Work Paper WPSCGREWH170412A

**Revision 0**

**Program Administrator**

**Residential Pool and Spa Heaters**

# At-a-Glance Summary

|  |  |
| --- | --- |
| **Measure Codes** | Pool heater 84% or above (tier 1) and Pool heater 90% TE or above (tier 2) |
| **Measure Description** | This energy efficiency measure is the replacement of existing residential gas-fired pool/spa water heaters with gas-fired water heaters having higher efficiency. |
| **Base Case Description** | The base case thermal efficiency of gas-fired pool/spa heaters manufactured after April 16, 2013 shall be not less than 82%. |
| **Units** | Each (per heater) |
| **Energy Savings** | SCG (average) 10.4 therms/yr for Tier 1 and 43.3 therms/yr for Tier 2 pool heater  Refer to Excel Calculation Attachment-G |
| **Full Measure Cost ($/unit)** | $3509 for Tier-I (84% TE) and $5838 for Tier-II (90% TE)  Refer to Excel Calculation Attachment-I |
| **Incremental Measure Cost ($/unit)** | $620 for Tier-I (84% TE) and $2949 for Tier-II (90% TE)  Refer to Excel Calculation Attachment-I |
| **Effective Useful Life** | 10 years (WtrHt-GPoolHtr-Res) |
| **Measure Installation Type** | New Construction, Replace on Burnout (RobNC) |
| **Net-to-Gross Ratio** | 0.70 (DEER NTGR ID: All-Default<=2yrs) |
| **Important Comments** | This work paper has a complementary Ex Ante Database data set that will be provided in a separate submission to the California Public Utilities Commission (CPUC). |

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# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev** | **Date** | **Author** | **Summary of Changes** |
| 0 | 4/1/17 | Raad Bashar, SCG | New workpaper |
|  |  |  |  |

# Section 1. General Measure & Baseline Data

## 1.1 Measure Description & Background

This energy efficiency measure is the replacement of existing residential gas-fired pool/ or spa water heaters with gas-fired pool/spa water heaters having higher efficiency. Current Title 20 Appliance Standards (1605.1g) require a minimum thermal efficiency of 82% that became effective April 16, 2013.

Table : Base, Standard, and Measure Cases

|  |  |
| --- | --- |
| **Case** | **Description of Typical Scenario** |
| Measure | Tier 1: 84% TE or above  Tier 2: 90% TE or above |
| Existing Condition | N/A |
| Code/Standard | 82% thermal efficiency |
| Industry Standard Practice | According to our marketing survey, 82%TE heater was determined as ISP |

To determine the average pool heater efficiency in the measure case, the California Energy Commission (CEC) Appliance Database was used.

Table : Measures and Codes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure Codes** | | | | **Measure Name** |
| SCG | SDG&E | SCE | PG&E |
| TBD |  |  |  | Install Pool heater of 84% TE or higher |
| TBD |  |  |  | Install Pool heater of 90% TE or higher |

Installation of high efficiency Pool / Spa heater in residential homes to reduce energy consumption associated with pool water heating. The workpaper evaluated two tier heaters from those available on the market:

* Tier-I is selected for water heaters in the range of 84% through 89%, with the average of 85%.
* Tier-II is selected for water heaters in the range of 90 % through 98%, with the average of 96%.

(See Figure 2 in Seciton 4.0)

## 1.2 Technical Description

This measure is for the replacement of gas-fired pool/ spa water heaters with higher efficiency units.

Pool and spa water heaters are types of commercial hot water boilers designed to tolerate the chemicals found in pool and spa water. Therefore, heaters normaly use Cupro-nickel heat exchangers and tubing that provide greater durability as compared to the standard copper units. Cupro-nickel alloy metals are better able to tolerate fluctuating pH levels and salts in the water.

Energy efficient units may have one or more of the following features: more insulation, high efficiency/low NOx burners, power burners, relatively large heat exchanger surfaces, and flue exhaust heat recovery systems.

## 1.3 Installation Types and Delivery Mechanisms

Replace on burnout (ROB) installation applied when existing equipment fails or maintenance requires replacement and Early Retirement installation (ER) may also be considered.

Table : Installation Type Descriptions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Installation Type** | **Savings** | | **Life** | |
| 1st Baseline (BL) | 2nd BL | 1st BL | 2nd BL |
| Replace on Burnout (ROB) | Above Code or Standard | N/A | EUL | N/A |
| New Construction (NC) | Above Code or Standard | N/A | EUL | N/A |

The preferred delivery method is a downstream prescriptive rebate offered to the residential gas customer purchasing the new pool/spa water heater.

However, a midstream point-of-sale rebate may also be implemented

Table : Incentive Method Descriptions

|  |  |
| --- | --- |
| **Incentive Method** | **Description** |
| Down-Stream Incentive | The customer installs qualifying energy efficient equipment and submits an incentive application to the utility program. Upon application approval, the utility program pays an incentive to the customer. Such an incentive may be deemed or customized. |
| Mid-Stream Incentive | The program gives a financial incentive to a midstream market actor, such as a retailer or contractor, to encourage the promotion of efficient measures. The incentive may or may not be passed on to the end-use customer. |

**Rebate requirements**

To be eligible for a rebate, the application must be for a SoCalGas natural gas customer. This rebate is available for swimming pool heating that replace pre-existing pool heater in Single Family homes. Proper documentation showing the unit thermal efficiency must be included with the application. The units must also meet NOx emissions standards in all low NOx areas (i.e., they must be SCAQMD Rule 1146.2 certified).

## 1.4 Measure Parameters

### 1.4.1 DEER Data

There are currently no DEER measures applicable to Residential Pool/Spa heaters.

Table : DEER Difference Summary

|  |  |
| --- | --- |
| **DEER Item** | **Used for Workpaper?** |
| Modified DEER methodology | No |
| Scaled DEER measure | No |
| DEER Base Case | No |
| DEER Measure Case | No |
| DEER Building Types | No |
| DEER Operating Hours | No |
| DEER eQUEST Prototypes | No |
| DEER Version | N/A |
| Reason for Deviation from DEER | DEER does not contain this type of measure. |
| DEER Measure IDs Used | N/A |

**Net-to-Gross Ratio**

The NTG values were obtained using the DEER READI tool. The relevant NTG values for the measures in this work paper are in the table below.

Table : NTGR

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **NTGR ID** | **Description** | **Sector** | **BldgType** | **Measure Delivery** | **NTGR** |
| All-Default<=2yrs | All other EEM with no evaluated NTGR; new technology in program for 2 or fewer years | Any | Any | Any | 0.70 |

**Spillage Rate**

Spillage rates are not tracked in work papers; they are tracked in an external document which will be supplied to the Commission Staff.

**Installation Rate**

The IR values were obtained using the DEER READI tool. The relevant IR values for the measures in this work paper are in the table below.

Table : GSIA

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **GSIA ID** | **Description** | **Sector** | **BldgType** | **ProgDelivID** | **GSIAValue** |
| Def-GSIA | Default GSIA values | Any | Any | Any | 1 |

**Effective and Remaining Useful Life**

The effective useful life (EUL) for residential pool/spa water heaters of 10 years is taken from the DEER 2014 for residential high efficiency pool pump EULs. However, commercial pool haeters are given 5 years in EUL due to it’s continuous operation. The EUL of the base case units and the higher efficiency measure case units are expected to be similar.

Commercial pool heaters are given 5 years of EUL (WtrHt-GPoolHtr) due to its continuous operation. Residential gas water heaters for pools and spas are generally expected have 10 years of EUL. An EUL ID of **WtrHt-GPoolHtr-Res** with 10 years of EUL is used for the measure in this document.

Table : EUL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **EUL ID** | **Description** | **Sector** | **UseCategory** | **EUL (Years)** | **RUL (Years)** |
| WtrHt-GPoolHtr-Res | Residential natural gas pool heaterp | Res | Pool | 10 | 3.34 |

### 1.4.2 Codes and Standards Analysis

Current California Title 20 Appliance Standards (1605.1g) require a minimum thermal efficiency of 82%, that became effective April 16, 2013. Therefore the assumed base case thermal efficiency for this measure use a code-minimum 82%.

Table : Code Summary

|  |  |  |
| --- | --- | --- |
| **Code** | **Reference** | **Effective Dates** |
| Title 20 (2016) | Section 1605.1(g) Pool Heaters | April 16, 2013 |
| DOE | Fedral standard is same as in Title-20 | April 16, 2016 |

## 1.5 EM&V, Market Potential, and Other Studies – Base Case and Measure Case Information

The following studies provided solid estimate for the national and local average energy consumption in residential pool and spa heating. They also verified our estimated baseline usage and savings calculation from customer based billing data and softare/calculators.

### 1.5.1 Study Title:

### CEE High Efficiency Residential Swimming Pool Initiative

Consortium of Energy Efficiency (CEE), December 2012, (*Attachment A)*

CEE has identified several promising opportunities to support energy savings in residential swimming pools. They include pool motors, pool timers, robotic cleaners, pool covers, and pool heaters.

DOE’s 2009 Residential Energy Consumption Survey (RECS) indicates that of the 8 million US households estimated to have pools (in-ground and above-ground) with filtration equipment, 2.1 million have pool heaters. Of these households, 1.1 million use natural gas, consuming an average 38 million Btu/yr. The 2009 Survey also indicates that 6.4 million US households have hot tub or spa heaters. Of these households, 1.5 million have natural gas heaters. Natural gas heaters on average consume 35.9 million Btu/yr.

The study also provided the following analysis:

* + In 1990, gas-fired pool heaters were required to have a thermal efficiency of 78 percent. On April 16, 2013 the required thermal efficiency increased to 82 percent. Energy savings from this change is around 1.6 MMBtu/yr per unit.
  + A pool heater with 78.2 percent efficiency consumes about 34.1 MMBtu/yr, whereas a pool heater with 82 percent efficiency consumes 32.5 MMBtu/yr.
  + The most efficient pool heaters in the market have a thermal efficiency of 95 percent and consume about 27.8 MMBtu/yr, providing energy savings of 6.3 MMBtu/yr per unit over the 1990 standard (78%) or 18 percent savings and 4.7 MMBtu/yr per unit over the 2013 standard (82%) or 15 percent savings.

### 2009 California Residential Appliance Saturation Study

Prepared for the CEC by: KEMA, Inc., October 2010, (*Attachment B*)

The study presents key findings from the 2009 California Residential Appliance Saturation Study (RASS) that was sponsored by the California Energy Commission. The study yielded unit energy consumption estimates for 27 electric and 10 natural gas residential end uses and appliance saturations for households within the California territories of the participating utilities.

The study was implemented as a mail survey that requested households to provide information on appliances, equipment, and general consumption patterns. Data collection was completed in early 2010.

Table ES-4 in the attachment, presents natural gas UECs by dwelling type. Where Pool Heating and Spa Heating for Single Family homes in Southern California, use approximately 220 and 52 therms/yr, respectively.

## 1.6 Data Quality and Future Data Needs

To verify the baseline gas heating for swimming pools and spas in residential homes, gas bills were collected from customers with heated pools/spas in five different cities in SoCal. Utility billing analysis were done to baseline the home’s heating and water heating energy usage. Data for regional heating degree days (HDDs) were collected and charted against the monthly gas usage from the billing data. Linear regression analyses were done to identify the relationships between heating gas usage and HDDs. The gas usage at the point where the linear regression line intercepts the Y axis at zero heating degree days was deemed non-space heating gas usage, and assumed to be for hot water heating and other indoor gas usage activities. The difference between the annual gas usage and the calculated loads were given to the swimming pools and spa heating, *(Attachment C)*

Figure : Utility Bill Heat Load Analysis

Field test data and an M&V plan may help in the verification of savings. The plan can vary in depth and scope, but may include spot measurements, or monitoring of pool heater use, and/or utility bill analysis.

# Section 2. Calculation Methodology

## 2.1 Heat Losses

In general, the hourly change in the average pool water temperature is equal to the sum of the heat transferred into the pool each hour, divided by the specific heat of the pool.

 *Eqn-1*

* + *Tpool* is hourly change in pool temperature, F
  + *qin* is heat added to the pool via each heat transfer mechanism, Btu/hr
  + *w* is the density of water, lb/ft3
  + Cw is the specific heat of water, Btu/lb-F
  + *Apool* is the area of pool, ft2
  + *dpool* is the average pool depth, ft

## 2.2 Energy Savings Calculation

The pool energy savings calculation accounts for the following heat transfer mechanisms:

* + - 1. Natural gas fired pool heater to maintain the pool water temperature
      2. Solar direct radiative heating of the pool surface (reduced by shading and atmospheric clearness factor, which includes haze and cloud cover)
      3. Evaporative cooling from the pool surface
      4. Radiation heat transfer from the pool surface to the sky
      5. Convection heat transfer from the pool surface to the air (free convection under calm conditions, forced convection when windy)
      6. Conduction heat transfer from the pool water to the piping and the soil
      7. Heating the makeup water needed to replace pool water lost by evaporation.

The details of the calculations are shown in SCG’s work paper for Pool Covers, *(Attachment D)*

The annual gas energy savings calculations are based on two models:

* 1. A pool heat transfer model, developed for swimming pools in California to ascertain the benefits of using efficient pool heater at various types of swimming pools in the California climate zones.
     + 1. Annual gas energy consumption is calculated for baseline conditions and measure conditions to determine the energy savings.
       2. The climate zone is determined from the pool location in California, and the incident solar radiation is determined at a centrally located airport weather station within each climate zone.
       3. Homeowners usually uses the pool heaters only for special occasions due to the high fuel costs associated with its use. As a result they do not have a regular heater-operating pattern. For purpose of this analysis, we selected a short schedule and calibrated the energy use with the pre-determined baseline.
       4. The energy savings calculation approach is based on an hourly Excel spreadsheet[[1]](#endnote-1) for one calendar year. The pool heat transfer model was compared to one of the most accurate swimming pool energy savings calculation methods, the Energy Smart Pools software program (RSPEC)[[2]](#endnote-2).

Table : Data, Assumptions and Results for Pool Heater, *(Attachment E)*

|  |  |  |  |
| --- | --- | --- | --- |
| **Constant** | **Description** | **Value** | **Units** |
| *Apool* | Pool surface area, | 500 | SQFT |
| *dpool* | Average Depth | 4.5 | FT |
| *Tpool* | Desired Temperature | 80 | ºF |
| Q*pool* | Pool heater capacity, | 300 | MBtuh |
| V̇post Avg | Baseline Thermal Efficiency,  *from 2013 Title-20 code* | 82% | unitless |
|  | Propose pool efficiency,  *Tier-I based on market research* | 85% | unitless |
| *qin, base* | Annual Gas Usage, *calculated* | 231 | Therms/yr |
| *qin, prop* | Proposed Gas Usage,  *calculated* | 223 | Therms/yr |
| *qpool* gas | Gas savings,  *for Tier-I heater 84% TE or above* | 8 | Therms/yr |

* 1. A spa heat transfer model, was developed for spa pools in California to determine the energy savings of the spa heater measures.
     + 1. A major difference between pools and spas is the manner in which the spa heater capacity is determined. The spa heater is sized to bring the spa water temperature from ambient (when the spa has been closed and the spa heater has been turned off for many days) to the desired temperature in a fixed time (assumed to be two hours before opening). The minimum ambient temperature is assumed to be the average air temperature during the coldest month of the year. The rated input of the spa heater is thus equal to the mass of the spa water times its specific heat, times the temperature change, divided by the thermal efficiency of the spa heater, divided by two hours.
       2. The approach was to adapt the Pool Energy Savings Tool Excel spreadsheet that was developed for calculating heat losses from swimming pools for an entire calendar year. A minimum change was needed for the input data. The pool surface area used in the pool heat loss calculation was replaced with the spa volume of water that are heated.

Table : Data, Assumptions and Results for Spa Heater, *(Attachment F)*

|  |  |  |  |
| --- | --- | --- | --- |
| **Constant** | **Description** | **Value** | **Units** |
| V̇spa | Spa capacity (volume), | 600 | Gallons |
| *dspa* | Footwell Depth | 3 | FT |
| *Tspa* | Desired Temperature | 90 | ºF |
| Q*spa* | Spa heater capacity, | 200 | MBtuh |
| Ƞbase | Baseline Thermal Efficiency,  *from 2013 Title-20 code* | 82% | unitless |
| ƞpost Avg | Propose pool efficiency,  *Tier-I based on market research* | 85% | unitless |
| *qin, base* | Annual Gas Usage, *calculated* | 53 | Therms/yr |
| *qin, post* | Proposed Gas Usage,  *calculated* | 51 | Therms/yr |
| *qspa* gas | Gas savings,  *for Tier-I heater 84% TE or above* | 2 | Therms/yr |

* 1. Marketing Survey: Based on annual consumer surveys an estimated 24% of in-ground pool owners in the LA market also own a hot tub. To validate this number we contacted many disributors of pool heaters serving the LA market, and they provided estimates that are much high. New heaters, like Pentair ETi 400 use a dual temperature controls for an easy change between the pool and Spa temperature settings.
  2. Pool and Spa Heater: Based on SCG marketing survey, many swimming pools and spas are connected to the same heater, therefore,we combined the saving estimates for both pool and spa heaters in this workpaper. Savings for the 16 climate weather zones in California, and the weighted average savings adjustment for pools /spas in SoCal zones are in *(Attachment-G).*

The following table indicates which measures are taken directly from or created with the DEER READI tool.

Table : READI Data Used

|  |  |  |
| --- | --- | --- |
| **Measure Code** | **Measure Name** | **READI Data** |
|  | N/A | N/A |

# Section 3. Load Shapes

The ideal load shape for net benefits estimates would represent the difference between the base case and measure case. The closest load shapes that are applicable to the measures in this work paper are listed in the table below.

Table : Building Types and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **Load Shape** | **E3 Alternate Building Type** |
| SF Residence | Any | RES |

# Section 4. Costs

A pool list was pulled off the CEC website that contain models of gas-fired pool heaters in different sizies and efficiencies. An extra column has been added that includes pricing provided by vendors, the internet and other sources like the RSMeans book. The cost data is shown in (*Attachment H).* The CEC database provided a list of eligible gas-fired pool heaters models. The list was sorted by rated efficiency. Then, an average cost was calculated for all models with efficiencies in the three categories: Baseline, Tier-I and Tier-II.

Figure 2, was selected for capacities of gas-fired units ranged from a low 100,000 Btu per hour input to a high of 500,000 Btu per hour. These prices do not include installation or setup costs at the pool site.

* Retail prices varied from about $1,000 to $2,400 for low-NOx emission units that are T-20 code compliant (82% TE).
* Tier-I has fewer than 20 models of high efficiency gas–fired units with efficiencies range from 84% to 88%, cost ranges from $2300 to $3100 (*attachment-H*). These units normally have higher efficiencies and exhibit much lower NOx emissions.
* Twenty more units from Tier-II, the condensing type heater has a listed efficiency rating of 94% to 98% with a price of about $3700 to $5700

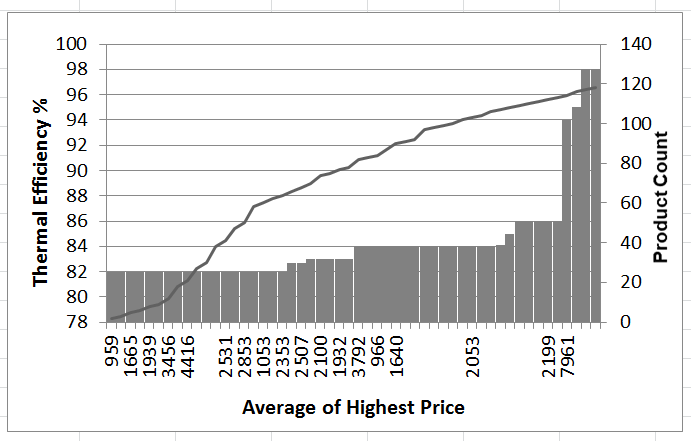


Figure : List of CEC Pool Heater models and cost

According to the Performance Study of Swimming Pool Heaters by Roger J. McDonald[[3]](#endnote-3): “The condensing units require certain hookup and plumbing for handling the condensate from the heat exchanger. This is slightly acidic and must be passed through a neutralizer prior to disposal down a drain. The heat exchanger must also be fabricated using materials designed for the corrosive environment of the condensate in the condensing unit. The heat exchangers used in this type of heater must be fabricated from a material with properties that will resist this corrosive environment while providing reasonable longevity over a period of many years of use. The materials of choice used for condensing heat exchangers are much more expensive than conventional materials and have a significant impact on the initial cost of a unit that incorporates a condensing heat exchanger.” Material cost are included in Table-14.

## Base Case Cost

The base case cost is that of a baseline (standard) pool or spa water heater that meets current California codes and federal standards.

The units must meet NOx emissions standards in all low NOx areas (i.e., they must be SCAQMD Rule 1146.2 certified).

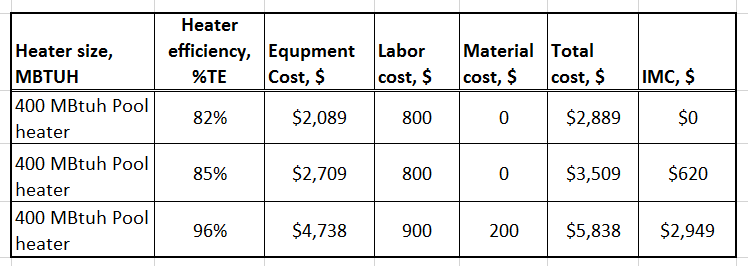
The base case costs are shown in Table 14. The table lists the results from the CEC cost estimate data and from a survey of equipment vendors that sell pool water heaters in California.

Table 14 represent an arithmetic average of the equipment cost per MBtu/hr in each category.

## Measure Case Cost

The measure costs include the cost of the equipment, labor and installation and start-up costs. For the purposes of determining incremental measure costs, the installation and start-up costs are assumed to be the same for the base case and Tier-I measure equipment. However, the incremental measure cost for the condensing pool heater (Tier-II) includes an added cost for plumbing and exhaust part, as shown in Table 14, below.

Table : Cost Summary from the CEC Appliance Database, (Attachment-H)



## Full and Incremental Measure Cost

The incremental measure cost is the difference between the measure total cost and the base total cost. In the NEW and ROB programs, the baseline total cost is $2889 (code) and N/A in the second, this programs have a measure total costs of $620 (Tier-I) and $2949 (Tier-II) in the first baseline and N/A in the second. Details are in (Attachment I).

Table : Full and Incremental Measure Cost Equations

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB | (MEC + MLC) – (BEC + BLC) | (MEC + MLC) – (BEC + BLC) | N/A |
| NEW/NC |

MEC = Measure Equipment Cost; MLC = Measure Labor Cost

BEC = Base Case Equipment Cost; BLC = Base Case Labor Cost

Table : Full and Incremental Costs

|  |  |  |  |
| --- | --- | --- | --- |
| **Installation Type** | **Incremental Measure Cost** | **Full Measure Cost** | |
| **1st Baseline** | **2nd Baseline** |
| ROB/NC, for Tier-I >84% and <90% TE | $620 | $620 | N/A |
| ROB/NC, for Tier-II >90% TE | $2949 | $2949 | N/A |

# Attachments

Attachment A – Customers database and analysis

Attachment B – 2009 California Residential Appliance Saturation Study

Attachment C – Customers database and heating baseline analysis.

Attachment D – WPSCGNRWH150309A\_Pool\_Cover\_workpaper\_rev0

Attachment E – Pool Heater Energy Savings model

Attachment F – Spa Heater Energy Savings model

Attachment H – Statewide and average SCG savings

Attachment H – CEC appliance database\_AHRI listing

Attachment I – Summary table for cost and savings

# References

1. Pool Cover and Pool Heater Energy Savings calculator, SoCalGas,

   <https://deeresources.info/cta> [↑](#endnote-ref-1)
2. Energy Smart Pools Software (RSPEC), developed by The U.S. Department of Energy. Programmed in 1993.

   <http://www.rlmartin.com/rspec/software.htm> [↑](#endnote-ref-2)
3. Roger J. McDonald, Energy Science and Technology Department/Energy Resources Division, Brookhaven National Laboratory, January 2009, Performance Study of Swimming Pool Heaters. BNL-93715-2009-IR.

   <https://www.bnl.gov/isd/documents/73878.pdf> [↑](#endnote-ref-3)