Save Money with Clean Heat (SMCH)

A new approach to getting MA housing to net zero by 2050 that saves the average homeowner $2,500 each year and requires no new taxes.

SMCH builds on the ideas in the Future of Clean Heat bill and the Clean Heat Standard.

How do we get to net zero on existing houses and save money?

By adding heat pumps to replace AC units (and keeping the furnace as a backup), adding insulation and solar panels, and using the subsidies in the IRA and from MassSave, the average 1,800sf home in MA can save $2,500 per year and cut their carbon emissions to zero.

An average house needs a 13kW array to reach net zero on its heat-pump heating, all other electricity needs and to charge an EV. This fits on the average roof.

Key benefits of the "Save Money with Clean Heat" (SMCH) bill:

1. Massachusetts cuts its carbon emissions from homes to net zero by 2050 (and will likely be the first state in the nation to do so). See Appendix 1.
2. By replacing their AC unit (not their furnace or boiler) with a heat pump, and adding solar panels and insulation, all homeowners will save money on their current heating and electric bills. An average homeowner will save $2,500 per year with SMCH which is likely to make it very popular with voters. See Appendix 2. Low-income households on discounted electricity can save money by heating with a heat pump even without adding solar panels.
3. Even including financing costs with the MCCB (Massachusetts Community Climate Bank) loans, which enable no cash down from the homeowner for both heat pumps and solar panels, costs decrease by $111/month for the average home in MA. See Appendix 3.
4. No one must remove their gas furnace (leaving cheap heat even in bitterly-cold winters) or gas stove (making allies of cooks)
5. Most of the cost of the insulation (see Appendix 4), heat pumps (see Appendix 5) and solar panels (see Appendix 6) comes from the federal IRA or from current MA legislation such as that for MassSave and net metering. With the combined subsides, for most homeowners, a heat pump is free or 80% off (see Appendix 5). Also, all homes newly fitted with heat pumps will now have AC, which is also likely to make the bill popular with voters.
6. No new taxes. This is likely to make the bill popular with everyone. Exploiting the current IRA and MA subsides is key and this is complicated.
7. This will mean training "Clean Heat Concierges" (hosted within MassSave) to help homeowners navigate it all. Note that the MA Community Climate Bank legislation includes concierges for exactly this reason.
8. Low or zero interest-rate financing provided by MassSave (the Heat Loan) and Mass Community Climate Bank means no cash is required up front from the homeowner. See Appendix 3. Even after including the loan financing costs (principal and interest) the total monthly cost (heating bill, plus electric bill, plus financing) drops by $111 per month.
9. No legal challenge from the gas utilities because no one is required to take out their natural gas furnace (they will just be using it a lot less).
10. By keeping the existing heater, every home that has a back-up generator today will have backup heat during grid outages, which is not possible if the furnace is replaced with a heat pump. Even with a furnace, back up heat requires a portable generator to run the circulating pumps or fans, but heat pumps require far too much electricity for a portable generator.

11. People can still cook on gas if they prefer that to cooking on an electric stove. This is not possible if the natural gas network is dismantled. However, electricity-powered induction stoves are heavily subsidized under the IRA and are almost free to low-income residents. This can be targeted to EJ communities like Springfield. After the IRA subsidy of $840, a new induction stove (which list for $899) costs only $59 to low-income households. Eliminating cooking on gas is the fastest way to improve indoor-air quality and reduce hospital admissions for asthma, which are common problems in EJ communities. Springfield was recently found to be "the asthma capital of the USA". That's the entire USA, not just MA.
12. A homeowner who adds solar panels will see an increase in their house price by about 4.1%. This is from a study by Zillow: https://www.zillow.com/research/solar-panels-house-sell-more-23798/ This study looked only at the presence or absence of solar panels, it did not look at the size of the solar panel array. Because a bigger array reduces the bills more than a smaller array, a bigger array will increase the house price more than a smaller array. In general (see the reference below), cutting utility bills by $1 per year leads to a $20 increase in house price. Using this rule, an array that offsets the entire electric bill (after adding a heat pump) would increase the house price about 7%.
13. In addition large-scale academic research shows that adding heat pumps also increases house prices by between 4-7% see here: https://greenzerocarbonhome.com/heat-pumps-increase-your-house-price-4-7/
14. Together, adding heat pumps and solar panels can increase the house price between 8-14%. On the average-priced house in MA ($630,000 in 2024) this is between $50,000 and $90,000 in additional benefit to the homeowner.

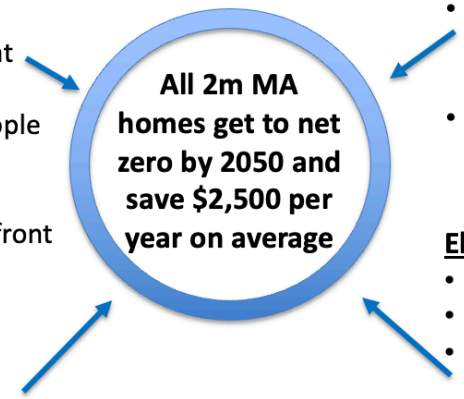
Key elements of the "Save Money with Clean Heat" Bill:

MassSave

- Triple **scale** to 75,000 homes p.a.
- Triple **scope** to include solar and heat pumps
- Add in IRA incentives allows tripling on current MA budget
- Shift cost from electricity to fossil fuels to incentivize heat pumps (and EVs)
- Need concierges to help people through it all
- Low (or zero) interest rate financing means no cash upfront
- MassSave to be run by new public authority (to avoid conflicts and IRA denial)

IRA

- Add IRA subsidies to MassSave ones
- Cap at current MassSave subsidy
- Limit total subsidy by income according to IRA rules
- Allows MassSave to triple on current budget



Electricity

- Solar, solar, solar
- New time-of-use tariff
- Smart metering to apply discounts to heat pump and EV usage, not entire bill
- Existing low-income discounts (up to 50%) already make heat pumps cheaper than natural gas

Heating

- Require all new AC units to be heat pumps
  - With IRA and MassSave subsidies HPs cheaper than new AC units.
  - Current AC units will need to be replaced by 2050 anyway. 60% of homes have window AC, 20% central
- Keep current furnace (as back up) and gas stove

MassSave

1. Triple the **scale** of MassSave from retrofitting 25,000 houses per year today to 75,000 houses per year so that all two million MA homes are retrofitted by 2050. Saving $2,500 a year is likely to be a major incentive for homeowners to use MassSave. So is getting a brand-new heating and AC system for free or 80% off. Likewise, adding AC to homes that do not have it today is a major incentive for homeowners. However, a marketing budget for outreach, particularly to EJ communities, will likely be required.
2. Expand the **scope** of the MassSave audit to include heat pumps and solar panels in addition to the current focus on insulation and draft sealing. Although MassSave currently heavily subsidizes heat pumps, the audit does not make recommendations on how the running costs compare to the existing heating bill. This new audit will include energy analysis and financial analysis, such as the investment, subsidies and the payback period for insulation, heat pumps and solar panels.

3. Tripling the **scale** and **scope** of MassSave without increasing its budget can be achieved by adding the IRA subsidies for insulation to the MassSave ones. See the next section for details. This cuts the MassSave subsidy by 76% and keeps the total subsidy to the homeowner the same as it currently is (see Appendix 4). There is no need for additional subsidies for heat pumps and solar panels, the current subsidies are very generous and make getting a new heating and AC system (a heat pump) free or 80% off for most homeowners. See Appendix 5. Window inserts (sometimes called interior storm windows) can be good value for money by blocking drafts and adding insulation, particularly on sash windows. Window inserts and are also subsidized under the IRA.
4. Shift the cost of MassSave to fossil fuels (including delivered fuels) away from electricity. This encourages heating with heat pumps rather than natural gas, and encourages the use of EVs.
5. The funding to pay for the "Clean Heat Concierge" program will come from extending the surcharge on natural gas and electricity to delivered fuels like propane, heating oil and biomass. Also, the shift in the funding of MassSave away from electricity and onto natural gas and other delivered fuels (heating oil and propane) can help to fund this program.
6. MassSave will extend its quality assurance overview of installers from the current focus on just insulation installers to include heat pump installers and solar panel installers. This reassurance is vital to giving homeowners the confidence to move forward with major renovations on their homes.
7. MassSave to be run by new authority (similar to MassPort?) to avoid conflicts and prevent the IRS from limiting the IRA subsidies which they do if the subsidy is from a utility, but they don't if the subsidy is from a state entity.

IRA

1. Supplement (or replace) the current MassSave subsidies (for insulation and heat pumps) with the IRA subsides, capped at the current MassSave subsidy, so that the increase in scale can be achieved with the current MassSave budget. Limit the total subsidies to the cost of the insulation and the heat pump (today they often exceed the total cost). Under IRA Part A Section 25C "Energy Efficient Home Improvement" tax credits up to 30% of the purchase cost (but not installation cost) of insulation on your "main" home up to $1,200 can be claimed each year with no lifetime maximum. If the insulation is spread over 2 years (e.g., the attic is insulated one year and the basement ceiling the next) then the total subsidy would be $2,400 or more than the $2,000 existing MassSave subsidy. In addition, the IRA Part B "Electrification Rebate" includes up to $1,600 for insulation (including installation) for "low" income, (less than $113,600 in eastern MA) and $800 for "medium" income (less than $213,000 in eastern MA). Part B has a maximum lifetime limit of $14,000. The IRA Part C "Energy-

Efficiency Rebates" are up to $8,000 and are based on cutting the modelled energy usage by more than 35% which is easily achievable with insulation and a heat pump. Parts B and C are limited by the IRA budget allocated to MA, but the budget is enough to run a pilot program. The results of this pilot program (which are likely to be very positive) can be used to lobby for an extension of the IRA or for replacement MA legislation. The IRA Part A tax credits are unlimited by budget allocations and can be taken each year. These alone could pay for 30% of the cost of buying (but not installing) the insulation for the attic one year and the basement ceiling the following year. The installation cost for insulation can be claimed under Part B. Both installation and insulation could be claimed under Part C. The MassSave subsidy (75% of the cost of insulation and installation up to $2,000, and up to $10,000 for a heat pump) should be integrated with these IRA subsides and cut back by the amount of all subsidies claimed under the IRA. Modelling of only the IRA Part A tax credits (and not including Part B or Part C) suggests that MassSave could triple the number of homes insulated each year on its existing budget. See Appendix 4 for an example for the subsidies for insulation and Appendix 5 for the subsidies for a heat pump.

2. The current MassSave auditors can be trained to become "Clean Heat Concierges" to assist homeowners through the complex products, economics and subsidies. Even though the IRA Part A tax credit of $2,000 was available to all Americans during 2023, only 1.5% of US homes used the IRA tax credits in 2023. Many electricity users with heat pumps are still paying the R1 rate when they could be getting the discounted R3 rate. It will be far cheaper to promote the use of the current incentives than to add new ones. Clean Heat Concierges are needed to explain all this to homeowners.

Heating

1. Require that all replacement AC units be heat pumps, which with MassSave and IRA subsides are cheaper than new AC units. See Appendix 5. AC units typically last 15 years so all will need to be replaced by 2050, whereas furnaces last 40 years and we do not have 40 years to get to net zero. About 80% of MA homes have AC today, about 20% have central AC and 60% have window-mounted AC units (source: EIA.gov). Hence, the focus on replacing AC units, not furnaces. Also, almost every house in MA heated with a heat pump will need fossil-fuel back up on bitterly-cold winter days to stay at 70F. Finally, heating with natural gas is cheaper than heating with a heat pump on utility-priced electricity at outdoor temperatures above about 40F. Without a backup source of heat, heating year round on sheat pumps on utility electricity will double the heating bill, see Appendix 2. With the current 50% low-income electricity discount, heating with heat pumps is cheaper than heating with natural gas no matter what the outdoor temperature.

2. All homes should retain their existing heater. If they do not add solar panels or do not get discounted electricity then, in order to ensure that the overall heating and electricity bills do not increase, they should use the existing heater when the outdoor temperature is below 40F. This is set on the thermostat, and it ensures that everyone's bills go down after adding a heat pump. Houses without AC today will now have it. Installers should be required to set the thermostat to the optimal temperature at installation and update the homeowner each year because this temperature changes with the relative prices for heating fuels and electricity.

Electricity

1. Require electric utilities to introduce a time-of-use (TOU) electricity tariff to reduce the strain on the grid (and cut both the pollution and the high cost of peaker plants) and provide low-cost electricity to low-income people, including tenants. Target this to EJ communities. TOU tariffs in other states generally have lower cost electricity at night. This becomes the perfect time to charge the EV, run the dishwasher, do the laundry, and run the clothes dryer and other heavy loads.
2. The TOU tariff should include incentives for charging EVs and running heat pumps. The existing R3 rate is for electric heating and heat pumps count. This is approximately a 1.5c/kWh (5%) reduction in the cost of utility electricity for every kWh used on the meter, not just those used for the heat pump. Few people know about this, and simply promoting it would help accelerate the adoption of heat pumps. Unitil just increased the winter-time discount to 6c from the 1.5c currently offered by Eversource. This R3 rate could be made more generous and incorporated into the TOU rate to encourage heat pump use early in the mornings so that the house is warmed up before most of the day's demand ramps up.
3. A similar tariff could be introduced for charging EVs. These tariff rates can be interactive and allow the utility to curtail heavy loads at peak times of usage in return for a big discount. MA electric utilities already offer substantial discounts on Basic Rate service for low-income residents. These discounts vary from 10% to 50%. This existing rate structure makes heat pumps and EVs far more financially attractive to low-income residents.
4. In addition, use smart metering to apply discounted rates only to heat pump or EV usage, not the entire bill.
5. Allow rolling 20 mins curtailment during peak demand, in return for big discount per kWh. Texas runs a program like this with a 20-30% discount on the monthly bill. California has a similar program. These programs are widely credited with keeping the lights on during energy emergencies.
6. Simplify the solar interconnection process with electric utilities to make it far easier (and quicker) for homes to add rooftop solar panels so that they can cut their electric bill in half. Most roofs have space for enough solar panels to offset the entire electric

bill including the additional electricity required to run the heat pump. Many homes have roof space for enough solar panels to charge an EV too at one quarter of the cost of charging it with utility electricity – this will accelerate the adoption of EVs.

7. Encourage the scale up of Community-Sourced Solar (or CSS, such as NexAmp) so that tenants (and homeowners with shady roofs) can benefit from cheap, clean solar power. Encourage towns, groups of residents, MLPs, big box stores, and utilities to provide CSS and sell the cheap electricity to residents via the existing z-metering law (which is how CSS works). This would make electricity for tenants (and homeowners with shady roofs) a lot cheaper (e.g., a 50% cut in bills) vs a 10-12.5% cut with today's CSS providers. If electricity is 40% off Basic Rate, heating with a heat pump is the same cost as heating with natural gas. This means that low-income tenants (who currently qualify for a discount of up to 50% on their electric bill) would not need to install their own solar panels to get to net zero and cut their bills substantially.
8. Also permit towns, landlords, groups of residents, MLPs, and utilities to install networked geothermal systems for apartments and condos (once the feasibility of this is proven in the current trials in ten towns).
9. An array big enough to provide all the electricity to run both a heat pump and all current electricity uses in the home (a 9kW array) will occupy only 35% of the roof area on the average 1,800sf home in MA. This assumes the house have a typical sloped roof. To also provide enough electricity to power an EV doing 12,000 miles per year requires a 13kW array which would occupy approximately half the roof area. See Appendix 8.

Financing

1. Because of the fragmentary nature of the incentives under the IRA, MassSave and utility programs, which often create delays between the purchase of the product and the receipt of the money by the homeowner, a bridge financing mechanism will be needed, see below.
2. The MassSave Heat Loan does this today, by providing 0% interest financing on up to $25,000 for 7 years that allows the homeowner to start the program and pay down the loan when the rebates and savings come in. To allow this to be expanded to cover a 3x increase in the scale of MassSave, the 0% interest should be limited to low-income households with a medium interest rate (perhaps 2% to match the Massachusetts Community Climate Bank interest rates) for medium-income households and set to market rate (perhaps 5%) for high-income households.
3. For the IRA tax credits, the IRS should permit the payment to be made to the installer (for instance of insulation, heat pumps or solar) at the time of purchase, with the taxpayer responsible only if they do not have the taxable income at tax time. This is the same way the IRA rebates (and the MA MOR-EV rebates) for EVs

currently work and is essential to allow low- and medium- income households to use the rebates.

4. The Energy Saver Home Loan program (introduced in the MA Community Climate Bank, MCCB) funds up to $100,000 of home energy improvements. In the Boston area, families earning up to $190,000 a year are eligible. The loan is a 20-year subordinate mortgage with interest of 0.5% to 2% depending on income. The first 18 months are interest only. This is big enough to allow a homeowner to move forward with the expensive items like solar and heat pumps without the heavy upfront cash outlay (that is a barrier to many homeowners) and avoids them turning to leasing companies that often charge usurious interest rates and high commissions that are reminiscent of the sub-prime mortgage era. Using this MCCB loan to fund solar panels and a heat pump is illustrated in Appendix 3. Even after including the principal and interest payments, total costs (heating, electricity and loan costs) drop by $111 per month or $1,332 per year. This homeowner now has a brand-new heating system (heat pump). If they have AC already, they now have a brand-new AC system. If they do not have AC, they now have it. And their carbon emissions from their home have been cut to zero.
5. With a few extra solar panels, they can also charge an EV or two at home with cheap, clean solar electricity and drive from Boston to NYC and back for about $8. That journey in a gas-powered car would cost about $40. This saves the average driver about $125 a month ($1,500 a year) on top of the $1,332 on the heating and electricity bills. See Appendix 7. This cuts the carbon emissions from the home's cars to zero also.

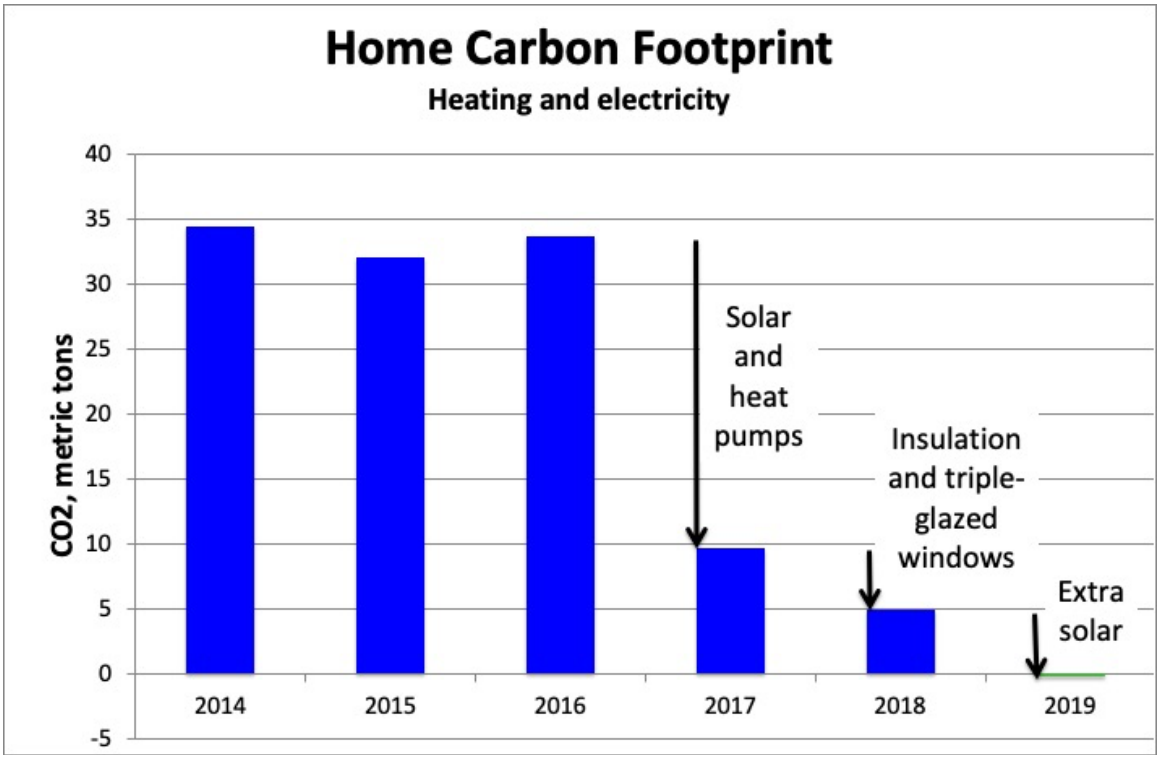
Utilities

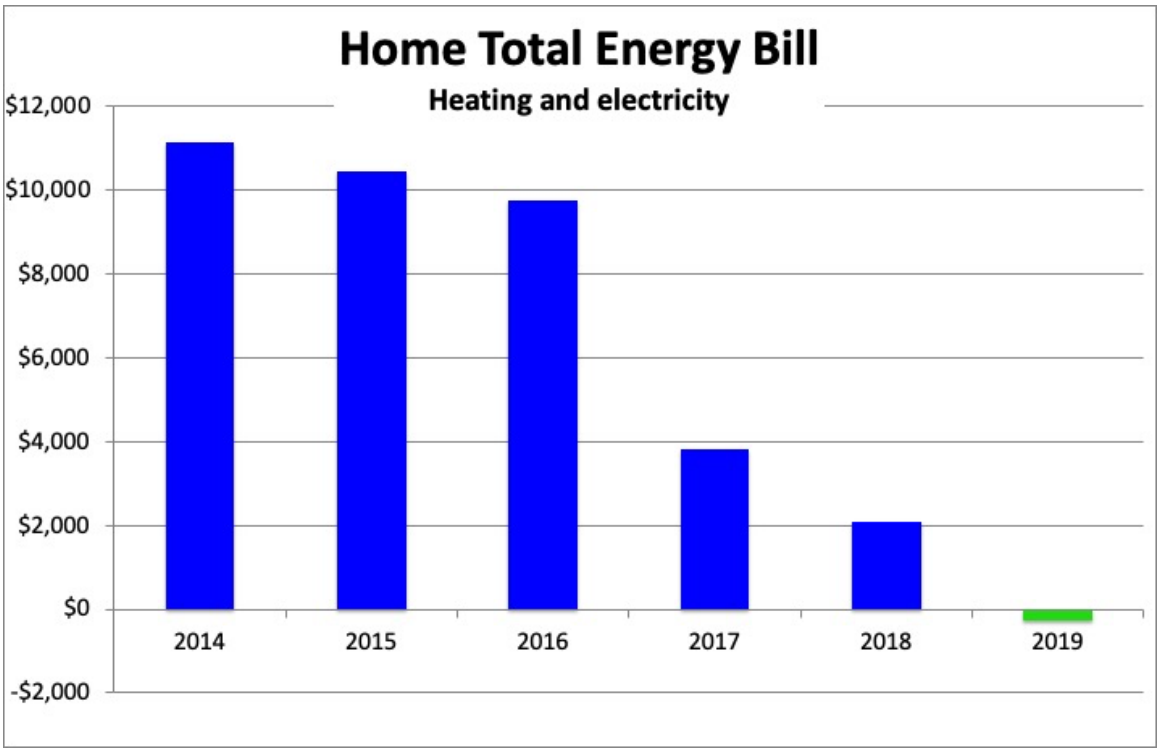
1. Require the gas utilities to create plans for operating the transmission network on the lower gas volumes created by the SMCH bill without leaving either ratepayers or taxpayers to pay for stranded assets. Spreading the fixed cost of the gas-transmission infrastructure over fewer therms of gas will lead to increases in the price of gas which will accelerate homeowners' transition to heat pumps and solar. Allow the DPU to order a less expensive "repair" in place of "replacement" for gas pipes.
2. Require electric utilities to create plans for generating and distributing the large increase in electricity required by this plan.
3. Siting of new grid infrastructure (such as new electricity substations that will be necessary to increase the electricity provided by the grid to power heat pumps and EVs) should require consultation with the effected towns and people.

   Please note that this is a draft outline for legislation. It is presented for your ideas, input and criticism with the goal of making it more effective.

Appendix 1:

Case study of a large home in Dover, MA getting to net zero carbon and net zero bills:





Summary of results for example home:

	Total money invested (after subsidies and tax credits)	Total Money Saved	Years to pay for itself	Return on Investment (after tax)	Total carbon footprint reduction (CO2 per year)
Heat pumps	$26,250	$2,888	9.1	9%	20 Tons
Insulation	$1,000	$2,923	0.3	100%	7 Tons
Triple windows	$4,500	$974	4.6	19%	2 Tons
Solar panels	$42,791	$5,572	7.7	13%	14 Tons
Total	$74,541	$12,358	6.0	15%	43 Tons

This homeowner achieved net zero carbon, net zero bills; could have financed all of it with the Heat Loan and Mass Community Climate Bank loans; and paid off the loans with the energy-bill savings before the loans were due.

Appendix 2:

Average homeowner costs before and after SMCH:

Bills today and with SMCH for average home in MA heated with natural gas

						Current bills			Bills with heat pumps but not solar		Bills under Save Money with Clean Heat law	
	Energy use - average MA house		therms translated into kWh			**Bills - house heated with natural gas**	3	COP (efficiency of heat pump)	**Bills - house heated with heat pump on utility electricity**		**Bills - house with heat pump with solar panels**	
Heating Using EIA RECS 2020 NE average heating energy psf	594	therms	17,410	kWh		$1,151	5,803	kWh needed to run heat pump	$1,894		$464	
Electricity Using EIA RECS 2020 NE average electricity psf	7,560	kWh				$2,467	7,560	kWh other electricity	$2,467	New electricity bill with heat pump, at utility prices	$605	New electricity bill with heat pump and solar
Total all bills						**$3,618**	13,363	kWh total electricity with heat pump	**$4,361**	New total bills with heat pump	**$1,069**	New total bills with heat pump and solar
Asssumptions:	Cost of natural gas		$1.94	per therm	from:	https://www.eia.gov/dnav/ng/NG_SUM_LSUM_A_EPG0_PRS_DMCF_M.htm						
	Cost of utility electricity		$0.33	c/kWh	from:	https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a						
	Cost of solar electricity		$0.08	c/kWh	from:	current quotes for solar panels in MA at $3.07 per Watt						
	Average house in MA has floor area of:		1,800	sf	from	https://www.ahs.com/home-matters/real-estate/the-2022-american-home-size-index/						

$2,500 SAVING

Appendix 3.
Estimated monthly bills with and without heat pumps and solar, including loan costs:

Impact of adding either heat pumps alone or heat pumps and solar panels to an average 1,800sf home heated by natural gas, with median family income in eastern MA (from EIA data)			
	Current monthly utility bills	Monthly utility bills after adding heat pump on utility electricity	Cost per month after adding heat pump and solar panels
Heating with natural gas	$96	$0	$0
Electricity (not for heat pump)	$206	$206	$39
Electricity for heat pump	$0	$158	$50
Total utility bills	$301	$363	$89
Adding a heat pump:			
List price of heat pump		$14,310	$14,310
MassSave rebate for heat pump (under current law)		$6,500	$6,500
IRA Part A tax credit for heat pump		$2,000	$2,000
IRA Part B low income rebate for heat pump		$8,000	$8,000
IRA Part C energy efficiency rebate for heat pump (not yet available)		$0	$0
Net price of heat pump after all rebates and credits		-$2,190	-$2,190
Reduced MassSave rebate under SMCH (which leaves the net price at zero)		$4,310	$4,310
Net price, and loan amount, for heat pump after all rebates and credits under SMCH		$0	$0
Adding solar panels:			
List price of enough solar panels to offset electric bill after adding the heat pump			$26,236
Federal tax credit of 30%			$7,871
MA tax credit , max $1,000			$1,000
Net price, and loan amount, for solar panels after tax credits			$17,366
Total loan amount for heat pump and solar panels under SMCH after rebates and tax credits		$0	$17,366
Note, max loan size is $100,000			
MCCB loan amortization, first 18 months*		$0	$0
MCCB loan amortization, after first 18 months**		$0	$72
Maximum monthly loan interest (until rebates and credits are received, max 12 months)		$24	$68
Monthly loan interest after rebates and credits are received		$0	$29
Total loan service bill during the first 18 months		$24	$68
Total loan service bill after the first 18 months		$0	$101
Total bills (utlity plus loan service) during the first 18 months	$301	$387	$157
Total bills (utlity plus loan service), after the first 18 months	$301	$363	$190
* the MCCB (Massachusetts Community Climate Bank) loan is interest only for the first 18 months			
** the entire amount of the MCCB loan for the heat pump is paid off with the credits and rebates within the first 18 months			

Note this table does not include the IRA Part C Energy Efficiency Rebates, which can be up to $8,000, because the subsidy is not yet available. However, it will become available during the implementation of SMCH which makes these savings even higher, the net price even lower, and the cash benefit (NPV) even higher. The IRA Part C Energy Efficiency Rebates can also be claimed for any of (or a combination of): heat pumps; a heat-pump hot-water tank; insulation; and window upgrades (i.e., anything that reduces energy use). Part C cannot be claimed for: electrical panel upgrades or wiring upgrades (because they do not cut energy use), but these can be claimed under Part B. All of Parts A, B and C can be claimed as long as the resident is eligible based on income. Parts B and C cannot be claimed for the same project e.g., a heat pump, but can be claimed for different projects.

Appendix 4.
Insulation costs after integrating the IRA Part A tax credits into MassSave:

Cost to insulate the average 1,800sf home in MA			
Current MassSave subsidy compared to new subsidy required to make the cost to homeowner the same after the IRA			
	Year 1	**Year 2**	**Total**
	Add 10" fiberglass to ceiling of basement	Add 12" fiberglass to attic	
Current MassSave rebate calculation:			
Cost of fiberglass batts from Home Depot	$1,120	$1,545	$2,665
Labor to install (8 hours x 2 people @ $45/hour all in)	$303	$417	$720
Total cost	$1,422	$1,962	$3,385
Current MassSave subsidy			$2,000
Net cost to homeowner			$1,385
IRA Part A tax credit calculation:			
Cost of fiberglass batts from Home Depot	$1,120	$1,545	$2,665
30% tax credit	$336	$463	$799
Net cost to homeowner	$784	$1,081	$1,865
Homeowner installs the fiberglass themselves or claims the installation cost under IRA Part B			
Current MassSave subsidy to homeowner			$2,000
New MassSave subsidy to make net cost the same with IRA Part A tax credit			$481
Cut in MassSave subsidy by adding IRA subsidy			$1,519
Cut in MassSave subsidy by adding IRA subsidy, %			76%
IRA Part B (Electrification Rebate) calculation			
Income less than $113,000 (in eastern MA)	$1,600	$1,600	$3,200
income over $113,000 but less than $213,000 (eastern MA)	$800	$800	$1,600
Net cost to homeowner after IRA Part A tax credit and IRA Part B rebate			
Income less than $113,000 (in eastern MA)	-$816	-$519	-$1,335
income over $113,000 but less than $213,000 (eastern MA)	-$16	$281	$265

Appendix 5.

Heat pumps estimated cost before and after subsidies (by income level) for an average homeowner living in an 1,800sf house in eastern MA:

Ducted Heat Pump FINANCIAL estimates - including the benefit of 0% interest MA Heat Loan, IRA and MassSave subsidies

This calculates for a **DUCTED** system at a year-round COP (efficiency) of 3.0.

	Annual income under $113,600	Annual income between $113,600 and $213,000	Annual income over $213,000
Estimated heat pump size (tons)	5	5	5
Heat pumps est. list price:	$15,555	$15,555	$15,555
Est. MassSave rebate	$6,250	$6,250	$6,250
MA Heat Loan/4% CD interest*	$4,355	$4,355	$4,355
IRA Part A Tax Credit for heat pump	$2,000	$2,000	$2,000
IRA Part B Electrification Rebate for heat pump	$8,000	$4,000	$0
IRA Part C Energy Efficiency Rebate for heat pump	?	?	?
Total Subsidies	*$20,605*	*$16,605*	*$12,605*
Net price	-$5,051	-$1,051	$2,949
Approximate cash benefit (NPV) of a ducted heat pump at utility electricity prices:	$7,333	$3,333	-$667
Approximate cash benefit (NPV) of a ducted heat pump at LCOE from rooftop solar:	$25,092	$21,092	$17,092
Approximate cash benefit (NPV) of a ducted heat pump at extra cost vs replacing AC units at utility electricity prices:	$18,495	$14,495	$10,495
Approximate cash benefit (NPV) of a ducted heat pump at extra cost vs replacing AC units at LCOE from rooftop solar:	$36,254	$32,254	$28,254

Please note: a green cell indicates a good financial investment, a red cell indicates a poor one, or at least one where the non-cash benefits such as reducing asthma and carbon emissions should be considered as well as the financial benefits.

** Some families may not have the cash available to invest in a CD even after using the 0% Heat Loan and so may not be able to take advantage of the CD interest. If this is the case for you, then eliminate the savings on this line.*

Appendix 6. Estimated cost and savings for solar panels on the average 1,800sf house in MA.

Solar Panel FINANCIAL estimates WITHOUT battery			
9 kW array	generates appro›	10,170 kWh/year	
	Gross installed cost, array only		$26,236
	Net cost after 30% FTC and $1,000 STC, array only		$17,366
	NPV SMART, array only, after tax		$1,457
	Net cost after FTC, STC, NPV SMART (array only) after tax		$15,908
	Cash benefit (after-tax NPV array cash flows (without battery))		$53,804
	Current electric bill		$2,331
	Discount rate		3.0%
	Return on investment (after-tax IRR)		24%
	Payback period, years		5
	Cost per kWh (LCOE) over 25 years (after subsidies)		$0.068
	Current price of electricity		$0.326
Cut in elec bill $1,845	Cut in current cost of electricity		79%
	Do solar panels make financial sense?	yes	

This array generates enough electricity to get to net zero while heating with a heat pump. To get to net zero on the house and charging an EV, add another 3kW to the array. A heat-pump hot-water tank requires another 1kW, total 13kW which will fit on the roof of an average 1,800sf house.

Appendix 7. Estimated cost savings for driving an EV compared to a gas-powered equivalent car on utility electricity and on rooftop solar panels.

	Tesla Model 3 Long Range RWD	Toyota Camry XLE
List price (Kelly's Blue Book)	$42,480	$31,000
Cost of level 2 home charger	$2,000	
IRA tax credit	$7,500	$0
MA MOREV rebate	$3,500	$0
Net cost	$33,480	$31,000
5-year maintenance	$1,115	$1,168
Cost per mile ($4/gal, 30c/kWh)	$0.08	$0.14
Cost per year to drive 12,000 miles	$900	$1,714
Cost per mile (solar @ 8c/kWh)	$0.02	$0.14
Cost per year to drive 12,000 miles	$240	$1,714

The yellow highlight indicates the lowest cost vehicle in each category of: net cost; 5-year maintenance; and cost to drive on either utility electricity or on electricity from solar panels. When powered by roof-top solar panels, the Tesla Model 3 costs about $1,500 per year (or $125 per month) less to run than the Toyota Camry XLE. It takes about 8 extras solar panels (3kW) to power an EV doing 10,000 miles per year.

Appendix 8. Does the solar array fit on the roof?

Does the Solar Array fit on the Roof?

Does a solar array to get to net zero fit on the roof?		
	average 1,800sf house in MA	
Additional array size needed to generate all electricity used (heat pumps plus house load)	9	kilowatts
New array electricity produced per year	10,170	kWh per year
Electricity purchased from utility per year	0	kWh per year
Electricity purchased from utility per year	$0	per year
Panel size	21.0	sf
Panel power	425	W
Number of panels needed	20	panels
Array area needed	422	sf
Existing roof area (as flat roof)	851	sf
Existing roof area as half of sloped roof area	595	sf
Existing roof area as both sides of sloped roof area	1,191	sf
Array area as % of both sides of sloped roof area	35%	
Panel cost per watt before tax credits and subsidies	$3.07	per watt DC
Array cost (before tax credits and subsidies)	$26,236	Array cost (before tax credits and subsidies)

A rooftop solar-panel array that generates enough electricity to get the average home in MA to net zero using a heat pump for heating and also powering all other electricity uses (but not including charging an EV) occupies only 35% of the roof area of the house. To get to net zero on the house and one EV travelling 12,000 miles per year requires a 13kW array that would occupy approximately half the roof area.

The following people and/or organizations have contributed to this draft:

David Green, member State Legislative Team (SLT) of 350.MA, zero-carbon consultant, author of the book *Zero Carbon Home* and "*Zero Carbon, Zero Bills*" webinar. Member of Heat Smart Alliance (HSA).
Mark Dyen, member of SLT of 350.MA, energy-policy consultant.
Michael Duclos, member of (HSA), former advisor to Governor Baker, Passive House consultant, and HERS rater.
Marc Breslow, Founder of MCAN and Arlington heat pump coach.
Arnie Epstein, member of HSA and Elders' Climate Action.
David Fay and Steve Breit, members of HSA.
Utah Nickel, member of the UCCA node of 350.MA.
Michael Lesser, Chairman of the Energy Committee, Sherborn, MA.

We have incorporated ideas championed by Senator Mike Barrett, Asst. Majority Leader, Chair Joint Committee on Transportation, Utilities and Energy and ideas that originated in the Future of Clean Heat bill and in the Clean Heat Standard.

The analyses supporting the main points were performed by David Green who can be contacted at davidlcgreen@gmail.com with any questions, comments, criticism or ideas.