software point within an EMCS*
8. *The controls shall have capabilities to remotely reset the temperatures in all noncritical zones to original operating levels on signal from a centralized contact or software point within an EMCS.*
9. *The controls shall be programmed to provide an adjustable rate of change for the temperature increase, decrease, and reset.*
10. *The controls shall have the following features:*
    A. *Disabled. Disabled by authorized facility operators; and*
    B. *Manual control. Manual control by authorized facility operators to allow adjustment of heating and cooling set points globally from a single point in the EMCS; and*
    C. *Automatic Demand Shed Control. Upon receipt of a demand response signal, the space-conditining systems shall conduct a centralized demand shed, as specified in Sections 110.12(b)1 and 110.12(b)2, for noncritical zones during the demand response period.*

2025 CA Title 24, Part 6, Section 120.2– Required Controls for Space-Conditioning Systems

120.2(b) Criteria for zonal thermostatic controls*:*

4. Thermostatic controls for all single zone, air conditioners and heat pumps shall comply with the requirements of Sections 110.2(c) and 110.12(a) and, if equipped with DDC to the Zone level, with the Automatic Demand Shed Controls of Section 110.12(b).

Exception 1 to Section 120.2(b)4: *Systems serving non-covered process loads that must have constant temperatures to prevent degradation of materials, a process, plants or animals.*

Exception 2 to Section 120.2(b)4: *Package terminal air conditioners, package terminal heat pumps, room air conditioners and room air conditioner heat pumps.*

Exception 3 to Section 120.2(b)4: *Systems serving healthcare facilities.*

2025 CA Title 24, Part 6, Section 140.4– Prescriptive Requirements for Space Conditioning Systems

140.4(g) Electric resistance heating*:*

Electric resistance heating systems shall not be used for space heating.

Exception 1 to Section 140.4(g): *Where an electric resistance heating system supplements a heating system in which at least 60 percent of the annual energy requirement is supplied by site-solar or recovered energy.*

Exception 2 to Section 140.4(g): *Where an electric resistance heating system supplements a heat pump heating system, and the heating capacity of the heat pump is more than 75 percent of the design heating load calculated in accordance with Section 140.4(a) at the design outdoor temperature specified in Section 140.4(b)4.*

Exception 3 to Section 140.4(g): *Where the total capacity of all electric resistance heating systems serving the entire building is less than 10 percent of the total design output capacity of all heating equipment serving the entire building.*

Exception 4 to Section 140.4(g): *Where the total capacity of all electric resistance heating systems serving the entire building, excluding those allowed under Exception 2, is no more than 3 kW.*

Exception 5 to Section 140.4(g): *Where an electric resistance heating system serves an entire building that is not a hotel/motel building; and has a conditioned floor area no greater than 5,000 square feet; and has no mechanical cooling; and is in an area where natural gas is not currently available.*

Exception 6 to Section 140.4(g): *Heating systems serving as emergency backup to gas heating equipment.*

Exception 7 to Section 140.4(g): *Supplemental electric resistance heating systems complying with Section 140.4(a)3C.*

2025 CA Title 24, Part 6, Section 160.3– Mandatory Requirements for Space Conditioning Systems in Multifamily Buildings

160.3(c) Heat pump controls*:*

All heat pumps with supplementary electric resistance heaters shall be installed with controls that comply with Section 110.2(b).

Eligible Climate Zones, Building Types, & Project Scopes

Eligible Climate Zones

This high-performance measure applies statewide in **California Climate Zones 1-16** (Title 24). Applicants must identify the project's climate zone in the submittal.

Eligible Building Types

This high-performance measure applies to:

- **High-Rise Multifamily**: Buildings with **four (4) or more habitable stories above grade**.
- **Nonresidential**: **Commercial, public, agricultural, and industrial** facilities (e.g., offices, retail, lodging, education, healthcare, food service, warehouses, manufacturing, civic buildings).

Eligible Project Scopes

This high-performance measure applies to:

- **New construction**, **additions**, and **major alterations/retrofits** to systems served by the measure.
- **Buildings with a total gross-area greater than 100,000 ft².**
    - Smaller buildings may be applicable for this system if thermal loads or base loads are high (e.g. labs, aquatic centers, or data centers).

This high-performance measure does not apply to (not in scope):

- **Low-rise residential** (single-family and multifamily ≤3 habitable stories above grade).

Measure Exclusions

- Buildings with total gross-area less than or equal to 100,000 ft²

Reviewer Checklist

HPM Reviewer Checklist: LM401 – Ground Source Heat Pumps – V1.2

Checklist Description: This checklist captures the elements that must be present in the project design to be eligible for the high-performance measure inducement or consideration for additional site metering.

Project Name: _____ **Review Date:** _____

Assessment:

- ☐ Approved
- ☐ Not approved

Notes:

Reviewer: _____ **Signature:** _____

High-Performance Measure Requirements	Comments

System Eligibility

- ☐ Ground-coupled heat pump system is a **closed-loop system** (e.g., vertical borehole heat exchanger, horizontal heat exchanger, or surface water heat exchanger)
- ☐ System does **not** utilize open-loop groundwater heat pump configuration
- ☐ GSHP devices achieve at least **25% of the peak heating load determined for the site**
- ☐ Primary heating and cooling are provided by heat pumps
- ☐ Additional heating and/or additional capacity for redundancy or backup heating is permitted
- ☐ Additional cooling and/or additional capacity for redundancy or backup cooling is permitted
- ☐ Ability to monitor the ground temperature is provided

Documentation Requirements

- ☐ Documentation of the GSHP system(s) including **efficiency and ground heat exchanger dimensions** (ground loop design details: length, depth, configuration)
- ☐ Equipment specifications provided (capacity, model, manufacturer)
- ☐ Heat pump and heat exchanger sizing method documented (heating/cooling, target % of peak)
- ☐ Geological data for heat exchanger location provided (soil reports/type)
- ☐ Equipment costs documented
- ☐ Installation costs documented, including breakdown of costs (drilling, ground loop installation, etc.)

Efficiency Requirements

- ☐ Equipment efficiency meets or exceeds **Title 24, Part 6, 2025 Table 110.2-B minimum efficiency requirements**
- ☐ For buildings built after January 1, 2026, equipment efficiency meets updated Title 24, 2025 minimum requirements

Version History Log

Version	Effective Date	End Date	Change Description
1	February 23, 2023	February 19, 2026	N/A
1.2	February 20, 2026	Active	Updated measure to the current CEDA HPM format, IMC, and added reviewer checklist

The version identified as 'Active' is the current published version and remains in effect until superseded by a subsequent published version. CEDA may update, replace, or retire High-Performance Measures without prior notice. End dates are assigned to prior versions once superseded.