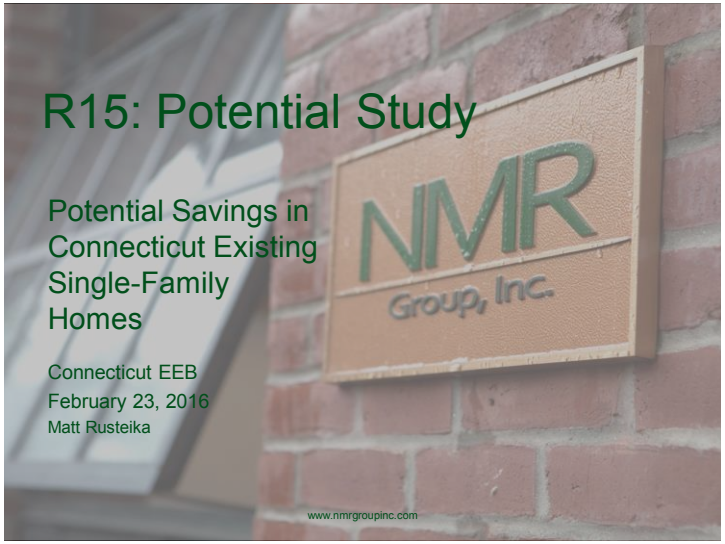


Introduction

- Used for program planning, measure targeting, context
- Quantifies potential savings for existing single-family homes only
  - Electricity, natural gas, fuel oil, and propane
- 43 upgrade measures, including building shell, HVAC, DHW, appliances, lighting, water measures, and renewables

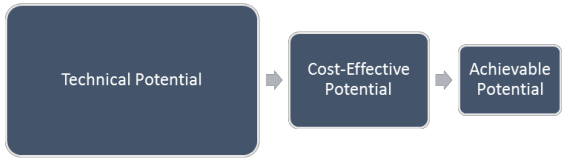
Introduction

- REM/Rate models of 180 actual homes audited for Weatherization Baseline
  - Industry standard for home energy modeling: stretch code, Energy Star Homes program
  - High level of detail: hundreds of model inputs
  - Real on-site data (instead of prototypes) & representative sample lend accuracy to results

Study Components

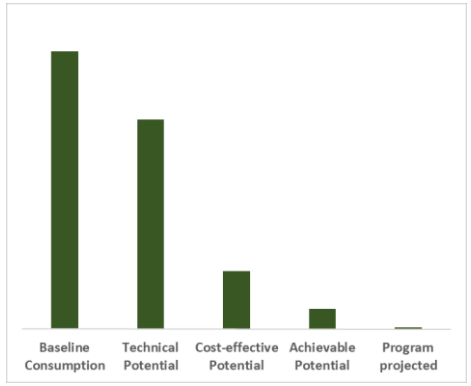
- Technical potential
  - All upgrades that are technically feasible
  - Presented with and without solar upgrades
- Cost-effective potential
  - All upgrades passing cost-effectiveness test
  - Total Resource Cost (TRC) test as threshold
- Achievable potential
  - CE savings adjusted for replacement schedules & expected market adoption levels
  - Does not take into account program activity

Progressive Modeling



Achievable potential savings are a subset of cost-effective potential savings, which are in turn a subset of technical potential savings.

Progressive Modeling



Study Components

- Fuel switching
  - Savings from switching oil or LP heating & DHW equipment to gas or heat pump
  - Separate from other study components
- Each component examines savings in four fuel types:
  - Electric (kWh and kW)
  - Fuel oil (gallons or MMBtu)
  - Natural gas (CCF or MMBtu)
  - Propane (gallons or MMBtu)

Sample Weighting

Category	CT Population (ACS)	Sample Count	Population Weight
Low income with oil, propane, or wood/pellet	128,495	20	6,425
Low income with gas or electric	72,766	14	5,198
Non-low income with oil, propane, or wood/pellet	475,295	98	4,850
Non-low income with gas or electric	216,042	48	4,501
Statewide	892,598	180	--

Population weighting scales up energy usage data from a representative sample of homes to reflect statewide consumption and potential savings.

Upgrade Measures

Building Shell
- Air sealing
- Above-grade wall insulation
- Flat attic insulation
- Vaulted ceiling insulation
- Frame floor insulation
- Foundation wall insulation
- Rim joist insulation
- Duct insulation
- Duct sealing

HVAC
- Oil boiler
- Oil furnace
- Gas boiler
- Gas furnace
- Propane boiler
- Propane furnace
- Central air conditioner
- Room air conditioner
- ECM fan motor

Upgrade Measures

Water Heating
- Gas instantaneous
- Gas condensing
- Gas storage
- Propane instantaneous
- Propane condensing
- Propane storage
- Oil storage
- Integrated tank
- Heat pump water heater
- Tank wrap

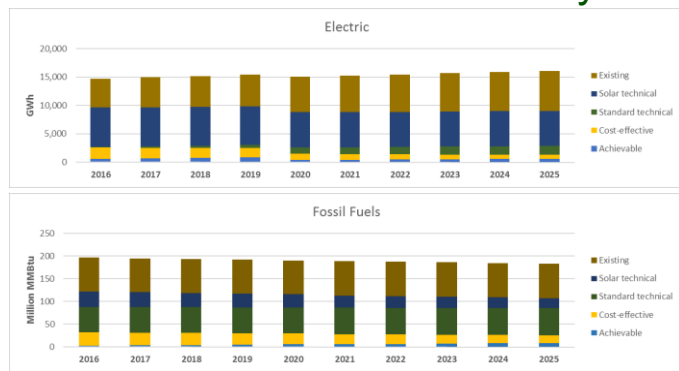
Appliances & Lighting
- 100% efficient lighting
- Refrigerator
- Freezer
- Dishwasher
- Dehumidifier

Upgrade Measures

Heat Pump & Solar
- Photovoltaic array
- Solar hot water system
- Ductless mini-split
- Air source heat pump
- Ground source heat pump

Non-REM Measures
- Clothes washer
- Pipe insulation
- Low-flow showerheads
- Faucet aerators

Overall Results Summary



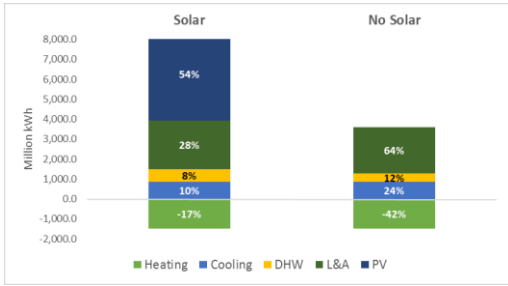
Technical Potential

Methodology

- Separate REM file for each individual applicable upgrade & all applicable together
  - All other model characteristics the same
  - Resulted in 3,909 separate REM files
- Upgrades applied to homes that have a given feature but with a lower efficiency than the upgrade value
  - E.g. HPWH upgrade was applied at sites with existing electric water heating
- Less conventional upgrades (e.g. PV) applied to a sample of homes
- Non-REM measures assessed separately

Technical Potential

Electric Savings (kWh) by End Use

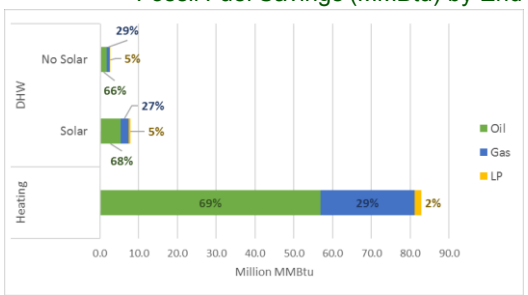


Negative savings at the heating end use are due to the influence of fuel switch measures (heat pumps) in the models.

Most savings from conventional measures are from lights & appliances.

Technical Potential

Fossil Fuel Savings (MMBtu) by End Use

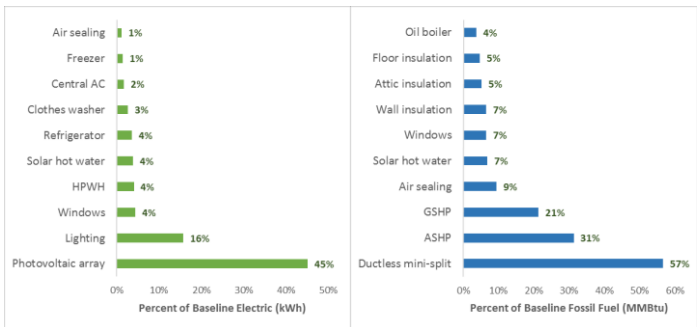


Even with solar thermal included, most technical potential fossil fuel savings are at the heating end use.

Oil accounts for more than two thirds of technical potential heating savings.

Technical Potential

Top Ten Individual Upgrades as a Percentage of Baseline Consumption



Cost-Effective Potential

Methodology (1)

- TRC ratio ≥1.0 used as threshold
  - TRC counts costs & benefits to both program and participant, rather than just program
- Net measure cost: full cost of upgrade minus a deferred replacement credit
  - Incremental cost ≤ NMC ≤ Full cost
- Avoided costs provided by Companies
  - Electric energy & capacity, T&D, gas, oil, propane, emissions, water, etc.

Cost-Effective Potential

Methodology (2)

- For measures subject to federal standards, savings used in screening were adjusted
  - Early retirement: high-efficiency upgrade compared to existing
  - Lost opportunity (current): high-efficiency upgrade compared to minimum efficiency replacement under current standard
  - Lost opportunity (future): high-efficiency upgrade compared to minimum efficiency replacement under future standard
- Applied based on remaining useful lifetime of the existing equipment

Cost-Effective Potential

Screening Results for Technical Potential Top Ten in Electric (kWh) Savings

Measure	Sites Applied	Percent of Sites	Pass Percent	Mean TRC Ratio
Photovoltaics	108	60%	0%	0.3
Lighting	**180**	**100%**	**100%**	**2.2**
Windows	180	100%	0%	0.3
HPWH	**42**	**23%**	**98%**	**4.7**
Solar hot water	108	60%	28%	0.8
Refrigerator	**180**	**100%**	**78%**	**1.8**
Clothes washer	**177**	**98%**	**98%**	**2.1**
Central AC	76	42%	0%	0.2
Freezer	**60**	**33%**	**82%**	**3.9**
Air sealing	**142**	**79%**	**96%**	**2.5**

Cost-Effective Potential

Screening Results for Technical Potential Top Ten in Fossil Fuel (MMBtu) Savings

Measure	Sites Applied	Percent of Sites	Pass Percent	Mean TRC Ratio
Ductless mini-split	176	98%	6%	-1.8
ASHP	104	58%	7%	-1.2
GSHP	103	57%	0%	-3.4
Air sealing	**142**	**79%**	**96%**	**2.5**
Solar hot water	108	60%	28%	0.8
Windows	180	100%	0%	0.3
Wall insulation	**165**	**92%**	**33%**	**1.3**
Attic insulation	**166**	**92%**	**54%**	**1.9**
Floor insulation	**161**	**89%**	**44%**	**1.2**
Oil boiler	80	44%	14%	0.7

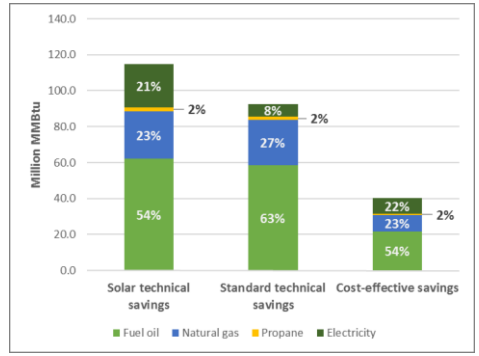
Cost-Effective Potential

Screening Results for Top Ten Most Cost-Effective Measures

Measure	Sites Applied	Percent of Sites	Pass Percent	Mean TRC Ratio
Dishwasher	153	85%	55%	8.5
Faucet aerators	180	100%	100%	6.3
DHW tank wrap	102	57%	90%	6.2
HPWH	42	23%	98%	4.7
Freezer	60	33%	82%	3.9
Duct sealing	50	28%	84%	2.7
Oil furnace	28	16%	89%	2.5
Air sealing	142	79%	96%	2.5
Low-flow showerheads	180	100%	99%	2.2
Lighting	180	100%	100%	2.2

Ten-Year Aggregate Savings

Technical vs. Cost-Effective



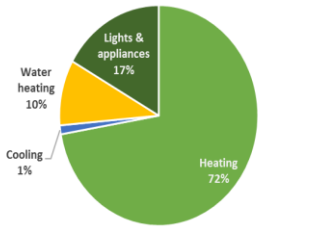
Cost-effective savings overall (in MMBtu) represent 31% of solar TP and 39% of non-solar TP

Cost-effective electric savings (kWh) are 25% of solar TP and 84% of non-solar TP

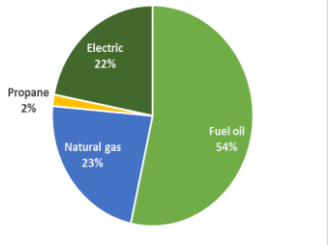
Cost-effective fossil fuel savings (MMBtu) are 33% of solar TP and 35% of non-solar TP

First Year (2016) Cost-Effective Savings

By End Use



By Fuel Type



Electric savings here are converted to MMBtu for the purpose of direct comparison between fuels.

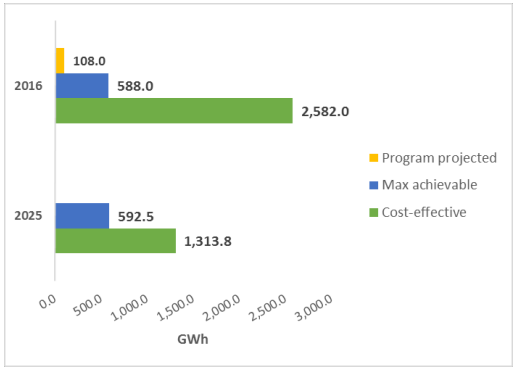
Achievable Potential

Methodology

- Very conservative assumptions
- Replacement schedules
  - Cost-effective savings adjusted to reflect consumers replacing equipment only after it fails
- Market adoption rates
  - Savings further adjusted down to reflect gradual adoption of efficiency measures over time
  - Data from 2009 EPRI potential study used to estimate possible market penetration of measures in 2025

Achievable Potential

Electric (GWh)

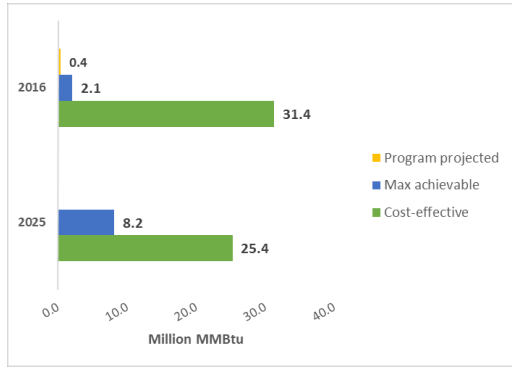


Achievable savings represent about 23% of cost-effective savings in the first year, but rise to 45% in year ten.

Projected program savings for 2016 represent about 18% of achievable savings.

Achievable Potential

Fossil Fuels (million MMBtu)

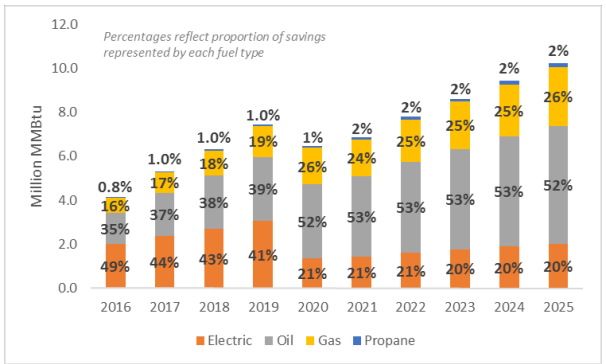


Achievable fossil fuel savings (including oil, gas, and propane) represent about 7% of cost-effective potential savings in the first year of analysis, but that percentage rises to 32% by year ten.

Projected program fossil fuel savings for 2016 represent 19% of achievable savings.

Achievable Potential

Savings Growth: 2016-2025



Fuel Switching

Methodology

- Heating & DHW equipment converted from oil or propane to natural gas or heat pump
  - Base case: new equipment efficiency from CT UDRH
  - Upgrade case: new equipment efficiency from Technical Potential
- Sites split into three groups:
  - Group A: non-gas homes in gas-served towns, switched to gas (49 sites)
  - Group B: non-gas homes in gas-served towns, switched to heat pump (65 sites)
  - Group C: non-gas homes in non-gas towns, switched to heat pump (20 sites)

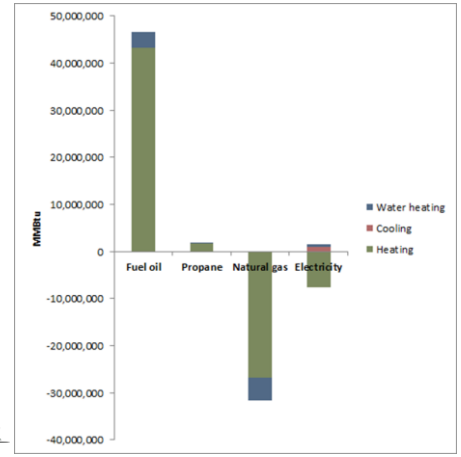
Fuel Switching

Methodology

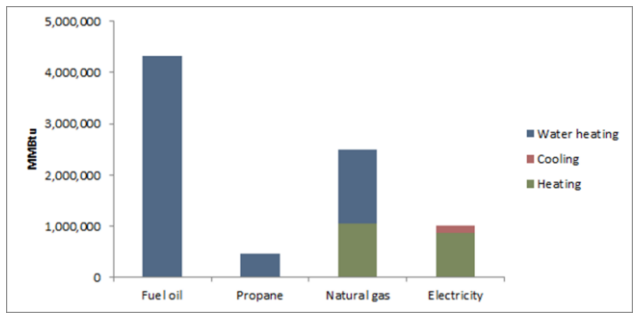
- Four conversion rates assessed: 25%, 50%, 75%, and 100%

Overall Conversion Rate	Rates of Uptake				Percent of Homes with Primary Heating Fuel in Year 10		
	Year 2.5	Year 5	Year 7.5	Year 10	Natural Gas[i]	Electric[ii]	Other Fuels
25%	6.25%	12.5%	18.75%	25%	32%	18%	50%
50%	12.5%	25%	37.5%	50%	39%	28%	33%
75%	18.75%	37.5%	56.25%	75%	46%	37%	17%
100%	25%	50%	75%	100%	53%	47%	0%

Base Case Savings: 10th Year



Upgrade Case Savings: 10th Year



Conclusions

- Building shell measures are mostly cost-effective for both program & participant
  - Analysis shows that these measures represent a proportion of achievable savings that will increase going forward
- Electric measures—including appliances and, prominently, lighting—will result in increasingly lower savings in the future
  - More stringent federal minimum efficiency standards for these products are the cause

Conclusions

- The HES and HES-IE programs are already targeting the majority of cost-effective measures
  - Fuel switch measures and high-savings/high-cost measures like PV tended not to screen as cost-effective in the analysis
- The impact of incentives for fuel switching would be mostly in water heating end use