Codes and Standards Enhancement Initiative
For PY2004: Title 20 Standards Development

Analysis of Standards Options For Portable Electric Spas

Prepared for:
Gary B. Fernstrom, PG&E

Pacific Gas and Electric Company

Prepared by:
Davis Energy Group
Energy Solutions

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1 Overview

The Pacific Gas and Electric Company (PG&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 standards and options for portable electric spas.

2 Product Description

Portable electric spas are pre-fabricated, self-contained electric spas or hot tubs, as opposed to "in-ground" units (such as those attached to a pool), other permanently installed residential spas, public spas, or spas that are operated for medical treatment or physical therapy.[1] We define portable spas to be electrically heated; this constraint has the advantages of fitting with the market reality of the portable spa as a consumer product, and of defining a category sufficiently narrow to facilitate the adoption of a reasonably streamlined, uniform standard. Although some portable spas exceed 500 gallons, the most popular models range from around 210 to 380 gallons. Filtration pumping, water heating, shell insulation, and cover, are the primary components affecting energy efficiency. There is no current standard testing procedure for measuring the energy efficiency of portable spas. While the National Spa and Pool Institute (NSPI) has a standard that covers certain aspects of spa design, equipment characteristics, and operation and installation issues, the standard does not address energy use or efficiency issues.[2]

The vast majority of electrically-heated portable spas are located in single family homes—96% according to RECS 1997. Typical owners of portable spas are married, middle-aged, well educated and live in middle-to-upper-income areas of cities or suburbs. Recent research suggests that spa ownership is extending to a younger and less affluent group of Americans, which may reflect the drop in spa prices in recent years[3].

The term "portable" might seem to imply that owners relocate their spa when they move to a new home, and indeed specialty "spa relocation" firms do exist. However, a spa upgrade often happens coincident with the move. Portability is better understood as representing the advantage of a straightforward and low-cost installation.

[1] In addition, portable spas are usually operated to maintain a constant water temperature level, while in-ground units use natural gas and typically are only turned on to heat up water for each use.
[2] ANSI/NSPI-6 1999.
[3] Personal communication, NSPI

Figure 1: Example of a Portable Spa

3 Market Status

3.1 Market Penetration

The spa market is quite diffuse, with the number of manufacturers entering into the hundreds. According to the NSPI, in 2000 there were 3.4 million portable spas in use within the US, and annual sales were 370,000 units. California has around 12% of the nation's population, but spa penetration is thought to be substantially above the national average. The number of electric portable units currently in use in California is not well known, but several estimations exist, and are summarized in Table 1.

Table 1. Stock Estimates of Electrically Heated Portable Spas in California

Source	*Total Stock Nationwide*	*Percent in CA*	*Penetration in CA*	*Single Family CA Residences*	*Total Units in California*
NSPI (2000)	3.4 million	--	--	--	--
CEC Demand Forecast (03-13)	--	--	5.4%	7.8 million	421,000
DOE RECS 2001 (HC5-7a)	3.3 million	12.1%	--	--	400,000
PG&E RESR (1997)	--	--	5.7%	7.8 million	445,000

The RECS national stock number is close to the NSPI estimate, but their California stock estimate is questionable as it has not increased since 1997 and we believe that the penetration for California is higher than the nationwide average. We therefore use the nationwide NSPI data and a portion of total US stock of 13%--slightly higher than the nationwide average, resulting in an estimate of 440,000 spas.

3.2 Sales Volume

Using 13% as California's portion of national sales, we estimate approximately 48,000 spas are sold in the state each year. Treating this as an average annual sales figure, with a 10-year turnover of the existing stock and sales growth of 1% per year, the projected long-term population would be around 544,000 units in the year 2013.

3.3 Market Penetration of High Efficiency Options

Given both the demographics of spa ownership, and the spa's typical place as the largest electric load in homes that possess one, many spa owners recognize energy use as an important issue and one deserving of attention and potential added investment. Typically, after a first experience with an inexpensive spa that was energy intensive and perhaps inadequate in other ways, long-time spa owners eventually upgrade to a unit that is perceived to be more efficient, as well as possibly outfitted with additional features.[4] However, because there are no standard tests or ratings, consumers have no way of knowing which spas are truly energy efficient.

Higher-end spas tend to have more insulation under the shell and in the cover, and some have an independent circulation pump that saves energy over the more common standard two-speed pump configuration. They may also have LED lighting - more efficient than standard incandescent lighting that comes in most spas. Additionally, some spas market control features such as an "economy mode" allowing the temperature decrease during periods of nonuse. Each of these options might be considered an energy efficiency measure. Some of the options offered as "efficient" generate substantial savings and some may not; sales and marketing representatives from manufacturers tend not to provide information regarding the specific energy savings associated with individual measures.

4 Savings Potential

4.1 Spa Construction

4.1.1 Shell

Rather than the familiar wooden tub of old, the vast majority of new portable spas are made of a shell of molded fiberglass or acrylic. The shell may be solid-surface or laminated; various manufacturing techniques exist. Stated shell lifetimes vary from around 8 to 15 years or longer. Manufacturer warranties against shell leakage or delamination range from 5 to 12 years. Single piece construction decreases leaks as compared to older wooden tubs.

[4] Anecdotal evidence indicates that a common scenario is that a consumer replaces an older unit at least partly due to perceived high operating costs.

4.1.2 Insulation Characteristics

High R-value is the single most important factor affecting spa energy efficiency. The majority of heat loss is from the water surface, and thus improved covers are important for overall efficiency improvements.[5] The spa cover presents particular challenges for efficiency. Covers with insulation comparable to that of the rest of the spa are often sold as options, while a less efficient cover comes standard. In addition to having denser and thicker insulation, high-efficiency covers may be designed with form-fitting gaskets and skirts around the tub exterior. The cover is the first component of the spa that is likely to be replaced by the user, creating the possibility of variable efficiency through the life of the spa. In any case, test procedures should specify that each unit's standard cover be used.

Insulation of the spa shell itself is also important. Insulation method, uniformity and thickness vary between manufacturers. Most spas will have at least a 1-2" layer of open- or closed-cell insulation spray-coated directly onto the underside of the tub shell during assembly. Depending on the manufacturer, spas may have little additional insulation, may use fiberglass batts within the interior cavity, or may have the entire cavity filled with foam insulation.[6] For purposes of efficiency, more insulation is better, but there is a diminishing rate of return and the longevity and serviceability impacts of different insulation methods and materials can be significant.

4.1.3 Heating Systems

Heating energy accounts for over half the energy consumed by a typical spa. Heating requirements are in large part determined by standby losses through the cover and shell, and heat loss and water evaporation during use. Most portable electric spas rely on resistance heaters to maintain their temperature, though some inexpensive ones use just pump friction. Most resistance heated spas use direct-contact heaters, which can boast efficiencies of 98% or higher. The element and other heater components must be of high quality to resist corrosion and decay from constant contact with the spa's chemical-charged water. Some firms tout the maintenance benefits from heaters that separate the spas water from the heating element itself. Up to 96% efficiency claims are made for these systems. Thus heater efficiency is generally quite high, with little difference between different design approaches.

4.1.4 Pumping Systems

Pumping is the second major component of spa energy use, accounting for around 25-50% of the energy used in a portable spa. Portable spas have at least one pump to provide filtering and circulation and to run the jets when the user turns them on. Several configurations are possible, resulting in widely variable pumping energy use; some models include a separate, small pump for filtration and circulation duties, which can

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[5] Joe Stone, Balboa Instruments, current president of the Hot Tub Council, Personal communication, 10/24/02.

[6] Filling the cavity with foam has the advantage of adding structural rigidity to thinner-walled shells as well as providing insulation value. Open-cell foam can vary in quality, but will generally absorb water and will thus lose some of its insulation qualities if allowed to get wet. Some manufacturers place an ABS tub beneath the foam to prevent water uptake from the ground surface. Foam has the added drawback that leaks are difficult to find and fix since many components are embedded. Foam is, however, a formidable insulator and can be a low-cost manufacturing method to increase the R-value of a one-piece tub.

reduce energy requirements. Smaller spas, and less expensive spas generally, tend to have one multi-speed pump that both runs the circulation and filtration system, and powers the jets.

Pumping energy use is further complicated by the fact that a significant portion of heat generated by the motors and pumps effectively contributes to heating the spa. Therefore a fraction of the energy savings from pump and motor improvements will have to be replaced by resistance heat. How much waste heat is lost depends on the location of the pump and the insulation configuration of the spa. The heat from filter pump operation may also overheat a well insulated spa during warm summer months.

Related to pumping is the presence of increasing numbers of jets and hoses in new spas. Ever more powerful jets are incorporated to provide health and relaxation benefits to the user. In essence the hoses can act as heat exchangers with the surrounding air, losing heat and increasing heating energy requirements. Additionally, air is often introduced to the water being pumped to the jets. Ambient air used for this purpose can accelerate the spa's cool-down. Some spas use air from the pump cabinet for this purpose and so take advantage of the pump's waste heat, thus saving some energy.

4.1.5 Controls

Controls for spas in all sectors of the market focus on keeping the water adequately filtered and heated to the temperature programmed by the user. Most new controls are equipped with many of the advantages enabled by simple electronic circuitry: digital temperature controls, password-protection prohibiting unauthorized use, timed automatic jet shut-off, etc. Some models already include energy-saving set-backs that lower the temperature when indicated by the user, or by a programmable time clock. As a rule, however, control panels do not include these and other so-called "smart" features. Smart controls could save significant amounts of energy—perhaps 5-10% of a spa's heating energy requirement—and could provide important reductions in peak load per unit, although the coincidence between peak spa heating demand and utility summer on-peak periods is low.

4.1.6 Lighting

Some manufacturers' spas include LED lighting systems, which are more efficient and longer-lived than more typical incandescent lighting. While incandescent lights each require 12-15 watts or more, LED lights (replacement or OEM) demand around 3 watts. Further, LED lights can last up to 100,000 hours of operation, whereas incandescents typically last 500 to 2,000 hours of use at best. As with pumps, waste heat from inefficient lighting to some extent offsets heating loads and therefore reduces the benefits of efficiency lighting. No data is available on the time of use for typical in-spa lighting systems, so no definitive conclusions can be made about the cost-effectiveness of such an upgrade. It is presumed, however, that spa lighting would not be on during daylight, on-peak hours.

4.2 Baseline Energy Use

Spa energy usage can be divided into three phases for purposes of energy use analysis: startup, standby, and use phases. First is the "startup" phase, during which the newlyfilled, or cold spa is brought up to a stable temperature. Ninety to ninety-five percent of the energy used in this phase is used by the heater, with the remainder used by the circulation pump, which must run continuously when the heater is on. Startup might be expected to take place around twice per year, or whenever the user is restarting the spa after an extended un-heated period. Given that most spas' heaters are of comparable efficiency, energy use during this phase will depend solely on volume, regardless of their relative overall efficiency or construction quality. The main difference between units is the time required to heat the water; this depends on the individual heater's power and the spa volume. Heaters using 220VAC will heat 4 times as fast as the same model wired for 110VAC, though the overall amount of energy used will be similar. All other factors being equal, a spa with twice the volume will take twice the time to heat up and use twice the energy to do so. A typical 350 gallon spa will use 36 kWh to bring the water to 102°F for each fill.

Second is the "standby" phase. While a heated spa is on but not being used, it consumes energy only to maintain its temperature and to keep the water mixed and filtered. This "standby" energy consumption is a true reflection of the efficiency of a given unit, since it represents the majority (75%) of the spa's annual energy use.

Finally, the "use" phase might be described as the intended operating environment of the portable spa. That is, the spa is being used perhaps once per day for at most an hour, with the cover off and the jets operating, with some external air being introduced through them. Such a usage pattern will increase energy requirements by around 25-35% over the standby scenario; the actual proportional increase depends on the particulars of the spa, its inherent efficiency, the type of use it receives, the ambient air temperature, and any on-demand features dormant during standby phase.

4.2.1 Spa Energy Consumption Estimates

Spa per unit energy consumption depends on a variety of factors including the unit's volume, design and construction (described section 4.1), the climate, hours of use per week, amount of jet use, etc. In determining average energy use and power draw of a portable spa, we drew upon many available sources of energy use data, which are summarized in Table 2.

The wide variation of unit energy consumption is notable in the table. Also, the test procedures, including usage profile and ambient temperature (two items that most influence energy consumption even among similar models) are without uniformity. Additionally, several of the estimates shown, including the lowest ones, likely include gas-heated spas not covered by this document.

Table 2: Spa End-Use Data Sources

Source	*UEC (kWh/year)*	*Notes*
Rainer, Leo, Steve Greenberg and Alan Meier 1990 "The Miscellaneous Electrical Energy Use in Homes" ACEEE Summer Study 1990.	Range:1,500-4,000 Average. 2,300	Subsequently referenced in the E-Source Tech Atlas (1996), ACEEE Consumer Guide to Home Energy Savings (1999), and various other journal articles and reports
DOE RECS (1997)	2,300	Source quoted in RECS: "Elect. Consumption by small end uses in Residential Buildings" A.D.Little, Inc., 1998
PG&E R&D, "Spa Testing Report" Report 008.1-89.9 (1989)	Standby use only: 970; 2,370; 4,200	Calculated by the authors from this report. Based on results of one test over 54 hours, for three specific spas from three different manufacturers. Spas were fully covered and unused during test period.
J-Rad Engineering "Energy Consumption Analysis of Watkins 115V Classic and 230V Classic Spa Models (1992, Sponsored by Watkins)	San Francisco: 2,214; 2,999 Sacramento: 2,136; 2,890	Model of annual use based on chamber data collected at 0, 20, 40 and 70F. Includes daily use of 1 hour with cover off and 30 minutes with jets running.
Manufacturer Data (1992-2002)	2,232 @ 60ºF ambient	www.hotspring.com; tests reported were done by Exponent Inc. Usage regimen: 6 times per week; 30 min. with cover off and 15 min. jet use.
A.D. Little (2001)	Average: 2,600	Quoted 10/24/02 by Joe Stone, Balboa Instruments, President of the Hot Tub Council. The report was commissioned by the NSPI and is confidential so details were not available.
PG&E (2004) Field Tests of Ten Portable Electric Spas	Standby use only: Range: 1,127 - 2,392 Average: 1,879	Measured standby energy use of ten new spas extrapolated to average California outdoor temperature.

Several reports warrant additional comment. First, Rainer et al (1990), the first study to list this end use explicitly, was widely quoted over the subsequent 6 years (ACEEE, Meier et al (1992 and 1994), E-Source Tech Atlas, others), and so the annual consumption figure of 2,300 kWh became a widely established reference point.

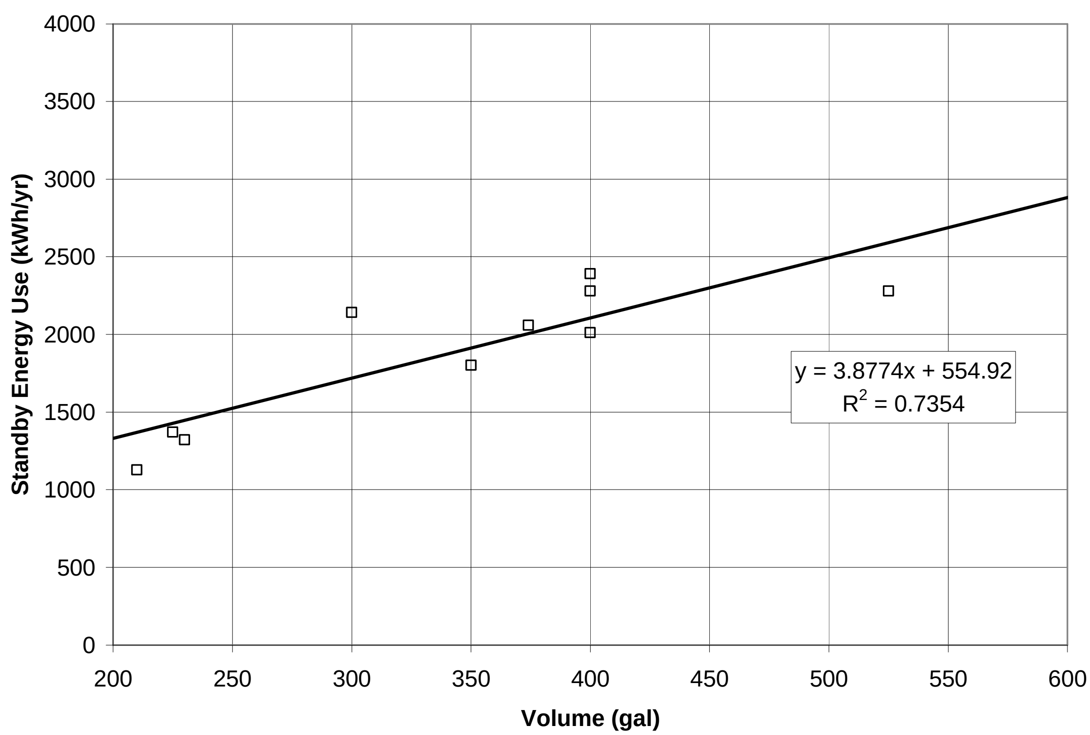
Second, PG&E (1989) testing showed a very large variation in the energy use for different spa models, particularly in the standby phase that is most relevant for the standard proposed here. The document reports only one set of tests on three particular spas, and makes no claim to be comprehensive; it is also the oldest source encountered in the literature.

Third, J-Rad's report (1992) for Watkins Manufacturing, Inc. (makers of HotSpring and other brands) gives numbers that would seem to be realistic for a generally efficient Spa receiving regular daily use of up to one hour. More recent tests contracted by Watkins, conducted by Exponent Inc. and reported on Watkins' web site, indicate UEC of 2,232 kWh for a 115V mid-size (Sovereign) model at 60ºF ambient, with just one-half of the usage assumed by J-Rad.

Fourth, RECS 1997 indicates a UEC of 2,300 kWh/year as well. It is interesting that this number, or ranges around it, appears consistently in various unrelated sources either as a bulk average usage or as a usage level representing a relatively efficient new individual spa. This makes some intuitive sense since such an average likely includes the entire range of efficiencies and usage patterns and possibly including older, smaller less powerful (and less efficient) spas.

Fifth, and last, the most recent PG&E monitoring study (2004) was designed to support this CASE study and used a consistent monitoring protocol to measure the standby energy use of new spas under field conditions. Ten spas ranging in volume from 210 to 525 gallons were monitored for three days at constant water temperature with their covers on. During this period water temperature, air temperature, and pump and heater status were all recorded and the resulting energy use was normalized to temperature difference. Figure 2 shows the distribution of annual standby energy, normalized to 60°F average outdoor temperature, by spa volume for the ten monitored spas. Adding 70 kWh for two startup cycles and 565 kWh for spa use results in a total average energy use of 2,514 kWh per year.

Figure 2: Monitored Spa Standby Energy Use



Drawing upon varied consumption data from these sources, we estimate that the average annual consumption of residential spas is around 2,500 kWh, in rough agreement with Rainer et al, RECS, and A. D. Little. In other words, given the convergence around 2,500 kWh/year as a typical consumption level for the spa population as a whole, we consider this number to represent a reasonable basis for calculations to determine recommended maximum allowable energy use under a proposed standard.

Comparing models from the same manufacturer, overall energy use is higher for larger units than the average, but per-gallon energy use tends to be lower due to decreased surface area per unit volume. Similarly, smaller units may consume less energy, but per-gallon consumption can be higher due to larger proportional losses.

4.2.2 Peak Demand

Based on a unit consumption of 2,500 kWh per year, the average load of the typical spa is 0.29 kW[7]. Because spa usage and heating energy requirements both decrease with rising temperature, the demand that is coincident with the summertime system peak will be lower. A.D. Little estimated the load factor for electric spas to be 42%[8] which results in a load of 0.12 kW, most of which will be pumping load.

4.3 Proposed Test Method

No broadly accepted standard test method currently exists for portable spas, but manufacturers literature exhibit two general approaches for comparing spas. Most common, is the calculated-energy approach, derived from component characteristics and time-of-use estimates. This approach is of limited usefulness for obtaining real-world results. Second, and rarer, are actual performance tests: prior to the field testing done in support of this CASE study work, we have found only two such studies available to the public, one funded by PG&E and one commissioned by a manufacturer. NSPI member companies indicate that the group has begun working towards the definition of an acceptable testing protocol.

A simple testing protocol focusing on the most common features and usage scenarios will encourage consistent compliance on the part of manufacturers. We propose to focus solely on standby use, since this state is where the important efficiency differences between units are most clearly revealed. This approach avoids apples-to-oranges comparisons inherent in nonstandard usage patterns and user-controlled options across brands. In addition it simplifies the test method, eliminates disagreements over what are typical spa usage patterns, and avoids penalizing added features that use energy only during the use phase such as additional jets. A reasonable test protocol would include the following elements:

- At least one test must be performed for each spa, at an ambient temperature of 60ºF[9].

[7] 2,500 kWh divided by 8,760 hours per year.
[8] From "Spas: The Straight Story" in Aqua Magazine, January, 2002.
[9] The average annual air temperature of California's 16 climate zones. Tests at higher temperatures may be reasonable if the energy use is normalized to temperature difference. This would ease the burden on manufacturers to perform tests in specialized test chambers.

- Minimum continuous testing time of 72 hours[10].
- Minimum spa water temperature of 102ºF. That is, the water temperature must remain at or above the test temperature of 102ºF for the duration of the test.
- Maximum ambient air temperature of 60ºF. That is, the air temperature must remain at or below the test temperature of 60ºF for the duration of the test.
- The standard cover that comes with the unit must be used during the test.
- Begin the test after water temperature has been at 102ºF for at least four hours.
- Record total energy use for period of test, starting at the end of the first heating cycle after the four hour stabilization period, and finishing at the end of the first heating cycle after 72 hours has elapsed.
- Unit is to remain covered and in the default operation mode during the test. Energy-conserving circulation functions, if present, must not be enabled if not appropriate for continuous, long-term use.
- Data reported will include: spa identification (make, model, S/N, specifications); volume of the unit in gallons; cover R-value; supply voltage; relative humidity; min/max/average water temperature; min/max/average ambient air temperature; date of test; length of test (hours:minutes); total energy use during the test to the nearest 0.1 kWh; and standby power (energy use divided by length of test).

4.4 Efficiency Measures

Measure 1: Improved cover and increased spa insulation levels.

Plentiful insulation in the spa cover and body, properly installed, is the main route to decreasing spa energy consumption, and would decrease energy use by up to 30% for a spa of average-to-low efficiency—more for the least efficient spas. It is likely that these measures would be the first ones deployed, since they require little additional engineering and design work.

Measure 2: Circulation/filtering pump Improvements.

In general this change would be understood as the addition of a low-wattage circulation pump, but other equivalent options could be imagined to achieve the same effect, such as improved pump efficiency, innovative multi-speed motor designs, variable speed control and the like. This option could save roughly 15% of the energy consumption of the average-efficiency spa and up to half of the pumping energy used for circulation and filtering. This measure would require some manufacturers to invest in product development and design work, and would likely be deployed after insulation improvements.

Measure 3: Automated programmable controls.

Controls could save about 5% of a spa’s energy consumption by permitting the user to customize settings based on anticipated usage patterns. Another potentially important

[10] This is especially important for efficient 240V spas which may have less than two heater cycles per day.

benefit would be the demand savings associated with deferring load, whether heating or routine circulation, to off-peak hours.

4.5 Standards Options

The two potential regulatory strategies for portable spas are a prescriptive standard and a performance-based standard. Prescriptive standards are advised in product categories with very similar products, few manufacturers and/or little technological or design evolution. The market for portable spas does not conform to these characteristics, and so the end goal here is to improve efficiency of spas without dictating design elements or otherwise limiting manufacturers' action within the market.

In order to implement a performance standard, a test procedure such as proposed in section 4.3 above must be used. Adoption of such a procedure would establish an objective data set with which different spas from distinct manufacturers could be compared. An appropriate performance standard should set a target maximum standby electricity consumption, in units of kWh/year, kWh/day, or simply average watts. Three approaches to defining performance requirements in terms of maximum standby consumption were considered:

1. A fixed maximum standby energy or average power limit. This has the advantage of simplicity, but could penalize large spas if set too low and could forgo savings from improvements to small spas if set too high.
2. A maximum standby energy or average power indexed to spa volume. Although there is no standard method for measuring spa volume, it is the most universally used indicator of spa size and appears to be used consistently within the industry. This method would remove the penalty imposed by a fixed limit on large spas but because spa standby energy use is directly related to total surface area (top, sides and bottom together) and not volume, it would allow large spas to be less efficient.[11]
3. A maximum standby indexed to total spa surface area. This would require all sizes of spas to be equally efficient. However, spa area is not easily defined and there is no standard for measuring it. A simpler solution that approximates indexing to surface area is to use spa volume raised to the 2/3 power. This is a value that increases linearly with total spa surface area.

The third approach for defining maximum standby consumption is proposed due to its simplicity and neutrality towards spa volume.

Given the dearth of consistent, measured, standby performance data, it was possible to establish a reasonable estimate for the average standby consumption, but more difficult to infer the distribution of performances of available models. So, rather than comparing a range of somewhat arbitrary standards levels or options, the savings associated with a series of discrete efficiency measures were assessed. This efficiency measure analysis indicates generally what savings (and associated cost-effectiveness) are available relative

[11] For a fixed proportion solid, the ratio of volume to surface area increases with size. Thus, adopting a maximum energy standard that is proportional to volume makes achieving the standard relatively easier at the larger sizes.

to a typical model. From that analysis, an appropriate performance requirement can be established.

4.6 Energy Savings

The efficiency measures discussed in section 4.4 would result in approximate average energy and demand savings as summarized in Table 3. Energy and demand savings assume 48,000 units sold per year. Aggregate numbers assume stock of 440,000 units statewide.

Table 3: Estimated Long-term Savings for Efficiency Measures

Improvement Options	*Projected Unit Savings (%)*	*Average Unit Annual Savings (kWh)*	*Projected Statewide Annual Savings (GWh)*		*Projected Statewide Demand Savings (MW)*[b]	
			1st Year	*Potential*	*1st Year*	*Potential*
Cover[a]	10%	250	12	110	0.6	5.3
Insulation	10%	250	12	110	0.6	5.3
Motor	15%	375	18	165	0.9	7.9
Controls	5%	125	6	55	0.3	2.6

[a] assumes replacement after year 5 with a second efficient cover.
[b] based on reductions from a peak-coincident unit load of 0.12kW.

As suggested in section 4.5 above, specific measures are not used to define the standard option in section 7 below, but show a range of possible efficiency gains that support the selection of a surface area normalized standby performance requirement.

5 Economic Analysis

From the point of view of energy consumption the most important factors are insulation characteristics and pumping system configuration. Lighting plays a minor role in energy consumption, though improvements are possible. In addition, the use of “smart controls”, heretofore underutilized in the market, presents the potential both for lessened energy consumption and reductions of coincident loads associated with spas. This section provides cost and lifetime assumptions for the four primary efficiency measures, and then presents an incremental cost analysis for the four levels of efficiency improvements that would result from their adoption.

5.1 Incremental Costs

Table 4 lists the estimated incremental costs for the most common energy efficiency measures applicable to portable spas. With respect to controls, while the first units might require a larger adder as the market adapts to such a change and fully develops the technology for wider application, with increased acceptance the added cost should decrease significantly.

Table 4: Incremental Cost for Various Energy Efficiency Measures

Measure	*Incremental Cost*
Improved cover	$100
Improved spa insulation	$200
Improved motor configurations and efficiency	$300
Intelligent controls	$50

5.2 Design Life

The design life of a new portable spa is estimated to be 5-15 years; the more reputable manufacturers indicate 10-15 years. We assume 10 years for the spa including motors and controls, and 5 years for the cover.

5.3 Life Cycle Costs

Based on the costs, savings and lifetimes for the efficiency measures described above, we calculated the net present values for four efficiency measures, relative to the market average of 2,500 kWh/year. Note that we are considering here the actual projected savings from actual consumption, not simply from the standby use measured by the proposed testing protocol. Also, these are average savings for the spa population. Savings generated by improvements to the least efficient spas will be considerably greater than those shown here.

Table 5: Analysis of Customer Net Benefit

Improvement Options	*Design Life (years)*	*Annual Energy Savings (kWh)*	*Present Value of Energy Savings**	*Incremental Cost*	*Net Present Value***
Cover	5	250	$118	$100	$18
Insulation	10	250	$233	$200	$33
Motor	10	375	$349	$300	$49
Controls	10	125	$116	$50	$66

*Present value of energy savings calculated using a Life Cycle Cost of $0.47/kWh for 5 year options and $0.931/kWh for 10 year options (CEC 2001).

**Positive value indicates a reduced total cost of ownership over the life of the appliance

Measures that could improve efficiency by a total of almost 40% for a spa of average-to-low efficiency (annual consumption of 2,500 kWh or greater) are cost-effective from a life cycle perspective. Three of four of the savings measures are possible with current technology and within the design parameters currently in use among most if not all spa manufacturers. Beyond that, “smart” controls and increased user programmability, involve a certain amount of market development on the part of the manufacturers.

6 Acceptance Issues

6.1 Infrastructure Issues

The proposed standard is meant to spur basic efficiency upgrades to the least efficient new spas being sold in California. The majority of new portable electric spas currently sold in California would already comply with the proposed standard. For noncompliant units, current manufacturing techniques would allow straightforward implementation of the principle efficiency measures outlined here. Thus, no major infrastructure obstacles exist that might hamper the adoption of the proposed standard.

6.2 Existing Standards

The ANSI/NSPI-6 1999 standard covers portable spas. While it is commendable that the industry has made the effort to create this standard, the standard contains little to no information with respect to energy efficiency. Article 10 covers electrical connections, and article 12 covers heater and temperature requirements; both of these articles largely focus on mitigating safety risks, including both that associated with the electrical connection itself and that to the user from excessive water temperature. NSPI is said to be working on a testing protocol that would address energy efficiency issues, but no date has been established for completion of a final rule.

7 Recommendations

7.1 Recommended Standards Options

In order to require improvements to the lowest performing models, for which simple and cost effective improvements are readily available, without eliminating average and better performance products, we recommend that spa standby energy use have an upper limit calculated according to the following equation:

$$P_S = 5 \times V_S^{2/3}$$

Where:

P_S = maximum average standby power at 60°F (in watts)

V_S = spa volume (in gallons)

For a typical 350 gallon spa this results in a maximum average power use of 248 watts or 2,175 kWh/year. This is 16% greater than the average standby power found in the PG&E field monitoring study. We believe that using watts for units makes the most sense in this instance as it is measuring average standby power, not total energy use. Using kWh/year or kWh/day, while somewhat familiar units to consumers, might be misconstrued to indicate expected energy use.

7.2 Proposed Changes to the Title 20 Code Language

The following standards language is proposed for section 1605.3:

(X) Portable Electric Spas
The standby power of portable electric spas sold on or after January 1, 2006, shall be not greater than the applicable values shown in Table 6 .

Table 6

Standards for Portable Electric Spas

Appliance	*Maximum Standby Power (watts)*
Portable Electric Spa	$5V^{2/3}$

V = total volume (gallons)

8 Bibliography

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