U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE Packaged CHP Accelerator

"Renewable Natural Gas: Opportunities and Challenges for the CHP Industry"

November 5, 2020

Agenda

- Bruce Hedman, *Introduction*
- Rick Murphy, American Gas Association
  - *Reducing GHG Reductions and implications of policy-driven electrification (American Gas Association study prepared by ICF in 2018)*
- Philip Sheehy, ICF
  - *Understanding the resource potential, cost, and emissions benefits of RNG (American Gas Foundation study prepared by ICF in 2019)*
- Emily O'Connell, American Gas Association
  - *Gas industry efforts to advance RNG market development*
- Anna Chittum, NW Natural
  - *NW Natural's perspective on RNG market development*
- Wrap-Up

This Webinar Is Being Recorded

CHP, Natural Gas, and Decarbonization

- Decarbonization is a major policy topic in many states and cities
  - Aggressive CO_2/greenhouse (GHG) reductions - 40% by 2030 and 80% by 2050
  - Focus on economy-wide electrification to get to net zero carbon

- Major push against natural gas in some areas
  - 20 cities in California and others in the Northeast have banned natural gas in new construction
  - Efforts to stop investment in natural gas infrastructure
    - Pipelines
    - Natural gas CHP

CHP provides emissions reductions today

- CHP and renewables generally displace marginal grid generation (including T&D losses)
- Marginal generation is currently a mix of coal and natural gas in most regions of the country
- Natural gas CHP's high net electric efficiency and high annual capacity factor result in energy and emissions savings on par with PV and wind
- Natural gas CHP is more efficient than state-of-the-art natural gas marginal generation (NGCC)

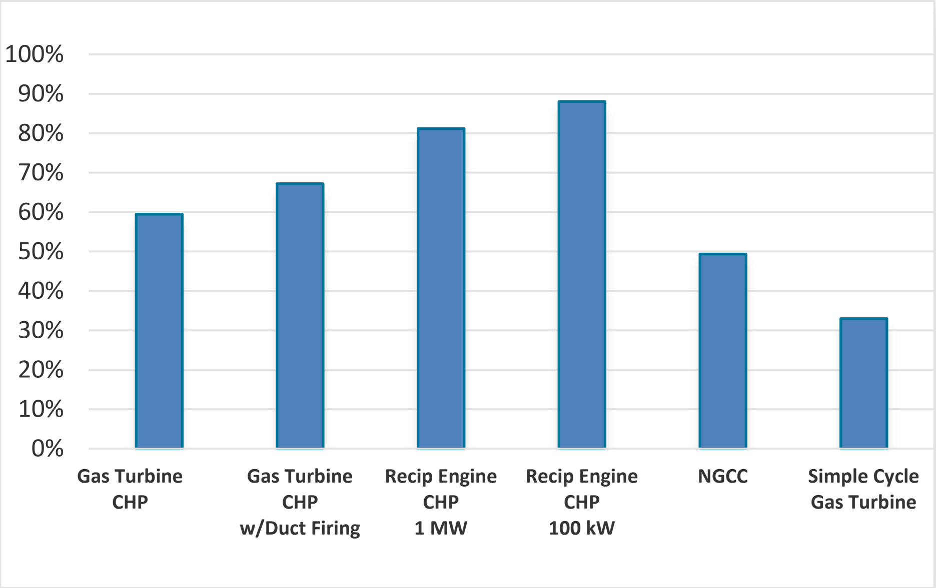
Category	10 MW CHP	10 MW PV	10 MW Wind	10 MW NGCC
Annual Capacity Factor	85%	26.1%	37.4%	57.6%
Annual Electricity, MWh	74,460	22,864	32,762	50,458
Annual Useful Heat Provided, MWh_{th}	97,505	None	None	None
Annual Energy Savings, MMBtu	**265,086**	**203,042**	**290,950**	**115,074**
Annual CO_2 Savings, Tons	**33,533**	**17,159**	**24,501**	**18,403**
Annual NOx Savings, Tons	38.5	12.5	17.9	26.0

Savings based on EPA eGRID Non-Baseload Generation as a first level estimate of displaced marginal generation

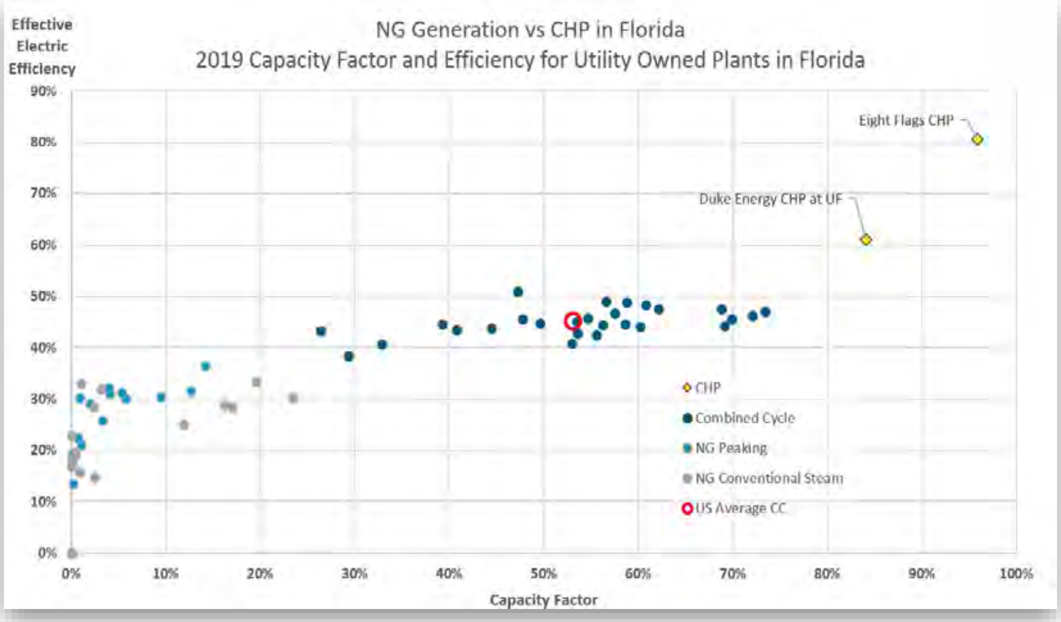
CHP is the most efficient use of natural gas

CHP systems have higher effective generation efficiency than marginal natural gas generation due to thermal energy recovery and elimination of T&D losses

Effective Electric Efficiency, %



Source: DOE CHP Deployment Program

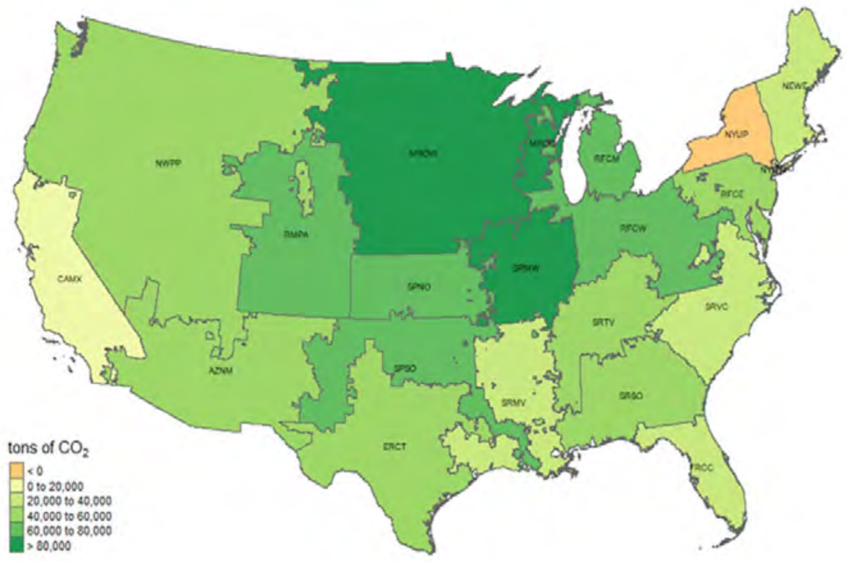


Source: Sterling Energy LLC

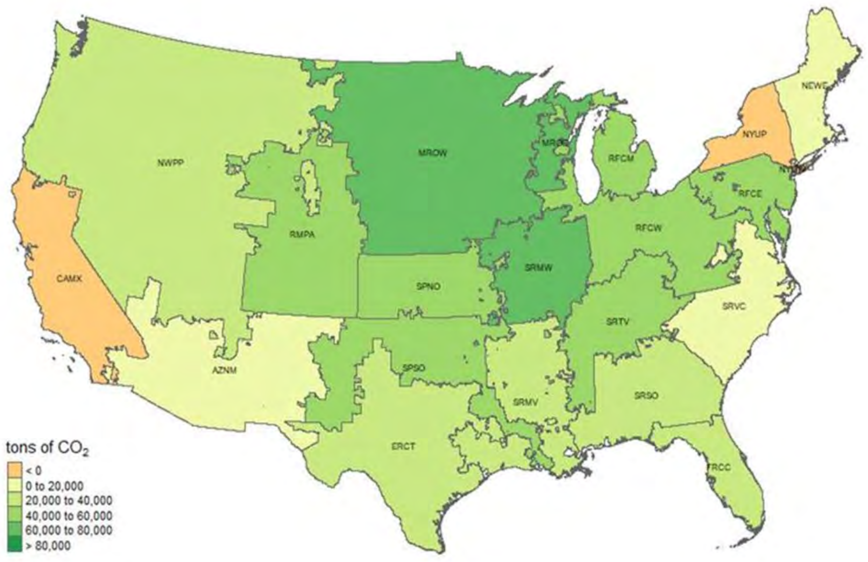
CHP's higher annual capacity factors generates additional energy and emissions savings compared to central station marginal generation

CHP’s high efficiency will continue to reduce emissions in most areas as regional grids decarbonize over time

2020-2035



2035-2050



Source: ICF and Energy Solutions Center

- As the electric grid decarbonizes, marginal generation will continue to be served by natural gas in most areas of the country. CHP is the most efficient way to generate power with natural gas.
- Natural CHP will continue to reduce emissions in most U.S. locations through 2050
- Emission reduction potential depends on location and timing, and marginal generation in that region
- For states with 100% clean/renewable energy mandates, natural gas CHP will become a net emitter as the grid goes green, but *timing is uncertain*

CHP can be part of the long-term solution

- CHP is the most efficient way to generate power with a fossil fuel and reduces GHG emissions today - CHP systems have higher net generation efficiency than marginal natural gas generation (NGCC) and will reduce emissions as long as fossil fuels are on the margin
- CHP can support the transition to a low carbon economy by enabling greater integration of renewables in the distribution grid, microgrids, and individual facilities, while helping businesses adapt to changing conditions by enhancing energy resilience and security
- CHP technologies currently use renewable fuels, low carbon waste fuels, and hydrogen mixtures where available, and will be ready to use higher levels of renewable natural gas (RNG) and hydrogen in the future.
- CHP's efficiency, emissions, flexibility and resilience advantages will remain as the natural gas infrastructure decarbonizes
- CHP can ultimately be carbon free by using RNG/hydrogen and/or carbon capture - CHP can decarbonize thermally based industrial processes and facilities that rely on on-site generation for resilience

Overview of AGA Research Findings related to RNG

Rick Murphy, AGA

Philip Sheehy, ICF

Emily O'Connell, AGA

Renewable Natural Gas:

Opportunities and Challenges for the CHP Industry

CHP Accelerator Webinar

November 5, 2020

Rick Murphy, AGA
Emily O'Connell, AGA
Philip Sheehy, ICF

American Gas Association

Climate Change Position Statement

The American Gas Association is committed to reducing greenhouse gas emissions through smart innovation, new and modernized infrastructure, and advanced technologies that maintain reliable, resilient, and affordable energy service choices for consumers.

www.aga.org/climate

Principles for Action

1. All sectors of the economy should contribute to reducing greenhouse gas emissions.

2. Recognize the potential benefits of natural gas and natural gas infrastructure to reduce emissions effectively and quickly.

3. Recognize natural gas as a clean, flexible, reliable, versatile, and affordable energy source that enables the expansion of renewable and other energy technologies.

4. Remove barriers that prevent the modernization of natural gas infrastructure, which is key to lowering greenhouse gas emissions.

5. Policy should recognize that improving energy efficiency is a cornerstone strategy.

6. Policy should promote greater development and use of renewable natural gas and recognize and incent the ability of the gas system to provide substantial renewable energy seasonal storage and delivery through power to gas.

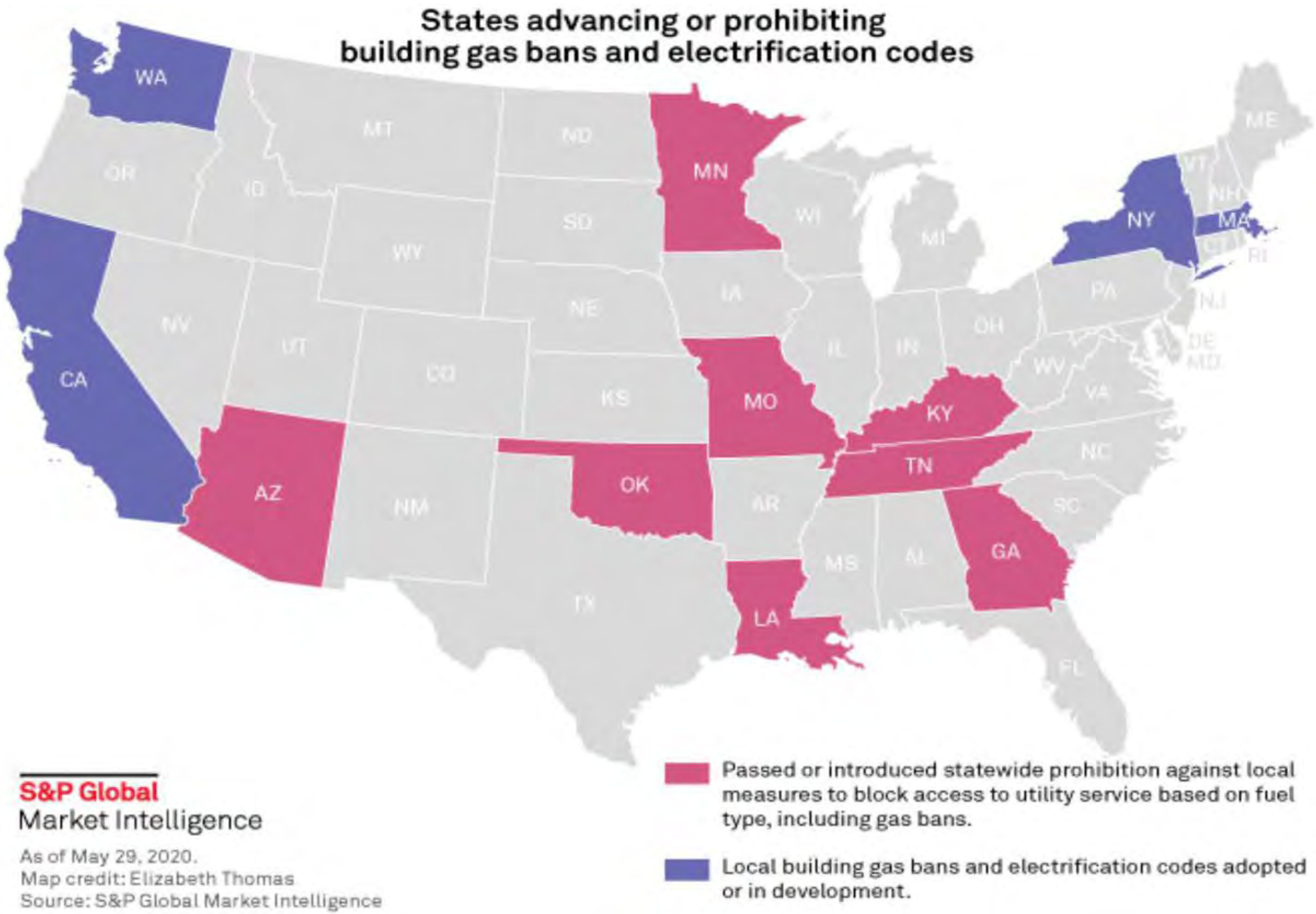
7. Expand investment into research, development, deployment, and commercialization.

8. Any effective public policy should include the option of natural gas for consumers and preserve customer choice of energy

Current Utility Commitments To Reduce Greenhouse Gas Emissions

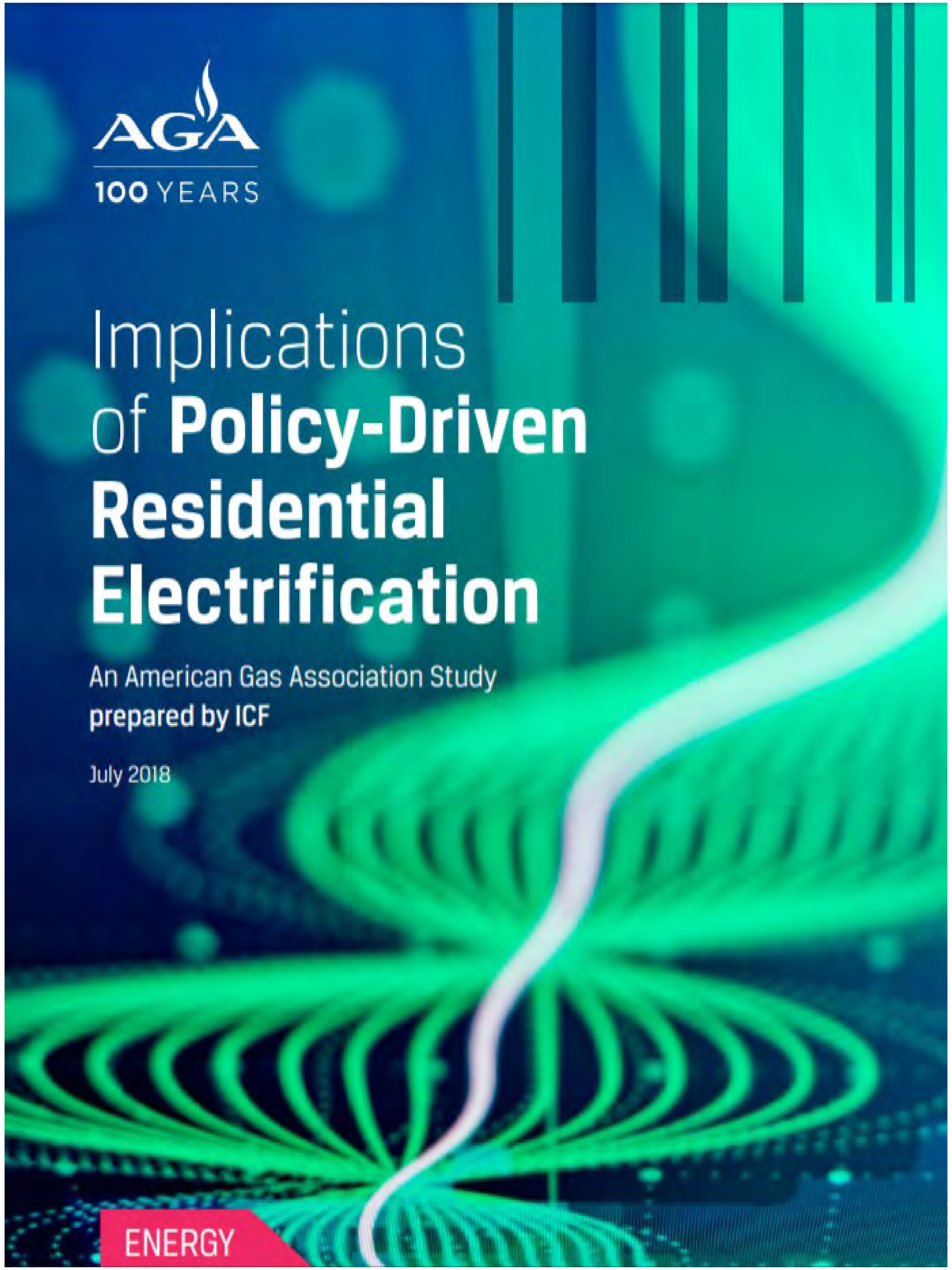
- 22 AGA member companies have a net-zero, carbon neutral, or 100% clean electricity goal.
- Nearly 60% of AGA member companies' gas throughput comes from a utility with a carbon-neutral or net-zero commitment.
- One quarter of Fortune Global 500 companies have made a public commitment that they are, or will be by 2030, carbon neutral, using 100% renewable power, or meeting a science-based target.

Local efforts are shaping the current U.S. climate change debate



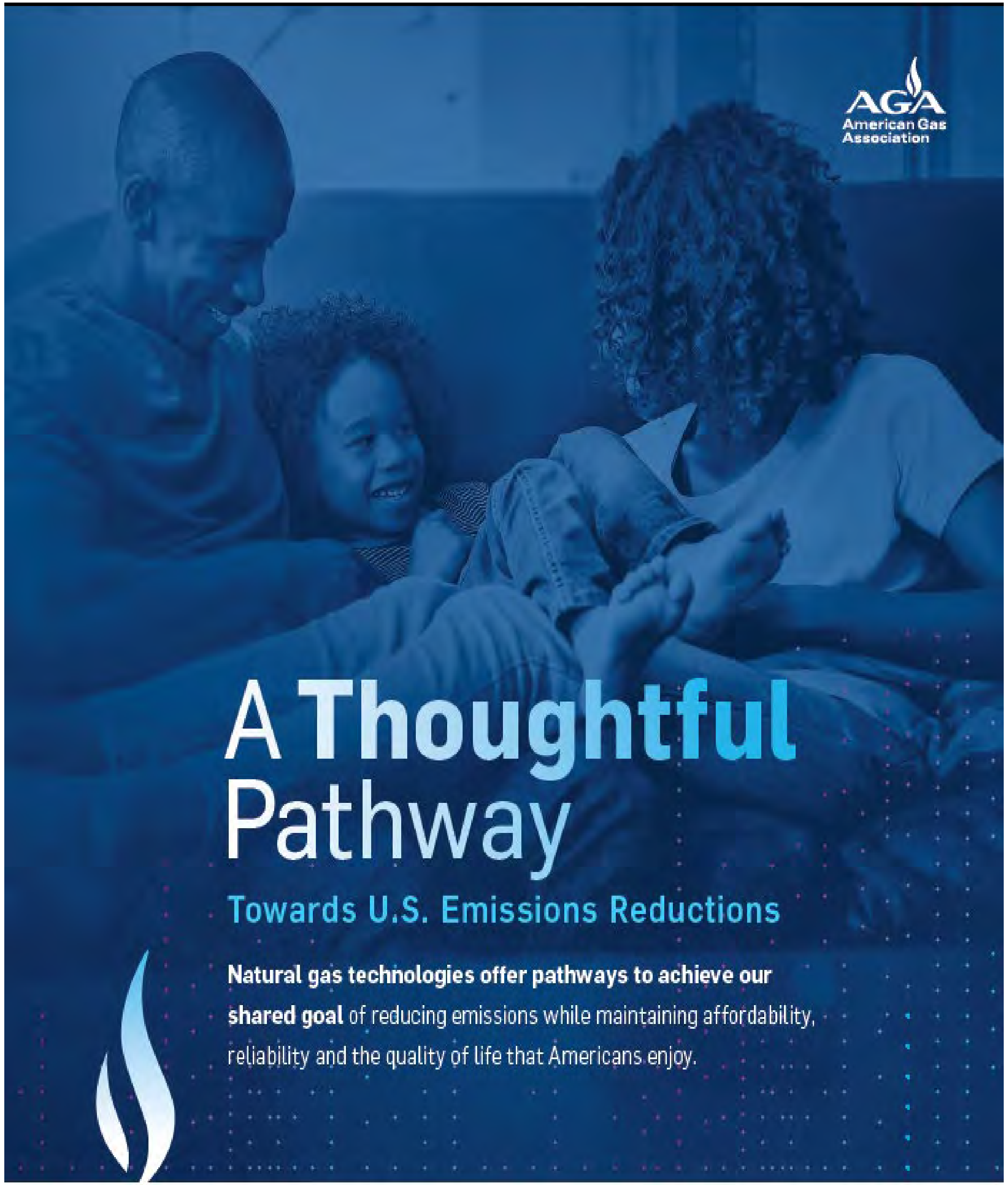
S&P Global
Market Intelligence

As of May 29, 2020.
Map credit: Elizabeth Thomas
Source: S&P Global Market Intelligence



Key Findings from Study

- **$155 to $426 billion** in incremental generation capacity requirements and transmission system upgrade costs
- **Overall emissions could be reduced by just 1 to 1.5%**
- **Consumer energy costs could increase by: $750 to $910 per year.**
- **Cost of reducing carbon dioxide through Residential Electrification: $572 to $806 per ton**



Actions

- Continued Commitment to Energy Efficiency
- Advance the deployment of next generation technologies
- Develop renewable sources of supply


American Gas
FOUNDATION
Studies
News
The Foundation
Contact Us
Informing Energy and Environmental Public Policy
AGF funds independent, critical research that can be used by policy experts, government officials, the media and others to help formulate fact-based energy policies that will serve this country well in the future
www.gasfoundation.org

Renewable Sources of Natural Gas: Supply & Emission Reduction Assessment Study

Study Objective: To contribute a fact-based analysis that informs ongoing policy discussions around renewable natural gas and provide current data including estimates on:

- **The supply potential of domestic RNG resources**
- **RNG greenhouse gas emission reduction potential**
- **RNG costs**

RNG Technologies and Feedstocks

Three Production Technologies

Anaerobic Digestion

- *Landfill gas (LFG)*
- *Animal manure*
- *Water resource recovery facilities (WRRF)*
- *Food waste*

Thermal Gasification

- *Agricultural residue*
- *Forestry and forest product residue*
- *Energy crops*
- *Municipal solid waste (MSW)*

Power to Gas

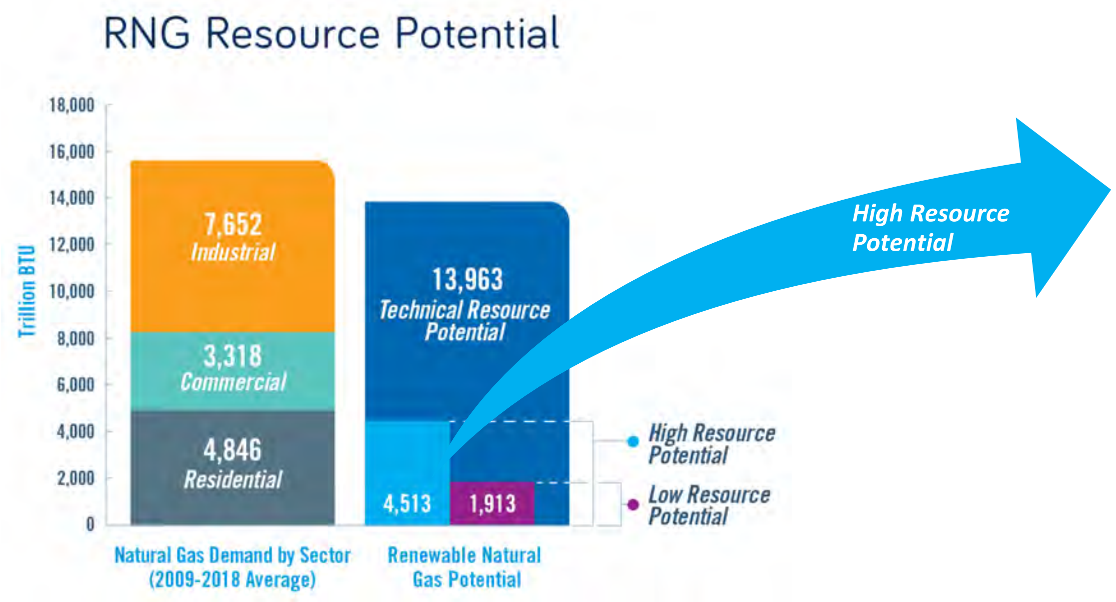
- *Renewable electricity*

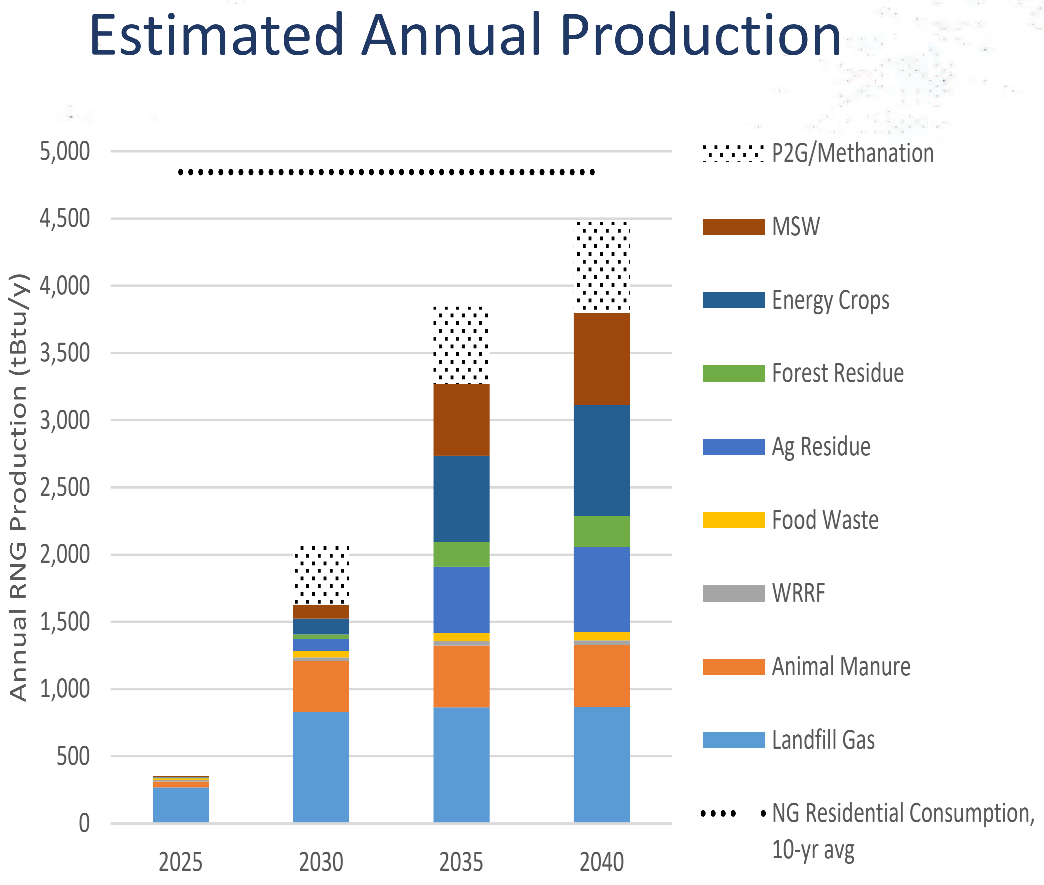
Nine Feedstocks

Executive Summary

Key Findings

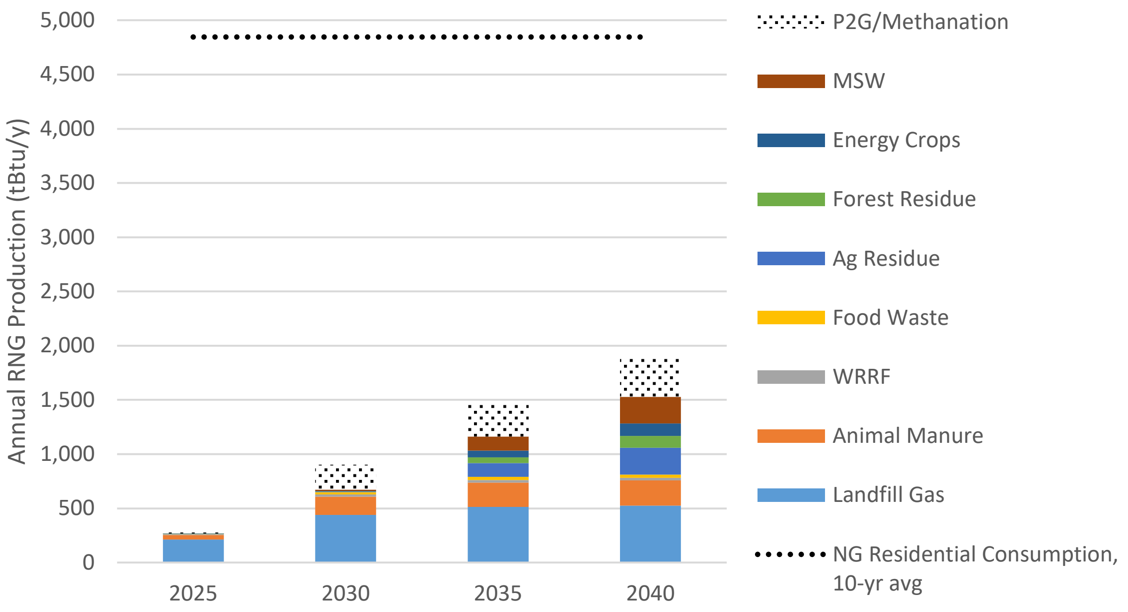
- Potential to Offset Residential Demand with RNG
- Represents up to a **95% reduction** in residential GHG emissions from natural gas
- RNG Costs are Competitive with Other Emission Reduction Strategies, $55-300/ton of GHG Emission Reductions



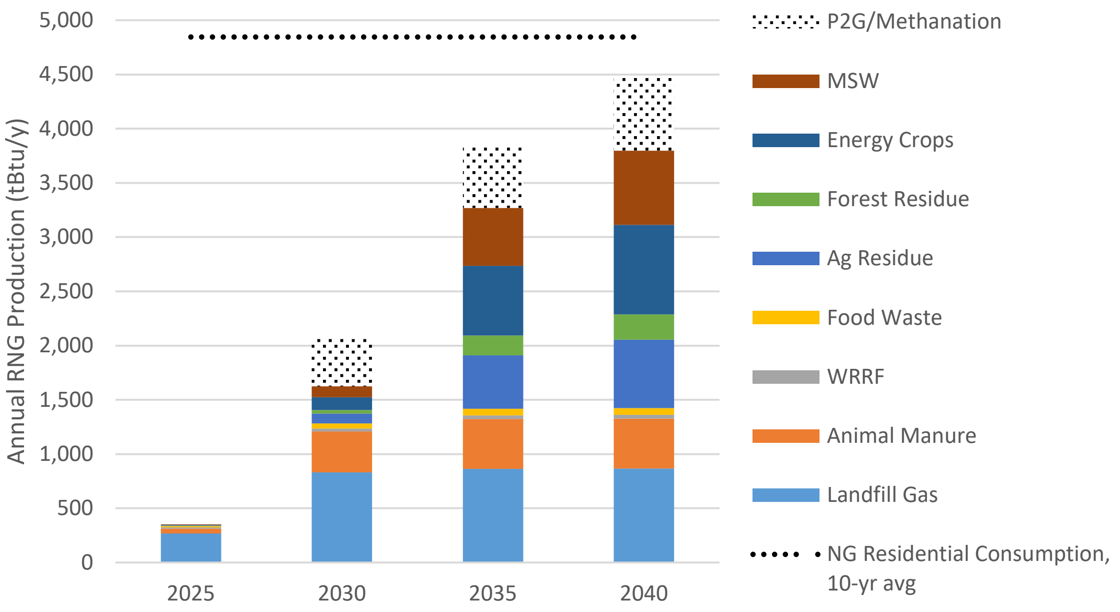


RNG Resource Potentials

Est. Annual RNG Production, Low Resource Potential Scenario



Est. Annual RNG Production, High Resource Potential Scenario



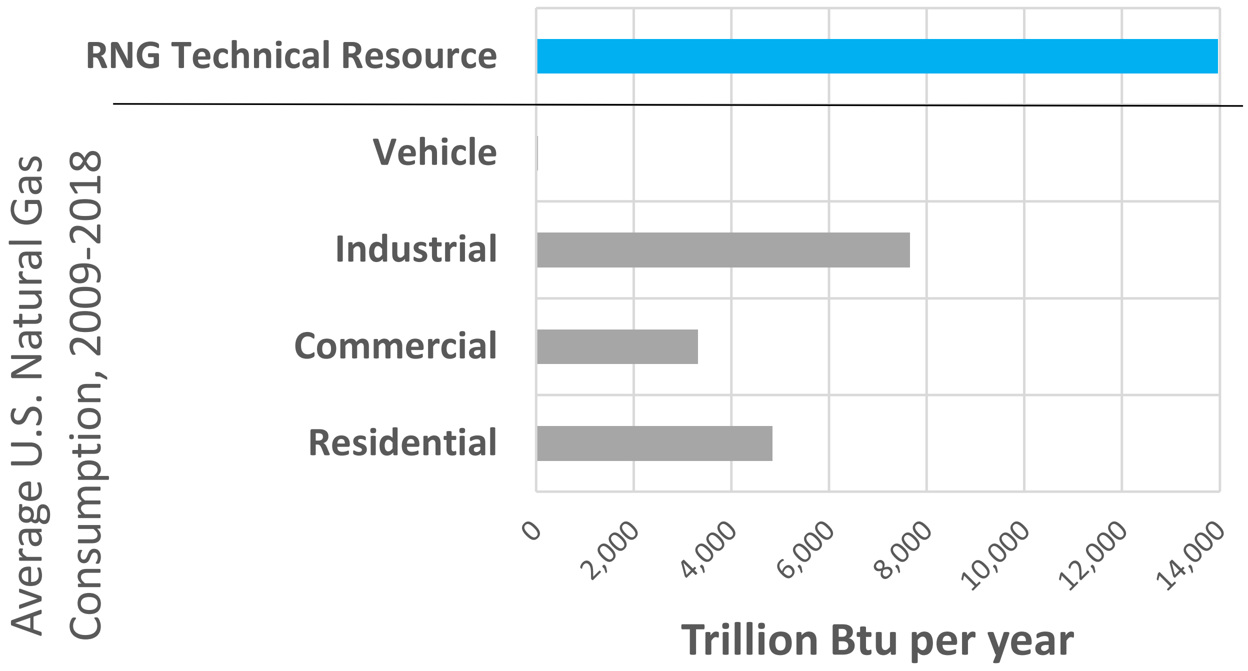
For the sake of comparison, the 10-year average (2009 to 2018) for residential natural gas consumption nationwide is 4,846 tBtu; this is shown as the black-dotted line in both figures.

RNG Feedstock Utilization Assumptions

RNG Feedstock	Low Resource	High Resource
LFG	• 40% of the LFG facilities that have collection systems in place • 30% of the LFG facilities that do not have collections systems in place • 50% of EPA's candidate landfills	• 65% of the LFG facilities that have collection systems in place • 60% of the LFG facilities that do not have collections systems in place • 80% of EPA's candidate landfills
Animal manure	• 30% of technically available animal manure	• 60% of technically available animal manure
WRRF	• 30% of WRRFs with a capacity greater than 7.25 million gallons per day	• 50% of WRRFs with a capacity greater than 3.3 million gallons per day
Food waste	• 40% of the food waste available at $70/dry ton	• 70% of the food waste available at $100/dry ton
Agricultural residue	• 20% of the agricultural residues available at $50/dry ton	• 50% of the agricultural residues available at $50/dry ton
Forestry and forest product residue	• 30% of the forest and forestry product residues available at $30/dry ton	• 60% of the forest and forestry product residues available at $60/dry ton
Energy crops	• 50% of the energy crops available at $50/dry ton	• 50% of the energy crops available at $70/dry ton
Municipal solid waste (MSW)	• 30% of the non-biogenic fraction of MSW available at $30/dry ton	• 60% of the non-biogenic fraction of MSW available at $100/dry ton
P2G	• 50% capacity factor for dedicated renewables	• 80% capacity for dedicated renewables

RNG Technical Resource Potential

- Technical potential: **14,000 tBtu/y**
- ICF generally finds that the potential for RNG deployment could exceed the estimated high resource potential scenario because moderately conservative assumptions were employed regarding the expected utilization of various feedstocks.

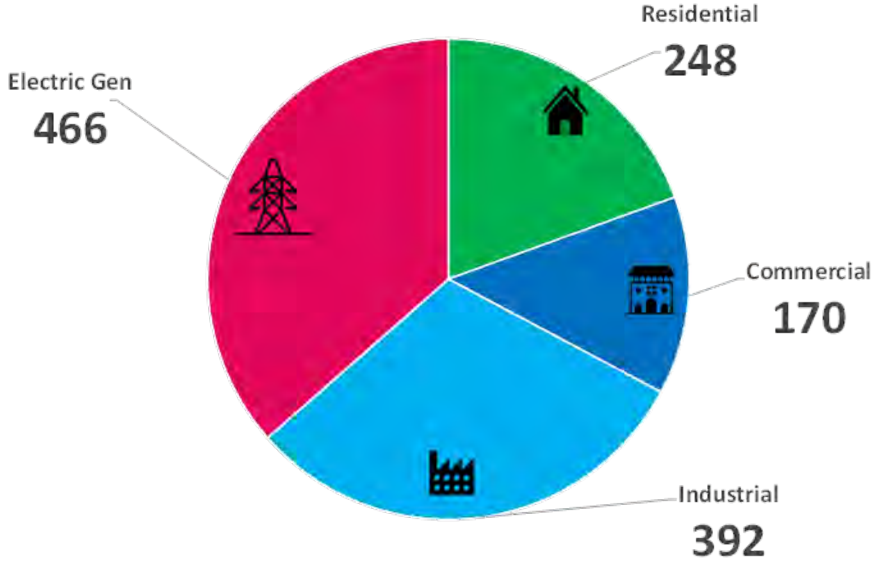


RNG Emission Reduction Potential

- GHG emission reduction potential conducted using two accounting frameworks
- RNG deployment could achieve 101 to 235 MMT of GHG emission reductions by 2040
- Represents up to a **95% reduction** in residential GHG emissions from natural gas

For the sake of reference …

Average Annual Carbon Dioxide Emissions (MMT) from Natural Gas Consumption in the U.S.
(2009-2018)



RNG Cost Assessment

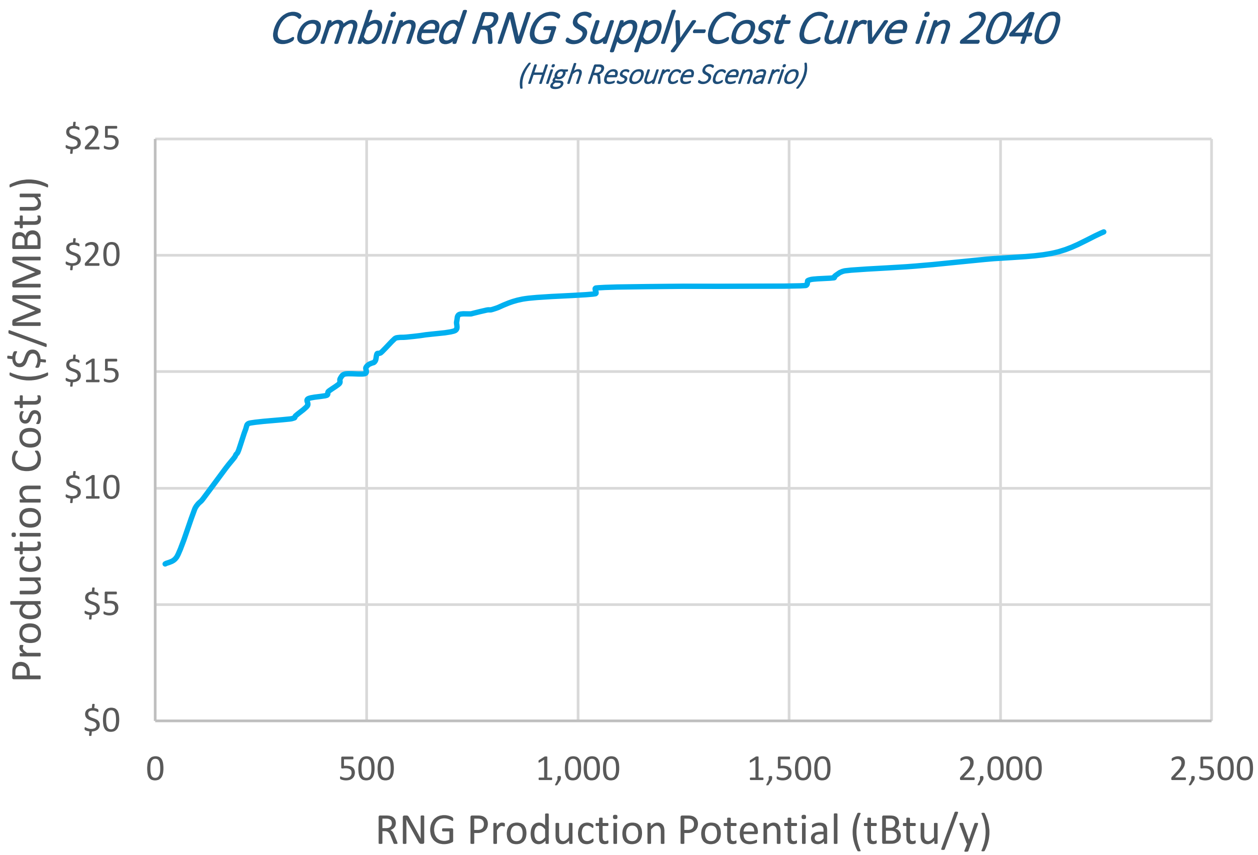
- Cost estimates are not intended to replicate an RNG project developer's estimate.
  - Conditioning and upgrading represent a multitude of project specific issues
  - Interconnections will vary considerably between jurisdictions

Cost Parameter	ICF Cost Assumptions
Facility Sizing	• Differentiate by feedstock and technology type: AD and TG • Prioritize larger facilities to the extent feasible, but driven by resource estimate
Gas Conditioning and Upgrade	• These costs depend on the feedstock and the technology required.
Compression	• Capital costs for compressing the conditioned/upgraded gas for pipeline injection.
Operational Costs	• Costs for each equipment type–digesters, conditioning equipment, collection equipment, and compressors–as well as utility charges for estimated electricity consumption.
Feedstock	• Feedstock costs (for thermal gasification), ranging from $30 to $100 per dry ton.
Financing	• Financing costs, including carrying costs of capital (assuming a 60/40 debt/equity ratio and an interest rate of 7%), an expected rate of return on investment (set at 10%), and a 15 year repayment period.
Interconnection	• Costs of interconnection—representing the point of receipt and any pipeline extension. This cost is in line with financing, constructing, and maintaining a pipeline of about 1-mile in length. The costs of delivering the same volumes of RNG that require pipeline construction greater than 1-mile will increase, depending on feedstock/technology type, with a typical range of $1-5/MMBtu.
Project lifetimes	• 20 years. The levelized cost of gas was calculated based on the initial capital costs in Year 1, annual operational costs discounted at an annual rate of 5% over 20 years, and biogas production discounted at an annual rate of 5% for 20 years.

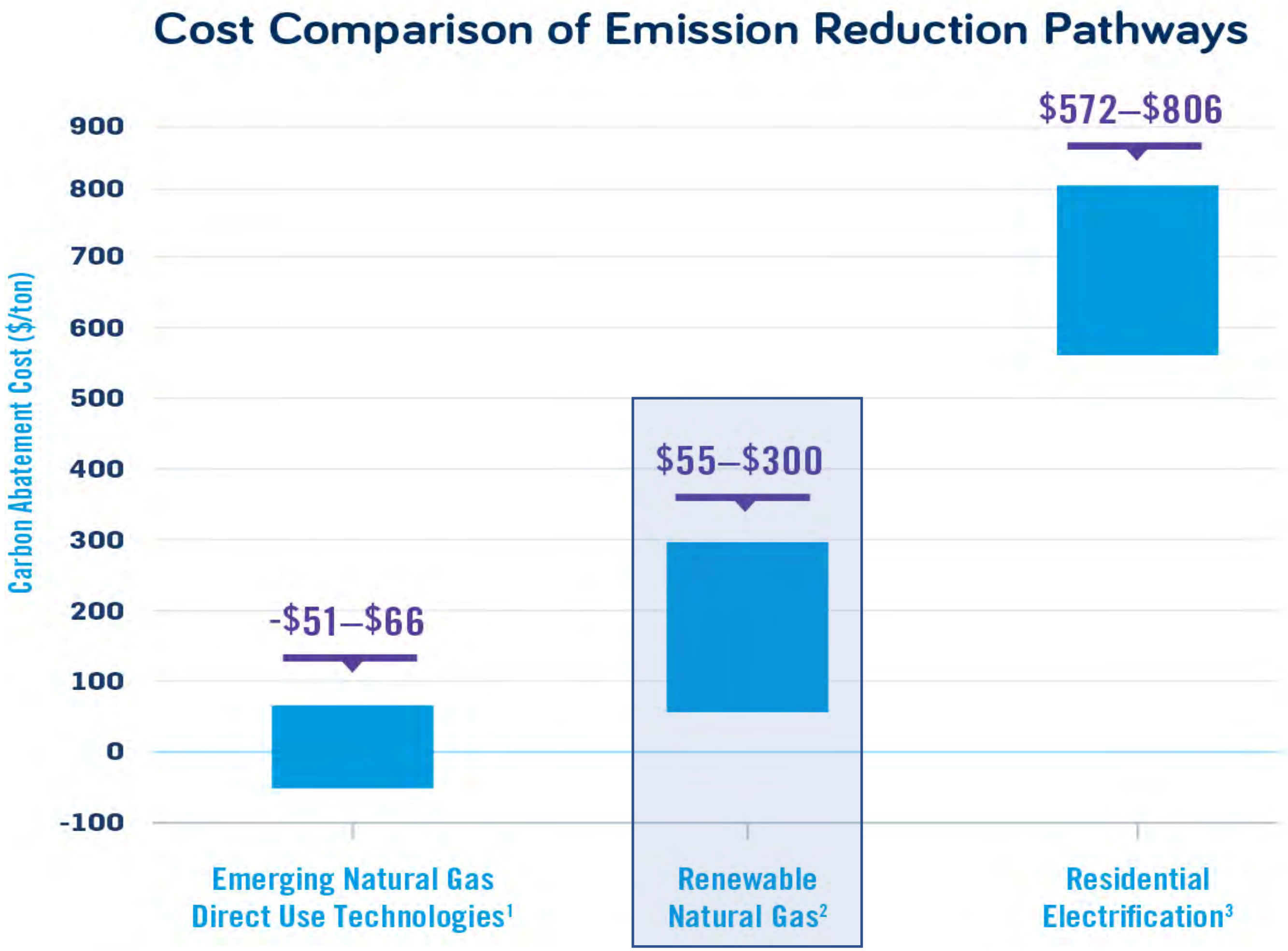
KEY FINDINGS

- Broad range of expected costs: $7- 45/MMBtu
- ICF estimates that a majority of RNG can be available in the range of **$7-$20/MMBtu**
- Costs include estimates for: feedstock, biogas conditioning and upgrading, interconnection, and corresponding O&M costs
- There is potential for cost reductions as the RNG for pipeline injection market matures, production volumes increase, and the underlying structure of the market evolves

RNG Can Be a Cost Effective Solution to Reducing Emissions



RNG Is Competitive with Other Emission Reduction Strategies



1 Opportunities for Reducing Greenhouse Gas Emissions Through Emerging Natural Gas Direct-Use Technologies, 2019 | 2 Renewable Sources of Natural Gas Supply & Emissions Reduction Assessment Study, 2019 | 3 Implications of Policy-Driven Residential Electrification, 2018

Summary of Key Findings

- Significant Resource Potential in Both the Low and High Cases
- RNG Feedstocks are Diverse and Multiple Production Technologies can Help Realize the Full Potential of the RNG Market
- RNG Could Help Reduce GHG Emissions from the use of Natural Gas in the Residential Sector by 95%
- RNG Costs are Competitive with other Emission Reduction Strategies

Gas Industry Efforts to Advance RNG Market Development

AGA
American Gas Association

Direct Outreach to Stakeholder Groups

- ✓Department of Energy
- ✓National Labs
- ✓Environmental Protection Agency
- ✓US Congress
- ✓Energy Efficiency and Environmental Advocates
- ✓Energy Think Tanks and Consulting Groups
- ✓HVAC Manufacturers and Industry Associations
- ✓Renewable Natural Gas Industry Associations

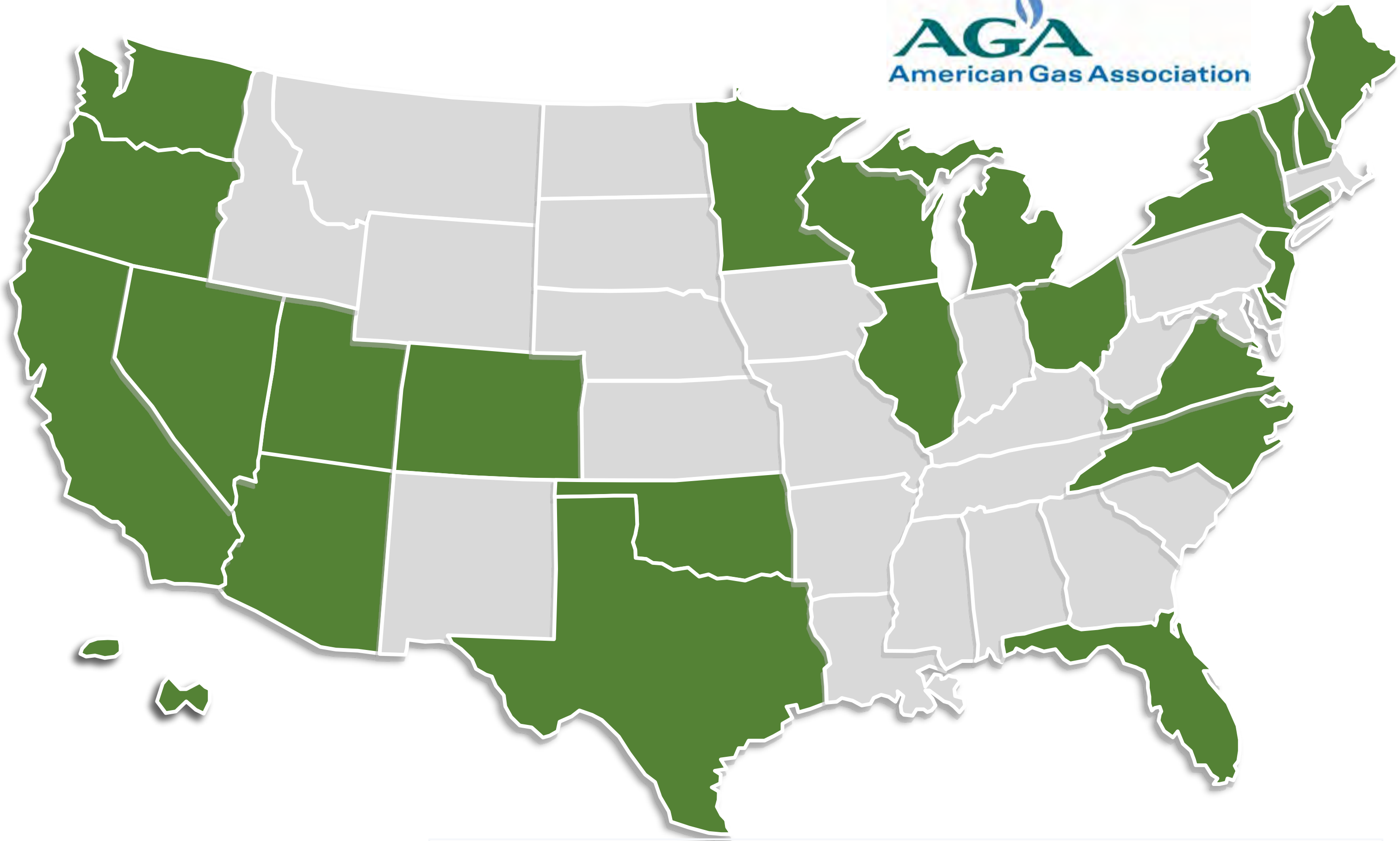
Renewable Natural Gas State Activity

AGA
American Gas Association

31 Bills have been introduced
17 Bills have become law
State Legislative Proposals

10 Natural Gas Utilities have begun developing or have implemented Voluntary Green Tariffs
Voluntary Programs

15 Natural Gas Utilities are engaged in RNG production projects
Utility Led RNG Projects



Activity in 25 states to promote the use of RNG in the residential or commercial sector through either legislative, regulatory, or utility led action.

*this data does not include RNG interconnection activity

RNG Market Developments

Green-e® Renewable Fuels Standard for Canada and the United States

Center for Resource Solutions (CRS) has embarked upon a process to create a new Green-e® standard and certification program for biomethane products and associated environmental attributes. Publication is expected by the end of 2020. In the future, CRS will consider expansion of the program to address other renewable fuels and renewable thermal energy products.

Natural Gas STAR Methane Challenge Program

Continuous Improvement Proposal Create a Commitment Option for Supply of Renewable Natural Gas

M-RETS Renewable Thermal Tracking System

Thank you!
Questions?

"With its low to negative life-cycle carbon footprint, RNG has great potential to continue driving down emissions and helping meet our nation's environmental goals."

- American Gas Foundation
2019 Renewable Sources of Natural Gas
Supply & Emission Reduction Assessment Study

Utility Perspective and Experience with RNG

Anna Chittum, NW Natural

U.S. DEPARTMENT OF ENERGY

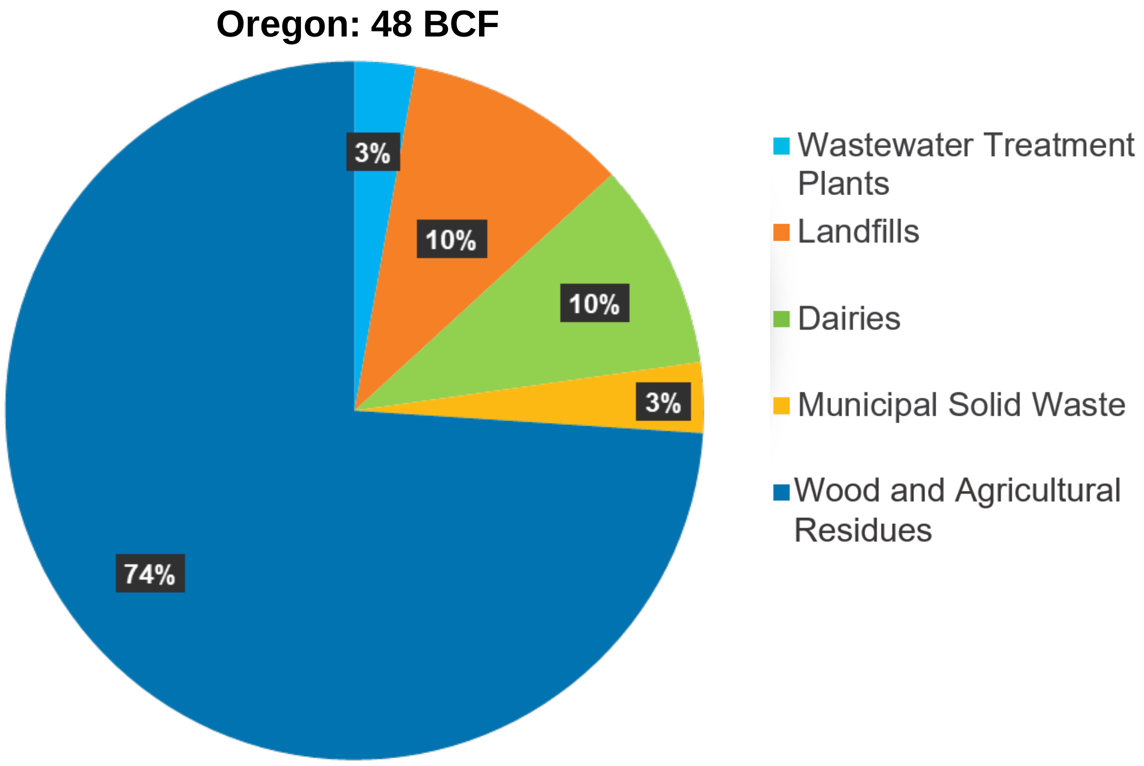
Senate Bill 98 and Renewable Natural Gas in Oregon

Renewable Resources

November 4, 2020

NW Natural®

Oregon RNG Technical Potential



Total OR direct annual natural gas consumption:
236 BCF

Total OR direct annual natural gas consumption by residential sector:
48 BCF

Total NWN annual natural gas sales:
65 – 75 BCF

Source: Oregon Department of Energy: https://www.oregon.gov/energy/Data-and-Reports/Documents/2018-RNG-Inventory-Report.pdf

(1) "Wood and Agricultural Residues" is defined differently by different studies but generally includes urban waste wood, primary and secondary mill residues, and residues left after logging operations (e.g., trees cut or killed and left on the ground). It assumes a large amount (35%-50%) is left on the forest floor to "maintain ecological functions." Sources for data: https://www.nrel.gov/docs/fy14osti/60178.pdf#, NREL Bioenergy Database, U.S. EPA LMOP Database, Oregon DEQ Material Recovery and Waste Generation Survey, Oregon Department of Agriculture, and Oregon Department of Energy.

Oregon Senate Bill 98:

- Gas utilities can purchase RNG (including hydrogen) for all customers as part of our utility resource mix. This is a significant change, as prior to the passage of the bill, we could only buy the least-cost gas, which was not RNG.
- Gas utilities can invest in and own the equipment necessary to bring raw biogas and landfill gas up to pipeline quality, as well as the facilities to connect to the local gas distribution system
- We must adhere to a spending limit to protect customers: we can spend up to 5% of our annual Revenue Requirement on the incremental cost of RNG
- There are different rules for large and small utilities; only NWN is “large”

Passed in 2019, with bipartisan support. Final rules adopted July 2020.

Oregon S.B. 98 Volumetric Targets

- Large gas utilities may procure RNG for sales customers up to established volumetric targets:

	% Target	in Dth
		(assume total sales of 750,000,000 therms/year)
2020 - 2024	5%	3,750,000
2025 - 2029	10%	7,500,000
2030 - 2034	15%	11,250,000
2035 - 2039	20%	15,000,000
2040 - 2044	25%	18,750,000
2045 - 2050	30%	22,500,000

For Comparison:
Current RNG Interconnect Projects

Project	Feedstock	% of Our Sales Volume
City of Portland	Wastewater	0.50
Eugene-Springfield	Wastewater	0.13
Shell New Energies	Agricultural Waste	1.30

How is RNG Defined in S.B. 98?

- **RNG means any of the following products processed to meet pipeline quality standards or transportation fuel requirements:**
  - Biogas (e.g., landfill gas or gas produced from anaerobic digestion);
  - Hydrogen gas derived from renewable energy sources; or
  - Methane gas derived from any combination of:
    - Biogas;
    - Hydrogen gas or carbon oxides derived from renewable energy sources; or
    - Waste carbon dioxide

Who Gets RNG?

o S.B. 98: all of our sales customers

- All RNG purchases under S.B. 98 are delivered to all sales customers, and the cost is shared among all sales customers
- This means that transport customers – customers that we don’t buy gas for, but who pay to transport their purchased gas over our pipes – are not getting RNG, and are not paying for it
- Customers do not “opt in” or “opt out” of RNG under S.B. 98. All sales customers receive it, just as all core electric utility customers receive a portion of the renewable electricity the utility must procure under state Renewable Portfolio Standards

How Can We Acquire RNG?

- **RNG may be procured via:**
  - Supply contracts (e.g., long-term gas purchase agreements for RNG)
  - Qualified capital investments (to produce the RNG)
  - A combination of both

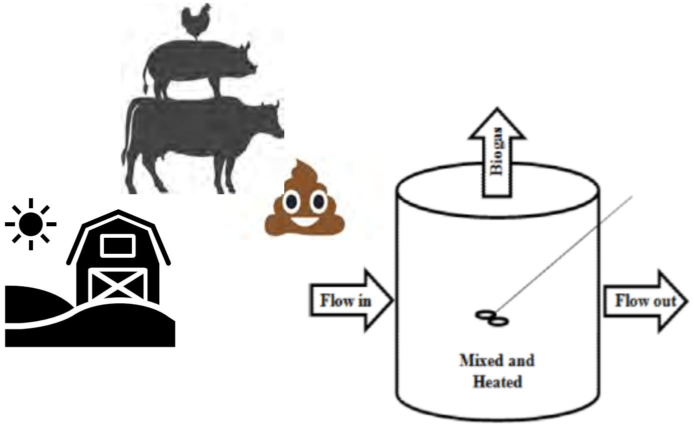
- **RNG may be procured from:**
  - Anywhere! From throughout the U.S., from Canada, etc. Just like our conventional natural gas resources.

What Can We Invest In?

- A *qualified investment* is a capital investment in RNG infrastructure incurred by a natural gas utility for the purpose of providing natural gas service under a renewable natural gas program

- Qualified investments would be linked to the ownership of the RNG or the delivery of RNG to our customers

Qualified Investments

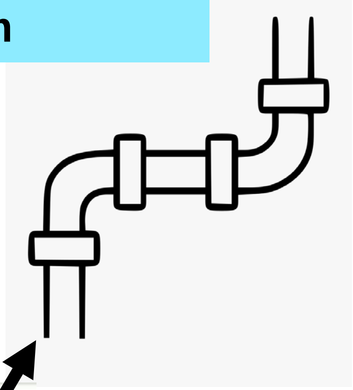


Digesters*
- At farms
- At wastewater treatment plants

Landfill Gas Collection Systems*

Gas Cleaning and Conditioning Equipment
- To bring raw biogas to pipeline quality standards

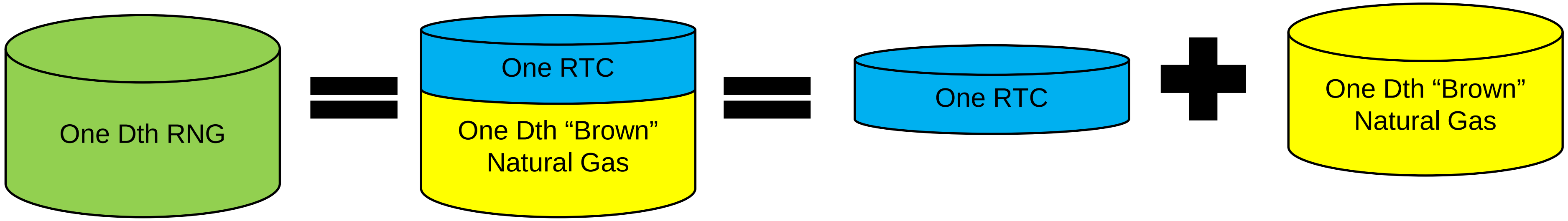
Interconnection Equipment and Pipeline Extensions to Distribution System



*We cannot invest in digesters or gas collection systems at facilities with greater than 250 SCFM of gas at livestock facilities, or 1,000 SCFM at all other types of facilities

How is RNG Transacted?

- **Renewable Thermal Certificates (RTCs) are instruments that represent the legal property rights to the 'renewable-ness' (i.e. environmental attributes) of RNG**
  - One RTC is created for every Dth of RNG produced and injected into the "common carrier" network or an LDC's distribution system. RTCs can be unbundled from the underlying gas and sold separately.



  - RTCs will be issued, tracked, transferred, and retired through M-RETS, an online certificate system
  - To satisfy S.B. 98 goals, we will need to show how many RTCs are retired each year

How Do We Offer RNG to Customers?

- **Under S.B. 98, all sales customers will receive an increasing percentage of RNG as part of their existing tariffs**
- **In the near future: customers will have options to subscribe to voluntary programs and tariffs if they would like more RNG**
  - We will provide RNG to volunteers who opt in to purchase more RNG than what would be otherwise delivered to them under our S.B. 98 goals
  - We will have different offerings for different classes of customers, and may combine those offerings with offsets to help customers cost-effectively meet their emissions or renewable energy goals

Gas System as a Battery

- **In Oregon alone, the gas system has 20 billion cubic feet of seasonal storage – storage that can be used for renewable molecules as easily as it is for conventional natural gas.**
  - 20 billion cubic feet is about 5 million MW-hours of storage, or a $2 trillion battery, assuming current lithium ion technology
  - Renewable energy can be stored very cheaply in our existing storage resources: a large power-to-gas plant can enable renewable energy storage in the gas system for about half the cost per kW-hour of a battery storing the same energy
  - These gas system storage resources already exist
  - Renewable energy stored in the gas system does not degrade
  - Batteries: great short-term solution; gas system: great for longer-term storage needs we have in this region

Power to Gas

Pursuing Pilot Project in Eugene with these Partners:

EWEB

empowering business to be in balance

- Project would be first-of-its kind in U.S.; Memorandum of Understanding signed among parties, and project development underway
- Utilize excess renewable electricity to produce hydrogen to be methanated with waste CO_2 streams
- Blend into natural gas pipeline to decarbonize and offer long-term seasonal storage for renewables
- 2 – 10 MW project will utilize excess / low value renewable electricity from EWEB to generate hydrogen via electrolysis
- Final size will depend on total amount of waste CO_2 available

Thank you!

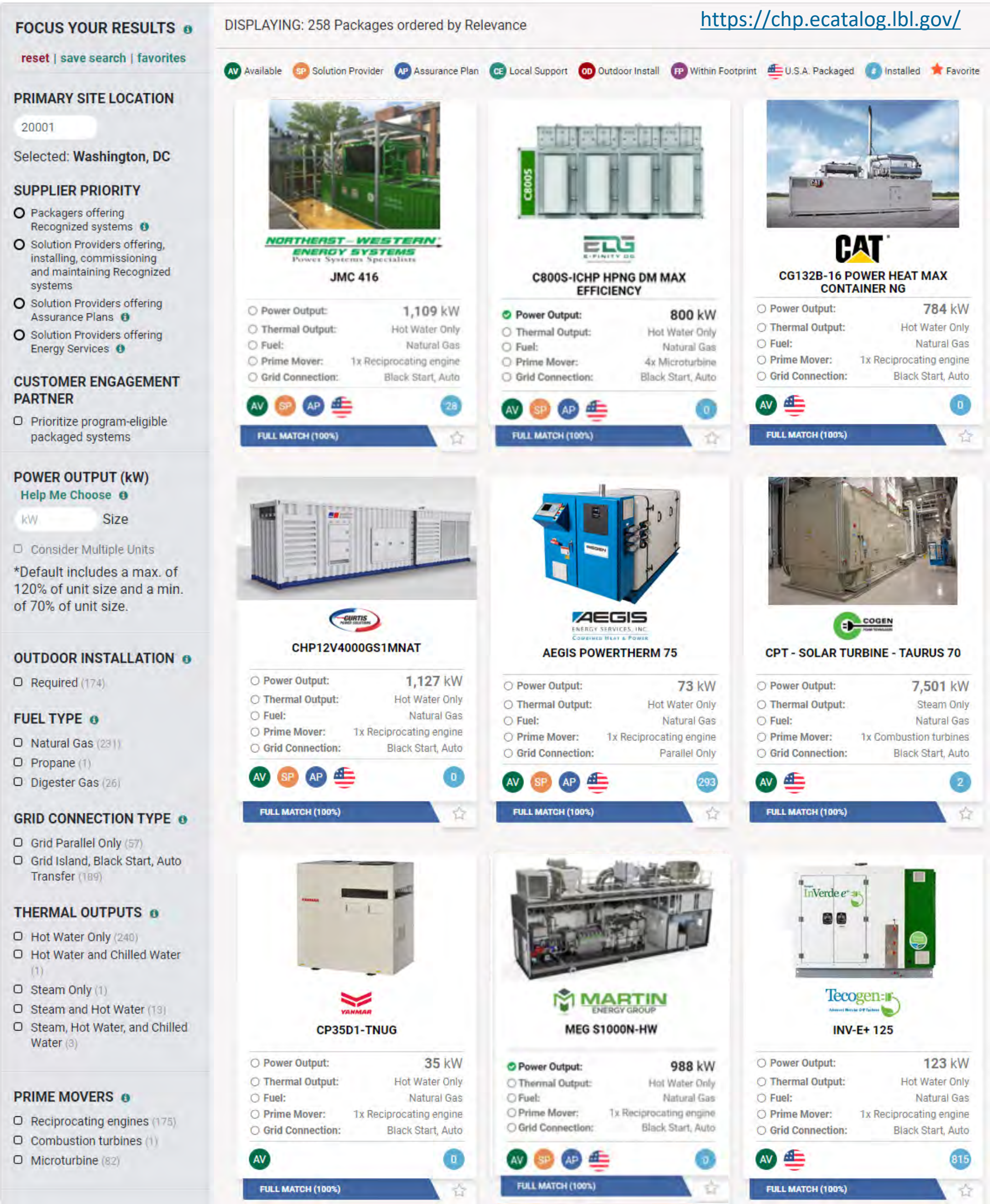
Anna Chittum – Anna.Chittum@nwnatural.com

NW Natural®

Wrap-Up

Packaged CHP eCatalog – Reducing Risk and Lowering Cost

https://chp.ecatalog.lbl.gov/



* Status as of October 30, 2020

Accelerator Winter Partner Meeting – Save-the-date

- **What:** Packaged CHP Accelerator Winter Partner Meeting
- **When:** Afternoon of either **December 8th** or **December 10th** (2 – 3-hour meeting)
- **Where:** Virtual (Zoom meeting like Accelerator webinar series, with more opportunity for discussion & engagement)
- **Why:** To get updates on the future of the accelerator and the packaged CHP landscape, discuss eCatalog updates and future plans, and learn about CHP trade ally networks

Accelerator Winter Partner Meeting – *Tentative Schedule*

- **DOE Update**
  - Strategic outreach for the eCatalog and partner programs
- **Accelerator Update**
  - Plan for final year of accelerator and final deliverables
  - Packaged CHP market outlook
- **eCatalog Updates → Version 2.0**
  - How people are using the eCatalog
  - Current updates, planned updates, and partner feedback
- **CHP Trade Ally Discussion**
  - CHP trade ally network list
  - How to integrate existing networks into the eCatalog
  - Partner discussion

DOE Team

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