The electricity impacts of Earth Hour and other coordinated energy demand shifting actions

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Abstract

The annual Earth Hour event is a coordinated, mass effort to reduce electricity consumption for one hour. Earth Hour's objective is to call attention to environmentally sustainable action through the collective impact made when individuals, businesses, governments and communities voluntarily combine electricity conservation efforts. Earth Hour events have taken place in Australia, Canada, Philippines, Europe, and other countries since 2007. We compiled 274 measurements of observed changes in electricity demand caused by Earth Hour events in 10 countries, spanning 6 years. During the Earth Hour event, these coordinated actions reduced electricity consumption an average of 4.0 %, with a range of +2 % (New Zealand) to -28 % (Canada).

While the goal of Earth Hour is not to achieve measurable electricity savings, the collective events illustrate how purposeful behaviour can quantitatively affect regional electricity demand. Similar actions may be a useful demand-control strategy during temporary electricity shortfalls or other crises. The policy challenge is to convert these short-term events into longer-term actions, including sustained changes in behaviour and investment.

Other events cause coordinated reductions or increases in electrical demand, such as popular television programs and sporting events. These sharp drops and peaks lead to inefficient generation requirements and, potentially, grid failure. In one case, a coordinated, mass, increase in consumption was used for political purposes. Together these events demonstrate the importance of short-term behaviour on energy demand and possible applications to energy policies.

Introduction

Earth Hour is a coordinated, mass effort to reduce electricity consumption for one hour one day per year. Since the first event was held in Australia in 2007, Earth Hour's objective has been to call attention to environmentally sustainable action through the collective impact made when individuals, businesses, governments and communities voluntarily combine electricity conservation efforts. Earth Hour's awareness efforts respond to the rise of global electricity demand that is placing unprecedented strain on the electricity grid and increasing amounts of greenhouse gas (GHG) emissions into the atmosphere as a result of fossil fuel combustion.

This paper examines cases where short-term energy behaviour change has resulted in recorded and measurable shifts in electricity demand at the grid level. Research found that no similar research compilation has been done to date. It is therefore assumed that this portfolio of examples is the first recorded identification and collection of occurrences of measured short-term energy demand shifts caused by individual human behaviour change in order to determine whether or not mass coordinated human behavior change can impact energy demand.

BEHAVIOUR PERSISTENCE

There is evidence that incremental changes and short-term intervention and behaviour modification can contribute to longer-term change. For example, Ockene et al. found that brief physician interventions can have a long-term impact on smok-

ers who benefit initially, supporting the value of short-term intervention to achieve initial impact and long-term effects on smoking cessation rates (1994). Persistence has also been extensively examined in the fight against obesity. French et al. examined a population's weight control behaviours over a 4-year period. The study found that although individuals' weight fluctuated, weight gain could be avoided with age when short-term weight control strategies were employed in longer durations (1999). Additionally, incremental changes in diet and physical activity have been recommended to achieve lasting results by first stabilizing and then gradually decreasing obesity rates (Hill, 2009). These findings support the notion that short-term efforts to improve individual consumer conservation behaviour may be a sustainable way to improve longer-term electricity conservation and energy efficiency investments.

EARTH HOUR

The first Earth Hour event was held in Sydney, Australia, in 2007. Organized by the World Wildlife Fund (WWF) to promote climate change awareness, the campaign called for citizens to voluntarily limit or cease their electricity consumption for a single hour on March 31. In 2008, the campaign expanded globally and growth has continued in a number of countries and territories that actively participate in the event. Unifying themes of the campaign have been that all individuals have the ability to alter their environment and the collective power of positive action by many people can have a beneficial impact on the Earth. In 2011 and 2012, Earth Hour organizers encouraged event participants to take their actions to fight climate change beyond the titular hour and commit to environmentally conscious behaviour throughout the year.

Across the globe, many service providers, utilities and news outlets report anecdotal evidence of grid impacts that result from mass individual short-term behaviour change. Press releases and stories reporting these events are often promulgated for their human-interest value as well as educational pieces on grid demand. Since 2008, the majority of these reported incidents are associated with Earth Hour. The reports citing specific electricity saving figures are issued by electricity system operators, utilities and electricity distributors and sometimes cited by regional news outlets. The WWF does not promote electricity savings accounting, but instead focuses on campaign participation measurements of social media engagement, commitment pledges and physical turnout to organized events. The number of participating cities, municipalities, towns, universities and landmarks, as well as key government figurehead and celebrity endorsement, is also often highlighted to indicate the reach and visibility of the campaign. The WWF has indicated that measurable electricity savings is not an accurate indicator of the campaign's success since external factors such as weather can influence results (3 News, 2012). This is particularly true when inconsistent or simple methodologies that compare electricity demand changes to a single historical period are used.

OTHER EVENTS CAUSE COORDINATED REDUCTIONS OR INCREASES IN ELECTRICAL DEMAND

As noted above, some service providers, utilities and news outlets report anecdotal evidence of grid impacts that result from mass individual short-term behaviour change beyond Earth Hour. Other mass events that cause or attempt to cause coordinated reductions or increases in electrical demand include conservation in times of crisis, popular televised programs or events and political protest. We include documentation of a selection of these events here to ensure robust coverage of short-term mass behaviour change caused electricity demand shifts. These events are also important to note because they show that mass synchronized behaviour can cause electricity demand change in the presense or absence of encouraged conservation and this change may or may not be predictable.

Emergency energy conservation

During temporary electricity shortfalls due to natural disaster or other crises, leaders often turn to promoting demand-control strategies throughout affected populations even if the use of price motivators is not an option. A successful avoidance of blackout was documented by Leighty and Meier when a 2008 avalanche destroyed the central hydroelectric transmission line to Juneau, Alaska (2011). Reacting to an organized call for electricity consumption by leaders, consumers were able to avoid a blackout by adopting energy efficient behaviour and technologies, thereby reducing grid demand by 25 %. Although a price signal that may have attributed to this reduction was eventually sent to consumers through an increase of $0.50/kWh, 77 % of surveyed residents began electricity conservation actions within one day of the avalanche. The Juneau case indicates that if a supply disruption is anticipated, leaders should not hesitate to request that consumers in affected regions to modify their behaviour, potentially lessening the overall impact of the shortage or mitigating blackout. It should be noted that research conducted by Holladay et al. suggests that during calls for summertime electricity conservation in Maryland in 2011, consumers simply shifted their energy consumption through the day with little reduction in overall consumption (2012). If leaders call upon demand-control strategies during times of energy crisis, they must be careful to request that, in addition to conserving energy usage, consumers not shift their electricity consumption to times of high demand.

Television pickup

Television pickup occurs when a large percentage of electricity system customers cease their daily routine to view the same televised program or event at the same time. Unlike individuals' active participation in Earth Hour, television pickup represents a mass passive participation of individuals in an event that results in observable grid demand shifts. Not a modern-day phenomenon, television pickup has been observed in locations such as Great Britain since the 1960s (Bunn and Seigal, 1983). This action causes displacement, a measurable drop in electricity demand when the television viewing displaces other household activity, and release, a corresponding increase in demand is seen when those individuals move from their television sets to resume their household activity at commercial break or at the conclusion of the viewing.

Sporting events have been reported to cause television pickup observations in various countries across the world. On August 10, 2012, EirGrid plc, the Transmission System Operator for Ireland, reported that Irish boxer Katie Taylor caused a displacement reduction of 6 % as the country collectively paused to view her bout in the finals as she contested for the gold medal (2012a). In 2012, Irish soccer enthusiasts accounted for a displacement demand reduction of 3 % at the start of the

Euro 2012 soccer match and the release at the game's conclusion caused an increase of approximately 7 %. EirGrid grid disruptions from soccer matches are recorded as far back as the 1990 World Cup game (2012b). In the United States, ISO New England captured television pickup effects resulting from football fans during the Patriots Super Bowl Game in 2012 (2012). Canada's affinity for hockey is reflected in British Columbia's displacement during playoff finals (BC Hydro, 2011).

Like the predictability of Earth Hour, the predictable nature of televised events allow system operators to monitor television schedules to anticipate and prepare for behaviour-caused electricity demand shifts. For example, to handle the fluctuating demand associated with television pickups throughout the 2012 Summer Olympics, Great Britain's National Grid utilized the Short Term Operating Reserves Program (STOR) to access demand response solutions such as reducing electricity needs of frozen food distribution warehouses (KiWi Power, 2012).

Civilian protest

With proper planning and response from system operators, sharp drops and peaks in demand can be effectively managed and inefficient generation requirements and grid failure can be avoided. In less stable grid environments, however, ineffective system management and high electricity demands can result in grid failure. If mass populations act in a coordinated way to disrupt already unstable grid systems, the result can be consequential to grid reliability. On July 21, 2009, dissenting Iranians banded together to protest the presidential reelection of Mahmoud Ahmadinejad through a collective electrical protest. The goal of the event, scheduled to coincide with nightly newscast, was to collectively turn on high electricity consuming devices at the same time in an attempt to cause a strain on the grid great enough to create a nationwide blackout. Although no specific increase or decrease was reported by official sources and no nationwide blackout occurred, reports of localized grid failure were made by citizens (Bordbar, 2009).

Method

DATA COLLECTION

To the authors' knowledge, no formal review of achieved energy conservation during the Earth Hour events has been conducted to date. We therefore identified and compiled a database of recorded and measured examples of individual behaviour-caused electricity demand shifts during the Earth Hour event. We conducted an online search of company records and press releases of electricity system operators, utilities and electricity distributors was conducted for Earth Hour electricity demand changes. International periodicals, websites and blogs were reviewed for notation of demand shifts that indicated citation of primary company sources. To allow for as much consistency between sources as possible, only demand shifts recorded in percentages were collected. Demand shifts recorded in absolute numbers, such as megawatts reduced, were noted for anecdotal evidence. For each demand shift data point collected, methodologies used to calculate reported electricity demand changes were identified and recorded. In multiple cases, email correspondence was used to communicate with reporting entities where the demand change calculation methodology was absent from publicized records.

RESULTS

We compiled 274 measurements of observed changes in electricity demand reportedly caused by Earth Hour events in 10 countries spanning 6 years from 2007 through 2012. Australia, New Zealand, Indonesia, Qatar, United Arab Emirates, Israel, Ireland, Sweden, United States and Canada are the countries for which Earth Hour electricity demand shift documentation were found (Table 1).

Figure 1 illustrates the distribution of the 274 electricity demand changes recorded during the Earth Hour event. These coordinated one-hour actions reduced electricity consumption an average of 4.0 % and had a median reduction of electricity of -2.6 %. Unique electricity demand shifts ranged from of +2 % (observed in New Zealand) to -28 % (observed in Canada).

Methodologies used to calculate percent electricity demand change were available for 97 %, or 266 of the 274 cases. Only 23 %, or 64 of the 274 of these cases were published with calculation methodology accompanying the percent electricity demand change. The calculation methodology for 203 of the remaining cases was obtained through personal communication with the reporting entity. For 8 cases, the reporting entity was either unresponsive or indicated that a comparison methodology was unavailable. Where methodology was available, the reports fell into three categories – those that compared observed demand to a forecasted demand (196 cases), those that

Table 1. Countries with recorded Earth Hour demand shifts.

Country	Number of Events	Average % Electricity Demand Change
Australia	18	-6.6%
Canada	231	-3.9%
Indonesia	3	-3.9%
Ireland	1	0%
Israel	4	-5.3%
New Zealand	5	-3.6%
Qatar	1	-10.0%
Sweden	2	-2.3%
United Arab Emirates	1	-2.4%
United States	8	-1.8%
Total	274	-4.0%

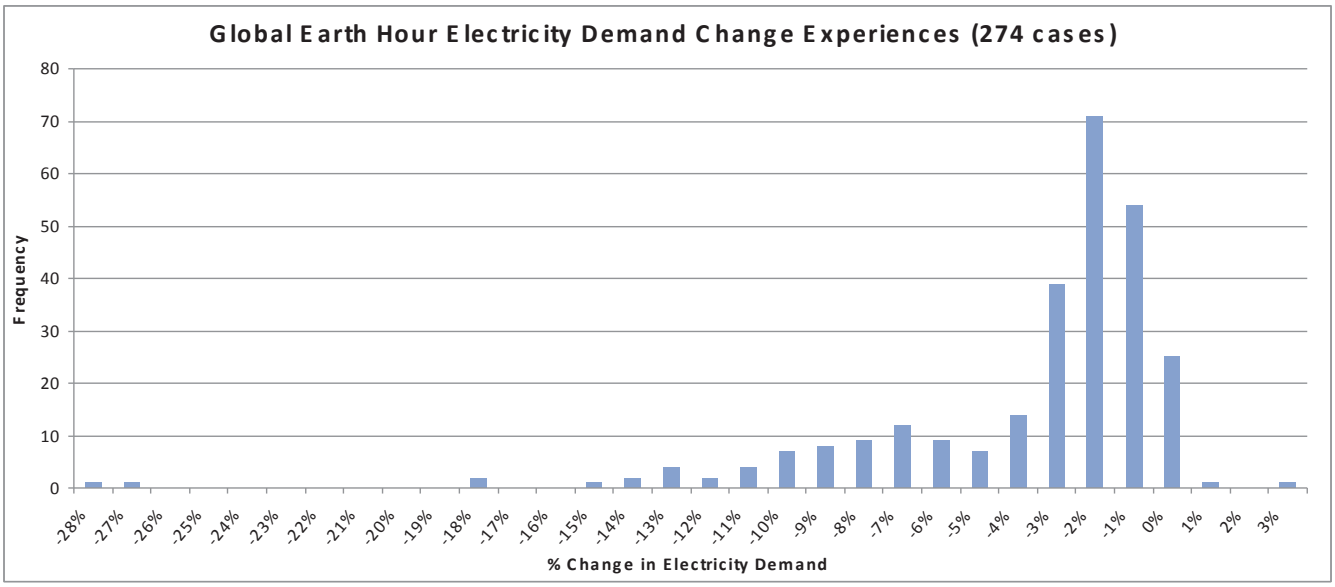

Figure 1. Global Earth Hour Demand Shift Experiences.

compared observed demand to a normal or average demand experience (64 cases) and those that compared to the time immediately prior to Earth Hour (6 cases).

Discussion

While the goal of Earth Hour is not to achieve measurable electricity savings, this compilation of recorded and measurable individual behaviour-caused electricity demand shifts has shown that the mass purposeful behaviour undertaken by Earth Hour participants can quantitatively affect regional electricity demand for periods of one hour. The Earth Hour event also shows that measurable electricity demand reduction change is possible on a mass scale with large portions of populations acting at least for a short-term, without the use of price motivators. This may prove to be important to industry leaders and policymakers in the days and hours leading up to an electricity shortage when the electricity price has not yet increased. Additionally, multiple regions have undertaken the event annually with documentation of sustained electricity savings. The repeat participation and electricity demand savings shows that continual community interest in the electricity conservation event can have sustained impact on an annual basis. Extending these efficiency gains beyond the Earth Hour is a challenge that can be addressed through policy that encourages longer-term behavior changes and investment in energy efficient technology.

DEMAND CHANGE METHODOLOGIES

Our research shows that a consistent methodology and assumptions used to calculate individual behaviour-caused electricity demand changes is needed. The wide range of methodologies used to document demand change experienced during Earth Hour highlights the incongruence between cases and may increase skepticism that real demand changes occur as a result of behaviour change. In some cases, methodologies used by the same reporting entity changed from year to year. In one document case, the percent demand change and associated methodology used by a reporting entity was initially published by the company and a second release two days later revised the assumptions used in that methodology to change the percent demand change (ComEd, 2008a, 2008b). This further reinforces the need for the utilization of consistent methodology and assumptions when reporting electricity demand changes.

Simple methodologies that electricity demand increase or decrease to the same date one week or one-year prior is not adequate to give an accurate estimate of demand change. The recommended methodology is one that compares a given electricity demand increase or decrease to the projected electricity demand. Projected demand should be that which is forecast with system operator tools that consider appropriate equivalent experienced days and adjust for temperature, cloud cover and other major weather events and holidays. This data-driven recommended methodology will ensure consistent electricity demand change reporting, allowing consumers from one community to the next a reliable source of Earth Hour impact information.

Conclusion

Since 2007, the Earth Hour event has captured the attention of individuals across the globe to highlight the potential impact that can be made with a mass, coordinated effort for environmentally sustainable action. The single-hour goal of Earth Hour is great – participants cease all possible electricity consumption for a period of one hour. While this level of energy conservation is unsustainable, a primary goal of the Earth Hour event is also one of the most significant factors that influences long-term residential energy use and conservation – consumers' awareness and understanding of their own energy usage (Steg, 2008).

Over the six years that Earth Hour has been held, our research found 274 instances of observed changes in electricity demand caused by the event. These cases were found to reduce electricity consumption an average of 4.0 %. This Earth

Hour data, along with anecdotal evidence from other events that cause coordinated reductions or increases in electrical demand, illustrates the importance of short-term behaviour on grid demand. Additionally, it shows that short-term mass individual energy behaviour change can result in a measurable shifts in electricity demand at the grid level. While behavioural research shows that short-term behaviour change can lead to sustained change, more research must be done to determine if Earth Hour conservation behaviour is persistent. More research should also be done to determine how short-term behaviour change can be applied during times of temporary electricity shortfall or other crises, especially when a price signal is not available to curb electicity demand. Finally, consumption pattern effects of the Earth Hour such as increased electricity consumption before or after the event, should be investigated.

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