Decarbonization Analysis & Technology Opportunities

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We develop and deploy solutions in the transition to low-carbon, low-cost energy systems

We work collaboratively to address critical energy challenges impacting gases, liquids, efficiency and infrastructure.
Meta-NZ Study

Meta-Analysis of U.S. Economy-Wide, Net-Zero Studies

1. Low Carbon Resources Initiative (EPRI, GTI Energy)
2. Open Energy Outlook (Carnegie Mellon University, NC State)
3. Evolved Energy Research
4. Princeton University
5. Decarb America (Bipartisan Policy Center, Clean Air Task Force, Third Way)

5 leading independent U.S. economy-wide studies

23 scenarios for least-cost pathways to net-zero
Today’s Energy Systems

Source
- Solar, Wind, & Other
- Biomass & Waste
- Nuclear
- Natural Gas
- Petroleum
- Coal

Make
- Electricity
- Biofuels

Move
- Electricity
- Pipeline Gas
- Liquid Hydrocarbons
- Solid Fuels

Store

Use
- Buildings
- Transportation
- Industry
Net-Zero Energy Systems

Source
- Solar, Wind, & Other
- Biomass & Waste
- Nuclear
- Natural Gas
- Petroleum
- Coal
- Direct Air Capture

Make
- Electricity
- Hydrogen
- Ammonia
- Biofuels
- Synthetic Fuels
- Liquid Hydrocarbons
- Solid Fuels
- Carbon Dioxide

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**Use**
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Variety in electricity + variety in fuels + carbon management + efficiency
pipeline gas is used in **every** net-zero scenario
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Gas infrastructure peak throughput (Btu/hr) remains.
Primary and Final Energy

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**Use**
- Final Energy

Primary Energy

Final Energy
Primary Energy Consumption (Sources)

Shaded regions indicate the range of values across net-zero studies. Each data point represents a different net-zero scenario.

Top to bottom:
- Low Carbon Resources Initiative (EPRI, GTI Energy)
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Geothermal and hydro account for <2% of primary energy across net-zero scenarios.
Primary Energy Consumption (Sources)

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[Diagram showing energy sources and their shares in current and 2050 net-zero scenarios.]

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Natural gas is used in all scenarios, except those that explicitly exclude fossil fuels.

Report available at gti.energy/meta-nz/
Includes non-energy uses of fuels. Liquid fuels include ammonia and hydrocarbon fuels derived from petroleum, bioenergy, and synthetic pathways. Pipeline gas includes fossil natural gas, renewable natural gas, synthetic natural gas, and blended hydrogen. Coal and biomass account for <2% and <4% of final energy across net-zero scenarios, respectively.

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Final Energy Consumption (End-Use)

Includes non-energy uses of fuels.

Liquid fuels include ammonia and hydrocarbon fuels derived from petroleum, bioenergy, and synthetic pathways.

Pipeline gas includes fossil natural gas, renewable natural gas, synthetic natural gas, and blended hydrogen.

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pipeline gas is used for electricity generation, industry, and buildings in every net-zero scenario.

peak gas infrastructure throughput (Btu/hr) remains
Today’s Energy System

U.S. Final End-Use Energy Consumption (2020, Quad Btu)

Based on EIA data
Excludes non-energy uses of fuels
Today’s Energy System

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Gas storage capacity is capable of meeting average demand for
~8 weeks
Today’s Energy System

U.S. Final End-Use Energy Consumption (2020, Quad Btu)

- **Solid**
- **Liquid**
- **Gas**
- **Gas-fired**
- **Electricity**
- **Wind & Solar**

**Liquid storage capacity** is capable of meeting average demand for

~7 weeks

**Gas storage capacity** is capable of meeting average demand for

~8 weeks

Based on EIA data
Excludes non-energy uses of fuels
TECHNOLOGIES
“Hybrid” space conditioning systems

1. Replace conventional air conditioner with electric heat pump (electric EE programs)
2. Retain/use high-efficiency gas furnace as appropriate (natural gas EE programs)
3. Smart thermostat chooses electric or gas space heating depending on outdoor temperature, operating cost, or other factors

“Hybrid” space conditioning systems create opportunities for consumers to improve efficiency and reduce costs and emissions.
Residential Space and Water Heating: Gas Heat Pumps

**What is a Gas Heat Pump?**

- Just like an electric heat pump, it sits outside and extracts heat from the outside air.
- The difference, it uses heat instead of an electric compressor to drive process.

**Why do we need Gas Heat Pumps?**

- Best-in-class operating efficiency
  - Condensing furnace is 95-98 AFUE vs GHP is 140 AFUE
  - GTI Energy field demos showed 33-46% therm savings (space and water heat)
- Systems operate during the coldest days, meeting the heating load without back-up resistance heating
- Commonly use natural refrigerants with low/no GWP
- 30-50% reduction in operating GHG emissions, with combustion outside

Skinny R30 Wall Retrofit Systems - InSoFast
- (NYSERDA, UTD, NEEA)
- Taking existing commercialized ICF panel and fabricating with R-50 VIP inserts for area-weighted R30 in 3.5" thick retrofit
- Advancing from feasibility testing to prototype development; demonstration in NY planned late 2024

Robotics in Deep Energy Retrofits
- NYSERDA, National Fuel
- Increase cost-effectiveness with robotics
- Reduce time for panelized retrofits

Comm-INDOWS
- Advanced secondary window system (SWS) (CEC, NEEA, SoCalGas)
- Targeting commercial buildings
- Laboratory testing with field validation
- Triple-pane, aerogel, and vacuum glass options
- Alpen, Inovues, AeroShield, V-Glass, LBNL

USACE – Advanced Glazing Systems
- Evaluating commercialized products working with Alpen and Inovues
- Testing both double-pane and vacuum glass

Solar Cogeneration
- Solar thermal behind PV (PVT)
- Heat sink improves kWh generation (perhaps ~5% / yr)
- PVT + heat pumps can assist cold-climate capacity
- Capable of nighttime heat rejection for cooling savings

Integrated Envelope+Mech - Hydronic Shell
- Water-based heat/cooling/vent
- Paired with rooftop A2W heat pump
- Non-invasive install w/ R30 wall retrofit
Whole Building Integrated Solutions: GTI Energy’s Microgrid Test Bed

- Solar PV
- Solar Thermal
- Cold-climate ASHPs
- EV Charging
Decarbonizing Pipeline Gas

Using Renewable Gas or Clean Hydrogen

RNG and clean hydrogen can have carbon intensities (CI's) that are low, zero or negative depending on production process and feedstocks.

Renewable gases can be used to decarbonize gas space heating or gas power generation and production processes can be coupled with CO2 sequestration to achieve negative CI's.
Veritas has four Technical Protocols

- **Measurement & Reconciliation:** Describe how to take measurements and reconcile emission-factor inventories with actual measurements.

- **Methane Emissions Intensity:** Define methane intensities.

- **Value Chain Summation:** Add multiple segments to reach a total emissions intensity.

- **Assurance:** Provide guidance for verifying emissions inventory.

Veritas covers **six segments** of the natural gas supply chain.
What is Network Geothermal?

Geothermal District Heating & Cooling 101

This illustration is one configuration of a geothermal district heating and cooling (GDHC) system, in this case using geothermal heat pumps. There are many other GDHC solutions that might also work for your community.

Source: U.S. DOE
Hydrogen Pathways for Gas Decarbonization

Centralized Hydrogen Production

Blending into Current Grid

How do H₂/NG blends impact existing customer gas assets and gas-fired equipment?

Studying the blended hydrogen safety/efficiency/emissions impacts

Convert to Hydrogen Dist.

How can we assure that new gas equipment and retrofits are hydrogen-ready?

RD&D/Tech Transfer with equipment and sensors for hydrogen end use

Dist. H₂ Generation

Hydrogen Microgrids

How do we design and prepare for hydrogen fuel-flexible systems?

Developing and demonstrating fuel-flexible combustion/CHP systems
Hydrogen Economy – Utility Investments

• RNG/Biomethane, Bio-LPG, available in many markets to reduce GHG emissions
• SNG/E-methane projects underway, H₂ with captured CO₂
• Numerous States/Provinces have one or more H₂/NG blending demo projects in planning/underway
  – Several involving 100s – 1,000s of utility customers
• H₂ distribution projects are ramping up in US/Canada

Many North American natural gas companies have active H₂ demo projects
Buildings – Project Portfolio by GHG Savings

**Near-Term (25-50+%)**
- Expanded use of high-efficiency gas equipment
- Hybrid natural gas furnace/boilers and electric heat pump systems
- Building envelope improvement

**Next-Gen (40-60+%)**
- Heat pumps for space & water heating
- Micro CHP systems
- Deep building retrofits

**Renewables (Added 10-30%)**
- Renewable gas blends (bio-methane, hydrogen)
- Solar thermal/natural gas space & water heating systems

**Reducing full-cycle natural gas methane emissions**
- Lower Methane Emissions (5-10%)
Meta NZ analysis shows gases and fuels will be used in 2050 net zero scenarios

Natural gas is a very large portion of our nation’s energy mix

All decarbonization solutions have costs
  – Which ones will be most cost effective in short, medium and long term?
  – Continued analysis and R&D needed

Decarbonization opportunities
  – Hybrid natural gas/electric space heating systems
  – Thermal heat pumps
  – Building envelope & deep EE retrofits
  – Micro CHP – onsite renewables and power
  – Decarbonizing pipeline gas (renewable gas, H₂, CO₂ capture)
  – Network or community geothermal
  – Reduction of upstream methane emissions