Utilities Policy 51 (2018) 12–17

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

The long-run price elasticity of residential demand for electricity: Results from a natural experiment☆

James P. Feehan

Department of Economics, Memorial University of Newfoundland, Elizabeth Avenue, St. John's, NL A1C 5S7, Canada

ARTICLE INFO

Keywords:
Residential demand for electricity
Price elasticity
Difference-in-differences

ABSTRACT

In one of two otherwise similar adjacent regions in a Canadian province, the price of electricity changed abruptly, substantially, and permanently. That natural experiment allows for a simple differences-in-differences calculation of the long-run price elasticity of residential demand for electricity. This analysis is of interest for two reasons. First, it is a rare circumstance when such a methodology can be used. Secondly, the magnitude of the elasticity estimate has substantial implications for utilities, regulators, and policymakers.

1. Introduction

Decisions about the electricity usage, pricing, and infrastructure investment depend on many considerations. Among them, the price elasticity of demand for electricity is especially crucial. The focus herein is on residential demand for electricity in the long run. Estimates of its price elasticity are plentiful and diverse, and reflect both differences in space and time but also in estimation techniques. In a frequently cited contribution, Espey and Espey (2004) carried out a meta-analysis of price and income elasticity estimates from 36 studies published over the period 1947 to 1997. From the 123 estimates that they analysed, short-run price elasticities ran from −2.01 to −0.004 with a mean of −0.35; and 125 estimates of long-run price elasticity fell in the range from −2.25 to −0.04 with a mean of −0.85.[1] Differences in econometric techniques may explain some of the variation, but even with the same methodology, a wide range of estimates can be obtained. For example Krishnamurthy and Kristöm (2015), using a common methodology, obtained a range of price elasticities between −0.27 and −1.4 for a set of 11 OECD countries.[2]

In more recent years, the feasibility of real-time pricing has sparked interest in determining near-immediate price elasticities when consumers have informational feedback. A great deal of this research is based on experiments (see Faruqui and Sergici (2010) and Jessoe and Rapson (2014) for experimental evidence with respect to residential demand). That is in contrast to econometric studies focusing on short-run and long-run price elasticities, which use either time series, cross-sectional, or panel data sets that are typically from surveys rather than from experiments. One exception is the study by Battalio et al. (1979), which dealt with short-run rather than real-time elasticity. Using a system of rebates and information, the researchers conducted a field experiment on a sample of residential customers in College Station, Texas, over a three-month period. By offering cash payments to a subset of customers for each percentage reduction in their electricity consumption compared to a year earlier, they obtained an estimate of short-run price elasticity of demand. While interesting, experiments of that type have severe limitations. The participants know that they are in an experiment and the experiment is for a short period of time, so there is no incentive for them to invest in changing heating and cooling systems or electrical appliances. Thus, such experiments give no insight into long-run price elasticity.

The findings reported in this paper are based on a very rare set of circumstances that yields a long-run elasticity via a natural experiment.[3] Among other things, the subjects involved do not perceive that they are in an experiment, nor was an experiment even intended. It is based on a homogeneous area in the Canadian province of Newfoundland and Labrador, where all residential customers initially faced the same price schedule, but then those in a geographic subset were switched to a different price regime. The change in price was abrupt,

☆ I am very grateful to two anonymous referees, whose thorough and constructive comments led to substantial improvements. I remain solely responsible for any errors.
E-mail address: feehan@mun.ca.

[1] Boogen et al. (2017) offer a very recent review of studies on the price elasticity of residential demand for electricity.

[2] Those differences are not surprising since the countries likely have numerous differences in terms of price-setting, housing stock, incomes, climates, demographics, and other factors that would influence the nature of their respective demand curves.

[3] Two recent applications of natural experiment data to electricity issues are reported in Choi et al. (2017) and Deryugina et al. (2017). However, the former is concerned with the impact of daylight-savings time, not price, on electricity demand. The latter's focus is on price elasticity but, because it involves many communities over a wide area of Illinois, a more sophisticated analysis was appropriately undertaken. By contrast, in this paper, the similarity of the two groups supports a common-trends assumption and therefore a direct calculation of price elasticity.

https://doi.org/10.1016/j.jup.2018.02.003
Received 21 May 2017; Received in revised form 18 February 2018; Accepted 18 February 2018

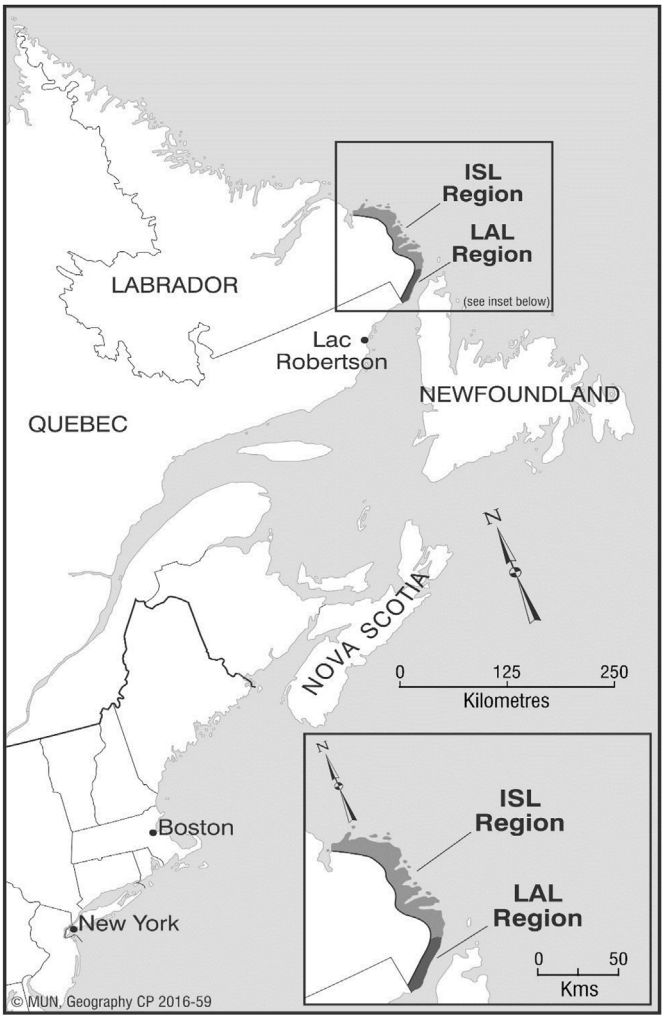

Fig. 1. Northeastern North America and the ISL and LAL regions.

substantial, and long lasting. Data on electricity consumption for both groups is available and provides insight into consumer adjustment. In particular, the similarity of the two groups allows for a simple differences-in-differences approach to estimating the long-run impact of the price change.

The next section provides the background on the natural experiment. Section 3 illustrates the magnitude of the price shock and how electricity consumption patterns changed in its aftermath. In Section 4, the long-run price elasticity is determined. Section 5 briefly discusses that result and policy implications, the latter of which are substantial if a similar elasticity value applies to residential customers elsewhere in the same province.

2. The setting

The focus is on residential demand in communities located on the south coast of the Labrador area of the province. That coastal area and the two regions of interest there are identified in the map of northeastern North America in Fig. 1. One of the two regions is L'Anse au Loup (LAL), named for the largest community within it. The other region will be referred to herein as the Isolated Southern Labrador (ISL) one.

Until late in 1996 all of their electricity demand was met by diesel turbines operated by the government-owned utility, Newfoundland and Labrador Hydro Corporation (NL Hydro). Diesel generation is expensive and, despite charging higher rates in isolated areas serviced in this way, NL Hydro incurred operating losses there. Full recovery was not possible because of provincial government policy that constrains NL Hydro in its rate design. The entire area's residential customers faced increasing-block pricing but subject to the government directive that the basic customer charge and per-kilowatt hour (KWh) rate for the first block of energy both be the same as those approved by the regulator for the residential customers on the interconnected grid in the Newfoundland area of the province. For illustration, as of July 1, 1996, all LAL and ISL residential customers faced the following monthly charges, in Canadian currency [4]:

Basic Customer Charge	$16.72
First Block (up to 700 KWh)	6.6 cents per KWh
Second Block (in excess of 700 KWh to 1000 KWh)	9.6 cents per KWh
Third Block (in excess of 1000 KWh)	13.0 cents per KWh

These rates also applied to other isolated communities that were served by diesel generators. Those communities were mostly further north on the Labrador coast but also included a small number on the island of Newfoundland. However, importantly, the pricing differed for the island interconnected residential customers. Those customers were charged the same basic charge but the 6.6 cent per KWh rate was a flat rate, regardless of consumption. The island basic charge and per kWh rate were set by the regulator but, as a policy, also automatically applied to the isolated systems up to the limit of those systems' first block. The higher second and third block rates applied only to the isolated customers and, while below the marginal cost of diesel generation, served to deter higher consumption in order to limit NL Hydro's cross-subsidization of diesel service.

In late 1996, there was a price shock. Residential customers in the LAL region were removed from the block-pricing scheme. NL Hydro entered into an agreement by which it would import electricity from Quebec. That province's utility, Hydro-Quebec, agreed to sell surplus electricity from its new small 22-MW hydro-electric plant at Lac Robertson, located on the Quebec side of the provincial border near the LAL system, to NL Hydro. [5] That amount of energy was sufficient to displace NL Hydro's diesel plants supplying the LAL system and was less expensive. Following that agreement, the government of Newfoundland and Labrador, through an order to the province's regulator, the Board of Commissioners of Public Utilities (the PUB), directed that once the connection was in place NL Hydro would charge the same residential rates in the LAL system as applied to interconnected customers on the island of Newfoundland.[6] NL Hydro had wanted to maintain separate rates for L'Anse au Loup ratepayers because the unit cost in the area, even with cost savings from connection to Lac Robertson, would still be much higher than the unit cost on the interconnected system; see PUB (1996, 32). However, the government order prevailed and the LAL residential customers were removed from having to pay the second and third block rates. This change did not apply to the ISL system, which was not connected to the Lac Robertson plant and continued under the block-rate regime. This policy remains in effect to the present. Hence, there was a marked, immediate and sustained deviation of the prices in the two neighbouring Labrador systems, where customers had previously faced exactly the same prices.

The price change set the stage for a natural experiment with the ISL region serving as the control group and the LAL region being the test

[4] These rates were provided by NL Hydro on request. For recent details of this pricing, see https://www.nlhydro.com/wp-content/uploads/2014/04/Schedule-of-Rates-and-Regulations.pdf.

[5] That plant was commissioned in 1995 (http://www.hydroquebec.com/generation/centrale-hydroelectrique.html).

[6] PUB, 1996/97 Order P.U.5 set this policy and it refers to Government order MC 96–0567 as the basis for doing so; see http://pub.nl.ca/orders/pu97.htm.

group. Such an approach is especially apt here because of the similarity of the two regions. They are served by the same utility and they are geographically adjacent along a coastline, so they experience identical weather conditions characterized by a northeastern Atlantic climate with very cold and lengthy winters and cool summers. Moreover, they share very similar demographic and socioeconomic characteristics and trends. This can be confirmed by reference to the Community Accounts maintained by the Government of Newfoundland and Labrador. Those accounts provide extensive statistical profiles for 20 economic zones corresponding to different areas of the province. Rather fortuitously, the LAL and the ISL region each correspond to two distinct economic zones.[7] Drawing on those accounts, the remainder of this section briefly highlights the regional similarities.

In terms of demographics, each region is rural, consisting of eight to ten small communities, mostly with populations in the hundreds and none with a population of a thousand or more. All are on or near the coast and connected by the sole coastal road. Residents have the same ethno-linguistic origins. Both regions are characterized by declining populations due to falling birth rates and out-migration. From 1996 to 2011, the LAL experienced a decline in population from 2885 to 2215, while the ISL went from 2060 to 1,645, which are declines of 23 percent and 20 percent, respectively. Household sizes are also alike and are characterized by similar trends as illustrated in Table 1.

Table 1
Household size by census year.[a]
Source: Census: Family Characteristics, Newfoundland and Labrador Community Accounts.

	1996	2001	2005	2011
LAL	3.87	3.37	3.29	3.18
ISL	3.52	3.24	3.23	3.07

[a] Calculated by dividing the population by the number of census families in private dwellings; data on both are from Newfoundland and Labrador Community Accounts; see note 7.

Economic conditions in both regions are also quite similar. Unemployment rates tend to be high and employment is highly seasonal. Sources of income are also the same. While median family income in the ISL region has been consistently lower than in the LAL region throughout the period of the following analysis, 1992 to 2016, at approximately 15 percent less, this differential has been quite consistent over that study period. Median family income in both regions has followed a common trend. In sum, conditions in the two regions are either identical or follow common trends. The outstanding exceptions to that observation are electricity prices and electricity consumption.

3. The price change and consumption patterns

The key change in the price regimes is illustrated in Fig. 2. It shows two time-series. One series, which begins in 1991 and goes to 2016, shows isolated systems' residential rates per KWh, expressed in 2015 dollars, for consumption in excess of 1000 KWh per month.[8] Those rates applied to the ISL region throughout the period and the LAL region only up to late in 1996. The second time-series comprises the rates, also in 2015 dollars, for the LAL region after the change in its price regime. The emphasis here is on the price of electricity in excess of 1000 KWh per month because that amount is the threshold above which the third-block rates apply and it is where the difference in post-1996 price regimes is substantial. For instance, in 2015 the third block rate was 16.3 cents per KWh, almost 55 percent higher than the LAL and island flat rate of 10.6 cents per KWh. [9]

A large and persistent change in price is expected to have an impact on consumption. In that regard, Fig. 3 illustrates the two sets of residential customers' consumption patterns before and after the price change. For the six years prior to the change, 1991–1996, the average consumption levels were very similar and tracked one another in parallel fashion. [10] As shown, average annual residential consumption on the LAL system was consistently and modestly higher than in the neighbouring ISL system its average consumption was (731 KWh higher or 9.2 percent). The persistent difference in family income, as noted in Section 2, may explain much of this phenomenon. However, as also noted, pattern of income in the two regions follows a common trend over the study period. In the period after the change in price regimes, the similarity in the consumption patterns was disrupted. At first, the change was small but by 1999–2000, the LAL system's average residential consumption had moved up significantly relative to the ISL system, at 11.3 percent higher. Thereafter, LAL consumption deviated from the ISL trend in a far more pronounced way. By 2016, average residential consumption in the LAL system was 103.4 percent higher than in the ISL system.

Associated with the large increase in LAL average annual residential consumption has been the adoption of electric space heating as the primary source of heat there. Annual penetration rates for electric heat in the LAL communities for the years from 1991 to 2016 are shown in Fig. 4. From 1991 to 1997, the use of electric space heating was negligible; oil and wood fuels were used for heating purposes; there are no natural gas pipeline distribution systems in those regions nor anywhere else in the province. By 2001, the penetration rate had risen modestly, from zero, to six percent but increased dramatically thereafter. This initial slowness in installing electric heat may well reflect the time needed by consumers to believe that the capital investment would pay off over time. Importantly, as Spees and Lave (2007, 81) observe, electricity consumers react to a change in price when they believe it will be long lasting. By 2015 half of the residential customers in the region had installed electrical heating systems. Since reliance on electric space heating remained negligible in the ISL communities, the clear implication is that the lower price motivated the move to electric heat. As long as the price regime continues, it is reasonable to expect that the trend in electric heat penetration will continue until it reaches a convergence point. In that regard, Fig. 4 seems to imply a move towards convergence as the growth in the penetration rate since 2011 has slowed, with very little change from 2014 to 2016.

Adoption of electric space heating has important implications in the cold climate of Newfoundland and Labrador coastal communities. Turning specifically to the communities in the LAL system, in 2016, average electricity consumption by residential customers relying primarily on electric space heating there was 26.4 thousand KWh. The other LAL residential customers, i.e., those who did not use electric heating systems, consumed much lower quantities of electricity; they averaged 11.4 thousand KWh. Nevertheless, even those non-electric heat consumers had much higher consumption that those in the ISL system. In 2016, non-electric heat LAL consumers used an average of 2.1 thousand more KWh than the 9.3 thousand KWh average in the ISL system (approximately 23 percent more). That is a substantially greater than the 9.2 percent differential in consumption that occurred when the two regions faced the same electricity prices. In short, the change in price regime for LAL residential consumers has over time led to a substantial and continuing increase in electricity consumption there, apparently driven by the increasing use of electric space heating, but also by a general increase in consumption for other uses.

[7] They are Zone 4 and Zone 5, respectively, and statistical profiles on each are available (see http://nl.communityaccounts.ca/profiles.asp?_=vb7En4WVgb2uzqVj).

[8] The Consumer Price Index (CPI) for Newfoundland and Labrador was used to express prices in 2015 constant dollars and all nominal price information, which is in Canadian currency, was provided by NL Hydro on request.

[9] The second-block rate, which applies to only a modest amount of consumption, was 12.0 cents per KWh.

[10] Over that six-year period, average annual consumption levels were 8655 KWh and 7924 KWh in the LAL and ISL systems, respectively. Consumption data prior to 1991 are not available.

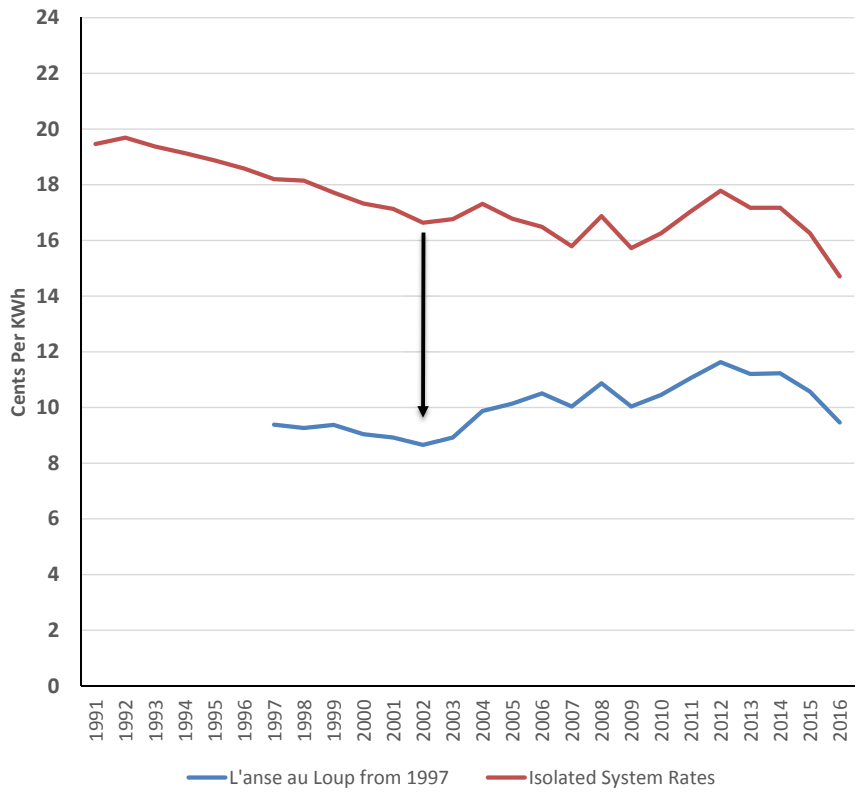

Fig. 2. Marginal price per KWh in excess of 1000 KWh per month, in 2015 constant Dollars.
Data Sources: Nominal Prices were provided by NL Hydro on request. Provincial CPI data used to express prices in constant dollars were obtained from http://www.stats.gov.nl.ca/statistics/Prices/PDF/CPI_Allitem.pdf.

4. Price elasticity of demand

The reaction to the price change by LAL residential consumers can be quantified by determining the price elasticity of demand (η), i.e., the ratio of the percentage change in consumption to the percentage change in price. Since those changes are large, the arc formula, by which a percentage change is measured relative to the mid-point of the start and end values, is used to calculate the percentage changes.

Estimating the percentage change in average consumption of electricity due to the price change, as opposed to other influences on consumption, requires some adjustments. In other words, the higher level of consumption in the post-price shock period may reflect influences other than price. In light of the similarity of the two groups, the common weather conditions, service being provided from the same utility, the identical alternate sources for space heating, and their common demographic and economic trends, a basic difference-in-differences approach can be used to determine that change in consumption attributable to the new price regime. The ISL customers serve as the control group and the LAL customers are the test group. The basis for the difference-in-difference methodology is that the similarities of the two groups and the common trends experienced by them mean that the pre-1997 consumption difference between them would have persisted in the absence of the price shock.

In what follows, the average consumption during the last three years of the pre-shock period, i.e., 1994–1996, and the average of consumption in the most recent three years, i.e., 2014–2016, are used as comparators. Relying on three-year averages lessens the impact of any one anomalous year and avoids using any of the many years that, as in Fig. 3, are times of transition. Table 2 provides the consumption averages for the pre-shock and post-shock periods. The table also shows the across-region and across-time differences in those consumption figures. The difference in those differences is 9,222 KWh, which is the amount of the LAL's region's overall increase in consumption of 10,375 KWh that can be attributed to the change in price. Based on that estimated price-induced change in consumption, the arc formula calculation yields 69.1 percent.

Table 2
Annual average electricity consumption (KWh): Difference-in-differences.

	Post-Shock: 2014–2016 Avg.	Pre-Shock: 1994–1996 Avg.	Difference
LAL Region	19,101	8,726	10,375
ISL Region	9,199	8,046	1,153
Difference	9,902	680	9,222

The change in the price in the LAL and the elasticity can be readily calculated. The average prices, in real terms, in the selected pre-shock and post-shock periods were 18.86 cents and 10.42 cents, respectively. The arc calculation expresses that as a −57.7 percent change. Hence, the implied price elasticity of demand is:

$$\eta = (69.1 / -57.7) = -1.20,$$

which indicates that residential demand for electricity in the LAL region is price-elastic (that is, a value greater than −1.0 in absolute value).[11]

This estimate of −1.20 is the 20-year price elasticity of demand, which can be taken as a reasonable estimate for the long-run price elasticity. Interestingly, this finding is consistent with results obtained for the neighbouring province of Quebec. Bernard et al. (2011) applied sophisticated econometric techniques to a large set of panel data to

[11] The result is little affected if the proportionate difference rather than absolute difference in consumption is used; the elasticity would be −1.15 in that case. Similarly, if only the end-years of 1996 and 2016 are used, demand remains elastic with a value of −1.06. Using a point estimate, the elasticity would be approximately −2.36 rather than the −1.20 given above.

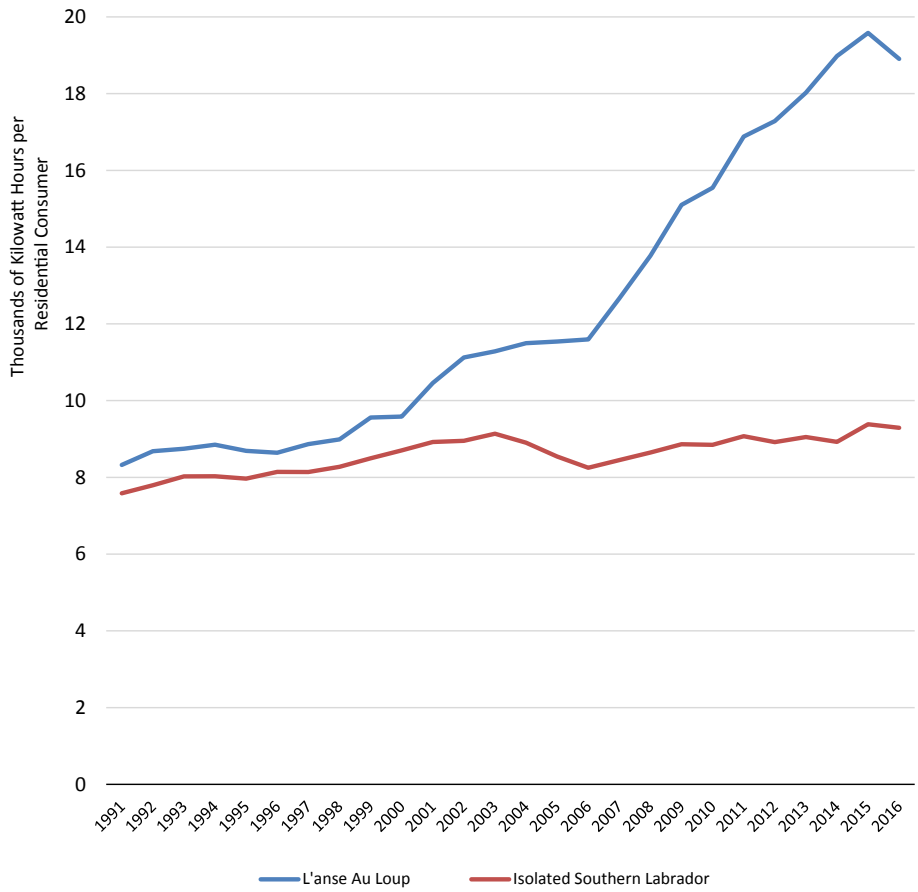

Fig. 3. Average annual residential electricity consumption.
Data Source: NL Hydro provided consumption data on request.

estimate price and income elasticities. That study concluded that residential demand for electricity in Quebec was price-elastic; the estimated long-run price elasticity of −1.32 is comparable to the results of this analysis.[12]

5. Discussion and policy implications

The finding that demand is price-elastic in the LAL region has direct policy implications for that region. As stated in Section 2, the rates for residential customers there must, as a matter of government policy, be equal to the PUB-approved rates for customers on the island's interconnected grid. That means that there is no connection between the price of electricity in the LAL region and the higher unit cost of providing service there. Price-elastic demand has led to a substantial increase in consumption in the area, which requires greater imports of electricity from Hydro-Quebec causing the initial savings from substitution away from diesel generation to be eroded. Specifically, total residential customer consumption there grew from 6,195 megawatt hours (MWh) in 1996 to 15,331 MWh in 2016.[13] This suggests that reconsideration of pricing policy may be in order. Linking the LAL price to the unit cost of purchased energy could improve efficiency and reduce cross-subsidization from NL Hydro's other customers.

There is another broader implication. There are no published estimates of the price-elasticity of demand for the entire province. Buttressed by the results of Bernard et al. (2011), the finding that residential demand in one region of Newfoundland and Labrador is price-elastic intimates that residential demand might well be price-elastic elsewhere in the province, with implications for consumers on the island portion of the province. The bulk of the province's population, approximately 500,000 out of 525,000, are located on the island of Newfoundland. These customers are mostly located near the coast and exposed to a North Atlantic climate, with similar options for space heating and where NL Hydro is also the main provider and transmitter of electricity.[14] Residential demand on the island of Newfoundland accounts for approximately 55 percent of electricity consumption there. A major new multi-billion dollar addition to generating capacity is under construction and due to be completed by 2020. While located at Muskrat Falls in central Labrador, that 824 MW hydro-electric facility will be dedicated to supplying the island and will be connected to it by direct-current transmission lines and subsea cables. Not everyone agrees on the merits of this project; for instance, Feehan (2012) argued that there were better alternatives, such as a mix of smaller projects, conservation measures, and marginal-cost pricing. In addition, there have been environmental and community concerns, and the PUB reported that it could not conclude that the project was the least-cost option for meeting Newfoundland's energy needs; see PUB (2012). However, despite the controversy, the provincial government, the owner of NL Hydro, exempted the project from PUB jurisdiction and in

[12] The finding here that residential demand for electricity is price-elastic is also consistent with the findings in econometric studies by Narayan et al. (2007) and Krishnamurthy and Kristöm (2015). However, those estimates are based on national data across countries rather than sub-regions as considered here.

[13] This information was provided by NL Hydro.

[14] NL Hydro is also the retailer in some rural areas on the island, as it is for all the Labrador region of the province. Most of the retail electricity distribution on the island is provided by Newfoundland Power Inc., which acquires most of its electricity from NL Hydro. However, both utilities charge the same residential prices on the island as required by the regulator, the PUB. The only exception is for a few isolated diesel systems which are served by NL Hydro and where increasing-block pricing is applied.

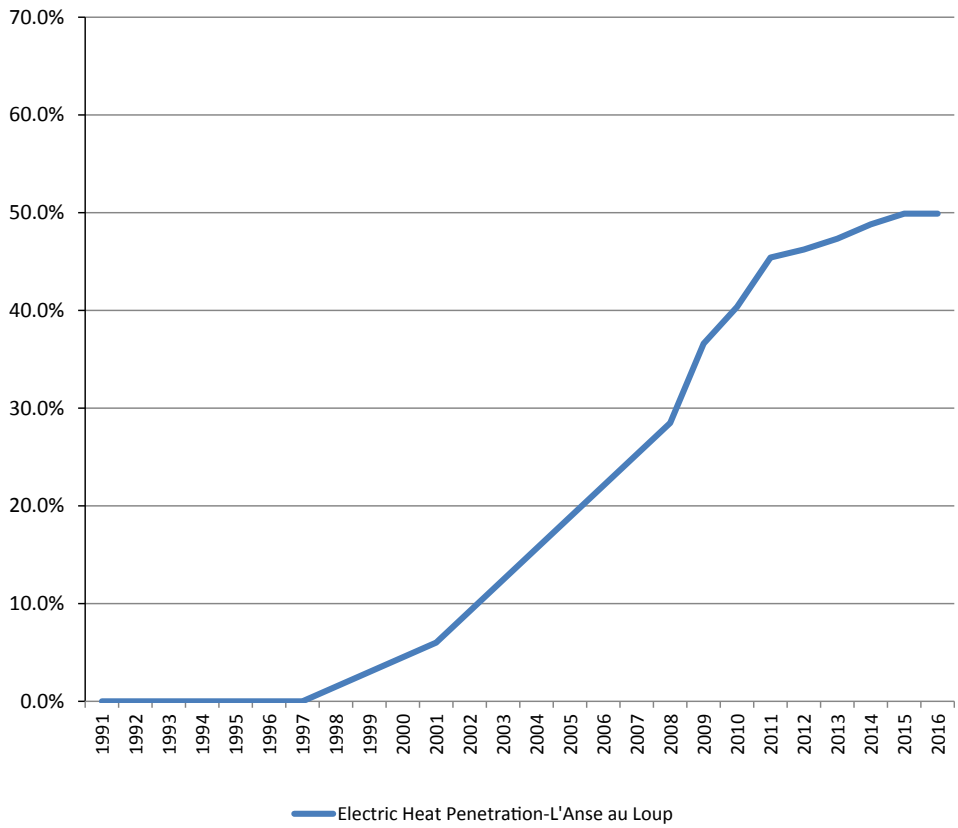

Fig. 4. Electric Heat Penetration-L'Anse au Loup.
Data Source: Provided by NL Hydro on request.

late 2012 made the policy decision to proceed. The project is being completed by another government owned entity, Nalcor, which is also the parent of NL Hydro and from which NL Hydro is contractually required to purchase the energy on a cost-plus basis.

Under current legislation, the PUB follows a traditional cost-of-service (COS) approach to setting rates. The estimated cost of that project has escalated so much, from $6.2 billion in 2011 to $12.7 billion by mid-2017, that under the regulatory COS system, the residential price of electricity on the island would more than double once the project is completed; see Nalcor (2016). That would make the flat per KWh price of electricity there even higher than the third-block rate in isolated diesel systems like the ISL one. If residential demand is price-elastic in the long run, then such a large change in price could affect the realization of revenues from that customer class. Thus, reconsideration of the regulatory approach to cost recovery appears inevitable.

In conclusion, the natural experiment aspect of this analysis is of methodological interest in its own right. However, the actual results are of practical importance. In the case at hand, the apparent response to change in price is large enough to suggest that residential electricity demand is indeed price-elastic. That finding sends a message to utilities, regulators, and policymakers. That is, when faced with a large permanent change in the real price of electricity, which customers perceive as long lasting, the long-run consumption response can be substantial.

References

Battalio, Raymond C., Kagel, John H., Winkler, Robin C., Winett, Richard A., 1979. Residential electricity demand: an experimental study. Rev. Econ. Stat. 62 (2), 180–189.

Bernard, Jean-Thomas, Bolduc, Denis, Yameogo, Nadège-Désirée, 2011. A pseudo-panel data model of household electricity demand. Resour. Energy Econ. 33 (1), 315–325.

Boogen, Nina, Datta, Souvik, Filippini, Massimo, 2017. Dynamic models of residential demand: evidence from Switzerland. Energy Strat. Rev. 18, 85–92.

Choi, Seungmoon, Pellen, Alistair, Masson, Virginie, 2017. How does daylight saving time affect electricity demand? An answer using aggregate data from a natural experiment in Western Australia. Energy Econ. 66, 247–260.

Deryugina, Tatyana, MacKay, Alexander, Reif, Julian, 2017. The Log-run Dynamics of Electricity Demand: Evidence from Municipal Aggregation. June, NBER Working Paper No. w23483.

Espey, J., Espey, M., 2004. Turning on the lights: a meta-analysis of residential electricity demand elasticities. J. Agric. Appl. Econ. 36 (1), 65–81.

Faruqui, Ahmed, Sergici, Sanem, 2010. Household response to dynamic pricing of electricity: a survey of 15 experiments. J. Regul. Econ. 38 (2), 193–225.

Feehan, James P., 2012. Newfoundland's Electricity Options: Making the Right Choice Requires an Efficient Pricing Regime. C. D. Howe Institute e-brief 129. C. D. Howe Institute, Toronto. https://www.cdhowe.org/sites/default/files/attachments/research_papers/mixed/ebrief_129_0.pdf.

Jessoe, Katrina, Rapson, David, 2014. Knowledge is (less) power: experimental evidence from residential energy use. Am. Econ. Rev. 104 (4), 1417–1438.

Krishnamurthy, Chandra Kiran B., Kristöm, Bengt, 2015. A cross-country analysis of residential electricity demand in 11 OECD-countries. Resour. Energy Econ. 39, 68–88.

Nalcor, 2016. Muskrat Falls Update: Technical Briefing. June 24, 2016. Nalcor Energy, St. John's, Newfoundland and Labrador.

Narayan, Paresh Kumar, Smyth, Russell, Prasad, Arti, 2007. Electricity consumption in G7 countries: a panel cointegration analysis of residential demand elasticities. Energy Pol. 37, 4485–4494.

PUB, 1996. Report of The Board of Commissioners of Public Utilities to the Honourable Minister of Mines and Energy Government of Newfoundland and Labrador on a Referral by The Lieutenant-Governor in Council on Electrical Rates in the Labrador Straits Area From L'Anse au Clair to Red Bay. July 12, 1996, Available at: http://pub.nl.ca/applications/NLH2013GRA-Amended/files/rfi/IN-NLH-103.pdf.

PUB, 2012. Review of Two Generation Expansion Options for the Least-cost Supply of Power to Island Interconnected Customers for the Period 2011–2067. Newfoundland and Labrador Board of Commissioners of Public Utilities, St. John's. http://www.gov.nl.ca/lowerchurchillproject/muskrat_falls_pub_final_report.pdf.

Spees, Kathleen, Lave, Lester B., 2007. Demand response and electricity market efficiency. Electr. J. 20 (3), 69–85.