Clean Heat

National Grid's plan for a fossil free future

March 2022 - Confidential

nationalgrid

National Grid Fossil Free Plan

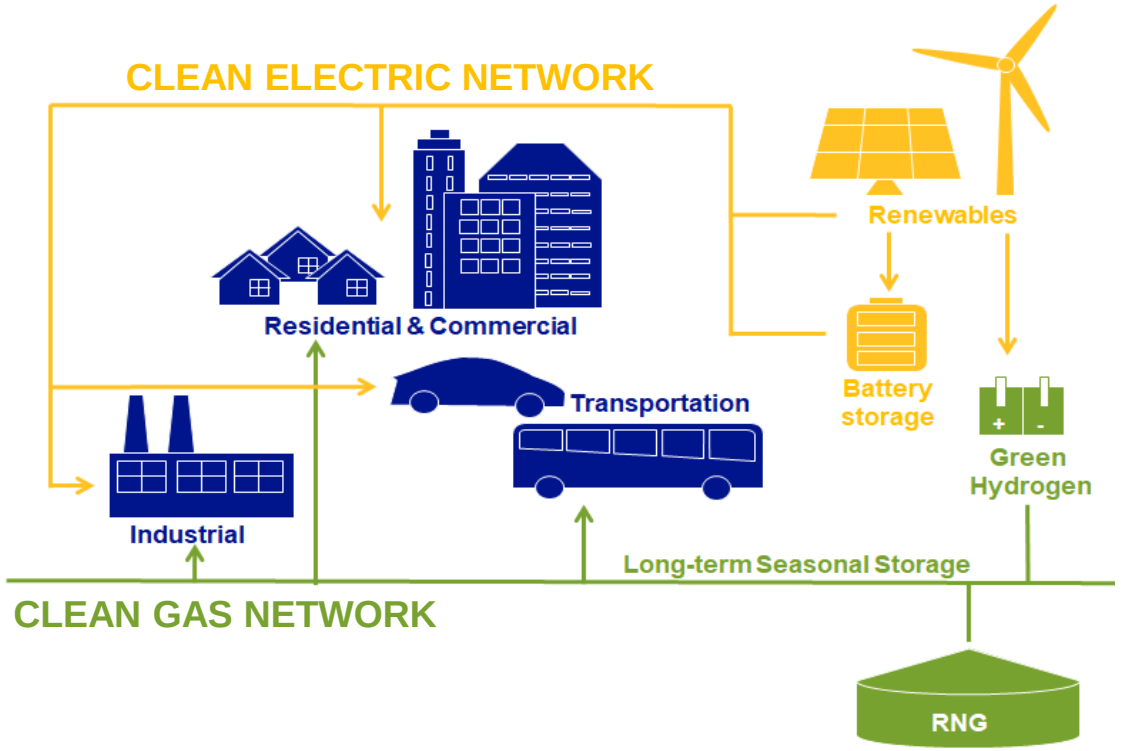
National Grid's ambition is to fully eliminate fossil fuel from our network no later than 2050, with near-term milestone to back all new connections with renewable gas within five years

- This pledge sets out a pathway that utilizes existing technology (RNG) and builds upon expectations for advancements in green hydrogen (Green H2)
- Our analysis of cost and practicality favors this approach for our customers versus full electrification.
- A concrete list of state and federal policies would allow progress towards this future, including:
  - Backing all new connections with renewable gas starting within five years
  - Seeking federal funding for a hydrogen hub
  - Investments like the ones we are already making in H2 pilots (blending and 'hydrogen home')
  - Updated federal appliance standards, especially H2-ready boilers
  - Growth from complementary advancements in heating technology, such as network geothermal
  - Complementary regulatory proposals such as combined gas/electric planning

Delivering on New York climate goals

A **hybrid approach to heat decarbonization through an integrated clean gas and electric system** can more affordably and practically achieve net zero through:

1) **Widespread energy efficiency**
   Prioritizing building envelope improvements
2) **Fossil Free Gas**
   Renewable Natural Gas and Green Hydrogen
3) **"Dual-fuel" heating**
   Customers with heat pumps for cooling, heating in the shoulder months, gas for the coldest periods
4) **Targeted Electrification/Geothermal**
   Targeted electrification where cost-effective, employing air-source heat pumps and/or networked geothermal heat pumps

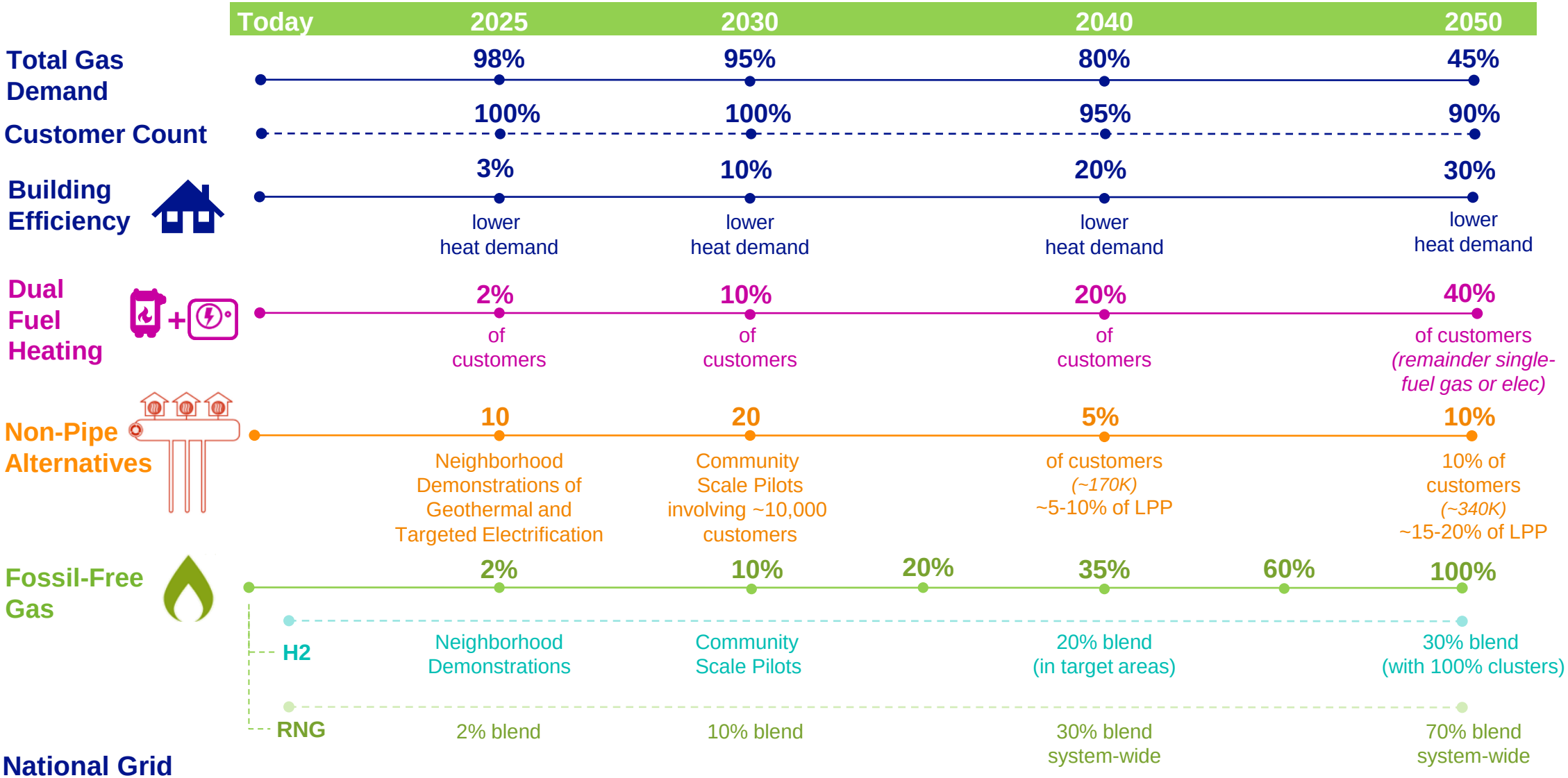


"A **coordinated gas and electric** decarbonization strategy, utilizing a diverse set of technologies and strategies, is likely to be **better able to manage the costs and feasibility risks** of decarbonization than scenarios that rely more heavily on single technologies or strategies."

– E3 MA DPU 20-80 report

National Grid's Gas Business Strategy to Achieve our State Net Zero Targets

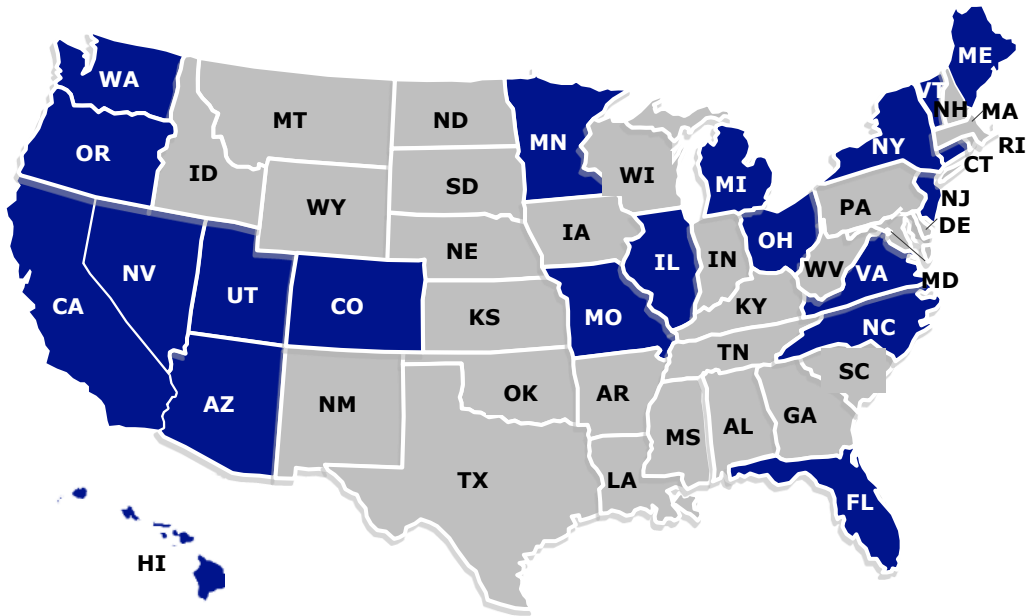
Our **Fossil Free** strategy targets these energy and customer milestones to achieve Net Zero by 2050



An integrated clean gas & electric system is best for customers

Benefits	Key point	Data
✓ **Most affordable**	**Our approach provides ~15 - 25% lower heating cost for customers**	Higher commodity costs for green gas are offset by leveraging $200 billion in existing infrastructure investments.
✓ **Supports customer choice**	**Our approach meets net zero without relying on atypical adoption rates or bans on customer choice**	Based on annual heating stock turnover of 5%/year, converting all customers to electric risks missing adoption goals by 40% and puts Net Zero target at risk.
✓ **Recognizes building stock limitations**	**Our approach recognizes that millions of buildings in New York are difficult to electrify**	~70% of buildings NYC are very difficult to fully electrify, while 15-25% are difficult to electrify outside of major cities.
✓ **Provides resiliency – not "all eggs in one basket"**	**Relying on one system for everything (heat, transport, power) is risky. An underground pipeline system doesn't have outages during severe storms**	The gas system adheres to higher reliability requirements. Hospitals and other institutions are required by law to have 2 sources of energy.
✓ **Delivers clean energy on existing infrastructure.**	**Our approach avoids siting & permitting ~80 GW of new electric capacity to serve winter peak (~50GW in NYISO), equivalent to ~100 OSW farms or ~60 Tx lines**	Our approach leverages a network that already moves 3x more peak energy than the electric grid in the winter.
✓ **Feasible volumes of fossil-free gas**	**We will transform our gas network to flow fossil-free gas by blending RNG and Green Hydrogen**	Today NGUSA procures ~15% of residential & commercial gas in the Eastern US. Net zero requires obtaining 10-20% of RNG resource potential in Eastern US and 20% blending of H2.

RNG & Hydrogen Policies: Other states have advanced policies to enable a clean gas future, mainly focused on advancing RNG mandates and customer programs



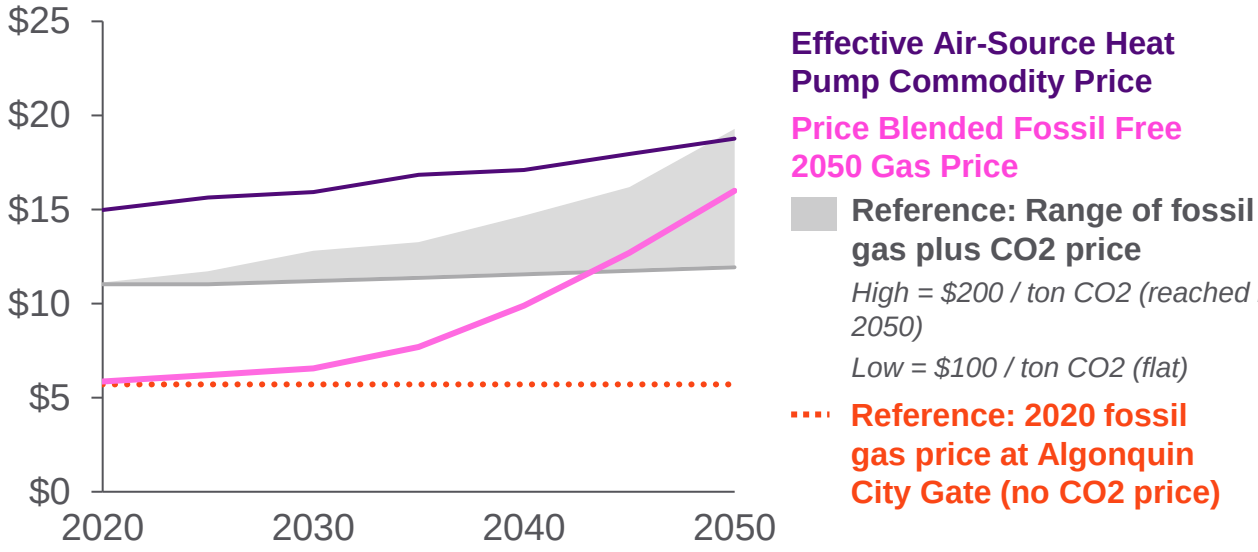
RNG and / or H2 Policy proposed or passed

Not exhaustive

Policy Mechanism	States	Example(s)
Renewable gas portfolio or procurement standards	CA, CT, HI, IL, NJ, NV, OR, VT	California PUC unanimously approved 12% x 2030 RNG procurement requirem't for all core customers (2022) Oregon established RPS setting RNG target of 15% x 2030, 30% x 2050 (2019)
RNG supply incentives, financing or cost recovery	FL, HI, ME, MI MN, MO, NY, NV, OH, OR, VA, WA	Washington state law provides tax incentives to promote investment in RNG supply (2018)
Voluntary customer tariff / adder / service	CA, CO, IL, ME, MI, MN, MO, UT, VT, WA	Many states allow gas utilities to offer voluntary tariffs to customers seeking to decarbonize faster to choose higher blends of renewable gas
Pilot or demo / innovation support	AZ, CA, CO, ME, MN, NC, NJ, NV, NY, OR, UT	National Grid HyGrid project to blend green H2 into existing gas distribution system, heat homes & fuel vehicles

Commodity prices for heating with clean gas are lower than heating with clean electricity on a $/MMBTU of heat

Weighted average gas commodity + transmission cost ($2021/MMBtu)



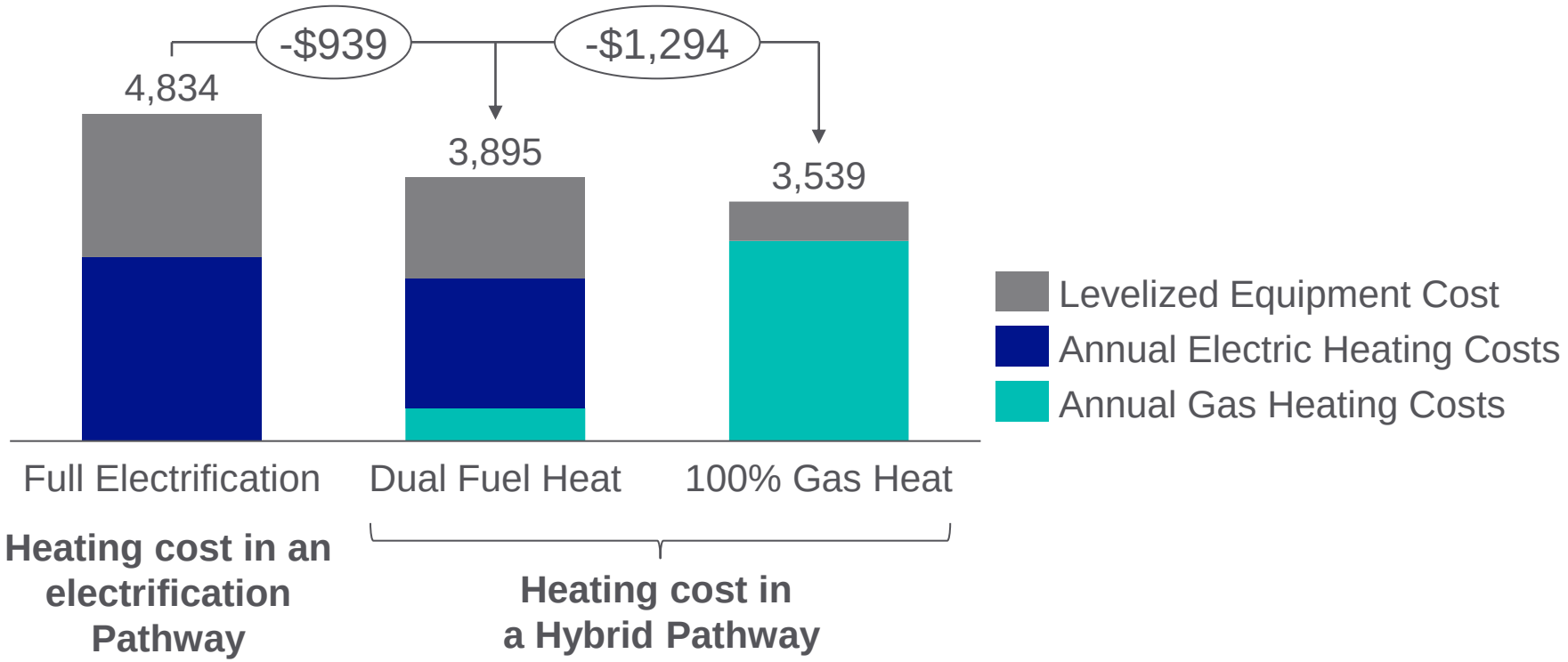
Progressive blending of clean gas over time keeps commodity costs manageable, as do building efficiency and avoided electric infrastructure investment

- Hydrogen costs are expected to fall nearly 80% by 2050.[1]
- US DOE's Hydrogen Earthshot achieves its cost target for Hydrogen of $1/kg by 2030. This level of reduction is inline with the cost reductions seen by solar, wind and storage after receiving federal support.[2]
- RNG commodity costs are driven by promptly securing available feedstocks, and long-term contracts for low-cost supply can manage costs.[3]

Sources: [1] Bloomberg New Energy Finance, 2021; [2] In 2021, US Department of Energy launched the "Hydrogen Earthshot" initiative to reduce H2 commodity costs (excluding delivery) to $7/MMBtu by 2030 (an 80% reduction vs today); Lazard "Levelized Cost of Hydrogen" 2021; [3] American Gas Foundation/ICF RNG Resource Potential Study (2019)

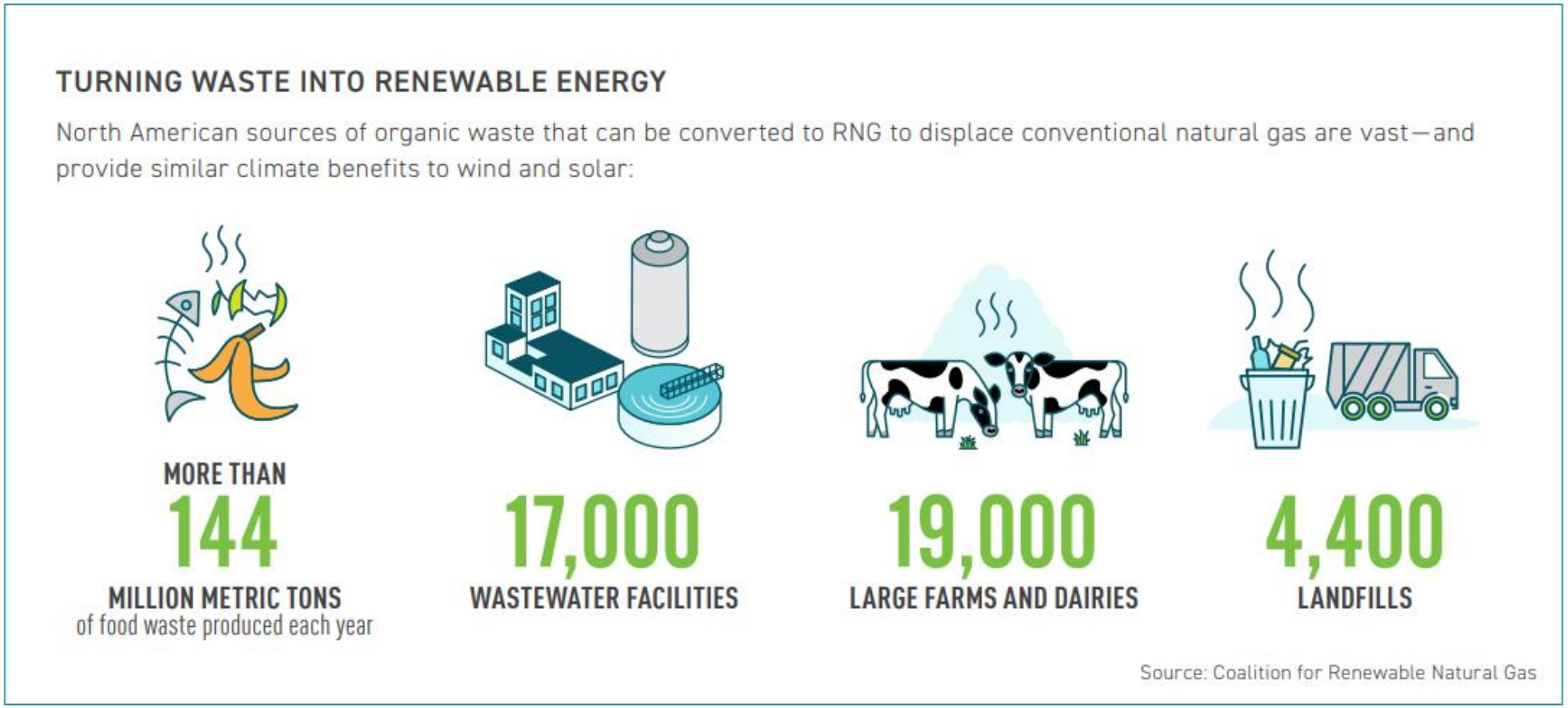
Customer affordability: Utilizing existing gas infrastructure lowers cost for customers and allows an equitable transition for all

Annualized heating-related costs for a typical customer in 2040, accounting for fuel costs and levelized equipment costs



RNG Supply

Renewable natural gas turns the problem of waste into a climate solution using our existing pipeline network

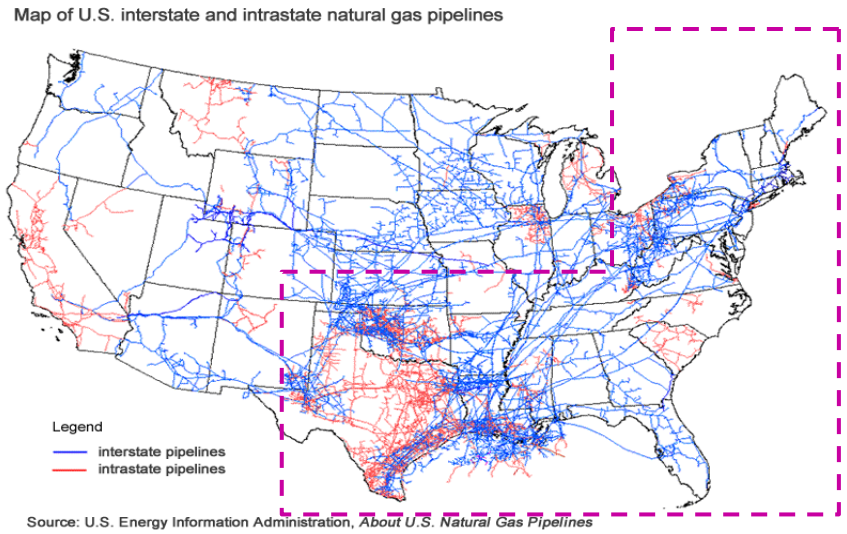


We need 200 – 280 RNG projects in the Eastern US to achieve our Fossil Free vision for New York

Networks and Infrastructure: Renewable Natural Gas

RNG supply in the US is growing and could be delivered into the region using existing pipelines at volumes required. We can achieve a zero fossil future **by procuring our pro-rata share** of eastern US RNG potential.

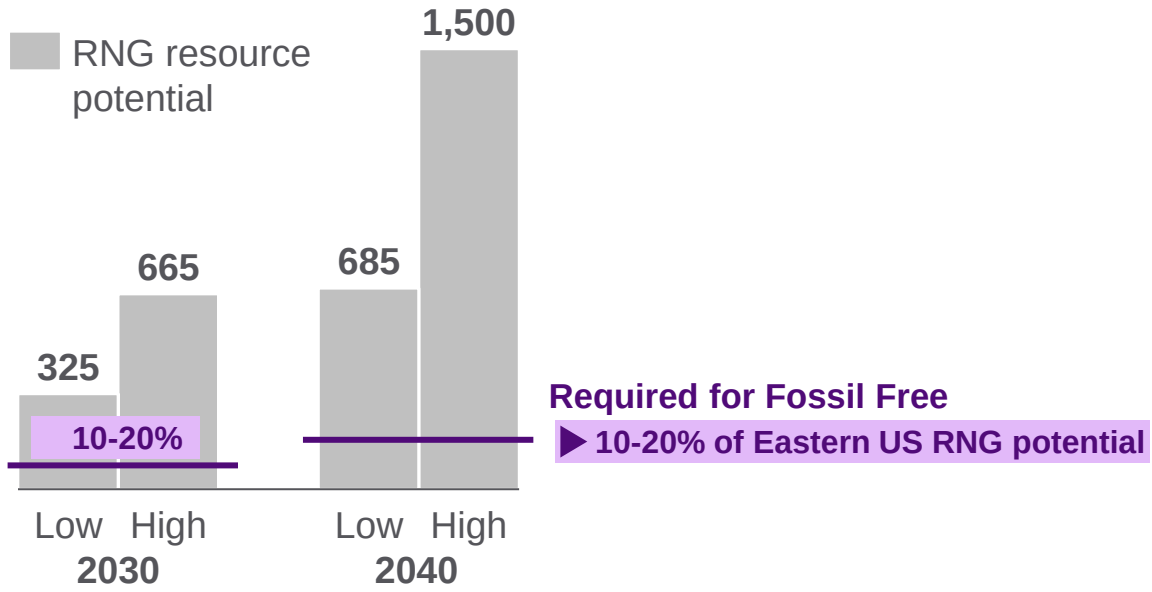
US natural gas supply and pipeline network



Pipeline network serving Eastern US

Today, National Grid (MA and NY) accounts for **15% of residential and commercial gas demand in the Eastern US**

Forecasted RNG supply in Eastern US region (TBtu/yr)



In the future, if National Grid procures **10-20% of Eastern US RNG potential**, we can achieve our Fossil Free plan

Source: American Gas Foundation/ICF RNG Resource Potential Study (2019)

2050 RNG Supply

In-Region supply: ~60–110 Tbtu

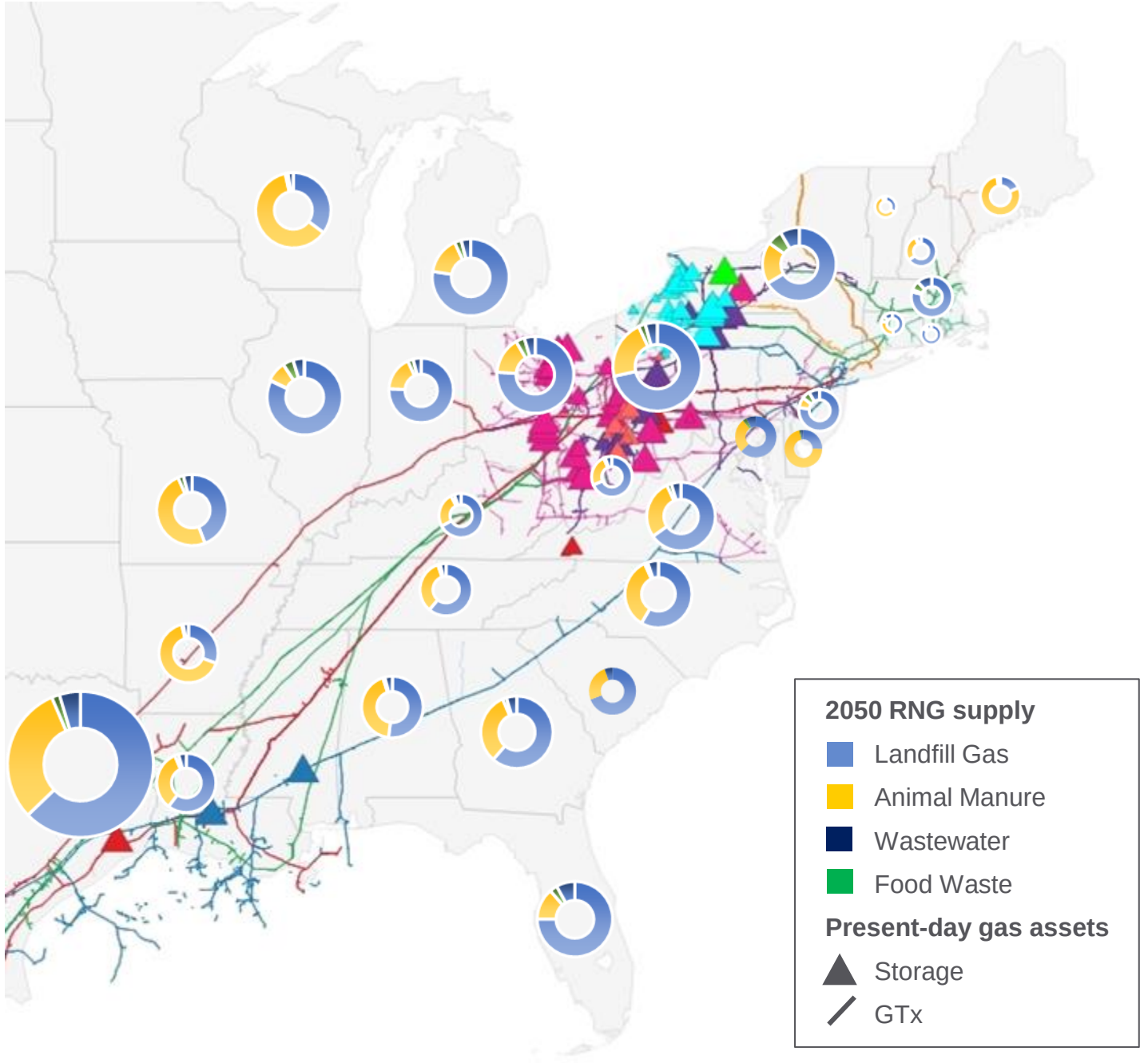
Out-of-Region supply available to connect to our existing network: ~625–1,390 Tbtu

Eastern US RNG Potential by feedstock. We include the following feedstocks from the eastern US:

- landfill gas
- animal manure
- wastewater
- food waste
- agricultural waste
- forestry residue

We exclude energy crops and municipal solid waste.

US RNG Lifecycle Emissions. Each feedstock has a distinct emissions profile. With the exclusions above, the overall weighted average emissions profile of this blend is CO_2 negative, falling in the range of -10 to 0 kg CO_2e / MMBtu



RNG Case Studies

- **RNG supply** has grown historically at a **30% CAGR** and will continue growing at rates that **allows us to hit our projections**.[1]
- **RNG supply is going to states with utility incentives or standards for renewables fuels**.

Landfill

*Seneca, **NY***

Wastewater Facility

*Phoenix, **AZ***

Animal Waste

*Tar Heel, **NC***

Newtown Creek (pilot)

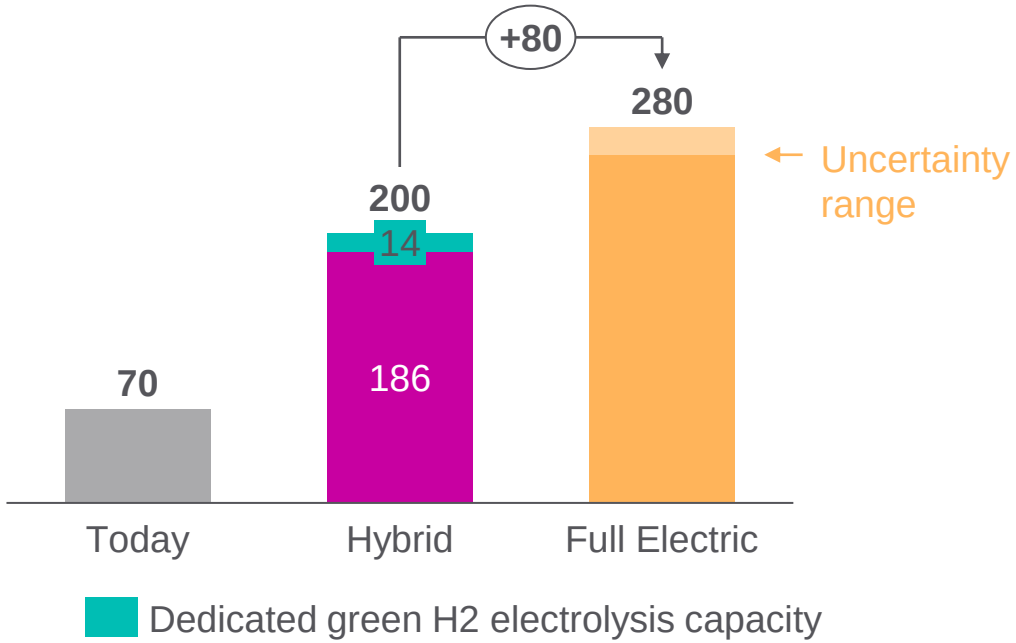
*Brooklyn, **NY***

Year operational	2016	2019	2020	2022
MMBTU/ year	1,630,000	1,770,000	140,000	169,000
Developer	Aria Energy + Innovative Energy Syst	Ameresco	Smithfield Renewables	NG + AECOM
Offtaker	BP + SMUD (**CA** utility)	Sold on open market as vehicle fuel under EPA	Duke Energy (NC utility)	NW Natural (**Oregon** LDC)

[1] AGA Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment

Electric infrastructure requirements: Leveraging existing infrastructure to deliver clean energy reduces the cost, siting and permitting challenges

2050 NYISO/ISO-NE installed electric capacity for economy-wide load (GW)

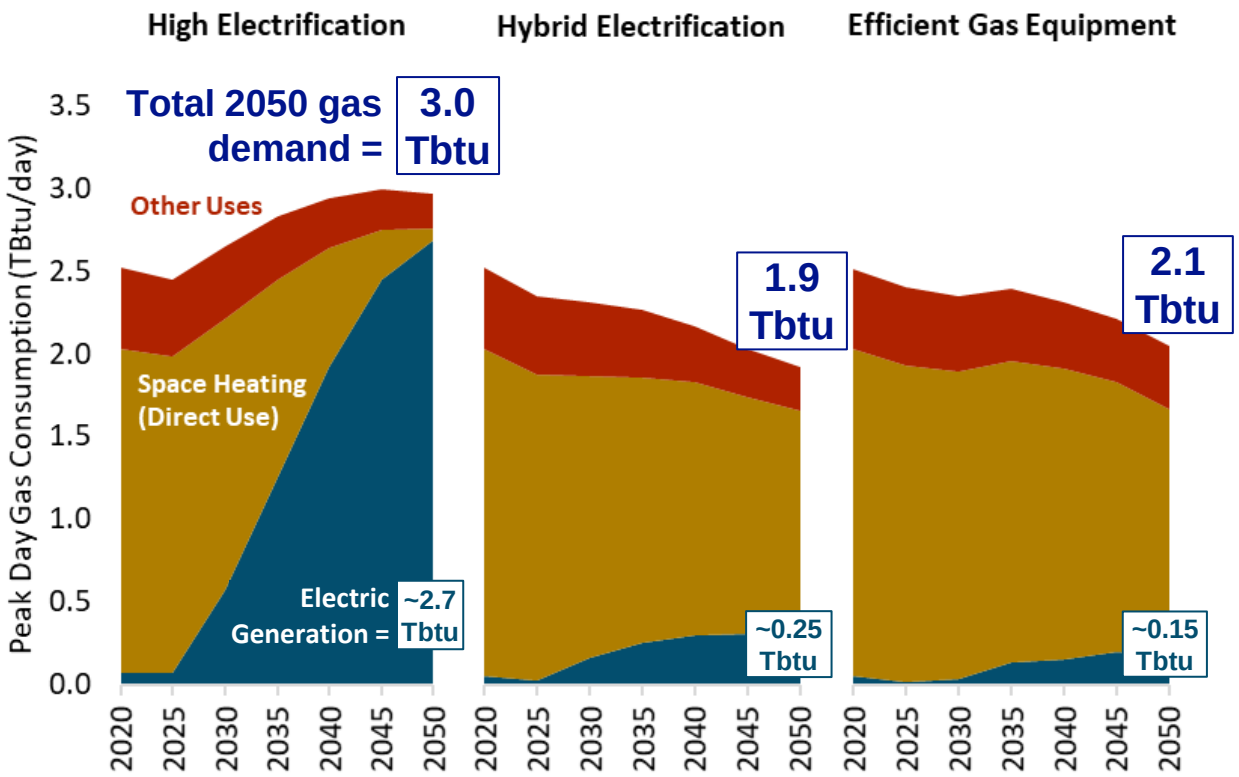


Hybrid requires less new electric infrastructure, even when taking into account green hydrogen production. Hybrid avoids nearly **~80 GW** of new generation and transmission versus a **Full Electric** future, more than today's NYISO/ISO-NE generation fleet. **~50 GW** of this avoided capacity would be in NYISO.

All Net Zero Pathways require clean gas to eliminate fossil fuels.

Electrify Everything scenarios increase reliance on gas for winter peak.

E3's MA state peak day gas demand (Tbtu/day)[1]



- There is a 50% higher reliance on gas for winter peak days in a future that electrifies heat versus a future that continues the use of gas for heating.
- Increasing electric load from heat electrification requires more electric firm capacity, which increases the need for clean gas in the power sector such as RNG and hydrogen.
- These results are expected to be similar in New York.

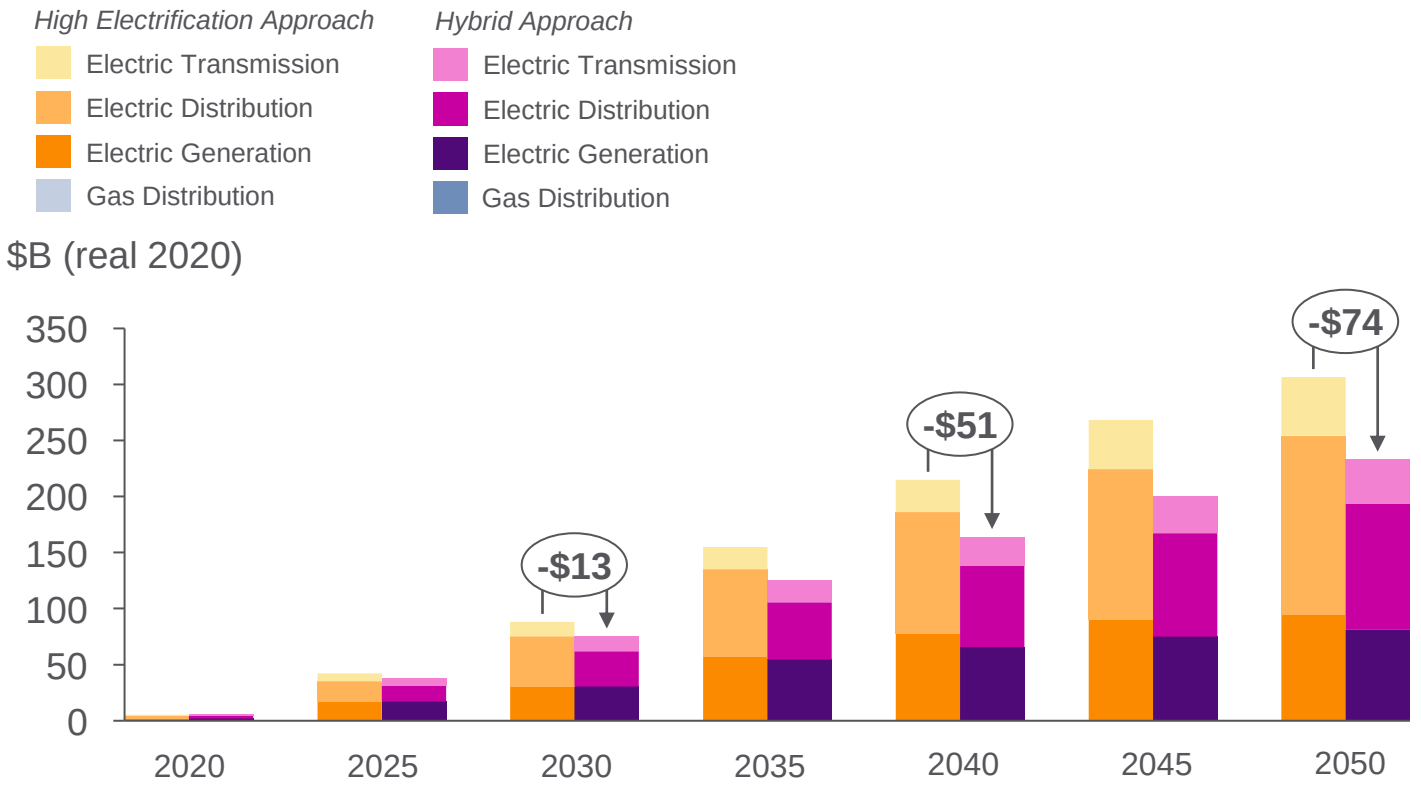
[1]**Source**: MA DPU 20-80 draft report by independent consultant E3, Figure 25. Illustration of changes in peak winter day gas volumes for three decarbonization pathways. Total gas volumes include zero-carbon pipeline gas, including hydrogen.

Full heat electrification costs New York consumers over $70 Billion more

Heating policy choices alone can result in **roughly $74B in incremental electric sector investment** in New York.

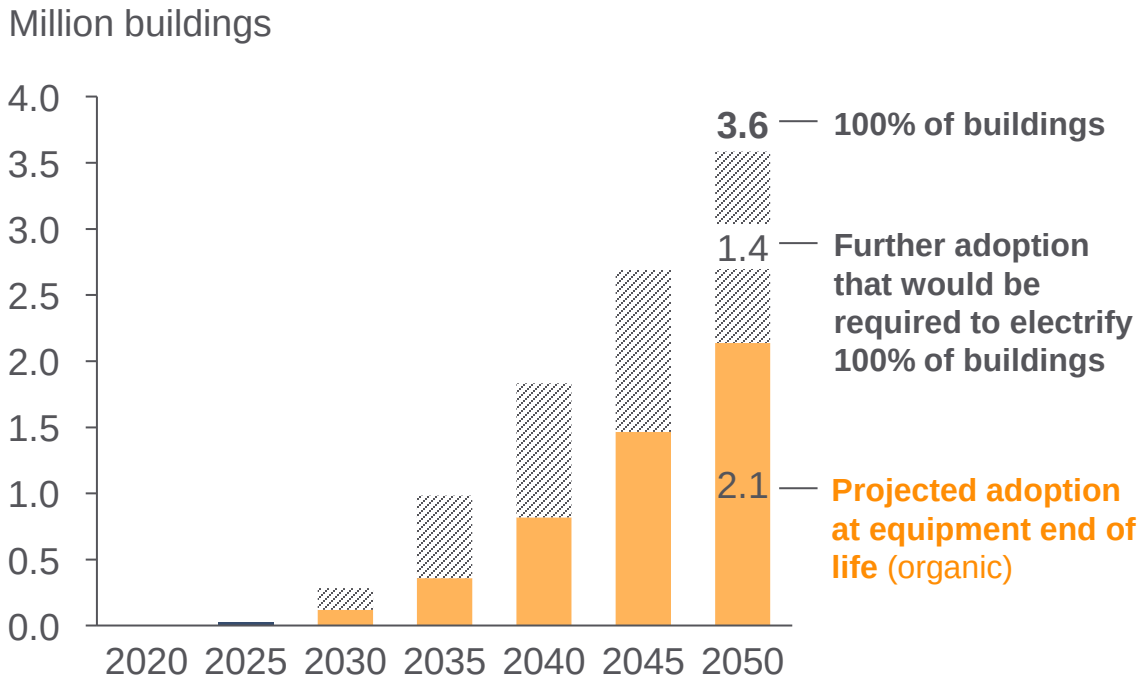
Managing winter peaks with dual fuel heating and gas network utilization **saves money for New York consumers.**

Estimated cumulative New York capex for electric generation, transmission, and distribution infrastructure, 2020-2050



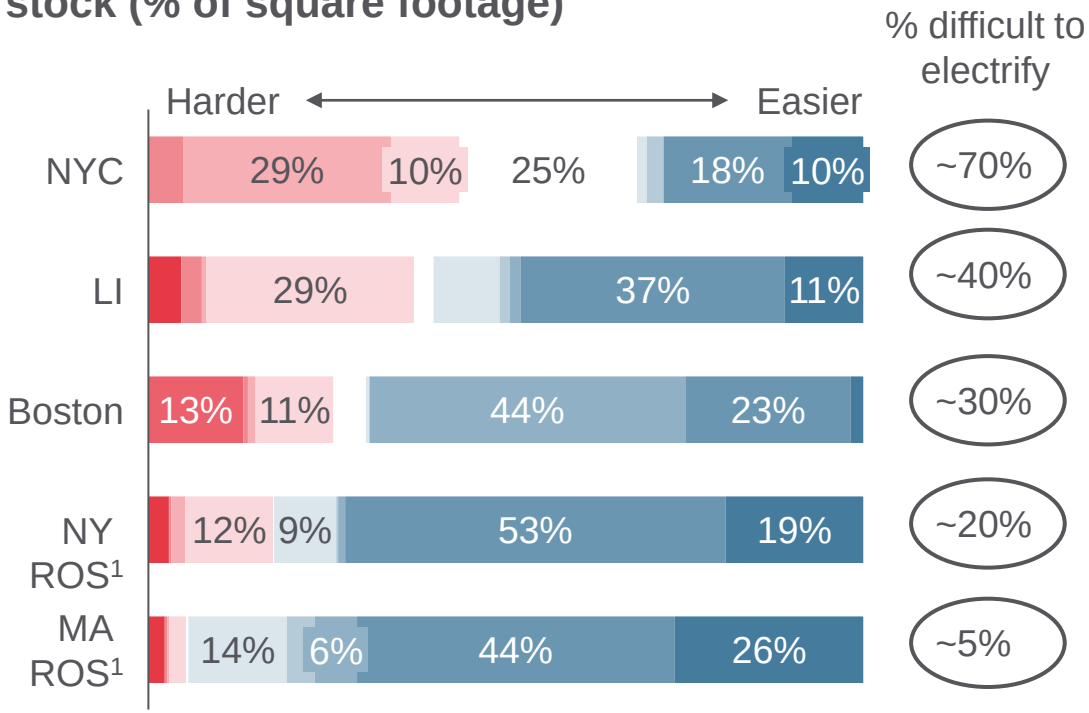
Customer practicality: Achieving an 'all electric' future could be challenged by customer adoption rates and building stock limitations, particularly in urban areas

Cumulative buildings (in NGUSA territory) adopting heat pumps in an all Electric pathway



At normal levels of heating equipment turnover, the Northeast cannot electrify everything by 2050. Adoption rates at historical levels imply a **40-50% shortfall.**

"Ease of Electrification" for US Northeast building stock (% of square footage)



US Northeast **building stock presents challenges to electrification**, particularly in urban areas where National Grid operate gas networks

Source: ARUP Building Stock Assessment for National Grid (2021) [1] NY ROS and MA ROS reflect data for 'rest of state', excluding NYC and Boston.

nationalgrid