Pools Heaters

Codes and Standards Enhancement (CASE) Initiative
For PY 2013: Title 20 Standards Development

Analysis *of* Standards Proposal for
Residential Gas Fired Pool Heaters

Docket #12-AAER-2F

California Energy Commission
DOCKETED
12-AAER-2F
TN 71754
JUL 29 2013

July 29, 2013

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This report was prepared by the California Statewide Utility Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

*A*cknowledgements

We gratefully acknowledge the Association of Pool and Spa Professionals-15 Committee and the general pool industry for continuing to innovate and build energy efficient pool products.

The CASE Team would also like to thank NRDC, in particular Meg Waltner for her contributions in the development of this standards proposal.

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1 Executive Summary

The Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), San Diego Gas & Electric (SDG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE Report covers a standard proposal to reduce the back pressure introduced by residential gas fired pool heaters on the pool hydraulic system while not in service. The standard aims to set a minimum TDH (total dynamic head) a pool heater can introduce to a system. This TDH reduction can be achieved through a variety of technologies, including but not limited to, improved manifold design or an integrated bypass valve. If adopted, these measures (assuming the pool uses a variable speed filtration pump) will produce approximate electric energy and demand savings of 28 gigawatt-hours (GWh) and 5 megawatts (MW) in the first year, and 170 GWh and 32 MW after full stock turnover in 6 years.

2 Product Description

Basic gas-fired pool heaters are comprised of a thermostat, flow sensor, heat exchanger, burner, pilot ignition system and control valve, a blower motor, and thermostatically regulated valves, as depicted in Figure 2.1. The blower supplies air, which mixes with gas allowing burners to fire under a heat exchanger. Exhaust gases (i.e. the products of combustion) then exit through the exhaust flu. Water delivered by the filtration pump passes a series of thermal regulator valves and a pressure-responsive bypass to maintain the correct balance of flow to satisfy the desired exiting water temperature and to protect the system from firing when inadequate pressure is sensed.

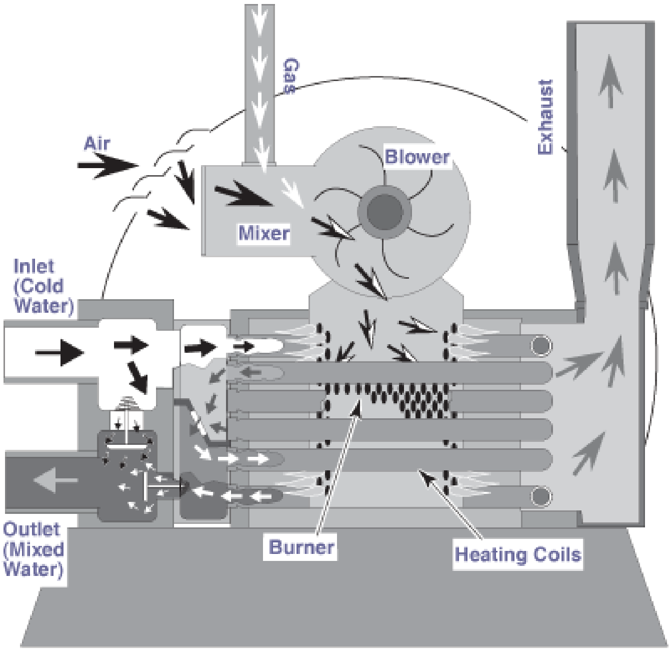


Figure 2.1 Simplified Diagram of Gas Fired Pool Heater

Source: [SOLAR DIRECT 2013]

In typical pool installations, the pool heater is plumbed directly in the circulation circuit after the filtration pump and filter, as shown in Figure 2.2. The filtration pump must work to overcome friction losses in the piping, restriction in the filter and in the heater, culminating in a total head loss or total dynamic head (TDH) measured as the differential in feet of water, between the suction and discharge head pressures. Since these heaters are permanently plumbed in line, the filtration pump must overcome the additional head introduced by the heater, regardless of whether the unit is in service. This CASE Report aims to reduce pumping energy when the heater is not in use, thereby increasing the energy efficiency of the pool filtration system as a whole.

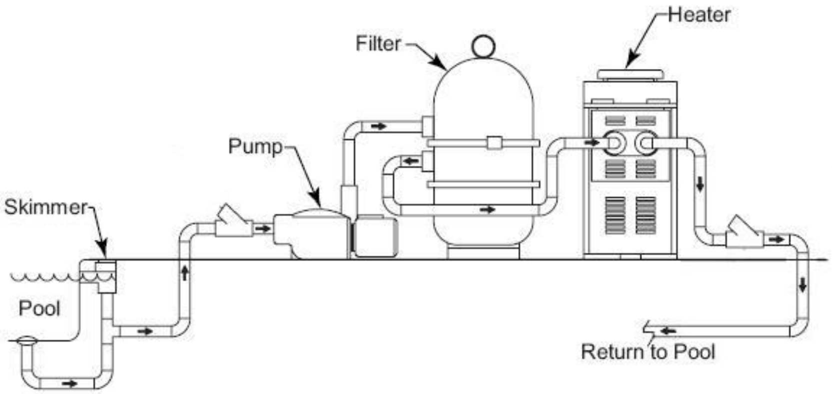


Figure 2.2 Typical Plumbing Schematic

Source: [Google Images]

The head loss from the pool heater contributes to the incremental pumping energy required to maintain a given flow rate. In other words, if you can reduce the head, you can reduce the speed, and therefore, the power required to maintain the same flow. Because of the cubed relationship between motor speed and power consumption due to the pump affinity laws, reducing the speed of the motor by a small amount can yield exponential (cubed) energy savings. For this analysis, it was assumed that all heaters were coupled with a variable speed motor, where a reduction in head could be coupled with an adjustment of motor speeds by a pool professional.

The major manufacturers of pool heater provided head loss characteristic curves for evaluation as can be seen in Figure 2.3. A sampling of heaters was also field tested to confirm the reported pressure responses. These curves show regions of slow increases in head pressure in typical operating flows due to the response of the internal temperature bypass valves. This effect is non-uniform across the sampling of heaters. As can be seen in Figure 2.3, on average, the heaters introduce 10 feet of head at 60 gallons per minute (GPM), while one heater introduced a minimum of 3.67 feet of head at 60 GPM.

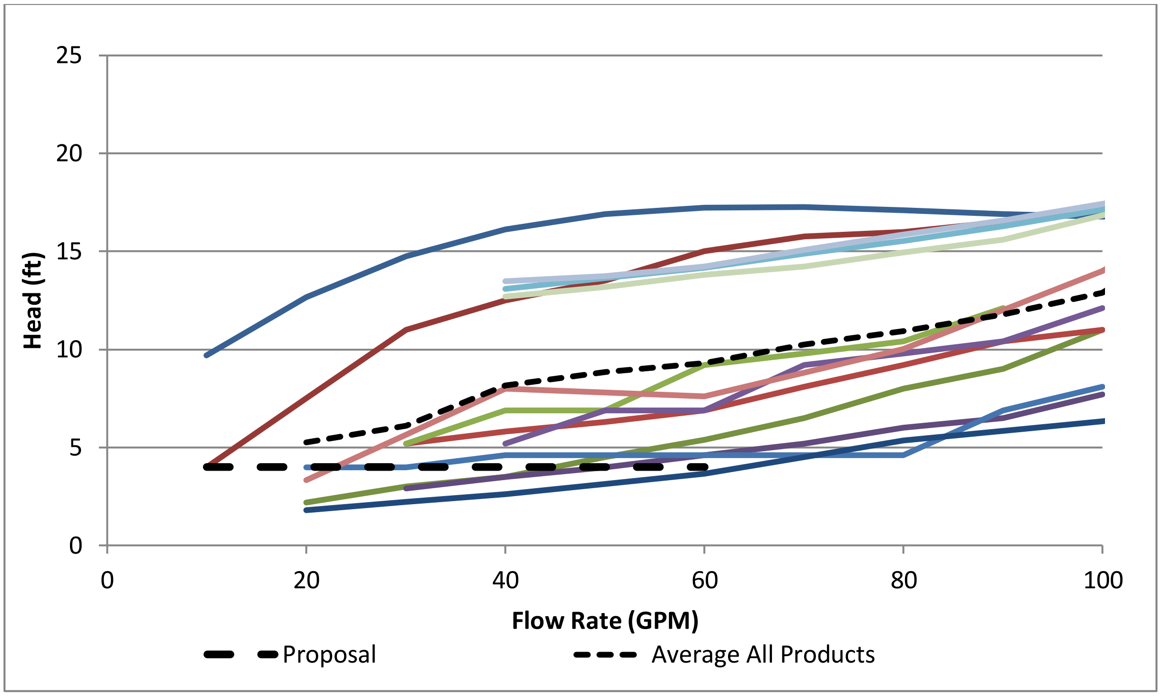


Figure 2.3 Head loss characteristics of sampling of current market residential gas-fired pool heaters

Source: IOU 2012

Calculation of energy savings is based on the characterization of TDH experienced by the filtration pump at various flow rates. The TDH that a pump must overcome can be modeled with the three pool system curves developed by the CEC:

- CEC Curve A – Typical new construction (Title 24 compliant) with 2” PVC pipe;
- CEC Curve B – Typical older pool with 1.5” copper pipe; and
- CEC Curve C – Pools greater than 25,000 gallons (GAL), and well designed, low pressure drop.

In this analysis, to determine the approximate savings from including an integral bypass valve and/ or improve manifold design within a pool heater, CEC Curve A is contrasted with a modified CEC Curve A with lower TDH levels at 60 GPM and 20 GPM. CEC Curve A was chosen as it is the most representative of the general pool market in California (CA) and is also the system curve used for pool pump ENERGY STAR® compliance.

3 Manufacturing and Market Channel Overview

Market assessment reveals only five manufacturers of gas-fired pool heater products. They are listed in alphabetical order below:

- Hayward Industries Inc.
- Jandy Pool Products, Inc.
- Lochinvar Inc.
- Pentair Water Pool and Spa, Inc.
- Raypak Inc.

Market share data is unavailable due to the size of the market and confidentiality concerns (DOE 2010).

Distribution of products to consumers follows two typical pathways. For new installations, pool builders typically purchase equipment from a distributer or wholesaler. Replacement pool heaters typically are sold through retailers and distributors to service companies and installers.

4 Energy Usage

4.1 Test Methods

4.1.1 Current Test Methods

Current testing of gas fired pool heaters is only aimed at defining the thermal efficiency and not the hydraulic performance. Standards outlined in APSP-15/ANSI Z21.56 define the thermal efficiency of the unit.

4.1.2 Proposed Test Methods

The proposed tests would provide means to calculate the energy efficiency of the pool filtration system as a whole. The test would evaluate the hydraulic performance of the heaters and the head loss be reported for the following flow rates: 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 GPM while non-operational (off/ not firing mode). Compliant heaters would be expected to meet the highest acceptable head loss while not firing of 4 feet at any of the above flow rates. Compliant heaters would be required to not exceed 4 feet of head while not firing at all of the above flow rates up to, and including 60 GPM.

4.2 System Characteristics for Non-Qualifying & Qualifying Products

The average unit energy use (of a variable speed filtration pump) when coupled with non-qualifying products was determined by using the CEC Curve A system curve which is representative of most pools in California. This system curve also includes heaters, which given that currently most all heaters are non-qualified, would represent a non-qualifying system curve. The energy required to pump against CEC Curve A was determined using the Pentair Intelliflo Variable Speed energy calculator (Pentair 2012). The Pentair Intelliflo pump is considered to be a typical variable speed pump. Given that Title 20 currently requires all new filtration pumps to be dual, multi, or variable speed pumps over one total horsepower and that the Pentair Intelliflo pump has been most popular variable speed pump on the market, we believe these assumptions to be representative of the current market. Additionally, with continued stock turnover and utility incentives, variable speed pumps will be prevalent in all residential filtration applications in the future. The next section provides the assumptions for the analysis of non-qualifying and qualified products.

4.2.1 Assumptions

System Curve- CEC Curve A

This system curve is the moderate CEC curve in terms of system design and represents a pool with 2" inch plumbing. We believe this to be representative of most pools in CA that currently have gas fired pool heaters. CEC Curve A is also the system curve that ENERGY STAR uses to qualifying their pumps.

Pool Size- 25,000 gallons

A pool size of 25,000 gallons is considered to be a normal pool size for residential pools in California.

Filtration Pump- 3HP Pentair Intelliflo SVRS+VS

The Pentair Intelliflo pump is the most common pump on the market that meets California's Title 20 prescriptive pump requirements. While a dual speed pump could be used and meet Title 20 standards, we believe that variable speed pumps currently capture roughly 75 percent of market and are growing. This model assumes use of a variable speed pump which can be adjusted to maintain a given flow.

Water turns per day- 1.0
An industry rule of thumb for residential pools is to filter all of the water once per day to maintain a clean and sanitary pool.

Hours per day at high speed- 3.0
Running the pump at high speed for 3 hours per day will allow enough time for a suction or pressure side cleaner to operate.

Desired flow at high speed- 60 GPM, at low speed- 20 GPM
A high speed flow rate of 60 GPM is all that may be necessary to operate a pressure side cleaner and 20GPM is considered an optimal flow rate at low speed to conserve energy.

4.2.2 Total Dynamic Head for Qualifying and Non-Qualifying Products

The TDH for non-qualifying products and qualifying products can be calculated based on the data that is represented in Figure 2.3. The TDH for non-qualifying products is calculated by averaging the TDH for products which have greater than four feet of TDH at 20 and 60 GPM. Similarly, the qualifying products are calculated by averaging the TDH for products which have less than four feet of TDH at 20 and 60 GPM. The difference between the two is considered the average savings potential.

It should be noted that CEC Curve A is assumed to include non-qualifying products and by subtracting the potential head reduction, as seen in Table 4.1 below, the savings for the qualifying products can be determined.

Table 4.1 Total Dynamic Head of Qualifying and Non-Qualifying Heaters

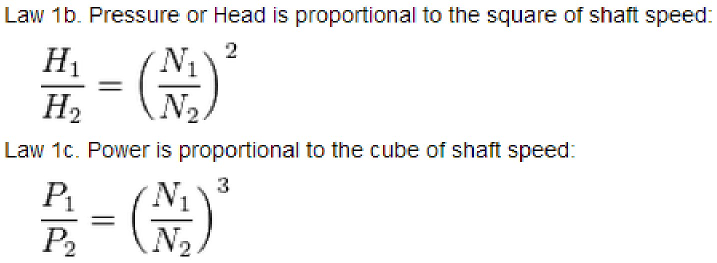
	Non-Qualifying	Qualifying	Potential Head Reduction
TDH @ 60 GPM	10.0	3.7	6.3
TDH @ 20 GPM	5.0	2.9	2.0

Source: IOU 2012

4.2.3 Energy Savings Analysis Approach

Using the assumptions noted in Section 4.2.1 and the TDH reduction potential the filtration pump energy consumption can be calculated for a system with a non-qualified heater and a qualified heater. The pool pump manufacturer Pentair provides an online tool in which the non-qualified system and energy consumption can be modeled using CEC Curve A and a 3HP Intelliflo SVRS+VS pool pump. The qualified products' energy consumption can then be determined by using the pump affinity laws 1b and 1c as shown below (Pump 2013). First, affinity law 1b is used to determine the new speed given the reduction of TDH at both 20 GPM and 60 GPM. With the lower (at high and low) speeds, new lower power consumptions can be extrapolated using affinity law 1c. As can be seen in Equation 4.1 below, there is a cubed relationship between speed and power consumption.

Equation 4.1 Pump Affinity Laws



Law 1b. Pressure or Head is proportional to the square of shaft speed:

$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2$$

Law 1c. Power is proportional to the cube of shaft speed:

$$\frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3$$

Source: Pump 2013

The results of this analysis can be seen below in Table 4.2. At high speed (60 GPM) a reduction of 6.3 feet has the potential to reduce the power draw from 1420 watts (W) to 1202 W, a savings of 220 W. Similarly, for low speed the power savings are estimated to be 41 W. It should be noted that the low speed power consumption does not entirely follow the affinity laws, as there is a technical lower power limit to pumps, such as the Intelliflo, which bottoms out at 110 W. The result is that pool filtration pumps with a qualified heater can operate at the same flow, for the same amount of time and realize roughly 18 percent energy savings.

Table 4.2 System Characteristics and Energy Consumption for Non-Qualifying & Qualifying Products

System Characteristics		**Non-Qualifying**	**Qualifying**	**Units**
High Speed	*Head w/ heater*	60	54	*Feet*
	Flow	60	60	*GPM*
	Pump Speed	2800	2700	*RPM*
	Power	1420	1200	*Watts*
Low Speed	*Head w/ heater*	6.7	4.6	*Feet*
	Flow	20	20	*GPM*
	Pump Speed	900	740	*RPM*
	Power	150	110	*Watts*
Operating Hours	*Time at low speed*	12	12	*hours*
	Gallons low speed	14,200	14,200	*gallons*
	Time at high speed	3	3	*hours*
	Gallons high speed	10,800	10,800	*gallons*
	Annual high speed hours	1,100	1,100	*hours*
	Annual low speed hours	4,300	4,300	*hours*

Source: Pentair 2012, IOU 2012, CEC 2010

4.3 Energy Use per Unit for Non-Qualifying Products

The non-qualifying product's effect on a variable speed filtration pump's energy consumption (UEC) is calculated using CEC Curve A, which is assumed to represent the current heaters on the market, most all of which are non-qualifying. The other assumptions are listed in Section 4.2.1. The UEC of non-qualifying products is calculated to be 2,200 kilowatt-hours per year (kWh/year). This is consistent with Residential Appliance Saturation Survey (RASS) reported data of 3,500 kWh for an average residential pool with a filtration and booster pump (KEMA 2010).

Table 4.3 Average Energy Use for Non-Qualifying Products

Product Class	**Annual High Speed Operating Hours[a]**	**Annual Low Speed Operating Hours[a]**	**Unit Energy Consumption[b] (kWh/yr)**
Gas Fired Residential Pool Heater (Off)	1,100	4,300	2,200

[a] Assumes an average of 3 hours per day on high speed and 12 hours per day on low speed.

[b] UEC is representative of the variable speed filtration pump energy when coupled with a non-qualifying heater.

4.4 Efficiency Measures

Reduction of the total dynamic head on gas-fired pool heaters during non-operation may be achieved by integrating a relief circuit in the pool heater and/or improved manifold design. Most simply, an external bypass circuit could be composed of an auxiliary set of electronically-controlled valves added before and after the pool heater's inlet and outlet. The valves would redirect flow around the heater and be controlled based on heating calls. The controls would need an additional time delay after a heating call has been satisfied to continue to flow water through the heat exchanger, removing any residual heat and prolonging the life of the unit. However, the CASE Team believes the best option is some form of an internal bypass circuit, in addition to the existing thermal and pressure regulators. This option is expected to be relatively inexpensive for manufacturer adoption, and ensures an appropriate amount of water to circulate in the heat exchanger, preventing damage. This option would ensure highest compliance as it is internal to the unit and would also avoid any plumbing special issues on often crowded and tight pool equipment skids. In consideration that at least some flow is needed on a regular basis to minimize corrosive effects, the estimate of savings presented assumes that the total dynamic head introduced by the heater is not entirely forgone, but significantly reduced during non-operation.

4.5 Energy Use per Unit for Qualifying Products

Qualifying units in this analysis would effectively reduce the total dynamic head to a level corresponding to no more than 4 feet of water at 60 GPM. This would reduce the overall system TDH and allow the filtration pump to operate at a lower speed and power draw to maintain the same flow. This is illustrated in Figure 4.1 below. The method for calculating the energy use of products that would meet the proposed standard are the same as described in Section 4.2.3. The UEC for the variable speed filtration pump coupled with qualifying heaters is 1,800 kWh per year.

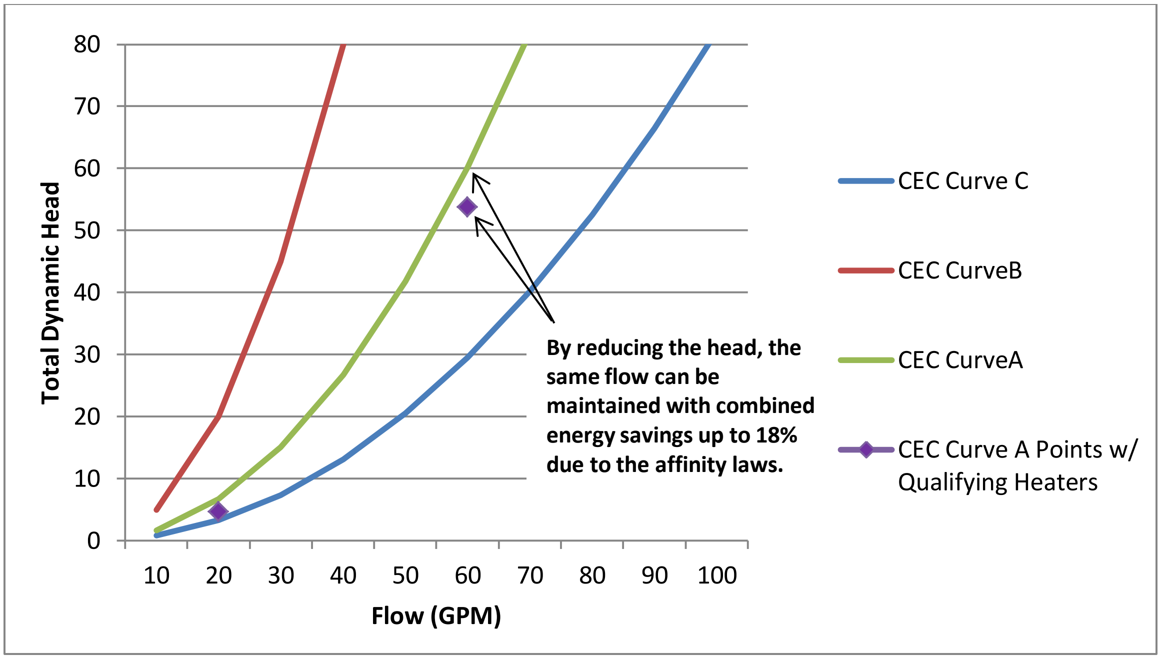


Figure 4.1 System Curves with Qualifying Heaters

Source: CEC 2010

Table 4.4 Average Energy Use for Qualifying Products

Product Class	Annual High Speed Operating Hours[A]	Annual Low Speed Operating Hours[a]	Unit Energy Consumption[b] (kWh/yr)
Gas Fired Residential Pool Heater (Off)	1,100	4,300	1,800

[a] Assumes an average of 3 hours per day on high speed and 12 hours per day on low speed.

[b] UEC is representative of the variable speed filtration pump energy when coupled with a qualifying heater.

5 Market Saturation & Sales

5.1 Current Market Situation

The most recent market evaluation by P.K. Data, a group that evaluates national and state pool markets, shows a 4 percent reduction in new in-ground pool installations. New in-ground pool installations in 2011 were 10,802, and the installed base is approximately 1.3 million or 24 percent of the United States market. P.K. Data also reported there being 540,000 above-ground pools installed in California as of 2012. While growth in the market is slow (0.8 percent in 2011), California remains the largest market in both installed and new pool installations. (P.K. Data 2012)

Sales figures specific to California are not known but can be estimated to be 73,164 units if calculating from the current stock of heaters (438,974) and assuming the product average lifetime is 6 years (KEMA 2010).

According to the CEC's 2009 RASS, approximately ten percent of California residences have pools, with more than a third of pools having a gas fired pool heater. It is estimated that the current stock of residential gas-fired pool heaters to be 438,974 units (KEMA 2010). The distribution across investor owned utilities (IOU) service territories varies significantly, with the majority of pool heaters located in southern California.

Table 5.1 Estimate of Distribution of Pool Heaters by Investor-Owned Utility in CA

Utility	Pool Heaters
PG&E	118,344
SDG&E	38,585
SCE	276,860
Other	5,195
Total	**438,974**
% of All Households	**3.81%**

Source: CEC RASS- Figures are estimates and weighted from surveyed sample.

5.1.1 Saturation of Qualified Products

Currently, most heaters are considered non-qualifying products. However, the Hayward Universal H series pool heater uses a balancing valve and improved manifold design, and introduces the least amount of head pressure at 60 GPM of 3.6 feet. While Hayward has developed one type of technology to achieve this, we believe there are many ways for manufacturers to achieve this low head design. The most simple of which is having an integrated controlled bypass valve which could in theory have a head close to zero at all flows.

Qualifying products would be expected to enter the market after the proposed standard takes effect at a rate equivalent to the replacement rate of 6 years (DOE 2010). New residential construction has slowed significantly in the past few years and is unlikely to be much more significant than heater replacements. This analysis assumed a conservative annual growth rate of 0.8% per year. (P.K. Data 2012)

Table 5.2 California Stock and Sales

Product Class	**Annual Sales** (units)	**Stock** (units) [a]
Gas Fired Residential Pool Heater (Off)	73,162	438,974

[a] Source: KEMA 2010

The market penetration rate was estimated using a flat Naturally Occurring Market Adoption (NOMAD) bass curve estimate of 8 percent. This low conservative estimate assumes equal market share of the 13 different heaters evaluated in this analysis and no shift in the market unless this standard is implemented.

Table 5.3 provides estimates for statewide energy consumption of pool pumps coupled with gas fired heaters.

Table 5.3 California Statewide Pool Pump with Heaters Energy Use – 2013

	Annual Sales		**Stock**	
Year	Annual Energy Consumption (GWh/yr)	Coincident Peak Demand Reduction (MW) [A]	Annual Energy Consumption (GWh/yr)	Coincident Peak Demand Reduction (MW) [a]
2015	170	30	1,000	200

[a] Statewide demand (and demand reduction) is quantified as coincident peak load (and coincident peak load reduction), the simultaneous peak load for all end users, as defined by (Koomey and Brown 2002).

6 Savings Potential

6.1 Statewide California Energy Savings

Statewide energy use estimates are shown in Table 6.2. The annual energy consumption for standard and non-standard units was calculated based on the assumption of total stock turnover within the product lifetime, as there are no current estimates on annual heater shipments in California. As is, one-sixth of the total expected demand reduction is likely experienced within the first year's sales.

Table 6.1 California Statewide Non-Standards Case Energy Use & Peak Demand

	Annual Sales		Stock	
Year	Annual Energy Consumption (GWh/yr)	Coincident Peak Demand Reduction (MW)	Annual Energy Consumption (GWh/yr)	Coincident Peak Demand Reduction (MW)
2015	170	30	1,000	200

Table 6.2 California Statewide Standards Case Energy Use & Peak Demand

	Annual Sales		Stock	
Year	Annual Energy Consumption (GWh/yr)	Coincident Peak Demand Reduction (MW)	Annual Energy Consumption (GWh/yr)	Coincident Peak Demand Reduction (MW)
2015	140	27	860	160

Table 6.3 Estimated California Statewide Energy Savings & Peak Demand Reduction with Standards Case

	Annual Sales		Stock	
Year	Energy Use (GWh/yr)	Peak Demand (MW) [a]	Energy Use (GWh/yr)	Peak Demand (MW) [A]
2015	28	5	170	32

[a] Statewide demand (and demand reduction) is quantified as coincident peak load (and coincident peak load reduction), the simultaneous peak load for all end users, as defined by (Koomey and Brown 2002).

6.2 State or Local Government Costs and Savings

There are no known additional costs to state or local governments from the implementation of the standards proposal, given the CEC's existing authority for establishing appliance standards and staffing to administer the process. Energy savings are expected for local and state governments from the purchase of more efficient products as a result of the proposed standard, with the savings amount dependent on the volume of products purchased.

7 Economic Analysis

7.1 Incremental Cost

The incremental cost for heaters with internal bypass circuits and improved manifold designs are expected to be minimal as the heaters are already designed with pressure and thermal regulated bypass circuits. The maximum incremental cost would be associated with installing an external bypass added to an existing heater. The proposed design change would take advantage of one electronically-controlled valve, an additional set of PVC piping, pipe tees and a check valve, totaling approximately $160. This value was determined using retail prices from www.poolsupplyworld.com and www.lowes.com, providing for the highest incremental cost scenario.

Testing and reporting the hydraulic performance of products is expected to be a cost that the manufacturer would likely pass onto the consumer. Volume of sales would be enough to satisfy the cost by spreading it out across consumers such that its effect on pricing is nearly negligible.

7.2 Design Life

The average service life of pool heaters is six years (DOE 2010). By requiring that a minimum flow, or that daily purge cycles are incorporated into the design, it is not expected that the design life would be affected by the proposed change.

7.3 Lifecycle Cost / Net Benefit

The lifecycle cost for integrating bypass circuit in gas-fired heaters is calculated using the standard CEC methodology presented in Table 7.1. As surveyed, most owners do not typically service heaters. Therefore, maintenance costs are not included in the estimate.

Table 7.1 Costs and Benefits per Unit for Qualifying Products

		Lifecycle Costs per Unit (Present Value $)			**Lifecycle Benefits per Unit (Present Value $)**		
Product Class	Design Life (years)	Incremental Cost	Add'l Costs[a]	**Total PV Costs**	Energy Savings[b]	Add'l Benefits[c]	**Total PV Benefits**
Gas Fired Residential Pool Heater (Off)	6	$160	$ -	$160	$400	$ -	$400

PV = Present Value

[a] Added maintenance costs

[b] Calculated using the CEC's average statewide present value statewide energy rates that assume a 3 percent discount rate (CEC 2010)

[c] Reduced maintenance costs

Table 7.2 Lifecycle Costs and Benefits for Standards Options

	Lifecycle Benefit / Cost	**Net Present Value**[bd]		
Product Class	**Ratio**[a]	Per Unit ($)	For First Year Sales (Million $)	After Entire Stock Turnover (Million $)[c]
Gas Fired Residential Pool Heater (Off)	2.5	$240	$17	$110

[a] Total present value benefits divided by total present value costs.

[b] Positive value indicates a reduced total cost of ownership over the life of the appliance.

[c] Stock Turnover Net Present Value (NPV) is calculated by taking the sum of the NPVs for the products purchased each year following the standard's effective date through the stock turnover year, i.e., the NPV of "turning over" the whole stock of less efficient products that were in use at the effective date to more efficient products, plus any additional non-replacement units due to market growth, if applicable. For example, for a standard effective in 2015 applying to a product with a 5 year design life, the NPV of the products purchased in the 5th year (2019) includes lifecycle cost and benefits through 2024, and therefore, so does the Stock Turnover NPV.

[d] For price of electricity, average annual rates were used, starting in the effective year (see Appendix A: for more details). It should be noted that while the proposed standard is cost-effective, it may be more cost-effective if using alternative rate structures. For example, marginal utility rates may more accurately reflect what customers save on utility bills as result of the standard.

8 Acceptance Issues

8.1 Infrastructure issues

At present time, no heaters qualify for the proposed standard. The proposed changes are not expected to significantly impact current designs and can easily be augmented with a variety of technologies such as an integrated bypass and control valve as described in Section 4.4.

8.2 Existing Standards

There are no existing standards for gas-fired pool heaters that regulate hydraulic performance.

8.3 Stakeholder Positions

Stakeholders include pool heater manufacturers, equipment distributors, and pool service individuals. Industry associates that serve sectors of the pool industry include APSP (Association of Pool and Spa Professionals, formerly NSPI, National Spa and Pool Institute).

Discussions with pool heater manufacturers while requesting pool heater performance curves were amicable, with several representatives expressing interest in the initiative. A representative from the Foundation for Pool and Spa Industry Education (FPSIE), who also supported the draft of Association of Pool and Spa Professional Energy Efficiency Standards (APSP-15), was also interested and supportive of this initiative.

9 Environmental Impacts

9.1 Hazardous Materials

There are no known incremental hazardous materials impacts from the efficiency improvements as a result of the proposed standards.

9.2 Air Quality

This proposed measure is estimated to reduce total criteria pollutant emissions in California by 29,000 lbs/year in 2020, after stock turnover, as shown in Table 9.1 due to 170 GWh in reduced end user electricity consumption with an estimated value of $1,400,000. Criteria pollutant emission factors for California electricity generation were calculated per MWh based on California Air Resources Board data of emission rates by power plant type and expected generation mix (CARB 2010). The monetization of these criteria pollutant emission reductions is based on CARB power plant air pollution emission rate data times the dollar per ton value of these reductions based on Carl Moyer values where available, and San Joaquin Valley UAPCD "BACT" thresholds for sulfur oxides (SOx). These dollar per ton values vary significantly for fine particulates, as discussed in Appendix B: (CARB 2011a, CARB 2013a and San Joaquin Valley UAPCD).

Table 9.1 Estimated California Criteria Pollutant Reduction Benefits (lbs/year) After Stock Turnover

	lbs/year	**Carl Moyer $/ton (2013)**	**Monetization**
ROG	4,700	$17,460	$41,000
Nox	16,000	$17,460	$140,000
Sox	1,700	$18,300	$15,000
PM2.5	6,900	$349,200	$1,200,000
Total	29,000		$1,400,000

9.3 Greenhouse Gases

Table 9.2 shows the annual and stock GHG savings by year and the range of the societal benefits as a result of the standard. By stock turnover in 2020, this standard would save 74,000 metric tons of CO2e, equal to between $$3,900,000 and $11,700,000 of societal benefits. The total avoided CO2e is based on CARB's estimate of 437 MT CO2e/GWh) of energy savings from energy efficiency improvements, and includes additional electrical transmission and distribution loses estimated at 7.8% (CARB 2008). The range of societal benefits per year is based on a range of annual $ per metric ton of CO2 (in 2013 dollars) sourced from the U.S. Government's Interagency Working Group on Social Cost of Carbon (SCC) (Interagency Working Group 2013). The low end uses the average SCC, while the high end incorporates SCC values which use climate sensitivity values in the 95th percentile, both with 3% discount rate. It is important to note that this range can be lower and higher, depending on the approach used, so policy judgments should consider this uncertainty. See Appendix C: for more details regarding this and other approaches.

Table 9.2 Estimated California Statewide Greenhouse Gas Savings and Cost Savings for Standards Case

Year	Annual GHG Savings (MT of CO2e/yr)	Stock GHG Savings (MT of CO2e/yr)	Value of Stock GHG Savings - low ($)	Value of Stock GHG Savings - high ($)
2015	12,000	12,000	$560,000	$1,600,000
2016	12,000	24,000	$1,100,000	$3,400,000
2017	12,000	36,000	$1,800,000	$5,200,000
2018	12,000	49,000	$2,500,000	$7,200,000
2019	13,000	61,000	$3,200,000	$9,400,000
2020	13,000	74,000	$3,900,000	$11,700,000

10 Recommendations

10.1 Recommended Standards Proposal

The recommended standards for the hydraulic efficiency of residential gas fired heaters is that the total dynamic head while the pool heater is non-operational shall be no greater than 4 feet of water at all flow rates up to, and including, 60 GPM. The CASE Team believes this standard can be achieved in a variety of ways. (See Section 4.4)

10.2 Proposed Changes to the Title 20 Code Language

Proposed additions to the code language are underlined, and deletions are ~~struck out~~. Ellipses (…) are used to indicate spaces or "skips" between code language.

1604 (g) Pool Heaters, Portable Electric Spas, Residential Pool Pump and Motor Combinations, and Replacement Residential Pool Pump Motors.

(1) Test Methods for Pool Heaters

(A) Thermal Efficiency - The test methods for pool heaters are shown in Table G.

Table G - Pool Heater Test Methods

Appliance	Test Method
Gas-fired and oil-fired pool heaters	ANSI Z21.56-1994
Electric resistance pool heaters	ANSI/ASHRAE 146-1998
Heat pump pool heaters	ANSI/ASHRAE 146-1998, as modified by Addendum Test Procedure published by Pool Heat Pump Manufacturers Association dated April, 1999, Rev 4: Feb. 28, 2000:

Reading	Standard Temperature Rating	Low-Temperature Rating	Spa Conditions Rating
Air Temperature			
Dry-Bulb	27.0°C (80.6°F)	10.0°C (50.0°F)	27.0°C (80.6°F)
Wet-bulb	21.7°C (71.0°F)	6.9°C (44.4°F)	21.7°C (71.0°F)
Relative Humidity	63%	63%	63%
Pool Water Temperature	26.7°C (80.0°F)	26.7°C (80.0°F)	40.0°C (104.0°F)

(B) Hydraulic Performance: The test method for measuring hydraulic pool heater performance is shown below:

1. Plumb the pool heater with a pool pump with pressure sensors at both the inlet and outlet of the pool heater.
2. Ensure heater is "off" or in "standby" mode
3. Turn on pump and adjust flow to 10 GPM
4. Record pressure drop and calculate TDH in feet of water
5. Repeat for 20, 30, 40, 50, 60, 70, 80, 90, 100 GPM
6. Ensure measurements are +/5 % accurate.

7. Reported data shall include: Manufacturer, Model and TDH at 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 GPM

1065.1(g) Pool Heaters, Portable Electric Spas, Residential Pool Pump and Motor Combinations, and Replacement Residential Pool Pump Motors.

(1) **Energy Efficiency Standard for Gas-Fired Pool Heaters and Oil-Fired Pool Heaters.** The thermal efficiency of gas-fired pool heaters and oil-fired pool heaters shall be not less than 78 percent.

(2) **Energy Efficiency Standards for Heat Pump Pool Heaters.** See Section 1605.3(g) for energy efficiency standards for heat pump pool heaters.

(3) **Energy Efficiency Standard for Electric Resistance Pool Heaters.** There is no energy efficiency standard for electric resistance pool heaters.

(4) **Energy Design Standards for Pool Heaters.** See Section 1605.3(g) for energy design standards for pool heaters.

(5) **Energy Efficiency Standards for Portable Electric Spas**. See Section 1605.3(g) for energy efficiency standards for portable electric spas.

(6) **Energy Efficiency Standards and Energy Design Standards for Residential Pool Pump and Motor Combinations and Replacement Residential Pool Pump Motors.** See Section 1605.3(g) for energy efficiency standards and energy design standards for residential pool pump and motor combinations and replacement residential pool pump motors.

(7) **Hydraulic Performance of Gas-Fired Pool Heaters**. The total dynamic head while the pool heater is non-operational shall be no greater than 4 feet of water at all flow rates up to, and including 60GPM.

1605.3(g) Pool Heaters, Portable Electric Spas, Residential Pool Pump and Motor Combinations, and Replacement Residential Pool Pump Motors.

(1) **Energy Design Standard for Natural Gas Pool Heaters.** Natural gas pool heaters shall not be equipped with constant burning pilots. The total dynamic head shall be no greater than 4 feet of water at while the heater is non-operational at all flow rates up to, and including 60GPM.

Section 1606. Filing by Manufacturers; Listing of Appliances in Database.

Table X Continued - Data Submittal Requirements

	Appliance	Required Information		Permissible Answers
G	Hydraulic Efficiency of Gas Fired Pool Heaters	Manufacturer		
		Model		
		BTUs		
		Total Dynamic Head while heater is “off” at the following flow rates:	10 GPM	
			20 GPM	
			30 GPM	
			40 GPM	
			50 GPM	
			60 GPM	
			70 GPM	
			80 GPM	
			90 GPM	
			100 GPM	

* “Identifier” information as described in Section 1602(a).

1 = Voluntary for federally-regulated appliances
2 = Voluntary for state-regulated appliances

10.3 Implementation Plan

The expected implementation for this standards proposal is for the CEC to proceed with its appliance standards rulemaking authority, from pre-rulemaking and rulemaking through adoption, and for manufacturer compliance upon effective date.

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Appendix A: Cost Analysis Assumptions

The electricity rates used in the analysis of this CASE Report were derived from projected future prices for residential, commercial and industrial sectors in the CEC's "Mid-case" projection of the 2012 Demand Forecast (2012), which used a 3% discount rate and provide prices in 2010 dollars. The sales weighted average of the 5 largest utilities in California was converted to 2013 dollars using an inflation adjustment of 1.07 (DOL 2013). A sector weighted average electricity rate was then calculated using 0% commercial, 100% residential, 0% industrial. See the rates by year below in Table A.1.

Table A.1 Statewide Weighted Average Electricity Rates 2015 - 2040 (PG&E, SCE, SDG&E, LADWP and SMUD - 5 largest Utilities) in 2013 cents/kWh

Year	**Residential**	**Commercial**	**Industrial**	**Sector Weighted Average**
2015	16.82	14.67	11.31	16.66
2016	17.02	14.84	11.43	16.86
2017	17.24	15.02	11.56	17.08
2018	17.47	15.22	11.70	17.31
2019	17.71	15.42	11.84	17.54
2020	18.00	15.67	12.01	17.83
2021	18.34	15.98	12.23	18.17
2022	18.70	16.29	12.45	18.52
2023	19.06	16.61	12.67	18.88
2024	19.43	16.93	12.90	19.25
2025	19.81	17.27	13.13	19.62
2026	20.19	17.60	13.37	20.00
2027	20.59	17.95	13.61	20.39
2028	20.98	18.30	13.86	20.79
2029	21.39	18.66	14.12	21.19
2030	21.81	19.03	14.38	21.60
2031	22.23	19.40	14.64	22.02
2032	22.66	19.78	14.92	22.45
2033	23.10	20.17	15.19	22.89
2034	23.55	20.57	15.48	23.33
2035	24.01	20.97	15.77	23.79
2036	24.48	21.38	16.06	24.25
2037	24.96	21.80	16.37	24.72
2038	25.44	22.23	16.68	25.20
2039	25.94	22.67	16.99	25.69
2040	26.44	23.12	17.32	26.20

Appendix B: Criteria Pollutant Emissions and Monetization

B.1 Criteria Pollutant Emissions Calculation

To calculate the statewide emissions rate for California, the incremental emissions between CARB's high load and low load power generation forecasts for 2020 were divided by the incremental generation between CARB's high load and low load power generation forecast for 2020. Incremental emissions were calculated based on the delta between California emissions in the high and low generation forecasts divided by the delta of total electricity generated in those two scenarios. This emission rate per MWh is intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario instead of the high load scenario. While emission rates may change somewhat over time, 2020 was considered a representative year for this measure.

B.2 Criteria Pollutant Emissions Monetization

Avoided ambient ozone precursor and fine particulate air pollution benefits were monetized based on avoided control costs rather than damage costs due to the availability of emission control cost-effectiveness thresholds, as well as challenges in quantifying a specific value for damages per ton of pollutants.

Two sources of data for cost-effectiveness thresholds were evaluated. The first is Carl Moyer cost-effectiveness thresholds for ozone precursors and fine particulates (CARB 2011a, CARB 2013a and 2013b). The Carl Moyer program has provided incentives for voluntary reductions in criteria pollutant reductions from a variety of mobile combustion sources as well as stationary agricultural pumps that meet specified cost-effectiveness cut-offs.

The second is the San Joaquin Valley UAPCD Best-Available Control Technology ("BACT") cost-effectiveness thresholds study. Pollution reduction technologies that are not yet demonstrated in practice (in which case they are required without a cost-effectiveness evaluation) can be required at new power plants and other sources if technologically feasible and within cost-effectiveness thresholds. San Joaquin Valley UAPCD conducted a state-wide study as the basis for updating their BACT thresholds in 2008.

This CASE report relies primarily on the Carl Moyer thresholds due to their state-wide nature and applicability to combustion sources[1]. In addition, the Carl Moyer fine particulate values for fine particulate apply to combustion sources with specific health impacts, while BACT thresholds include both combustion sources and dust. The Carl Moyer values are somewhat more conservative for ozone precursors than San Joaquin Valley UAPCD BACT thresholds, and significantly higher for fine particulate[2].The Carl Moyer program does not address sulfur oxides, however, thus the San Joaquin BACT thresholds were used for this pollutant.

Price reports for California Emission Reduction Credit (ERCs, i.e. air pollution credits purchased to offset regulated emission increases) for 2011 and 2012 were also compared to the values selected

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[1] Further evaluation of the qualitative impacts of combustion fine particulate emissions from power generation and transportation sources may be beneficial.

[2] We note that both the Carl Moyer and San Joaquin Valley UAPCD BACT cost-effectiveness thresholds for fine particulates fall within the wide range of fine particulate ERC trading prices in California in 2011 and 2012.

in this CASE report. For each pollutant there is a wide range of ERC values per ton that are both higher and lower than the values per ton used in this CASE report [CARB 2011b and 2012]. Due to wide variability and low trading volumes, ERC values were evaluated for comparative purposes only.

Appendix C: Greenhouse Gas Valuation Discussion

The climate impacts of pollution from fossil fuel combustion and other human activities, including the greenhouse gas effect, present a major risk to global economies, public health and the environment. While there are uncertainties of the exact magnitude given the interconnectedness of ecological systems, at least three methods exist for estimating the societal costs of greenhouse gases: 1) the Damage Cost Approach 2) the Abatement Cost Approach and 3) the Regulated Carbon Market Approach. See below for more details regarding each approach.

C.1 Damage Cost Approach

In 2007, the U.S. Court of Appeals for the Ninth Circuit ruled that the National Highway Transportation Traffic Safety Administration (NHTSA) was required to assign a dollar value to benefits from abated carbon dioxide emissions. The court stated that while there are a wide range of estimates of monetary values, the price of carbon dioxide abatement is indisputably non-zero. In 2009, to meet the necessity of a consistent value for use by government agencies, the Obama Administration established the Interagency Working Group on the Social Cost of Carbon to establish official estimates (Johnson and Hope).

The Interagency Working Group primarily uses estimates of avoided damages from climate change which are valued at a price per ton of carbon dioxide, a method known as the damage cost approach.

C.1.1 Interagency Working Group Estimates

The Interagency Working Group SCC estimates, based on the damage cost approach, were calculated using three climate economic models called integrated assessment models which include the Dynamic Integrated Climate Economy (DICE), Policy Analysis of the Greenhouse Effect (PAGE), and Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) models. These models incorporate projections of future emissions translated into atmospheric concentration levels which are then translated into temperature changes and human welfare and ecosystem impacts with inherent economic values. As part of the Federal rulemaking process, DOE publishes estimated monetary benefits using Interagency Working Group SCC values for each Trial Standard Level considered in their analyses, calculated as a net present value of benefits received by society from emission reductions and avoided damages over the lifetime of the product. The recent U.S. DOE Final Rulemaking for microwave ovens contains a Social Cost of Carbon section that presents the Interagency Working Group's most recent SCC values over a range of discount rates (DOE 2013) as shown in Table C.1. The two $ metric ton of values used in this CASE report were taken from the two highlighted columns, and converted to 2013 dollars.

Table C.1 Social Cost of CO_2 2010 – 2050 (in 2007 dollars per metric ton of CO_2) (source: Interagency Working Group on Social Cost of Carbon, United States Government, 2013)

Discount Rate	5.0%	3.0%	2.5%	3.0%
Year	Avg	Avg	Avg	95th
2010	11	33	52	90
2015	12	38	58	109
2020	12	43	65	129
2025	14	48	70	144
2030	16	52	76	159
2035	19	57	81	176
2040	21	62	87	192
2045	24	66	92	206
2050	27	71	98	221

The Interagency Working Group decision to implement a global estimate of the SCC rather than a domestic value reflects the reality of environmental damages which are expected to occur worldwide. Excluding global damages is inconsistent with U.S. regulatory policy aimed at incorporating international issues related to resource use, humanitarian interests, and national security. As such, a regional SCC value specific to the Western United States or California specifically should be at similarly inclusive of global damages. Various studies state that certain values may be understated due to the asymmetrical risk of catastrophic damage if climate change impacts are above median predictions, and some estimates indicate that the upper end of possible damage costs could be substantially higher than indicated by the IWG (Ackerman and Stanton 2012, Horii and Williams 2013).

C.2 Abatement Cost Approach

Abating carbon dioxide emissions can impose costs associated with more efficient technologies and processes, and policy-makers could also compare strategies using a different by estimating the annualized costs of reducing one ton of carbon dioxide net of savings and co-benefits. The cost of abatement approach could reflect established greenhouse gas reduction policies and establish values for carbon dioxide reductions relative to electricity de-carbonization and other measures. (While recognizing the potential usefulness of this method, this report utilizes the IWG SCC approach and we note that the value lies within the range of abatement costs discussed further below.)

The cost abatement approach utilizes market information regarding emission abatement technologies and processes and presents a wide-range of values for the price per ton of carbon dioxide. The California Air Resources Board data of the cost-effectiveness of energy efficiency measures and emission regulations would provide one source of potential data for an analysis under this method. To meet the AB 32 target, ARB has established the "Cost of a Bundle of Strategies Approach" which includes a range of cost-effective strategies and regulations (CARB 2008b). The results of this approach within the framework of the Climate Action Team Macroeconomic Analysis are provided for California, Arizona, New Mexico, the United States, and a global total identified in that same report, as shown in Table C.2 below.

Table C.2 Cost-effectiveness Range for the CAT Macroeconomic Analysis

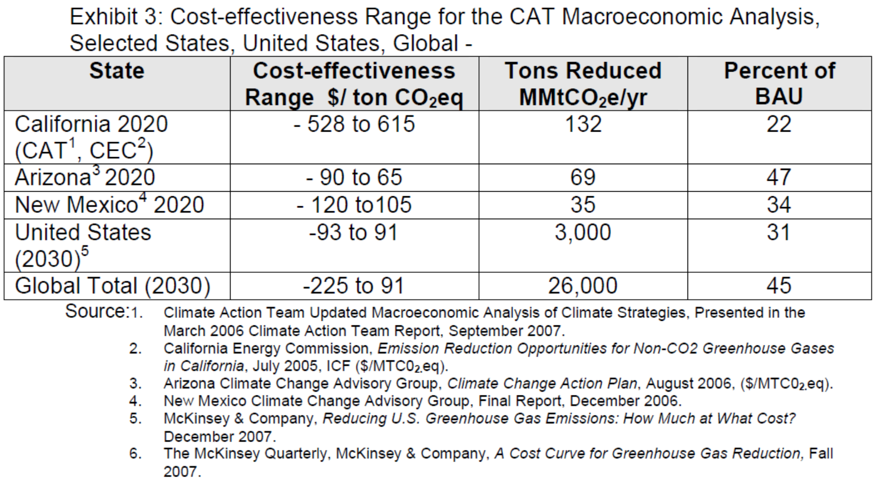

Exhibit 3: Cost-effectiveness Range for the CAT Macroeconomic Analysis, Selected States, United States, Global -

State	Cost-effectiveness Range $/ ton CO_2eq	Tons Reduced MMtCO_2e/yr	Percent of BAU
California 2020 (CAT[1], CEC[2])	- 528 to 615	132	22
Arizona[3] 2020	- 90 to 65	69	47
New Mexico[4] 2020	- 120 to105	35	34
United States (2030)[5]	-93 to 91	3,000	31
Global Total (2030)	-225 to 91	26,000	45

Source:
1. Climate Action Team Updated Macroeconomic Analysis of Climate Strategies, Presented in the March 2006 Climate Action Team Report, September 2007.
2. California Energy Commission, *Emission Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, July 2005, ICF ($/MT$CO_2$eq).
3. Arizona Climate Change Advisory Group, *Climate Change Action Plan*, August 2006, ($/MTC$0_2$eq).
4. New Mexico Climate Change Advisory Group, Final Report, December 2006.
5. McKinsey & Company, *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* December 2007.
6. The McKinsey Quarterly, McKinsey & Company, *A Cost Curve for Greenhouse Gas Reduction*, Fall 2007.

Source: CARB 2008b

Energy and Environmental Economics (E3) study defines the cost abatement approach more specifically as electricity de-carbonization and is based on annual emissions targets consistent with existing California climate policy. Long-term costs are determined by large-scale factors such as electricity grid stability, technological advancements, and alternative fuel prices. Near-term costs per ton of avoided carbon could be$200/ton in the near-term (Horii and Williams 2013), thus as noted earlier the value used in this report may be conservative.

C.3 Regulated Carbon Market Approach

Emissions allowance markets provide a third potential method for valuing carbon dioxide. Examples include the European Union Emissions Trading System and the California AB32 cap and trade system as described below. Allowances serve as permits authorizing emissions and are traded through the cap-and-trade market between actors whose economic demands dictate the sale or purchase of permits. In theory, allowance prices could serve as a proxy for the cost of abatement. However, this report does not rely on the prices of cap-and-trade allowances due to the vulnerability of the allowance market to external fluctuations, and the influence of regulatory decisions affecting scarcity or over-allocation unrelated to damages or abatement costs.

C.3.1 European Union Emissions Trading System

The European Union Emissions Trading System (EU ETS) covers more than 11,000 power stations, industrial plants, and airlines in 31 countries. However, the market is constantly affected by over-supply following the 2008 global recession and has seen prices drop to dramatic lows in early 2013, resulting in the practice of “back-loading” (delaying issuances of permits) by the European parliament. At the end of June 2013, prices of permits dropped to $5.41/ton, a price which is well below damage cost estimates and sub-optimal for encouraging innovative carbon dioxide emission abatement strategies.

C.3.2 California Cap & Trade

In comparison, California cap-and-trade allowance prices were reported to be at least $14/ton in May of 2013, with over 14.5 million total allowances sold for 2013 (CARB 2013b). However, cap-and-trade markets are likely to cover only subsets of emitting sectors of the industry covered by AB 32. In addition, the market prices of allowances are determined only partly by costs incurred by society or industry actors and largely by the stringency of the cap determined by regulatory agencies and uncontrollable market forces, as seen by the failure of the EU ETS to set a consistent and effective signal to curb carbon dioxide emissions.