Behavioural analytics for use in causal attribution in a market transformational energy efficiency program

Kevin Monte de Ramos, KMDR Recherche, Montreal, QC
Carl Acocella, Hydro Quebec, Montreal, QC

ABSTRACT

Without a framework for evaluating market effects, free ridership may be overstated and net savings reduced. In this paper, we highlight how one electric utility is approaching this issue. *KMDR Recherche* will present a framework for the GWh attribution of market transformational effects and the underlying tasks involved. If your program impacts the market, going through this process will transform your evaluations.

RECYC-FRIGO, an appliance recycling program launched in 2008, seeks to remove and properly dispose of inefficient refrigerators and freezers from the residential market. Households are encouraged through a series of promotional campaigns and financial incentives to retire old and under-utilized refrigeration units.

The electric utility funds activities with the expectation that by changing the market structure and developing new consumer attitudes ongoing energy impacts are realized. A simplified program theory consists of four program activities, six anticipated outcomes, and a single targeted impact … energy savings.

Recyc Frigo targets known market hurdles, such as the consumer's valuation of functional appliances and the lack of infrastructure to recycle hazardous waste. As such, an evaluation framework was developed that quantifies both program and market effects.

It is hypothesized that changes in market attitudes and abilities will effect behavioural outcomes; leading to the removal and safe disposal of inefficient refrigeration units from the homes. We realized electricity savings from the incremental rise in end-use efficiencies as aged refrigeration units were disposed of sooner rather later and replaced by more efficient models.

This staged transformational model relies on changes in market attitudes and abilities to effect sustained market effects. The timing of transformation is limited only by the ability of the market to move through each of the six stages of change; in much the same way as students progress through grades toward graduation before enrolling at the university.

In this paper, we present an approach to assess market transformation via theory-based evaluation, causal attribution models, and behavioural analytics. Therefore, providing a market-based evaluation that moves us from away from NTGRs that historically have been constrained in programs yielding significant market effects.

Key concepts to be presented are based on a 'staged transformational model' adopted at this leading electric utility in North America; suggesting that cognitive and market outcomes lead to longer-term behavioural changes among market actors and structural changes in the overall residential energy efficiency market.

CONTEXT OF OUR WORK

Like other North American utilities, Hydro Quebec has been asked to deliver greater and greater energy savings. In an effort to meet their 11 TWh energy efficiency commitment, the utility has extended their offerings.

Among the traditional resource acquisition programs, Hydro Quebec has begun to explore market transformational savings. In a province where home heat is often electric and North American trends are tempered by language, Hydro Quebec is better situated than most utilities to attribute market effects to their efforts.

Still, the pursuit of market transformational energy savings requires detailed planning, coordination, and commitment. Marian Brown of Southern California Edison presented short course before the 2008 Kansas Corporation Commission Workshop on Energy Efficiency. The presentation was titled "Savings Estimation Methods for Energy Efficiency Programs: A Half-Hour Guide".

She introduced a valuable concept; that traditional Net-to-Gross approaches are inappropriate 'when one or more related programs have long-term effects on a market'. She explains we must monitor the market itself over time and attempt to determine which changes have resulted from the program(s) of interest. Marian Brown concedes that attribution is both difficult and often imprecise, but concludes that substantial program impacts simply cannot be ignored.

In a resource acquisition program the two approaches are equivalent, but the net effects approach is more expensive because it relies on an extended series of attitudinal, behavioral, and market characterization studies to provide for longitudinal analysis of market effect. Therefore, net effects evaluations are recommended only when significant incremental savings are expected from market effects. Selection of the proper approach rests in the ratio: incremental savings per incremental evaluation cost. Where this ratio meets the cost-effectiveness test, the net effects should be selected.

Realizing a net-to-gross evaluation would miss valued kWh savings, Hydro Quebec requested that *KMDR Recherche* develop a net effects evaluation framework to capture the impact of changing the overall market infrastructure.

PROGRAM OVERVIEW

Our work began with a resource acquisition program that would significantly impact the market, both in the near-term and the long-term. The program selected to illustrate market transformational effects was a refrigerator recycling program known to Hydro Quebec's customers as Recyc-Frigo.

Recyc-Frigo appears as an incentive-based program seeking to keep aged refrigeration units from returning to the grid once disposed by a household. However, program administrators introduced a new appliance recycler that would be active across Quebec, planned marketing efforts that would significantly raise the number of aged refrigeration units disposed from the home, and promoted legislative initiatives that favor the permanent removal of appliance disposals from returning to the electric grid via secondary market actors.

We could discuss sophisticated program efforts to transition from resource acquisition approaches to market transformational interventions over extended periods of time. We could highlight the opportunities and risks that were weighed in the design and development of the program. And we could highlight the challenge of integrating market transformational theory into an established energy efficiency portfolio. While these topics are interesting and worthy of further inquiry, our focus for this paper is on the techniques and methods necessary to demonstrate market transformational effects.

A FRAMEWORK FOR MARKET EFFECTS STUDY

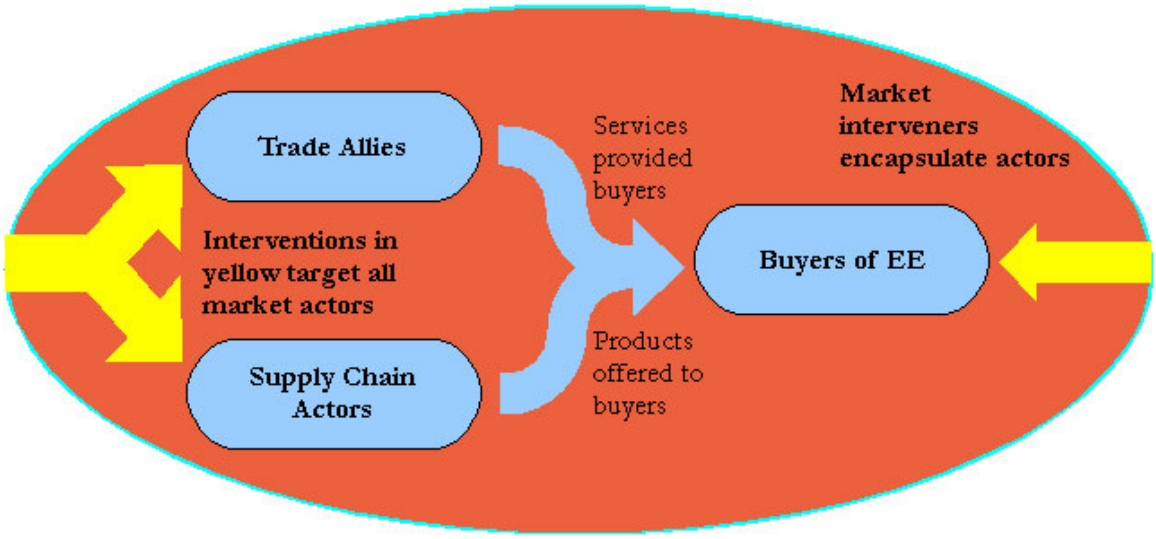
Anyone wishing to demonstrate market effects must realize that the utility, whether conscious of their own efforts or not, must manage the market in addition to the program. While it is possible to impact a market without intent, it is nearly impossible to attribute the resulting impacts without a strategic intent and an allocation of resources to market tracking.

KMDR Recherche offered a simplified view of the market to facilitate program planning. In the diagram the follows, we introduce a set of key actors in the market: (1) buyers of energy efficiency, (2) supply chain actors, (3) trade allies/service providers, and (4) broad market stakeholders/regulators.

By offering this simplified view of the energy efficiency market, one can appreciate the scope of the market and visualize points of potential intervention. This prospective is important when planning market transformational initiatives and coordinating market effects assessment.

The complexity of markets makes concision difficult, obscures consensus, and defies the precise attribution of impacts. Still, Hydro Quebec chose to pursue these types of initiatives after a careful consideration of both risk and reward.

Illustration 1: A Simplified View of the Energy Efficiency Market[1]



Another important tool for market transformational initiatives and their evaluation is a model of behavioral change. The approach utilized was that of a generic logic model for market transformational initiatives.

In the transformational model that follows, the utility expends resources to inform, educate, and train, as well as invest in the market; thereby, creating measurable outputs. The outputs sought within Recyc-Frigo include, but were not limited to, the awareness that aged refrigerators may consume as much as 4.8 times the electricity of a new refrigerator, introduction of new recyclers, knowledge of specific contaminants associated with refrigerators, and the linkage of a refrigerator disposal with broader environmental concerns.

Once the market acquired the outputs, Hydro Quebec expected new attitudes and/or abilities to emerge. Specifically, we expected a growing dissatisfaction with aged refrigeration units, added convenience in the removal of refrigeration units from the home, and a recycling facility able to recycle 95% of materials that compose a residential class refrigerator or freezer.

As market actors acknowledge these outcomes, Hydro Quebec anticipated desired behaviors to be adopted. The behaviors desired were twofold: to increase the number of qualified units being disposed from the households and higher proportion of disposals meeting their end of life.

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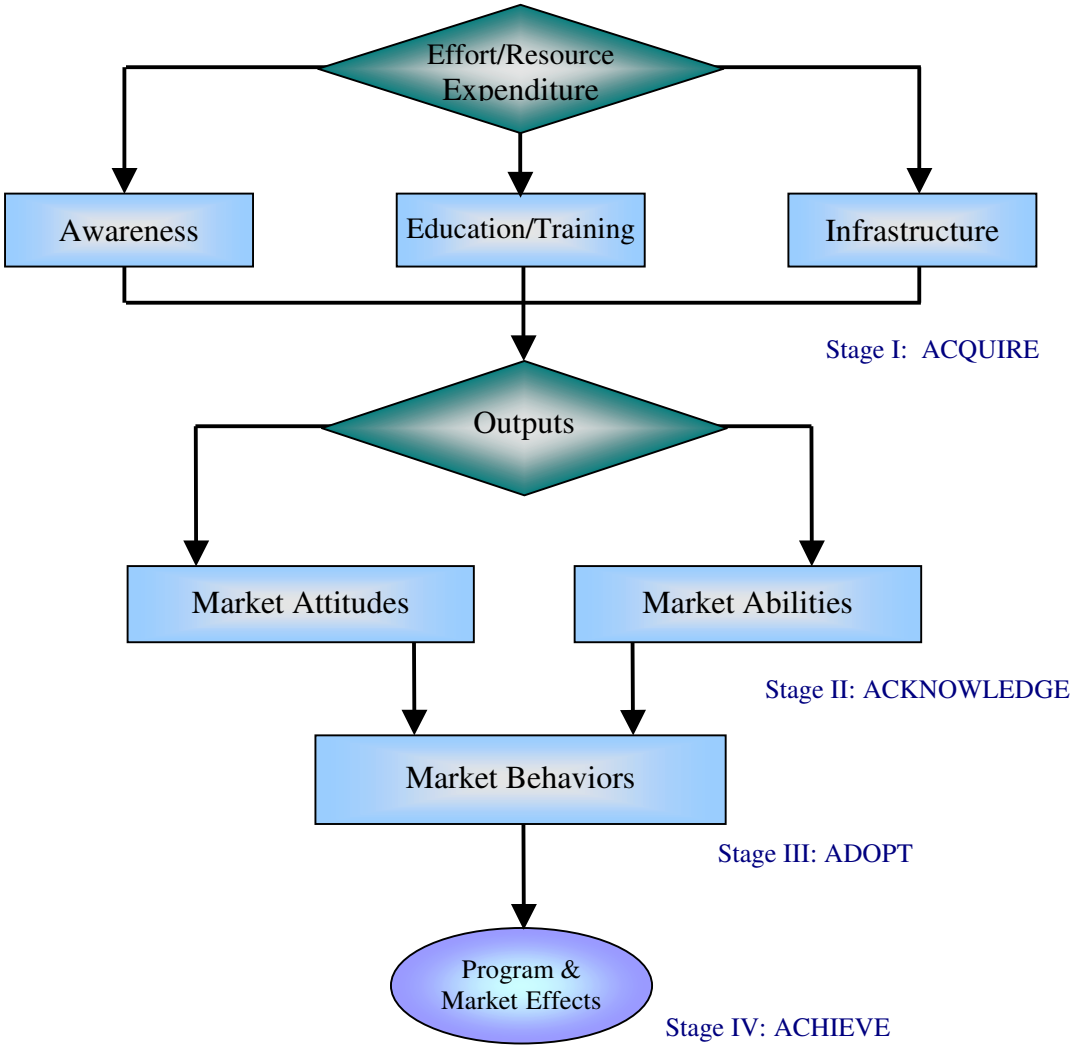
[1] Monte de Ramos, Kevin, "An Approach to Integrate Market Effects Research into the Design of Hydro Quebec's CI&I Energy Efficiency Programs", The Quebec Energy Efficiency Market, October 29, 2007, page 4.

An intentional omission from the transformational model is that infrastructure alone can alter behaviors. Not only providing an outlet for pent up demand, but also facilitating a new awareness of options previously unavailable to the households. Ultimately this may change key attitudes regarding available options. Furthermore, *KMDR Recherche* acknowledges behaviors may themselves reinforce key attitudes and critical infrastructure components; each behavior that results in a valued experience justifies the thought process leading to the behavior.

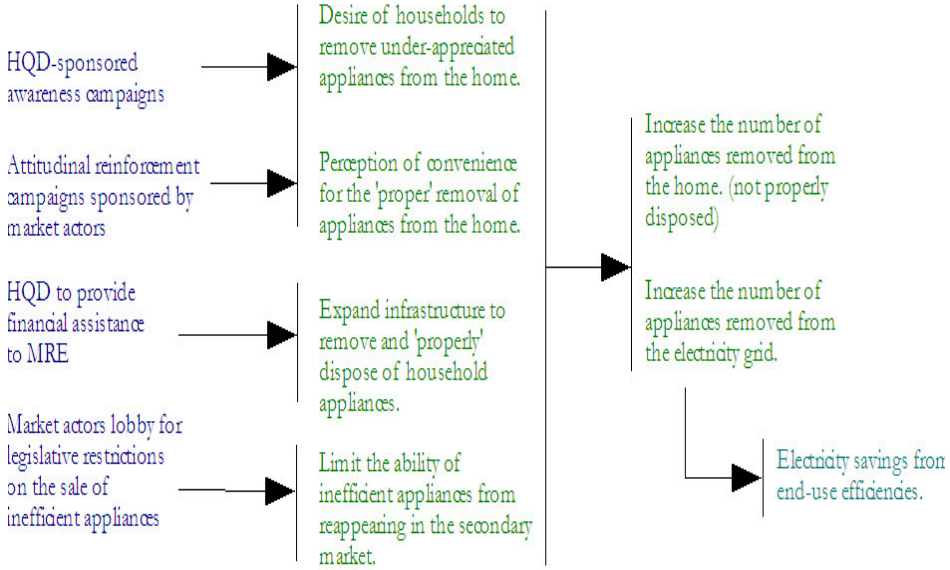
These aspects of market transformation are ignored within Recyc-Frigo because the behaviors sought by Hydro Quebec were singular transactions over the planning horizon: namely, the disposal of aged refrigeration units from a given home are expected only once over the eight years of study. As such, the generic transformational model offered by *KMDR Recherche w*as customized to suit the logic of the program intervention.

Illustration 2: The Staged Transformational Model



The growing proportion of units removed from the grid are the final step in the model; generating electricity savings as ever-younger units replace the aged refrigeration units. The following program logic model helps to illustrate the outcomes expected for Recyc-Frigo along with the tactics leveraged to bring about those changes.

Illustration 3: Recyc-Frigo Program Logic Model



THE ASSESSMENT OF MARKET EFFECTS

Market effects research requires both the measurement of the market and the classification of temporary and sustained impacts. The latter results from market transformational initiatives. Since attributing these impacts are more difficult and encompass short-term spillover effects, our approach to evaluation planning started with the investigation of how to best attribute transformational effects.

Following generally from the California Evaluation Framework, we advised Hydro Quebec that market effects evaluation requires the following questions be addressed:

1. Does program theory identify specific market effects to be measured?

2. Does program theory provide a causal linkage between program activities and the expected outcomes?

3. Does program theory establish a pathway for sustained market intervention or the reoccurrence of program impacts beyond the program period?

4. Is there a high probability that observed market changes resulted from program activities?

Our efforts began by answering each of these questions with respect to the program.

Does program theory identify specific market effects to be measured? Yes, program administrators implemented tracking studies of market attitudes favoring the disposal of inefficient refrigeration units and the market's ability to properly remove these units from the electricity grid.

Attitudes thought important were the perceived convenience of appliance disposal, acknowledged concern for the environment, energy costs, electricity availability, and their intention to dispose of under-appreciated appliances within their home.

Market abilities were correlated with the extent of the infrastructure from point of pick-up through the processing of disposed of units, regulatory controls that limit the resale of inefficient appliances, and the ability of service professionals to meet the market demand.

Tracking appliance recyclers and supply chain actors also were added to further characterize the appliance recycling market. In addition, three points of measure were sought to triangulate the level of achieved market effects; an effort to overcome the inherent imprecision of broad market study.

Does program theory provide a causal linkage between program activities and the expected outcomes? Hydro Quebec has provided logic models for both program and market transformational effects resulting from program activities. Casual linkages are hypothesized between program activities and critical outcomes.

Awareness campaigns funded by Hydro Quebec throughout the formative years of the program are expected to create the desire of consumers to dispose of inefficient appliances from the home. Hydro Quebec stipulates that this attitude will require some level of reinforcement through on-going awareness campaigns to be funded in part or in full by market actors with a vested interest in the recycling industry; namely recycling plant owners and municipalities. Where market actors fail to reinforce consumer attitudes for appliance removal, Hydro Quebec has contingency plans to sponsor reinforcement campaigns as needed to maintain consumer attitudes.

Financing provided within the program provided for the construction and operation of a state-of-the-art recycling plant within Quebec. Currently, Hydro Quebec has committed to cover a significant portion of the required start-up capital expenditures and operating expenses for the first three years of plant operation.

Hydro Quebec has become involved with lobbies seeking to limit the resale of inefficient appliances and to raise energy efficiency standards for new appliances. Hydro Quebec also sought stakeholders to promote the enforcement of existing environmental legislation; thereby, promoting the utilization of assets created within the context of the program.

Does program theory establish a pathway for a sustained market intervention or the reoccurrence of program impacts beyond the program period? Yes, encapsulated in the per unit rate offered program actors was the cost of advertising, customer call centers, pick-up services, and the means of transporting units from across the province to a centralized processing facility.

These assets are thought to have a life well beyond the horizon of the current energy efficiency plan. As such, Hydro Quebec expects program activities to raise market capacity to recycle aged appliances well beyond the 3-year program horizon.

Involved market actors will reinforce market attitudes created during program implementation. Hydro Quebec will leverage support from municipalities and others to assist with this reinforcement. It is thought the residential customers and later business clientele will continue to utilize the recycling facilities established.

Program activities include lobbying efforts to pass new and enforce existing environmental legislation. If successful, these limitations on market actors will promote the continued removal of inefficient appliances from the electricity grid for many years beyond the program.

Is there a high probability that observed market changes resulted from program efforts? There exist three key metrics to test the causation of market effects: consumer attitudes, market capacity, and regulatory action. Program activities are linked directly to baseline measurements associated with each. Where program actions are taken and the resulting outcomes are observed, program theory establishes a plausible attribution of observed market effects; both energy and non-energy benefits.

To provide the reader with the planned work, we offer the following tables taken from the market effects evaluation plan.

Illustration 4: Market Effects Tracking Metrics

Activities to monitor	Monitoring & Verification Metrics	Frequency of Measure	Purpose/ Usefulness
HQD-sponsored awareness campaigns	Annual budget allocations	Upon change	Demonstrate the level of planned intervention and qualify the expectation of consumer attitudes for the removal of inefficient appliances from the home.
	Monthly campaign budgets	Monthly	
	Geo-mapping of planned activities	Upon change	
	Monthly campaign/activity spending	Monthly	Document the timing and level of market intervention and provide a basis for causal influence on observed market outcomes.
	Geo-mapping of activities/campaigns	Monthly	
	Date-stamping of implemented campaigns	Upon change	
	Sentiment towards sustainability issues: cost of electricity, resource conservation, and other environmental issues	Annually & after large campaigns	Qualify and quantify output from program activities and demonstrate precedent outcomes thought necessary for the realization of long-term attitudinal outcomes leading to desired behaviors during the program period.
	Perceived convenience of appliance disposal	Quarterly	
	Specific recall of critical messages	Quarterly	
	Number of calls received in response to ads	Monthly	
	Request for informational materials	Monthly	

Outcomes monitored	Program and Market Evaluation Metrics	Frequency of Measure	Purpose/ Usefulness
Desire of households to remove unappreciated appliances	Proportion of residents who acknowledge a dissatisfaction with existing appliances; qualified by the rationale for dissatisfaction.	Quarterly Baseline Measurement	Qualify the causal linkages between promotional and informational strategies toward the removal of aged or unused appliances.
	Extent of their dissatisfaction; measured in the duration of their malcontent, the imminence of appliance removal from the home, and the anticipated method of removal.		Better understand factors influencing consumer attitudes regarding appliance removal.
	Types, models, and ages of appliances targeted by consumer for removal.		Establish degree of correlation between the emergence of market attitudes and the timing of messages embedded in the promotional and informational efforts
	Stated barriers to appliance removal.		
Expand the infrastructure to remove and properly dispose of home appliances	Market capacity for appliance recycling.	Annual Baseline Measurement	Quantify the added capacity resulting from HQD's intervention. Estimate the value-added of incentives and added convenience of call center and pick-up services.
	Profile of market actors and the process/incentives used to encourage appliance removal.		

MEASURING THE IMPACTS

Energy savings for the first three years of program operation rest in just three categories: program volume, program spillover, and market spillover. Within the first three years of operation, no legislative action is expected and therefore, no GWh has been planned for this category of action.

Annually, the recycling plant put into the market by Hydro Quebec was expected to collect 110,000 units in its first year of full operation. Planned program volume was 85,000 units with an additional 25,000 coming from other market actors; thereby, total plant volume added up to 110,000 units. An additional 27,500 units were to be processed by other actors in the market.

The volumes specified are incremental; unit volume above and beyond the observed market trend. At the end of the first year of full operation, Hydro Quebec planned for an additional 137,500 refrigeration units to be removed from the electricity grid; beyond the 45,000 units that naturally reach their end of life. This would be more than a threefold increase in the number of qualifying refrigeration units being removed from the grid; resulting in an estimated 130 GWh of electricity savings per year.

Illustration 5: Planned Program and Market Effects

Activity Description	During Program 2008-2010 3 years
Promotional and informational campaigns funded by HQD to realize planned program volume	68% of plant capacity 255,000 units **242 GWh**
Promotional and informational campaigns funded by HQD that spillover into the broader market	20% spillover to other centers 82,500 units **78 GWh**
Market effect on plant production	20% of plant capacity 75,000 units **71 GWh**
HQD and MRE support of new legislation to limit the resale of inefficient/aged appliances	Passage assumed somewhere within this 3-year period with some pre-legislation adoption
*Claimed Savings = 895 GWh	391 GWh

After two years of operation, the market tracking had been analyzed and presented in the following dashboard (Illustration 6 on the following page). Although it may be difficult for readers to see the numbers, this quantitative portrait of market behaviors shows the volume of qualifying disposals through their removed from the grid.

Three stars appearing in the dashboard relate to the planned program forecasts summarized in Illustration 5 above. First, we want to know how many qualifying units are disposed of annually; represented by the blue refrigerator just to the right of center. Prior to the program, 145,000 qualifying refrigeration units were disposed from the home. In the first full year of operation following the start of Recyc-Frigo, the number of qualifying disposals was estimated to be 314,000. This is an increase 160,000 units; exceeding the planned incremental volume of 137,500 units by 23,500 units.

The second step was to find out what happened to the qualifying disposals. The easiest number to track is the program volume; represented by the star just below the blue fridge and to the left. Prior to the program, this market did not exist and therefore process zero units. During the first year following the program, the recycling plant was credited with the pick-up and removal of 128,000 units. This volume is above the planned 110,000 units; exceeding planned plant volume by 18,000 in its first full year of operation.

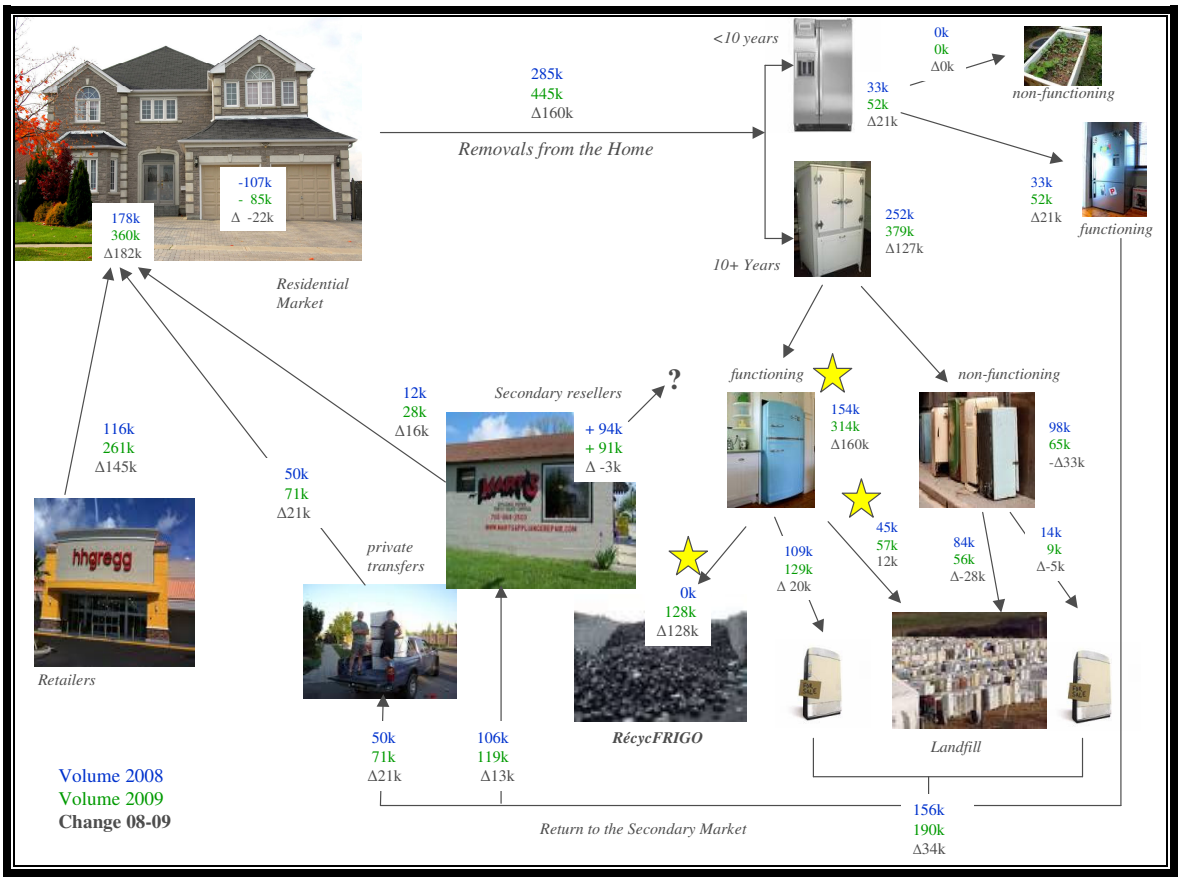
The next step was to appreciate the number of qualifying units that were removed from the electric grid within Quebec. This value is provided by the star just below and to the right of the blue fridge. In the year prior to program start, 45,000 units met their natural end of life.

Ignoring the 1.52% organic growth across the Province of Quebec, an incremental number of units from the grid rose to 185,000 units. Of course, 128,000 refrigeration units were directly attributable to the program, leaving 57,000 units as a market outcome. Subtracting the former from the later, we observed a net market effect of 12,000 units.

This is well below the planned 27,500 units that were to be processed by the market; however, the difference is explained by the expanded program mandate which allowed the recycling plant to operate at higher utilization rates than was planned; thereby, allowing units to flow into the program verses meeting their end of life via other market actors.

While this means Hydro Quebec may have paid for units that would have otherwise met their end of life, it does not imply free ridership because we are talking of disposals that were unlikely to have happened without program activities.

Illustration 6: Behavioral Tracking Dashboard



SUMMARY OF KEY PROGRAM METRICS

The following chart that follows in Illustration 7 highlights that Quebec realized the disposal of 160,000 aged refrigeration units from the home; exceeding program targets by 22,500 units. The recycling plant established by Hydro Quebec process 128,000 refrigeration units verses the 110,000 units planned. Other actors did not pick-up the desired practices as expected; falling 15,500 units short of program targets. Still, overall Hydro Quebec's Recyc-Frigo saw an overall surplus of 2,500 units beyond program targets.

Illustration 7: Summary of Program Metrics

Targeted Effects	Pre-Program	Post-Program	Commentary
Number of qualifying units disposed from the home	**154k**	**314k**	**160k incremental 137.5k planned**
Number of qualify disposals removed by the program	**0k**	**128k**	**128k incremental 110k planned**
Number of qualify disposals removed by the other actors	**45k**	**57k**	**12.0k additional 27.5k planned**
Number of units removed from the grid (total)	**45k *(29%)***	**185k *(59%)***	**140k incremental 137.5k planned 2.5k surplus**

ESTABLISHING NET EFFECTS

Applying a standard net-to-gross approach to a program that has a large market effect not only misses key impacts, it can also distorts savings estimates. Let us examine a net-to-gross approach versus a net market effects approach.

Net-to-Gross Approach. Without market tracking, evaluators would likely measure in their participant and non-participant studies the same effects that we observed in our market tracking studies. The difference would be in the timing of the findings and a lack of supporting market characterization studies. As such, the same behaviors could be interpreted differently.

Evaluators would find that 314k qualifying units were disposed during the first program year. Of these qualifying disposals, program service providers would remove 128k units from the grid. This would leave 186k qualifying non-participant disposals. Of those non-participant disposals, 57k (31%) units met their end of life 'naturally', leaving 129k (69%) units returning to the secondary market.

Without knowledge that the number of qualifying disposals increased dramatically, evaluators could wrongly conclude that in the absence the program 31% of units would have met their end-of-life. Therefore, a .69 net-to-gross ratio would have been established for the unit volume. Under this scenario, the program would be credited with just 128k x .69 or 89k units. Using the established per unit savings estimate established from the program pilot of 948 kWh per unit, the net program effect would be 89k units x 948 kWh/unit or 84 GWh annually.

Net Effects Approach. Compare this with net market effects calculations. We observed that qualifying disposals rose from 154k units to 314k units; a difference of 160k units.

Anecdotal evidence provided by market actors saying the program significantly impacted the availability of aged refrigeration units on the secondary market coupled with attitudinal research showing strong environmental concern and a perceived ease of disposal resulting from the program provides confidence that the program had a causal influence on the number of qualifying disposals.

Accepting the incremental effect was largely due to the program, we sought to document the number of units that were removed from the electric grid. Our research found that 128k units were processed within the Recyc-Frigo program and other market actors removed an incremental 12k units from the grid.

In summary, we observed that 140k more units met their life after the program than in the year prior. Of this incremental effect, 128k were attributed to the program and 12k attributed as a market

spillover effect. As such, the program would be credited with 140k units times the same 948 kWh/unit or 133 GWh per year. This is the equivalent of applying a net-to-gross ratio of 1.09.

Net-to-Gross verses Net Effects. Without knowledge of the increased number of qualifying disposals from the home, evaluators would have established the market trend at 57k qualifying disposals being removed from the grid annually verses this being a desirable and intended program effect. As a result, the net-to-gross calculations would have attributed just 89k units; whereas, the market tracking studies allow for the attribution of 140k units to the program. This is a difference of 49k units; approximated 49 GWH annually in savings.

VALUE ADDED OF THE MARKET STUDIES

Hydro Quebec spent approximately $300,000 additional to conduct the suite of market studies required and hired a market transformational expert to serve as the performance analyst for an additional $250,000. In total, $550,000 more was spent on the net effects study than following the typical net-to-gross evaluation approach.

The benefit of the market transformational consulting and market tracking is the difference between the two approaches; namely 133 GWh minus 84 GWh. The result is 49 GWh per year. Dividing the cost by the incremental energy savings, the cost of conserved energy is equal to $0.0112 or just over 1¢ per kWh.

This is significantly cheaper than the 29¢ per kWh paid Hydro Quebec to realize the savings. In fact, the same level of savings within the program would have cost Hydro Quebec an additional $14.2 million.

CONCLUSSIONS

KMDR Recherche cautions readers that energy savings at 1¢ per kWh are not readily available. Hydro Quebec had to spend the 29¢ per kWh to achieve the savings. Still, we advise that programs seeking to impact the energy markets should explore market effects study and be willing to make the necessary expenditures when the proper business case presents itself. By doing so, additional energy savings can be attributed to program efforts at a relatively small incremental cost.

Our experience with market effects study suggests that moving from resource acquisition planning to market transformational implementation is not a simple process. This first effort by Hydro Quebec had some relatively high transaction costs; namely, the coaching needed to connect the concerns for savings attribution with the program design. The integration of experimental design concepts often conflicts with the desire of implementers who seek to maximize productivity versus the sponsoring entity that must realize energy savings for their investment of resources.

Following the knowledge transfer that occurred, the need for coaching is expected to be half. Additionally, the cost of market tracking can be significantly reduced within the scope of Hydro Quebec's energy efficiency portfolio. Our experience suggests that markets often overlap; allowing sponsoring utilities to track more than one intervention within a single set of market studies.

We offer that market effects study can capture program market effects at a fraction of the program cost per GWh. Therefore, we encourage other utilities to explore program theory for avenues that lead to market effects. By building a business case for market effects study, you may find that energy savings are achievable at or below a few cents per kilowatt hour.