How one city cut its electricity use over 30 % in six weeks

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Abstract

In April 2008, an avalanche severed the transmission line delivering hydroelectric power to the city of Juneau, Alaska (population 31,000). As a result, the utility was forced to generate electricity with diesel, costing five times more. The utility expected that repairs to the transmission line would require about three months. This appeared to be a financial catastrophe for the city and especially for the 20% of homes relying on electricity for space heating.

In response, the citizens of Juneau undertook an unprecedented conservation campaign. Individuals turned off lights, lowered room temperatures in electrically-heated buildings, and installed compact fluorescent lamps. The city's stores quickly ran out of insulation, fluorescent lamps, power strips, and other materials needed to conserve electricity. Two weeks after the avalanche the city, along with various local organizations, launched a coordinated campaign to disseminate information about the most effective conservation measures and to encourage further actions. Special programs were developed to target vulnerable groups. The city also planned to alert and educate the one million tourists expected to visit Juneau that summer on cruise liners so that they would not be deterred by darkened stores and to cooperate in conservation efforts.

In less than six weeks, Juneau's total daily electricity consumption fell over 30%. Some reductions were a consequence of warmer temperatures and longer days but the net reduction compared to the previous year was 30%. The transmission line was repaired ahead of schedule, but electricity consumption did not return to pre-avalanche levels. Consumption remained about 10% lower than in the previous year.

In January 2009, a second avalanche cut the transmission line. Consumers cut use 10% in two days and the citizens expressed much less anxiety compared to the previous year. Juneau's experience demonstrates the effectiveness of broad mobilization to save energy and extent to which the energy savings persist.

Introduction

Most utilities are able to provide electricity to their customers with near-perfect reliability. However, major technical failures, severe weather, earthquakes, and other environmental incidents can lead to temporary interruptions. Sometimes it takes days, weeks, or even months, to re-establish normal supplies. In these cases, regions must quickly reduce electricity demand or suffer black-outs (International Energy Agency 2005). In 2001, Brazil, for example, was confronted with a severe drought that drastically cut hydroelectric supplies. The federal government took immediate responsibility for managing the crisis and created a "crisis cabinet" at the highest government level (Parente 2002). To avoid the economic repercussions of widespread and unpredictable blackouts, the government undertook an aggressive conservation campaign. In less than three months, the entire country's electricity consumption fell 20%. The savings persisted such that, in 2008, average household electricity consumption was still below 2001 levels (Geller 2008).

California's electricity shortage in 2001was caused by a combination of drought, supply shortages, and market manipulation. The state launched a massive and creative (Bender et al.

Figure 1. Location of Juneau, Alaska.

2002) conservation program that reduced state-wide electricity usage by 6% and average monthly peak demand by 8% compared to the previous year (Goldman, Eto, and Barbose 2002). These savings were sufficient for the state to avoid blackouts during the critical summer period. These, and many other temporary shortfalls in electricity supply, are described in a recent publication *Saving Electricity in a Hurry* (International Energy Agency 2005). Each shortfall has unique characteristics but most successful strategies involved a vigorous effort to reduce electricity demand.

Sometimes sufficient electricity supplies exist but the cheapest source is temporarily unavailable. In these cases, the problem is more precisely described as a "price crisis" rather than an actual shortage of electricity. This was the case in Norway in 2002-2003, when a drought and a cold wave contributed to a shortage of cheap hydroelectric power (Moen 2003). This was also the case in Juneau, Alaska, in 2008, where a loss of hydroelectric power stimulated one of the largest reductions in electricity consumption. Juneau's experience illustrates the role of prices, technology, and behaviour on electricity demand. It also has implications for demand forecasting and the design of electricity conservation programs.

Juneau's Avalanche and Electricity Crisis

Juneau is a coastal city of about 31,000 inhabitants in southern Alaska. It is the capital of Alaska so, despite its small population, it plays a critical role in the operation of the state. It is geographically isolated from the rest of Alaska (and the world) by steep mountains, glaciers, and water; the only access to the city is via sea or air (see Figure 1). The majority of supplies arrive on a weekly barge from Seattle, Washington, about 1400 km to the south. During the summer, cruise ships regularly stop at Juneau, bringing over half a million tourists.

Juneau's principal industry is government administration, with federal, state, and regional offices. It has a small fisheries industry. Thus, the majority of electricity consumption is in the residential and commercial sectors. Electric resistance heating is used in 20% of the homes, although many homes can burn oil or wood, too. A greater fraction of homes heat water with electric resistance heat. Electricity represents a major outlay for many Juneau residents.

Over 90% of Juneau's electricity comes from hydroelectric facilities and about 85% of that is transmitted via a single transmission line from the Snettisham reservoir, about 60 km south of the city. A privately-owned utility, Alaska Electric Power & Light (AEL&P) is responsible for generating, transmitting, and distributing the electricity to customers. AEL&P is a small utility and has no experience operating conservation programs. A utility typically maintains enough generation capacity to maintain supplies in the event that it loses its largest generator. In AEL&P's case, the reserve is a bank of diesel generators kept on standby in the event that Snettisham goes off line.

On 16 April, 2008 a huge avalanche severed the transmission line between Snettisham and Juneau. The diesel generators immediately switched on but, from that point on, Juneau's electricity was generated almost exclusively from diesel fuel. The timing was particularly unfortunate because the price of diesel was at record levels. The price of a kilowatt-hour of electricity delivered to customers rose from about 11 cents/kWh to over 50 cents/kWh. Thus, Juneau's customers would see a roughly 5-fold increase in electricity prices. Repairs were expected to take at least three months.

The utility immediately sought to pass through the increased generation costs to its customers. The city government recognized that many of its citizens could not afford the higher bills and feared that the high electricity prices would destroy the city's economy (JEDC 2008). Many citizens felt that significant savings were not feasible. Others expressed fear or confusion (Golden 2009). The city's first action was to try to shift the costs to the state or federal government. There was some justification for this request because Alaska has traditionally subsidized fuel deliveries in villages; however these villages were remote and lacked other, cheaper supplies. But Juneau is not a small, remote, village and the high prices were only temporary, so the state politicians mostly opposed subsidizing Juneau's electricity. The controversy was further complicated because of hostility towards the privately-owned AEL&P. The political discussions continued for months and delayed the appearance of the higher bills.

Juneau Creates a Conservation Program

Juneau's city government realized that the only way to reduce its residents' and business' electricity bills was to use less electricity—much less electricity—and to reduce it quickly. The city began to search for strategies. They were especially concerned about the 40% of homes relying on electricity for space or water heat (though nobody knew exactly how many homes fell into this category). Many of these persons were poor and some spoke little or no English. It was even possible that these groups had not yet learned of the avalanche and electricity price increases. The city was also concerned about its own electricity bill since it had not budgeted for this unexpected cost. Juneau requested the U.S. Department of Energy (DOE) to send the city an expert to advise them on conservation programs. The

Figure 2. Juneau's slogan and logo to "brand" the conservation campaign.

expert—the author of this paper—arrived several days after DOE received the request.

In the meantime, customers acted without any special plan or program (Skinner 2008). With the knowledge that their utility bills would soon rise five-fold, they lowered thermostat settings, switched to wood stoves, switched off lights and unplugged appliances. The stores quickly exhausted their supplies of insulation, compact fluorescent lamps (CFLs) and switchable power strips. Even lines for drying clothes were sold out. The technical opportunities for conserving electricity were therefore limited because supplies could only be replenished via the weekly barge from Seattle. The Airport – the city of Juneau's third largest end use—switched off the airport runway lights from midnight to sunrise (the airport was closed during this time anyway). Within a few days after the avalanche, electricity demand had already fallen about 10% although part of the reduction was a result of milder weather and increased sunlight. But still more savings would be needed to minimize the impact (Yardley 2008).

A group already responsible for encouraging economic development of Juneau, the Juneau Economic Development Council (JEDC), took the lead in organizing the campaign to save electricity. It was important for a neutral group to be responsible because of the politically charged situation. (For this reason, the utility could play only a minor role). They assembled city leaders, including merchants, heads of non-profit welfare groups, church elders, politicians, and school representatives. The goal was to establish a single voice and message. One of the earliest actions was to "brand" the campaign with a slogan and logo. They selected "Juneau Unplugged" (Figure 2) as the slogan and quickly created a logo to accompany it.

The message was intended to be positive, upbeat, and not critical of any particular group. Another goal of the campaign was to convey the concept that conserving electricity was part of being a "good citizen" and not something to be embarrassed about. By linking electricity conservation to civic responsibility, stores and other institutions would be less reluctant to switch off lights and implement other measures. The "Juneau Unplugged" slogan and logo appeared in store windows and other highly visible spots as a way to remind people to conserve (and sometimes to explain why lights were switched off in a store).

Many activities needed to be undertaken in parallel, but all with the same positive message. The first objective was to give reliable advice to residents about energy conservation. Much of the generic conservation advice offered by state and federal information agencies was not appropriate for an electricity crisis. For example, in a crisis, abrupt changes in behaviour were acceptable but these were typically downplayed in conventional information. In addition, these sources rarely helped the consumer prioritise options and decide which measures to do first.

The centrepiece of the information campaign was a flurry of appearances on television and radio programs by the visiting expert. There were also newspaper interviews, public lectures, and energy audits. The public information campaign had two goals. First, the campaign advised about the residents of the most effective means of conserving electricity and to avoid measures that saved little. For example, the expert explained that hot water represented a large, almost invisible use of electricity in many homes. The first measure should be to lower the temperature of storage tank and then followed by a sequence of additional measures requiring greater efforts or vigilance. At the same time, the expert explained that unplugging their mobile phone chargers saved very little electricity compared to, say, switching off the outside light for a few hours. The second goal was to warn residents against conservation measures that could backfire. For example, residents were cautioned against setting upwards the thermostat in their refrigerators and freezers. A small error could lead to expensive food spoilage.

The city was also concerned about the influx of tourists, which was likely to begin before the transmission line was repaired. Over half a million tourists visit Juneau each summer, usually arriving on large cruise ships. These tourists needed to be informed of the electricity shortage before they arrived so that they would also conserve and, possibly more important, not be surprised if stores were unusually dark. The increased electricity demand caused by the ships themselves - they were required to plug into the city's grid while docked so as to minimize air pollution - also needed to be considered.

Separate strategies needed to be developed to conserve electricity in state and federal office buildings. Curiously, the staff were often more receptive than the management in implementing conservation measures. The office-workers themselves took the initiative to switch off and unplug equipment before management could formulate its own policy.

The city of Juneau also needed to conserve power and set an ambitious goal of its own. Streetlights were an obvious target for conservation. Crews quickly started rewiring streetlights to enable operation of alternating lights (where safe). But the three largest electrical loads were actually the sewage treatment system, the water supply system, and the airport. So a surprising electricity-saving recommendation emerged in very-wet Juneau: conserve cold water (in addition to hot water). Every litre of water conserved translated into saved electricity in the water supply system and, eventually, in sewage treatment.

Finally, the utility needed to participate in the campaign. AEL&P provided a daily update on the progress of the repairs to the transmission line on its website. Photographs showed the new towers being airlifted into place and installed. The media repeated this information in news reports and articles. These updates were important because they reminded Juneau residents that each day they were getting closer to the end of the crisis and (presumably) could then stop making special efforts to conserve.

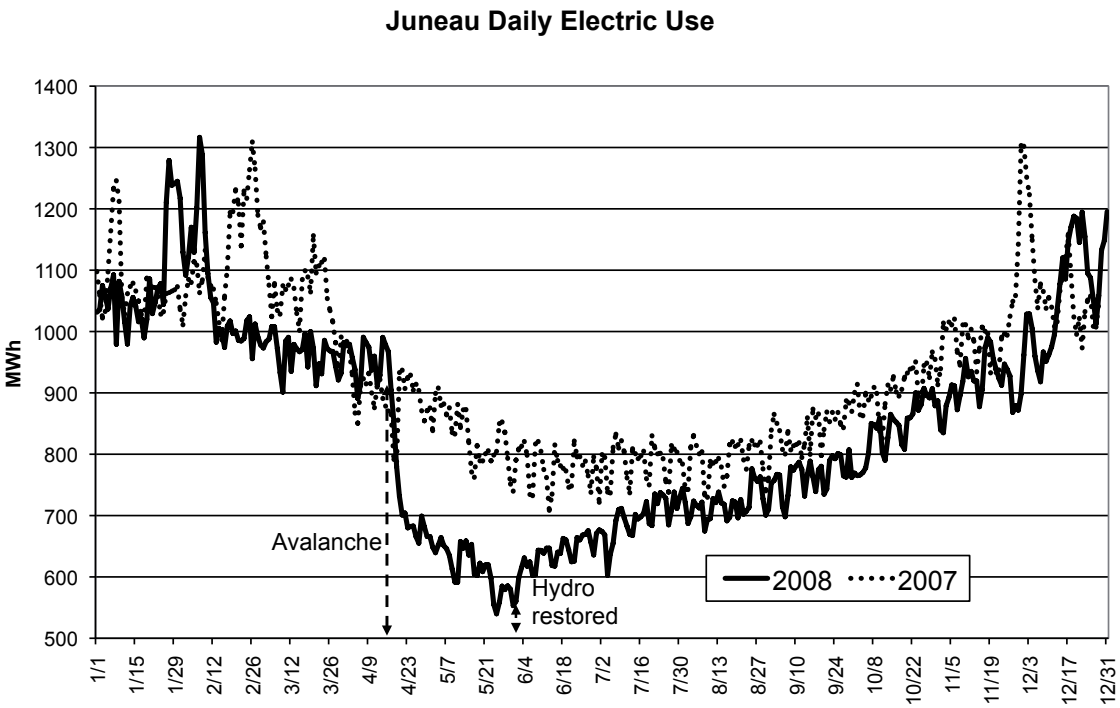

Figure 3. Juneau's daily electricity use before and after the avalanche.

The Transmission Line is Repaired

On 1 June, the transmission line was repaired and hydroelectric power again supplied Juneau. The repairs were finished six weeks ahead of schedule because of favourable weather and because the utility had deliberately overestimated the time needed to finish the repairs. The mayor immediately declared an end to the emergency (even though the disposition of additional fuel costs had not been fully settled).

Electricity Savings Exceed 30 %

Before the avalanche, Juneau used about 1000 MWh/day. Six weeks after the avalanche, it was down to less than 600 MWh/day (see Figure 3). This reduction corresponds to a gross savings of over 40%. Some of these savings were to be expected because the weather was getting warmer and days longer (meaning less lighting). A more appropriate comparison is therefore with the prior year. In this case the electricity savings are roughly 30% compared to the same period in 2007. These savings are also uncertain because of differences in weather. In addition, Juneau's electricity consumption had been rising at about 3% per year; when the projected demand is adjusted upwards to reflect this growth, the savings probably exceed 30%. While Juneau's economy did not exactly flourish, there is no record of businesses failing as a result of the electricity crisis.

There was not enough information to determine the largest source of electricity savings, though it was almost certainly the residential sector simply because it is the largest. The contribution of factors, such as the extent of fuel switching or installation of CFLs, is also unknown. A survey is underway to determine the roles of technologies and behaviours in achieving the energy savings (Leighty 2009) but the results are not yet available.

Electricity consumption quickly rebounded after the crisis ended, but not to original levels. The difference between 2007 and 2008 gradually diminished but some savings – about 10% – persisted (a precise estimate is impossible because winter weather variations after October complicate year-to-year comparisons). This difference probably represents the savings accomplished through some technical efficiency improvements (CFLs), certain semi-permanent changes in operation (such as lowering the water heater storage tank temperature), and new, energy-saving behaviours. Whatever the underlying causes, Juneau's overall electricity growth trend shifted downwards as a result of the avalanche.

AEL&P was not permitted to bill consumers at the higher rates until only a few weeks before the transmission line was restored. Thus, most of the conservation occurred while consumers were paying the lower, pre-avalanche rates. The price signal was communicated only through the media and word of mouth rather than through actual bills.

The citizens of Juneau appeared to be proud of their accomplishment. Some were aware of Brazil's electricity conservation campaign—the most successful program to date—and felt special pleasure that they had surpassed Brazil's record.

One Year Later: Another Avalanche

In January 2009, a second avalanche cut the transmission line. Even though this interruption occurred during the coldest month, consumer reaction was very different from the previous year. First, the avalanche was less serious, damaging only two transmission towers, so the interruption was expected to be much briefer. Second, the price of diesel had fallen dramatically, so the cost of the replacement electricity was not so breathtaking. Lastly, consumers had already confronted this kind of crisis and knew what measures to take (Golden 2009).

The attitude of "been there, done that" prevailed. Once again, consumption fell 10% almost immediately. The transmission line was repaired before further conservation measures could be put in place.

Conclusions

With a reduction of over 30% Juneau saved more electricity and faster than any other region in the world without resorting to blackouts. A five-fold increase in electricity prices provided the stimulus but the savings were accomplished through mostly behavioural measures. Adoption of energy-saving behaviours played the dominant role since the range of technical measures was severely constrained. These results are consistent with those found by Bruel (Bruel 2007). When compared to programs using economic and regulatory instruments, programs relying on behavioural change aimed at consumers are relatively easy to establish (and terminate), less expensive, highly visible, and suitable for mass media. Also, during an electricity crisis, it is socially acceptable—indeed "patriotic" - to wear warmer clothes, switch off lights, and modify lifestyles in ways that would be resisted during ordinary times. Fewer than half of the energy-saving measures persisted after the crisis ended. Electricity use remains about 10% below the previous year. Juneau's experience demonstrates the key role behaviour plays in reducing energy use. Juneau's success also hinged on quickly establishing a consistent, positive, message. Longer energy shortages and tackling climate change may require different strategies but the results from Juneau show that large energy savings are feasible given the right combination of conditions, incentives, and strategies.

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