Short-Term Electricity Conservation in Juneau, Alaska: A Study of Household Activities

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ABSTRACT

An avalanche destroyed a section of the main hydroelectric transmission line to Juneau, Alaska on April 16, 2008. Backup generators replaced the lost capacity but the use of diesel fuel for generation caused electricity prices to increase 500 percent for a 45-day period. Response to this electricity "crisis" included electricity conservation that began within two days of the event and reduced electricity use by 25% over the period of supply disruption relative to the same period in 2007. Conservation of about 8% relative to 2007 persisted after the transmission line was repaired and electricity rates returned to normal. A second avalanche on January 9, 2009 damaged the same section of transmission line and caused a second supply disruption, albeit shorter in duration (19 days) and magnitude of price increase (200 percent). This time observed conservation during the disruption was less (12% relative to 2007) while persistent conservation after the event increased by two percentage points to 10% relative to 2007.

We conducted a survey of residential consumers after the second avalanche to investigate the actions taken in response to these supply disruptions. The average household undertook an average of 10 conservation actions, with major changes in lighting, space heating, fuel switching, and water and appliance use accounting for the observed aggregate conservation. Conservation began in *anticipation* of a complex price signal, and persisted after the disruption through both installed technology and new habits. Although past experience with short-term electricity supply shortfalls suggested demand reduction of 3% within a few days and 20% in a few months was possible, it now appears feasible to cut electricity demand, without significant economic damage, by 25% or more in only a few days in special circumstances. The crisis appears to have induced consumers to adopt energy-saving habits that would have not been acceptable in normal circumstances; however some of these habits became persistent new behavior. These new behaviors, including greater uptake of energy-efficient technologies, explains a permanent 8% reduction in electricity use.

Introduction

This paper evaluates the residential consumer response to a short-term electricity supply disruption that occurred in Juneau, Alaska in 2008. Short-term electricity shortfalls vary in magnitude, duration, and response (IEA, 2005). Juneau experienced the largest recorded price increase and largest recorded electricity demand decrease (Figure 1). The case study affords an opportunity to study the outer limits of electricity conservation through behavioral changes that

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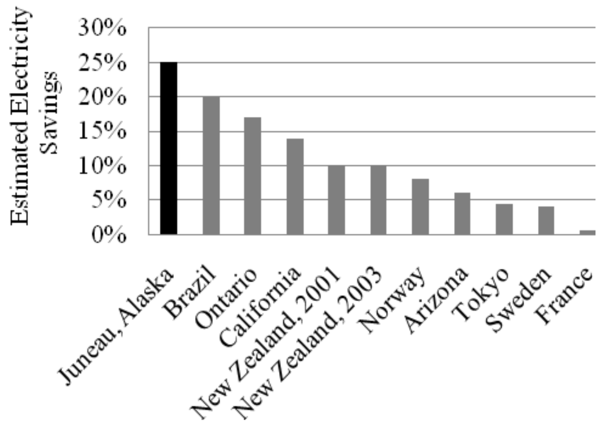
[1] The authors would like to thank the sponsors of the Sustainable Transportation Energy Pathways (STEPS) Program and Energy Efficiency Center at the University of California-Davis for funding. Gratitude is also expressed to Scott Willis and Gayle Wood from AEL&P for electricity use data and helpful review and input throughout this project. The views and opinions expressed in this paper are those of the authors alone and do not necessarily represent those of any sponsoring organization.

occurred under extreme conditions that included a strong but complex price signal. A multi-disciplinary research approach is taken, drawing on economics, social science, survey research methods and statistics. Through analysis of household survey data, we gain better understanding of the specific activities that produced the observed aggregate electricity conservation in Juneau. Our research addresses the following interconnected questions:

- What *magnitude* of demand-side conservation can occur under the extreme conditions of a short-term electricity supply shortfall; at what *rate* can the underlying efficiency improvements and conservation activities be implemented; and what savings will *persist* after the shortfall has been rectified?
- What specific actions account for the immediate and persistent electricity conservation observed? How many of these involve technological versus behavioral change?
- What motivates conservation behavior in the context of short-term supply shortfall events? What aspects of the response observed in Juneau are unique to this context and what aspects may be applicable to other situations?

Figure 1. Estimated electricity savings achieved in Juneau and other regions during short-term supply disruptions



Source: adapted from IEA, 2005

Figure 2. A tower on the Snettisham transmission line destroyed by avalanche

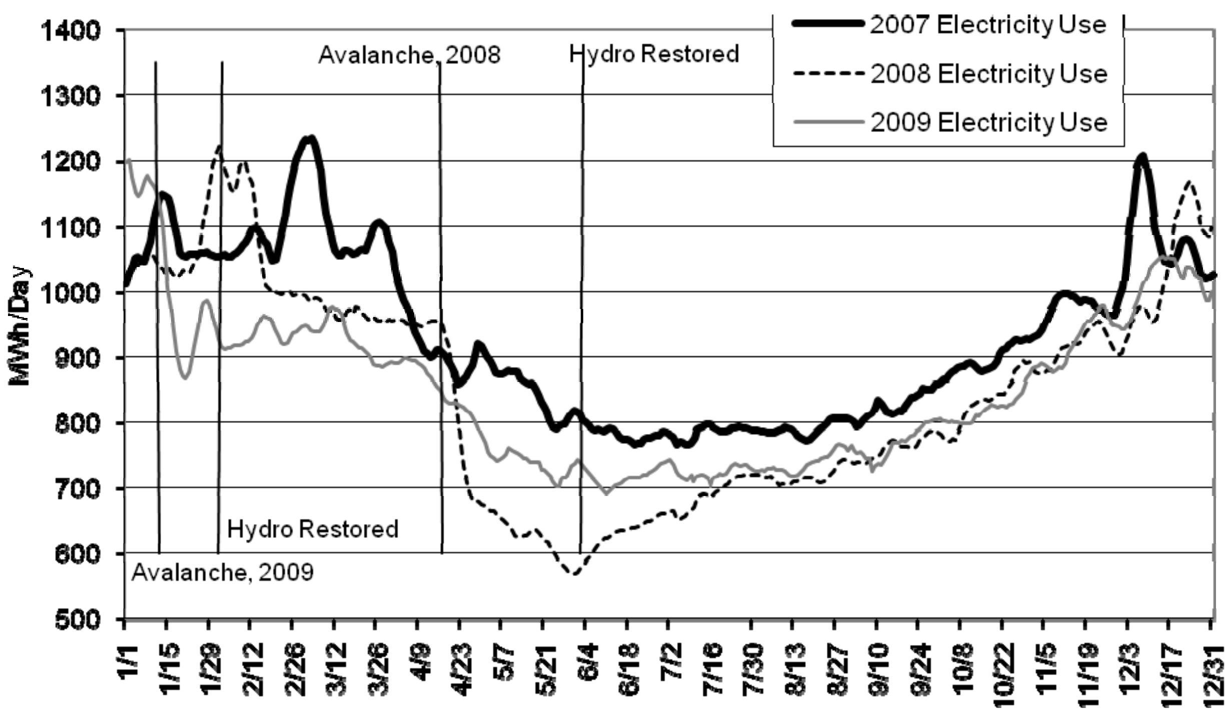
Source: Michael Penn, Juneau Empire

The capital city of Alaska, Juneau sits among mountains, glaciers and fiords in southeast Alaska. The population of approximately 30,000 works primarily in government, tourism, mining and seafood industries, with average wages of approximately $41,600 (JEDC, 2009). Located within the Pacific Northwest temperate rainforest biome, Juneau receives 140-228cm of annual rainfall and 236cm of annual snowfall with average high temperature in July of 18.3 °C and average low temperature in January of -6.7 °C. Buildings do not have air conditioning and approximately 40% of Juneau households use electricity for space heating. No road or electric grid connections exist between Juneau and other communities and electricity is 100% hydroelectric, generated almost entirely from two alpine lakes at the Snettisham hydroelectric facility, 71 km south of Juneau (Eriksen et al., 2009).

On April 16, 2008, an avalanche severed the single 138-kV electric transmission line connecting Juneau to Snettisham. Diesel generators instantly replaced the lost power but with diesel prices over four dollars per gallon, the price of electricity jumped 500% to $0.52 per kWh

(Alexander, 2009). Repair time was estimated to be three months, with an estimated 100,000 gallons of diesel costing $400,000 required per day to replace the lost hydroelectric supply (Eriksen et al., 2009). But within days Juneau had reduced its energy use nearly 25%, after adjusting for season and heating degree days (Figure 3). The average total electricity conservation during the supply disruption was approximately 205-220 MWh/day. Local stores reported selling out of compact fluorescent (CFL) light bulbs and laundry could be seen line-drying around the town. Although this period became known as the "electricity crisis" in Juneau, we use the term "supply disruption" throughout this paper in order to avoid any implied judgment.

Figure 3. Rolling one-week average of Juneau daily "firm" electricity use (i.e., net of interruptible dual-fuel customers, cruise ships, and the Greens Creek Mine) in 2007 - 2009, showing 25% conservation from the year previous during the 2008 supply disruption and 12% conservation relative to 2007 during the 2009 supply disruption. Persistent conservation after hydroelectric supply was restored is 8% in 2008 and 10% in 2009 vis-à-vis 2007. The percentage electricity savings is estimated adjusting for weather by comparing seven-day periods with the same number of heating degree days. Large spikes in electricity use during winter months due to periods of especially cold weather complicate estimation of conservation during the 2009 supply disruption.

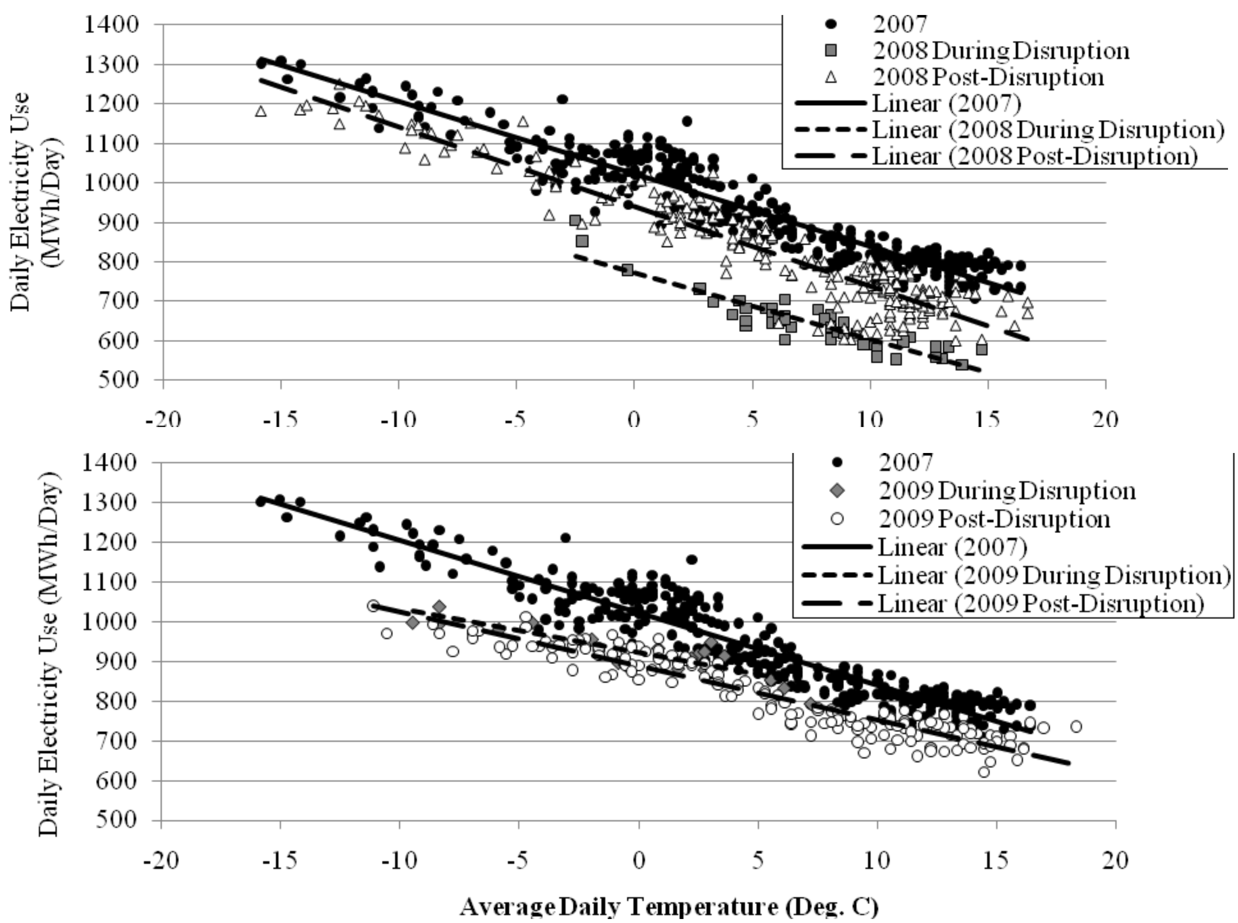


Source: Scott Willis, Alaska Electric Light and Power (AEL&P)

At the site of the transmission line damage, avalanche experts, electrical engineers, and work crews used a stretch of good spring weather to reconnect the city to Snettisham in just six weeks, half the time expected. The high-cost diesel-generated electricity was used for a total of 45 days but the price signal for this period was obscured by the rolling billing cycle used by the utility under which approximately 4.5% of customers received their electric bill – and rolled onto or off of the higher billing rate - on each weekday of the month. As customers rolled back onto the standard summer rate of $0.079 per kWh after the hydroelectric connection was restored, electricity use crept back up but remained approximately 8% below pre-disruption levels.

Seven months later, on January 12, 2009, a smaller avalanche in the same area knocked out the same section of Snettisham transmission line again for 21 days. This time, however, residents were still using approximately 8% less electricity than before the first supply disruption and electricity rates increased only 200% due to decrease in diesel price since the first supply disruption ($2.25 per gallon vs. $4.00). Observed conservation during the second disruption was less than during the first (12% relative to 2007 rather than 25%) while persistent conservation after the second disruption ended increased from what it had been after the first supply disruption (10% relative to 2007 rather than 8%). Variation in weather conditions between the three years does not account for changes in electricity use (Figure 4).

Figure 4. Comparison of the relationship between average temperature and daily electricity use across five periods: 2007 (baseline), during and after the 2008 disruption (top panel), during and after the 2009 disruption (bottom panel). Inverse correlation shows electricity use varies with temperature, in part due to high penetration of electric baseboard heating in Juneau (38%). Parallel shifts from 2007 to 2008 during and after the supply disruption show conservation not explained by differences in weather or changes in the relationship between temperature and electricity use (top panel). Changes in slope between 2007 and 2009 during and after the supply disruption suggest a change in the relationship between temperature and electricity use, perhaps due to lower thermostat settings (bottom panel).



Methods

We investigated the actions taken by consumers during and after the April, 2008 electricity supply disruption with an on-line survey. The survey was publicized through local Juneau media including newspaper, radio, legislative e-news, viral email, and AEL&P bill stuffers. The survey was launched on February 1st, 2009, 9.5 months after the first electricity supply disruption occurred, and closed three days after the anniversary of the first avalanche (April 19, 2009).

The survey was designed to elicit information about what happened inside homes to produce the rapid 25% electricity conservation observed during the supply disruption and the persistent 8% conservation after the hydroelectric connection had been restored. Respondents were asked about equipment and its use as well as conservation behavior in order to decompose the observed electricity conservation into technological and behavioral components. We asked what behaviors and/or technologies accounted for the conservation, what motivations produced these actions, and how residents of Juneau perceived the situation.

The survey was also designed to minimize bias and cognitive burden in order to obtain the most reliable information possible from a rather lengthy questionnaire. We used results from open-ended surveys by Lutzenhiser et al. (2003) on electricity conservation behavior during the 2001 California energy crisis and analysis of these data by Woods (2008) to inform the design of the mostly closed-ended questions in our survey. We used the term “crisis” in the survey despite potential bias from its connotations in order to reduce question complexity since this terminology had become common parlance in Juneau.

We intentionally delayed our survey until eight months after the first electricity supply disruption in Juneau had ended in order to allow behaviors to revert so we could collect information on conservation activity during the 45-day electricity supply disruption as well as activity afterward. By doing so, we were able to ask respondents about what they did during the supply disruption to reduce electricity use, what they were continuing eight months afterward, what they discontinued, and what they initiated as new behavior. Although allowing eight months to elapse may have obscured respondents’ memory of events during the electricity supply disruption, the unexpected second avalanche refreshed those memories. We emphasized in the survey wording that our questions pertained to actions taken during and after the first supply disruption of 2008 only.

Results

Table 1. Comparison of survey sample socio-demographics with Juneau population

	Survey Sample	Juneau Population
Female	59.7%	49.8%
Over-25 with Bachelor’s degree or higher	69%	36%
Household Income (median)	$87,500	$60,195
Household Size	2.5	2.6
Home Ownership	85%	63.7%

A total of 539 responses were received, of which 424 were complete. Our sample consisted only of those choosing to participate, so it is not surprising that the respondents did not fully represent the Juneau population in socio-demographic characteristics; respondents were more likely to be women with higher than average income and education (Table 1). There was also a higher rate of home ownership in the sample than in the Juneau population as a whole. The sample was, however, geographically representative of the whole community. Although it is likely that Juneau residents who were more aware and engaged in conservation chose to participate in our survey, this is the sub-population of interest for our focus on understanding *how* the observed electricity conservation was achieved.

Awareness and Motivation

Survey respondents were uniformly aware of the supply disruption, with 99% aware of the transmission line damage and 98% aware that diesel generators were providing backup power.

However, only 68% of respondents answered correctly that Juneau was *not* in danger of running out of electricity, since backup generation capacity was more than adequate for meeting demand. Furthermore, 76% were motivated to conserve through concern for others, 54% conserved during the supply disruption to help others, and 51% said they benefitted from others' electricity conservation despite the fact that conservation would have negligible impact on electricity price since nearly 100% diesel generation would be used regardless of the level of demand. Thus, altruism appeared to be a motivation for conservation, in part due to incorrect perceptions of shortage and ability to influence price.

The share of respondents who were motivated to conserve electricity for environmental reasons stayed nearly constant before (42%), during (43%) and after (42%) the supply disruption. This is surprising given the stark differences in environmental impact between diesel and alpine lake hydroelectric generation.

In contrast, the share of respondents who were motivated to conserve to reduce utility bills increased from 66% before to 86% during the supply disruption, but then remained at 73% afterward. Thus, the supply disruption may have had a lasting effect on increasing electricity price awareness and sensitivity.

While motivation for engaging in electricity conservation came both from concern for self and from concern for others, respondents were somewhat more motivated by personal concern about electricity shortage (85% agreed) than by potential consequences for others (77% agreed). A general perception of little difficulty in conservation complemented these motivations in generating conservation action, with 65% of respondents agreeing that it was not difficult to conserve.

Respondents also generally agreed they were not using as little electricity as possible before the supply disruption (65%), which suggests recognition (albeit after the disruption) of their ability to reduce electricity use. For the one third of respondents who believed they were already using as little electricity as possible before the supply disruption, nearly all found a way to use even less during the disruption. New information or attention may have revealed previously unknown ways to conserve, or the definition of what was "possible" may have changed during the disruption.

Respondents used an average of four different sources for information on electricity conservation and supply; the most common were radio (58-78%), newspaper (55-65%), and word of mouth (56-59%). The frequency of word-of-mouth suggests active dialog as the electricity crisis became the talk of the town. The electric utility (29%), friends and neighbors (16%), the mayor (9%), and local government (8%) were most frequently cited as having provided leadership. This contrasts with many previous short-term supply disruptions in which the utility and government were subjected to blame (IEA, 2005).[2]

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[2] Complaints against the utility company in Juneau centered on the occurrence of a supply disruption (i.e., accusation of inadequate avalanche protection for the transmission line) and passing the cost on to ratepayers.

A Complex Price Signal

Initial announcement of the avalanche damage included the intent to increase electricity rates to at least $0.50 per kWh immediately (Golden, 2008). Several days later, however, the decision was made to assess the rate increase according the existing rolling billing cycle, with 1/22nd of customers rolling onto the higher rate on each new weekday of the supply disruption and 1/22nd rolling off the higher rate each weekday after transmission line repairs were complete.

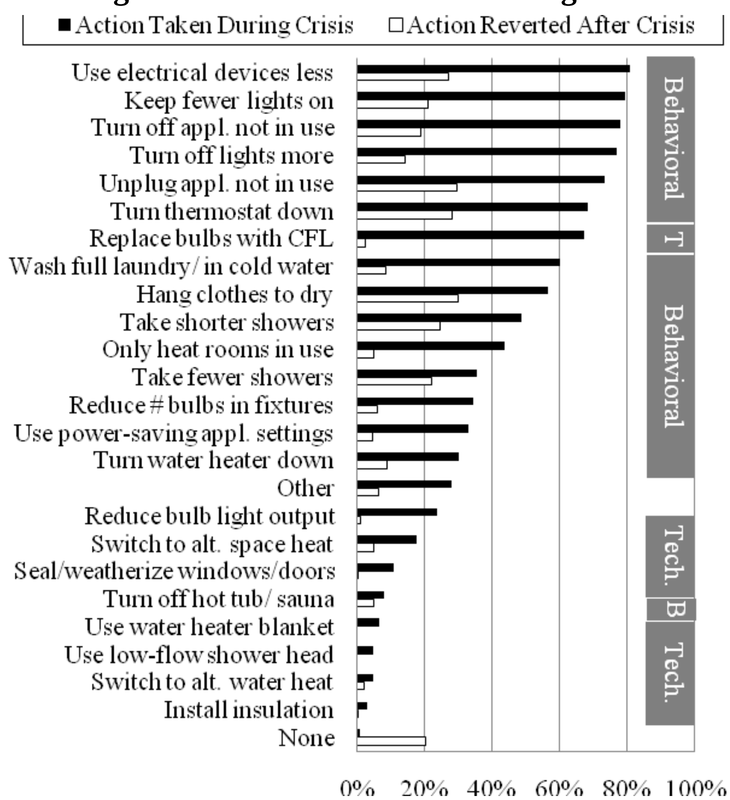
Response to announcement of the avalanche was very rapid, with 77% of respondents taking their first action to conserve electricity within one day of the avalanche. In contrast, the average time between announcement of completion of the transmission line repairs and reversion of conservation behavior was a more gradual 14 days. One explanation for this difference may be increasing awareness among customers of when they would be paying the higher electricity rates. The rapid conservation response may have occurred under the presumption of an immediate rate increase while the more gradual reversion pattern may have been in response to the rolling schedule for rate decreases.

Conservation Actions Taken During & After the Electricity Supply Disruption

On average, respondents took about 10 actions (mean 9.75) to reduce electricity use during the supply disruption (Figure 5).[3] In contrast, respondents reported stopping or reverting an average of only three actions after the hydro-electric connection had been restored. This difference suggests persistent energy conservation from actions taken during the supply disruption that had not been reverted eight months later at the time of our survey.

Fuel switching. Redundancy in existing household home heating and cooking appliances afforded the potential for electricity conservation through fuel switching. Multiple sources

Figure 5. Conservation actions taken during and reverted after the 2008 Juneau electricity supply disruption, grouped according to a behavioral versus technological dichotomy



Complaints against government centered around not doing enough to conserve (e.g., streetlights left on) and not securing a disaster declaration and subsidy for the higher cost of electricity generation.

[3] Although we asked specifically for actions taken during the supply disruption in order to reduce electricity use, we cannot tell what fraction of these actions were entirely new as opposed to enhancements of existing behaviors.

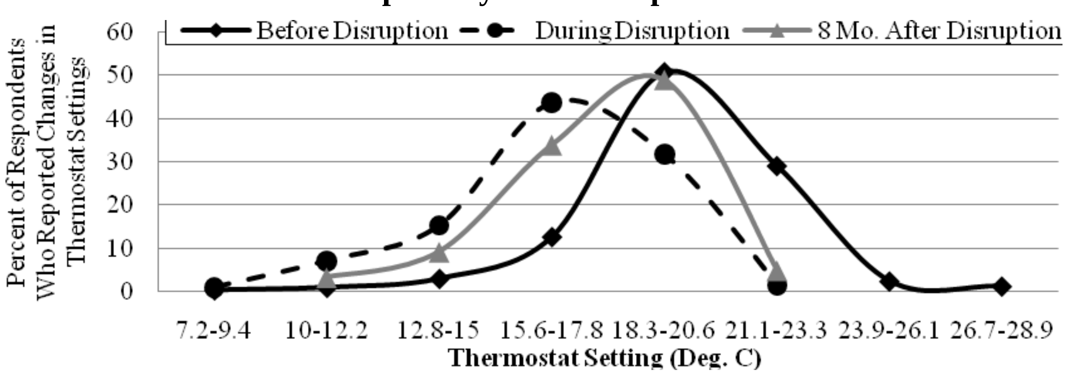
for space heating exist in as many as 66% of respondent homes. For the 18% of respondents who switched to an alternative source of space heating during the supply disruption, 68% switched to wood and 23% switched to oil or diesel. In contrast to space heat, however, 94% of respondents had only one source for water heating. Without redundancy in water heating sources for electricity conservation through fuel switching the primary options remaining for electricity conservation in water heating were the following: 60% of respondents washed full loads of laundry and/or washed in cold water, 49% took shorter showers, 36% took fewer showers, 30% turned down the temperature on their water heater, 8% switched off their hot tub or sauna, 7% installed water heater blanket(s), 5% installed low-flow shower heads, and 2% installed a water heater timer or switched off the heater at the breaker (the equivalent of unplugging when not in use).

Lighting. Respondents reduced electricity use in lighting through both technology and behavior change. The 67% of respondents who installed CFLs replaced an average of 12 incandescent bulbs and were using CFLs in 73% of their light fixtures eight months after the supply disruption had ended. Note, however, that the 100,000 total CFL sales implied by this reported behavior if repeated equally across the Juneau population (i.e., 12,500 households x 67% x 12 bulbs/household) exceeds the total quantity supplied in Juneau.

The 79% of respondents who kept fewer lights on during the supply disruption reduced the number of lights kept on by an average of 4.4, with average persistent reduction of 26% among the 58% of respondents who maintained fewer lights on after the disruption had ended. Thus, an increased install base for CFLs and keeping fewer lights on appear to be sources of persistent electricity savings induced by the supply disruption.

Space heating. On average, respondents reduced their thermostat setting by 3.5 degrees Celsius during the electricity supply disruption, from 19.6 deg. C to 16.1 deg. C (Figure 6).[4] Although the distribution of thermostat settings shifted back toward higher temperatures after the disruption ended, persistent electricity conservation through persistent change to lower thermostat settings is evident. The average increase from thermostat settings during the disruption was only 1.2 deg. C and survey respondents' average thermostat setting after the supply disruption had ended was 2.0 deg. C lower than it had been before the disruption began (17.6 C after vs. 19.6 C before).

Figure 6. Thermostat settings before, during, and 8 months after the electricity supply disruption by 66% of respondents



[4] The distribution has a long tail with 9 respondents reducing their thermostat setting by more than 8.3 deg. C. These outliers may include people who supplemented electric heat with an alternative source (e.g., wood stove).

Appliances. The 30% of respondents who used power-saving settings on appliances during the supply disruption did so with only one or two appliances (average 1.4). But unlike some other behaviors, use of power-saving settings continued unabated after the disruption, with the share of respondents using these settings holding at 29% eight months after the disruption and the average number of appliance types for which a power-saving setting was in use increasing slightly to 1.5. The most common appliance type for use of power-saving settings was the dishwasher (55-59%), followed by the clothes washer (17-20%), clothes dryer (7-8%), and computer (5%). However, 59% of respondents who used power-saving settings had been doing so prior to the disruption, which implies a 59% discount on electricity savings attributed to this behavior.

Only 10% of respondents replaced appliances with more efficient ones after the supply disruption (mean of 1.8 appliances replaced for those who did), and 70% of these people said they would have replaced the appliances even if the disruption had not occurred.

The phenomenon of standby power loss was widely recognized by respondents, with 67% taking action to reduce the loss by unplugging at least one appliance during the electricity supply disruption (mean of 4.2 appliance types unplugged). Some of this behavior persisted after the disruption ended, with 38% of respondents still unplugging at least one appliance when not in use eight months after the hydroelectric connection was restored (mean of 3.2 appliances for those doing so). Anecdotally, many “forgotten” or “spare” devices like clocks and televisions in guest rooms and spare refrigerators or freezers remained unplugged.

Water heating and use. The 49% of respondents who shortened their showers during the supply disruption did so by an average of five minutes and 49% of these people kept their shower duration after the disruption had ended shorter than before the disruption by an average of three and one-half minutes.[5] The 36% of respondents who took fewer showers during the disruption cut down by an average of two and one-half showers per week and 38% of these people kept the number of showers per week fewer after the disruption had ended than before it started by an average of two per week. Thus, for about 21% of respondents, shortening the length of showers appears to be a persistent behavior change that accounts for some of the persistent electricity conservation and for about 12% of respondents the same can be said for reducing the frequency of showering.

New actions taken after the supply disruption. The electricity supply disruption prompted continued actions to conserve electricity even after the hydroelectric connection was restored. Fifty-five percent of respondents took a *new* action after the supply disruption had ended, with installing additional insulation (18%), replacing appliances (10%), replacing windows (5%) and switching to an alternative source for space heating (5%) the most common. Anecdotal evidence from survey comments suggests these actions were taken because of new awareness about the payback of investments in energy efficiency and/or for preparedness in anticipation of future supply disruption events.

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[5] Questions about shower duration are difficult to answer with precision or accuracy and we did not conduct any metering to verify the survey results. Consequently, these results are reported to the nearest one-half minute.

Could Even More Electricity Conservation Occur?

Nearly half (48%) of respondents said nothing prevented them from taking other energy-saving actions during the supply disruption. This suggests even greater electricity conservation may have been possible through increased conservation activities for half of respondents and through technology (if affordable and with equal or greater service) for the other half. When asked what next action they would take if the electricity supply disruption had been "bigger" in some way, only 17% of respondents said they would not take any further action and only 7% did not know what the next action would have been. These results suggest that conservation could have been even greater than the 25% observed if the disruption had been "bigger" (e.g., risk of blackouts) and that access to information would not inhibit these actions. The most frequent categories of next actions mentioned were to use appliances less (16%), switch to an alternative energy source for appliances or heat (13%), increase conservation behavior like turning down the heat (12%), add insulation (9%), and move to a smaller house or out of Juneau entirely (8%).

Discussion

Comparison to the California Energy Crisis of 2001

One of the most thorough investigations of conservation actions during a short-term electricity supply shortfall was conducted during the 2000-2001 California energy crisis by Lutzenhiser et al. (2003). Our findings for Juneau's experience with conservation behavior are generally consistent with their observations for California. Changes in behavior as opposed to hardware efficiency improvements accounted for most of the observed short-term electricity conservation during the crises in both California and Juneau. Consumer willingness to conserve through changes in their household temperature – by turning off air conditioning in California and turning down thermostats in Juneau – produced large electricity savings due to the frequency of action and magnitude of electricity savings produced by it. This finding is important because it supports greater emphasis on residential heating and cooling in energy efficiency programs.

Conservation action was also taken in both California and Juneau in *anticipation* of price increases that came *after* the conservation action was initiated. This finding suggests that the short-term price elasticity of demand, with action taken in *response* to price changes, does not fully explain dynamics in energy use. In situations where forecasting the rate of adjustment to price signals is important (e.g., for utilities facing supply disruptions), an additional framework for analysis is needed to complement traditional methods.

The specific conservation actions chosen appear to be influenced by constraints on the ability to take each action. For example, behaviors where everyone had equal opportunity to act (e.g., switching off unused lights and equipment) were taken equally while home owners were more likely to make investments in the house (e.g., insulation, energy efficient appliances), apartment renters were more likely to make investments in energy efficient small appliances and lights, and lower income groups were less likely to make building and appliance changes (due to having fewer resources and less home ownership). Thus, behavioral changes are more of an equal-opportunity action than investments in technological change and are therefore distributed more evenly across socio-demographic segments.

Electricity conservation persisted in both cases after the supply shortfall was resolved through a combination of changed habits and installed technology, with continuing action for new conservation measures mostly in the area of longer-term technology investments.[6] Conservation can persist through behavioral change, although to a lesser degree and with less certainty than technological change. However, our results suggest several additional nuances. First, CFL purchase and installation appears to be a sticky behavior, with 96% of households who purchased CFLs during the disruption continuing to do so afterward. This implies some persistence on the behavioral side of technological change as well. Second, there also appears to be a component of persistent conservation related to following through with technological changes since the new conservation actions taken after the supply disruption were primarily longer-term and bigger investments that couldn't be completed during the disruption and hadn't been completed prior to it. Thus, the supply disruption may have prompted new long-term actions and/or motivated follow-through on things like adding insulation and replacing windows. Repeated supply disruptions may also induce larger investments in technology retrofit that deliver increase in persistent conservation as consumers increasingly believe preparation for the next event will pay off.

The Disruption Induced Consumers to Try New Habits

Conservation behavior is generally thought to be less persistent than technological change. Although we do not find evidence to the contrary, it does appear that voluntary conservation continues after a supply disruption event (Table 2).

For example, 38% of all survey respondents were still unplugging an average of 3.2 appliances to reduce standby power loss eight months after the hydroelectric connection was restored (52% persistence).[7] Similarly, nearly *all* of the 30% of respondents who used power-saving settings on appliances during the disruption continued to do so after it ended (97% persistence). We also found 43% persistence in reduced shower duration among the 49% of respondents who took this action and 33% persistence in reduced shower frequency among the 36% of respondents who took this action.

Table 2. Summary of some persistent behavior change showing a process of disruption inducing trial with large changes that persist in recalibration to new preferences (i.e., habits)

Activity (% of Respondents)	Before Disruption	During Disruption	After Disruption
Avg. Thermostat Setting	19.6 deg. C (100%)	16.1 deg. C (66%)	17.6 deg. C (66%)
CFL bulb use	Baseline N/A	12 new bulbs (67%)	CFL in 73% of fixtures (67%)
Fewer Lights On	Baseline (0 Fewer) (100%)	4.4 Fewer (79%)	26% Fewer (58%)
Average Number of Unplugged Appliances	Baseline N/A	4.2 Appliances (67%)	3.2 Appliances (38%)
Avg. Number of Appliances Used on Power-Saving Setting	Avg. Number N/A (18%)	1.4 Appliances (30%)	1.5 Appliances (29%)
Showering	Baseline	4.9 Minutes Shorter (49%) 2.6 Fewer per Week (36%)	3.6 Minutes shorter (21%) 2.1 Fewer per week (12%)

[6] About half of the 7% conservation observed in the California energy crisis persisted into 2002 after controlling for differences in weather and changes in the economy (CEC, 2003).
[7] Persistence is defined here as the share of respondents who continued a conservation activity undertaken during the supply disruption.

Persistent electricity conservation through behavioral change in space heating occurred mostly through reduction in variance, with households lowering extremely high thermostat settings. Since thermal comfort is a function of more than just temperature, it appears survey respondents were able to find thermal comfort at a lower ambient temperature when prompted.

Thus, it appears that a short-term energy crisis like the supply disruption in Juneau can induce trial and acceptance of large changes in thermostat settings and other electricity use behaviors. In general, supply disruptions induce trial with larger changes in behavior than would otherwise occur and this trial causes a recalibration of what is preferred for some people. The result is persistent electricity savings through formation of new habits.

External Validity

Relatively few places in the world share the unique context found in Juneau: 100% hydro-electricity, geographic isolation from road and grid networks, temperate maritime climate where heat is used nearly year-round. These conditions may accentuate the ability for more dramatic short-term electricity conservation for at least two reasons. First, a relatively large share of total energy use is in the form of electricity, creating more opportunities for conservation. Second, a relatively high percentage of homes use electricity as the primary heat source, enabling conservation through thermostat reduction. Furthermore, many homes have a secondary heating alternative that enables fuel switching as well. The astounding rate of conservation response in Juneau, with 25% conservation achieved in less than a week, may have been due in part to the prevalence of electricity use as a primary source of home heating and redundancy in home heating systems that enabled large impact from fuel switching and thermostat reduction. Thus, the 25% demand reduction achieved in Juneau may not be feasible in other situations.

Conclusions

In this paper, we have documented a short-term electricity supply disruption of exceptional magnitude in price increase and demand reduction. Through a questionnaire of closed-ended questions, we sought to understand *how* the conservation occurred.

Past experience with short-term electricity supply shortfalls has shown that demand reduction of 3% in only a few days and 20% in a few months is possible (IEA, 2005). It now appears that in circumstances like those present in Juneau, it is feasible to cut electricity demand by 25% or *more* in only a few *days*. Furthermore, changes in behavior and technology induced by a transient crisis can produce persistent electricity conservation.

The magnitude of electricity conservation during the supply disruptions decreased from the first to the second disruption (25% vs. 12%) such that the implied price elasticity of demand was nearly identical. This suggests that price is a prime motivator for conservation. However, the persistent conservation after these disruptions increased (8% vs. 10%). Thus, it also appears that persistent conservation may increase as the "crisis" becomes more "routine" and new habits are learned.

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