Perspectives for Decarbonizing the Peak Focus Area Working Group from the *MA 2050 Roadmap* and other relevant research & analysis

Michael Walsh, 6/17/25

Groundwork Data is a public-interest advisory, research, and technology firm supporting a clean, equitable, and reliable energy transition.

State & Local Integrated Decarbonization Planning

Gas Pipeline Economics & Policy

Urban Infrastructure →

Future of Heat

Gas Transition Planning

Smart Use of Sustainable Fuels

https://www.groundworkdata.org/research

Today’s Goals

1

Review
“**Net-Zero**” &
alternative fuels

↓

Alternative fuels play a specific situational role in decarbonization.

2

Review
2050 Roadmap:
alt. fuels & DTP

↓

MA economy-wide situational context

3

Case studies:
H_2 & RNG

↓

Some alternative fuels could work, others won't

4

Consider policy implications

↓

Start with local pilots that address multiple local problems and opportunities

Think locally and find applications that support decarbonization and other goals

Net Zero & Alternative Fuels

Alternative fuels play a specific situational role in decarbonization.

Net-Zero Objectives

Low **Cost**

Convenient for Customers

Healthy

Enriching **Employment**

Equitable

Emissions Eliminating

Reliable

Resilient

Safe

Principles of Net Zero Energy-System Planning

Fuel Saving

- Renewable Electricity
- Energy and Material Efficiency
- Widespread Electrification

Clean, local, emissions-free energy resources, with novel customer value propositions.

Systems-Building

- Increased Integration

Share energy and resources across space and time.

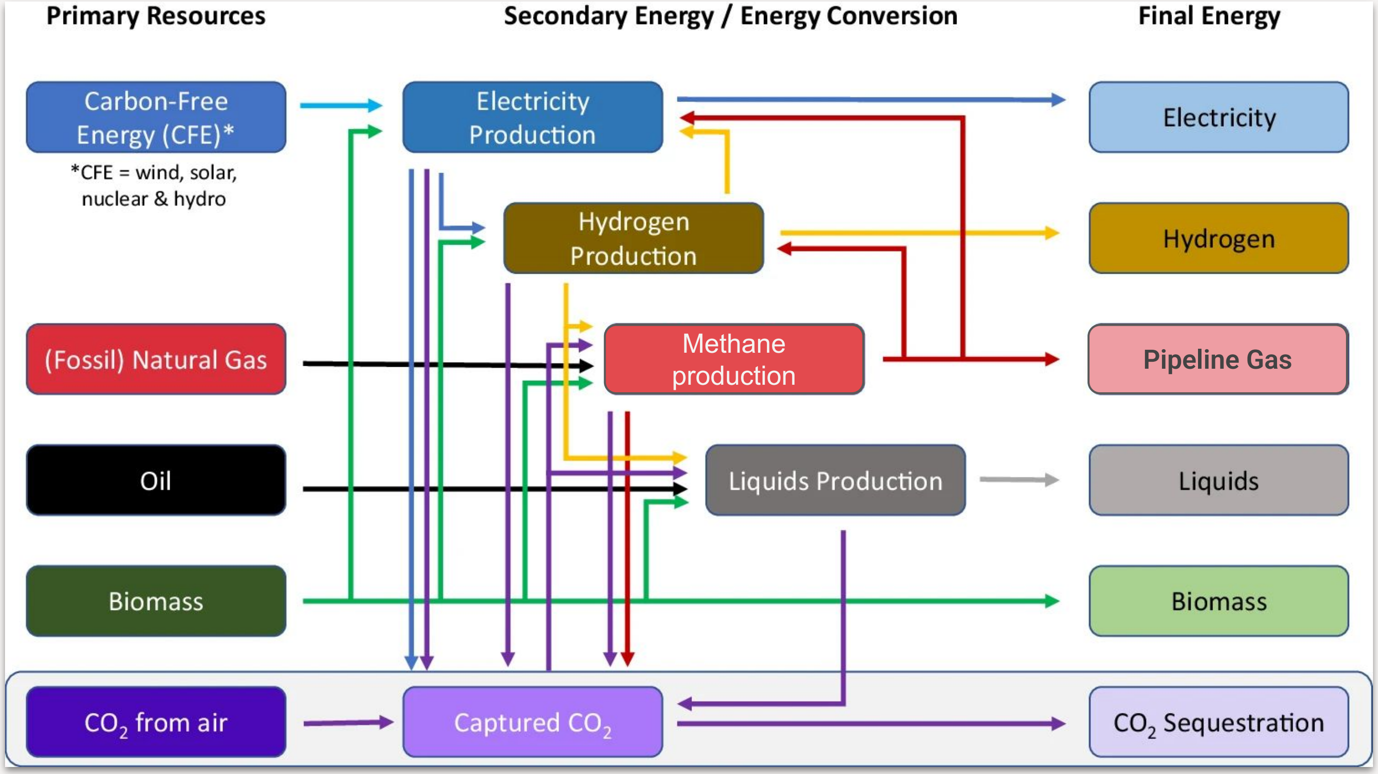
Situational Fuel Use & CO_2 Management

- *Bio-wastes & H_2* → Alternative Fuels for Hard-to-Electrify Sectors
- Limited use of Fossil fuels
- CO_2 Carbon Dioxide Removal

Fills in the gaps while reducing and reversing the net flow of GHGs in to the atmosphere.

Informed by: Princeton Net Zero America Study, 2021 https://netzeroamerica.princeton.edu/
Net-zero emissions energy systems: What we know and do not know, Energy and Climate Change, 2021 https://doi.org/10.1016/j.egycc.2021.100049
Northeast Roadmaps (NYS Scoping Study, MA Decarbonization Roadmap and 2050 Clean Energy and Climate Plan, etc.)

Fuels & CO_2 management



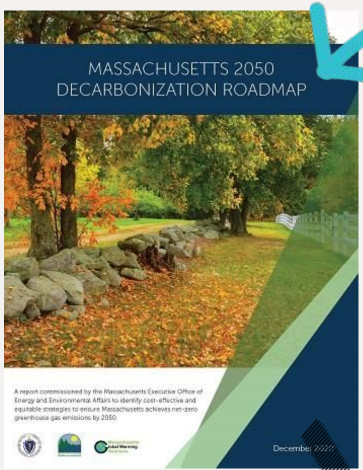
Some pathways are more favorable than others:
The efficacy of alternative fuel strategies to meet final energy demands will be dependent on the situational context of energy needs and available resources

Adapted from: Drivers and implications of alternative routes to fuels decarbonization in net-zero energy systems | Nature Communications (2024)

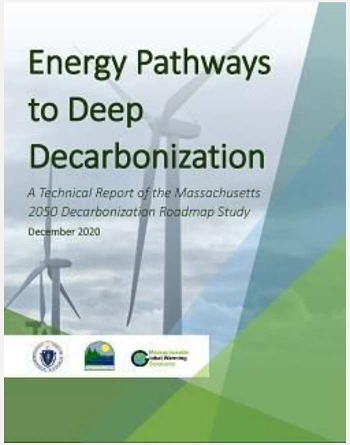
Massachusetts 2050 Decarbonization Roadmap

MA economy-wide situational context

2050 Roadmap & Decarbonizing the Peak



Summary of core strategies need to achieve Net Zero



Economy-wide analysis of decarbonization pathways

https://www.mass.gov/MA2050Roadmap

What is the impact of "decarbonizing the peak" by?

1. Eliminating thermal (gas & oil) peakers largely through greater solar + storage: ***No Thermal*** pathway
2. Going all the way to "zero emissions" with 100% renewable fuels: ***100% Renewable*** pathway
3. Relying on ***Pipeline Gas*** in the heating sector over electrification

MA 2050 Roadmap Pathways for DTP

Energy markets are optimized on cost while emissions are constrained

Pathway	Research Question	Defining Assumptions	Key Finding
All Options	Under the most likely assumptions, what is the least-cost deployment of energy system technologies that achieves deep decarbonization?	This is the "benchmark compliant" decarbonization pathway, using midpoint assumptions across most technical parameters.	Deep electrification and broad renewable buildout create a reliable energy system that is only marginally more expensive than today.
Pipeline Gas	What are the impacts of continued reliance on natural gas in buildings? What role can a decarbonized gas product play in a Net Zero MA?	Building electrification is mostly limited to conversion from oil in the near term, with slower rates of gas-to-heat pump conversion in the long term.	Requires a substantial increase in imported low-carbon fuels, possibly above technically feasible quantities. Most of this fuel goes to high-value sectors to compensate for continued emissions from buildings using a fossil/clean fuel blend. Costs increase significantly.
100% Renewable Primary Energy	What does a 100% Renewable Energy Strategy across electricity and all fuels require in terms of resources, storage, and costs?	No fossil fuels allowed; zero-carbon combustion fuels allowed for electricity generation by thermal power plants.	Reliance on zero-carbon fuels needed for grid balancing and end uses leads to dramatically higher costs in 2050; demand may exceed feasible supply. Would likely require technological breakthroughs, yet to be identified, to meet resource constraints and contain costs.
No Thermal	What resources will be needed if thermal generation is not available to provide reliability services?	All thermal capacity retired by 2050.	Substantially higher reliance on solar power, particularly ground-mounted, and new, long-duration utility-scale energy storage to provide grid balancing, leading to dramatically higher costs.

MA 2050 Roadmap, page 15

Central benchmark pathway in this analysis. Supplanted by CECP "Phased Electrification" as benchmark scenario for MA.

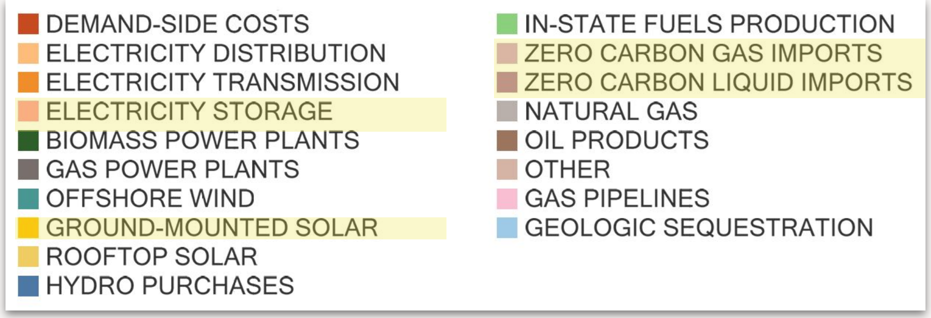
Finding remains uncontested. Corroborated by EPRI 2024 Study (page 50). 20-80 LDC Pathways Study did not attempt to refute the finding that residual gas use is best "netted" or offsetted rather than using RNG.

Large cost of "going all the way to **zero gross emissions**" without netting removals due to large reliance on renewable fuels.

Finding consistent with contemporary study by EFI/E3/Caltran Net Zero NE Study

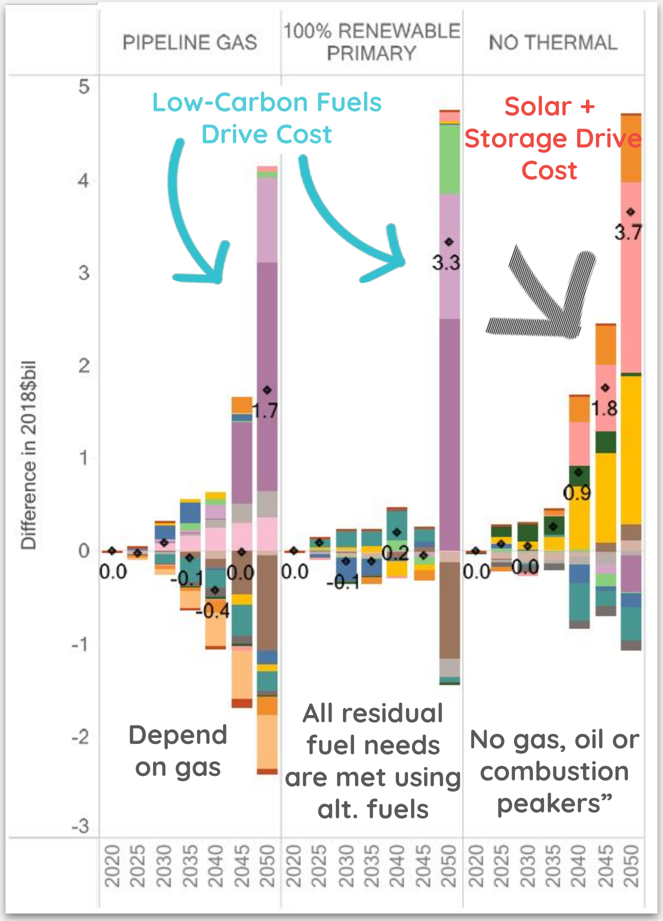
Alternative fuels and no peakers raise transition costs

1. ***No Thermal*** **increased costs due to higher need for underutilized solar + storage.**
2. **Going all the way in *100% Renewable* requires expensive low carbon fuels**
3. **Relying on *Pipeline Gas* in heating requires expensive low carbon fuels which are prioritized for transportation sector.**



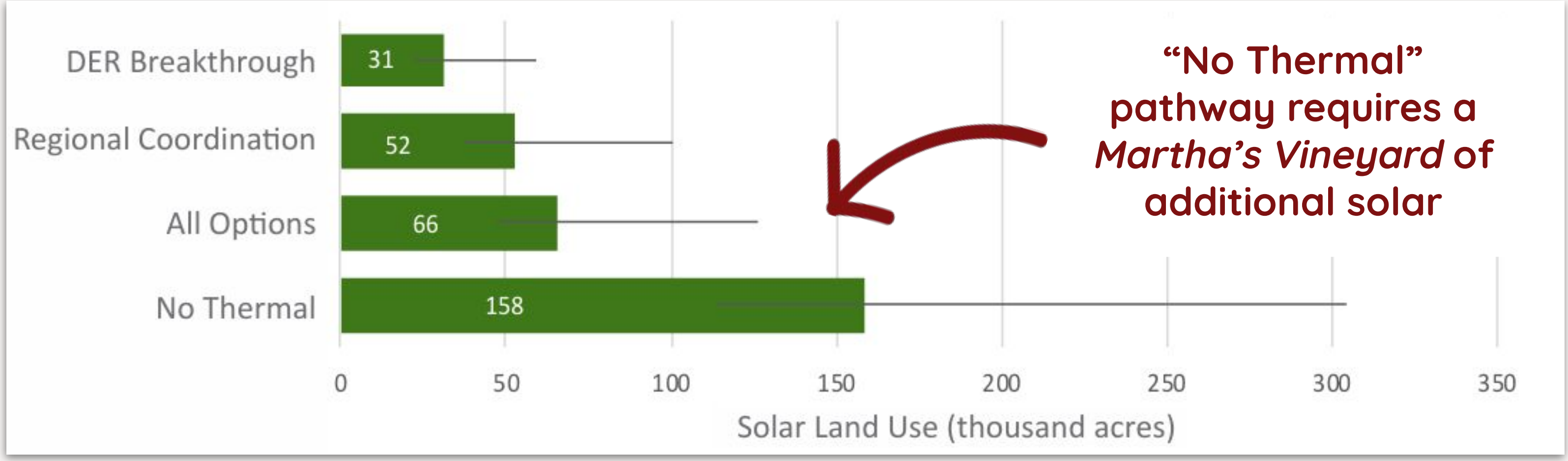
MA 2050 Roadmap: Energy Pathways Report (Page 72)

Costs relative to Benchmark Scenario



Dots indicate net cost of scenario relative to benchmark

“Peaker” Elimination Requires Overbuilding of Solar



MA 2050 Roadmap, page 64

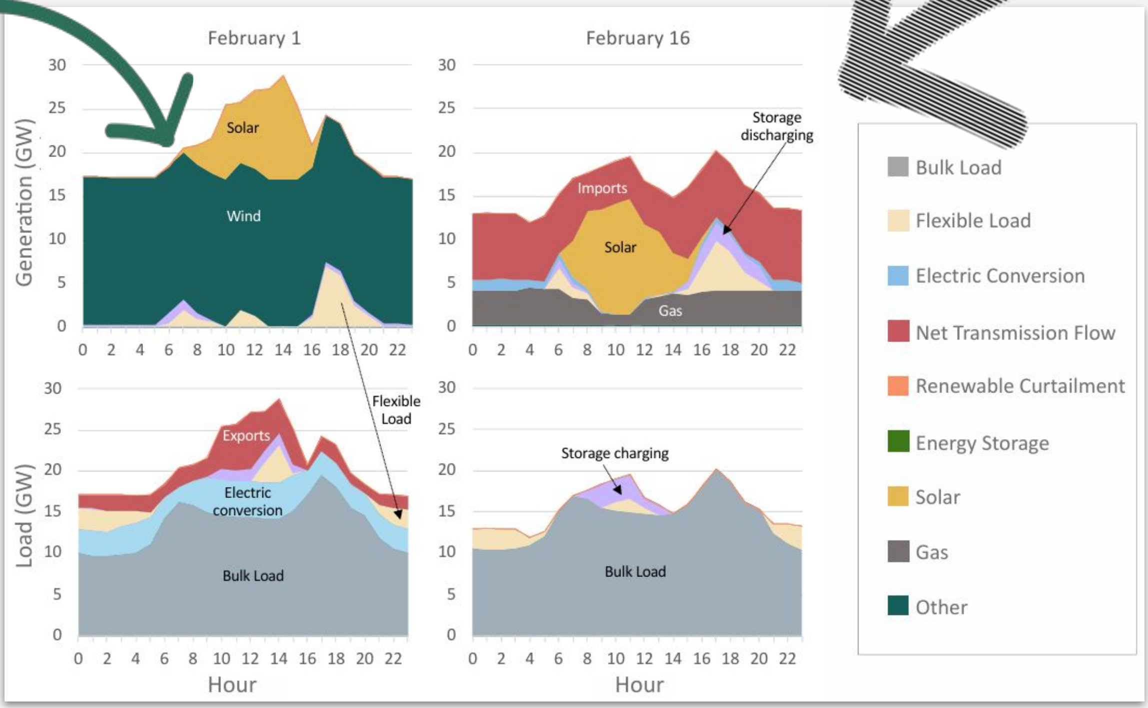
Challenge of Decarbonizing the Peak

Windy Day

Peak is decarbonized by lots of wind and solar.

No gas peakers needed.

MA becomes an energy exporter!



Cold and Still Day:

Imports and gas peakers are needed to meet demand.

Storage and flexible loads play a small but important role.

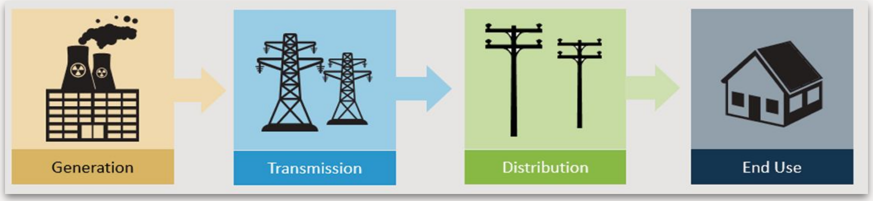
More solar+storage build-out leads to underutilization and higher costs.

MA 2050 Roadmap, page 62

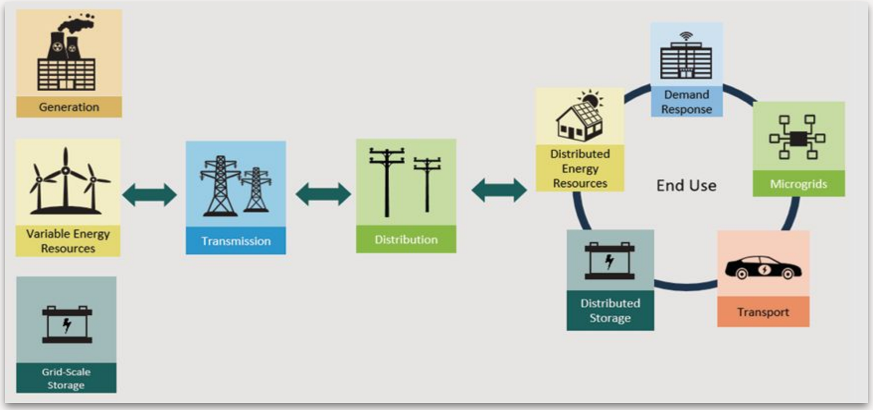
MA 2050 Roadmap's Perspective on Peaking

"As the quantity of renewables on the system grows, Massachusetts' use of, and reliance on, gas-fired generation will decline precipitously; these units could continue to be both useful and valuable but serve in a new role as a long-duration reliability resource. In such a role, the use of gas-fired generation in 2050 would be minimal and fully consistent with achieving Net Zero emissions statewide. Electricity-sector emissions with infrequent gas generation used only for system balance would closely approach, but not reach, zero by 2050. Blending hydrogen produced from excess renewables during periods of high production and low demand could further reduce those residual electricity sector emissions, as could deploying zero-carbon fuels or employing carbon capture." (MA 2050 Roadmap, pages 63 & 65)

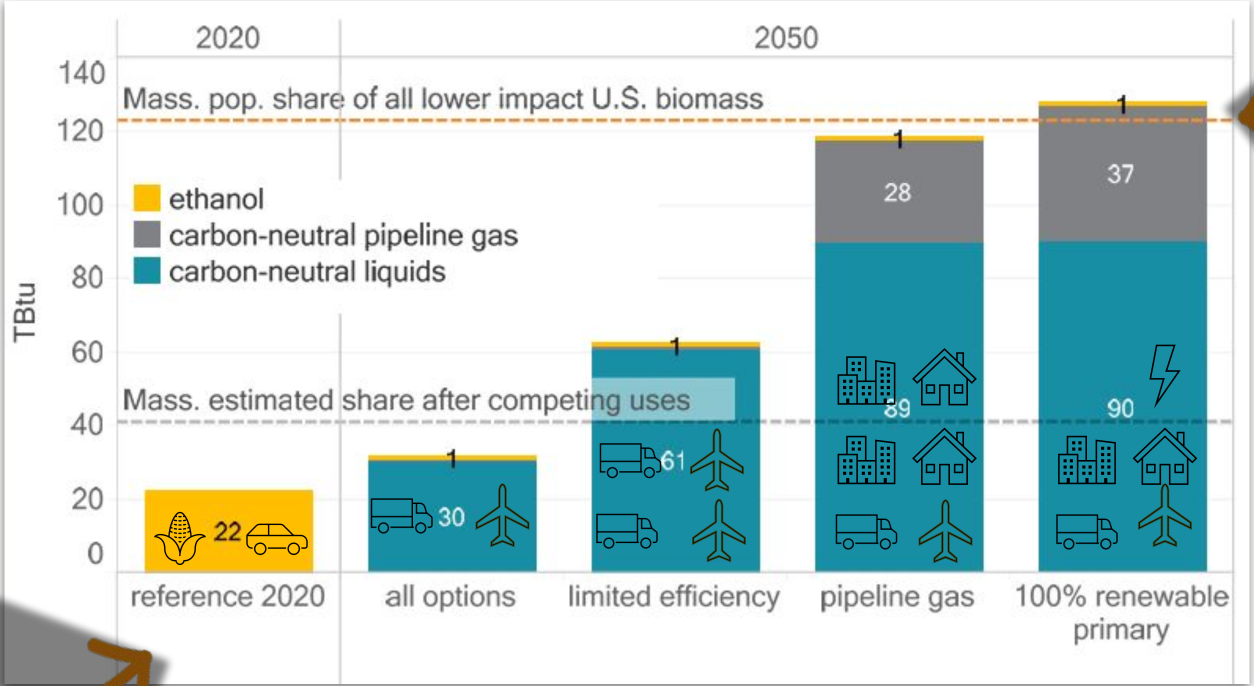
Today



Future Net Zero Grid



Over-Reliance on Alternative Fuels is Challenged by Limited Feedstocks



This is in your gas tank today and it's probably more emissions-intensive than gasoline!

High alt. fuel reliance pushes against feedstock availability.

MA 2050 Roadmap: Energy Pathways Report (Page 68)

MA 2050 Roadmap: Major Take-A-Ways

1

You're gonna have to burn something somewhere

Thermal resources "firm up" highly-renewable, highly-electrified systems.

New tech breakthrough is possible, but not certain enough.

2

Net-Zero means that fossil fuels can be used, albeit sparingly

2050 Limits still allow 10% of 1990 levels across energy sectors.

3

The application of "low-carbon fuels" should be situationally specific

Focus on "edge cases" that solve multiple problems: reliability, DERs, waste management

4

Over reliance on "low-carbon fuels" can induce second order impacts. MA can't assume these resources are infinitely available.

Second order impacts include as land use change, food prices, etc.

Case Studies in Renewable Fuels

Some alt. fuels could work, others don’t

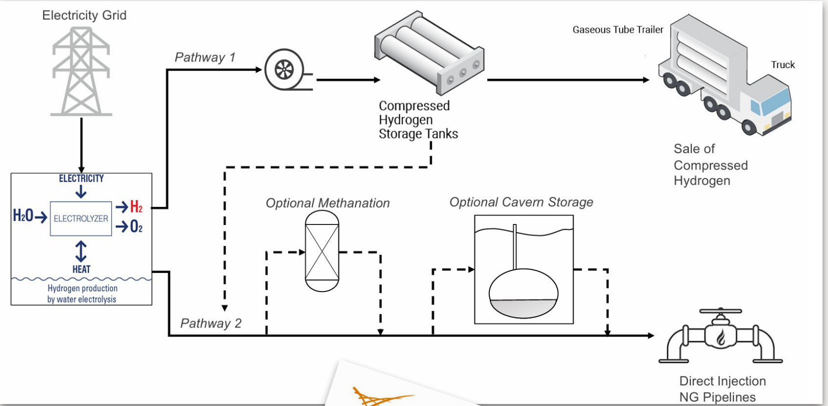
Case Study: H_2 in MA

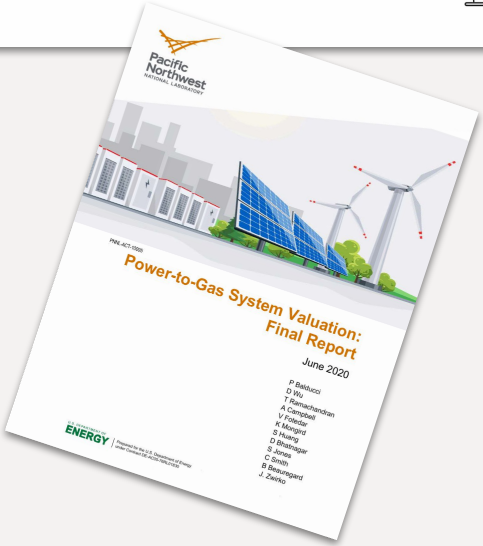
MassCEC-sponsored study by *PNNL* exploring H_2/power-to-gas in Holyoke MA

Only 6 of 82 modeled scenarios exhibited positive ROI:

- Zero energy prices + CO_2 tax
- Small-scale implementation that provided specific-yet-limited locational value.

Take-a-way: Alt. fuels need favorable economics and/or a specific niche purpose.





[Power-to-Gas System Valuation: Final Report | PNNL (June 2020)]

Case Study: RNG Production from a WWTP

National Grid (NY) Newtown Creek WWTP RNG

Brooklyn Gas Rate Design Panel, 4/28/23
Cases 23-G-0225 and 23-G-0226, (pg. 711)

	Rate Year 12-Mths Ending Mar 31, 2025
D3 Gas Produced (dth)	90,427
D5 Gas Producted (dth)	105,739
Total Gas (dth)	196,165
Estimated Weighted Average Cost of Gas	→ $3.25
Commodity Sales	$637,502

	2025
D3 RIN	$2.50
D3 RIN $/MMBtu	→ $29.32
LCFS $/MT of CO2 eq	$100.00
LCFS $/MMBtu	→ $14.48

D3 Credit Sales (Trend Projection)	$2,651,091
D3 Sales LCFS Credit	$1,309,381
Northwest Natural Purchase Price	→ $12.90
D5 Credit Sales	$1,364,027
Total Revenue Forecast	$5,962,002

Subsidy: $27.14/mmbtu **Value of gas:** $3.25/mmbtu

Today's RNG Projects are only viable because of lucrative Renewable Fuel Standard (RFS) California Low-Carbon Fuel Standard (LCFS) subsidies aimed at generating low-carbon transportation fuels.

In 2023 the EPA conducted rule making to create an "electric" RFS pathway that skipped upgrading of biogas to instead generate electricity via combustion or fuel cell.

WM "announced it will keep two sites [electric] — rather than converting them to RNG sites as planned — due to the proposed RFS changes."

Proposed rules were never adopted.

EPA releases final Renewable Fuel Standard rule without proposed credit market for EV fueling | Waste Dive

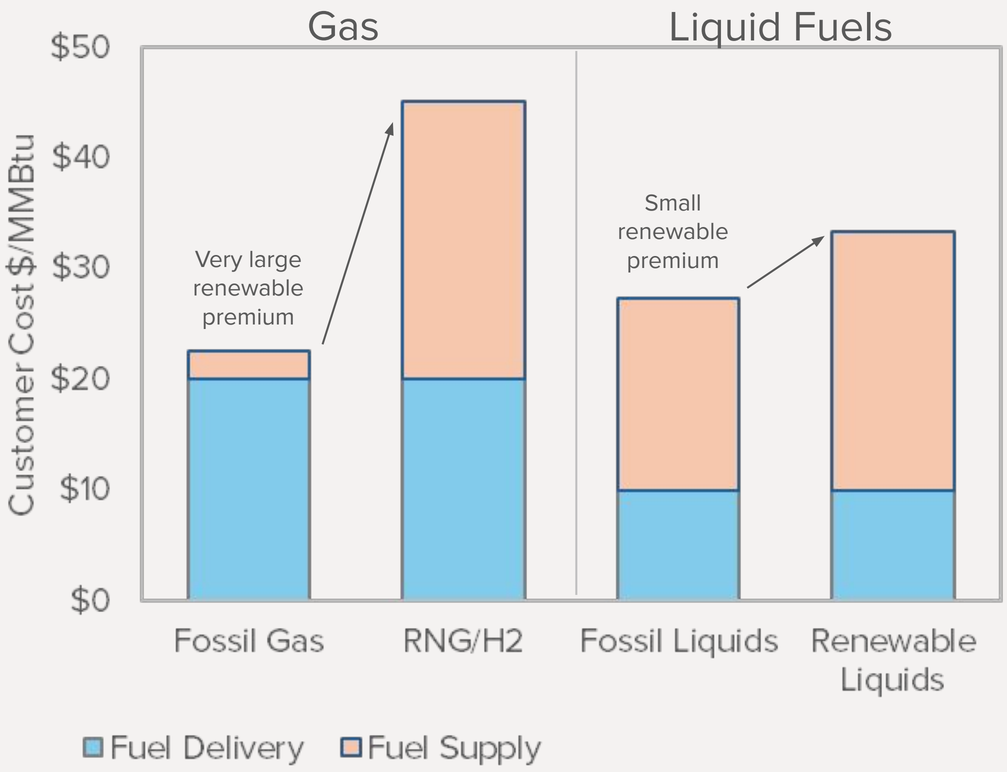
Creative Thinking in Renewable Fuels

Optimizing use across sectors

Renewable LPG could could support cleaner bus operations while avoiding challenges of fleet electrification

...or could support combined heat and power district system.

Renewable Fuels: Economics



Groundwork Data illustrative analysis

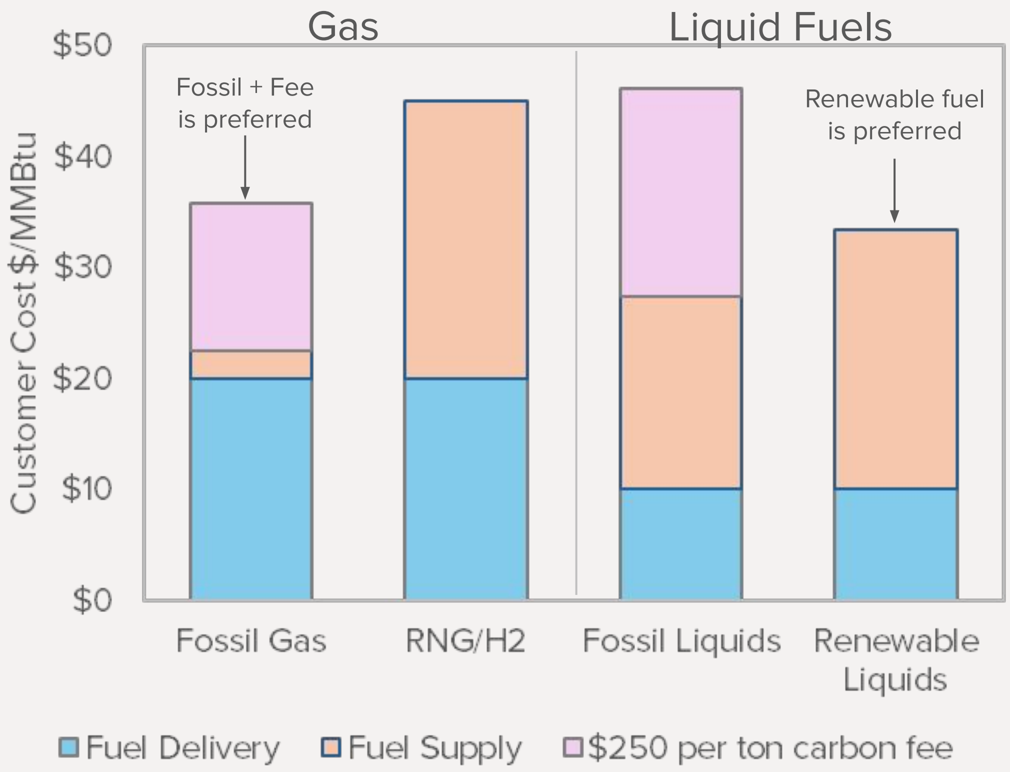
High cost of RNG would be a significant burden on customers without value creation: *an incentive to electrify*

A **consumer** would prefer to pay a carbon tax or compliance fee than buy the purchase

A **producer** would rather generate the market-competitive liquid renewable fuel over RNG

Today RNG projects proceed because of lucrative federal and California subsidies >$30 per MMBTU for transportation fuels

Renewable Fuels: Economics



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Policy Considerations & Conclusions

Start with local pilots that address multiple local problems and opportunities

Thinking Through Out-of-State Resources

An Attribute Mishmash

Large-scale Biomass or Captured CO_2

Conversion Technology	How compliance is realized
Renewable natural gas (RNG)	Injection into gas system + RNG “attribute” to displace fossil gas
Load-following biogas (25% efficiency)	Grid-firming peaking resource, Locational value on rural grid, REC
Biogas -> fuel cells (50% efficiency)	Baseload electricity, REC
Renewable liquids	Blending into liquids distribution + “attribute” to displace fossil liquids
Carbon dioxide removal	Attribute used to offset fossil fuel use

All physical emissions reductions likely occur out-of-state!

Maybe Greatest system value!

Maybe Least cost for MA!

Thinking Through Local Resources

Local sustainable bioenergy resources: at most ~3% of current state fuel consumption

Distributed Alternative Fuel Resources

Load-following biogas facilities at dairy farms, waste water, and large food waste sites.

Lack economies of scale but create local value.

Regional Alternative Fuel Resource

Regional organics collection to feed into a biorefinery for high value liquid fuels serving marginal fuel needs (incl. peaking).

Achieves economies of scale, but lacks local value

Deer Island: Low carbon systems integration at its finest

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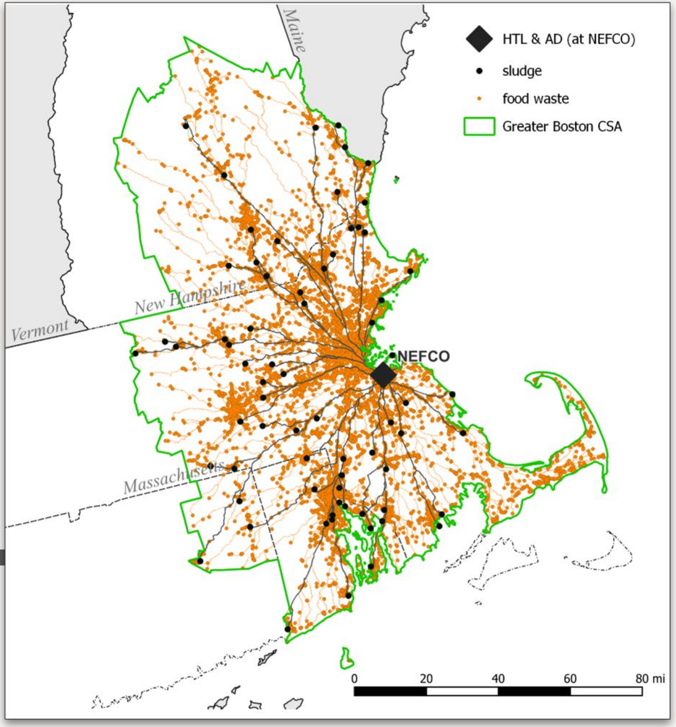


Groundwork Data and Pacific Northwest National Laboratory, Publication Pending

Alternative Fuels & Decarbonizing the Peak

Concluding thoughts: Innovate in tech. rather than GHG accounting

1

Out-of-state resources may be available for decarbonizing the peak, but ultimately require complex and sprawling accounting frameworks.

2

Instate resources are small but may provide local and regional value depending on the context. Situational context matters more than average cost, GHG, and an expansive list of broader indicators.

3

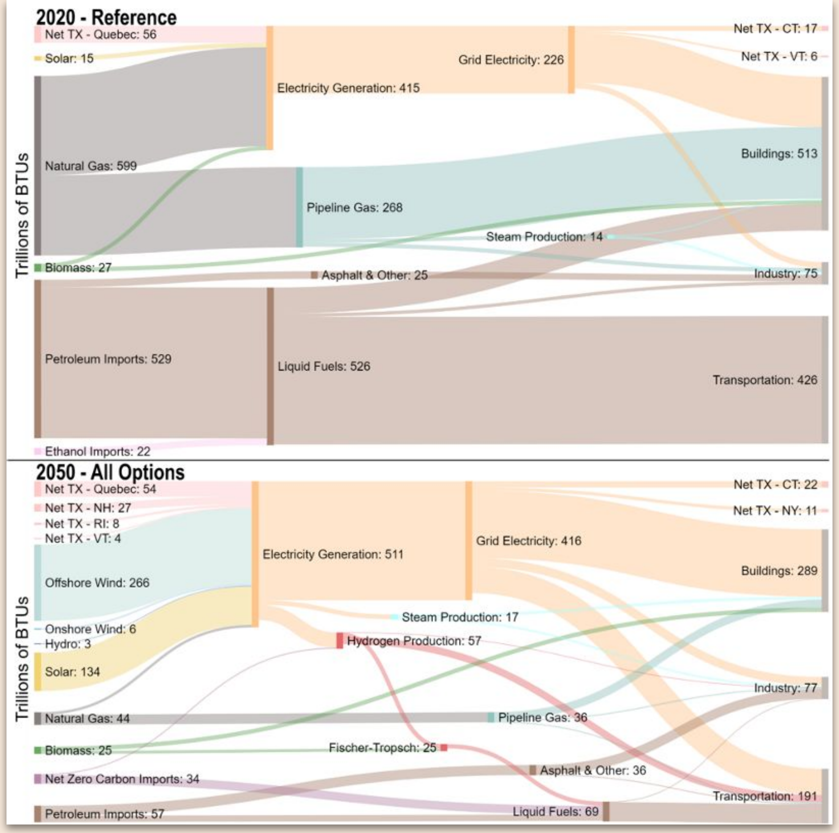
Create a policy environment that **values synergistic opportunities** for local and regional valorization of waste resources. Seek out and pilot demonstration projects.

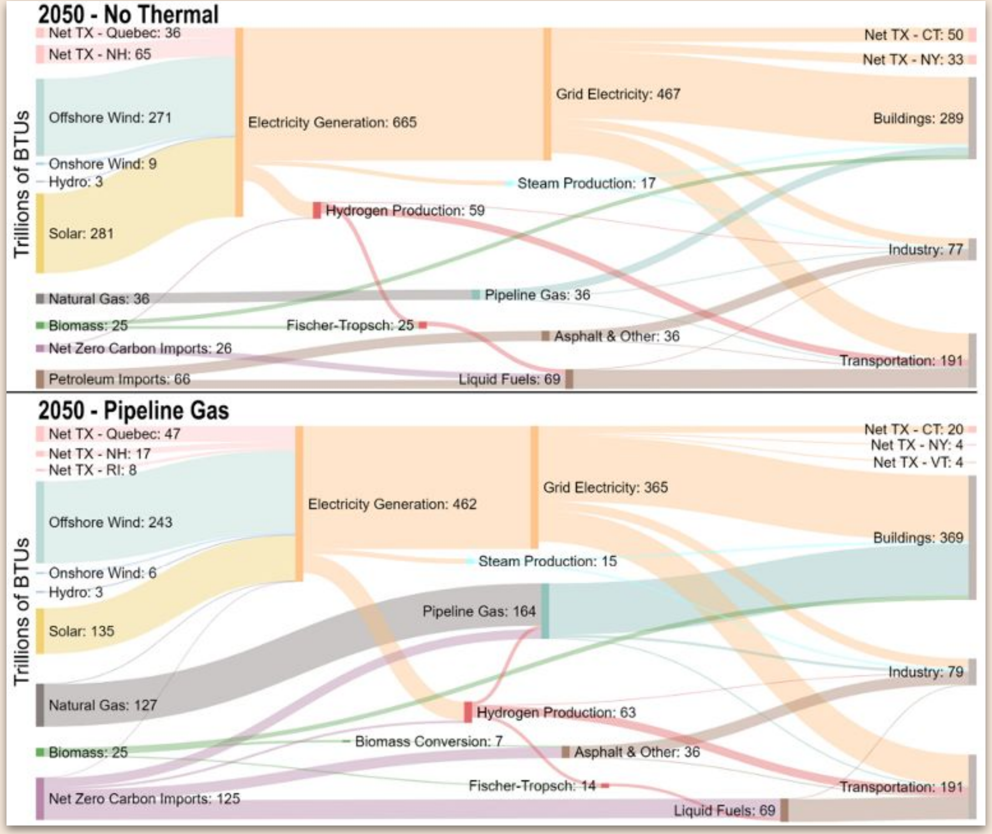
Thank you!

Questions?

Waste-to-X Indicators

Economic	Environmental	Social
1. Net present value	12. Total residuals	24. Total energy produced
2. Return on investment	13. Total air/water discharge	25. Energy service (size/type)
3. Feedstock capacity, by type	14. Total avoided disposal	26. Energy service flexibility
4. Total cost reduction	15. Total avoided effluent	27. Energy interconnection requirements
5. Unit profit (feedstock)	16. Energy conversion efficiency	28. Waste transport intensity
6. Total travel cost	17. Supply chain net GHG	29. Jobs
7. Maximum gate fee	18. Supply chain air pollutants	30. Employment carbon footprint
8. Profit-sharing gate fee (Cost reduction)	19. Supply chain water use	31. Net-zero emissions rating
9. Profit-sharing gate fee (NPV equalized)	20. Fossil energy use	32. Highest waste use (Zero waste hierarchy)
10. Break-even gate fee	21. Carbon intensity	33. Locational context
11. Levelized cost of energy	22. Nuisance potential	34. EJ impacts analysis
	23. Cumulative env. impacts	35. Cumulative health impacts
		36. Transparent lifecycle process
		37. Public involvement plan
		38. Risk and mitigation plan
		39. System ownership
		40. Local community benefit
		41. Neighborhood perception
		42. Land/View shed requirements





MA 2050 Roadmap: Energy Pathways Report (Pages 35-37)