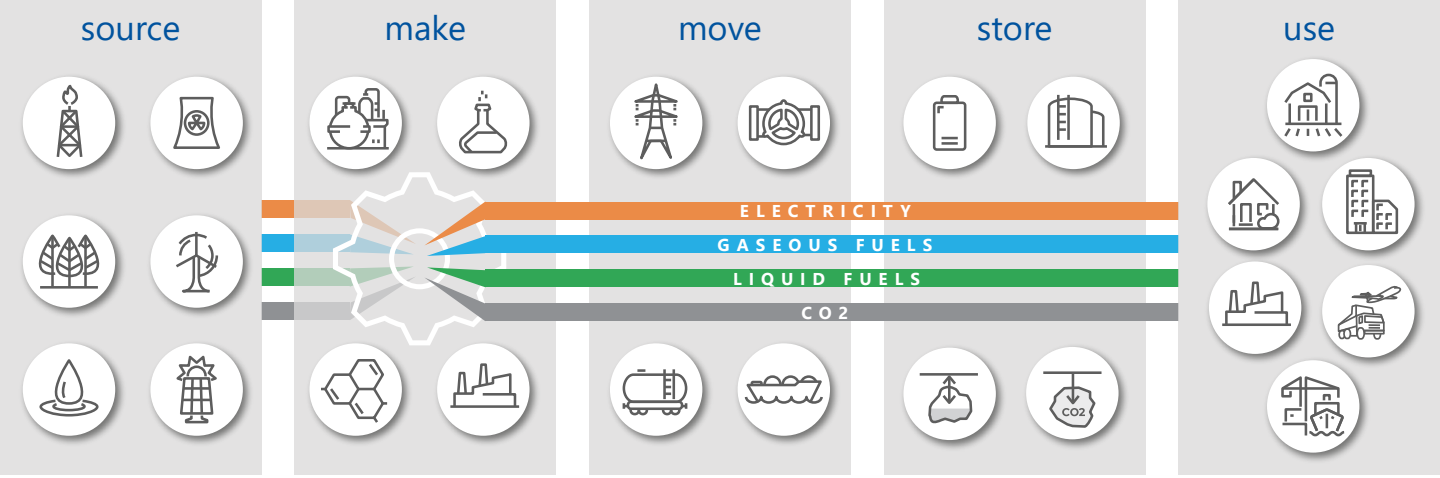
GTI ENERGY
solutions that transform

Energy Transitions: A Systems Perspective

HOW DO WE MOVE WITH SPEED AND SCALE TO TRANSITION OUR ENERGY SYSTEMS?

At GTI Energy, we are approaching this question from a systems perspective. As we consider how to achieve net-zero emissions by midcentury, while also fostering economic vitality and quality of life, our thinking is grounded in a clear-eyed appreciation for how energy systems work. Rather than focusing on a single sector, a single energy carrier, or a single technology, we are keeping the aperture wide. We're thinking about energy transitions with curiosity about the innovations yet to come, and the integration of those innovations to shape low-carbon, low-cost energy systems.

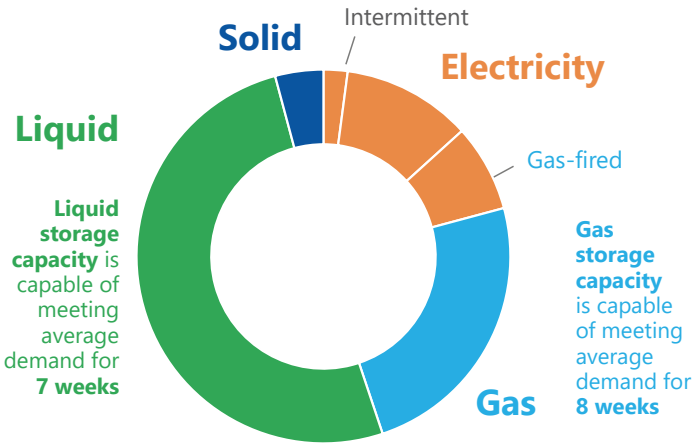


APPRECIATING HOW OUR ENERGY SYSTEMS WORK TODAY

In the United States today, **most energy products supplied to end use customers are in the form of a fuel**—roughly half as a liquid fuel, a quarter as a gaseous fuel, and a small share as a solid fuel. The remaining share of energy is supplied as electricity, a portion of which is generated by intermittent renewables. Because we can't control when the wind blows or when the sun shines, fuels-based power generation, especially from gas, is leveraged to balance renewables intermittency and respond to demand fluctuations. Altogether, about 95% of all final energy products used today are underpinned by fuels.

While there are historic reasons that fuels dominate today's energy mix, we have also come to leverage fuels because of their intrinsic qualities for supporting energy systems. Fuel molecules are energetically dense, which means they can store a large amount of energy in a small space. Fuel molecules are also stable, which means they can store energy for long periods of time. Those qualities make fuels well suited for moving and storing energy, allowing energy to be used where it's needed, when it's needed.

U.S. Final Energy Product Mix (2020, Quad Btu)



Source: U.S. Energy Information Administration

CONSIDERING THE VALUE OF OUR EXISTING INFRASTRUCTURE

The affordability, reliability, and safety of today's energy systems are built upon decades of technological advancement and infrastructure investment. We have invested in a pervasive network of systems to make, move, store, and use energy. For example, today's gas storage capacity is capable of meeting average U.S. demand for eight weeks. If we stopped producing natural gas today, we could continue to heat buildings, operate power plants, and drive industrial processes for roughly two months.

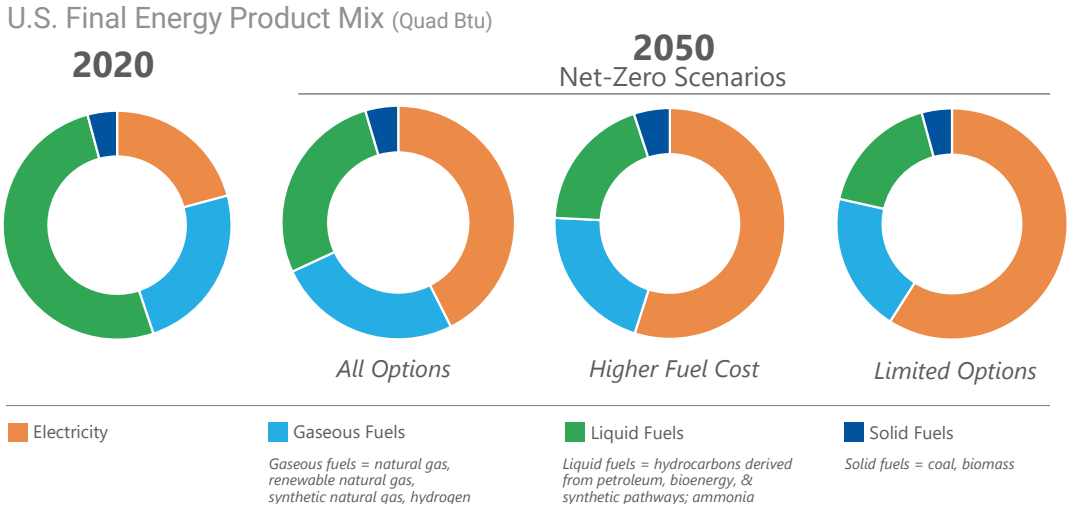
This is a vast level of storage given that gas underpins about a third of all final energy. Similarly, liquid fuels, which account for roughly half of all final energy, have storage infrastructure capacity capable of meeting seven weeks of average U.S. demand. The solid fuels systems leveraged today, both for power generation and direct end use, similarly provide storage capacities of several weeks.

APPLYING COMPREHENSIVE SYSTEMS THINKING AND ANALYSIS

What will meet the needs of low-carbon, low-cost energy systems? In addition to renewables, what other forms of electricity generation will we rely on? What forms of storage will we deploy, and what role will fuels play for energy storage and other purposes? What types of fuel molecules will we make, move, store, and use? What infrastructure will we build and leverage? How will we integrate and operate these systems?

Data-driven analysis and comprehensive systems thinking can shed light on these important questions. Under the Low Carbon Resources Initiative, a joint collaboration GTI Energy and EPRI, we have applied this kind of thinking and analysis in our Net-Zero 2050 Study. In this study, **we evaluated least-cost pathways to achieve net-zero carbon emissions across the U.S. economy by 2050**.

The results shown here highlight the final energy product mix in 2050 under different scenarios relative to the energy mix in 2020. Over three decades, the share of electricity grows considerably. This is consistent with trends we're seeing today, such as increasing deployments of wind and solar generation, and growth of electricity use outside of its traditional markets. Along with electricity, fuels continue to play a meaningful role. Under these net-zero scenarios, **roughly half of all energy is supplied to end-use markets as a fuel, and fuels-based generation constitutes a sizeable share of power generation capacity**. The intrinsic qualities of fuel molecules are relied upon in all end-use sectors, from industry to transport and buildings.



Source: LCRI Net-Zero 2050: U.S. Economy-Wide Deep Decarbonization Scenario Analysis

EMBRACING INNOVATION AND COLLABORATION

There are no solo acts in energy transitions. Our net-zero 2050 analysis reveals the persistent interdependencies of the dual imperatives in front of us—the need to deeply decarbonize energy systems and the need to safely and reliably supply the energy needed to support economic vitality and quality of life.

While our LCRI Net-Zero 2050 analysis provides a window into the kinds of technologies that may be needed to achieve low-carbon, low-cost energy systems, we can't predict the future. To be successful in transitioning our energy systems with speed and scale, we need to hold space for the innovative and disruptive breakthroughs yet to come. We will continue approaching this consequential challenge by keeping systems thinking, innovation, and collaboration front of mind, and drawing on insights from the graceful complexity of today's energy systems to help drive innovation in the design of tomorrow's energy systems.