The Price is Right: Aligning Utility Incentives with Decarbonization Goals

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Abstract

The goal of customer-facing utility programs has evolved from energy conservation to decarbonization, and correspondingly, incentives have expanded to include not only efficiency measures, but also renewables and electrification. How does a utility determine the relative value of a more efficient appliance compared to converting a customer to electric hot water? One answer: by using carbon mitigation as the common unit of analysis.

This paper introduces a carbon-based incentive model, which was developed to aid utilities in setting incentive levels that are based on the carbon mitigation potential of a measure. In addition to carbon mitigation by measure, the model also quantifies financial cost/benefit of a given measure for the utility, such that incentive levels can be informed by both carbon and net revenue impacts. This paper provides an overview of the model and examples of how it can be used.

Introduction

Electric utilities are pivotal players in the pace and success of economy-wide decarbonization. They procure energy and determine the extent to which it is renewable, and they influence customer consumption through their marketing and incentive programs. Robust incentive programs for utility customers can work to raise awareness and confidence in strategic electrification measures (e.g., heat pumps, induction stoves, electric yard equipment), to make measures more financially accessible, and to send market signals that help customers prioritize different measures. Gone are the days where it's sufficient to focus strictly on energy conservation—today's utility programs need to strike a dynamic balance between incentivizing efficiency and fuel switching such that building stock and vehicles are ready for a fossil-fuel-free future.

With support from the American Public Power Association's (APPA) Demonstration of Energy & Efficiency Developments (DEED) Program, CET and the Massachusetts Municipal Wholesale Electric Company (MMWEC) built a model to aid MMWEC's public utility members with setting energy efficiency and electrification incentives at levels that are fully aligned with Massachusetts' decarbonization objectives. The model uses carbon as the metric for deriving incentive levels and for comparing carbon benefits from a range of measure types, including efficiency, electrification, renewable energy, demand response, and storage. In addition to the carbon analysis, the model also calculates economic impacts of installed measures for the customer and utility. By adopting this approach to setting incentives, utilities will help climate-conscious (and wallet-conscious) customers prioritize measures and will optimize their programs for decarbonization.

Methods

Measures and model data and assumptions

Table 1 lists the measures considered in the carbon-based incentive model. For each measure, we used a combination of sources to estimate average annual electricity usage/savings (kWh/yr) and demand impacts (kW). These sources are all cited in the model and primarily include the Massachusetts Technical Reference Manual (MA TRM), Department of Energy, MA Clean Energy Center, Efficiency Maine, and ENERGY STAR. To ensure accuracy and the absence of computational errors, the model was peer reviewed by three public power professionals. Further, model users have full transparency into model assumptions and calculations.

Using the utility's pricing inputs and assumed values for electricity usage tied to each measure (sourced from the MA TRM and net positive or negative whether it is fuel switching or efficiency), the model calculates the economic impact on the customer of operating the measure (Appendix 1). The model does not account for capital cost nor does it consider historic energy costs in the operating cost calculation. The model also calculates the impact of each installed measure on the utility's revenue (Appendix 1). This analysis is broken down by contribution margin (i.e., revenue less variable costs) and demand savings/cost and the net benefits/costs. These values are presented alongside the estimated carbon mitigation impact of the measure. Other key modeling assumptions are detailed in Table 2.

Table 1. Measures included in the C-based incentive model.

Category	Measures
Building Envelope	Weatherization
Space & Water Heating	Heat pump water heater Air source heat pump Ground source heat pump
Appliances (induction / electric)	Induction stove Clothes washer Clothes dryer Heat pump clothes dryer DehumidifierRefrigerator Window AC Air purifier Pool pump
EV	Plug-in hybrid Plug-in electric
Yard Equipment	Push mower String/Hedge trimmer Leaf blower Pole saw
Demand Response	Battery Level 2 EV charger Electric hot water heater Heat pump controllers Wifi thermostat
Renewables & Storage	Solar PV

	Battery
Thermostats	Programmable Wifi

Table 2. Key assumptions intrinsic to the C-based incentive model.

Model Input / Output	Assumptions
Grid Emissions Factors (EFs)	The model calculates 10-yr, 15-yr, and 20-yr average emissions factors • EFs are calculated based on present-day emissions factor and target year for carbon neutrality (input by user); • Progress toward carbon neutrality is linear.
Annual electric usage and demand impact	• The following measures assume the customer switches from fossil fuel to electric: heat pumps, heat pump water heater, induction stove, clothes dryer, EV; • All other measures assume the customer is switching to a more efficient electric unit; • Weatherization is assumed for a home heated with heat pumps (i.e., this could be a customer switching from delivered fuel or radiant electric).
Energy prices	The model assumes flat pricing for both electricity and fossil fuels over the lifetime of the measures.
Measure carbon emissions	The 10, 15, and 20-year grid EFs are used for calculating lifetime emissions offsets for each measure; the model uses the EF that is closest to the expected lifetime of the measure.

Model use

The model is built for use by utility managers and analysts and is designed to be easily adapted to reflect the specific conditions of different utilities. Users have control over the following utility-specific model inputs:

- **Electricity pricing**. Users input total retail price and breakdown by energy, transmission, and distribution and capacity pricing.
- **Electricity carbon emissions**. Users input the current emissions factor for their energy portfolio and target date for carbon neutrality. Default values are provided if actual numbers are unknown.
- **Existing utility incentives**. For comparative purposes, users can input existing incentives for any measures currently incentivized. With this data, the model calculates the current incentive in terms of \$/ton CO_2.
- **Carbon price**. The model's recommended incentives are calculated based on the utility's willingness to pay for carbon. The user inputs a price per ton of carbon avoided (e.g., \$50/ton, \$100/ton CO_2) and the model calculates carbon-based incentives based on the willingness to pay.

A portion of the user input tab is shown in Figure 1.

UTILITY DATA INPUT SHEET

		Units	Notes
Electricity Pricing			
Retail price	$ 0.1417	$/kWh	
Residential price energy (variable)	$ 0.07	$/kWh	
Residential price transmission (fixed)	$ 0.03	$/kWh	
Residential price distribution (fixed)	$ 0.05	$/kWh	
Transmission & Capacity			
Capacity	3.26	$/kW-mo	3.26 = 2022-2024 average
Transmission RNS 9	11.98	$/kW-mo	11.98 = 2022-2024 average
Transmission RNS 1	0.16	$/kW-mo	0.16 = 2022-2024 average
Total	15.4	$/kW-mo	
Electricity Carbon Emissions			
Grid carbon emissions factor	0.343	lb/kWh	Default = 0.343 lb/kWh
Average peak emissions factor	0.85	lb/kWh	Default = 0.85 lb/kWh
Year carbon neutrality achieved	2050	target year	Default = 2050
Current year	2024		

INCENTIVE CALCULATOR

Cost of carbon	$100.00	$/ton
Net-revenue incentive	50%	

Figure 1. Screenshot of input tab of the carbon-based incentives model, where users input utility-specific information and willingness to pay for carbon.

Results & Discussion

Unless otherwise noted, the results and discussion presented here are based on the following adjustable assumptions about the utility's grid emissions: emissions factor = 0.343 lb/kWh; peak emissions factor = 0.84 lb/kWh; target date for carbon neutrality = 2050. These are average values for municipal light plants in Massachusetts. Where applicable, the carbon price is set at \$100/ton CO_2 mitigated.

Prioritizing incentives

It comes as no surprise that the measures with the largest recommended incentives are ground source and air source heat pumps, respectively (Table 3). The longer lifetime of the ground source heat pump, 25 vs. 18 years, is what drives the larger incentive. Other top measures from a carbon mitigation perspective are, in rank order: plug-in EVs, solar PV, and heat pump water heaters. For utilities with cleaner grids or near-term carbon neutrality goals, the C-based incentive for solar PV falls in size and ranking.

Table 3. Rank order of top five largest incentives and their relative size to one another using the C-based incentive model and the following assumptions: Grid emissions factor = 0.343 lb/kWh; peak emissions factor = 0.84 lb/kWh; carbon neutrality = 2050.

Measure	Relative incentive
1-ton Ground source heat pump (average across gas, oil, propane conversions)	1
1-ton Air source heat pumps (average across gas, oil, propane conversions)	0.74
Plug-in EV	0.58
Solar PV	0.55
Heat pump water heater	0.39

Incentives for energy efficient appliances are a compulsory component of most utility energy efficiency programs. From a strict carbon perspective, the model begs the question: how valuable are they in contributing to residential decarbonization goals (Table 4)? At a willingness to pay of

$100/ton CO_2, the model calculates an average incentive for ground source heat pumps of $3,739 *per ton* vs. $5 for a dishwasher.

On the other hand, relying strictly on this model to set incentive prices may unintentionally de-emphasize adoption of measures that have other benefits besides carbon mitigation (e.g., the health benefits of moving away from gas stoves) or that are key to whole-home decarbonization. For example, clothes dryers and stoves can mean the difference between a gas pipeline into the home or not. Utilities using the model may want to consider adding a “fuel switching” multiplier to applicable appliances to align market signals more accurately with the long-term and society-wide decarbonization benefits they yield.

Table 4. Relative size of the recommended C-Based incentive for appliances compared to a 1-ton ground source heat pump.

Measure	Relative incentive
1-ton Ground source heat pump (average across gas, oil, propane conversions)	1
Clothes washer	0.1
Induction stove	0.08
Heat pump clothes dryer	0.03
Clothes dryer	0.02
Pool pump	0.003
Dishwasher	0.001

Benefits to utility of incentivizing efficiency and electrification upgrades

An encouraging finding from this study is that most efficiency and electrification measures yield net financial benefits for utilities in terms of the combined contribution margin and demand savings. The exception to this is appliances. In cases where a customer is switching to a more efficient system, the reduction in sales and therefore contribution margin exceeds any demand savings, resulting in a small lifetime revenue loss to the utility in the range of tens to hundreds of dollars. The financial implications for customers adopting these measures are more site-specific and contingent on prevailing electricity and fossil fuel prices. In some parts of the country and for some fuels, electrification is more cost effective than others.

While induction stoves, heat pump water heaters, and heat pumps create new demand costs for utilities the costs are smaller than the contribution margin from the increased sale of electricity, making the measures an overall financial win for utilities (Table 5).

Table 5. Sample net revenue impact on utilities for strategic electrification measures under the following cost structure: residential energy = $0.08/kWh; transmission = $0.03/kWh; distribution = $0.05/kWh.

Measure	Lifetime Contribution Margin ($)	Lifetime Demand Impact ($)	Net Lifetime Revenue Impact ($)
Induction stove	$438	-$118	$319
Heat pump water heater	$1,731	-$1,033	$698

1-ton air source heat pump	$3,241	-$971	$2,270

Carbon cost equivalent under current incentives

Using incentives currently offered by one or more utilities in MMWEC's network, the analysis shows a range from $13 to $1,899 in the effective price paid for carbon (Table 6). This is among the most enlightening findings of the study because the results provide utilities with guidance for re-calibrating incentives in terms of both size and their relative scale compared to other incentives.

Table 6. Range in price paid per ton of CO_2 mitigated under current incentives offered by MMWEC utilities.

Measure	Current Incentive ($)	Effective Carbon Price ($/ton CO_2)	Calculated C-Based Incentive at $100/t CO2 ($)
Clothes washer (ENERGY STAR)	$50	$13	$382
Pool pump	$175	$1,899	$12

The model can highlight incentives that are particularly low from the perspective of incentivizing carbon mitigation. Based on incentives currently offered by utilities in the MMWEC network, the heat pump incentives stand out. At a flat rate of $1,000 regardless of system size, the incentive equates to an average $31/ton CO_2 for 1-ton heat pumps but drops to $13.50/ton for a 2.3-ton heat pump system, the average size assumed in the Massachusetts Technical Reference Manual (TRM) used by the Mass Save program. By comparison, the $10,000 whole-home air source heat pump incentive offered by Mass Save equates to an average $162/ton CO_2 for a 2.3-ton heat pump system (higher or lower depending on the original fuel) or about $100/ton CO_2 for a 3.5-ton system, which is the average size installed by customers accessing incentives from MMWEC member utilities.

Incentives for Connected Homes, MMWEC's demand response program, present an interesting case where the C-Based incentive calculated by the model is modest yet the financial motivation for utilities to promote participation is quite large. For example, the C-Based incentive for a battery and a Level 2 EV charger is $70 and $37, respectively, yet the net lifetime revenue impact for the utility when a customer enrolls their device in Connected Homes is $10,300 and $8,500, respectively. Note, the C-Based incentives for Connected Homes measures are calculated strictly based on the demand *shifting* that occurs as a result of participation. In the case of the Level 2 EV charger, emissions mitigated by switching from an internal combustion engine to EV are captured in the incentive for EVs, where calculations are done assuming no participation in Connected Homes. This is another example where utilities should use the model to help guide measure sizes and prioritization but should also apply some discretion for increasing or decreasing incentive sizes when there are other factors or co-benefits at play.

Impact of grid emissions factor on calculated C-Based incentives.

A utility's target carbon neutrality date has some influence on the incentive size calculated by the model. Logically, the nearer the carbon neutrality date, the greater the potential carbon mitigation associated with strategic electrification. Therefore, the incentive for fuel switching measures increases with a decrease in the number of years until carbon neutrality. Conversely, renewable energy measures and measures that shift usage away from dirtier peak demand (e.g. Connected Homes) decrease with a decrease in the number of years until carbon neutrality.

Table 7. Sample strategic electrification and renewable energy measures and comparative C-Based incentive assuming a carbon neutral grid in 2050 vs. 2035.

Measure	Current Incentive	Carbon Value at Current Incentive (C-neutral 2050)	C-neutral in 2050	C-neutral in 2035
Heat pump water heater	$500	$34	$733	$1,578
Air source heat pump (gas conversion)	$1000	$47/1-ton system $20/2.3-ton system	$2,129/ton	$2,337/ton
Plug-in electric vehicle	$0	$0	$2,561	$2,639
EV charger with enrollment in Connected Homes (demand response)	$10/month	$173	$73	$52
Solar PV (9 kW)	$0.30/Watt	$248	$1,974	$933
Induction stove	$750	$229	$332	$412
Electric leaf blower	$40	$51	$79	$79

Conclusions and Recommendations

Using a carbon-based incentive model can help utilities design energy-efficiency and electrification programs that maximize total carbon reductions and that allocate budgets to the measures that contribute most to climate resiliency and yield the best economic results for utilities and their customers.

Application of the model demonstrates strong rationale for large heat pump incentives and for incentives that increase with the size of the system. Results also encourage comparatively low incentives for electric appliances that will see increasingly small carbon reductions as utility power portfolios move toward net-zero carbon emissions. With respect to demand response measures (i.e., payments for peak load shifting), the model helps quantify the benefit of shifting customer usage from peak grid usage to periods of lower grid usage when less carbon intensive resources are providing power to the grid. The model also helps utilities evaluate the benefits of load shifting from both carbon emissions and economic perspectives.

It is important to recognize that the model has limitations. It focuses strictly on the carbon and financial impacts of energy efficiency and electrification measures and fails to account for other health and environmental co-benefits associated with many of the technologies. Users should use the model to guide the relative size and ranking of incentives but should also consider other factors when determining actual incentive values.

References

MA TRM (Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures). November 2021. Mass Save. https://www.masssavedata.com/TRL/Technical%20Reference%20Manual%202022-2024%20Final.pdf

Appendix 1: Screenshots of the Excel-based C-Based Incentive Model

The three screenshots below show the three categories of data presented in the output tab: electricity impact, financial impact (from the customer and utility perspective), and carbon impact and incentive analysis. In the model, these outputs are presented in contiguous columns, with one row per measure.

Measures	Electricity Impact		
Energy Audit Incentives	Annual Electric Usage (kWh/yr)	Lifetime Electric Usage (kWh/lifetime)	Demand Impact (kW)
Heat Pump Rebates			
1-ton Air Source Heat Pump (gas conversion)	2251	40516	0.29

Measures	Customer Economic Impact		MLP Revenue Impact				
Energy Audit Incentives	Annual Economic Impact ($/yr)	Lifetime Economic Impact ($/lifetime)	Annual Contribution Margin ($/yr)	Lifetime Contribution Margin ($/lifetime)	Demand Savings ($/yr)	Lifetime Demand Savings ($/lifetime)	Net Revenue Impact ($/lifetime)
Heat Pump Rebates							
1-ton Air Source Heat Pump (gas conversion)	$ 318.95	$ 5,741	$ 161	$ 2,905	$ (54)	$ (971)	$ 1,934

Measures	Carbon Impact		Incentive Analysis			
Energy Audit Incentives	Estimated CO2 Emissions Impact (t CO2/yr)	Estimated CO2 Emissions Impact (t CO2/lifetime)	Carbon-based Incentive Price ($/rebate)	Net revenue based Incentive ($/rebate)	Current MLP Incentive	Current Carbon Price ($/ton)
Heat Pump Rebates						
1-ton Air Source Heat Pump (gas conversion)	-1.30	-23.4	$ 2,337	$ 967	$1,000	$ 43