

### **Energy Industry Fundamentals**

### The Benefits of Natural Gas

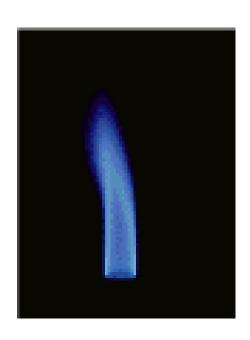
Eric Burgis, Energy Solutions Center

This unit is part of Energy Solutions Center's: Energy Industry Fundamentals Training Program

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### **Presentation Outline**

- Gas Production & Consumption
- Projected Reserves of Natural Gas in North America
- Energy Costs
- Efficient Energy
- Resiliency
- Environmentally friendly
- Natural Gas Technologies





### **Gas Production & Consumption**

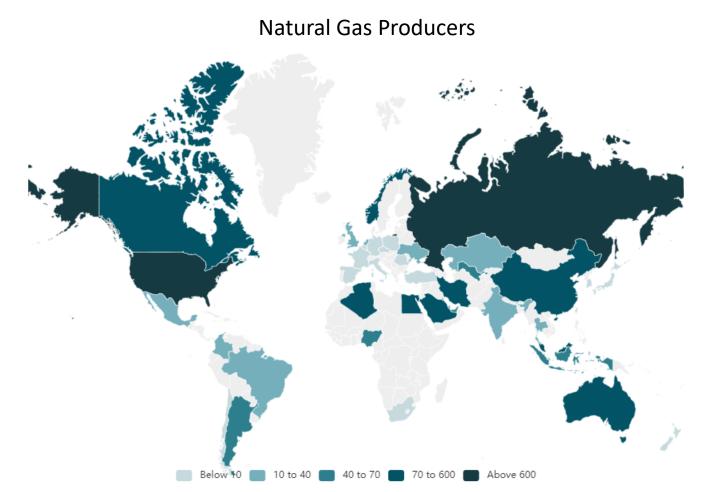
**Production outweighs consumption in North America** 

### **Natural Gas Worldwide**

### **Top 10 Net Producers & Consumers**

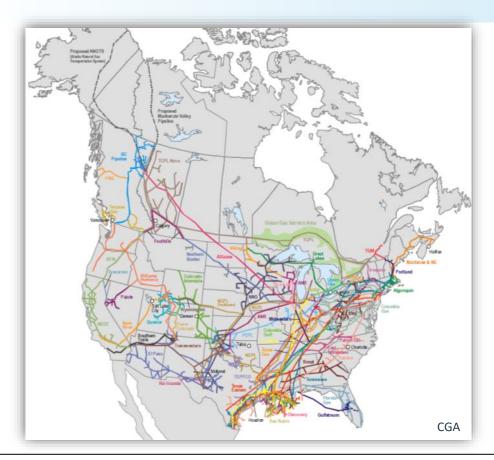
Production	ВСМ
<b>United States</b>	975
Russia	791
Iran	239
China	209
Canada	191
Qatar	169
Australia	143
Norway	119
Saudi Arabia	101
Algeria	90

Consumption	BCM
<b>United States</b>	862
Russian	565
China	365
Iran	233
Canada	133
Saudi Arabia	101
Japan	101
Germany	99
UK	79
Italy	76





### **Vast Interstate Pipeline Network**

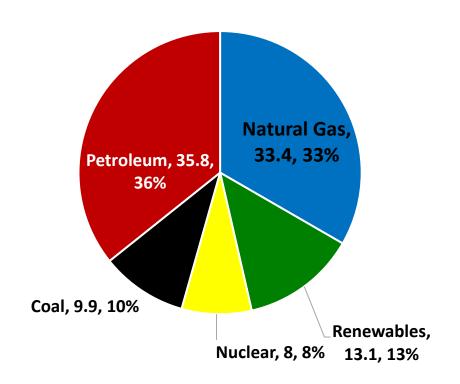


- 2.6 million miles of underground system
- ~2.2 million miles LDC, ~300,000 miles Transmission

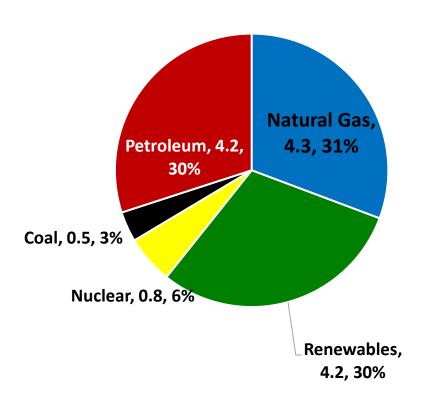


## Natural Gas Supports ~1/3 of Primary Energy Consumption

Total Primary U.S. Energy Consumption 2022 (Quadrillion BTUs)



Total Primary Canadian Energy Consumption 2021 (exajoules)

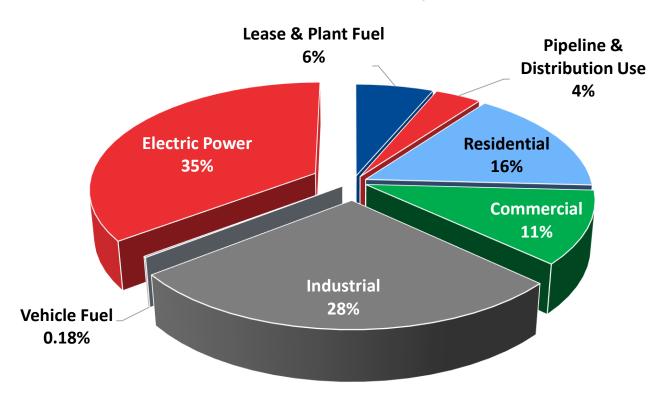




https://www.statista.com/statistics/265608/primary-energy-consumption-in-canada-by-fuel/

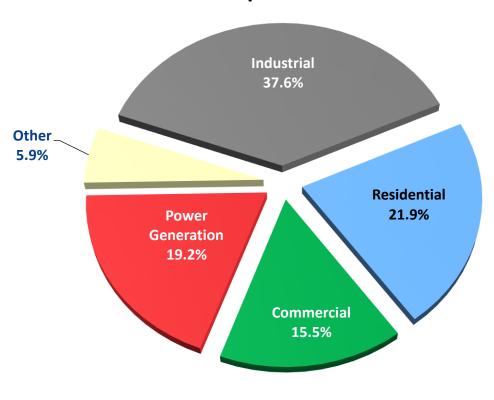
### **Natural Gas Consumption**

### **U.S. Natural Gas Consumption (MCF)**



#### http://www.eia.gov/dnav/ng/ng\_cons\_sum\_dcu\_nus\_a.htm

### **Gas Consumption in Canada**



Statistics Canada



### More than 6 in 10 North American Homes Use Natural Gas

- Natural Gas serves:
  - ■U.S. Homes
    - 75.3 Million of 123.5 U.S. Homes use natural gas (~61%)
  - Canadian Homes
    - Natural gas is used by approximately ¾ of Canadians in over 7.4 million customer locations across the country

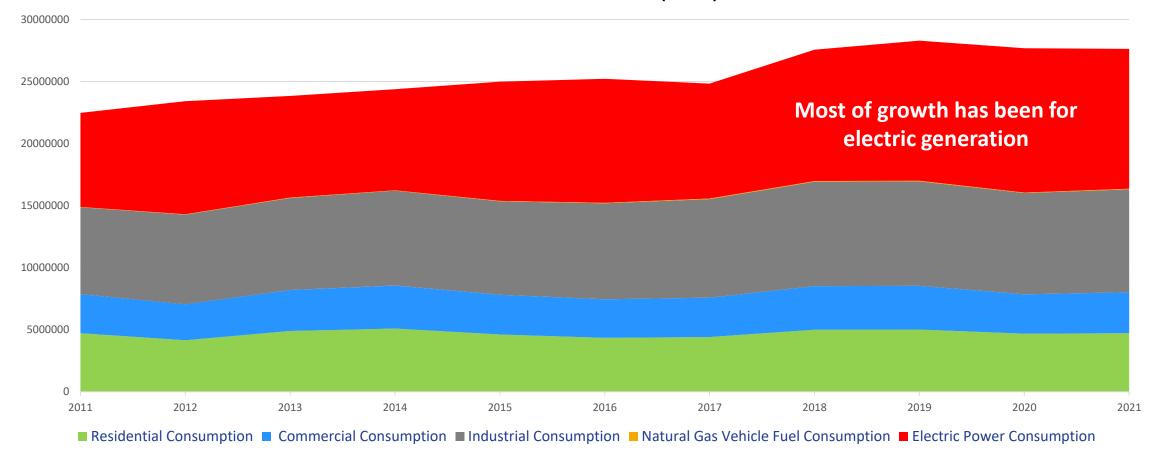
U.S. RECS data

https://www.cga.ca/natural-gas-statistics/natural-gas-facts/



## Gas Consumption Remains Consistent for the Residential, Commercial & Industrial Markets







### **Natural Gas Reserves**

> 100 Years of Reserves in the U.S. and > 200 years in Canada

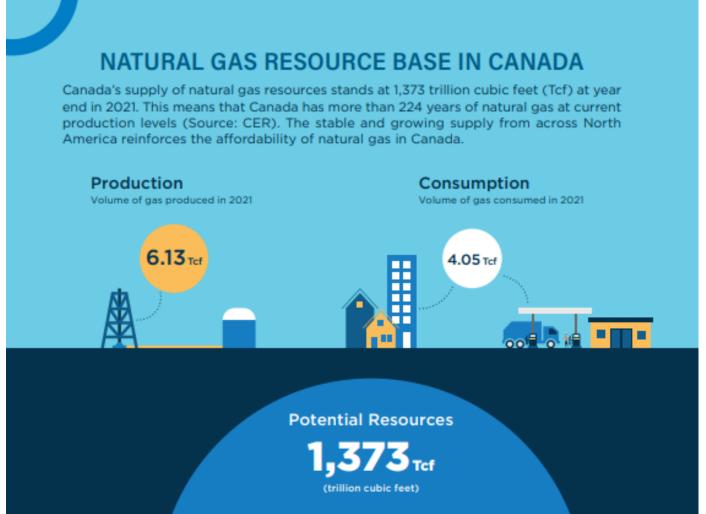
### More than 100 Years of Natural Gas Supply in U.S.







### Canada has Over 224 years of Gas Supply

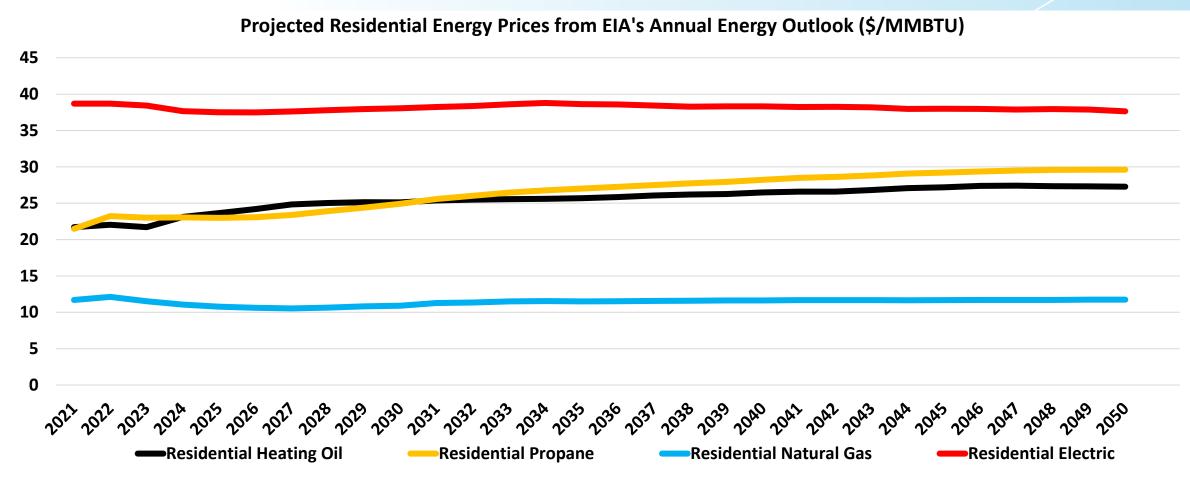




### **Energy Costs**

**Natural Gas is Economical** 

### **Future Residential Energy Pricing**

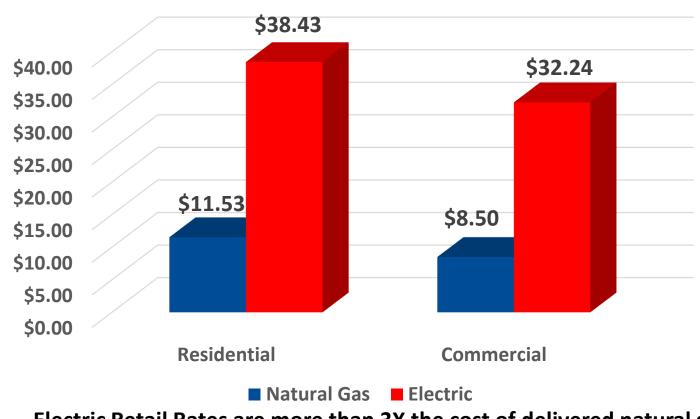


Natural Gas is projected to continue to be the lowest energy cost for homes on a BTU for BTU basis well into the future.



### **Current Average Retail Energy Prices (\$/MMBTU)**

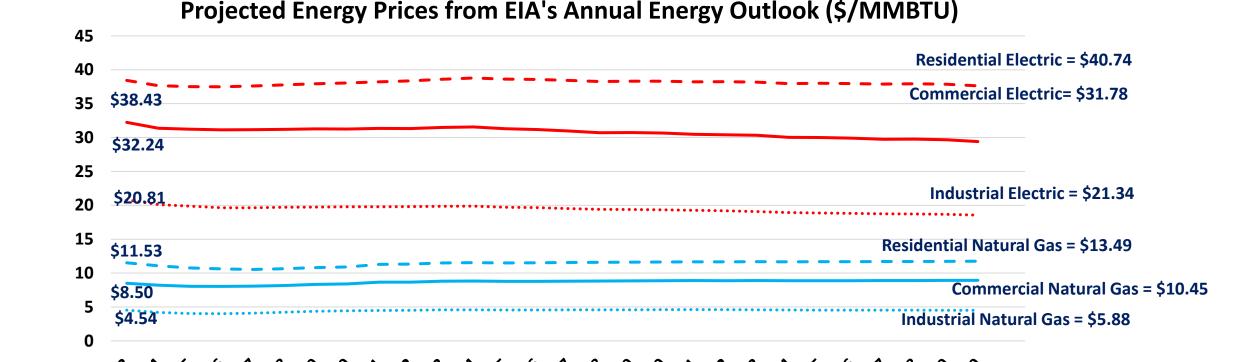




Electric Retail Rates are more than 3X the cost of delivered natural gas for residential & commercial customers.



### **Current Average Retail Energy Prices (\$/MMBTU)**





Natural Gas is projected to continue to be the lowest energy cost on a BTU for BTU basis for all markets well into the future.

Commercial Electric

····· Industrial Natural Gas

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Residential Natural Gas - - Residential Electric

Commercial Natural Gas ······ Industrial Electric

### **Gas Saves U.S. Homes and Businesses**











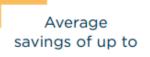
### **Gas Saves Canadian Home Owners Money**

#### **ABUNDANT SAVINGS**

At a national level (average), households that use natural gas for space and water heating save \$1,000 to \$3,000 per year, compared to homes using propane, electricity, and heating oil for the same applications. More recently, natural gas utilities have been looking at new approaches to meeting the evolving energy needs of consumers including hybrid heating — involving the combination of a heat pump and a high efficiency furnace. As we look forward, utilities are supporting the commercialization of gas heat pumps that offer a 40–50 per cent increase in energy efficiency vs. a high efficiency furnace.

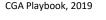
#### Residential Space and Water Heating Costs - Canada 2021





\$2,000

per year





## **Energy Efficiency**

Natural Gas is more efficient on a source basis

### **Typical Efficiencies**

### Efficiency Definition

The related energy output or effect as a result of energy input

### • Heating

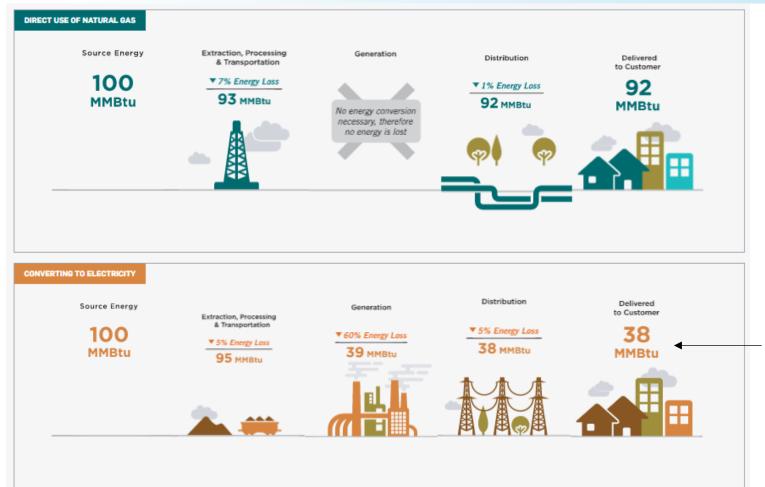
- With Natural Gas, Oil or Propane the standard efficiency today is around 80-82%
- Higher efficiency models are also available > 90 %
- Gas Heat Pumps are approx. 140% efficient

### • Electric Resistance Heating or Gas Infra Red

- There is no energy lost in the form of waste heat and is typically 99% efficient, but this
  efficiency is offset by energy cost
- **Electric Heat pumps** work differently and have efficiencies well over 100%. Electric heat pumps are typically rated in Heating Seasonal Performance Factors (HSPF)



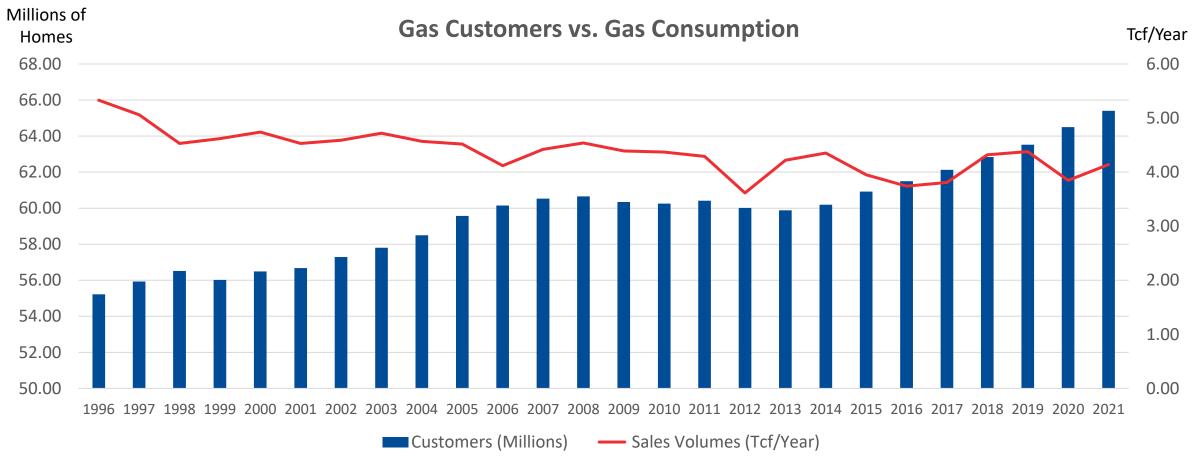
### Natural Gas is More Efficient on a Source versus Site Basis

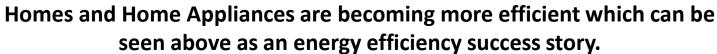


Overall electrical efficiency has increased over past several years as combined cycle gas plants replace old coal plants.



## Per Household Gas Use Decreasing While More Customers are Added to the System





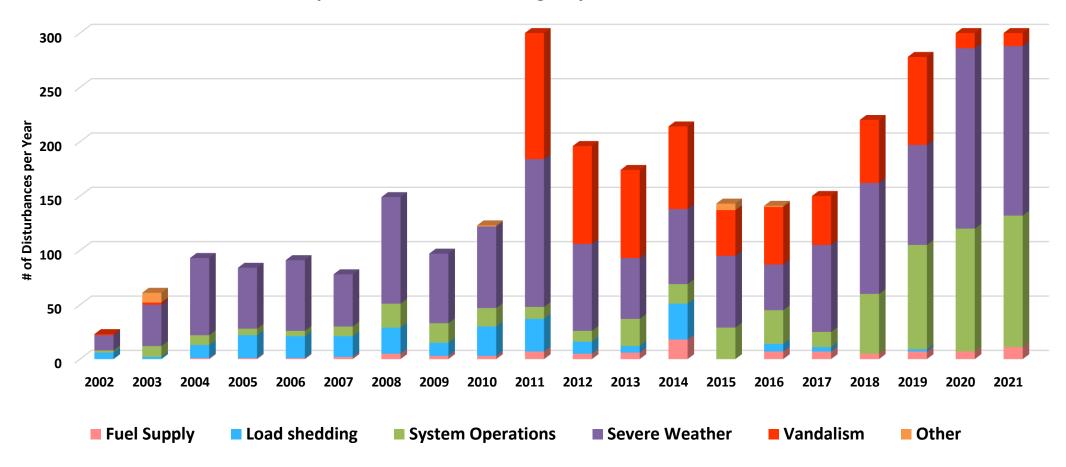


### Resiliency

Natural Gas is less prone to disruptions of service

## The Electric Grid is Stressed with Congestion and Constraints Leading to More Outages

**Reported U.S. Electric Emergency and Disturbances** 





### Why the Decline in Electric Grid Reliability?





V

8,000 MW



Generation: (Growing)



Transmission & Distribution: (?????)



Load: (Growing)

An aged electric transmission and distribution system cannot handle today's demand for power even if we can generate more power than needed by consumers. T&D Congestion and Constraints continue to increase. Natural Gas use reduces demand for electric helping to stabilize the grid.



### **Natural Gas is More Reliable**

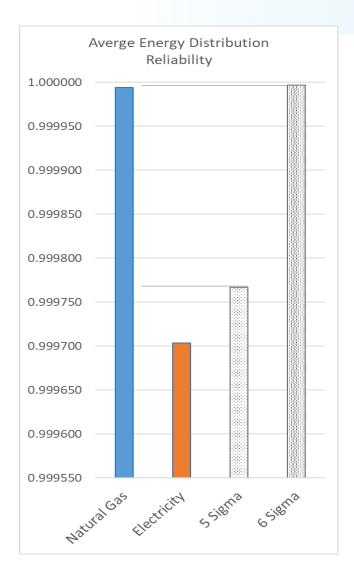


Table 1: Summary Energy Distribution Reliability and Outage Rate Results

	Natural Gas	Electric
Metric	Distribution	Distribution
Average Reliability/Availability (Planned and Unplanned)	0.999957	0.999703
Average Reliability/Availability (Unplanned)	0.9999991	
Average Outage Rate – Planned and Unplanned (Event Per Customer Per Year)	0.00895	1.017
Estimated Unplanned Outage Rate (Event Per Customer Per Year)	0.00125	

Data from GTI Topical Report: Assessment of Natural Gas & Electric Distribution Service Reliability—7/19/18.

Customers that require uninterrupted power want more 9's when it comes power reliability. A rating of 99.9999% reliable is better than just 99% reliable. This study concludes that natural gas is far more reliable than electric.

http://www.gastechnology.org/Solutions/Documents/Assessment-of-Natural-Gas-Electric-Distribution-Service-Reliability-TopicalReport-Jul2018.pdf



### **Environmentally Friendly**

On a source basis, Natural Gas typically has the lowest carbon footprint compared to other forms of energy

### Natural Gas Can be Used to Reduce CO2



### NATURAL GAS IS KEY **TO A LOW-CARBON ENERGY FUTURE.**

Natural gas is a vital part of our energy mix because it produces low CO2 emissions and provides reliable and efficient energy as we work toward a low carbon energy future.1



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### Natural Gas has Contributed to a Drop CO2 Emissions

(Million Metric Tons)

Sources	Residential	Commercial	Industrial	Transportat ion	Electric Power	Source Total	
Coal -2011	1	5	151	0	1,718	1,874	
Coal - 2017	0	2	109	0	1,207	1,318	
Coal - 2021	0	1	91	0	908	1,001	Down
Natural Gas - 2011	256	171	419	39	411	1,296	
Natural Gas - 2017	243	174	509	40	506	1,472	
Natural Gas - 2021	255	179	530	58	615	1,637	Up
Petroleum - 2011	78	49	345	1,802	25	2,299	
Petroleum - 2017	60	59	342	1,858	19	2,338	
Petroleum - 2021	63	61	340	1743	17	2,224	
Electricity - 2011	827	767	567	4		2,165	
Electricity - 2017	653	639	448	4		1,744	
Electricity - 2021	604	542	403	3		1,552	Down

Natural Gas and Renewables have replaced coal power, helping to reduce CO2 from electric generation. Overall source emissions have dropped by 16% in the last decade.

### **GHG Emissions**



### **GREENHOUSE GAS EMISSIONS BY SECTOR**

75% of greenhouse gas emissions in the United States comes from the transportation, electricity generation, and industrial sectors, with the rest coming from agricultural operations and commercial and residential buildings. Plus, over half of energy consumption in U.S. households is used for space heating and cooling.<sup>3</sup>



Total U.S. Greenhouse Gas Emissions by Economic Sector in 2020

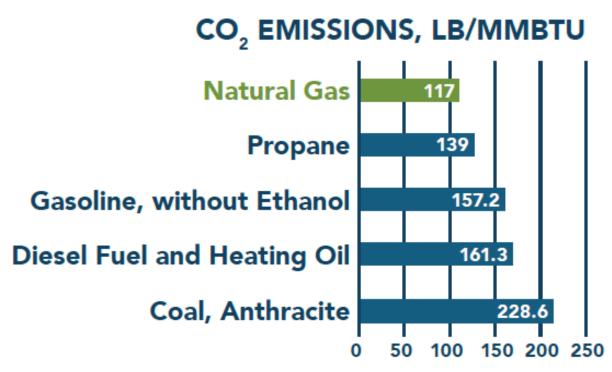


3. U.S. EIA, Use of Energy Explained, 2021

### Natural Gas has Lowest Carbon Footprint of any Fossil Fuel



The carbon intensity (i.e., the amount of CO<sub>2</sub> emitted per unit of energy consumed) of natural gas is lower than all other fossil fuels.<sup>1</sup> The fact that natural gas has replaced coal as the top fuel in the U.S. electricity sector is one of the main reasons why this sector has been able to reduce its emissions over the last 10 years.<sup>2</sup> Natural gas vehicles have reduced carbon emissions in the transportation sector.



Source: EIA, Carbon Dioxide Emissions Coefficients

2. U.S. EPA, Sources of Greenhouse Gas Emissions, 2022

Electric eGRID 2023: U.S. Total output = 852,300 LB/MWh. 852,300 LB/MWh / 3,412 MMBTU/MWh = **249.8 LB/MMBTU** 



### **Natural Gas Lowers Carbon Emissions in Many Ways**



## UPGRADED NATURAL GAS PIPELINES REDUCE EMISSIONS BY 73%<sup>4</sup>

- ✓ Better systems management³
- Diligent preventative maintenance
- Enhanced leak detection repair



# BIOGAS REFINING CONVERTS METHANE INTO CARBON-NEUTRAL RENEWABLE ENERGY<sup>5</sup>

- The capture of biomethane at wastewater treatment plants, agricultural waste, waste processing facilities and landfills, prevents methane release into the environment.
- Displacing carbon emitting gas with carbon neutral gas significantly lowers greenhouse gas emissions.



### NATURAL GAS HEAT PUMPS ARE RELIABLE AND EFFICIENT

- Efficiency and savings in moderate climates
- Added performance during very cold weather
- Extract heat from air, ground, or water sources



## OF NATURAL GAS IS 92% EFFICIENT

- According to the American Gas Association, the direct use of natural gas is more efficient than consuming gas-fired electricity from the grid.
- Direct use of natural gas for heating, cooling, water heating, cooking, and clothes drying cuts carbon emissions by almost 50%.6

### Renewable Natural Gas & Hydrogen Help Reduce Emissions

# RENEWABLE Natural Gas Reduces Carbon Emissions

The capture of biomethane prevents methane from being released into the environment.

Displacing carbon emitting gas with carbon neutral gas significantly lowers total greenhouse gas emissions.<sup>7</sup>

# 95% OF HYDROGEN Is Produced From Natural Gas

In the United States, 95% of hydrogen is produced by natural gas reforming in large central plants.8 The hydrogen production process, delivery and storage, and fuel cell electric vehicles reduce total greenhouse emissions by 50% compared to gasoline vehicles.

More and more waste streams are being identified to produce RNG. New methods to extract H2 from Natural Gas are cleaner and produce Blue or Turquoise Hydrogen.

## Renewable Natural Gas Could Replace a Significant Portion of Conventional Gas, Reducing the Overall Gas System Carbon Footprint



#### **FEEDSTOCKS AND PROCESSES**

RNG is derived from various biogenic feedstocks, including wastewater sludge, animal manure, food waste, agricultural residues, forest product residues, municipal waste and energy crops. Three processing systems can produce RNG:



1. Anaerobic digestion uses microbes to break down organic matter and converts the resulting organic acids into methane gas.



**2. Thermal gasification** is a high-temperature process that completely dries biomass, converting it into gas and char.



3. Power-to-gas technologies use electrolysis to convert renewable electricity into hydrogen or methane for natural gas pipeline injection.



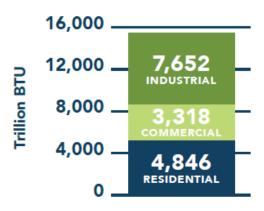
#### IMPACT OF RENEWABLE NATURAL GAS

RNG is interchangeable with conventional natural gas and can be used in residential, commercial, industrial and transportation applications. Use of RNG can make meaningful progress toward decarbonization.



RNG production could be enough to cover 59% of industrial or 93% of residential natural gas demand.<sup>3</sup>

#### RNG RESOURCE POTENTIAL



### Up to 30% Hydrogen can be Blended into the Gas System



### PRODUCING HYDROGEN

Hydrogen can be produced in several ways. The two most common methods include:

STEAM-METHANE REFORMING (SMR)

SMR uses high-temperature steam to heat methane from natural gas, producing hydrogen and carbon dioxide. More than **90**% of hydrogen produced today is through SMR.<sup>1</sup>

ELECTROLYSIS

Electrolysis uses an electrical current to split water molecules into oxygen and hydrogen.



### **BLENDING HYDROGEN WITH NATURAL GAS**

Natural gas pipelines and combustion equipment can incorporate hydrogen in blends up to **30**%, depending on equipment design and application.<sup>2</sup>





### Carbon Offsets & Carbon Capture Reduce our Carbon Footprint



#### WHAT ARE CARBON OFFSETS?<sup>2</sup>

Carbon offset projects are specific activities intended to reduce greenhouse gas emissions. Offsets work by eliminating emissions elsewhere to balance out carbon produced in another location.



2. https://www.epa.gov/sites/default/files/2018-03/documents/gpp\_guide\_recs\_offsets.pdf



### ADVANCEMENTS IN CARBON CAPTURE AND SEQUESTRATION TECHNOLOGY

Carbon capture and sequestration refers to technologies that remove carbon from exhaust emissions and store it safely where it causes little to no environmental impact.

- Geologic Sequestration
- Commercial Applications
- Biologic Sequestration
- Flue Gas Conversion



## **Benefits of Natural Gas Technologies**

Natural gas appliances are preferred by consumers for their comfort, convenience, lifestyle, environmental and cost savings

## **Lots of Natural Gas Water Heating Options to Choose From**



**Atmospheric Storage** 



**Boiler** 



**Tankless** 



Booster Water Heater



Solar/Gas Hybrid



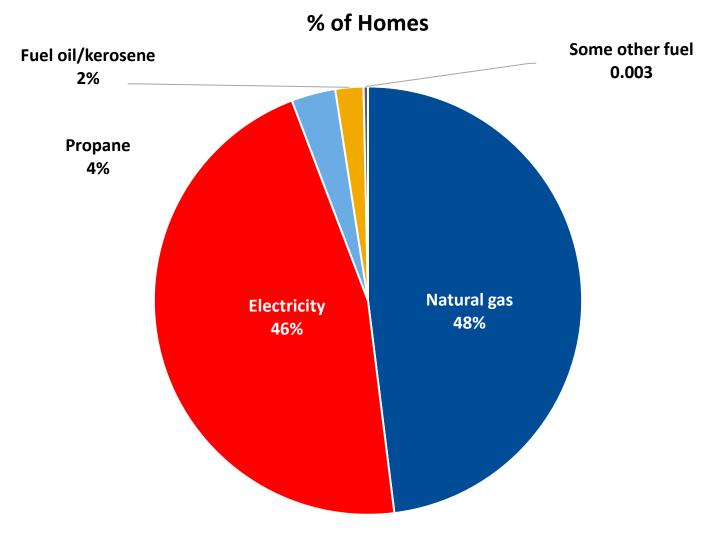


Fire-Tube Condensing





## Almost ½ of Homes Use Gas as Their Primary Energy to Make Hot Water





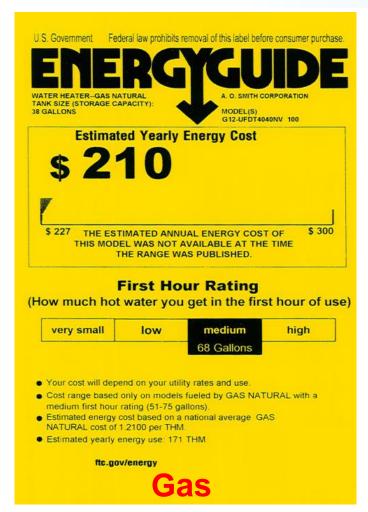
## Residential Gas Water Heaters have a Low Life Cycle Cost

Life Cycle Cost	Electric Tank	Gas Tank (Power Vent)	Gas Tankless (Standard)	Gas Tankless (Condensing)
Installed Cost – Year 1	\$ 750	\$ 1,200	\$ 1,800	\$ 2,500
Tank Replacement – After Yr 12	\$ 750	\$ 1,200	\$ 0	\$ 0
Operating Costs – Year 1	\$ 574	\$ 238	\$ 195	\$ 166
12 Year Life Cycle Cost	\$ 8,030	\$ 4,056	\$ 4,140	\$ 4,492
24 Year Life Cycle Cost	\$ 16,983	\$ 8,112	\$ 6,480	\$ 6,484

Assumes that electric prices increase at 1% per year and that gas prices hold stable for the foreseeable future.



### Tank Water Heater Comparison from the Label





- Gas Benefits:
- Save Money: \$210/Year to operate on gas versus \$489 for Electric
- Higher First Hour Rating with 68 gallons of hot water compared to 63 gallons with electric.
- Much faster recovery time from cold shower to recharged. From specifications for each water heater, the gas model recovers at a rate of 42 GPH at 90 Deg F versus just 25 GPH for the electric model.



# Improvements & Intelligence for Tank Water Heaters Add Convenience and Save Energy



Microprocessor controls

Tank maintains consistent temperatures

Integrated mixing devices

Allows for storage of hotter water – increasing amount of usable hot water available



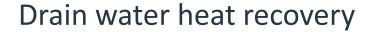
Set back controllers
Similar to programmable thermostat

Leak detection devices

Shuts off water if tank leak is detected



Atmospheric flue dampers Reduces standby losses







## Residential Gas Water Heating Has Lowest Carbon Emissions

#### Water Heating Carbon Footprint for family of 3

Water Heater Type	CO <sub>2</sub> #/Year
Electric Tank, .90 EF	4,128
Gas Tank, .62 EF	2,641
Gas Tankless, .82 EF	2,047



#### Residential Energy Calculator



Use this calculator to compare natural gas versus other fuels and discover the environmental advantages of using natural gas in your home. Disclaimer



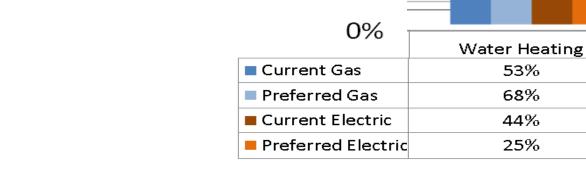
#### Home Information

Please provide information about your home. This information is used for all future energy calculations. You will have the ability to return to this page on future steps.



### **Homeowners Prefer Gas Water Heating**

- National Survey of New Home **Buyers**
- Customers prefer gas water heating:
  - 68% of homebuyers prefer gas water heaters
  - Only 25% want electric





53%

68%

44%

25%

80%

70%

60%

50%

40%

30%

20%

10%

### **Benefits of Natural Gas Water Heating**

- Uses less energy costing about ½ as much to operate versus electric
- Recovery time is much faster
- First hour rating for tank models is higher with gas
- Style and sizes to fit most installations
- Tankless Never run out of hot water
- High efficiency options available
- Long life 20 years or more with tankless



### Many Natural Gas Space Heat Options





Infrared

















**Combo System Space and Water Heat** 



**Boilers** 

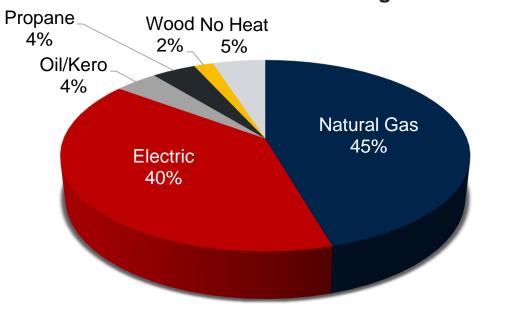
**Combine w/ Hydronic Floor Heating** 





## On Average, ~½ of North American Homes Heat with Natural Gas

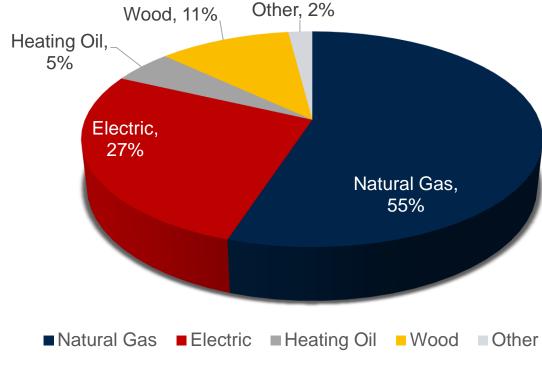
#### **U.S. Residential Main Heating Fuel**





■ Natural Gas ■ Electric ■ Oil/Kero ■ Propane ■ Wood ■ No Heat

#### **Space Heating Energy Use in Canada**

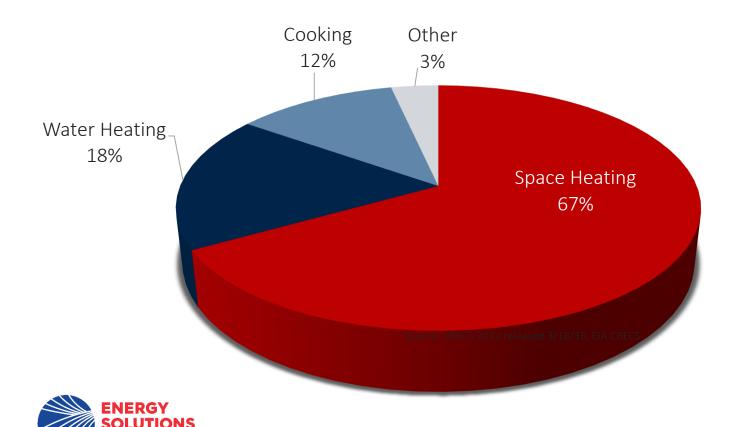


Source: Natural Resources Canada – Energy Fact Book 2022-2023

https://publications.gc.ca/collections/collection\_2022/rncan-nrcan/M136-1-2022-eng.pdf

#### **Commercial Market Gas Consumption**

#### Natural Gas Consumption for Total Commercial Market



The commercial sector typically uses natural gas as its energy source for space heating and hot water heating. Commercial buildings seeking energy savings and reductions in electric demand have also been using natural gas air conditioning systems for many years.

### Save CO<sup>2</sup> and \$\$\$ with Gas Heat

- Average U.S. 2,000 Sq Ft home
- EIA average retail energy prices of \$9.30/MMBTU and \$.13/KWH

	Natural Gas		Electric		
	80% Furnace	92% Furnace	8.7 HSPF Heat Pump	10 HSPF heat Pump	Electric Strip heat
#'s of CO <sup>2</sup> /Year (All Generation Sources)	7,260	6,313	15,589	14,106	24,672
#'s of CO <sup>2</sup> /Year (Fossil Mix)	7,260	6,313	22,075	19,976	34,938
Energy Cost (\$/Year)	\$577	\$543	\$973	\$816	\$1,781



#### **Natural Gas Space Heat Benefits**

- Save Money over Electric, Oil, Propane Heat
- Faster Warm Up compared to Electric Heat
- Cleaner Reduced Emissions
- Furnace feels warm and comfortable opposed to cold and drafty
- No Prepayment or waiting for Oil/Propane Deliveries with Gas Heat



## **Gas Heat Pumps (GHP) Provide High Efficiency Heat**

#### **Absorption Heat Pump**





#### **Engine Driven Heat Pump**









## **Types of Heat Pumps**

**Energy Source** 

Electric

Cycle

**Heat Source** 

Vapor Compression (Electric Motor or Gas Engine)

Absorption/Adsorption

Thermal Compression

Vapor Compression (Electric Motor or Gas Engine)

Absorption/Adsorption

**Thermal Compression** 

Vapor Compression (Electric Motor or Gas Engine)

Absorption/Adsorption

Thermal Compression

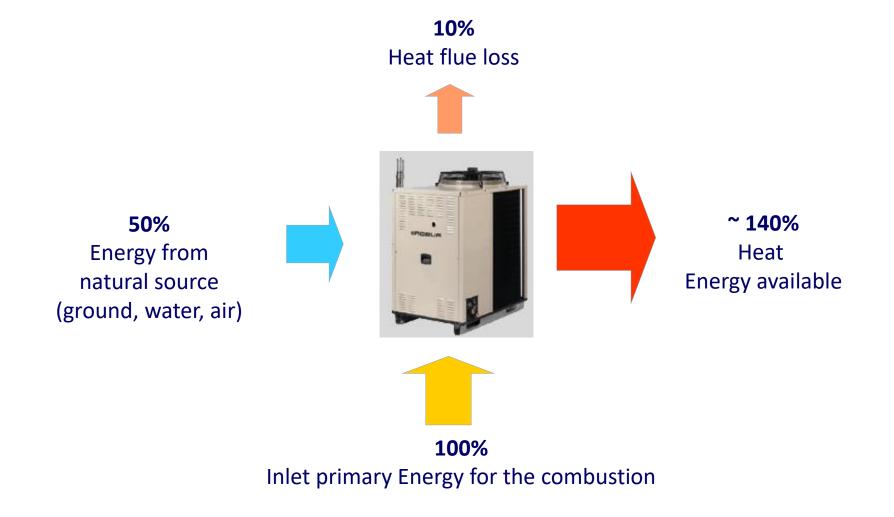
Air

Water (Open or Closed loop)

> Ground (Geo-Thermal)

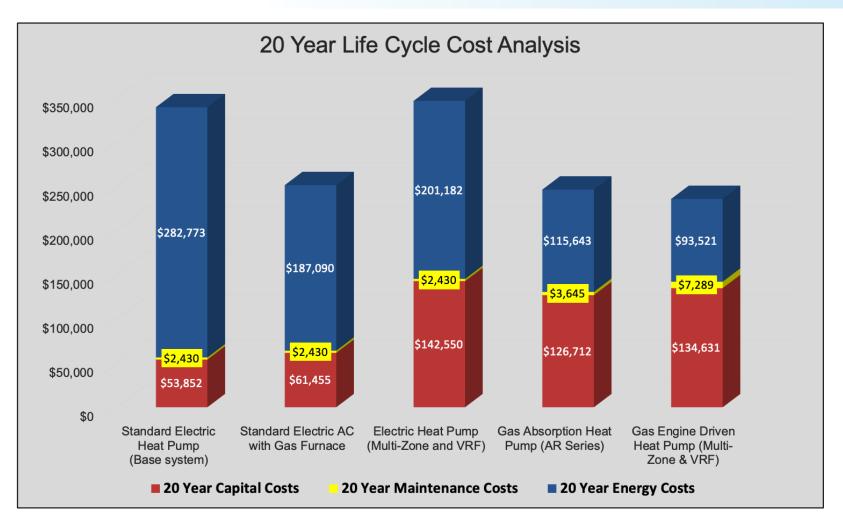
Gas

## **Break the >100% Thermal Efficiency Barrier with a GHP**





### **GHP Life Cycle Costs are Lower than Conventional Systems**



Note: GHPs can cost 3X that of conventional HVAC systems, but generally have overall lower life cycle costs than conventional systems.

Assumptions: 20-ton system amortized over 20 years at 5% interest with \$.17/kWh, \$10/kW, and \$.65/Therm energy rates, with 2% energy & maintenance inflation rates.

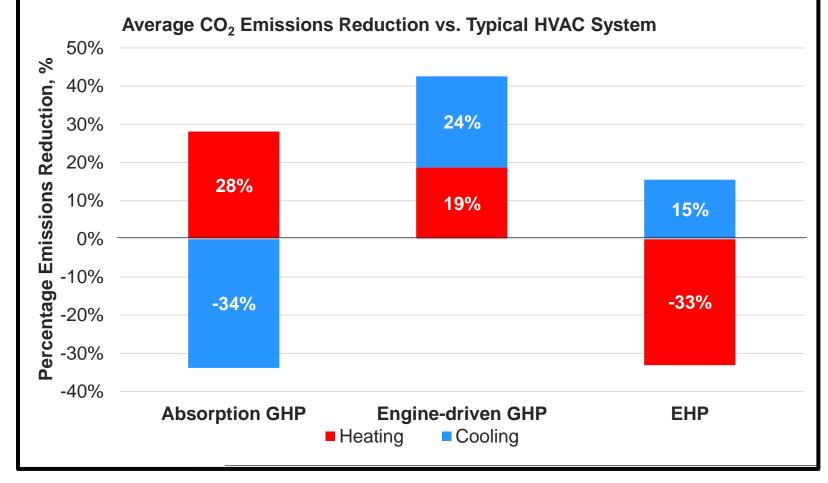
Note that life cycle costs will vary based on energy rates in your region.

https://gasairconditioning.com/general-resources/tools/



# Lifetime Emissions for Gas and Electric Heat Pumps at Commercial Buildings

Baseline is RTU with gas heat & electric cooling.





Source: <a href="https://consortia.myescenter.com/GHP/ESC\_GHP\_Operating\_Costs-Emissions-Study-ICF-August2021-Full.pdf">https://consortia.myescenter.com/GHP/ESC\_GHP\_Operating\_Costs-Emissions-Study-ICF-August2021-Full.pdf</a>

### **Gas Heat Pump Benefits**

- Save Money
  - ~140% efficient heating
  - Gas cooling
  - Lowest Life Cycle Costs
- Reduced CO2 compared to conventional systems
- Work well in cold climates
- Can obtain much higher efficiencies if simultaneous heating and cooling are needed



## **Natural Gas Cooling Options**



**Absorption Chillers** 







**Steam Turbine Driven Chiller** 

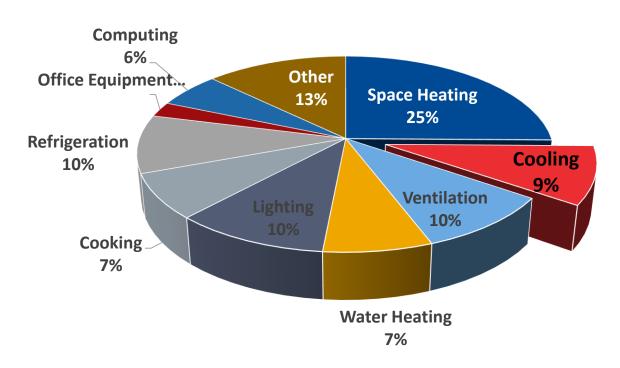
Engine Driven Chillers



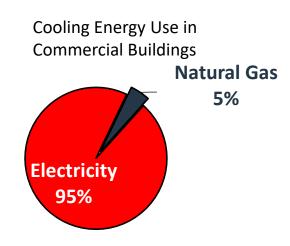


## Plenty of Opportunities for Gas Cooling in the Commercial Market





Source: EIA CBECS Table 5



Cooling accounts for 656 Trillion BTU's of energy per year consumed by commercial buildings.



#### **Natural Gas Cooling Benefits**

- Saves Money
- Reduces Electric KW and Demand Charges During Hot Summer Months
- Reduces Emissions
- Lower Cost Life Cycle Cost Analysis
- Can Reduce Back-Up Generator Size
- Can be coupled to CHP systems

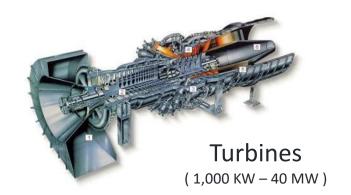


## **Improve Source Efficiency with Combined Heat & Power**

#### Power Generation Equipment Options



Reciprocating Engines
(5 KW - 8 MW)





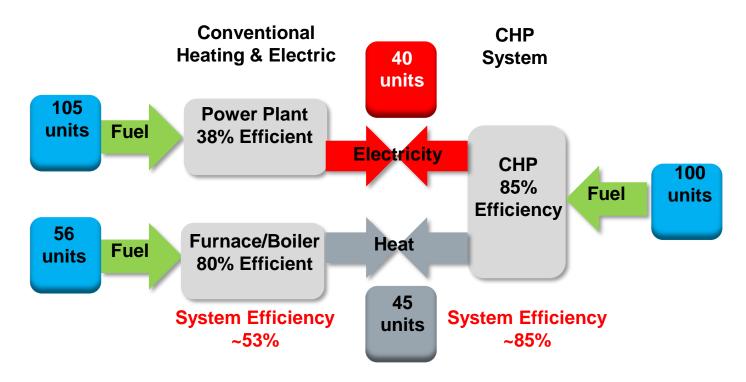
Micro – Turbines



Fuel Cells (10 – 200 KW)



#### CHP is more Efficient Than Grid Power & Gas Heat



Compared to purchasing electric from the grid and producing heat with a furnace or boiler for the home or business, CHP is much more efficient.

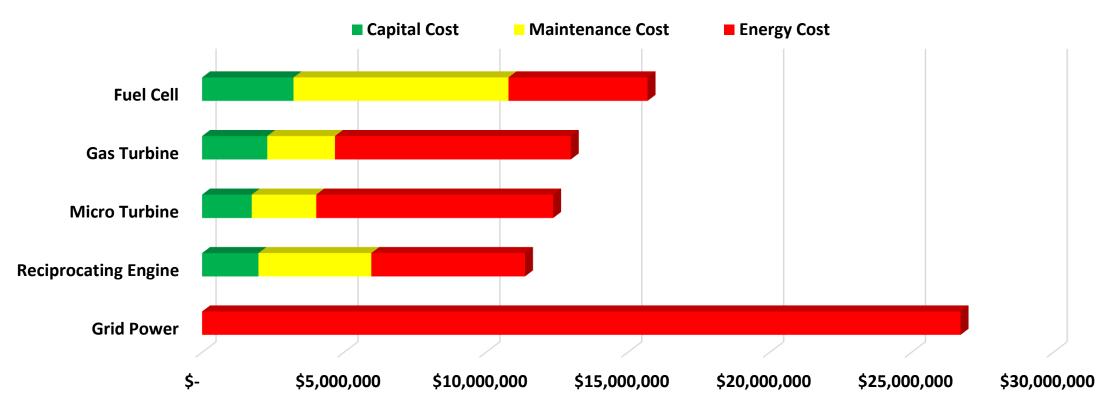


## Life Cycle Cost Tool: Assumptions & Simple Payback

Combined Heat & Power (I Use this tool to review various CHP equipm			0.10	ATION VISIT OUR WEBSITE
Company/Customer Name	Facility/Site Location			
User Inputs:				
Size CHP Electric Generator (KW)	1,000	8. Ave. Electric U	Jsage Rate (\$/KWH)	\$ 0.14
2. Hours of Cogeneration ( /Year)	•		nd Charge (\$/KW)	\$ 10.00
3. Number of months generating power	12.00		10. Ave. Natural Gas Rate (\$/MMBTU)	
4. #Years CHP Plant will be Financed	20			\$ 7.00 \$ 6.00
5. Interest Rate on Loan for Installed Cost	5%			•
		12. Please select Emissions Profile		US Average Fossil
6. Investment Tax Credit	30%	and state/province/region		US Average
7. CHP Incentive (\$)	\$ -	e-GRID Sub-Region Map		
Simple Payback (Years)	2.2	2.1	2.7	4.3
	Recip. Engine	Micro Turbine	Gas Turbine	Fuel Cell
CHP Size (KW)	1,000	1,000	1,000	1,000
Installed Cost	\$2,837,000	\$2,500,000	\$3,281,000	\$4,600,000
Federal CHP Investment Tax Credit	\$851,100	\$750,000	\$984,300	\$1,380,000
Cost Less CHP Incentive(s)	\$1,985,900	\$1,750,000	\$2,296,700	\$3,220,000
Ave. Annual Maintenance Cost	\$180,600 8,600,000	\$103,200 8.600.000	\$108,360	\$344,000
Power Produced (KWH) Annual Electric Saved on Demand	\$120,000	\$120,000	8,600,000 \$120,000	8,600,000 \$120.000
Annual Electric Saved on Demand Annual Electric Savings on Usage	\$1,204,000	\$1,204,000	\$1,204,000	\$1,204,000
Annual Gas Cost for Cogeneration	\$510.294	\$660,208	\$735,581	\$412.800
Recovered Heat (MMBTU/Year)	37.762	40.163	51,184	27.176
Annual Gas savings from waste heat use	\$264,332	\$281,139	\$358,289	\$190,232
Annual O&M cost CHP Plant	\$690,894	\$763,408	\$843,941	\$756,800
Electric and gas utility savings from CHP	\$1.588.332	\$1,605,139	\$1,682,289	\$1,514,232
Total Savings per year from CHP System	\$897,438	\$841,730	\$838,348	\$757,432

### **Gas CHP Systems Have Lowest Life Cycle Costs**

#### **CHP 20 Yr Life Cycle Cost Analysis**

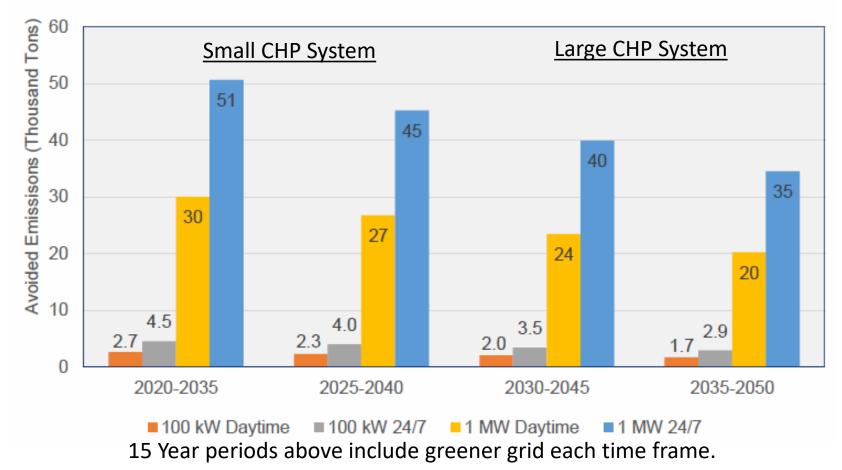






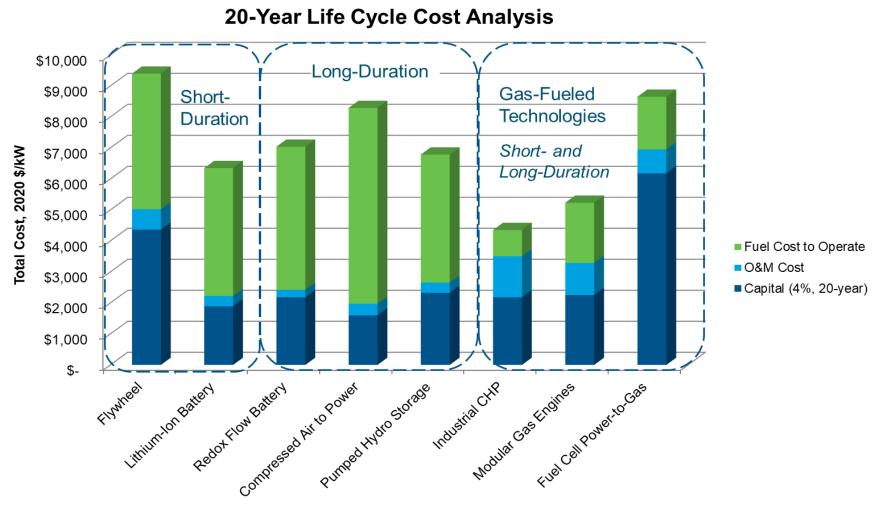
# CHP Carbon Emission Reductions (Thousand Tons) Over System Life, Compared to Average U.S. Marginal Grid Emissions

CHP Lifetime Carbon Emission Reductions (Total carbon avoided, 15 year life)





## CHP and Gas Power Gen have lowest Life Cycle Cost of any Electric Storage System





#### **Combined Heat & Power Benefits**

- More Efficient Use of Energy
- Reduced Emissions
- Reduced Energy Costs Lowest Life Cycle Costs
- Improved reliability and resiliency
- Not Reliant on Electric Power Grid



#### **Natural Gas Humidifiers**

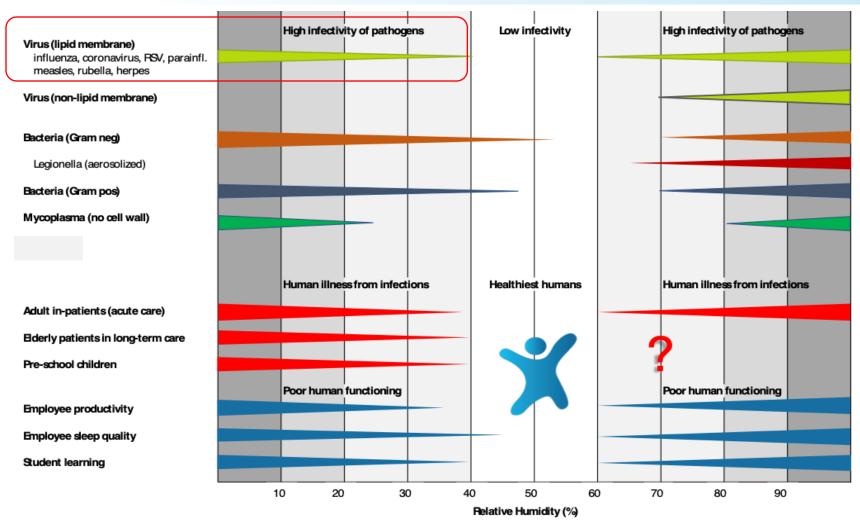
- Natural Gas Humidification
  - Natural gas humidifiers add moisture to dry air
  - Natural gas burners boil water to steam and deliver humidity via air handler or blower
  - Minimizes steam pressure
  - Eliminates boiler chemicals
  - Can be used in conjunction with existing boiler

Gas Humidifiers are designed to handle scale build up with daily cleaning and purge cycles





## Gas Humidification Helps Reduce the Spread of Viruses, etc.





#### **NGVs Produce Much Fewer Emissions**



**Heavy Trucks** 







Taxi & Delivery

Light Duty Personal Vehicles

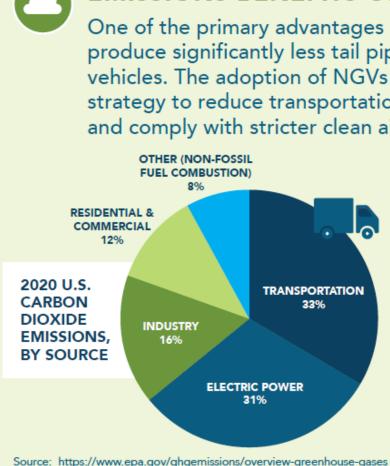




Garbage Trucks

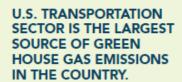


#### **Natural Gas Vehicles**



#### **EMISSIONS BENEFITS OF NATURAL GAS VEHICLES (NGV)**

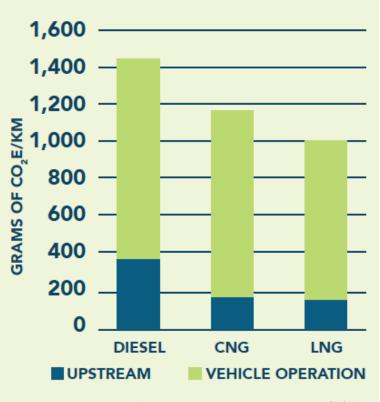
One of the primary advantages of NGVs is that they produce significantly less tail pipe emissions than diesel vehicles. The adoption of NGVs can be an effective strategy to reduce transportation-related emissions and comply with stricter clean air regulations.



**NGVS PRODUCE 21%** TO 30% LESS CO, **COMPARED TO** DIESEL-FUELED VEHICLES.3



RENEWABLE NATURAL **GAS (RNG) CAN REDUCE** EMISSIONS EVEN FURTHER.



Source: Natural Gas Use in Transportation Roundtable. "Natural Gas Use in the Canadian Transportation Sector"

### **Summary: Benefits of Gas**

- North American production outweighs consumption
- > 100 Years of Reserves in the U.S. and > 200 years in Canada
- Gas is less expensive than alternatives
- On a source basis, natural gas is more efficient than electricity
- Natural Gas is less prone to disruptions of service, and therefore, more resilient
- Gas is environmentally friendly
- Energy efficient natural gas technologies save money and emissions



## Thank you



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