A Sustainable Energy Model

Ensuring Robust Energy, Resilient Infrastructure, and Climate Balance

ALLIANCE FOR INNOVATION AND INFRASTRUCTURE

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About Aii

The Alliance for Innovation and Infrastructure (Aii) is an independent, national research and educational organization that explores the intersection of economics, law, and public policy in the areas of climate, damage prevention, energy, infrastructure, innovation, technology, and transportation.

The Alliance is a think tank consisting of two non-profits: the National Infrastructure Safety Foundation (NISF), a 501(c)(4) social welfare organization, and the Public Institute for Facility Safety (PIFS), a 501(c)(3) educational organization. Both non-profits are legally governed by volunteer boards of directors. These work in conjunction with the Alliance's own volunteer Advisory Council.

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Introduction

America's energy security must be balanced with environmental stewardship while accounting for the needs and impacts of current and future generations. While energy policy is a function of both market dynamics and public policy, it is time for industry leaders and corporations to take the lead in deploying a new model for robust energy that ensures vulnerable populations have access to reliable, low-cost power while minimizing the energy sector's environmental footprint.

With a simple three-pronged model, energy producers, the transportation industry, and even the broader corporate world can help revitalize American energy independence and propel the U.S. to be the unambiguous leader in climate solutions. This sustainable model incorporates natural gas, pipelines, and carbon offsets.

Natural gas – in both its traditional and renewable forms – is a vital source of high-density, low-cost, and minimal-impact energy. It has a relatively low land-use footprint as well as a comparatively low rate of carbon emission. The safest and most effective way to transport natural gas is through state-of-the-art pipelines. These will play an even more pivotal role in a future energy transition as a dependable infrastructure network already in place to transport renewable natural gas, carbon neutral fuels, carbon dioxide, hydrogen, and other products. Finally, the use of voluntary carbon offsets will afford companies the opportunity to neutralize their footprint without sacrificing efficiency or the quality of their products and services. In turn, carbon offsets will fuel a new industry centered around climate solutions.

This model incorporates existing resources and infrastructure alongside an innovative climate solutions incubator. Together, these components will power the U.S. not only in the short term, but well into the future, providing the energy, raw materials, and funding necessary to achieve climate balance and give rise to the coming circular carbon economy.

The Need for a Sustainable Model

Neither the energy nor environmental status quo are satisfactory for the long term. Energy users demand more reliable and low-cost power, while environmentalists criticize the emissions and impacts of the current energy industry.

From one standpoint, the existing model is acutely vulnerable to supply chains disruptions, price inflation, geopolitical strife, energy market volatility, and shifting regulatory regimes that stifle good infrastructure projects or enable activist lawsuits to derail properly issued permits. These disturbances threaten vulnerable populations in need of affordable electricity, including schools, hospitals, families, and producers from small businesses to manufacturers. Artificial supply constraints catapult costs for energy, but perhaps more potently, for manufacturers and producers.

At the same time, there is legitimate dissatisfaction with the impacts of the current system. Fossil fuels emit carbon dioxide, methane, other gasses, and particulates when combusted for energy or transportation fuel; land and waterways are utilized for pipeline crossings; and leaks and spills from various transportation and storage methods remain a challenge. These externalities range from local and acute to global and diffuse, yet all demand solutions.

The need has perhaps never been greater to ensure access to energy. The model to achieve this must balance out with real and anticipated environmental consequences of the energy, transportation, agricultural, and other sectors that generate emissions. This means that a sustainable model – capable of ensuring smooth and ample access to low-cost power, while also safeguarding our infrastructure and limiting environmental impacts – is needed for the short term and must be resilient enough to be maintained long into the future.

Why Natural Gas?

America needs energy, but it also needs raw materials to produce chemicals and critical goods. Natural gas uniquely provides this dynamic set of benefits. For this reason, it is more than a fossil *fuel*, it is a *resource*. This is one reason that we cannot abandon naturally occurring methane within our geologic formations, nor regulate natural gas out of the market. It is too essential for too broad a range of daily needs, and decreasing supply or raising costs directly harms those currently reliant on natural gas without viable alternatives. Access to energy directly correlates with escaping poverty and improving standard of living, and natural gas provides this opportunity as well or better than any alternative. Moreover, harnessing naturally occurring and captured methane will offer an economical solution to key climate issues.

As an Energy Source

Natural gas is highly energy dense, abundant, low cost, and produces a relatively low climate impact. While it does not rank first in all individual categories, its overall versatility and applicability make it an ideal energy source. Accounting for inefficiencies and power generation, it takes only 7.43 cubic feet of natural gas to generate a kilowatt-hour (kWh) of electricity.[1] The inherent heat value within gas means a small amount can serve energy to a large population, which also minimizes its land-use impact because its energy can be extracted efficiently. With 2.867 quadrillion cubic feet of technically recoverable natural gas in the U.S. alone, it is available in great supply, accessible, and economical. This is before accounting for renewable sources of methane. As natural gas displaces coal and oil, significant emission reductions also occur without sacrificing cost, reliability, or access to energy.

As a combustible hydrocarbon, natural gas is well suited for efficiently generating heat across many industries and can be transported and stored easily. In 2020, natural gas was responsible for the largest share of utility-scale electricity in the United States. Providing over 40 percent of the electricity generated that year, more than 1.6 trillion kWh from natural gas helped power homes, businesses, streetlights, and more.[2]

Beyond the grid, natural gas also provided over one-third of industrial power and energy, enabling the production and manufacturing of goods we rely on every day.[3] In fact, natural gas is relied on to provide the majority of energy in the manufacturing of aluminum, brick, glass, plastic, and polyurethane fiber among many others.[4]

While generating electricity is vital, natural gas is also a preferred source of heat. It is depended on to heat half of U.S. homes in the winter – as well as schools, hospitals, and government buildings. Natural gas is a critical resource in family and commercial kitchens to heat ovens and stove tops. And while making food and water safe to consume are life-sustaining, natural gas is also a choice fuel for water heaters (e.g., showers, laundry, dishes), fireplaces, and recreation.

Despite the transportation sector favoring petroleum, vehicles are also making use of natural gas. Most notably, public transit services and municipal buses employ natural gas as an alternative to gasoline and diesel fuel, which both generate higher levels of emissions than natural gas. Natural gas vehicles (NGV) are even joining the broader passenger fleet and can drive similar ranges as gasoline or electric vehicles. As an emission-reduction strategy, natural gas will be a key alternative to the petroleum-centric transportation sector.

Most critically, natural gas is virtually immune from many natural or technological limitations of other power sources. Plants can operate continuously and adjust energy generation in real time to match demand. The overall land use footprint does not require as much land as other energy sources, partially due to its energy density and heat efficiency. Finally, while it is already the lowest impact fossil fuel, by tapping into naturally occurring methane emissions from agriculture or landfills, the net carbon emissions from natural gas will actually fall over time. This both transitions the gas from finite to renewable, but prevents potent methane from reaching the atmosphere and instead utilizes it as a marketable carbon-neutral fuel.

As a Resource

Natural gas is needed for heat and power, but it is also vital to other industries beyond providing energy. As a feedstock, raw material, and chemical input, natural gas is relied on for products from North Face outdoor gear to agricultural fertilizers.[5]

The diverse set of products that rely on natural gas demonstrate its importance to the supply chain and criticality for life-sustaining industries like agriculture for food production, fabrics to clothe the nation, plastics to package food, medicine and medical supplies, and infrastructure components. Natural gas is essential to producing antifreeze, synthetic fabrics, fertilizer, pharmaceuticals, and plastics in addition to valuable chemicals such as ammonia, methanol, butane, ethane, propane, and acetic acid." [6,7,8,9]

Without natural gas, the cost of everyday products would soar, and availability would dwindle. The cost and reliability of energy would become dangerous liabilities to vulnerable communities, and entire industries would lose essential inputs. Eliminating natural gas would shutter the supply chain and cause unprecedented price inflation as alternative energy sources, inputs, and materials are sought. A glimpse into this outcome can already be seen in Europe, where multiple countries are experiencing fertilizer scarcity that is directly impacting food prices.[10]

Benefits and Costs

The impacts natural gas imposes must be contextualized against the benefits. From electricity to heat to feedstocks, natural gas is responsible for immense levels of economic activity, literally keeping lights on, making food and water safe to consume, and enabling products and services to be produced and brought to market. These benefits are nearly incalculable, as they also include human lives sustained and advanced. The costs, however, also implicate human lives alongside environmental and climate considerations.

The safety record of natural gas is among the best of any energy source per terawatt hour of electricity generated.[11,12] Safety records are lifecycle measurements, accounting for extraction, transportation, use, and end use impacts.[13] In addition to rare accidents and injuries, burning

natural gas produces emissions, which impact respiratory health outcomes. Accident and emission fatalities are not exclusive to fossil fuels, as even renewables require mining, transportation, and construction. While some energy sources have lower fatality rates, only fossil resources offer further and versatile non-power benefits.[14] Additionally, with new carbon capture technology, source emissions for natural gas have declined over time, improving its safety record.

Because of its prolific use for energy and necessity for everyday products, natural gas is responsible directly and indirectly for the lives and commerce of virtually every American and trillions of dollars in the U.S. economy.[15,16,17,18] With energy and feedstock uses projected to increase, natural gas is not simply a bridge fuel, it is an integral resource to modern life.

The value natural gas produces in American life so exceeds its costs that restricting its use is an act of imprudence and a detriment to the vulnerable. Even if the share of electricity natural gas produces is diminished as nuclear, solar, and wind power ramp up, natural gas is a needed and valuable component of the electricity sector and is irreplaceable in the broader supply chain and manufacturing industries. It will continue to be essential even well into the long term.

Why Pipelines?

Natural gas is a long-term resource for the United States. Whether used for electricity, heat, or manufacturing inputs, natural gas must be transported to the market. When surveying the available transportation methods, only one truly stands out. Not without certain faults, pipelines are universally recognized as the most effective, safest, and cleanest way to move hazardous materials.[19]

Comprising three main sectors – the upstream, midstream, and downstream industry segments – pipelines come in many different sizes and purposes. According to the Pipeline and Hazardous Materials Safety Administration (PHMSA) and industry data, even as pipeline mileage and product volumes have increased over the past decade, incident rates and lost volumes have declined.[20] This is attributable in part to the design and natural advantage of pipelines being secure subterranean conduits for liquids and gases, but also to the advent of new monitoring technology, maintenance practices, and remote shutoff capabilities.[21]

Pipelines are generally buried underground, protecting them from vehicles, third-party damage, and many natural phenomena. This provides a safety benefit as well as an environmental advantage, as it allows remediation and restoration of grass and brush on the surface. In sharp contrast, roads and rail are permanent surface features that enduringly claim land use for transportation and displace the natural ecosystem. Added to this, transporting energy resources on roads and rail contribute to public safety risks by interacting with the dynamic road or rail crossing activity of other drivers, distractions, weather, and more.

When it comes to emissions, pipelines maintain an edge over the alternatives. While pipelines do require energy to maintain product flow, they are more fuel efficient and emission-friendly than the alternatives. Industry data even demonstrates emission reduction progress. Despite a 42 percent increase in the number of large compressor stations between 2011 and 2019, methane emissions fell over 30 percent.[22] New methane detection technology paired with pipelines will continue to drive down fugitive emissions even further.

It is especially important that the U.S. maintain and continue to build pipelines, because they carry a lower impact fuel and generate a low impact themselves. The only alternatives will be emission-generating trucks and rail or restricting access to this natural gas – for both the energy sector and supply chain – by not bringing it to market at all.

Pipelines are an especially critical component of a sustainable future because of the promise of transporting other products as climate becomes more central to public policy and the economy. Carbon dioxide and other greenhouse gases with market value will need to be transported, not simply stored permanently in the ground.[23] Relying on this existing infrastructure will enable efficient and low-impact movement of these products and byproducts, but also prevent the need to build new infrastructure or rely on less desirable transportation methods. As the energy market transitions further, existing pipeline infrastructure will be ready for service to carry low-carbon fuels like hydrogen, synthetic methane, and renewable natural gas, facilitating a low and even zero-carbon energy market that would not be possible with other transportation methods.[24]

Why Carbon Offsets?

Virtually all of modern life impacts the environment, most often through emission of carbon dioxide and other GHGs. Whether it is the use of industrial equipment to obtain, refine, and produce goods or the vehicles to transport them, no commodity or infrastructure component is without a footprint. That is why even the most responsible and climate-conscious projects should consider voluntary carbon offset purchases.

These serve multiple purposes, not only providing a neutrality or reversal of carbon emissions, but also serving as an incubator for the best climate solution innovations.[25] Over time, this will create, promote, and sustain a new, independent, and thriving industry around climate solutions.[26]

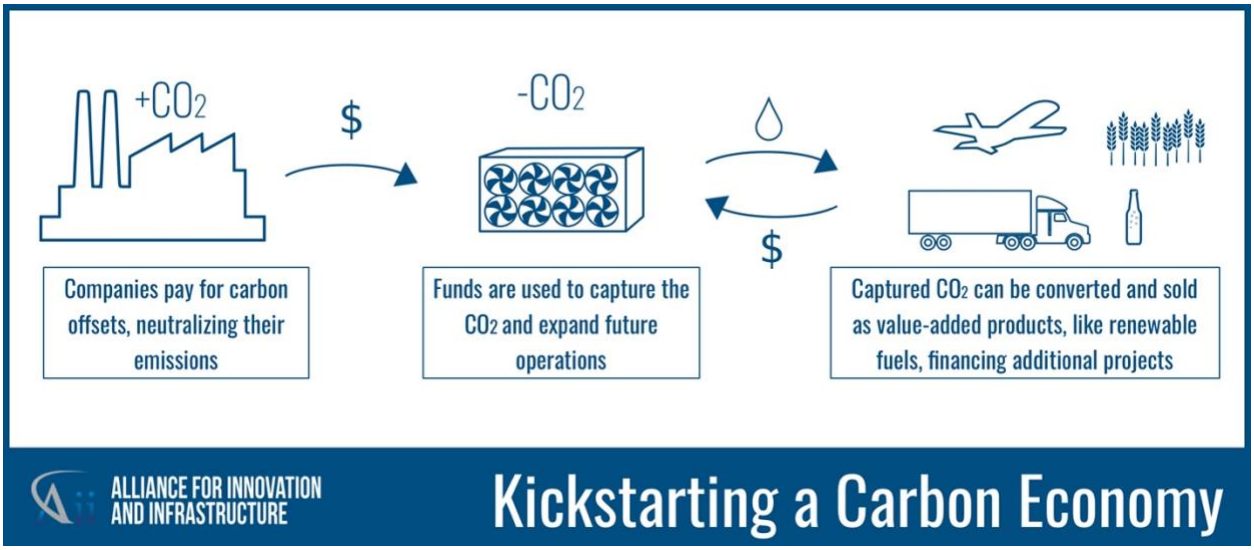
Carbon offsets are not necessary to justify the use or expansion of natural gas or pipelines, as these are needed and even favorable to their alternatives. But offsets do counteract many unwanted effects of gas and pipe. In practice, voluntary carbon offset purchases give individuals and companies the ability to reduce emissions elsewhere to balance out, in net, the impacts generated locally. With carbon dioxide and other GHGs mixing immediately in the atmosphere, offsets in any region have the same positive impact for the climate. When using high quality carbon offsets, companies can be assured that their dollars genuinely and meaningfully address the designated tonnage of carbon dioxide.[27]

This measurable offsetting enables organizations to meet climate pledges while continuing their normal operations without significant change or costly retrofitting. They can legitimately achieve carbon neutrality (as if they stopped emitting altogether) or can even pay for more than their operational emissions and reverse legacy emissions to become carbon negative. The obvious benefit is that a company can still produce its good or service and balance out emissions, whereas to stop emitting altogether would likely necessitate shuttering of the business. With carbon offsets, we get products and services *and* carbon reduction – or in the case of the power market: robust and accessible energy *and* improved atmospheric conditions.

There is still another substantial benefit to the use of carbon offsets, extending far beyond simply balancing emissions with reductions. It is the generation of a climate solutions industry – an entire market sector removing carbon dioxide and implementing sustainable solutions on its own.

Money spent on carbon offset purchases is paid to organizations implementing carbon removal technologies and offsetting projects. When carbon offsets are purchased, money and critical attention are given to projects, technologies, and programs that successfully capture, remove, store, or offset GHGs from the atmosphere.[28] This may include carbon capture, utilization and storage, direct air capture, tree-planting initiatives, renewable energy deployment, methane abatement, and more. Many qualifying offset projects are small operations with successful models that have not yet scaled up. With the injection of funds, these projects can overcome startup costs, purchase assets, improve technologies, deploy more units, or expand operations.

What is more, the beneficiaries of carbon offset funds often generate market value themselves. This means that they can become self-sufficient by selling a product or service and will not be reliant on carbon offset funds to function. On the one hand, carbon offsets finance the specific reduction of carbon dioxide paid for, while on the other side the same carbon can be sold, bringing in revenue to self-finance further carbon removal activities. With enough market activity, successful projects can go on removing GHGs indefinitely, continually reducing the atmospheric concentration of CO_2, methane, or other targeted compounds.



Some projects qualify as offsets because they generate emission-free electricity and therefore displace energy coming from coal or other fuels. Selling electricity is already a viable business model that can be augmented and expanded with offset funds, which act like private subsidies from companies purchasing offsets. Other value is created by repurposing carbon dioxide to generate sellable renewable carbon-neutral fuels like gasoline and jet fuel, incorporating CO_2 into building materials, supplying it as beverage carbonation, using gases as feedstocks for manufacturing, providing CO_2 to agricultural users, or injecting for enhanced oil recovery.[29]

In each of these cases, the carbon offsetting project can stand on its own, being kickstarted by private funds and selling the concentrated CO_2 or other GHG at market value to raise further

revenue to sustain and expand operations. They will be able to grow and expand as the market does, and over time, the market signal will be strong enough that many competitors enter to capture CO_2 themselves.

The arrival of a circular carbon market is imminent. Voluntary carbon offset purchases, which essentially subsidize and crowdfunded climate solution, will ensure the innovative carbon removal technologies are market-ready and scalable. This will in turn provide a supply of carbon dioxide to the circular economy demanding carbon inputs for construction products, beverages, fuels, greenhouses, food products, and more. With the right technology and market, this climate industry will be able to neutralize or even reverse the global concentration of GHGs by constantly pulling CO_2 from the air, ramping up conservation efforts, and generating new low-carbon technologies and energy sources.

Conclusion

Reassessing the energy and environmental status quo is essential to meeting the needs of a unique nation and striving to ensure the longevity of our infrastructure for the generations to come. It is clear that more is needed than the current approach to energy, and that calls for a three-pronged approach to ensure robust energy, infrastructure resilience, and climate balance.

This model is not altogether new, but each element has renewed importance. Innovation in design and engineering, alongside innovative funding mechanisms have made a new and sustainable energy model possible. By uniting the best resources, transportation methods, and stewardship practices, America will have the energy it needs without threatening the future our children will inherit.

While many have viewed natural gas as a bridge fuel, it is more than that. Natural gas is a long-term fuel, not only necessary but desirable. It is a vital energy resource and bedrock supply chain input. Further, capturing renewable natural gas will drive down inherent emissions and improve climate resilience even further.

This gas must be transported responsibly through pipelines, which will also be critical for the long term. Not only are pipelines the safest and most efficient transport method for gas and liquid, but this network will be critical for moving carbon dioxide, hydrogen, and other gas and liquid products and waste in the future.

Finally, and to account for the footprint these will inevitably produce, voluntary carbon offsets are the capstone of the model. These will first balance out existing emissions and ultimately revolutionize environmental stewardship and climate balance by jumpstarting the circular carbon economy that is on the horizon.

With these elements in place and a carbon economy imminent, market signals will incentivize increased capture of carbon dioxide and greenhouse gases, turn them into valuable products, and begin to reduce and reverse atmospheric concentrations of carbon dioxide. The innovative technology that will build and sustain that future will require substantial energy inputs, and this sustainable energy model will provide it.

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Citations and Notes

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