27th WORLD GAS CONFERENCE | JUNE 25-29
WASHINGTON DC | 2018
IGU

Case Studies of Future Residential Natural Gas and Electrification Scenarios in Leading Low-Carbon Regions

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Objective & Methods

- Examine energy use, environmental impact, and cost of policy scenarios for natural gas and electricity use in California and New York homes
- Pathways for CO_2 equivalent (CO_2e) emission reduction using efficient natural gas and electric products in homes
- Use two GTI-developed software tools:
  - **Energy Planning Analysis Tool** (EPAT; epat.gastechnology.org)
    - A comprehensive tool for energy and emissions analysis of a wide-range of typical home energy appliances
  - **Source Energy and Emissions Analysis Tool** (SEEAT), an analytical tool (cmictools.com) for comparing source or primary energy and environmental impacts.

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Objective & Methods

- Baseline scenario of typical mid-range efficiency natural gas products and alternative scenarios using natural gas and electricity

	Space Heating	Water Heating
Baseline Natural Gas Options	80% efficiency non-condensing furnace	Conventional storage water heater (Energy Factor, EF, 0.62)
Electric Energy Efficiency Options	HSPF 8.4 electric heat pump	Electric heat pump water heater (EF 2.0)
Mature Natural Gas Energy Efficiency Options	96% efficiency condensing furnace	95% efficiency tankless (EF 0.95)
Next-Generation Natural Gas Energy Efficiency	New York: 140% efficiency gas absorption heat pump (COP 1.4)	New York: 130% efficiency gas absorption heat pump (EF 1.3)
	California: 140% efficiency combination space and water heating gas absorption heat pump (COP 1.4)	

Plus complementary natural gas scenarios using 15% renewable natural gas blends.

Example EPAT and SEEAT Screenshots

Included?	Application	Baseline: Equipment and Appliances			Alternative: Equipment and Appliances		
☑	Space Heating	Natural Gas, AFUE 92%			14 SEER /8.4 HSPF Heat Pump		
		Electric Consumption:	0	(10^6 kWh)	Electric Consumption:	44,164	(10^6 kWh)
		Gas Consumption:	3,060	(10^6 Therm)	Gas Consumption:	0	(10^6 Therm)
		Installed Cost:	900	$/Unit	Installed Cost:	2,711	$/Unit
			+ 21.00	$/kBtuh		+ 42.00	$/kBtuh
		Unit Capacity:	70	kBtuh	Unit Capacity:	80	kBtuh
☐	Space Cooling	14 SEER(12.06 EER) A/C			14 SEER /8.4 HSPF Heat Pump		
		Electric Consumption:	1,482	(10^6 kWh)	Electric Consumption:	1,482	(10^6 kWh)
		Gas Consumption:	0	(10^6 Therm)	Gas Consumption:	0	(10^6 Therm)
		Installed Cost:	2,266	$/Unit	Installed Cost:	0	$/Unit
			+ 42.00	$/kBtuh		+ 0.00	$/kBtuh
		Unit Capacity:	30	kBtuh	Unit Capacity:	30	kBtuh
☐	HVAC Blower	Electric Consumption:	2,154	(10^6 kWh)	Electric Consumption:	1,958	(10^6 kWh)
☑	Water Heating	Natural Gas EF 0.67 - Energy Star Storage			Electric Resistance EF, 0.95		
		Electric Consumption:	0	(10^6 kWh)	Electric Consumption:	14,148	(10^6 kWh)
		Gas Consumption:	684	(10^6 Therm)	Gas Consumption:	0	(10^6 Therm)
		Installed Cost:	830	$/Unit	Installed Cost:	590	$/Unit
			11.00	$/gal		+ 3.50	$/gal
		Unit Capacity:	40	Gal	Unit Capacity:	40	Gal
☐	Lighting & Plug-in Loads	Electric Consumption:	17,853	(10^6 kWh)	Electric Consumption:	17,853	(10^6 kWh)
☐	Cooking Range	Electric Standard EF 0.74			Gas Standard		
		Electric Consumption:	3,231	(10^6 kWh)	Electric Consumption:	0	(10^6 kWh)
		Gas Consumption:	0	(10^6therm)	Gas Consumption:	219	(10^6 Therm)
		Installed Cost:	923	$/Unit	Installed Cost:	823	$/Unit
☐	Refrigerator	How many: 1			How many: 1		
		Electric Consumption:	3,579	(10^6 kWh)	Electric Consumption:	3,579	(10^6 kWh)
☐	Dishwasher	How many: 1			How many: 1		
		Electric Consumption:	920	(10^6 kWh)	Electric Consumption:	920	(10^6 kWh)
☐	Washer	How many: 1			How many: 1		
		Electric Consumption:	471	(10^6 kWh)	Electric Consumption:	471	(10^6 kWh)
☐	Clothes Dryer	Electric Standard EF 3.1			Gas Standard EF 2.75		
		Electric Consumption:	4,655	(10^6 kWh)	Electric Consumption:	337	(10^6 kWh)
		Gas Consumption:	0	(10^6 therm)	Gas Consumption:	214	(10^6 Therm)
		Installed Cost:	760	$/Unit	Installed Cost:	1,000	$/Unit

Source Energy Conversion Factors

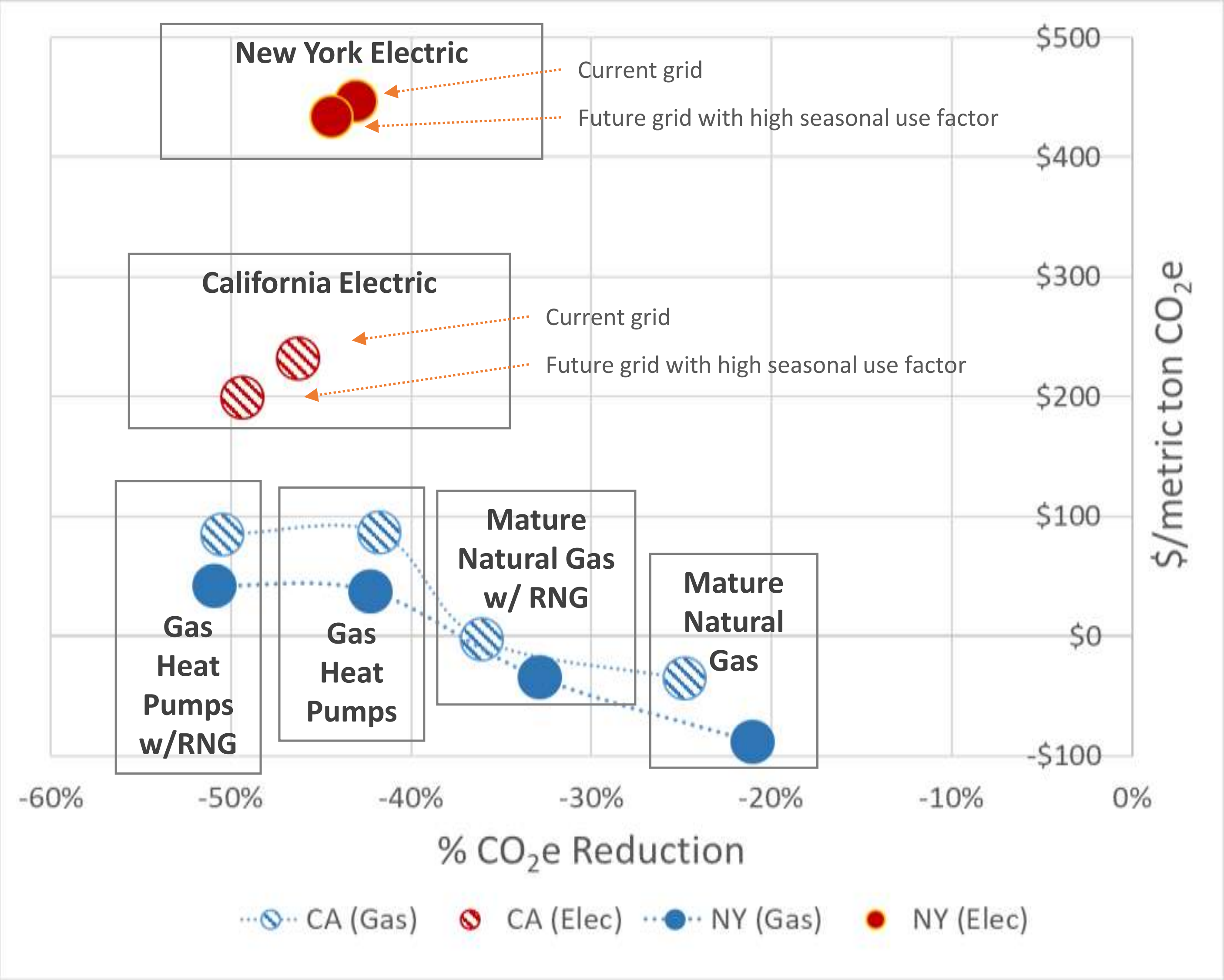
	Electric	Natural Gas	Fuel Oil	Propane
Btu/Btu	3.13	1.09	1.17	1.13

Step 4. Composite Emission Factors

View / Edit Emission Factors

Energy Form	CO_2	SO_2	NOx	CH_4	N_2O	CO_2e
Electricity (lb/MWh)	1,378.8	5.04	2.11	2.606	0.018	1,456.5
Natural Gas (Building Used, lb/MMBtu)	129.53	0.028	0.169	0.613	0.002	147.26
Fuel Oil (lb/MMBtu)	187.81	0.049	1.200	0.240	0.004	195.69
Propane (lb/MMBtu)	161.00	0.050	0.219	0.117	0.011	167.21
Natural Gas (mCHP NG Engine Used, lb/MMBtu)	136.50	0.027	1.889	1.476	0.000	177.93
Natural Gas (mCHP Fuel Cell Used, lb/MMBtu)	128.24	0.027	0.052	0.611	0.000	145.39

Included?	Application	Baseline	Alt
☑	Space Heating	Electric, Efficiency 100% 10 SEER /7.2 HSPF Heat Pump 13 SEER /8.1 HSPF Heat Pump 14 SEER /8.4 HSPF Heat Pump 16 SEER /8.6 HSPF Heat Pump 18 SEER /9.2 HSPF Heat Pump 20.5 SEER /13 HSPF Heat Pump Natural Gas, AFUE 75% Natural Gas, AFUE 80% Natural Gas, AFUE 90% Natural Gas, AFUE 92% Natural Gas, AFUE 94% Natural Gas, AFUE 96% Propane, AFUE 80% Propane, AFUE 82% Propane, AFUE 90% Propane, AFUE 92% Propane, AFUE 94% Propane, AFUE 96% 1.2 COP Natural Gas Engine Heat Pump (Prototype) 1.2 COP Propane Engine Heat Pump (Prototype) 1.4 AFUE Natural Gas Absorption Heat Pump (Prototype) 1.4 AFUE Propane Abosrption Heat Pump (Prototype)	
☐	Space Cooling		
☐	HVAC Blower		

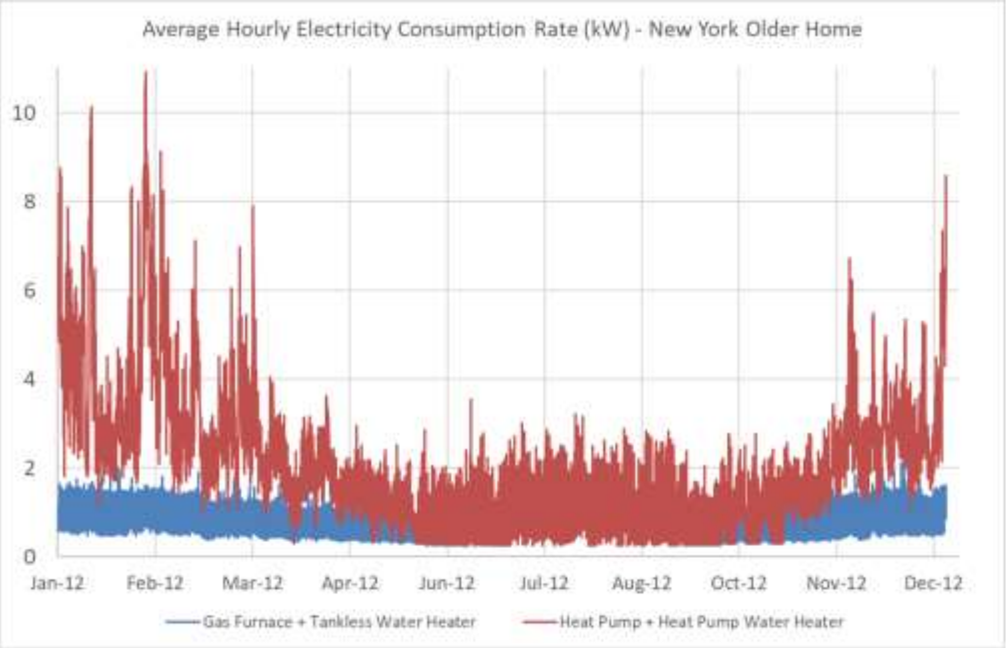


Additional CO_2e emission reductions possible for all options through building envelope improvements.

Is forced switching to electricity in California and New York:

- **Impactful? Yes** (but similar natural gas options are feasible)
- **Cost-effective? No**

Electric fuel switching increases consumer energy costs by at least 45% in CA and 90% in NY. Expensive carbon abatement option, with tremendous impact on peak electricity demand.



Conclusions

- Growing interest in electricity as a buildings and transportation GHG reduction strategy
  - Grid decarbonization can enable potential GHG reductions
- GTI software tools (EPAT, SEATT) enable scenario analyses
- Residential electrification of gas homes in California and New York expensive carbon abatement strategy
  - At least $200/metric ton and over $400/metric ton in colder climates
  - Space heating is major hurdle for all-electric homes
    - Intermittent seasonal load, diminished cold-weather electric heat pump performance, decrease in solar PV output during winter months
  - Viable cost-effective pathways with natural gas heat pumps and renewable natural gas blending