# The Status of Geothermal Heat Pumps in California

*How to Right the Sinking Ship*

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In 2015, California was ranked second in the American Council for an Energy-Efficient Economy (ACEEE) State Energy Efficiency scorecard,[1] only behind Massachusetts in the development and enforcement of energy efficiency policies. In its ranking, ACEEE noted that "California's [building] energy code is one of the most aggressive and best enforced energy codes in the country, and has been a powerful vehicle for advancing energy-efficiency standards for building equipment."[2] What may be surprising is that even within the context of strict building codes focused on energy efficiency, California has incredibly low installation rates of geothermal heat pumps, which offer the most efficient heating option on the market today.

***Geothermal Heat Pumps***

Geothermal heat pumps (GHPs), also known as ground source heat pumps or GeoExchange™ systems,[3] use the earth as a heat source (in the winter) and a heat sink (in the summer) to provide high-efficiency heating and cooling. It is important to make the distinction between GHPs and geothermal power stations, the latter of which tap into hot reserves inside the earth for power production. The location of these hot reserves are often identified by the existence of geysers or active volcanoes. Meanwhile, GHPs can be installed almost anywhere.

GHP energy efficiency is specified by the measure of Coefficient of Performance (COP). The COP indicates the ratio of heating or cooling provided to the electrical energy consumed. In 2013, typical COPs for GHPs were 3.2 for heating, with the most efficient units reporting COPs of around 4.5 for heating.[4] [5] Therefore, typical GHP systems provide approximately 3.2 kWhs of heating for every 1 kWh of electricity consumed. In comparison, Air Source Heat Pumps (ASHPs), which often compete for the

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[1] ACEEE. *The State Energy Efficiency Scorecard.* http://aceee.org/state-policy/scorecard.

[2] ACEEE. *California.* http://aceee.org/sites/default/files/pdf/state-sheet/2015/california.pdf.

[3] The Building Science Corporation notes that "GeoExchange™ is a newer and arguably more accurate term for the older and most accurate term Ground-Source Heat Pump."Straube, John. *BSD-113: Ground Source Heat Pumps ("Geothermal") for Residential Heating and Cooling: Carbon Emissions and Efficiency.* Building Science Corporation. February 2, 2009. http://buildingscience.com/documents/digests/bsd-113-ground-source-heat-pumps-geothermal-for-residential-heating-and-cooling-carbon-emissions-and-efficiency.

[4] U.S. Energy Information Administration. *Updated Buildings Sector Appliance and Equipment Costs and Efficiencies.* April 2015. http://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf

[5] The reported COP for geothermal heat pumps includes the power input for operating the compressor, any control or safety devices and conveying the heat transfer media through the heat pump, but it often does not include the energy required to pump the fluid through the tubes in the ground, which for certain system designs can reduce the overall efficiency of delivering heating and cooling using the geothermal heat pump system. http://buildingscience.com/documents/digests/bsd-113-ground-source-heat-pumps-geothermal-for-residential-heating-and-cooling-carbon-emissions-and-efficiency

title of most efficient heating and cooling system in the public eye, have typical COPs of around 2.4 for heating, with the most efficient versions of ASHPs boast heating COPs of around 2.6.[6]

***Benchmarking Geothermal Heat Pump Installations in California***

The U.S. Energy Information Administration (EIA), which provides the most comprehensive tracking of energy, renewable energy and energy efficiency technologies within the U.S., reports very few statistics on GHPs. The only source to consider a state-by-state installation rate for GHPs, was from the EIA's Renewable Energy Annual[7] published in 2012, with data from 2009. While the Renewable Energy Annual GHP data did not offer an installation rate by state, the report did provide information on GHP shipments by destination. The assumption was made that the GHP shipments to each state could serve as an estimate of the GHP installations by state.

In order to understand this state-by-state comparison of GHP activities, the total shipments were divided by the 2009 population of each state, to ensure that larger states with bigger populations, were compared fairly against the smaller states. The GHP shipments and the calculated GHPs shipments per capita by state are reported in Table 1. This comparison of GHP technology leads to some interesting trends.

1. The states in the Northern Midwest see the highest per capita shipments of GHP technology. The top five states as indicated by this analysis are North Dakota, Nebraska, Iowa, South Dakota and Minnesota, which form a tight geographic cluster.
2. The bottom three on the list is rounded out by Hawaii and Alaska which may be expected, and California which is relatively unexpected.

The 2009/2010 Geothermal Heating and Cooling Systems State Regulatory Oversight Survey[8] conducted by the National Ground Water Association (NGWA) polled all 50 states in regards to GHPs and received feedback from 34. Data was collected from these 34 states on nine different geothermal system configurations:

1. Open loop (1) – single well for water withdrawal, water returned to a surface source
2. Open loop (2) – single well for water withdrawal, water returned to a second well
3. Standing column – single well for water withdrawal and water return
4. Closed loop (1) – vertical boreholes
5. Closed loop (2) – subsurface trenched, or other configuration, but not vertical boreholes
6. Closed loop (3) – surface water body emplacement
7. Direct exchange (1) – vertical boreholes
8. Direct exchange (2) – subsurface trenched, or other configuration, but not vertical boreholes
9. Concentric pipe systems (heat exchange fluid flows to the bottom of the hole through a small diameter inner pipe and then up the annular space between the inner and outer pipes)

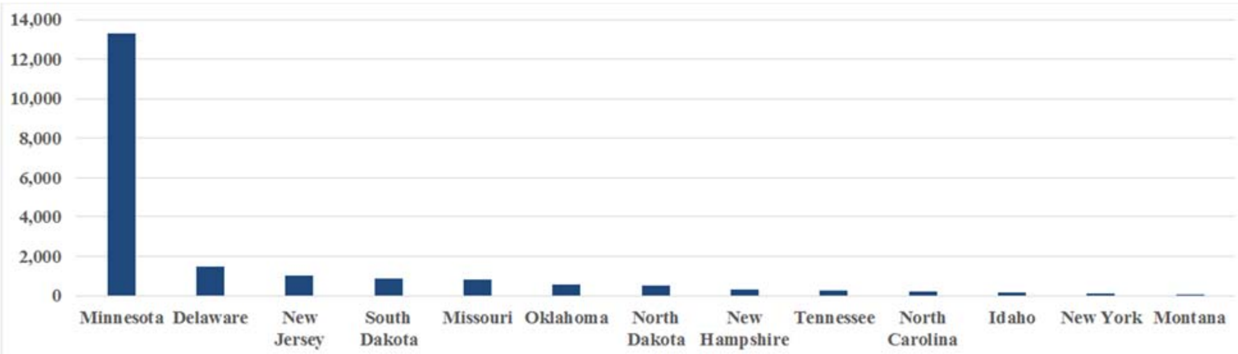
[6] U.S. Energy Information Administration. *Updated Buildings Sector Appliance and Equipment Costs and Efficiencies.* April 2015. http://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/full.pdf
[7] Renewable Energy Annual 2009, U.S. EIA, http://www.eia.gov/renewable/annual/pdf/rea_report.pdf
[8] National Ground Water Association (NGWA), Geothermal Heating and Cooling Systems State Regulatory Oversight Survey, 2009/2010.

*Table 1 – Geothermal Heat Pump Shipments per Capita, by Destination (EIA)*

| Destination | 2009 Shipments (Rated capacity in tons) | 2009 Shipments per Capita (Rated capacity in tons per capita) | Destination | 2009 Shipments (Rated capacity in tons) | 2009 Shipments per Capita (Rated capacity in tons per capita) |
|---|---|---|---|---|---|
| North Dakota | 5,789 | 0.008950 | New York | 18,142 | 0.000928 |
| Nebraska | 9,154 | 0.005095 | Idaho | 1,433 | 0.000927 |
| Iowa | 12,907 | 0.004291 | Vermont | 535 | 0.000860 |
| South Dakota | 2,729 | 0.003359 | Washington | 5,446 | 0.000817 |
| Minnesota | 16,823 | 0.003195 | Connecticut | 2,684 | 0.000763 |
| Delaware | 2,605 | 0.002943 | South Carolina | 3,405 | 0.000747 |
| Kentucky | 12,366 | 0.002866 | Nevada | 1,815 | 0.000687 |
| Indiana | 17,764 | 0.002766 | Colorado | 3,134 | 0.000624 |
| Missouri | 13,724 | 0.002292 | Arizona | 4,036 | 0.000612 |
| District of Columbia | 1,345 | 0.002243 | New Jersey | 5,131 | 0.000589 |
| New Hampshire | 2,812 | 0.002123 | Texas | 14,460 | 0.000583 |
| Ohio | 23,348 | 0.002023 | Georgia | 5,305 | 0.000540 |
| Oklahoma | 7,451 | 0.002021 | West Virginia | 976 | 0.000536 |
| Maryland | 11,062 | 0.001941 | Mississippi | 1,583 | 0.000536 |
| Montana | 1,766 | 0.001811 | New Mexico | 1,027 | 0.000511 |
| Pennsylvania | 21,357 | 0.001694 | Oregon | 1,875 | 0.000490 |
| Kansas | 4,447 | 0.001578 | Massachusetts | 3,054 | 0.000463 |
| Wisconsin | 8,370 | 0.001480 | Rhode Island | 470 | 0.000446 |
| Illinois | 18,795 | 0.001456 | Maine | 556 | 0.000422 |
| Wyoming | 723 | 0.001328 | North Carolina | 3,629 | 0.000387 |
| Michigan | 13,191 | 0.001323 | Alabama | 1,782 | 0.000378 |
| Arkansas | 3,558 | 0.001231 | Louisiana | 1,299 | 0.000289 |
| Tennessee | 7,625 | 0.001211 | Alaska | 190 | 0.000272 |
| Utah | 3,065 | 0.001101 | California | 6,998 | 0.000189 |
| Virginia | 8,338 | 0.001058 | Hawaii | 52 | 0.000040 |
| Florida | 18,558 | 0.001001 | **TOTAL** | **338,689** | **0.001103** |

Among the many questions asked of the states, one in particular asked, “For the five year period of 2004 - 2008, please indicate the number of each geothermal heating and cooling system (not holes, or other openings) listed that your agency is knowledgeable of being installed throughout your state.” Of the 34 states who provided feedback, 13 gave a quantitative response. The data from these 34 states is illustrated in Figure 1.

*Figure 1 – Number of Geothermal Heating and Cooling Systems Installed by State, from 2004 to 2008 (NGWA)*




The findings from the NGWA Geothermal Heating and Cooling Systems State Regulatory Oversight Survey show a slightly different order than what was found through the EIA data analysis. However, the general trends found in the EIA survey show up again in the NGWA report. The NGWA report presents data over a slightly different timeline than that of the EIA GHP shipment data, additionally this data is presented as total installations rather than per capita. Nonetheless, the fact that the general trends from the EIA data were confirmed through the self-reported NGWA survey, provides confidence in our conclusions. With that said, it is safe to say that California is indeed at the bottom of the list in terms of installations per capita although they did not provide quantitative data to the NGWA survey.

## *California Policy Challenges*

California, which prides itself as being one of the most energy efficient states in the nation, falls at the bottom of the list for GHP installations per capita. While this is a somewhat surprising revelation, California-specific regulations and policies point to some of the reasons why California may be so slow to embrace this efficient heating and cooling option. Regulatory and policy barriers to GHP installations in California include the certification requirements for geothermal well drilling, the energy modeling requirements set out in Title 24, and the use of Time Dependent Valuation (TDV) of energy as a cost-effectiveness metric.

### *Certification Requirements for GHP Well Drilling*

Across the nation, most regulation of GHPs occur at the state level. In California, The Department of Water Resources requires only water-well-drilling licensed technicians to drill geothermal wells, who often do not understand the requirements of geothermal wells. In fact, though most states require state licensing, a majority of those states do not require proof of having successfully completed any geothermal system installer training. This is puzzling, considering the regulatory emphasis is being placed on the wrong or less related part of the job. Nonetheless, it is very common across the nation, since most states require the structure to meet the legal definition of “well” requiring the individual and/or company constructing the well or borehole to be licensed, registered, or certified by the state in almost every type of GHP.[9]

Each state regulates GHPs differently. For open loop pump systems, forty six of the fifty states require licensing of well drillers, while about half also require separate licensing for pump installers.[10] For closed loop systems, borehole drilling are usually involved. Therefore, the state regulations for closed loop systems vary by a lot and sometimes discourage installations, since there is no existing body of regulations which are immediately appropriate for closed loop systems.[11] Some states have strict regulations on GHPs to ensure the underground water quality. For example, owners need to register pumps with the Department of Health and file well record in Ohio and Minnesota. The lack of regulation uniformity further restrains the penetration of GHPs.

According to the National Ground Water Association (NGWA) report (as referenced earlier)[12], states like North Dakota classify closed-loop systems using vertical boreholes as “Closed loop holes” rather than “Water wells,” yet the Water Well Board in North Dakota has developed specific regulations for geothermal system technologies. Imposing regulation where regulation may not be needed could impair market penetration of the GHP industry.

***Title 24 Energy Modeling Requirements***

In 1975, Public Resources Code Sections 25402 and 25402.1 were enacted, providing guidance in the establishment of the California Energy Commission (CEC). In response to a legislative mandate to reduce California’s energy consumption, the CEC established The Energy Efficiency Standards for Residential and Nonresidential Buildings, also known as Title 24 of the California Code of Regulations. The Energy Commission estimates that the energy efficiency standards associated with Title 24 “have saved Californians more than $74 billion in reduced electricity bills since 1977.”[13]

The standards outlined in Title 24 are updated periodically to allow for the possibility of incorporating new energy efficient technologies and methods. The 2013 update, which went into effect July 1, 2014, was designed to reduce the annual energy use of commercial buildings and new homes by 30 percent, as compared to current 2008 code update.[14] The mandates in the 2013 update are expected to “reduce statewide annual electricity consumption by approximately 613 gigawatt-hours per year, electrical peak demand by 195 megawatts, and natural gas consumption by 10 million therms per year.”[15]

There are two ways in which an energy efficient technology can comply with Title 24 requirements. The first is to comply via the *Prescriptive Method* in which each component of the proposed building must meet a prescribed minimum energy requirement. Although straightforward, this method of compliance is less flexible than the *Performance Method* whereby a computer program is used to calculate a general energy budget that the space

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[9] NGWA, Geothermal Heating and Cooling Systems State Regulatory Oversight Survey, 2009/2010.
[10] Den Braven, K., Survey of Geothermal Heat Pump Regulations in the United States, https://intraweb.stockton.edu/eyos/energy_studies/content/docs/proceedings/DENBR.pdf
[11] Den Braven, K., Survey of Geothermal Heat Pump Regulations in the United States, https://intraweb.stockton.edu/eyos/energy_studies/content/docs/proceedings/DENBR.pdf
[12] NGWA, Geothermal Heating and Cooling Systems State Regulatory Oversight Survey, 2009/2010.
[13] California Energy Commission. *California’s Energy Efficiency Standards Have Saved $74 Billion.* http://www.energy.ca.gov/efficiency/savings.html.
[14] USGBC. *Top10 Green Building Policies. http://www.usgbc.org/Docs/Archive/General/Docs18852.pdf*
[15] California Energy Commission. *2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings.* May 2012. http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf

must meet and a comparison is undertaken to actual performance data from an array of energy efficient technologies.[16] The CEC developed compliance software for a variety of industries in order to make such a comparison possible. With respect to Heating, Ventilation, and Air Conditioning (HVAC), technologies such as natural gas furnaces and ASHPs are accounted for in the modeling software while GHPs were excluded.[17]

Without software capable of analyzing the performance of GHPs, the benefits of this technology will not be able to help Californians meet Title 24 efficiency requirements. At present, the CEC has agreed to work with the GHP industry to create software such that this technology can be considered when constructing a building under Title 24 compliance. However, the CEC has placed the financial burden of developing this software, which is not insignificant, on the shoulders of the GHP community; this financial support was not required by any other industry in developing the Title 24 modeling software to show compliance.

***Time Dependent Valuation of Energy***

The California Title 24 building standards promote energy efficiency measures that have a positive cost-benefit ratio, when considered from a modified participant cost perspective. Since 2005, Time Dependent Valuation (TDV) has been used to define the metric of cost-effectiveness. "The concept behind TDV is that energy efficiency measure savings should be valued differently depending on the hours of the year the savings occur, to better reflect the actual costs of energy to consumers, to the utility system, and to society."[18] At its most basic, TDV ensures that more value is placed on energy efficiency measures that perform better on-peak versus those measures that do not.

The overall goal of the TDV metric helps to encourage cost-effective, energy efficiency, however the use of TDV as a cost-effectiveness metric has a significant impact on how much value is placed on GHP systems. In fact, "the energy costs of switching from gas heating to electric heat pumps is higher under TDV costing than traditional flat costing because electricity is allocated high costs during cold weather."[19] The costing strategy developed through the TDV metric discourages electric heating of any kind, because of the grid impact during cold weather on-peak periods. While, discouraging the use of electric heating during these on-peak periods makes general sense, it results in the TDV metric being used to encourage building heating from natural gas or other fossil fuel sources.

In fact, when considering the impact of heating loads using the TDV metric, it is not uncommon to see an increase in the building's energy consumption as natural gas measures are implemented to increase TDV performance.[20] Constructing buildings that perform best under the TDV metric does not necessarily mean constructing buildings that are the most-efficient, cost-effective options today. It also means that buildings constructed today, which will be around for the next century will be reliant on fossil fuels. Electric supplies could become carbon-free in the next century, if the prices of renewable production technologies and renewable storage systems drop; if so, all

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[16] "Title 24 Express: Certified Title 24 Energy Calculations and Compliance Reports For All California Projects." *Energy Performance Services*. N.p., 2015. Web. 5 Dec. 2015.

[17] Clutter, Ted. "CalGEO Working to Solve GHP Permitting Issues, Title 24." *Contractor: The Online Resource for Mechanical Contracting*. N.p., 20 May 2015. Web. 5 Dec. 2015.

[18] Energy Environmental Economics. *Time Dependent Valuation of Energy for Developing Building Efficiency Standards.* Feb. 2011. http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/Title24_2013_TDV_Methodology_Report_23Feb2011.pdf

[19] Heschong Mahone Group. *Time Dependent Valuation of Energy for Developing Building Efficiency Standards.* Dec. 6, 2000. CALMAC ID: PGE0313.01

[20] ARUP. *The Technical Feasibility of Zero Net Energy Buildings in California.* Dec. 2012. http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf

electric systems would become carbon-free as well. On the other hand, any systems reliant on fossil fuels have no opportunity to achieve the goal of a carbon-free system, at least not without significant financial investment.

## *Policy Opportunities for California as Informed by the Nation*

Compared to other states, California's policies and regulatory environment are hindering the growth of the GHP market. However, regulatory precedents exist, both inside California and across that nation that could foster the growth of the GHP market. The regulatory opportunities that could help support the GHP market include establishing a renewable thermal standard within the state's renewable portfolio standard to directly promote GHP market penetration and updating the state's Zero Net Energy definition to one focused on Zero Net Emissions. Each of these regulatory changes has the opportunity to promote the growth of the GHP market, which will in turn help California to meet the energy efficiency and emissions goals that have been mandated by the state.

### *Renewable Thermal Standards across the United States*

GHPs, as an alternative energy source, can be included as a part of renewable portfolio standards (RPSs), which sets a minimum threshold for the amount of energy supply that must come from renewable energy in a year. As in 2012, only six states included alternative resources in their RPSs.[21] In 2012, the geothermal heat source was not commonly listed as an eligible thermal resource in the state RPSs, unlike the various kinds of solar-related thermal systems. However, in 2015, eight states have already included geothermal energy in their RPSs, while California is not one of them.[22] Among those eight states, New Hampshire is the only state that requires a minimum amount of renewable thermal energy (2% of total renewable energy credit by 2023) that must be produced there.[23] [24]

Moreover, as GHPs can be classified as both energy efficient and a renewable energy technology, states chose various approaches in promoting geothermal energy other than the RPS. For example, in Pennsylvania, renewable thermal technologies can earn energy efficiency credits. In Wisconsin, renewable thermal technologies are treated as non-electric resources displacing electricity. Massachusetts has some of the most aggressive and best funded utility-sponsored energy efficiency programs in the nation. Utilities in the state support a subsidized financing program, the HEAT Loan, which provides qualifying homeowners with zero percent financing up to seven years on loans up to $25,000 and high efficiency GHPs are eligible for that.[25]

Setting up a renewable thermal standard will take a step further than the RPS, by requiring a minimum percentage of thermal energy generated to be obtained from renewable sources. Among the thermal renewables, geothermal energy provides both heating and cooling, which is advantageous over solar thermal and biomass heating. Overall, establishing a renewable thermal standard can foster additional incentives to support development and penetration of renewable energies.

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[21] Heeter, J. and Bird, L., Including Alternative Resources in State Renewable Portfolio Standards: Current Design and Implementation Experience, November 2012, National Renewable Energy Laboratory, http://www.nrel.gov/docs/fy13osti/55979.pdf
[22] Donalds, S., Renewable Thermal in State Renewable Portfolio Standards, Clean Energy States Alliance, April 2015, http://www.cesa.org/assets/Uploads/Renewable-Thermal-in-State-RPS-April-2015.pdf
[23] Donalds, S., Renewable Thermal in State Renewable Portfolio Standards, Clean Energy States Alliance, April 2015, http://www.cesa.org/assets/Uploads/Renewable-Thermal-in-State-RPS-April-2015.pdf
[24] Nixon, E. New Hampshire Renewable Portfolio Standard Thermal Energy Provisions, March 10, 2014, slides from the State-Federal RPS Collaborative Webinar, http://www.cesa.org/assets/Uploads/RPS-Webinar-Slides-3.10.14.pdf
[25] Meister Consultants Group, Massachusetts Renewable Heating and Cooling - Opportunities and Impacts Study, March 2012, http://www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf

***Zero Net Energy***

California has set the most ambitious goals in the nation in regards to building energy efficiency and Zero Net Energy (ZNE). In the January 2011 Energy Efficiency Strategic Update,[26] the California Public Utilities Commission (CPUC) outlines four goals, known as the *Big Bold Energy Efficiency Strategies* (BBEES) that highlight their thinking around ZNE and energy efficiency:

1. All new residential construction in California will be zero net energy by 2020;
2. All new commercial construction in California will be zero net energy by 2030;
3. Heating, Ventilation and Air Conditioning (HVAC) will be transformed to ensure that energy performance is optimal for California's climate; and
4. All eligible low-income customers will be given the opportunity to participate in the low income energy efficiency program by 2020.

The BBEES are meant to guide strategic thinking and market transformation in a number of key sectors, helping to achieve the goals that have been mandated by other legislation. For example, the BBEES will be used to advance the goals set out in AB32, which "requires California to reduce its GHG emissions to 1990 levels by 2020 - a reduction of approximately 15 percent below emissions expected under a 'business as usual' scenario."[27] The BBEES will also support the achievement of SB350, the Clean Energy and Pollution Reduction Act of 2015 which requires, "to double the energy efficiency savings in electricity and natural gas final end uses of retail customers through energy efficiency and conservation."[28]

One would assume that the ZNE goals set out by California in the BBEES will support the achievement of AB32 and SB350; and they will, but they could be doing more. California's ZNE goals are driven by a very specific definition, one that places TDV at the center of the ZNE equation. The California definition of ZNE is stated as, "A Zero Net Energy (ZNE) Code Building is one where the societal value of the amount of energy provided by on-site renewable energy sources is equal to the value of the energy consumed by the building annually at the level of a single 'project' seeking development entitlements and building code permits, measured using the California Energy Commission's TDV metric."[29] Because California's ZNE goals are supported by a definition that depends on the TDV metric, electric heating is discouraged in comparison to fossil fuel heating, meaning that these ZNE buildings will still have a negative environmental impact in terms of carbon emissions.

California must determine if the underlying purpose of mandating ZNE goals is one of reducing energy consumption, or to reduce emissions. Currently, California's ZNE goals are defined in such a way to reduce energy consumption, but don't focus on the issue of reducing emissions. California could instead consider the option of establishing ZNE goals around net zero emissions targets, such as defined by NREL as, "A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-

[26] Engage 360. CA|Energy Efficiency Strategic Plan, January 2011. http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.
[27] "Assembly Bill 32 Overview." *California Environmental Protection Agency Air Resources Board.* CA.gov, Aug. 5, 2014. Web. Nov. 17, 2015. http://www.arb.ca.gov/cc/ab32/ab32.htm.
[28] "SB-350 Clean Energy and Pollution Reduction Act of 2015." *California Legislative Information.* California Legislative Information, n.d. Web. Nov. 17, 2015. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350.
[29] http://www.cpuc.ca.gov/NR/rdonlyres/C27FC108-A1FD-4D67-AA59-7EA82011B257/0/3.pdf

producing energy sources."[30] If California re-established ZNE goals around emissions rather than energy consumption, GHPs would play an important role in supporting their achievement. In fact, a study completed for the CEC indicated that not only could energy use in fifteen of California's sixteen climate zones be reduced, with an average savings of 44 percent,  through the use of GHPs, but so could emissions from CO2, NOx and SO2.[31]

## *Conclusion*

On April 29, 2015, California Governor Edmund G. Brown Jr. signed Executive Order B-30-15, establishing a new statewide goal to reduce greenhouse gas emissions 40 percent below 1990 levels by 2030.[32] The Governor's 2030 target strengthens the state's position to meet its long-term goal of reducing greenhouse gas emissions 80 percent below 1990 levels by 2050.[33] Additionally, California AB2339,[34] passed in 2012, requires the CEC to recommend policies to overcome barriers to GHP development, since GHPs help reduce greenhouse gas emissions and can provide a clean energy future for California. A ZNE feasibility study suggested that if California wants a drop in natural gas consumption commensurate with the potential drops in electricity consumption, the state should investigate shifting some heating loads to heat pump mechanisms.[35] A study in Massachusetts also concluded that among all the renewable thermal technologies (including solar thermal and biodiesel), geothermal heat pumps can save the most money in terms of incremental lifecycle costs and reduce the most greenhouse gas emissions.[36]

Even with all of the opportunities offered by GHPs, California lags behind most of the rest of the nation in terms of GHP installations per capita. California's title as one of the states with the lowest rates of GHP installations per capita can be attributed to unique policy barriers including, certification requirements for geothermal well drilling, the energy modeling requirements set out in Title 24, and the use of Time Dependent Valuation (TDV) of energy as a cost-effectiveness metric. To take advantage of the opportunities offered by GHPs, California should consider regulatory opportunities to grow the market including establishing renewable thermal standards within the state's renewable portfolio standard and updating the state's Zero Net Energy definition to one focused on Zero Net Emissions. GHPs, as an energy efficiency measure, as well as a replacement for conventional carbon emitting technologies often used in the energy sector, can play an important role in achieving California's emission goal, but only if state agencies are willing to support their growth.

*NOTE: This white paper was written as part of a class project for Renewable Energy Policy (ENVS 5820). The policy challenge of encouraging GHP installations in California was identified by Bill Martin, President of CaliforniaGeo ([www.californiageo.org](http://www.californiageo.org)). This student team was asked to address the policy opportunities, identified from national research, to encourage GHP installations in California.*

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[30] Torcellini, P., S. Pless, M. Deru, and D. Crawley. *Zero Energy Buildings: A Critical Look at the Definition.* NREL/CP-550-39833. Golden, CO: National Renewable Energy Laboratory, 2006. http://www.nrel.gov/docs/fy06osti/39833.pdf.

[31] Glassley, William, Adam Asquith, Tucker Lance and Elise Brown. *Assessment of California's Low Temperature Geothermal Resources: Geothermal Heat Pump Efficiency by Region.* Apr. 2012. http://www.energy.ca.gov/2014publications/CEC-500-2014-060/CEC-500-2014-060.pdf

[32] Office of Governor, April 29, 2015, https://www.gov.ca.gov/news.php?id=18938

[33] Office of Governor, April 29, 2015, https://www.gov.ca.gov/news.php?id=18938

[34] Geothermal Technologies, California Assembly Bill No. 2339, Chapter 608, http://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201120120AB2339

[35] ARUP, The Technical Feasibility of Zero Net Energy Buildings in California, December 2012, http://www.energydataweb.com/cpucfiles/pdadocs/904/california_zne_technical_feasibility_report_final.pdf

[36] Meister Consultants Group, Massachusetts Renewable Heating and Cooling - Opportunities and Impacts Study, March 2012, http://www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf