Carbon-Based Incentives: Aligning Utility Incentives with the Decarbonization Impacts of Efficiency and Electrification Measures

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Introduction

Electric utilities are pivotal players in the pace and success of our 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 of focusing strictly on energy conservation—today's utility programs need to strike a dynamic balance between incentivizing efficiency and fuel switching such that our 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, the Center for EcoTechnology (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 the Commonwealth's 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.

The following report details methods used to build the model and key findings and recommendations.

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.

Using the utility's pricing inputs and assumed values for electricity usage tied to each measure (net positive or negative whether it is fuel switching or efficiency), the model calculates the economic impact on the customer of operating the measure. 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. 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 Dehumidifier Refrigerator 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

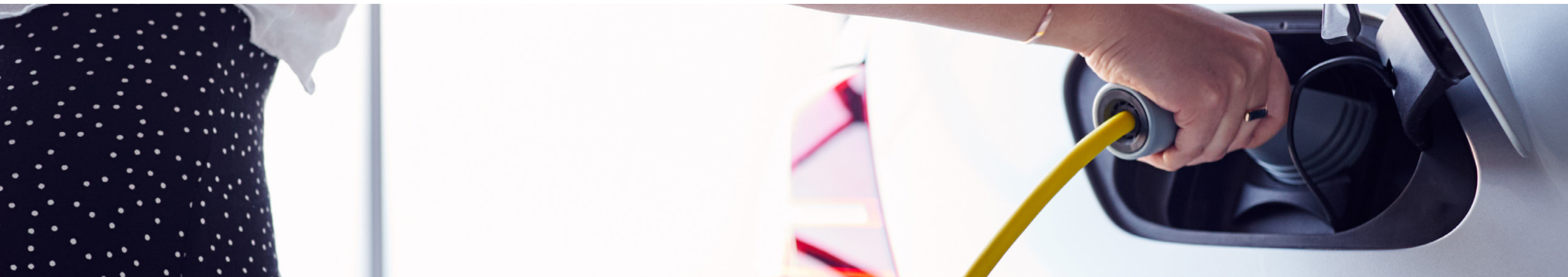
Table 2. Key assumptions intrinsic to the C-based incentive model.

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.



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.

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 utility's 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.

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 \$50/ton CO_2, the model calculates an average incentive for ground source heat pumps of \$1,862 per ton vs. \$6 for a pool pump.

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.

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

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.

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 equivalent 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 ($)	Equivalent Carbon Price ($/ton CO_2)	Calculated C-Based Incentive at $50/t CO_2 ($)
Clothes washer (ENERGY STAR)	$50	$13	$191
Pool pump	$175	$1,899	$6

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.

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	$730	$778
Air source heat pump (gas conversion)	$1000	$47/1-ton system $20/2.3-ton system	$1,058/ ton	$1,476/ ton
Plug-in electric vehicle	$0	$0	$1,279	$1309
EV charger with enrollment in Connected Homes (demand response)	$10/ month	$173	$89	$29
Solar PV (9 kW)	$0.30/ Watt	$248	$1,028	$544
Induction stove	$750	$229	$164	$198
Electric leaf blower	$40	$51	$40	$40

Key Takeaways and Recommendations

- The carbon-based incentive model can help MMWEC members and other utilities design energy-efficiency programs and incentives based on total carbon reductions. This means that municipal utilities can direct budgets to the most impactful measures that yield the best economic results for municipal utilities and their customers.

- The model provides rationale for strong heat pump incentives and for incentives that increase with the size of the system. Conversely, the model supports lowering incentives for electric appliances that will see increasingly small carbon reductions as municipal utility power portfolios move toward net-zero carbon emissions.

- The model includes energy savings measures and demand response measures. Based on an analysis of the Connected Homes program, 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.

- The model 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.

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