Welcome to the Heating Sector Transformation Workshop

February 13, 2020

Please sign-in upon arrival and help yourself to refreshments!

Rhode Island
Heating Sector Transformation

PUBLIC WORKSHOP #2: INITIAL ANALYTIC FINDINGS AND POLICY DIRECTIONS

PRESENTED TO
RI Heating Sector Stakeholders

PRESENTED BY
Dean Murphy
Jurgen Weiss

February 13, 2020

THE Brattle GROUP

Agenda

1. Brief Review of Workshop #1
2. Analytic Findings
3. Potential Policy Approaches

1. Review of Workshop #1

- Team overview
- GHG reductions target
- Existing heat sector
- Heat decarbonization: primary options

Heating Sector Transformation Project Leads

STATE PROJECT TEAM

GOV

Maria Messick | *Policy Advisor*

OER

Nicholas Ucci | *Acting Commissioner*

Dr. Carrie Gill | *Chief, Program Development*

Becca Trietch | *Administrator of Energy Programs*

DPUC

Linda George | *Acting Administrator*

Jonathan Schrag | *Deputy Administrator*

Ron Gerwatowski | *Senior Regulatory Advisor*

Al Mancini | *Gas Infrastructure Lead*

Heating Sector Transformation Project Leads

CONSULTING TEAM

THE Brattle GROUP

An economic and energy consulting firm with 11 offices in North America, Europe, and Asia-Pacific, with over 50 principals and 350 professionals.

Dean Murphy

Jurgen Weiss

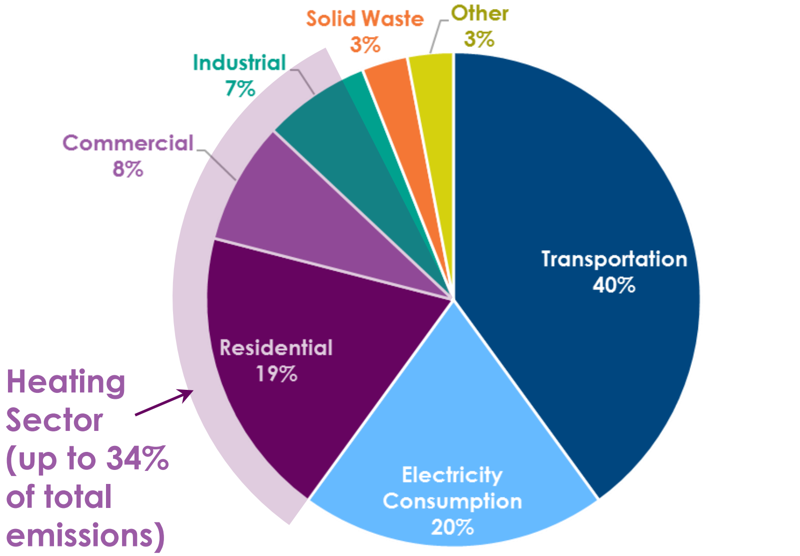
BUROHAPPOLD ENGINEERING

An international, integrated engineering consultancy operating in 23 locations worldwide, with 60 partners and over 1,900 employees.

Adam Friedberg

Resilient Rhode Island Act targets 80% reductions by 2050

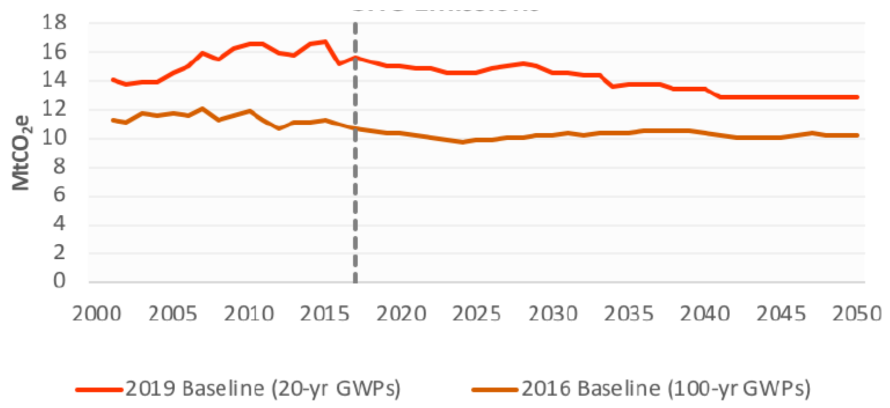
Rhode Island GHG Emissions by Sector (2015)



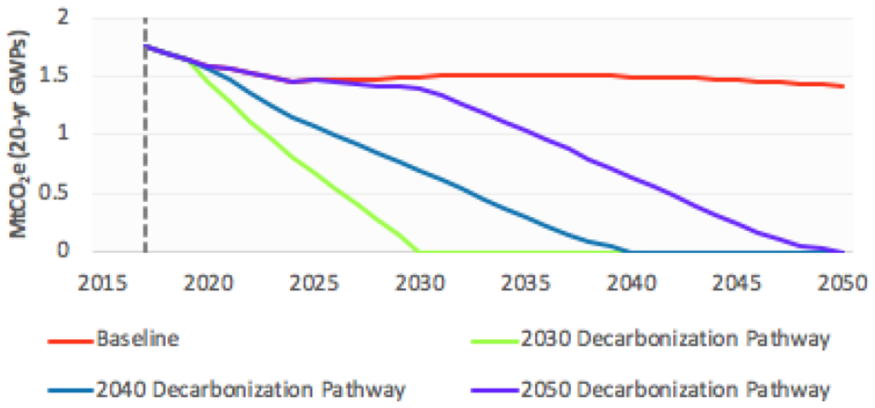
Note: Most but not all industrial GHG is related to heat generation, often for process heat.

"80x50" likely means (near) full decarbonization of residential and commercial heat – since full decarbonization of industrial and transport sectors is unlikely

Rhode Island GHG Emissions

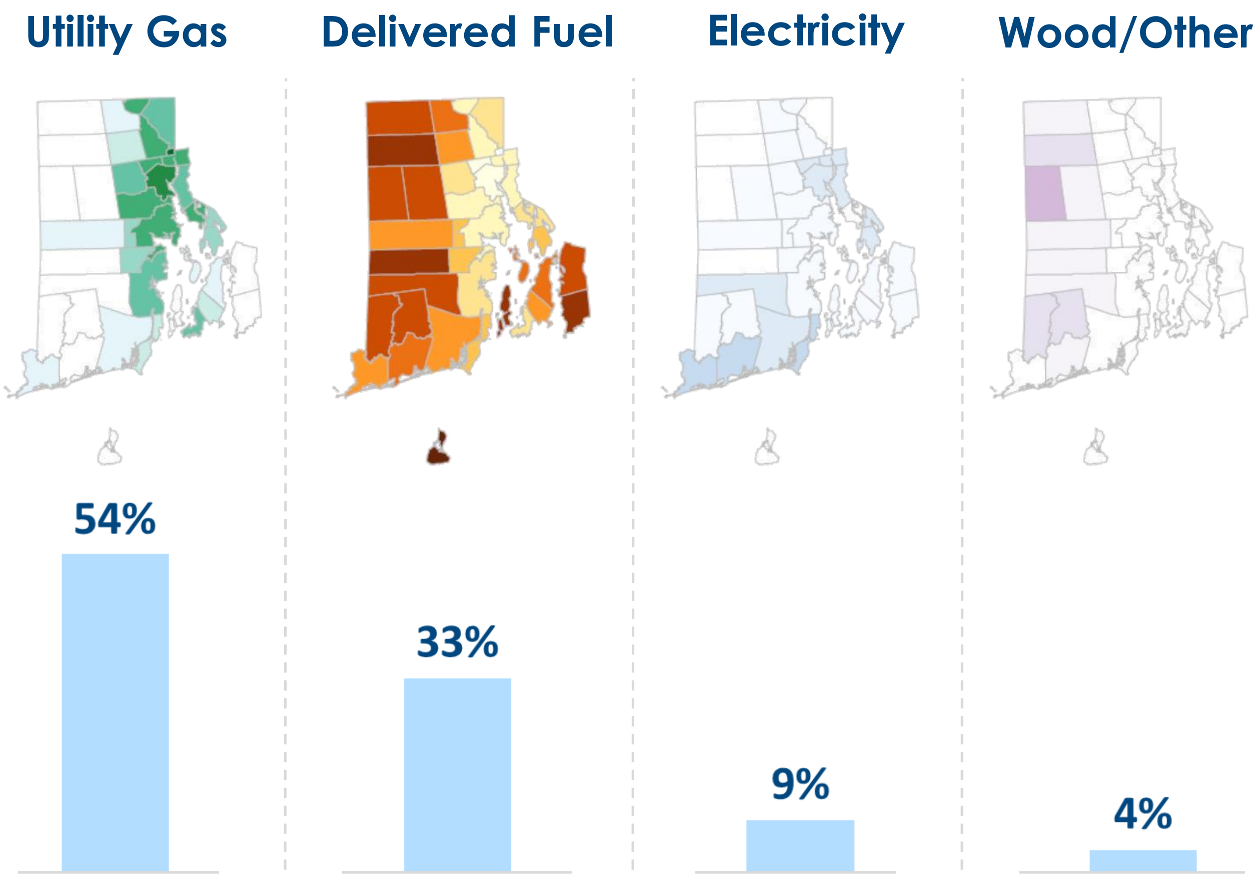


Rhode Island GHG Emissions from Heating and Cooling



Source: *Deeper Decarbonization in the Ocean State: The 2019 Rhode Island GHG Reduction Study*, September 12, 2019.

Rhode Island heating sector dominated by gas and delivered fuel, with urban/rural split



Source: *Rhode Island Renewable Thermal Market Development Strategy*, prepared by Meister Consultants Group for Rhode Island Office of Energy Resources, January 2017.
Notes: “Other” includes propane, kerosene, solar, and no heat.

The primary options

Space and water heat *Several primary options feasible across many pplications/buildings*	**Decarbonized Fuel** ***Limited supply from less-costly sources***	**Renewable gas/power-to-gas (P2G)** for gas customers – Landfill gas, anaerobic digesters, gasification, synthetic gas
		Biofuel or power-to-liquids (P2L) for most other customers – Biodiesel, ethanol, synthetic fuels
	Heat Pumps	**Air source heat pump** (ASHP)
		Ground source heat pump (GSHP) – Including GeoMicroDistrict

Industrial heat	– *May be more specialized (e.g., high-temp)* – *Possibly requires (decarbonized) fuel including hydrogen*

2. Analytic Findings

- Energy efficiency’s role
- Decarbonized heat is still necessary
- Evaluating space heat pathways
- Economics of decarbonized heat: Representative residential home
- Other heat needs

Role of energy efficiency: Improving building envelopes

Reducing heat load makes decarbonizing easier and cuts costs

- Very cost-effective in new construction
- More challenging (and highly idiosyncratic) for existing buildings
  - RI is mostly existing buildings – and most will last beyond 2050
- Some weatherization improvements may be available cheaply
  - Air sealing, weatherstripping, and attic insulation are often relatively inexpensive
  - They can yield modest energy savings of about 5–10%

Role of energy efficiency: Improving building envelopes

- But "deep energy retrofit" opportunities may be limited – and costs increase quickly
  - Residential deep energy retrofit: $50–$100k or more, for 30–75% reduction
  - Wall insulation and windows – more costly, perhaps not cost-effective, disruptive

Energy efficiency alone cannot <u>fully</u> decarbonize – decarbonized heat is still needed.

Decarbonized heat pathways

Technically feasible: Decarbonized heat technologies are available now and are in use today

- Though long-run costs are uncertain, and no technology is an outright winner
  - Each has advantages and disadvantages

Space heat is primary; also water and other heat needs

- Focus initially on space heat; consider other heat needs later

Two primary pathways to decarbonize space heat:

- **Heat pumps (air source or ground source)**
- **Decarbonized fuels (gaseous or liquid)**

Space heat: Heat pumps

Heat pumps can provide all heat, even in RI's cold climate

- Cold climate ASHPs have improved performance recently
- Equipment and installation costs are both likely to improve as technologies advance and volumes grow
  - Though ASHP efficiency decreases at low temps
  - Supplemental heat may be economic – resistance heat has similar efficiency at cold temps, allowing smaller heat pump
    - Peak capacity is needed in only a few hours per year

Managing cold temperatures is much easier for GSHP

- No difficulty drawing heat from "warm" ground at ~50˚F, even when outside temps fall to 0˚F or less
  - Though requires relatively costly ground loop

Space heat: Decarbonized fuels

Decarbonized fuels are very similar to fossil fuels

- "Drop-in fuels" perform similarly, often requiring little or no change to equipment and infrastructure
- Renewable natural gas (RNG) is methane, like natural gas – just a different source
  - Biological feed stocks (anaerobic digesters, gasification, landfill gas, etc.)
  - Power-2-Gas (P2G)
- Similarly, biodiesel can substitute directly for heating oil
  - All RI heating oil is already a 5% biodiesel blend
  - "B100" (100% biodiesel) from various biological feed stocks
  - Power-2-Liquids (P2L)

Space heat: Decarbonized fuels

Major concerns are availability, safety and “leaks” (of RNG)

- Supply of (less costly) decarbonized fuels may be limited
  - Limited biofuel feedstocks: To get large quantities likely requires turning to more costly technologies, pushing price (much) higher
- Combustion creates accident and indoor air quality risks
  - Primarily an issue for natural gas
  - Outdoor air quality may be an issue for renewable oil
- Leaks of bio-methane would lead to continued GHG emissions

Consider "Bookend Scenarios"

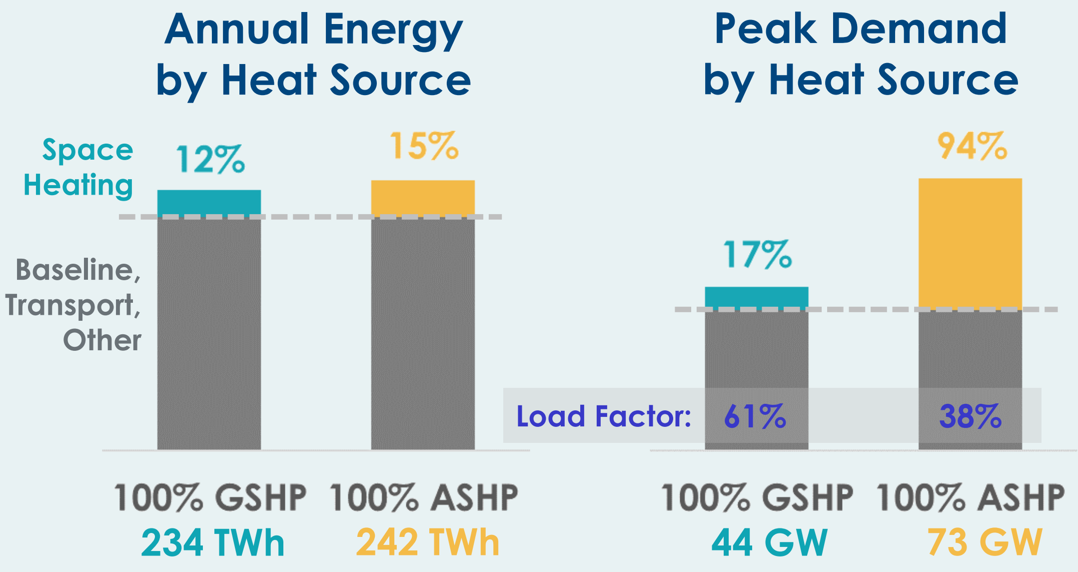
We considered several "bookend scenarios" in which
<u>all New England space heat</u> is from a single technology

- These bookend scenarios are unrealistic, but they illustrate important power sector impacts
  - Heat pumps add to overall electric load, and shift peak to winter
    - Electricity consumption now peaks on hottest summer days due to A/C
    - Electrified heat load is much bigger than A/C load
      - Must maintain bigger temperature difference: outside to inside
  - How much of this peak impact can be mitigated is an important determinant of the cost impact on consumers
  - Electric system must be designed and built to meet peak
    - Higher peak adds cost and operational challenges

Heating technology choice has a major impact on electric load shape

Electrified heat impact on **total electricity** use is **moderate**

- But **ASHP peak is extreme**: Cold increases heat need, cuts efficiency
  - 3-4 times the peak impact of GSHP
- Much **higher peak has cost implications** – for T&D, as well as G
  - Higher price affects cost of other electricity uses too



ASHP adds ~15% to average electric load but nearly doubles load for just a few very cold hours in winter

Even if peak can be partly mitigated (e.g., with thermal storage), it will be extreme

“GeoMicroDistricts” may enable GSHP

Common ground loop serving GSHP in multiple buildings

- Recently proposed to be piloted in Massachusetts
- Multiple configurations possible
  - Heat pumps centralized or at individual buildings
  - Differs from traditional district heating, but also has scale economies
- Can provide heat and A/C
- Scale may reduce ground loop costs, and yield operational diversity
- But likely requires high density and high participation to be effective
  - May be easiest for campus-like sites – many and/or large buildings, closely situated, with one decision-maker
    - Brown University is converting its existing district heat system to heat pumps, though it is using ASHP (geology not suited to GSHP)

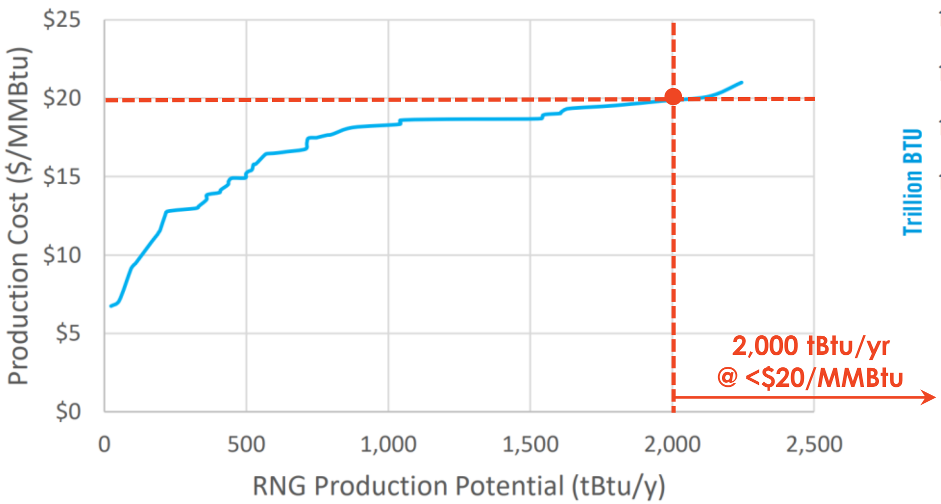
Decarbonized fuels are available: both gas and liquid

- Advantage: “Drop-in” fuel can use existing infrastructure
- Though supply from less costly sources is likely limited
  - Waste biofuels are typically cheapest, but they are by-products of other processes and thus have limited supply
    - Gas: Biogas from landfills, agricultural waste (anaerobic digester)
    - Liquid: biodiesel from waste cooking oil
  - More costly to harvest biomass to produce biofuels
    - Gasification of biomass, ethanol/methanol, biodiesel from crops
    - Major stress on agriculture/environment to meet current fuel volumes
  - Synthesizing gas or liquid fuels is most costly, and is likely to set the price to get volumes approaching current fuel consumption levels
    - Synthetic methane or liquids via P2G or P2L – hydrolysis, methanation ...

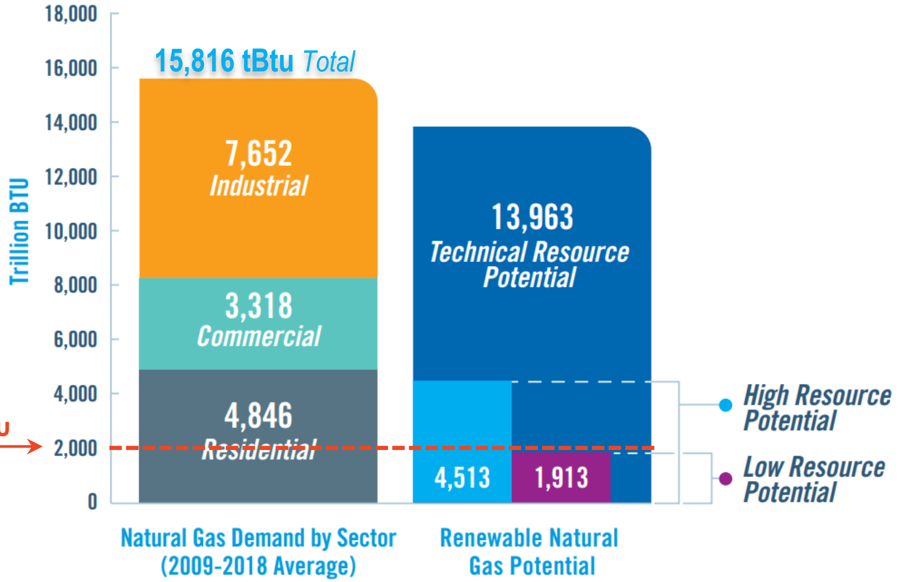
Low(ish) cost renewable gas is in limited supply; price is likely to be quite high

- American Gas Foundation: up to 4.5 tBtu RNG supply by 2040 (High Resource Scenario)
  - Only 2.0 tBtu of this is below $20/MMBtu (vs $2.50 Natural Gas)
  - This is 13% of total gas use; less than half of current Residential use
  - Implies long-run RNG price may be well above $20/MMBbtu

Combined RNG Supply-Cost Curve, 2040
AGF High Resource Potential Scenario



Gas Demand vs. RNG Resource Potential



Source: American Gas Foundation, Renewable Sources of Natural Gas, December 2019.

Impact of volume loss on gas LDC

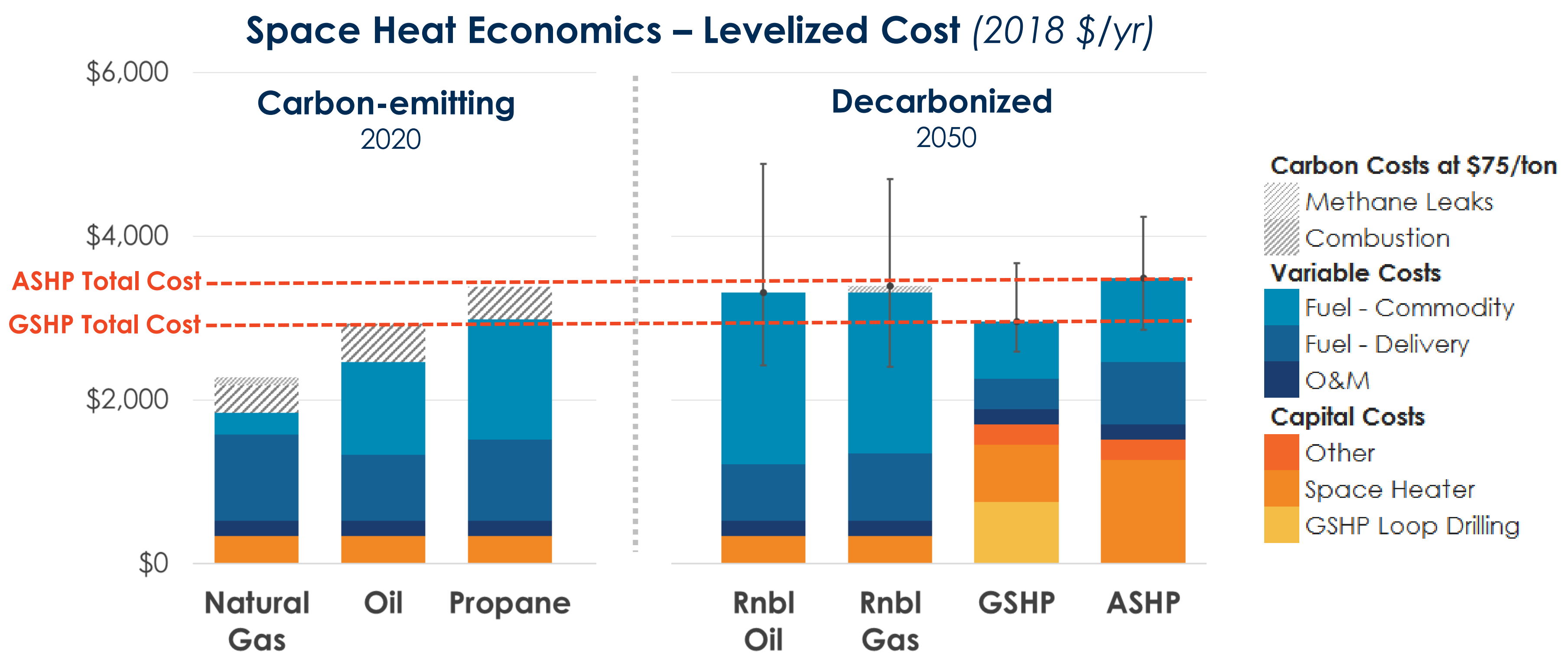
Even if "Decarbonized Gas" succeeds, delivered gas volumes could fall substantially

- Larger RNG supplies may not be available at reasonable price
- Some (many?) gas customers may switch to heat pumps
  - Using gas as backup (small heat pump as primary) = much less demand
  - EE cuts gas use even when gas retained as sole heat source
- Gas distribution costs are largely fixed
  - Delivery charges can be 50-70% of residential bill
    - Reduced volume raises unit rate – may drive more defections
  - How far can volumes fall and the system remain viable?
    - If it does not remain viable, how to "unwind" system without hurting vulnerable customers?
    - Spreading costs across both electric and gas customers may help. (One utility provides both services in RI.)

Economic comparison of decarbonized heat

- **We compared costs of primary decarbonized heat options**
  - Begin with Residential as an example
  - Size of home (heat load) does not affect relative costs significantly
  - Though individual buildings are idiosyncratic – this compares rough averages
    - Customization, ductwork, electrical upgrades, etc. may differ considerably in one home vs another
- **Annual cost – spreads capital cost across equipment life**
  - Note: This assumes initial cost is not a barrier!
- **Consider projected equipment, installation, fuel costs in 2050**
  - Use ranges to characterize uncertainty
  - E.g., Heat pump costs assumed to decline by 0.5-2%/yr (15-45% by 2050)

Economics of decarbonized heat: Representative single family home



Conclusion: Economics are inconclusive – for now

- Renewable fuels (Rnbl Gas, Rnbl Oil) and Heat Pumps have **similar costs, and mostly overlapping uncertainty ranges**

Comparison of different decarbonization approaches shows **no clear winner**

- **Economics depend on several critical but highly uncertain factors**
  - Cost of "drop-in" replacement fuels for gas and oil
  - Installed cost of heat pumps and ground source loops
  - Retail price of (almost-all-renewable) electricity
- **The "preferred" (most cost-effective) approach is sensitive to the choice of assumptions, within reasonable ranges**
- Some "themes" provide guidance:
  - **Heat pump systems** are more **capital intensive** – especially GSHP – with lower operating cost; may be relatively more **economic for larger** (heat and cool) **loads**
  - **ASHP** (if widely adopted) could cause an **extreme electric peak**
    - It may be possible to partially mitigate this
  - **Renewable fuels have potentially high cost**, and also high uncertainty
  - **RNG** is **susceptible to GHGs from leaks**, even if RNG itself is CO_2-free

Implications for commercial buildings

Small commercial buildings are similar to large residential buildings

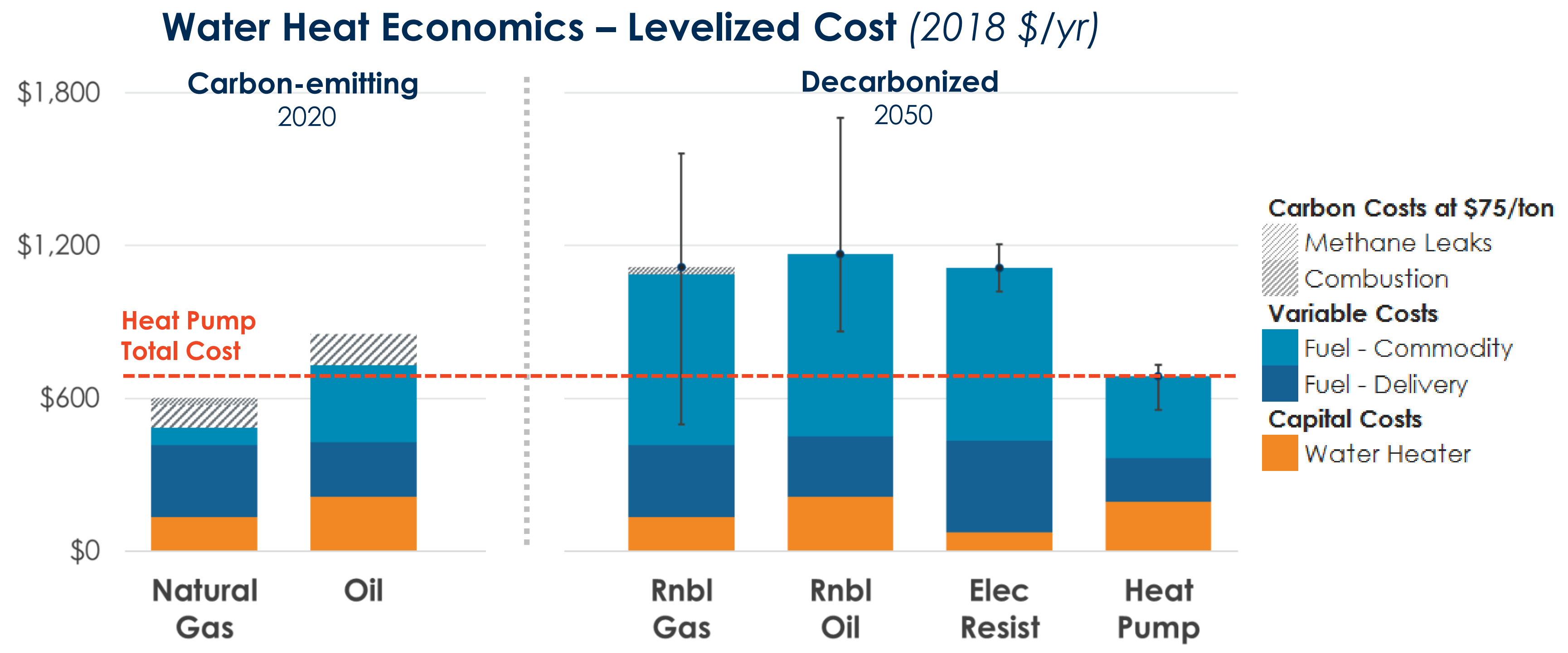
Larger commercial buildings are highly idiosyncratic

- **Many existing system types**, in many configurations
  - Gas/oil boilers; electric/absorption chillers; varied internal distribution systems
- **Relatively less heat needed**; cooling necessary even in heating season
  - Some waste heat available – e.g., heat pump can use condenser loop
- **Often flexible** – possibly convert just part of building or partial heat load
  - Very large building can resemble a small district heat system
- **Size may not be a key distinguisher** (though research continues)
  - Though bigger buildings might find higher capital cost solutions economic, since larger operating cost savings are possible
    - Thus may tend to favor heat pumps, possibly GSHP, where available

Other heat needs: Water, etc.

- **Other, smaller heat needs (water heat, cooking, drying) will often electrify**, especially if space heat is electrified
  - Can avoid a second delivery system and costs, for low volumes
    - Though legacy gas (or oil) system may be maintained for some time, for secondary uses and as space heat backup
    - Behavioral issues – reluctance to give up gas for cooking?
- **Industrial needs may be specialized – e.g., requiring high temperatures**
  - Electrification may not be workable or cost-effective for all applications
  - All decarbonization options likely increase energy costs for industrial users as well – and industry can move …

Water heat options



Heat pump water heat appears to be an attractive decarbonized option

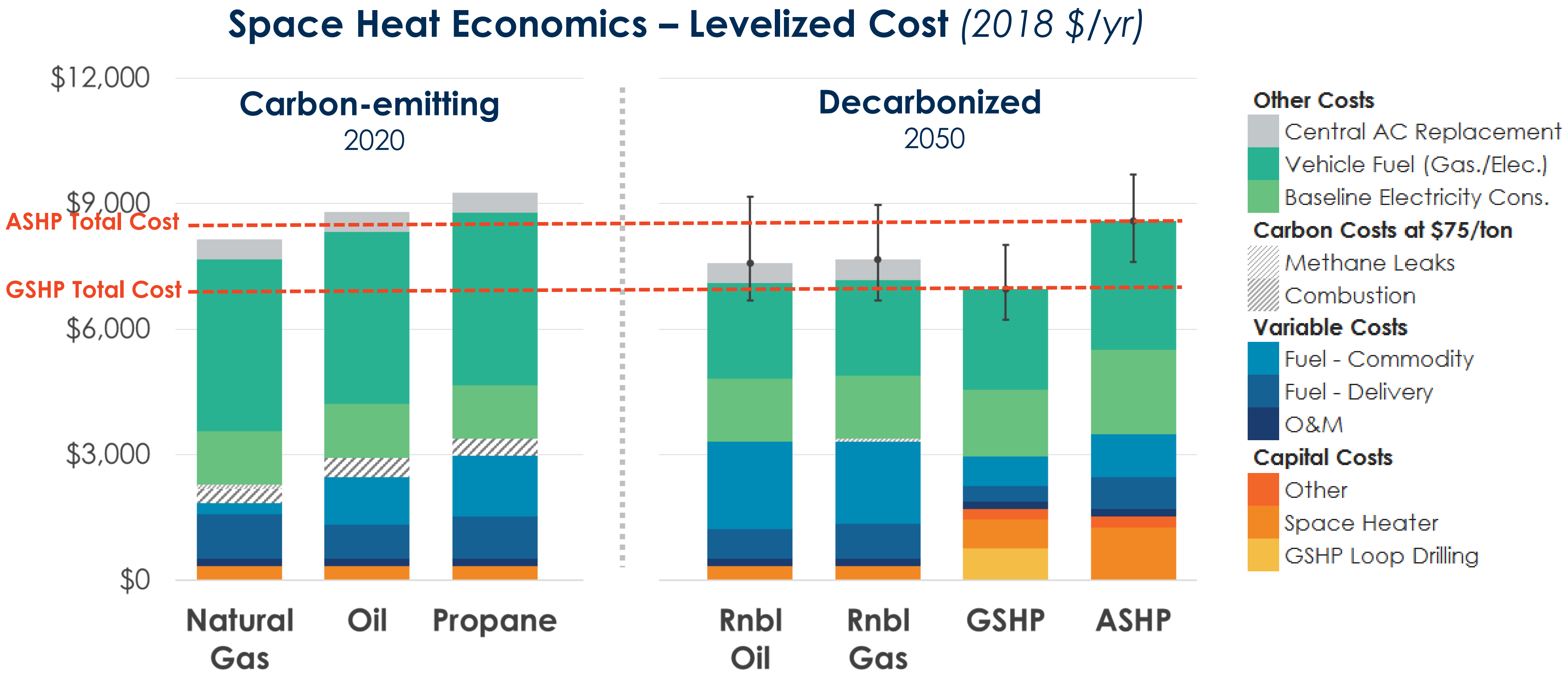
– Though gas/RNG may persist for a time if gas delivery system maintained

However, ASHP water heat may increase overall building heat need

– Draws heat from conditioned space – good in summer; may raise winter heating costs

About 50% higher cost than current natural gas water heat (ignoring carbon cost)

Average energy wallet: Decarbonized heat



Heating costs are likely to **rise to decarbonize** (vs NGas), but may be **offset by lower energy expenditures in other sectors** – especially transportation

- Much **lower cost** to **"fuel" an electric vehicle** (not considering vehicle purchase)
- **Offsets** somewhat **higher cost of heat, baseline electricity**

Other factors to consider

- **Air quality** impacts of fuel burning
  - Indoor from gas cooking; outdoor from burning gas and esp. oil
- **Safety risks** of gaseous fuels
- **Geology** may limit GSHP implementation
- **Work force** requirements
  - Especially for widespread heat pump deployment
- **Customer preferences**
  - Reluctance to give up gas for cooking, to endure disruption, etc.
- **High up-front cost** of heat pumps
  - The need for financing creates a barrier to adoption
- Heat pumps by themselves don't decarbonize heat
  - Must also **decarbonize electricity**

Advantages of a portfolio approach

- Not all alternatives will be available/equally cost-effective in all cases
  - Due to idiosyncratic attributes of building or location
    - Lack of space or fuel access; building configuration; geology
  - Since no decarbonized option is universally applicable (and customers have differing preferences and beliefs), most of the options will implemented in at least some instances
  - Very likely to end up with a mix of technologies
    - Resulting diversity is likely to be an advantage, avoiding some of the negatives of heavy reliance on a single technology
- Meeting 2050 targets may require making progress on parallel paths

Summary of analytic conclusions

- **Efficiency is important, but cannot achieve full decarbonization on its own**
  - Still need heat (esp. in existing buildings) and it must be decarbonized
- **Two primary pathways to decarbonized heat**
  - **Decarbonize fuel**
    - Quantities of lower-cost fuels are likely to be limited
      - Prices high if used at volumes approaching current fuel use
    - Lower gas volumes could challenge LDC viability – even if attempting to maintain it
    - RNG still creates GHGs via leaks, which limit GHG reduction potential
  - **Electrify via heat pump**
    - Heat pump solutions are capital-intensive, but have lower operating costs
    - ASHP causes extreme electric peak, if widely implemented
    - GSHP may be more cost-effective than ASHP, even considering ground loop cost
- **Heating cost will likely increase with decarbonization, though may be offset by lower energy costs for transport**

3. Potential Policy Implications

- Themes and principles
- Policy options

High-level themes for policy in the coming decade

In the absence of a clear "winner" technology, policy can and should act in a number of areas:

Ensure	Reduce carbon content of all heating fuels to zero over time – ensures progress no matter which technologies are used
Learn	Data collection, R&D, pilot projects
Inform	Educate customers and installers about pros and cons of options
Enable	Facilitate technology deployment by aligning rules and codes Increase the number and skill-level of the work-force

And some principles for policy

- **Focus policies on <u>“natural” investment moments</u>**
  - Much heating infrastructure is long-lived (gas pipes, power lines, boilers, furnaces, etc.)
  - Encourage long-term decision making, including potentially future proofing, when those investments are made
    - Electric Distribution System Upgrades, gas system upgrades, new building permits, furnace and boiler replacements
- **Implement <u>no-regrets</u> improvements** to current heating-related incentives, rates, investment decisions
  - Don’t stop there – leverage opportunities to learn about options
- **<u>Keep viable options open</u>**
  - Premature to dramatically alter (parts of the) gas infrastructure
  - Encourage scaling up of GSHPs, ASHPs, bio-fuel production, biomethane sourcing …
  - Even if not yet sure how large a role these may ultimately play, it is likely larger than now
- **<u>Plan for multiple possible futures</u>**
  - Example: “What if” the gas system had to operate at much lower volumes?

Policy options: Information/learning

- **Begin to close the information gap**
  - For customers, contractors and policymakers
- Pilots that **provide both learning for relevant policy makers, and awareness/information for potential adopters**
  - Use pilots to explore program design, solution delivery, outreach, etc.
  - RI is a small state, so pure technology pilots should be explored on a regionally or nationally coordinated level
  - Pilots that also make progress decarbonizing the heating sector might be best
- Encourage early adoption (pilots) **where it can have a large impact on public perception** and understanding
  - **Design carefully – these must work well!**
  - All-electric restaurants – show that induction cooking works
  - Heat pumps in public buildings, hotels, schools etc.; include educational/PR component

Energy efficiency: Complement or prerequisite for decarbonization?

EE cuts emissions – with or without decarbonizing heat

- **The converse is also true** – decarbonizing the heat source (even a partial source) cuts emissions, with or without EE

Cost-effective EE is a core component of decarbonization (and reduces long-term cost), but is **<u>not a substitute or prerequisite</u> for decarbonizing heat source**

- **Perfect vs. progress**: Requiring a major envelope upgrade to get a heat pump subsidy may discourage both
- **Either has positive effect <u>without</u> the other**; they need not occur simultaneously
  - Though synergies in implementing retrofits should be considered
  - Envelope improvements do help for meeting 100% of heat needs with current HPs; also reduce costs and provide other benefits

Policy options:
Decarbonizing **both** paths

- Given uncertainty, create success on both potential paths
  - **"Don't put all your eggs into one basket"**
- Begin electrifying heat; and also start decarbonizing fuels
  - **Encourage heat pumps** (pushing where economics are best)
  - **Require rising renewable fuel content** – path to 100% by 2050
  - Allow economics and ease of implementation (over time) to determine which path prevails
    - **Ensuring both pathways are decarbonized guarantees success**, and avoids the risk of betting on the wrong horse
- **May need both** – to decarbonize enough, fast enough
  - Progress on parallel fronts across multiple non-intersecting supply chains may improve chance of overall success
  - Each approach is likely to be the only one feasible in at least some circumstances

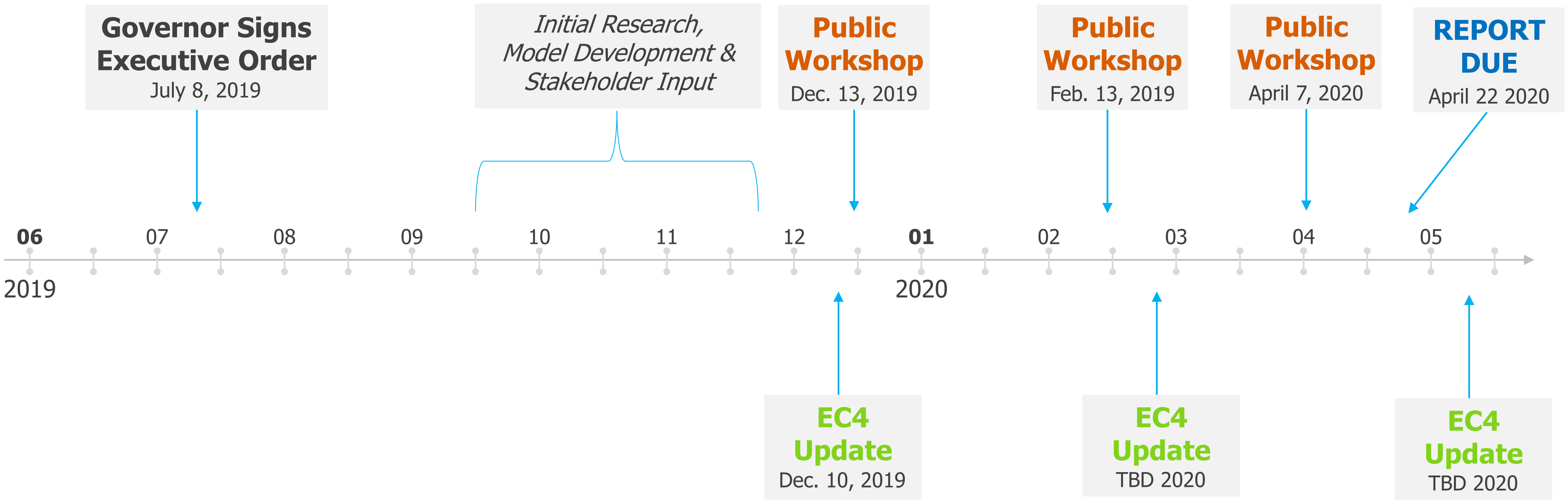
THE POWER OF **ECONOMICS**

brattle.com

THE Brattle GROUP

Project Timeline

Report due by April 22, 2020



Please note that all 2020 dates are subject to change.

Save the Date

HST Public Workshop #3

April 7, 2020

Event details and request for RSVP will be sent in March.

HST Webpage

www.energy.ri.gov/HST/

Workshop materials will be posted on this webpage.

Thank You

Energy.Resources@energy.ri.gov

Please note new email address for public comment.

We invite you to attend, contribute, and help shape pathways to a clean, reliable and affordable heating future!