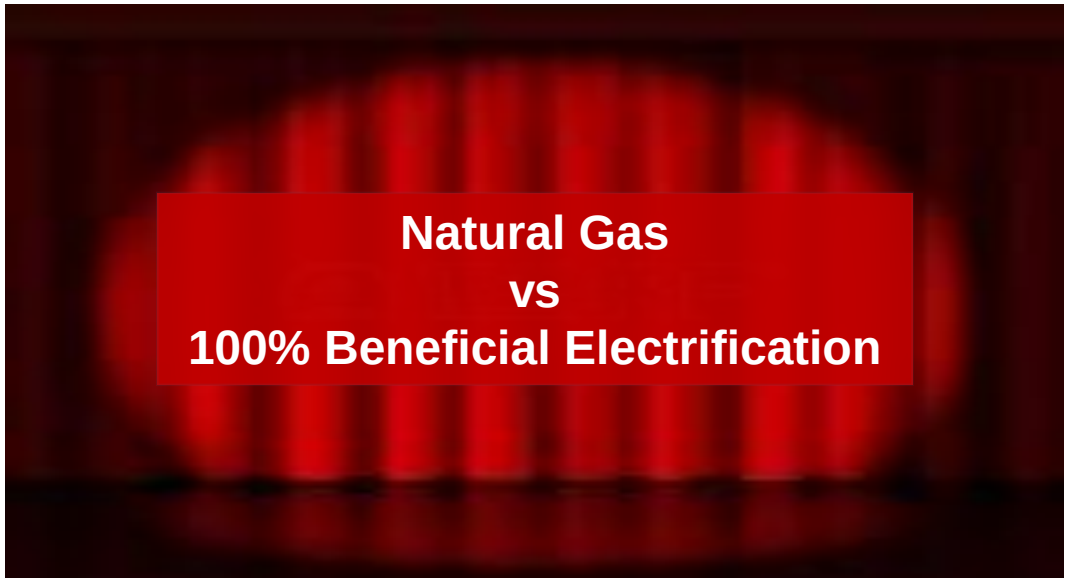
New York State
Energy Transformation 1990-2050

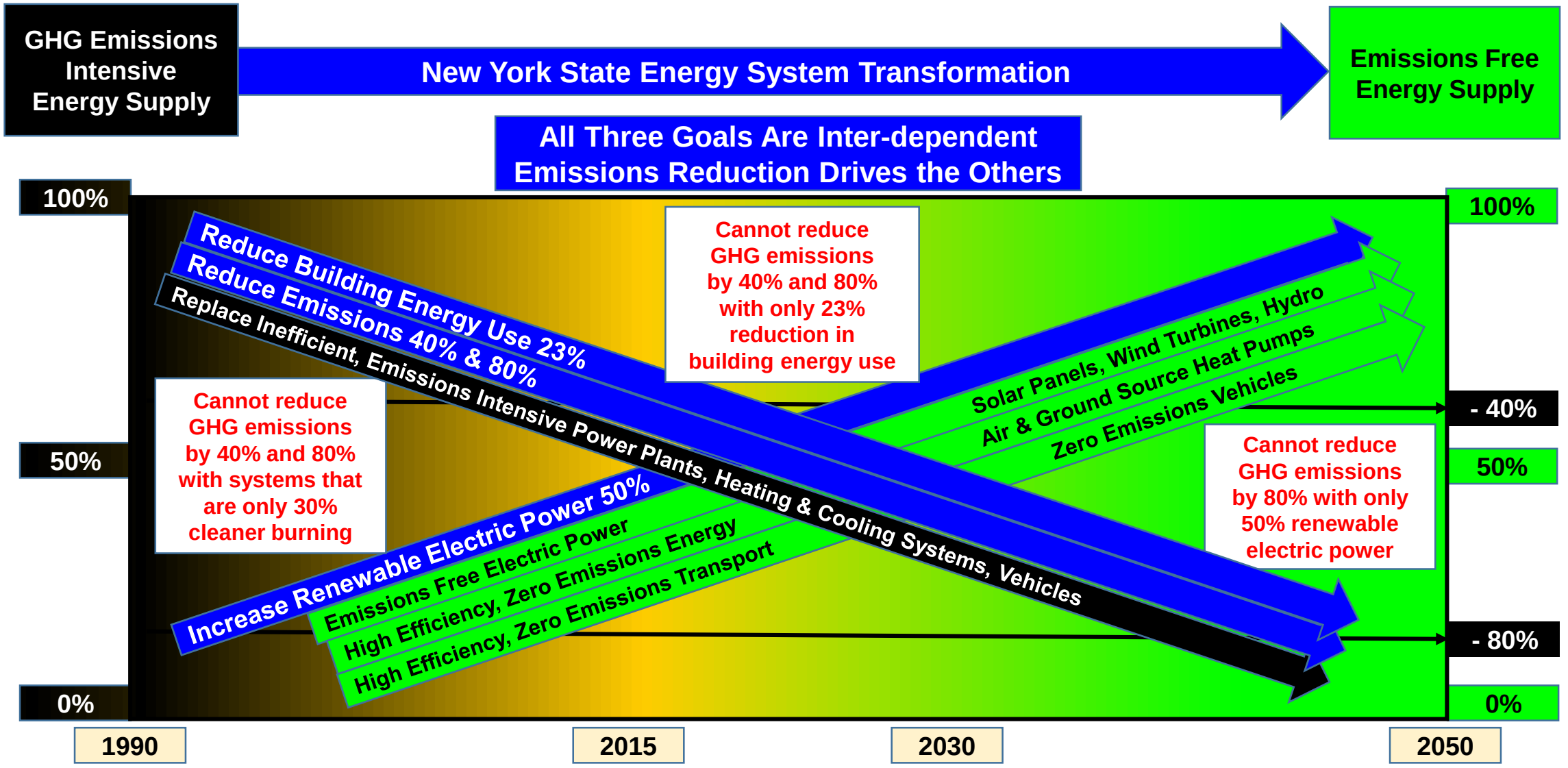
What is the Best Approach to Meet the
2015 New York State Energy Plan Goals?



Jerry Acton – Systems Engineer / Architect
Volunteer Systems Engineering Advisor -
Physicians, Scientists, and Engineers for Healthy Energy

New York State Energy Transformation 1990-2050

Transformation must comply with Laws of Physics



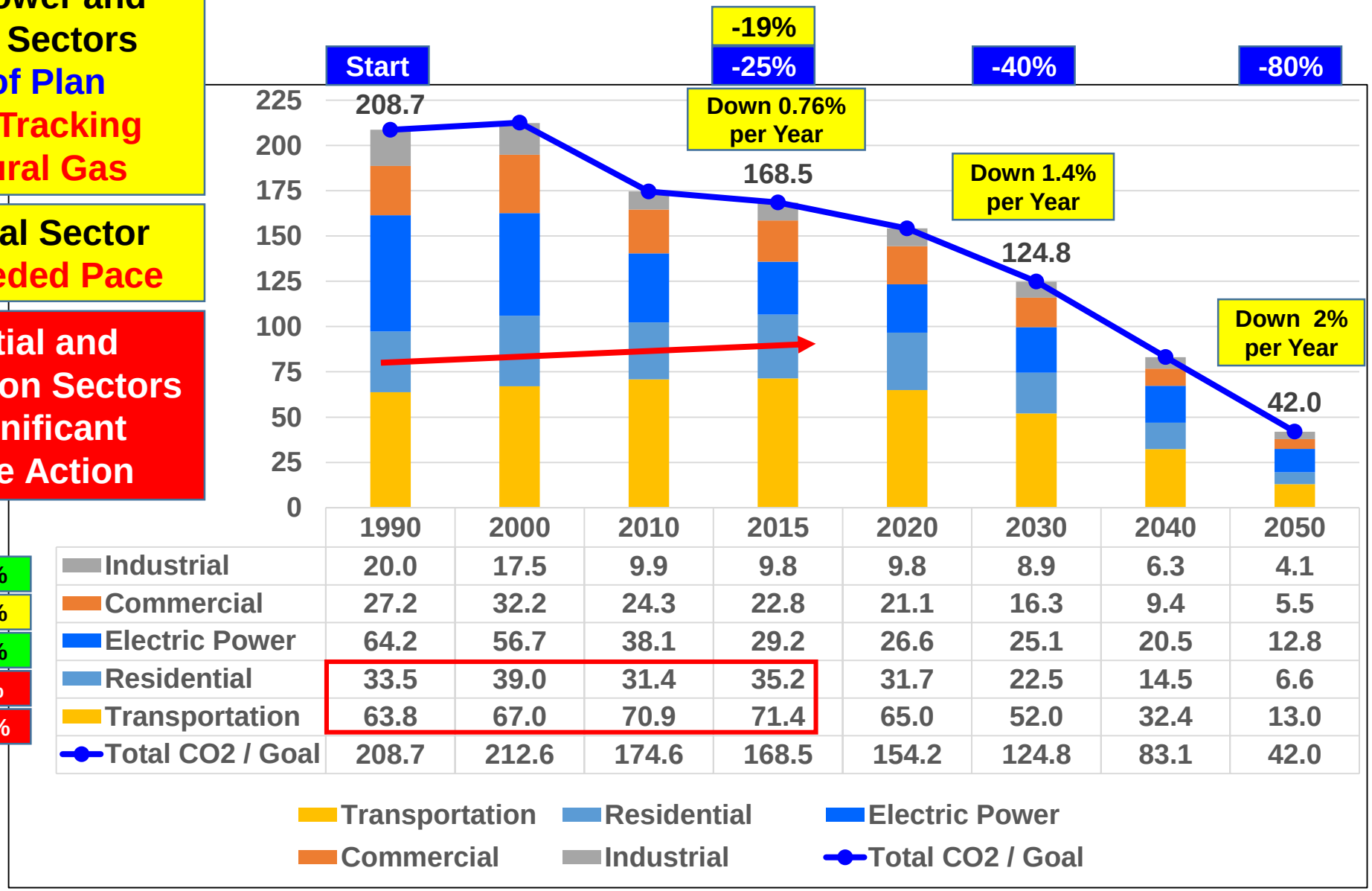
New York State Energy Transformation 1990-2050

Emission Reduction Targets by Sector

Electric Power and Industrial Sectors Ahead of Plan But Back Tracking with Natural Gas

Commercial Sector Behind Needed Pace

Residential and Transportation Sectors Need Significant Corrective Action

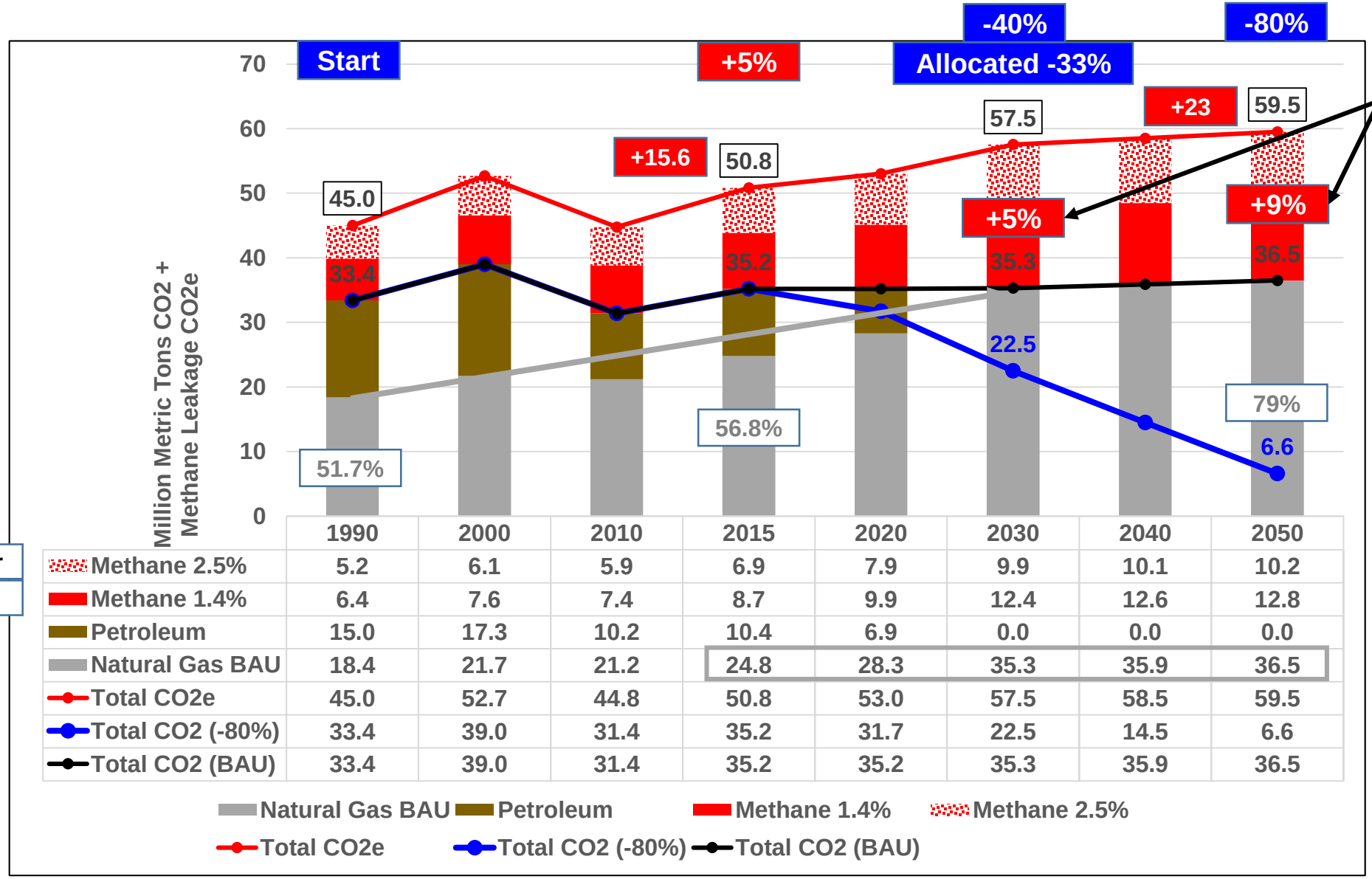


	1990	2000	2010	2015	2020	2030	2040	2050
Industrial	20.0	17.5	9.9	9.8	9.8	8.9	6.3	4.1
Commercial	27.2	32.2	24.3	22.8	21.1	16.3	9.4	5.5
Electric Power	64.2	56.7	38.1	29.2	26.6	25.1	20.5	12.8
Residential	33.5	39.0	31.4	35.2	31.7	22.5	14.5	6.6
Transportation	63.8	67.0	70.9	71.4	65.0	52.0	32.4	13.0
Total CO2 / Goal	208.7	212.6	174.6	168.5	154.2	124.8	83.1	42.0

-51%	Industrial
-16%	Commercial
-55%	Electric Power
+5%	Residential
+12%	Transportation

Residential Sector Energy Transformation 1990-2050

Fuel Source Trends versus Reduction Targets



	1990	2000	2010	2015	2020	2030	2040	2050
Methane 2.5%	5.2	6.1	5.9	6.9	7.9	9.9	10.1	10.2
Methane 1.4%	6.4	7.6	7.4	8.7	9.9	12.4	12.6	12.8
Petroleum	15.0	17.3	10.2	10.4	6.9	0.0	0.0	0.0
Natural Gas BAU	18.4	21.7	21.2	24.8	28.3	35.3	35.9	36.5
Total CO2e	45.0	52.7	44.8	50.8	53.0	57.5	58.5	59.5
Total CO2 (-80%)	33.4	39.0	31.4	35.2	31.7	22.5	14.5	6.6
Total CO2 (BAU)	33.4	39.0	31.4	35.2	35.2	35.3	35.9	36.5

Other

EPA

Natural Gas Approach Cannot Meet the 2030 or 2050 Emissions Reduction Goals

% of Housing Units

25 Year Trend Continues

Natural Gas Heavily Advertised and Subsidized

- Replacing Petroleum 84% to Natural Gas 16% to Electric
- Maximum Natural Gas for New Construction
- Upgrade Old Natural Gas with New

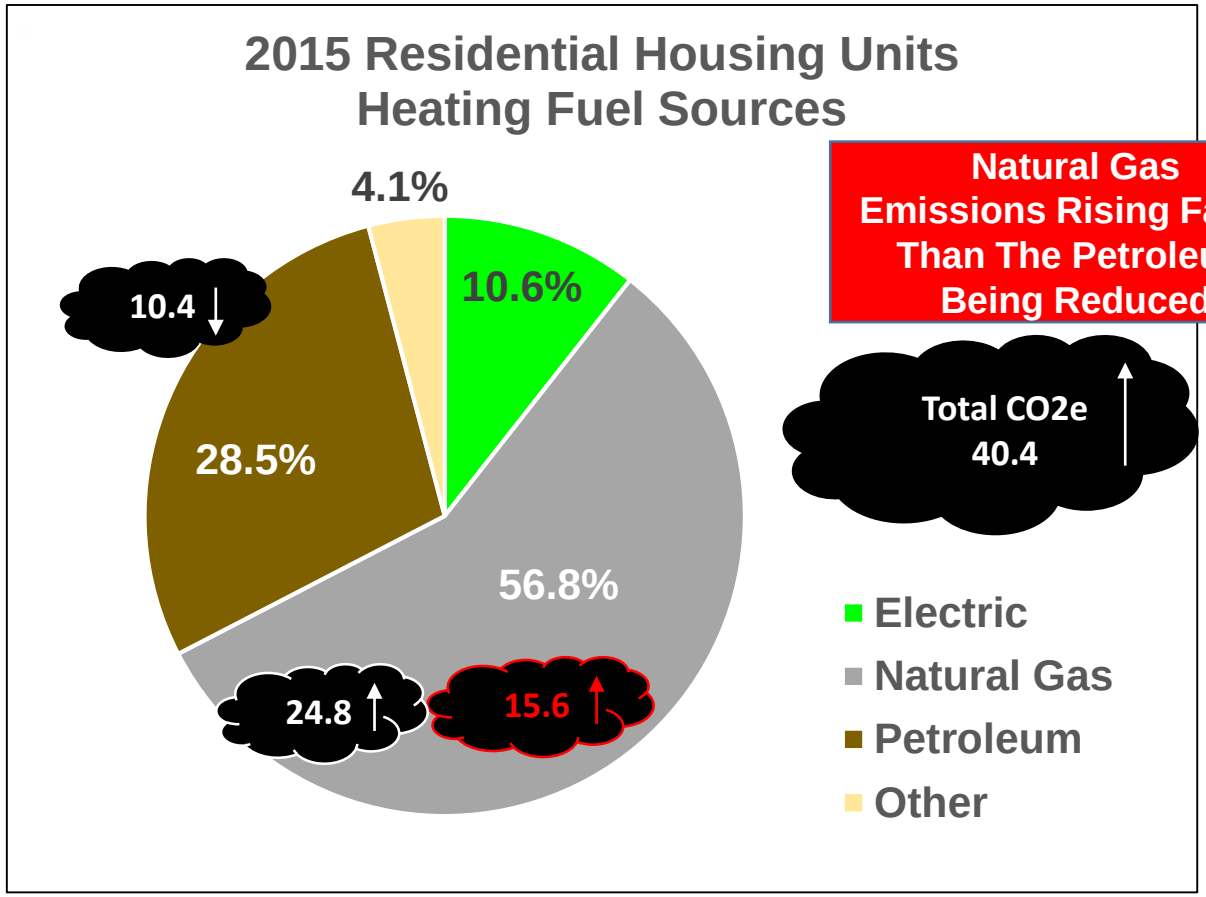
Residential Sector Energy Transformation 1990-2050

Housing Units by Heating Fuel Source - 2015

Fuel Source	% of Housing Units	# of Housing Units
Electric	10.6%	766,772
Natural Gas	56.8%	4,108,738
Petroleum	28.5%	2,061,603
Other	4.1%	296,581
	Occupied	7,233,694
	Unoccupied	874,409
	Total	8,108,103

Million Metric Tons Methane Leakage CO2e

Million Metric Tons CO2

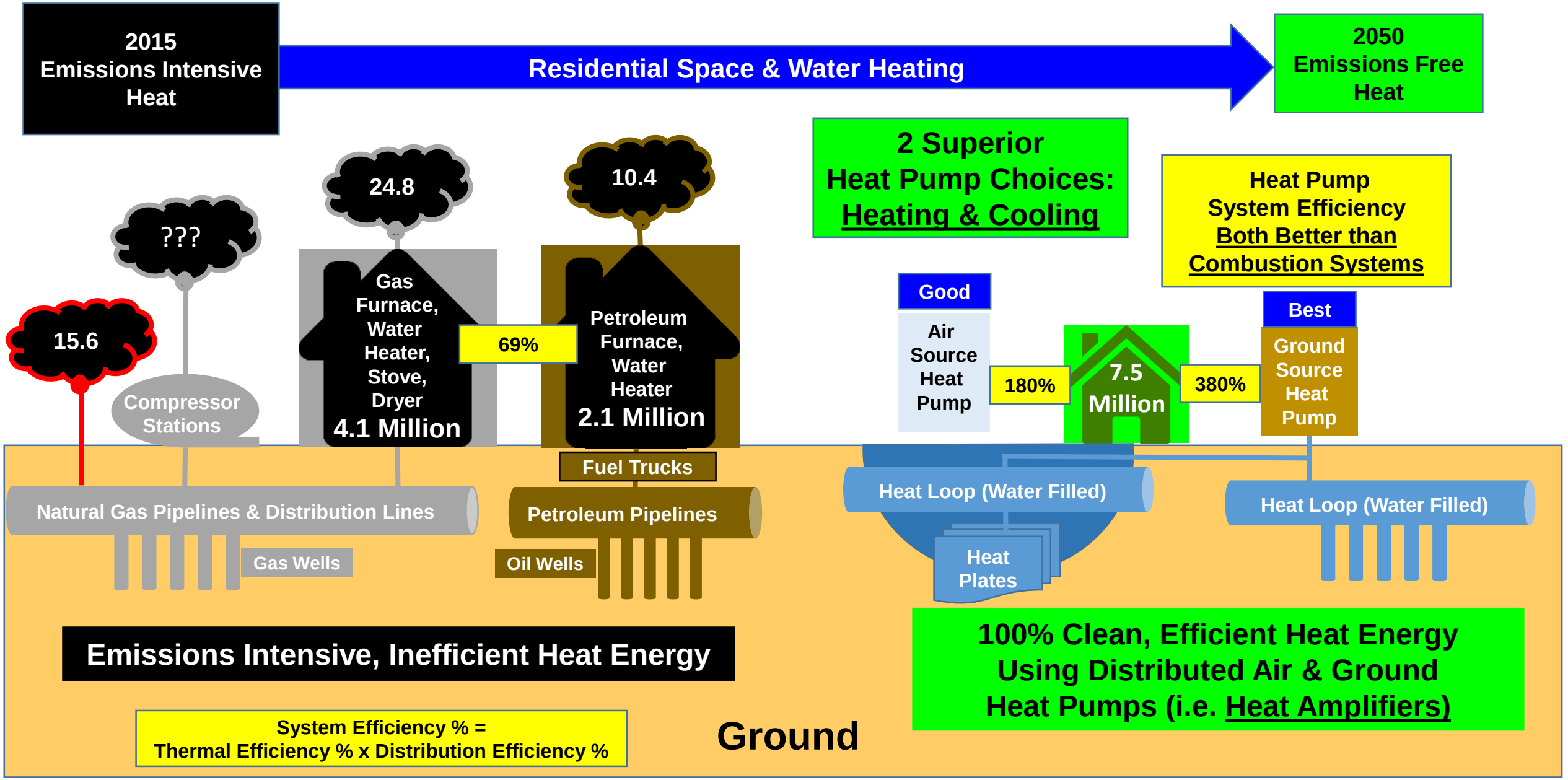


Natural Gas Emissions Rising Faster Than The Petroleum Being Reduced

Total CO2e 40.4

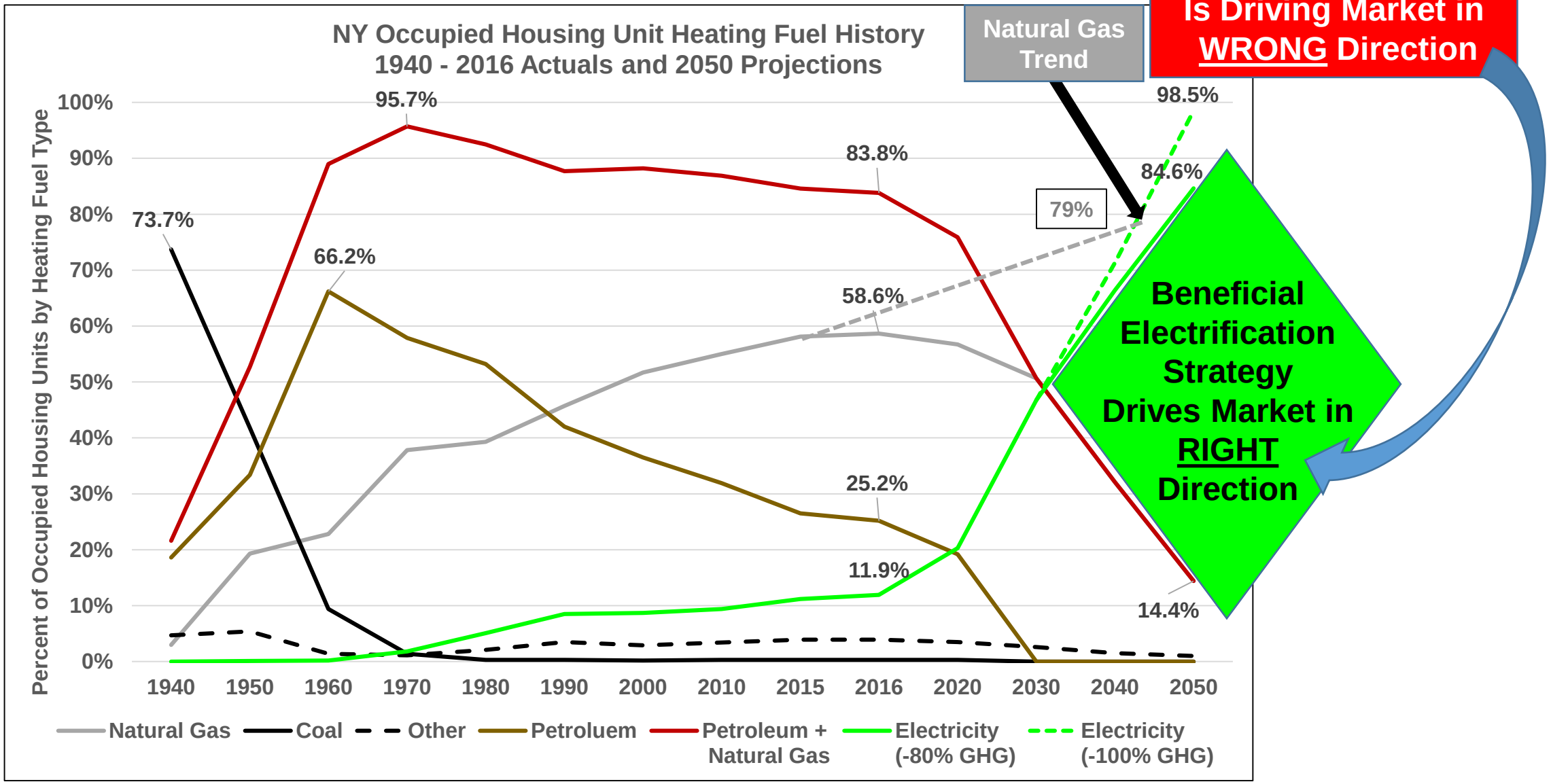
Subsidies and Advertising Are Encouraging Petroleum to Natural Gas Conversions

New York State Energy Transformation 2015-2050



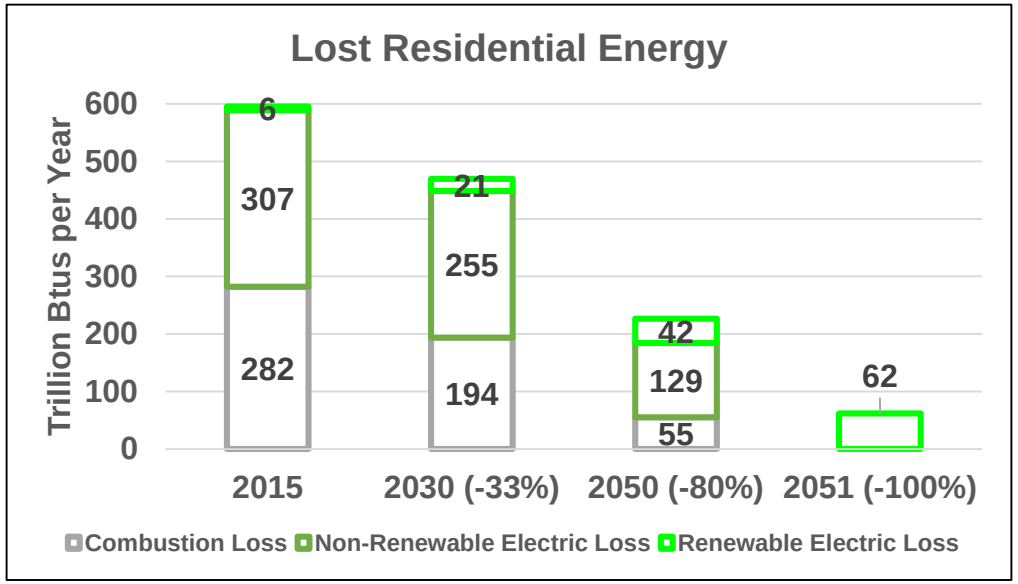
Residential Sector Energy Transformation 1940-2050

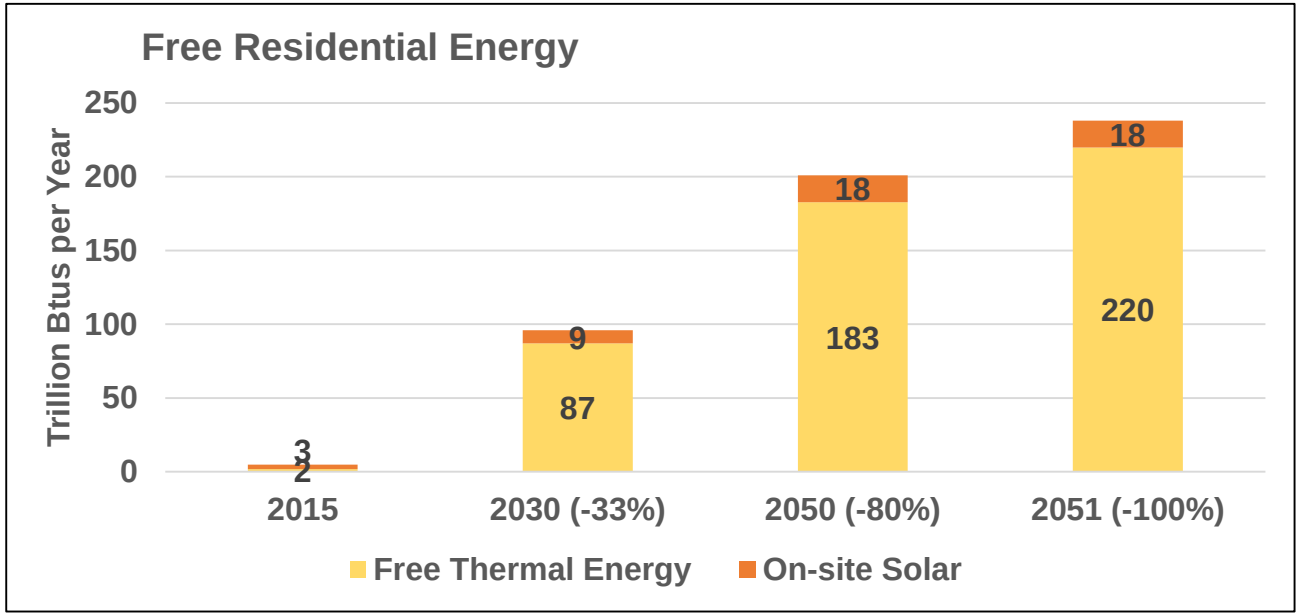
Beneficial Electrification Is the Right Solution

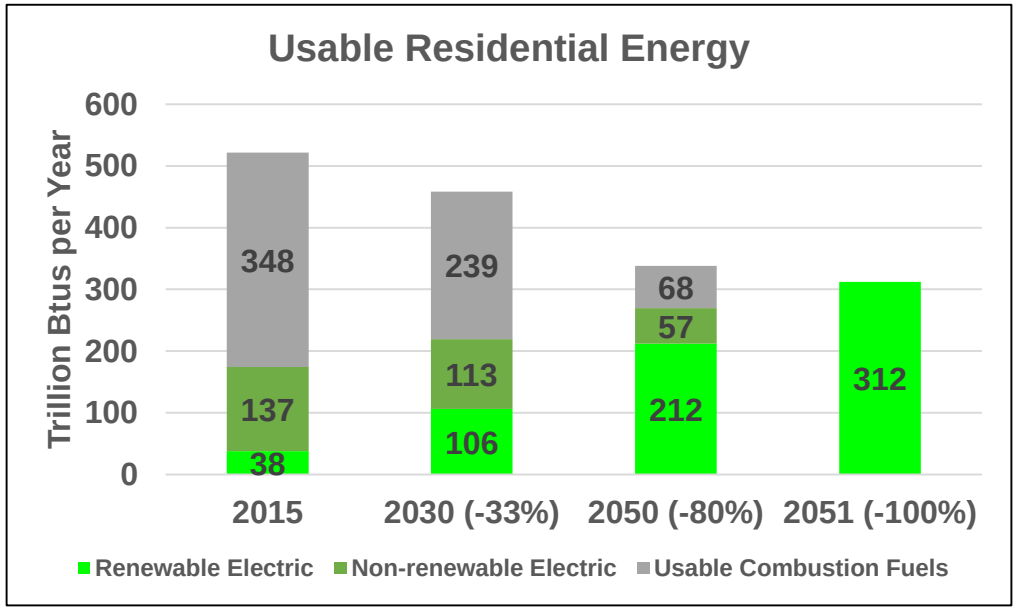


Residential Sector Energy Transformation 1990-2050

Residential Sector Energy Use – Trillion Btu (Tbtu) per Year 2015-2050





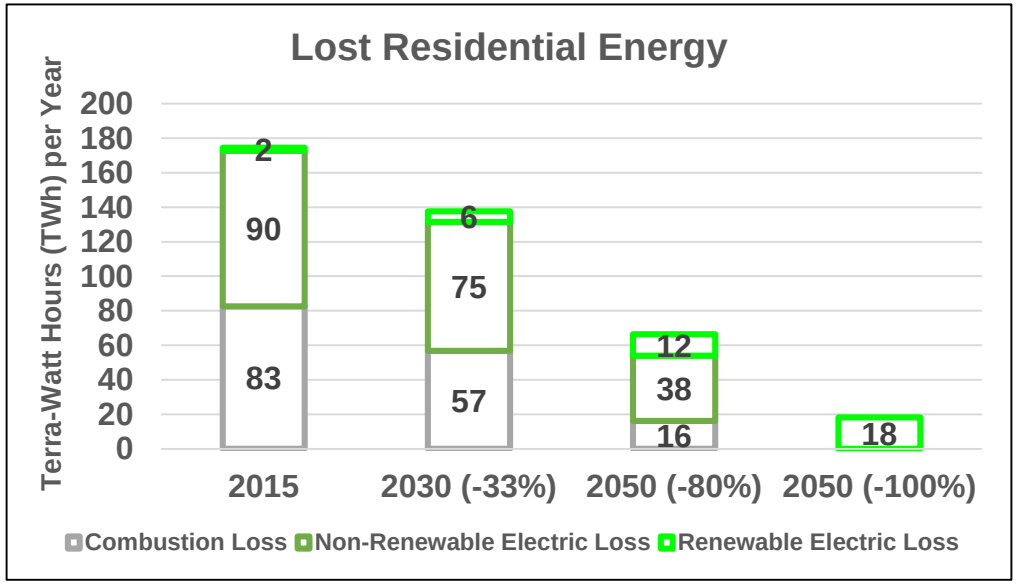


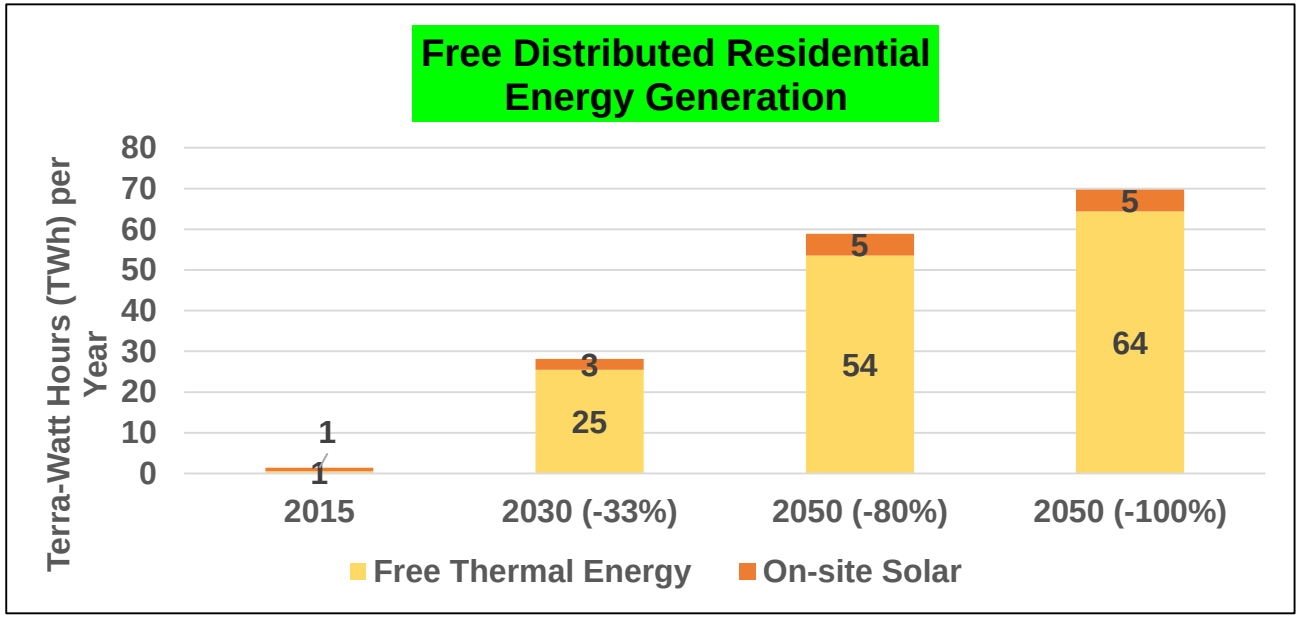
The Value of Beneficial Electrification

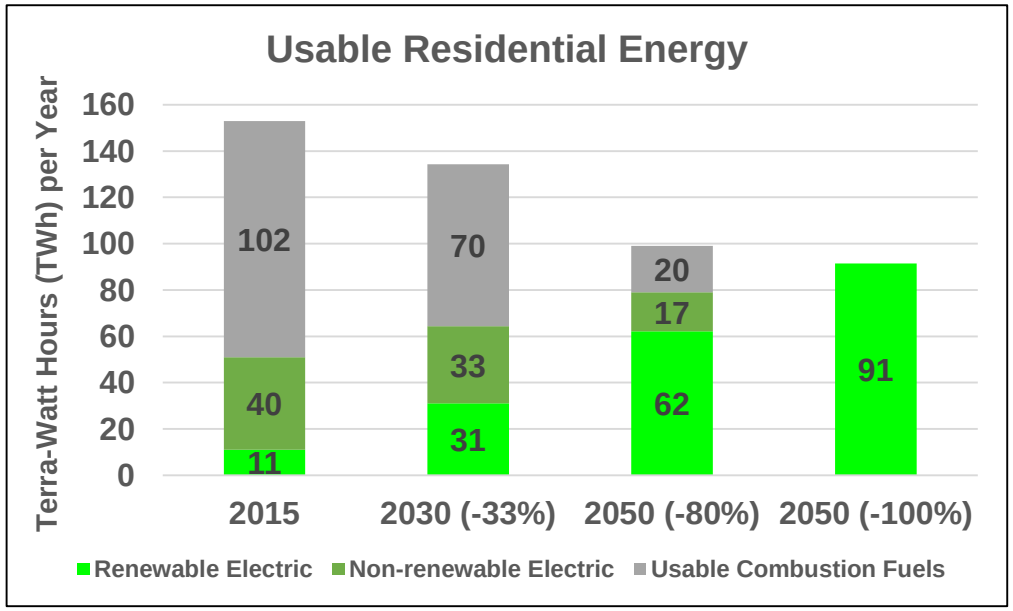
Beneficial Electrification Housing Units (Millions)	0.1 (est)	2.7	5.7	6.9
Total Energy - TBtu	1115.5	1023.8	765.4	612.2
Benefit	2015	2030 (-33%)	2050 (-80%)	2050 (-100%)
Loss Reduction	-	21%	62%	90%
Energy Use Reduction	-	19%	51%	61%
Energy Efficiency	47%	54%	70%	90%
% Renewable Electricity	22%	48%	79%	100%
% Free Energy	1%	17%	37%	43%

Residential Sector Energy Transformation 1990-2050

Residential Sector Energy Use – Terra-Watt Hours (TWh) per Year 2015-2050







The Value of Beneficial Electrification

Beneficial Electrification Housing Units (Millions)	0.1 (est)	2.7	5.7	6.9
Total Energy - TWh	327	300	224	179
Benefit	2015	2030 (-33%)	2050 (-80%)	2050 (-100%)
Loss Reduction	-	21%	62%	90%
Energy Use Reduction	-	19%	51%	61%
Energy Efficiency	47%	54%	70%	90%
% Renewable Electricity	22%	48%	79%	100%
% Free Energy	1%	17%	37%	43%

Residential Sector Energy Transformation 1990-2050

Heat Pumps Value Compared to Alternatives by Equivalent TWh

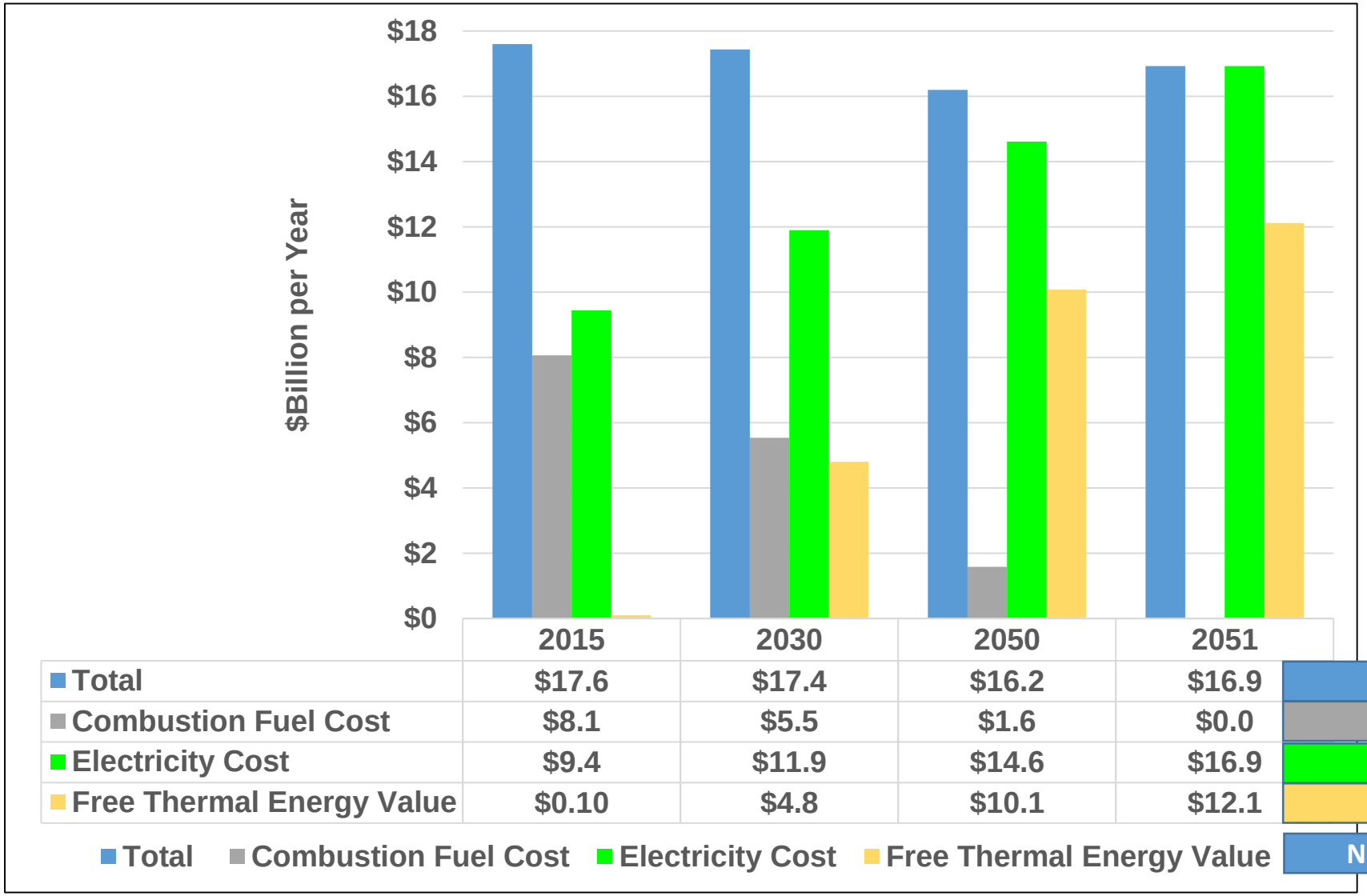
What is the Yearly Value of Heat Pumps ?
Heat Pumps are Distributed, Zero Emissions, Heat Generation Plants

	2030 (-40%)	2030 (-80%)	2030 (-100%)
Free Air & Ground Source Energy / Year 20% ASHP, 80% GSHP	2.7 Million Heat Pumps 25 TWh = 87 TBtu	5.7 Million Heat Pumps 54 TWh = 183 TBtu	6.9 Million Heat Pumps 64 TWh = 220 TBtu
Equivalent Fuel Oil Heating Energy At $2.65 / Gallon	$1.5 Billion / Year 25 TWh = 0.6 Billion Gallons	$3.25 Billion / Year 54 TWh = 1.3 Billion Gallons	$4 Billion / Year 64 TWh = 1.6 Billion Gallons
	or	or	or
Equivalent Natural Gas Heating Energy At 11.20 / Mcf	$.95 Billion / Year 25 TWh = 84 Billion Cubic Feet	$2 Billion / Year 54 TWh = 177 Billion Cubic Feet	$2.4 Billion / Year 64 TWh = 213 Billion Cubic Feet
	or	or	or
Equivalent Natural Gas Generators Energy At $0.185 / KWh	$4.6 Billion / Year 25 TWh = Top 20 Generators	$10 Billion / Year 54 TWh = Top 69 Generators	$11.8 Billion / Year 64 TWh = More than All 248 Generators
	or	or	or
Equivalent Nuclear Generators Energy At $0.185 / KWh	$4.6 Billion / Year Indian Point #2 & #3: 17 TWh 9 Mile #2: 8.7 TWh	$10 Billion More than All Generators 40.7 TWh Total	$11.8 Billion / Year More than All Generators 40.7 TWh Total

www.nyserda.ny.gov/~/media/files/publications/energy-analysis/Table-4-1a.xlsx

Residential Sector Energy Transformation 1990-2050

Residential Sector Energy Cost $Billion per Year 2015-2050



	2015	2030	2050	2051	
Total	$17.6	$17.4	$16.2	$16.9	Down 0.7 $B
Combustion Fuel Cost	$8.1	$5.5	$1.6	$0.0	Down 8.1 $B
Electricity Cost	$9.4	$11.9	$14.6	$16.9	Up 7.5 $B
Free Thermal Energy Value	$0.10	$4.8	$10.1	$12.1	Up 12 $B

Net Up 10.7 $B

Revenue Neutral

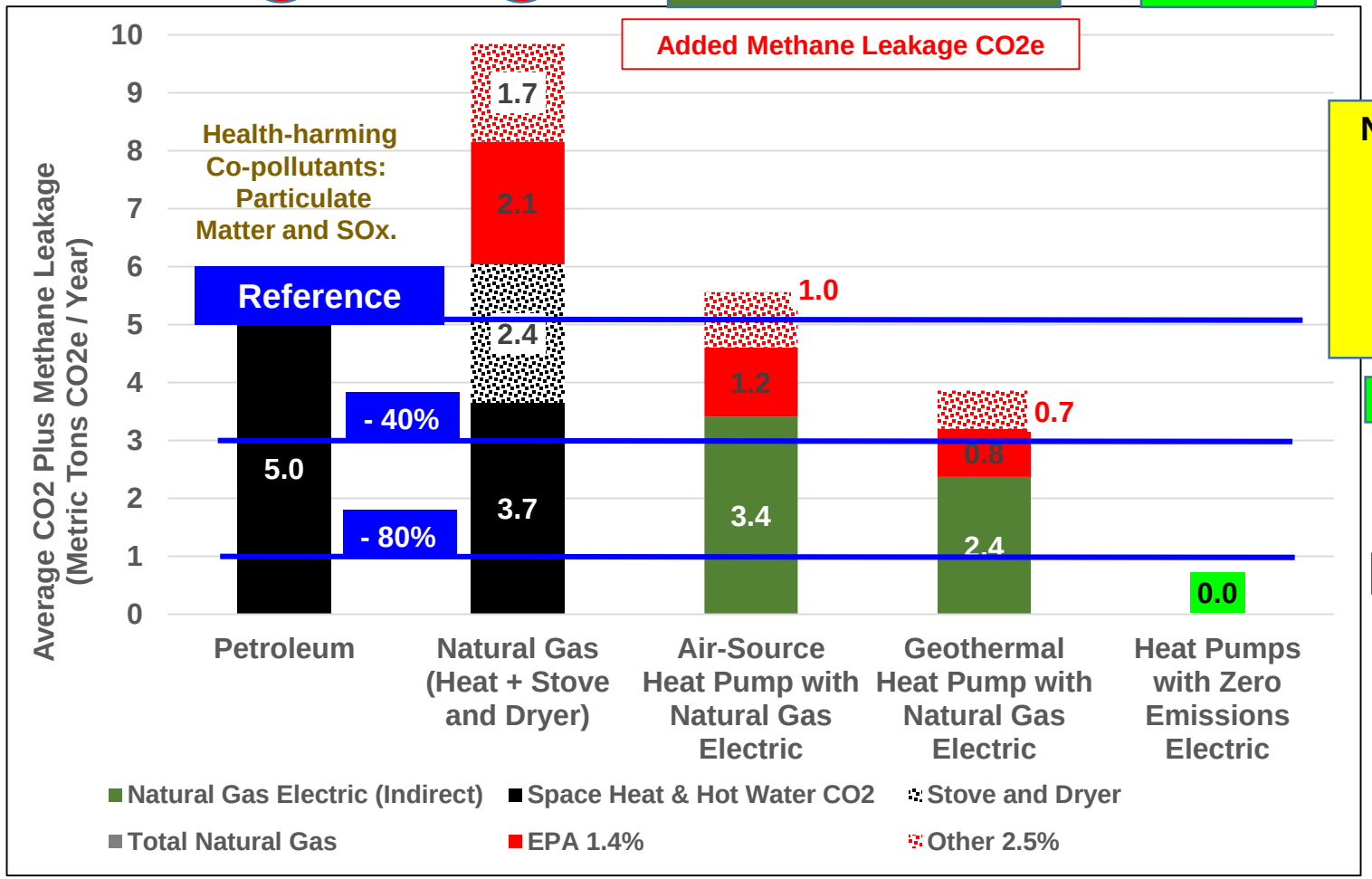
Consumption Cost Down 0.6

Net Value of Free Thermal Energy

Residential Sector Energy Transformation 1990-2050

Space Heating and Hot Water – Yearly Emissions by Fuel Source - 2015

Move to Zero Emissions Renewable Electric ASAP → Winning Solution



Natural Gas Does Not Meet Emissions Reduction Goals

	Yes	No
	☐	☑
	☐	☑

The More Complete Story About Residential Natural Gas Use

For Heating & Hot Water Natural Gas is 28% Cleaner Burning Than Petroleum or Wood

Add Stove and Dryer Use and Natural Gas Use CO_2 Is 20% Higher Than Petroleum

Add Methane Leakage and Natural Gas Use CO_2e Is 64% to 98% Higher Than Petroleum

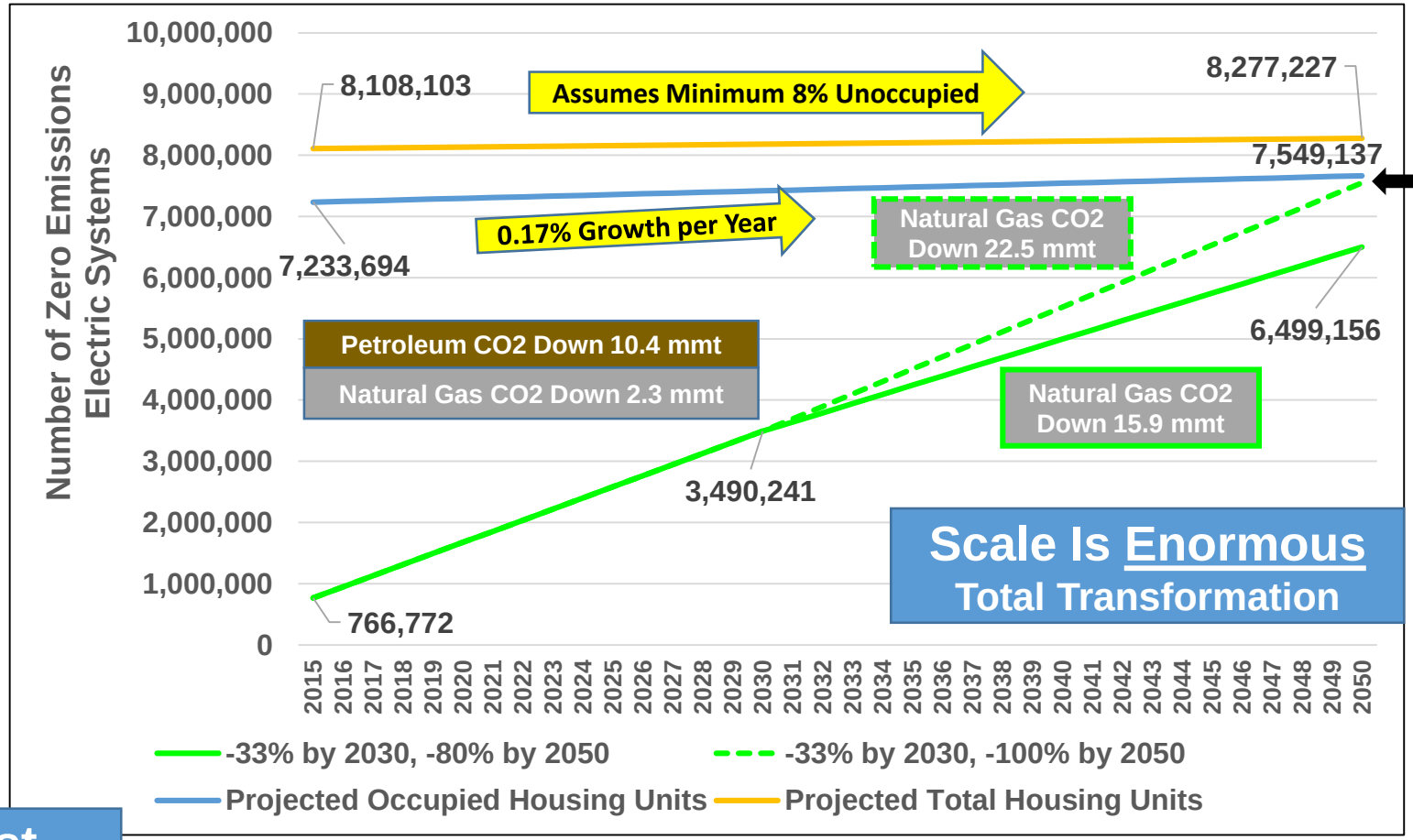
Natural Gas Electric Is CO_2 Emissions Intensive

Phase Out Subsidies & Advertising for Natural Gas, Petroleum, & Wood They Cannot Meet Goals

Sources: EIA Data Browser & US Census Bureau
2015 American Community Survey
EPA Power Plants Data - 2012

Residential Sector Energy Transformation 1990-2050

Heat Pump Conversions to Meet Emissions Reduction Goals



No Reason to Slow Down
Go for 98.5% Emissions Reduction

Scale Is Enormous
Total Transformation

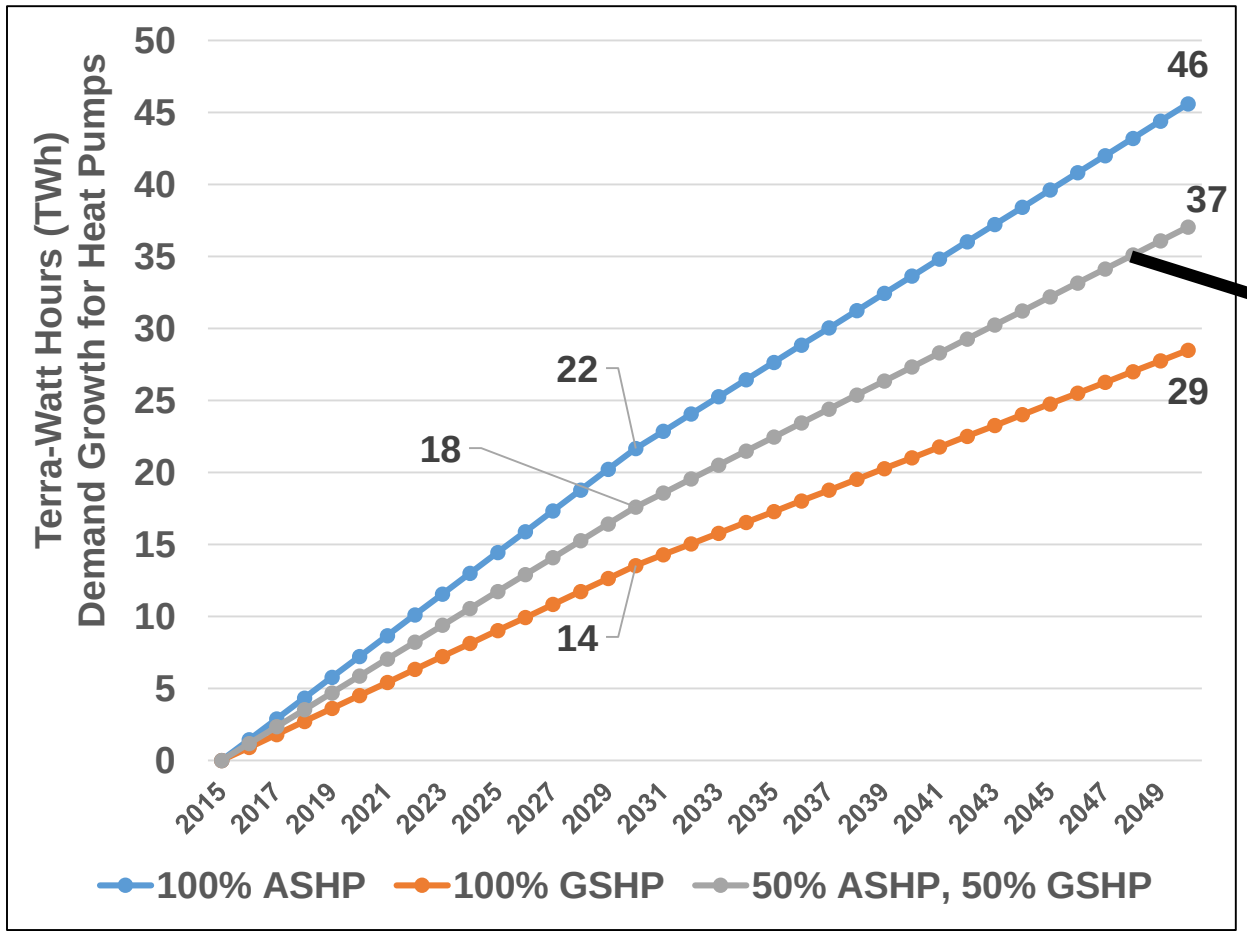
Pace Is Fast
Heat Pump Conversions Must Be 13 to 22 Times Greater Than the Past 25 Years

Conversions Pace	1990 - 2015	2015 - 2030 (-33%)	2030 - 2050 (-80%)	2030 - 2050 (-98.5%)
Total	202,429	2,723,470	3,008,915	4,058,896
Per Year	8,097	181,565	150,446	202,945
Per Month	675	15,130	12,537	16,912
Per Work Day (250)	32	726	602	812

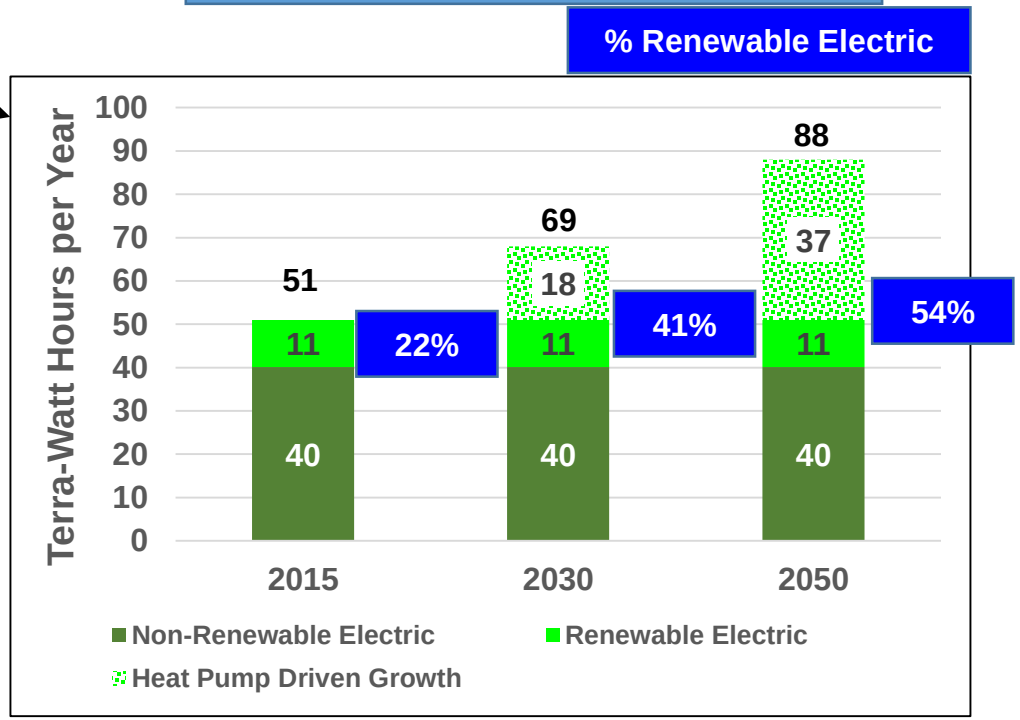
Residential Sector Energy Transformation 1990-2050

Additional Renewable Electricity Needed for Heat Pumps

Terra-Watt Hours per Year (TWh) 2015-2050

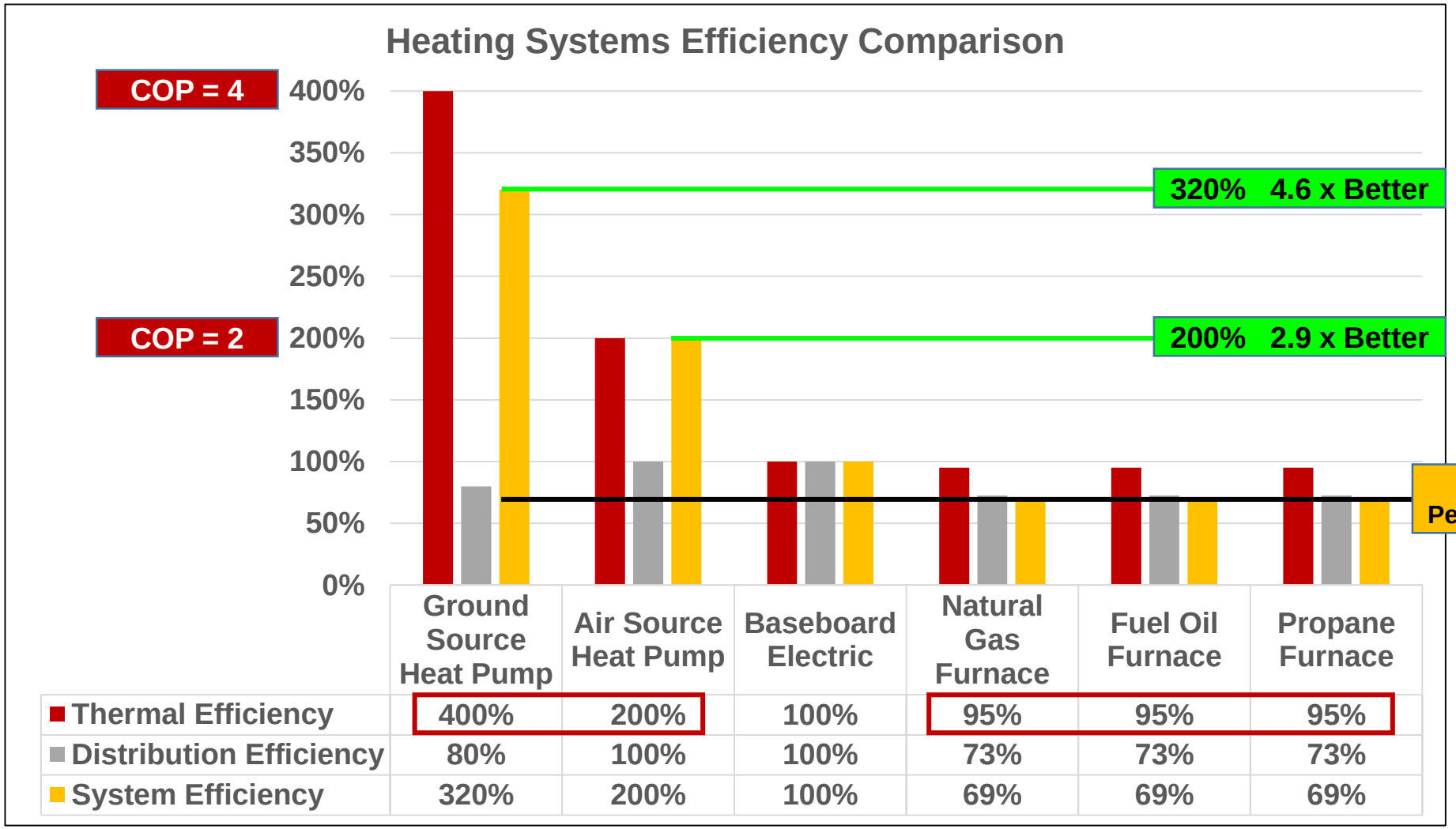


Assumption:
All Heat Pump Demand Growth is Met with Zero Emissions Electric



Residential Sector Energy Transformation 1990-2050

Housing Unit Heating Systems Efficiency



	Ground Source Heat Pump	Air Source Heat Pump	Baseboard Electric	Natural Gas Furnace	Fuel Oil Furnace	Propane Furnace
Thermal Efficiency	400%	200%	100%	95%	95%	95%
Distribution Efficiency	80%	100%	100%	73%	73%	73%
System Efficiency	320%	200%	100%	69%	69%	69%

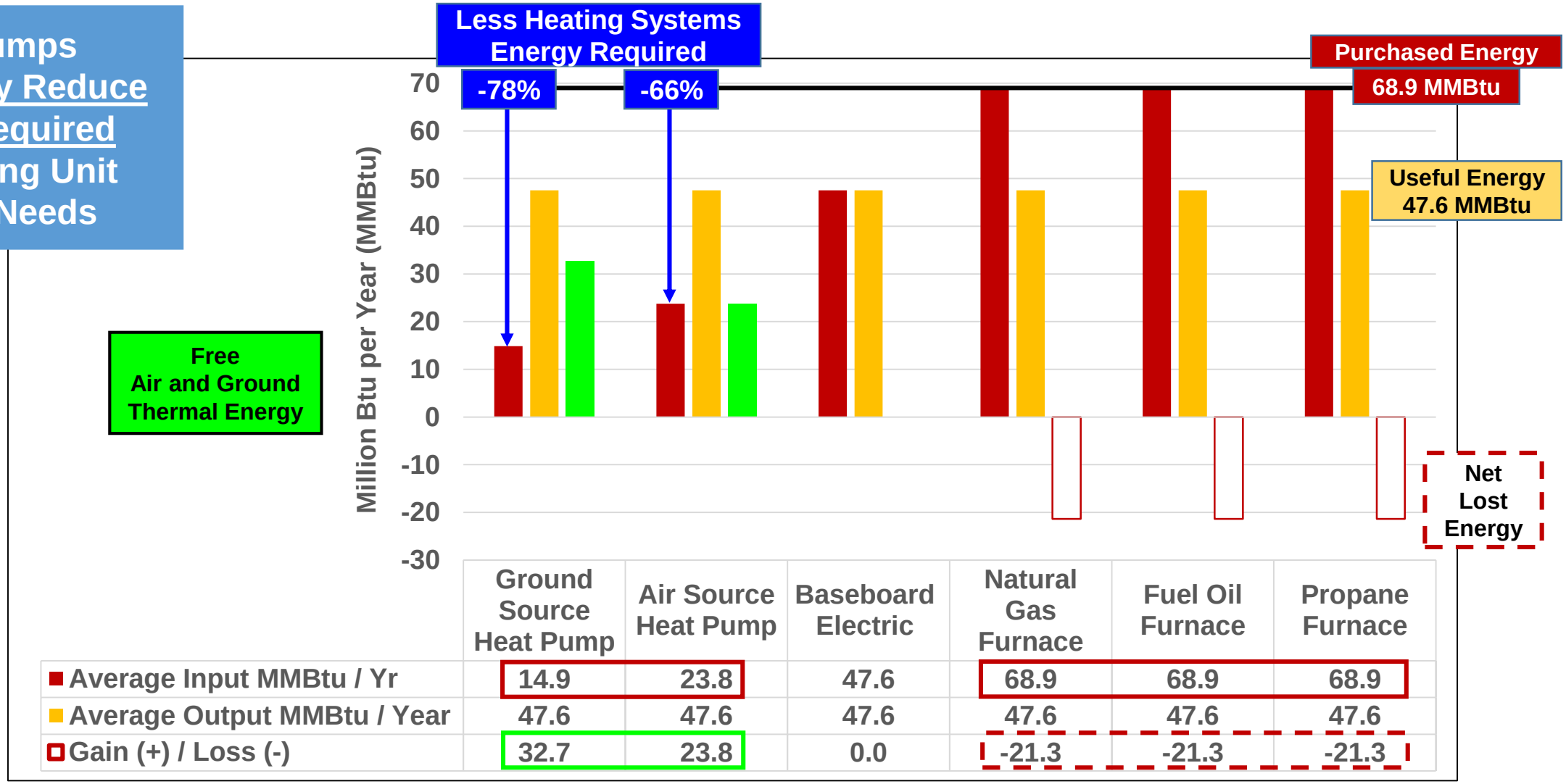
Heat Pumps Are Far More Efficient Than Combustion Systems

Residential Sector Energy Transformation 2015-2050

Housing Unit Average Yearly Heating Systems Energy Use

Reduce Building Energy Use by 23%

Heat Pumps Significantly Reduce Energy Required For Housing Unit Heating Needs



	Ground Source Heat Pump	Air Source Heat Pump	Baseboard Electric	Natural Gas Furnace	Fuel Oil Furnace	Propane Furnace
Average Input MMBtu / Yr	14.9	23.8	47.6	68.9	68.9	68.9
Average Output MMBtu / Year	47.6	47.6	47.6	47.6	47.6	47.6
Gain (+) / Loss (-)	32.7	23.8	0.0	-21.3	-21.3	-21.3