BEFORE THE AIR RESOURCES BOARD OF THE STATE OF CALIFORNIA

June 2008 Draft Scoping Plan Pursuant
to AB32, The California Global
Warming Solutions Act of 2006

Comments of the California Alternative Energy and Advanced Transportation Financing Authority Regarding the Inclusion of Broader Incentives for Zero-Emission Heating and Cooling Systems

California Alternative Energy and Advanced Transportation Financing Authority

September 30, 2008

Executive Summary

The California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) applauds the California Air Resources Board (ARB) and its staff for their comprehensive efforts to reduce greenhouse gas (GHG) emissions throughout the California economy, as outlined in the Draft Scoping Plan (the "Draft Plan"). These comments address the Draft Plan's recommended greenhouse gas reduction measures.[1] CAEATFA recommends that ARB expand these recommended reduction measures to include a program that specifically addresses California's heating and cooling sector.[2] **CAEATFA estimates that current annual GHG emissions in California from space, process, and water heating and cooling in the commercial, residential, and industrial sectors are approximately 125 MMTCO2e or 27% of emissions.[3] In order to address this, CAETFA recommends that ARB require the electric and gas utilities to implement a performance based incentive (PBI) for all near-zero emission[4] heating and/or cooling (ZEH/C) technologies.** ZEH/C technologies include solar thermal, geothermal, and fuel cells.[5] Substantial GHG reductions would be achieved by the deployment of these technologies, likely at cost-effective levels relative to other GHG reduction options that are being actively promoted in California. The Economic and Technology Advancement Advisory Committee (ETAAC) report found that advanced solar thermal (AST) alone could achieve in excess of 20 MMTCO2e reductions annually.[6] Given the scale up involved in developing a viable ZEH/C industry for California it would most likely take about ten years to achieve 20 MMTCO2e reductions annually assuming a well designed PBI program was implemented across the state.

Draft Scoping Plan

Currently, the Plan recommends 6.9 MMTCO2e reductions from the increased use of combined heat and power (CHP) and 0.1 MMTCO2e reductions from solar water heating (achieved through SB1470). Additionally, Appendix C of the Plan identifies a total of 6.2 MMTCO2e reduction potential from solar hot water systems. The Draft Plan fails to consider the benefits of zero-emission cooling or the use of AST, geothermal, or fuel cell technology for CHP or ZEH/C systems. If deployed, ZEH/C systems could provide substantial GHG emission reductions, discussed further below.

Significant GHG Reductions

The heating and cooling sector represents a significant portion of California's GHG emissions. CAEATFA found that heating and cooling[7] represents at least 27% of California's total GHG emissions or 125 MMTCO2e emissions annually, based on 2000-

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[1] Draft Scoping Plan, Table 2, pg. 11

[2] Includes space, process, and water heating and cooling in the commercial, residential, and industrial sectors.

[3] See Table 1 for detailed calculations and references.

[4] Near-zero emission is defined as a technology that produces no or low GHG emissions during use. For instance, geothermal heat pumps count as a ZEH/C technology even though they may require some electrical energy to pump fluids, which may result in GHG emissions.

[5] See appendix for description of technologies.

[6] ETAAC Report, pg. 10-43

[7] Includes space, process, and water heating and cooling in the commercial, residential, and industrial sectors.

Annual GHG Emissions from Thermal Uses in California (MMTCO2e)			
	Average Annual GHG Emissions	Percentage for Thermal Uses	Total Annual GHG Emissions from Thermal Uses
Residential Energy Use (Excluding Electricity)	29[8]	88%[9]	26
Commercial Energy Use (Excluding Electricity)	12[10]	68%[11]	8
Residential Electricity Use	28[12]	20%[13]	6
Commercial Electricity Use	33[14]	28%[15]	9
Industrial Energy Use (Excluding Electricity)	96[16]	80%[17]	77
Total Annual CA GHG Emissions from Thermal Uses			125
Total Average Annual CA GHG Emissions			469
Percentage of Emissions for Thermal Uses			27 %

Table 1: Calculation of annual GHG emissions in California from space, process, and water heating and cooling in the residential, commercial, and industrial sectors.[18] All GHG emissions are in units of MMTCO2e and are based on average values from 2000-2004. Numbers may not add up to totals due to independent rounding.

2004 average emissions. For more detailed calculations see Table 1 and corresponding footnotes. Although clearly not all of these emissions can be captured as reductions, these numbers show that this is a sector with significant GHG reduction potential; more than half the size of the entire transportation sector. Because of the magnitude of GHG savings potential, the ARB should address this sector through a comprehensive and flexible PBI program.

In addition to CAEATFA's estimates, the ETAAC report identified significant reduction potential from AST and solar hot water systems. The report cited a National Renewable Energy Laboratory (NREL) study which found that 65% of residential and 75% of commercial buildings in California could be outfitted with solar collectors for hot water. Additionally, the study found that the use of solar hot water systems could result in 7.8 to 8.6 MMTCO2e of annual savings from California's residential and commercial sectors. Although this study was limited to solar thermal hot water systems, the ETAAC report identified additional potential GHG reductions in excess of 15 MMTCO2e annually from

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[8] California Greenhouse Gas Inventory

[9] California Energy Efficiency Strategic Plan, Section 2, Page 8

[10] California Greenhouse Gas Inventory

[11] California Energy Efficiency Strategic Plan, Section 3, Page 25

[12] Calculated by multiplying 86 MMTCO2e (California Greenhouse Gas Inventory), the total annual GHG emissions from CA electricity use, by 32 % (California Energy Efficiency Strategic Plan, Section 2, Page 7), the amount of CA electricity used by the residential sector.

[13] California Energy Efficiency Strategic Plan, Section 2, Page 8

[14] Calculated by multiplying 86 MMTCO2e (California Greenhouse Gas Inventory), the total annual GHG emissions from CA electricity use, by 38 % (California Energy Efficiency Strategic Plan, Section 3, Page 25), the amount of CA electricity used by the commercial sector.

[15] California Energy Efficiency Strategic Plan, Section 2, Page 8

[16] Draft Scoping Plan, p. 8

[17] US Department of Energy, Energy Efficiency and Renewable Energy Program, Industrial Technologies Program, http://www1.eere.energy.gov/industry/energy_systems/

[18] Does not include residential and commercial cooking energy use.

AST systems. AST can provide the added benefit of space heating and cooling which displaces both natural gas and electricity generation needs. Space cooling is particularly advantageous during the summer in California, as residential and commercial cooling account for approximately 30 percent of the peak load and is generally met with the dirtiest, most expensive power generation.[19] ZEH/C using geothermal and fuel cells has great reduction potential as well, as these systems can be used almost anywhere and are not limited by roof characteristics like AST. Geothermal heat pumps can cut energy use by 70%, which would result in significant GHG emission reductions.[20] Fuel cells can be zero-emission as well or low-emission, depending on the fuel used. Fuel cells fueled by renewable sources provide additional GHG reductions (1.59 tons per MWh)[21] as they use renewable gases that would ordinarily be treated as a waste product and destroyed via combustion. ZEH/C technologies can also provide commercial and industrial process heating and cooling which could lead to further GHG reductions.

Substantial Distributed Generation Benefits

In addition to the GHG reduction potential from ZEH/C, the fact that they are employed as distributed generation leads to further benefits. The employment of ZEH/C avoids the cost of increased generation capacity (both capital and operation and maintenance costs), of transmission and distribution (both building capacity and efficiency losses), and of fuel. ZEH/C offers the additional benefits of deployment ease and speed, grid independence, fossil fuel price hedge, reduced water use, and reduced health effects. These benefits should be monetized and incorporated into the uniform ZEH/C PBI program. Finally these distributed thermal systems are cost effective over time and often more cost effective than other renewable options, with the potential for large savings from the investment.

Background

Although ZEH/C has large GHG reduction potential and substantial distributed generation benefits for the electric and gas ratepayers, California has no integrated comprehensive policy addressing it specifically. The policy that does exist is too narrow and often eliminates specific applications of these technologies because they may displace both natural gas and electricity. For instance, since AST can reduce both gas and electricity use simultaneously, it is not eligible under the Solar Water Heating Efficiency Act of 2007,the California Solar Initiative (CSI) or the New Solar Homes Program. Solar water heating is now eligible as an efficiency measure through the Public Utilities Commission (PUC). Similarly to California solar programs, fuel cell incentives (California Energy Commission's Emerging Renewables Program and the PUC's Self Generation Incentive Program) only apply to electricity generation and so do not explicitly encourage the deployment of these technologies for ZEH/C applications. There are also no state level incentives for the deployment of geothermal heat pumps. Under the Standard Performance Contract Program, operated by the investor owned utilities some conventional heating and cooling systems have been converted to heat pumps. The Self-Generation Program's minimum efficiency requirement has ensured usage of waste

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[19] http://enduse.lbl.gov/info/LBNL-47992.pdf

[20] http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12660

[21] Itron SGIP Sixth Year Impact Evaluation, August, 2007, page 1 -9.

heat from fuel cells and has indirectly encouraged ZEH/C. California's distributed generation incentives focus on individual technologies and specific applications. All of these programs mentioned above are worthwhile the important policy consideration here is that there is no comprehensive or targeted program aimed at reducing GHG emissions from the ZEH/C sectors.

On a global scale favorable policies and resource conditions have led to a greater deployment of ZEH/C than has been seen in California. Specific examples include:

- Over 88 GWth of solar thermal have been installed worldwide, with China accounting for 75% of annual global additions. Even Germany has nearly 5 GW of solar water heaters installed (around 750 000 units).
- More than 2 million geothermal heat pumps have been deployed globally, mostly in Europe and North America. About 30% of houses in Sweden have geothermal heat pumps with a combined capacity of nearly 4 GW.
- More countries and local jurisdictions are requiring solar water heating for all new residential and commercial buildings, such as Spain and Hawaii.
- The solar share of Germany's residential space heating market is approaching 50%.[22]
- Korea offers a feed-in tariff of $0.28 per kWh for fuel cells using CHP which is expected to result in installations of 50Mw of fuel cell projects by 2009.
- Arizona Public Service (APS) through their Renewable Incentive Program offers performance based incentives ranging from 5.1 to 7 cents per kWh for heating and from 12 to 16 cents kWh for cooling which can be applied to AST systems. The utility monitors the AST system over a one-year period and then makes a one time incentive payment based on the metered output of each system.

These examples demonstrate that ZEH/C is a proven technology, ready to provide significant GHG reductions for the state of California if a simple comprehensive PBI program can be implemented to deploy these technologies within our state.

One reason that ZEH/C requires government incentives is because of this substantial up-front capital costs. Solar thermal and geothermal ZEH/C technologies are more capital intensive compared to fossil fuel CHP or DHC, as all of the project's fuel is essentially purchased at the time of construction. Fuel cell ZEH/C is also capital intensive. Though their life cycle costs are acceptable, their first costs pose a significant barrier. Deployment will continue to be slow in markets that lack strong supporting incentive policies. All of these ZEH/C technologies require substantial upfront capital for deployment and warrant ratepayer supported PBIs. Ratepayers are also protected under a PBI program design as incentives are only paid over time based on measured useful output of ZEH/C produced.

CAEATFA Scoping Plan Policy Recommendations

The ARB should require the electric and gas utilities to establish a performance based incentive (PBI) for all near-zero emission[23] heating and/or cooling (ZEH/C)

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[22] IEA, "Renewables for Heating and Cooling: Untapped Potential"

technologies. ZEH/C refers to any system that has zero- or near zero-emissions[24] and that provides one or more of the following energy services: space heating, space cooling, process heating, process cooling, domestic hot water, and/or electricity. These services can be provided to an individual user or on a district level. The term ZEH/C can include both CHP and district heating and cooling (DHC) systems, if these systems obtain their energy from near-zero emissions sources.

CAEATFA recommends that ARB require the gas and electric utilities provide PBIs similar to the APS program that would pay an incentive rate per kWh equivalent of heating, cooling, and/or electricity generated. The incentive should include the value of distributed generation benefits. The key is that under the proposed ZEH/C uniform PBI incentive program, systems that generate one or more energy services would be eligible, whereas currently California does not encourage systems that provide more than one energy service. This broader program would allow greater flexibility and reward technologies accurately for the energy they actually produce, regardless of what form it takes. This flexibility and performance based approach would ultimately lead to the capture of more tons of reductions as a greater number and variety of technologies would be deployed over time.

A well designed ZEH/C PBI program could transform the market into a self-sustaining industry within a decade and provide the state with at least 20 MMTCO2e of reductions annually. PBI protects the ratepayer as incentives are provided based on the metered performance of the ZEH/C system not system costs. Under a PBI structure transparency, competition and innovation are encouraged resulting in lower installed costs as the market expands. As ZEH/C demand increases investment in manufacturing, installation and maintenance companies are established along with many new sustainable green collar jobs. As the ZEH/C market matures, new technology applications are likely to come forward. Key elements of program design should include:

1) Ten-year declining ratepayer incentives for residential, commercial and industrial customers based on metered useful output. A long term program ensures steady industry and economic growth. Declining ratepayer PBI incentives, combined with federal tax credits, renewable energy credits, GHG credits and increasing private customer investment over time is an effective program design for a public/private partnership that will lead to a competitive and sustainable ZEH/C industry within a decade.

2) Incentive payments should be based on a per kWh equivalent[25] of heating, cooling, and/or electricity generated which includes the value of distributed generation. These PBI payments are transparent, encourage innovation and competition that will ultimately drive installations costs down as the market expands. These PBI payments can be made over a five-year period along the lines of the CSI program design for larger PV systems.

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[23] As defined in footnote 4.

[24] As defined in footnote 4.

[25] 1 kilowatt equals 3,412 BTUs.

3) Project costs and incentive payments must be public, collected on an electronic database to ensure transparency, encourage program analysis and provide for program adjustment over time;

The ARB should direct the PUC in consultation with the CEC to establish PBI incentive rates for ZEH/C based on a per kWh equivalent of heating, cooling and/or electricity generated including the distributed generation benefits by June, 2009. Each gas and electric utility (including the municipal utilities) shall be required to file a ZEH/C tariff. Program administration should be determined by the PUC and CEC. An independent third party should be responsible for processing applications, data accumulation and establishing and maintaining a public data base.

The ARB should consider requiring the natural gas distributors to purchase allowances for any natural gas they distribute and refund the revenues to the ZEH/C PBI program rather than phasing in the natural gas sector into the cap and trade program over time. Alternately or additionally, CARB could assign a set number of tons of emission reductions, 7.5 MMTCO2e, to this measure in the "Cap and Trade" portion of the Scoping Plan under the natural gas sector and place that obligation on the natural gas distributors. In that way, the motivation to design an effective ZEH/C program would be clear and/or auction revenues from the sale of allowances to meet this obligation could be applied to fund the industry market transformation.

CAEATFA Tax Exempt Financing for District Heating and Cooling

Under the federal tax code, tax-exempt private activity bonds can be issued for district heating and cooling projects. CAEATFA is in the process of setting up a program to finance and encourage deployment of district ZEH/C using this authority and is actively looking for projects that it can finance. This federal tax exemption requires two or more energy users, which is why the CAEATFA financing program would be specifically for district systems. CAEATFA can also issue private activity bonds for non-profit organizations, and may use this authority to provide tax exempt financing for ZEH/C when appropriate. Additionally, other financing authorities can provide financing for ZEH/C, including the Health Facilities Financing, Pollution Control Financing, School Financing, and Educational Facilities Authorities.

Conclusion

In summary, CAEATFA commends ARB’s efforts to reduce GHG emissions throughout the California economy. CAEATFA recommends that ARB implement a comprehensive incentive program for ZEH/C using geothermal, fuel cell and AST technologies. Specifically, ARB should require gas and electric utilities to establish a performance based incentive for ZEH/C systems. The incentive should be based on the value of GHG reduction along with other distributed generation benefits and should reward systems based on kWh of heating, cooling, or electricity produced. The ARB should direct both gas and electric utilities (including municipal utilities) to file a tariff that reflects the distributed generation values through this incentive. Performance based incentives are necessary to ensure maximum GHG reductions, encourage innovation, transparency and competition within the heating and cooling sector. As discussed previously, the total heating and cooling sector accounts for over 25% of California's total annual GHG emissions, because of its significance this sector should be addressed specifically in the Scoping Plan. The expansion of ARB's current plan for reductions from solar hot water and CHP to one that broadly encompasses the entire heating and cooling sector would result in significant additional emissions reductions.

The ARB should consider requiring the natural gas distributors to purchase allowances for any natural gas they distribute and refund the revenues to the ZEH/C PBI program rather than phasing in the natural gas sector into the cap and trade program over time. Alternately or additionally, CARB could assign a set number of tons of emission reductions to this measure in the "Cap and Trade" portion of the Scoping Plan under the natural gas sector and place that obligation on the natural gas distributors. Under this format, the motivation to design an effective ZEH/C program would be clear and/or auction revenues from the sale of allowances to meet this obligation could be applied to fund the industry market transformation.

APPENDIX: ZEH/C Technologies

Solar Thermal and Advanced Solar Thermal: Solar thermal systems collect solar energy through a rooftop-type collector. Basic solar thermal systems use this thermal energy to heat domestic hot water. Advanced solar thermal systems use this energy for space heating and cooling, process heating and cooling, district heating and cooling, and domestic hot water. AST systems differ from traditional solar hot water systems in that they produce water at temperatures[26] high enough to run a chiller to produce cold water or air which can provide space and process cooling. AST systems are individually engineered, generally have O&M provided, are commercial quality, have longer paybacks, and allow for large domestic hot water systems. A diagram of an AST system is shown in figure 1.

AST Collectors: There are two main types of AST collectors used for ZEH/C: flat plate and evacuated tube. Flat plate collectors are generally simpler and cheaper than evacuated tube collectors. These collectors typically heat liquid or air at temperatures less than 180°F, and are commonly used for domestic hot water only systems. However, some companies have been able to produce water at 200-225°F, which allows flat plate collectors to also be used for cooling applications. See figure 2 for a drawing of a flat plate collector. Evacuated tube collectors can produce higher water temperatures ranging from 170°F to 350°F and are generally about twice as expensive as flat plate collectors. The collectors usually consist of parallel rows of transparent glass tubes.[27] See figure 2 for a drawing of an evacuated tube collector. A third type of collector, the parabolic trough, may also be used for AST heating and cooling applications. Parabolic troughs are more expensive and mechanically complicated than either of the other two collector types

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[26] Typical solar hot water systems produce water at 140°F. AST collectors produce water from 200°F to above 600°F.

[27] http://www1.eere.energy.gov/solar/sh_basics_collectors.html#flatplate

described, but in turn are capable of producing water above 600°F. They are more commonly used in large scale solar power plant applications.[28]

Chillers: In order to convert solar thermal energy into cooling, AST systems use absorption or adsorption chillers. Absorption chillers are more common, as adsorption chillers are a newer technology. Both chiller types are similar to the common vapor compression chiller (used in refrigeration and air conditioning), but use thermal heat instead of a mechanical compressor to create the high pressure vapor. Vapor compression chillers create cooling by allowing the refrigerant to expand (decrease in pressure) and consequently drop in temperature. See figure 3 for a schematic drawing a vapor compression chiller cycle.

Current Status: Although AST ZEH/C systems are commercially available, they have not been widely implemented in the US. As of 2005, there were 88 gigawatts-thermal (GWth) of solar thermal systems installed worldwide, provided by 46 million systems. However the majority of this energy is from systems which are limited to providing hot water, rather than space heating or cooling. There is significantly less data on the deployment of AST cooling systems, but estimates of the number of installed systems and capacity in Europe range from 40 to 200 and 4.4 MWth to 12 MWth, respectively. Only 5 to 10 AST cooling systems have been deployed in the US, while the majority of systems so far have been installed in Germany, Spain, and Greece.[29]

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[28] http://www.nrel.gov/docs/fy06osti/39459.pdf

[29] IEA, "Renewables for Heating and Cooling: Untapped Potential"

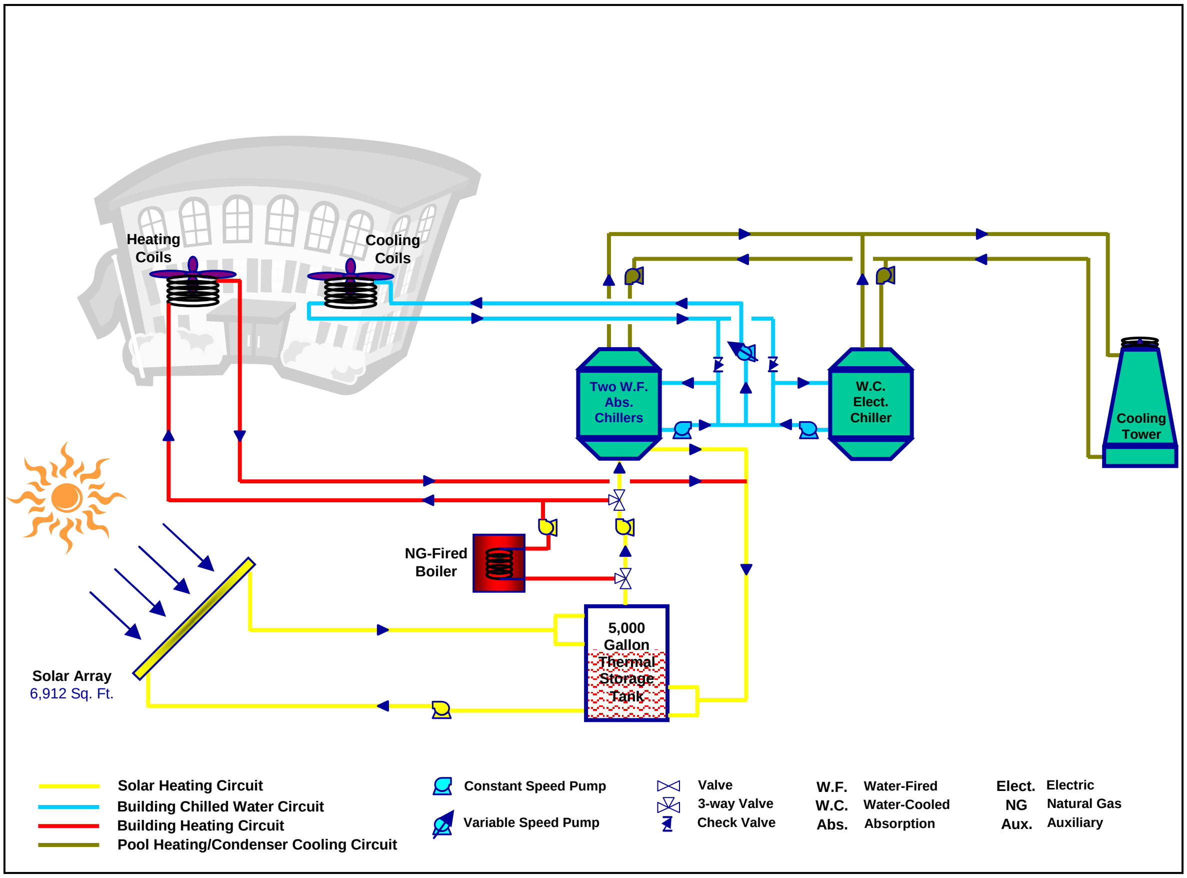

Figure 1: Schematic diagram of an AST heating and cooling system. Note that this schematic only shows one building, while a district system would serve multiple "users."

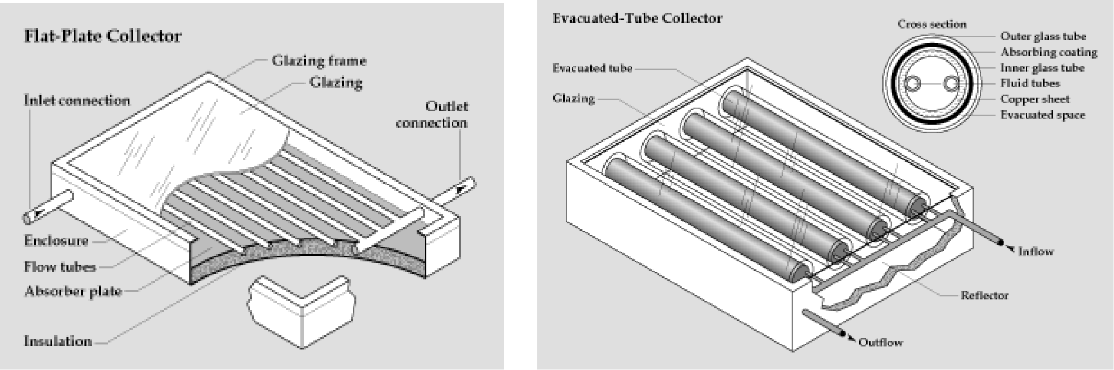

Figure 2: Schematic drawings of flat plate and evacuated tube solar thermal collectors.[30]

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[30] http://www1.eere.energy.gov/solar/sh_basics_collectors.html#evacuatedtube

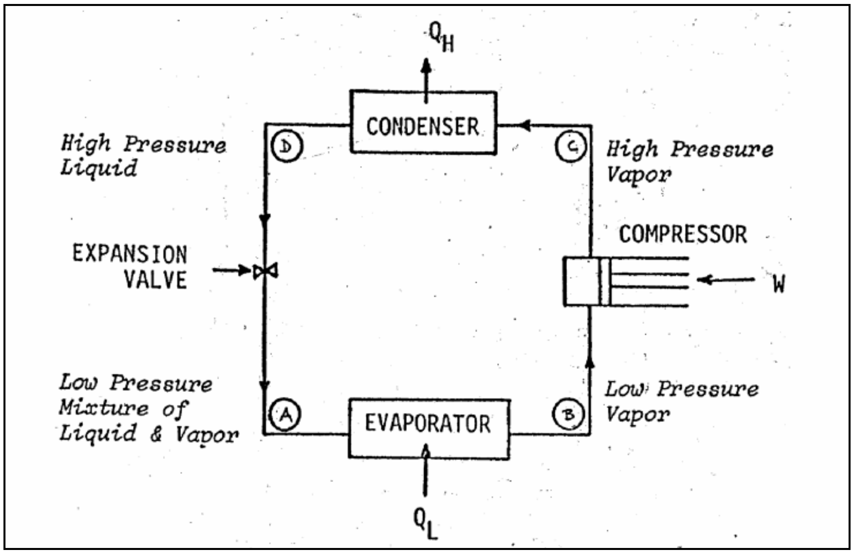

Figure 3: Schematic drawing of a vapor compression chiller cycle. This chiller cycle is similar to that of absorption and adsorption chillers, which use heat, rather than a mechanical system, to compress the vapor.

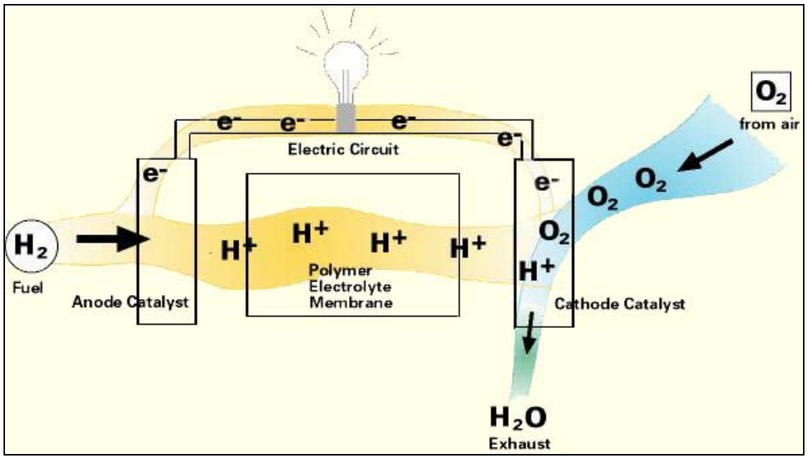

Figure 4: Schematic drawing of a fuel cell.[31]

Fuel Cells: Fuel cells produce electricity and heat electrochemically by combining a fuel and an oxidant. Common fuels include hydrogen, hydrocarbons (natural gas, diesel, waste or digester gas), and alcohols (methanol, ethanol). The most common oxidant is oxygen, but other oxidants include chlorine and chlorine dioxide. Fuel cells work similarly to batteries, but unlike a battery, they continually intake fuel and therefore are not depleted. In order to create electricity, the fuel flows over the anode. The anode is a catalyst that separates the electrons from the positive ions. The positive ions can flow through an electrolyte, while the electrons are forced to flow through an electric circuit, generating electricity. The positive ions, electrons, and oxidants are then recombined on the cathode, another catalyst. In the case where hydrogen is the fuel, the end products are water and heat. This heat can be used for district heating or can be used to drive chillers

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[31] http://auto.howstuffworks.com/framed.htm?parent=fuel-cell.htm&url=http://www.fuelcells.org

(described above) to provide cooling. When other carbon-based fuels are used, fuel cells also produce carbon dioxide. See figure 4 for a schematic diagram of a generic fuel cell.[32]

There are several types of fuel cells that serve a variety of applications. Specifically fuel cells can provide stationary power and heat, transportation power, and portable power. The main distinctions between different types of fuel cells are their operating temperatures and the type of electrolyte used. Examples of types of fuel cells are: molten carbonate or phosphoric acid, proton exchange membrane, solid oxide, alkaline, direct methanol, regenerative, zinc air, protonic ceramic, and microbial. Fuel cells with higher operating temperatures, such as phosphoric acid fuel cells, have applications in DHC, while those with lower operating temperatures, such as proton exchange membrane fuel cells, are generally better suited for transportation applications. See http://www.fuelcells.org/basics/types.html for more information on specific types of fuel cells.[33]

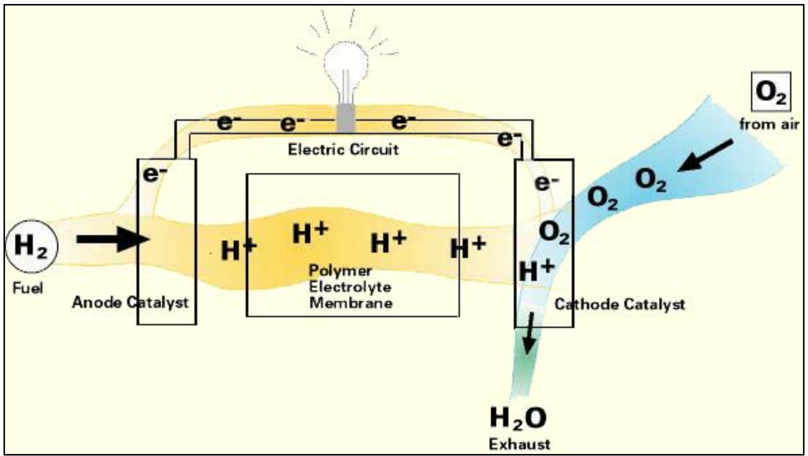

Figure 4: Schematic drawing of a fuel cell.[34]

Current Status and Potential: Fuel cells are primarily used to generate electricity and heat that can be used at consumer sites or in district or campus applications. Over 2500 stationary fuel cell systems have been installed worldwide. California has installed more than 20 MW of fuel cell capacity since 2003. About half of the installed capacity is customer generators, while the remaining half is for utility and waste water treatment facility power plants. The majority of these installations operate on renewable fuels, specifically anaerobic digester gas. Within California additional renewable fuels in the form of landfill gas and manure digesters at dairies could produce over 1,000 MW of fuel cell power and renewable ZEH/C.[35] A PBI incentive directed at the ZEH/C application would further result in the increased usage of these renewable fuels that are currently combusted in an effort to dispose of them.

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[32] http://www1.eere.energy.gov/hydrogenandfuelcells/fc_animation_components.html

[33] http://www.fuelcells.org/basics/types.html

[34] http://auto.howstuffworks.com/framed.htm?parent=fuel-cell.htm&url=http://www.fuelcells.org

[35] U.S. EPA Landfill Methane Outreach Program statistics.

Similar to the process previously described for AST projects, thermal energy from fuel cells can be used in an absorption or adsorption chiller to produce cooling as a byproduct of the energy generation process. A 1 MW fuel cell would produce sufficient waste heat to operate a 200-ton absorption chiller that would either offset or replace a conventional electric chiller.[36] The most common use of waste heat from fuel cells among the 20 MW of operational projects in California takes the form of hot water and replaces the use of a boiler.

A representative example of this type of ZEH/C can be seen at the Sheraton Hotel in San Diego where a 500 kW fuel cell serves a 300-room hotel and conference facility. On an annual basis, the fuel cell supplies 100% of the hotel's aggregate electrical demand while its thermal output replaces a set of boilers. The boilers no longer consume any gas as the fuel cell meets 100% of the load required for domestic hot water, kitchen usage, and laundry usage. Additional thermal energy is available for potential usage by an absorption chiller and a PBI program stimulating ZEH/C could enable the use of this additional energy source.

Unlike AST systems, fuel cells can deployed almost anywhere as they are not dependent on site conditions, such as roof size and orientation. There are no estimates of the potential GHG reductions from fuel cells in DHC systems. CAEATFA staff estimates that the potential is large, as industrial, commercial and residential heating and cooling account for approximately 27% of California's GHG emissions annually. Although not all of these emissions could be captured through DHC applications, and not all DHC applications would use fuel cells, these numbers show that there are significant potential reductions from fuel cell DHC.

Geothermal: There are two main types of geothermal energy systems: deep and shallow. Deep geothermal energy comes from heat reservoirs of steam or hot water that can be up to several miles below the earth's surface. Deep geothermal energy is typically used for power generation (with some potential for use in district heating/cooling systems), and is site specific to locations where the geothermal resources exist. The major identified deep geothermal resource areas in the state are: the Geysers north of San Francisco, Northeastern California, Western Nevada, the Mammoth Lakes area, Coso Hot Springs in Inyo County, and the Imperial Valley.

Shallow geothermal energy systems, also known as geothermal heat pumps, are used exclusively for heating and cooling applications and can be deployed almost anywhere. A prime ZEH/C technology, geothermal heat pumps use the earth's constant temperature (between 50 and 60°F) to provide heat in the winter, or serve as a heat sink during the summer. An external energy source must be used to move the heat "uphill," but coefficients of performance (COP) for geothermal heat pumps are high, generally in the range of 3 to 6.[37]

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[36] Fuel Cell Energy and UCI / National Fuel Cell Research Center calculations.

[37] http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12640

Shallow Geothermal Systems: There are four main types of shallow geothermal systems: horizontal, vertical, pond/lake, and open loop. Horizontal systems are generally the most cost-effective for residential installations, particularly for new construction where sufficient land is available. Large commercial buildings and schools often use vertical systems because there is not enough surface "footprint" for a horizontal system. When water resource are nearby, pond or lake systems can be the lowest cost option and consist of coils placed at least 8 feet below the surface of a lake. Finally, open-loop systems use well or surface body water as the heat exchange fluid that circulates directly through the heat pump system. See figure 5 for schematic drawings of the various types of shallow geothermal systems.

Current Status: The City of San Bernardino has one of the largest geothermal district heating projects in North America. That project heats 37 buildings with fluids sent through 15 miles of pipelines.[38] In addition, associated with California's sizable deep geothermal resource, there may be further potential to develop new deep geothermal district heating and cooling systems in developed areas near geothermal resources.

More broadly across California, even where deep geothermal resources do not exist, the opportunities for shallow geothermal in ZEH/C application are almost universal, and often highly cost-effective as a GHG reduction approach. It should be noted that shallow geothermal ZEH/C is not a new technology that is little-proven: by the end of 2005, more than 600,000 ground-source heat pumps had been installed in the United States, with new installations occurring at a rate of 50,000 to 60,000 per year.[39] City College of San Francisco has a district geothermal system currently under construction for their new Performing Arts Center, Advanced Technology Center and Bookstore. The City of American Canyon also has a geothermal construction project underway for their new High School which is scheduled to be open for class in the fall of 2009.

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[38] ETAAC Report, pg. 10-35

[39] http://www.ucsusa.org/clean_energy/renewable_energy_basics/offmen-how-geothermal-energy-works.html

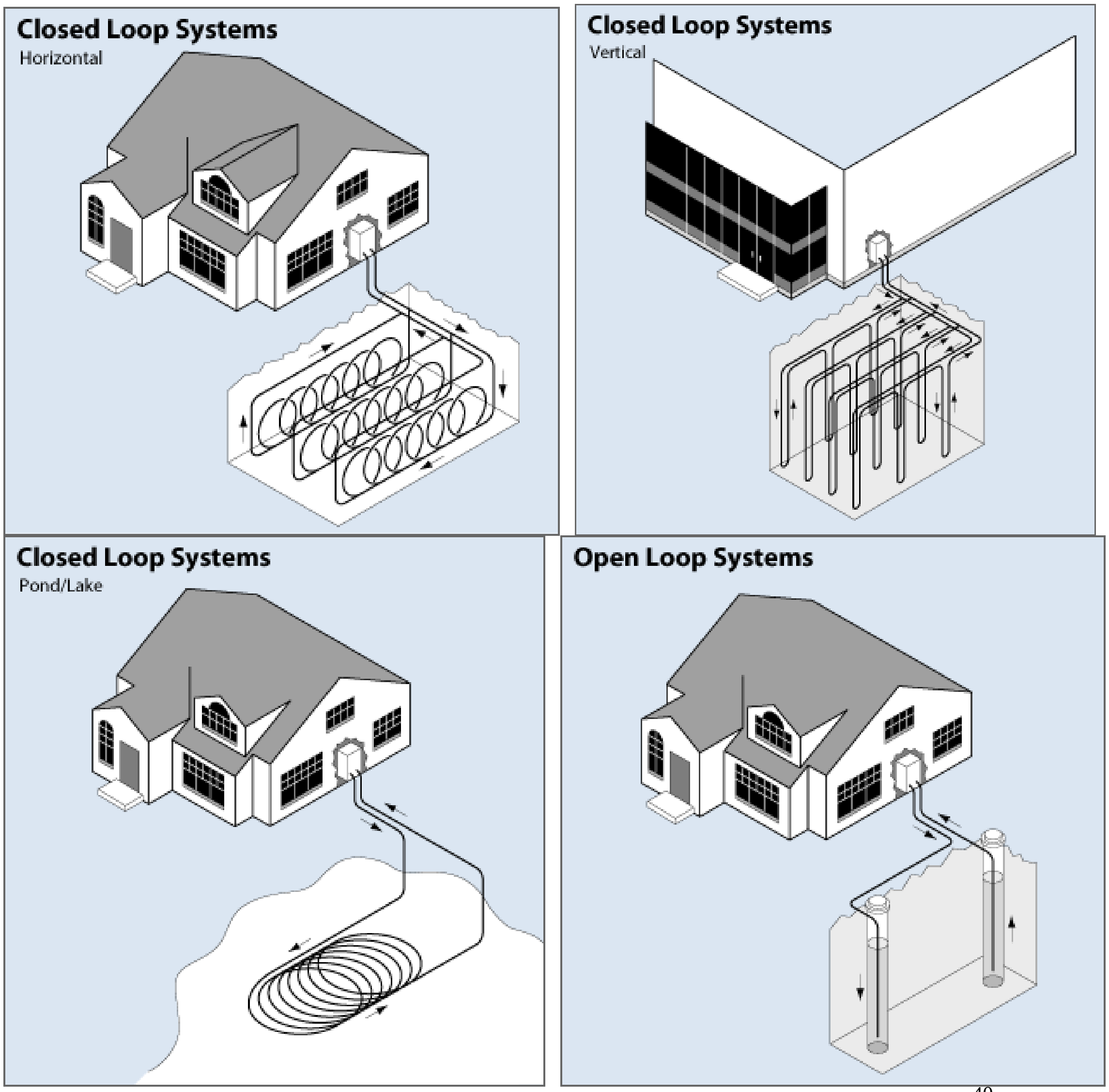

Figure 5: Schematic drawings of four types of geothermal heat pump systems.[40]

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[40] http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12650

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