NARUC Winter Policy Summit

Staff Subcommittee on Gas

Sunday, February 9, 2020


2020
Sustainable Energy in America
FACTBOOK
Growth Sectors of the U.S. Energy Economy
The Business Council for Sustainable
BloombergNEF
GET THE FACTS
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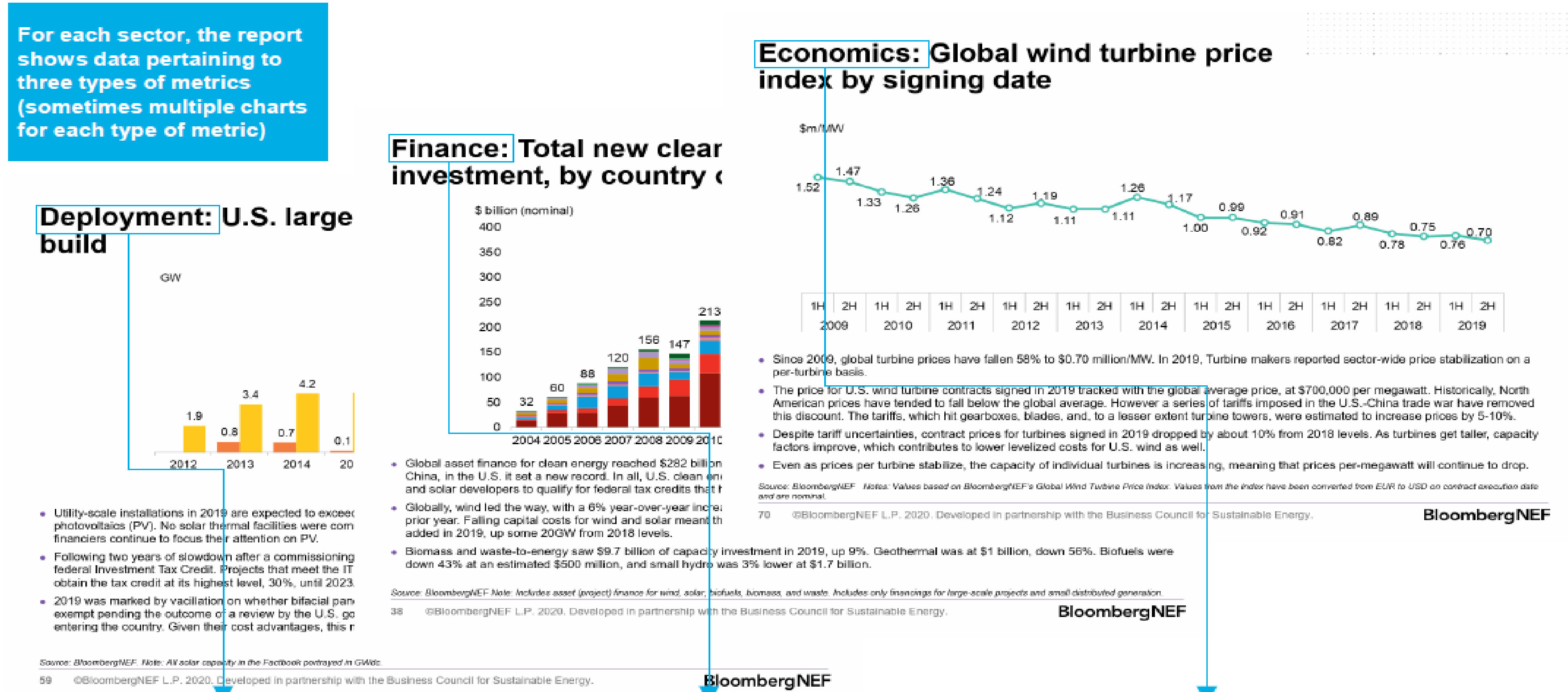
About the Factbook: The sub-sections within each sector

For each sector, the report shows data pertaining to three types of metrics (sometimes multiple charts for each type of metric)



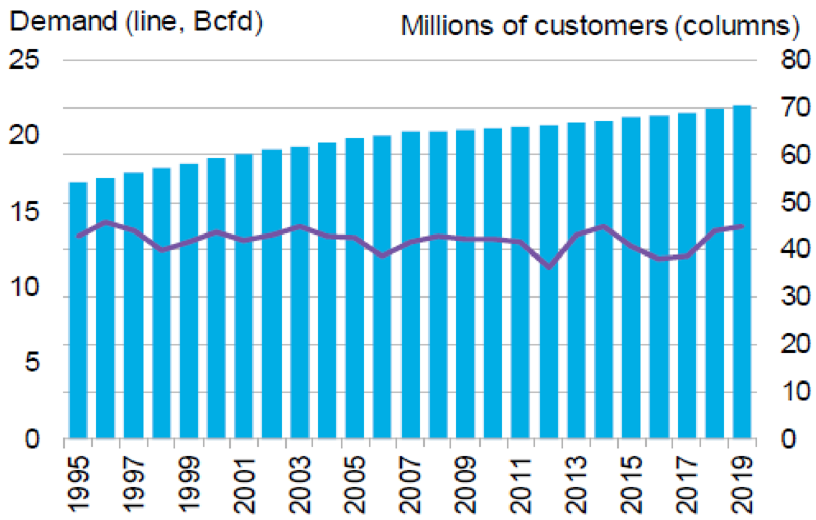
Deployment: captures how much activity is happening in the sector, typically in terms of new build or supply and demand

Finance: captures the amount of investment entering the sector

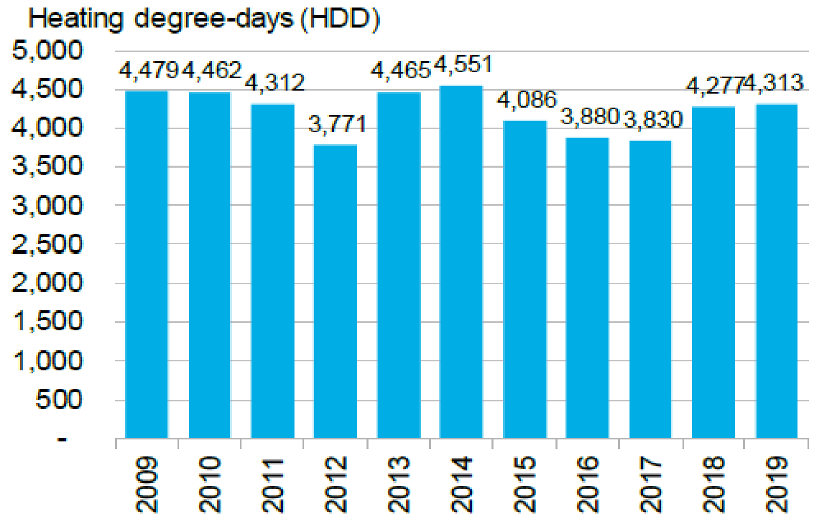
Economics: captures the costs of implementing projects or adopting technologies in the sector

Deployment: U.S. natural gas residential customers vs. consumption

Residential demand vs. consumption



Heating degree-days



- Residential natural gas consumption decreased by 2% in 2019 even as the number of customers grew by 1%. The customer base for residential gas has expanded by 5 million, or 8%, in the last decade – and by 12.1 million, or 21%, over the past 20 years. Meanwhile, residential consumption remained largely flat over the same time, rising 7% in 10 years, but only 8% in 20 years, due to efficiency gains in the use of gas.
- Residential gas consumption is volatile year-to-year as it's driven by weather patterns. Consumption dropped during the abnormally mild winter of 2012, which saw a 13% fall in the number of heating degree days from the previous winter. It then jumped during the polar vortices of 2013 and 2014. Year-on-year, 2019 will see a 1% rise in demand, partly due to atypically cold weather holding for the second year in a row.

Source: BloombergNEF, EIA Notes: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019). Heating degree-day data is available through September 2019.

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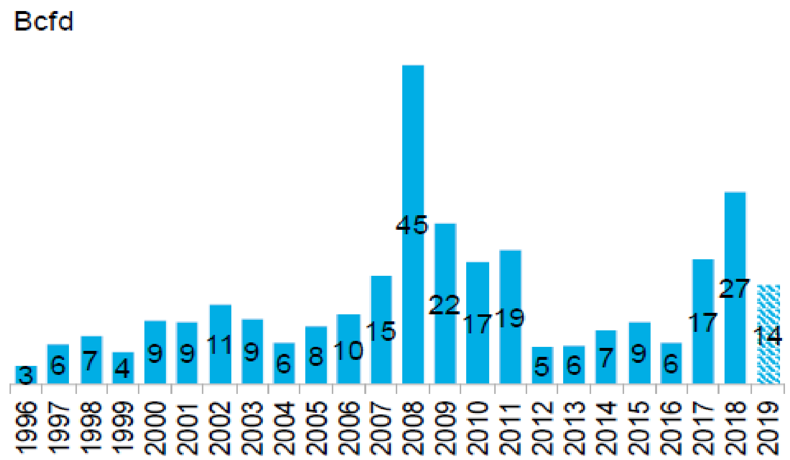
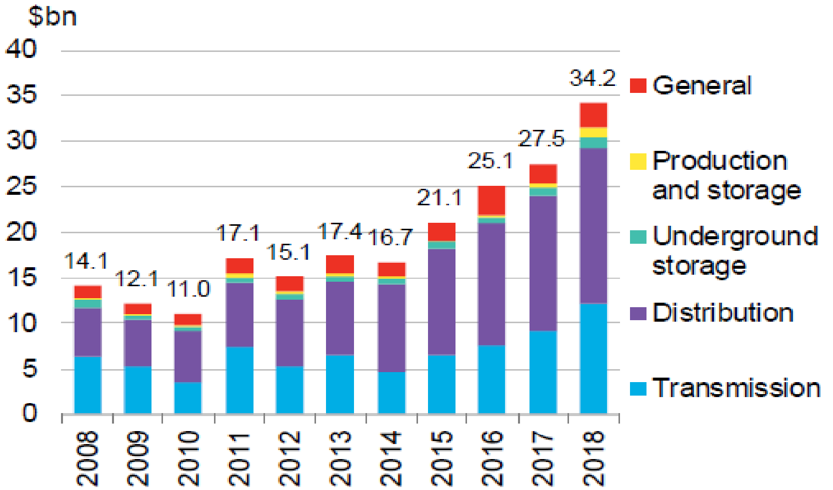
Deployment: U.S. midstream infrastructure capacity and investment

U.S. transmission pipeline capacity additions



U.S. midstream gas utility construction expenditures



- Completion delays at the end of 2018 resulted in a lower-than-expected total capacity additions in 2019. Growth in the lower 48 states pipeline network slowed in 2019. Only two new pipelines came online: Kinder Morgan's 2Bcfd Gulf Coast Express, which carries gas from the Permian to south Texas, and Enbridge's 2.6Bcfd Valley Crossing, which feeds into an export route to Mexico.
- Midstream expenditures kept rising in 2018, reflecting the strongest level of capacity additions since 2008. Total expenditure grew by 24% in 2018, after 25% growth in 2017. However, midstream investment appetite has begun to dry up with the 2018 MLP tax reforms and unfavorable market conditions for producers.

Source: BloombergNEF, American Gas Association, EIA Notes: EIA data include both first-mile takeaway capacity and pipeline additions that do not impact takeaway capacity. 2019 transmission capacity is a BloombergNEF estimate. Expenditure values reflect figures reported to the AGA by companies across the supply chain, including transmission companies, investor-owned local distribution companies, and municipal gas utilities. "General"" includes miscellaneous expenditures such as construction of administrative buildings. Totals may not sum due to rounding.

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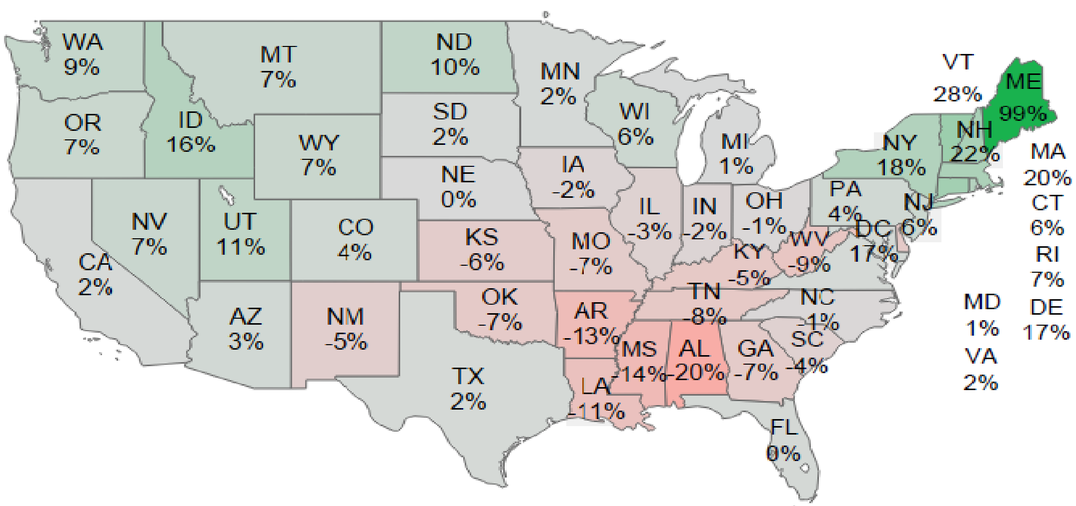
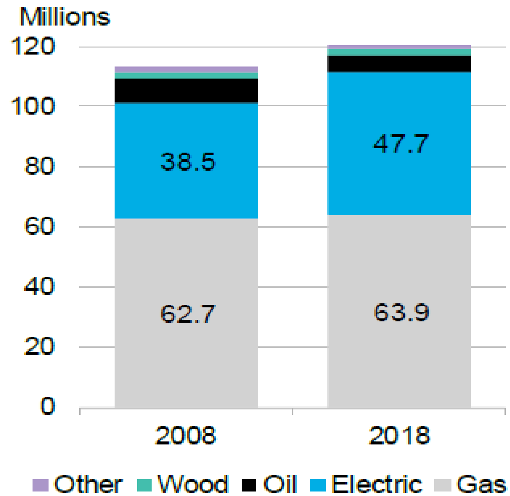
Deployment: Heating demand for natural gas

Percent change in households using natural gas for heating, 2008-2018



Primary heating source by household



- Natural gas is the largest heating source in the residential sector, with 63.9 million homes heated by utility natural gas or bottled propane. That is equivalent to 52% of U.S. households. The second largest heating source, electricity, accounts for 39% of households.
- In absolute terms nationwide, the total number of households using natural gas for heating has risen by 2% since 2008.
- However, changes have varied substantially by region. On a percentage basis, usage grew swiftly in the New England states as the share of consumers burning more costly home heating oil dropped by double digits in many states. However, gas usage declined in other regions of the country, where electric heating gained popularity.

Source: BloombergNEF, US Census Bureau

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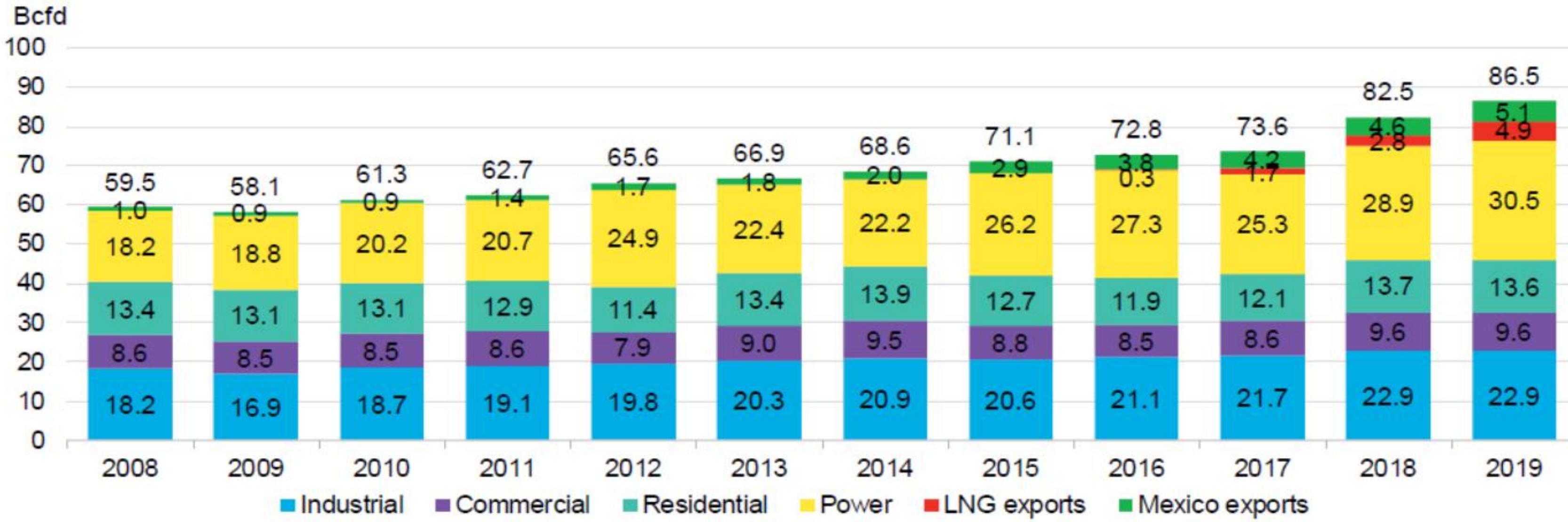
Deployment: U.S. natural gas demand by end use



- Total U.S. annual gas demand has grown 49% in the past decade and 5% in the last year alone to a record-setting 86.5 Bcfd in 2019.
- Power generation gas demand grew by 1.6Bcfd, despite a cooler summer. 12GW of coal-fired power plant retirements and lower year-on-year gas prices boosted demand.
- Industrial, residential and commercial heating demand held flat in 2019, thanks to a repeat relatively cold winter.
- LNG exports also significantly contributed to demand increase; 25MMtpa of new liquefaction capacity came online in 2019. However, this capacity had a utilization factor of less than 90%, due to technical issues at some of the newest plants.

Source: BloombergNEF, EIA. Note: Values for 2019 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2019).

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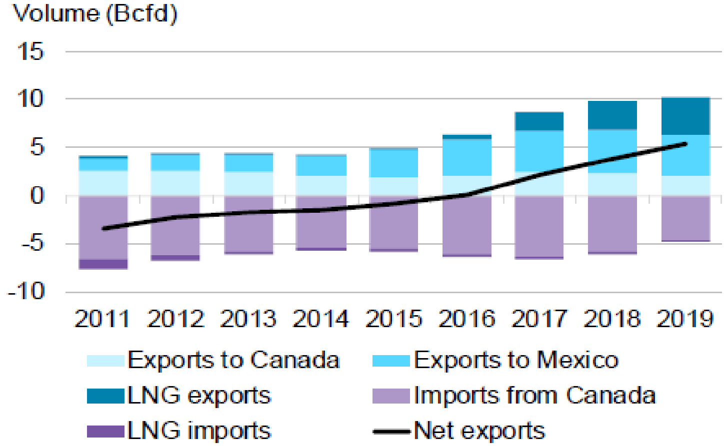
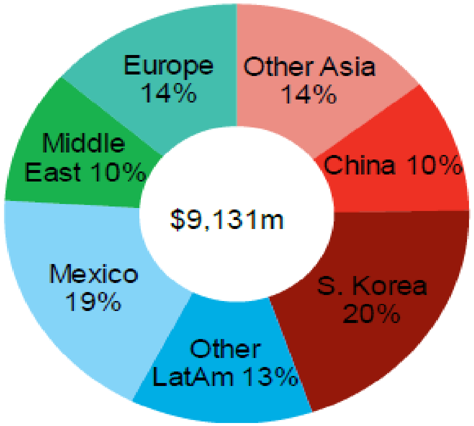
Deployment: U.S. natural gas exports and imports

Volume of LNG exports, 2016 – Oct 2019



Value of LNG exports, 2016 – Oct 2019



- Both pipeline and liquefied natural gas capacity additions contributed to increase gas exports in 2019.
- LNG exports grew by an annual average 1.6Bcfd thanks to the commissioning of the Cameron and Freeport LNG terminals (train 1 and 2 for each), as well as the completion of train 2 at the Corpus Christi terminal in South Texas.
- South Texas is also the exit point for the newest Mexico-bound export pipeline that came online in 2019. The 2.6Bcfd Sur-de-Texas pipeline can currently only flow 800MMcfd because of the lack of interconnecting capacity in the Southeast Mexican market. As intra-Mexico pipeline and power plant projects get completed in 2020, exports should increase out of Sur-de-Texas and other recent capacity originating in West Texas.
- South Korea is the single largest destination of U.S. LNG exports by value, representing 20% or $1.83bn of revenues. This contributes to Asia remaining by far the largest regional market for U.S. LNG, making up 44% of total export value from the start of 2016 through October 2019.

Source: Bloomberg Terminal, EIA, Department of Energy. Notes: Data through October 2019; dollar values represent the price at export point, times the value exported.

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Economics: Generating electricity from natural gas vs. coal in the U.S.

- In the U.S., power is the primary source of gas demand price elasticity. When the price of gas falls below that of coal, gas burn rises until the price differential (in $/MWh) between the two fuels closes.
- The 2019 increase in natural gas demand was due to both structural and market changes. Coal-burning capacity was reduced by 12GW in 2019, while 8.2GW of new natural gas-fired capacity was added. About 3.8GW of un-economic gas-fired generation was retired, but the impact on gas demand was minimal due to low capacity factors.
- Gas prices had to realize cheaper than equivalent coal prices during most of 2019 in to order increase demand and slow the pace of injection refills.

Source: BloombergNEF Notes: Assumes heat rates of 7,410Btu/kWh for CCGT and 10,360Btu/kWh for coal (both are fleet-wide generation-weighted medians); variable O&M of $3.15/MWh for CCGT and $4.25/MWh for coal. Gas price used is Henry Hub. CCGT stands for a combined-cycle gas turbine. CAPP represents Appalachian coal prices.

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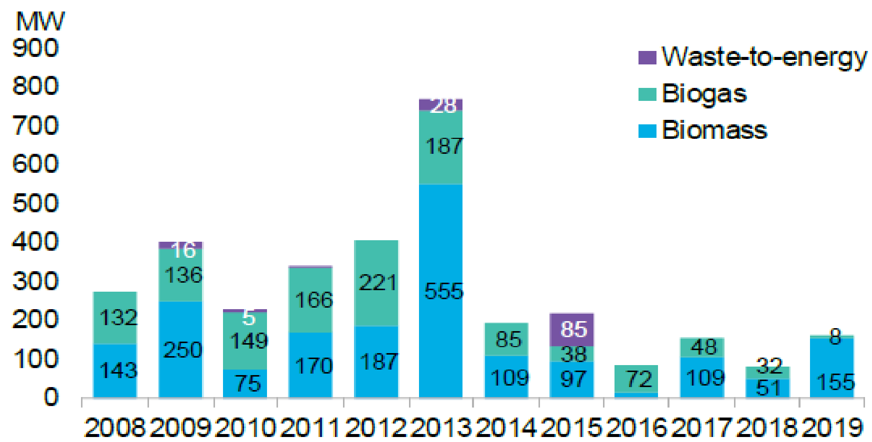
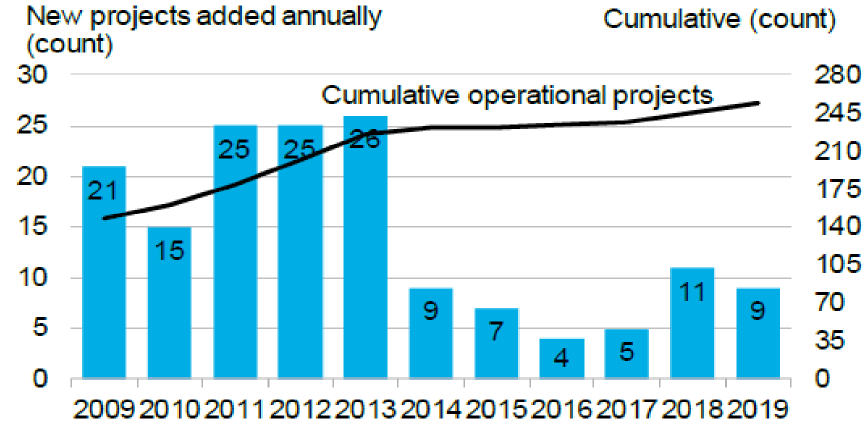
Deployment: U.S. bioenergy and anaerobic digester build

Annual build: large-scale bioenergy



Annual build: farm-based anaerobic digesters



- In 2019, the U.S. installed 155MW of biomass and 8MW of biogas projects. Bioenergy build has tapered since 2013, when the Production and Investment Tax Credits, as well as the 1603 Treasury grant program, encouraged nearly 800MW of new installations. However, these technologies will benefit from the PTC extension that Congress approved at the end of 2019.
- Waste-to-energy technology has seen more growth in countries such as China, where 111 projects representing 1,800MW were awarded in 2019, up from 86 and 64 projects in 2017 and 2018, respectively. In all, 3,700MW of waste-to-energy projects is expected online in China 2018-2020. The U.K. also has provided important policy support to waste-to-energy. There are now 49 operational plants in the U.K., 12 under construction, 11 in advanced development and another 17 possibly on the way.
- Nine new anaerobic digesters were added in 2019 in the U.S. On average, since 2014, seven new systems have been built annually. The total count of operational projects (accounting for retirements) has increased 9% since 2014. In addition, there were nearly 775 operational landfill gas plants, 66 food scrap digester systems and 1,269 wastewater digester systems in 2019, not shown in the graphs above.

Source: BloombergNEF, EIA, company announcements, EPA, WEF Notes: Biomass includes black liquor. Biogas includes anaerobic digestion (projects 1MW and above except wastewater treatment facilities). The graph on the right reflects anaerobic digesters on livestock farms in the U.S. and is sourced entirely from the EPA AgSTAR database.

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The US Biogas Market

Current

254 on Farm

1,269 Water

66 Food Scrap

645 at Landfills

Potential

8,300 on Farm

4,000 Wastewater

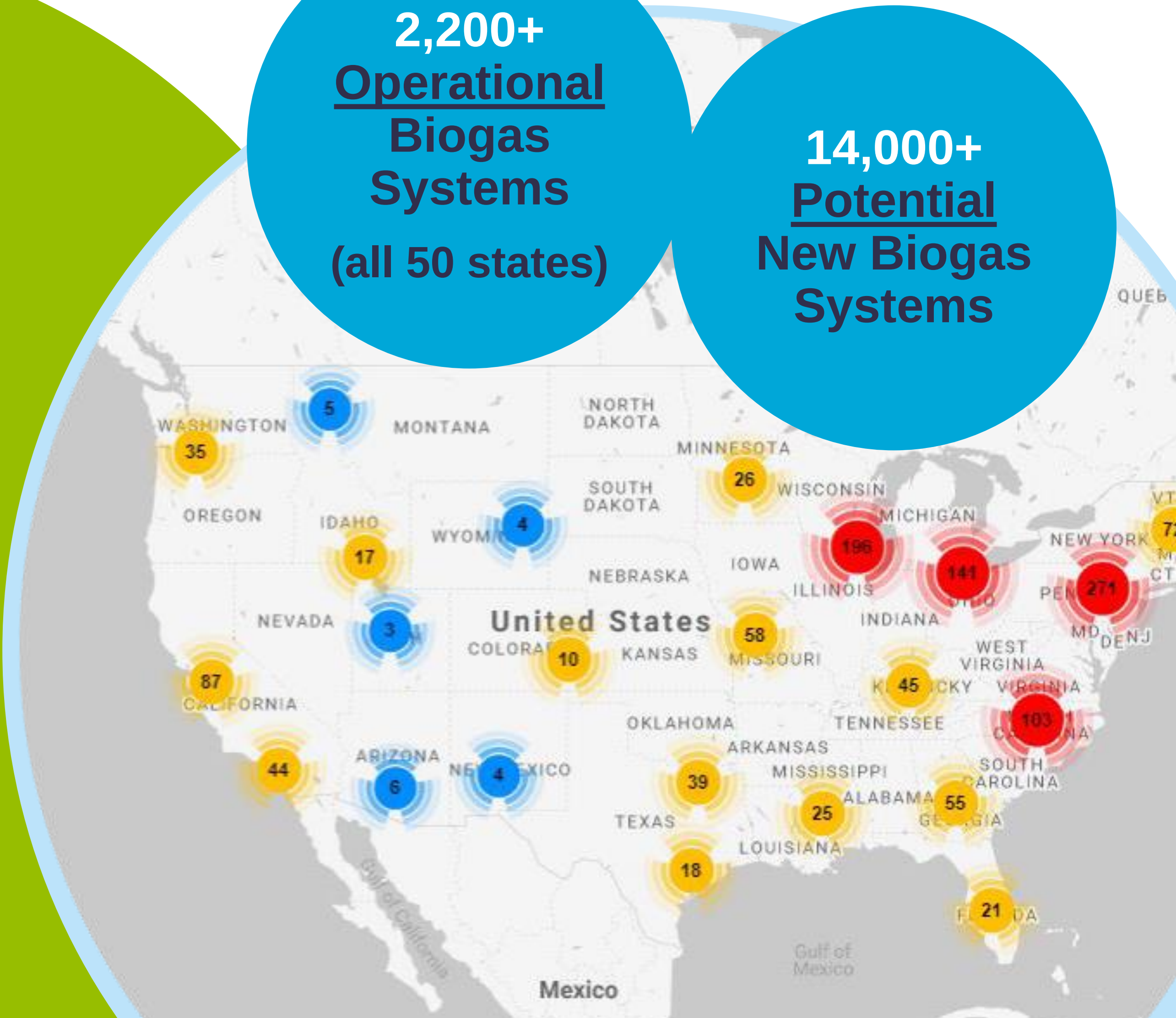
1,000 Food Scrap

440 at Landfills

2,200+
<u>Operational</u>
Biogas Systems

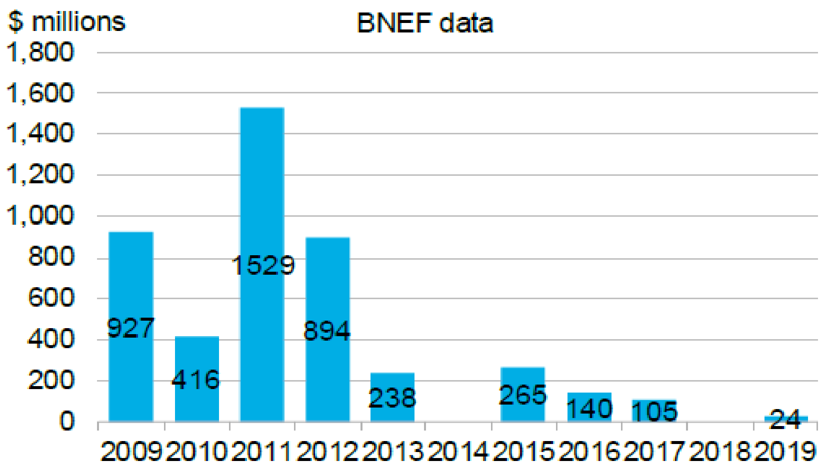
(all 50 states)

14,000+
<u>Potential</u>
New Biogas Systems

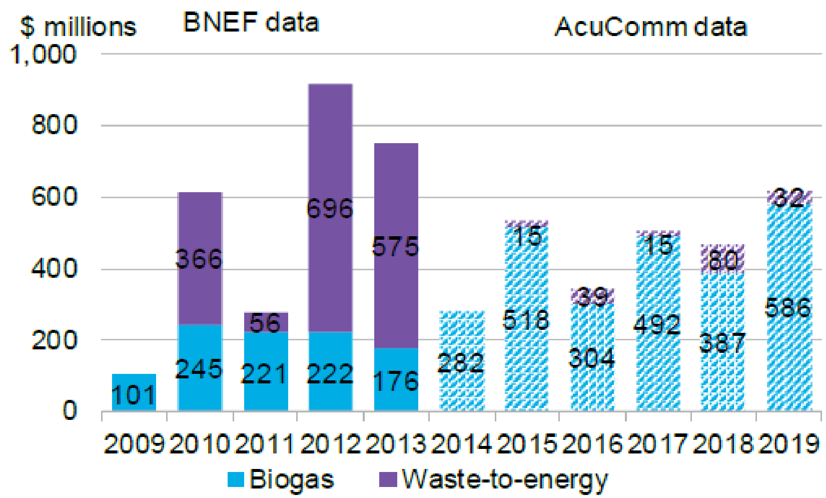


Financing: U.S. bioenergy asset finance

Asset finance for U.S. biomass



Asset finance for U.S. biogas, waste-to-energy



- Asset (project) finance for new biomass and biogas build continues to fluctuate, with an resurgence of biogas investment in 2017-2019. In 2019, AcuComm and BNEF tracked 15 investments into large biomass, biogas and waste-to-energy projects with a combined capacity of over 70MW and total investment value of $643 million, around double the capacity of – and 32% the investment value of – bioenergy plants financed in 2018.
- Lower investment for biomass in the past five years suggests that new build will continue to be subdued. Plants take two to four years to build and commission, so investment functions as a leading indicator for build.
- AcuComm is an alternate data provider providing coverage of select bioenergy plants throughout the U.S.

Source: BloombergNEF, EIA, company announcements, AcuComm Notes: Values are nominal and include estimates for deals with undisclosed values. Biogas includes anaerobic digestion (1MW and above, except for wastewater treatment facilities) and landfill gas.

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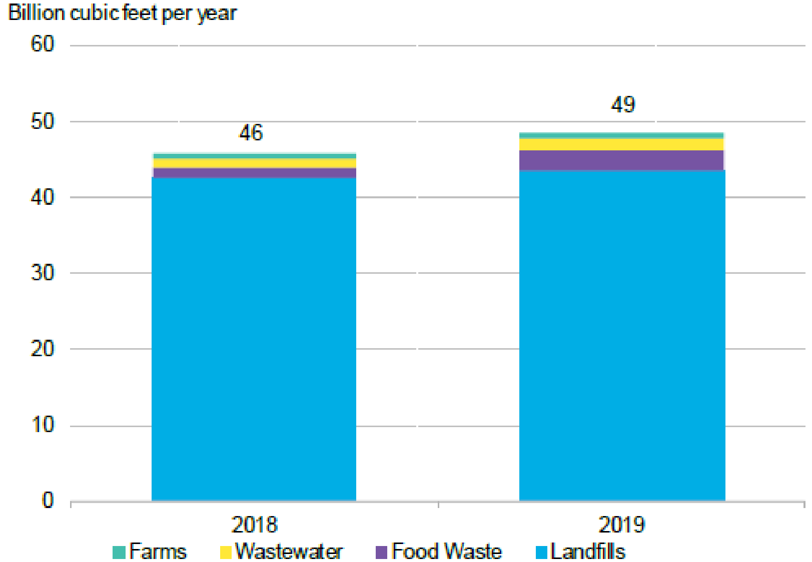
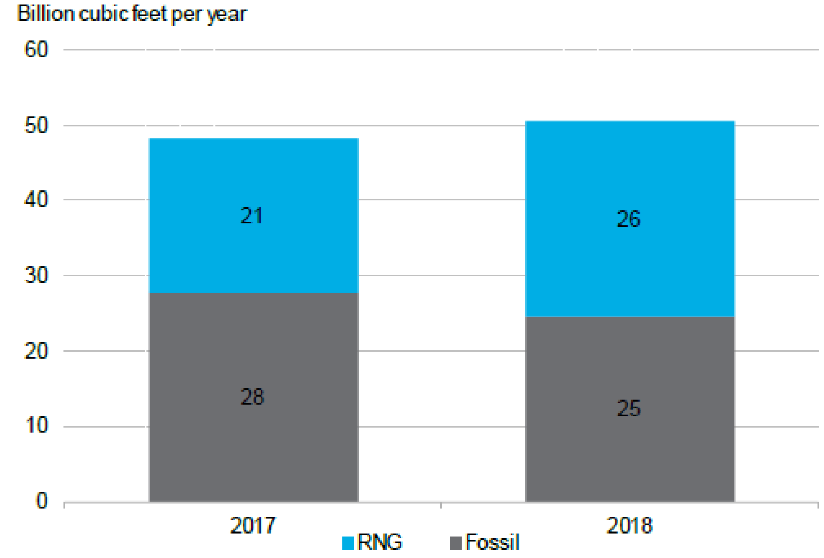
Renewable natural gas (RNG) deployment: Production and use in transportation

RNG production capacity, by source



Source: The Coalition For Renewable Natural Gas, Argonne National Laboratory (As of June 2019)

U.S. natural gas vehicle fuel consumption



Source: RNG: EPA – Moderated Transaction System, Fossil – EIA Natural Gas Consumption

- The vast majority of U.S. RNG is produced through biological decomposition of waste in landfills. In 2017, RNG met 43% of natural gas demand from the transportation sector, according to the EPA and EIA. In 2018 (the last year for which complete data exists), that rose to 51%.
- Key drivers of consumption have been the California Low Carbon Fuel Standard and the national Renewable Fuels Standard. Under the latter, credits known as renewable identification numbers (RINs) are critical to making RNG competitive, specifically “D3” RINs. In 2019, prices for RINS collapsed 57% from approximately $2.04/RIN in January, to $0.87 in October, according to the EPA. This drastic drop in price was triggered by small refinery exemptions granted by the EPA that diminished demand for D3 RINs.
- There were also and estimated 5.24 million gallons, 5.9 million gallons and 5-6.5 million gallons of U.S. renewable propane production in 2017, 2018 and 2019, respectively.

Source: BloombergNEF, FERC

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Staff Subcommittee on Gas

Sunday, February 9, 2020

REPAIR

Rapid Encapsulation of Pipelines Avoiding Intensive Replacement (REPAIR)

NARUC Subcommittee on Gas
February 9, 2020
Washington, D.C.

Jack Lewnard, Program Director ARPA-E
jack.lewnard@hq.doe.gov

What is ARPA-E?

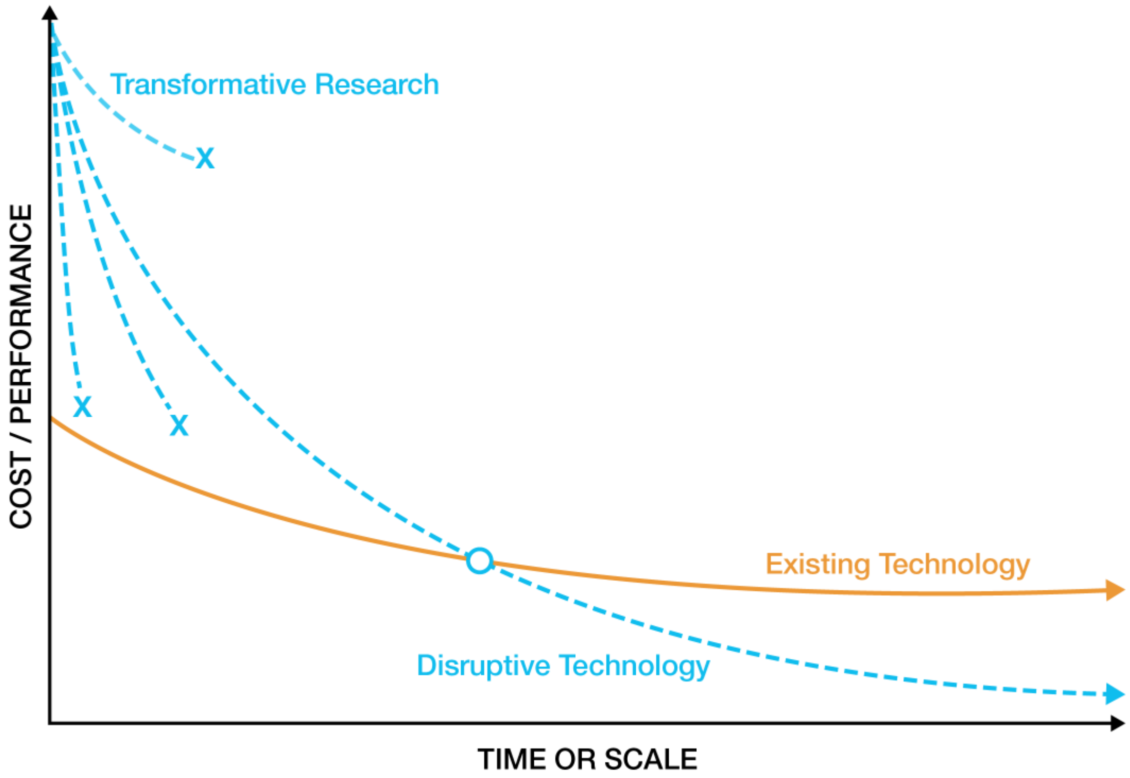
The Advanced Research Projects Agency-Energy (ARPA-E) is an agency within the U.S. Department of Energy that:

- Provides **Research and Development** funding for high-risk, high-reward, transformational ideas. FY 2020 budget $366MM
- Focuses on technologies that could **fundamentally change** the way we get, use, and store energy
- Accelerates energy innovations that will create a more secure, affordable, and sustainable **American energy future**

CHANGING WHAT'S POSSIBLE

U.S. DEPARTMENT OF ENERGY

Creating New Learning Curves, Disruptive Technologies



ARPA-E: Focused on Commercializing Technology

Since 2009 ARPA-E has provided

$2 billion

in R&D funding to more than **800 projects**

145 Projects have attracted more than

$2.9 billion

in private-sector follow-on funding

76 projects

have formed **new companies**

131 projects

have **partnered with other government agencies** for further development

2,489

peer-reviewed **journal articles** from ARPA-E projects

346 patents

issued by U.S. Patent and Trademark Office

As of March 2019

What Makes an ARPA-E Project?

IMPACT

- High impact on ARPA-E mission areas
- Credible path to market
- Large commercial application

TRANSFORM

- Challenges what is possible
- Disrupts existing learning curves
- Leaps beyond today's technologies

BRIDGE

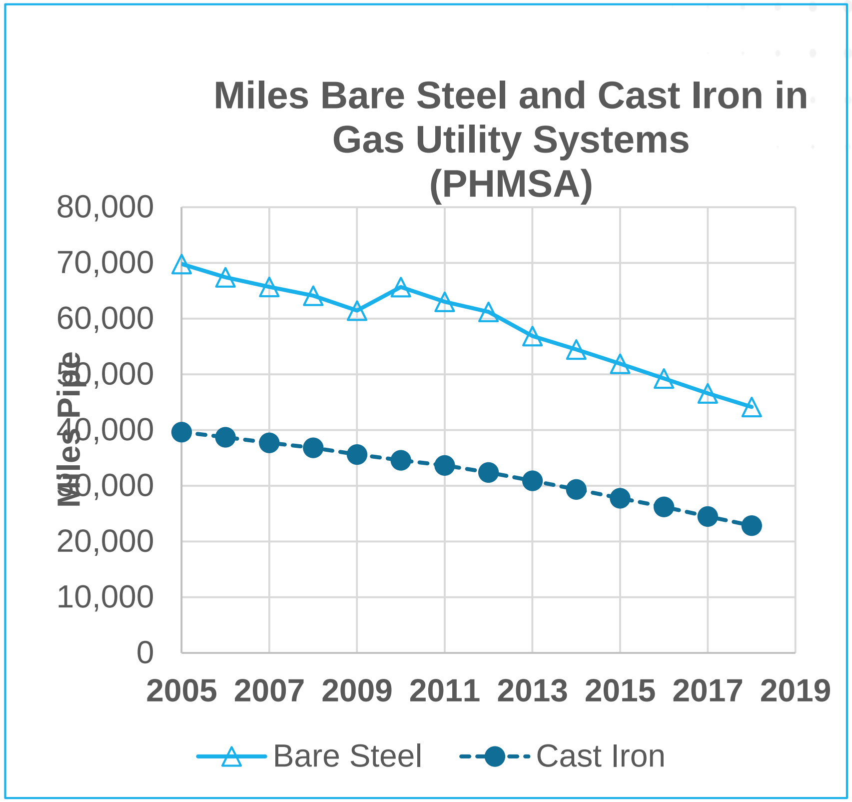
- Translates science into breakthrough technology
- Not researched or funded elsewhere
- Catalyzes new interest and investment

TEAM

- Comprised of best-in-class people
- Cross-disciplinary skill sets
- Translation oriented

REPAIR Goals

- Turn-key solutions for gas utilities and pipeline owners
  - Rehabilitate cast iron and bare steel pipes > 10-inch diameter
    - 50-year life
    - $1MM/mile cost
    - Accepted by regulators as equal to pipeline replacement
    - Costs allowed in rate base
  - 3D maps
    - Visualize gas pipes and adjacent underground infrastructure
    - Integrate data from coating tool, inspection tool(s), leak reports

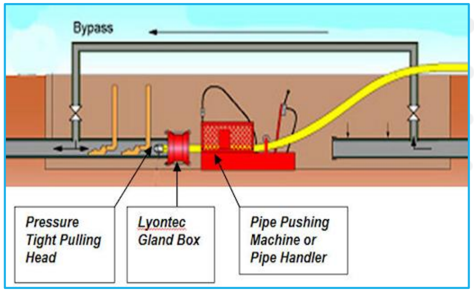


Commercial Alternatives to Excavate/Replace

Clamps

Wraps

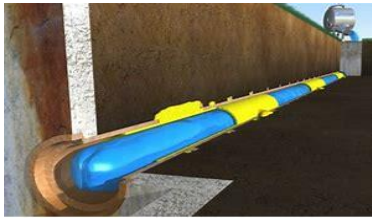
Pipe Bursting



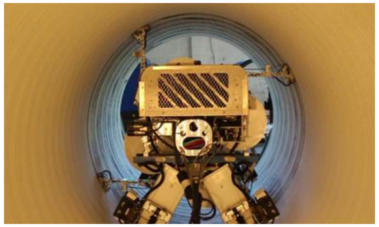
Slip-lining

Keyhole encap-sulaiton

CISBOT (robot)



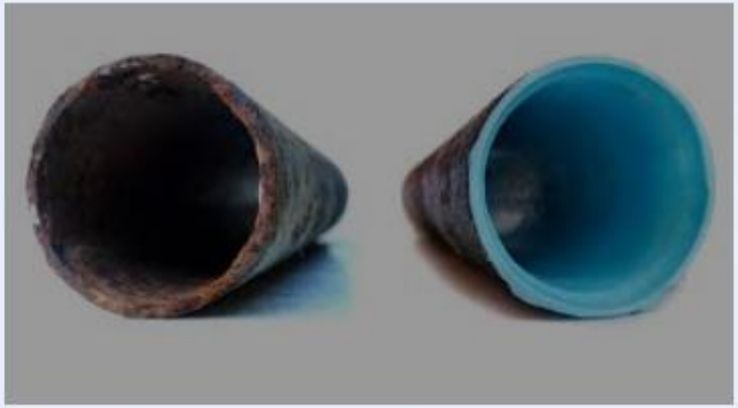
CIPP liner



MICP (robot + liner)

Approach

- Fabricate a new, “smart” pipe inside the old pipe
  - Leverage advances in materials, robotics, and inspection tools
  - Minimize gas service disruption
- Real-time 3D map/inspection with data visualization
- Demonstrate rehabilitated pipe is “better than new”
- Qualify rehabilitated pipe as a new assets in the utility rate base

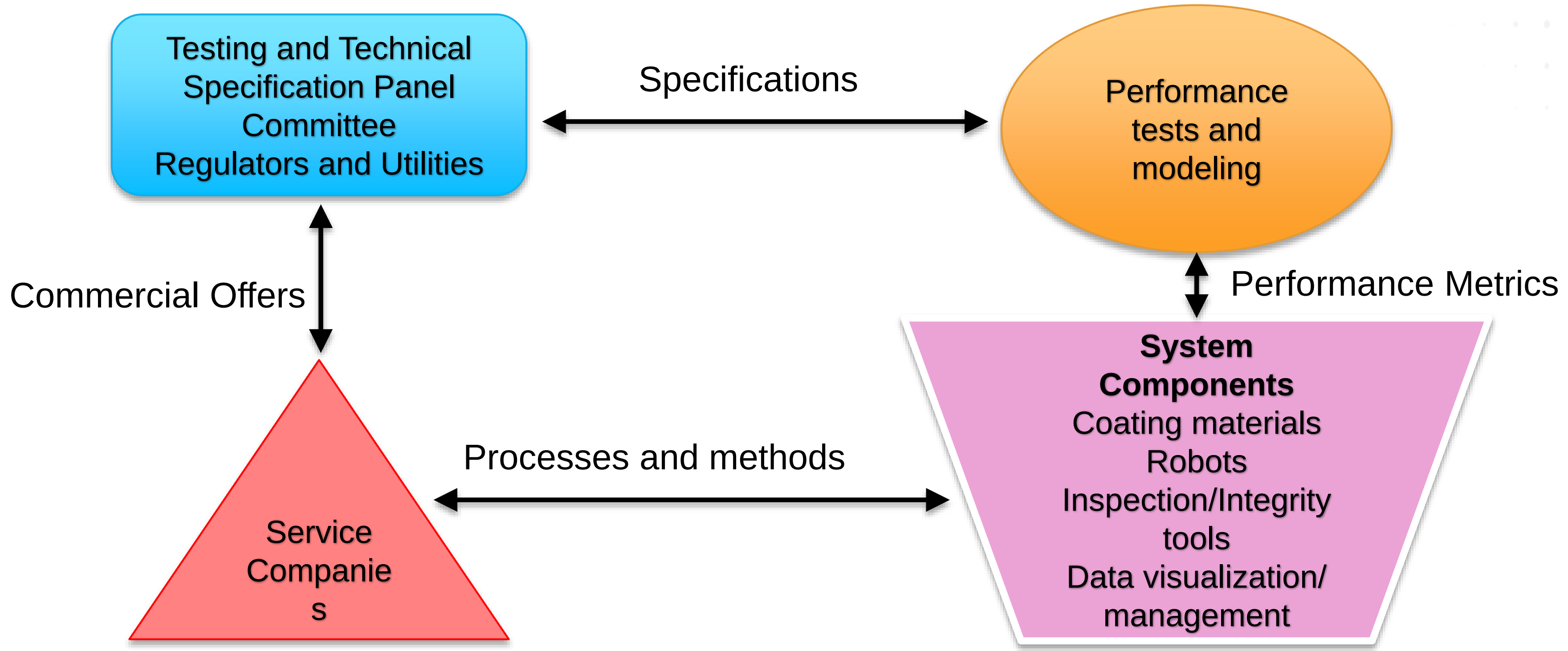


A New Pipe Inside of Your Old Pipe
nuflowmidwest.com

Benefits

- Minimize excavation
  - Lower cost
  - Less disruption
- Enhance assets
  - Rehabilitated pipe is stronger, smarter than new polyethylene
  - 3-D system map with detailed inspection record including composite materials certifications
- Same technology can be adapted for other pipelines
  - Gas gathering, water, sewer, and higher-pressure transmission lines
  - $500B-$1T infrastructure replacement costs

Teamwork, Communication, and Coordination



Diverse Expertise Needed – Including You

Testing and Technical Specification Panel

- Gas utility engineering and property management representatives (through OTD)
- PHMSA
- NAPSR
- State PUC's
- DOE Fossil Energy
- ASTM F-17; Codes and Standards

- Advises ARPA-E
  - Approve performance specifications, test methods, test procedures, material certification, and operator qualifications
  - Position rehabilitated pipe to qualify as a new asset for utilities

- Working to coordinate pipeline R&D programs (OTD, PRCI, DOT, DOE, CEC)

REPAIR Tasks

Testing and Technical Specification Panel (part of REPAIR, outside FOA)

Work Categories

1. Develop and execute tests, initiate standards required for adoption
2. Develop smart composite coating
3. Demonstrate robots to create pipe in pipe
4. Develop integrity test methods and tools, and deploy on robots
5. Integrated coating deposition and integrity test on real pipe
6. 3-D maps of pipes and subsurface infrastructure

- 3 yr, $38.5 million program

REPAIR Deliverables/Advances

Work Categories

1. Testing
   – Codes and standards for techniques
   – Predictive models with latest Bayesian statistics for DIMP

2-5. Integrated coating, deposition tool, integrity inspection tools
   – Coating with 50 year life without reliance on legacy pipe
   – Stronger than steel, non-corroding, self-healing and self-reporting capability
   – In-Line Inspection tools that can be incorporated into DIMP

6. Mapping *(accelerated program)*
   – 3D maps of gas pipes and adjacent underground infrastructure
   – Real-time visualization tools for utilities, One-Call, and contractors
   – GIS-enabled database with locations, material certs, deposition conditions, inspection results to allow work planning and forecasting

Questions

Back-up

Task 1 – Testing and Analysis

- **Scope**
  - **1.1** Define failure mechanisms
    - Precedents: ASTM test standards for polyethylene and steel pipes; CIPP test protocols
    - Identify failure modes for cast iron and bare steel pipes
    - Collaborate with TTSC for consensus to validate 50 year lifespan
  - **1.2** Model failure modes to identify critical physical properties and develop test methods
    - Communicate properties to coating material development teams
    - Critical properties are function of material, pressure, and legacy pipe dimensions
    - ISO 17025 practices, reviewing existing/available protocols
  - 1.3 Pipe testing and failure analysis
    - Samples fabricated by system integrators from Task 5

Potential tests, based on liners

- Deflection (lateral deformation), due to undermining, frost heave, ground subsidence, possibly earthquakes (i.e., liquefaction, lateral spreading).
- Axial deformation (axial displacement), due to thermal expansion/contraction, adjacent construction activity, and possibly earthquakes (i.e., transient wave propagation, permanent deformation from lateral spreading or landsliding)
- Vibrational loads, due to overhead traffic, which may cause fatigue failure
- Bonding/de-bonding at coating/pipe interface, due to differences in the thermal expansion of metal and coating or mechanical loads. Debonding could result in gas pockets at the composite/pipe interface, which may cause damage to the coating if the pipe is rapidly depressurized. Note that debonding may be advantageous in responding to some mechanical loads.
- Compatibility with current and future gas compositions with regard to corrosion and permeability, especially for hydrogen
- Cross-section ovalisation – this maybe critical for low modulus coatings
- Bends, tees, valves, and service connections - The presence of pipe fixtures and service connections may create stress concentrations and localized failures, in conjunction with the above failure mechanisms.

Comments on Testing

- Carved out as separate task
  - Requires expensive, specialized equipment. Can 't afford to have each team build their own pipe testing equipment

- Team working on Tasks 2-5 are expected to
  - conduct their own "coupon" scale testing
  - Include testing requirements in their proposals
  - Need stay within their testing request

- Budget for pipe testing will be set with Task 1 performers

- ARPA-E will coordinate access to testing

- Testing teams will have access to results from teams working on Tasks 2-5. Therefore they cannot also work on Tasks 2-5 to avoid any conflict of interest

Task 2 – Smart Coating Materials

- **Scope**
  - Develop smart coating materials consistent with:
    - Performance requirements per TTSC (i.e. 50 year life)
    - Requirements for deposition tool(s) forming coating pipes (i.e. viscosity, cure time)
  - Incorporate Smart features
    - Self healing
    - Self reporting Enhanced adhesion (as required)

Getting started

- Physical properties defined per failure modeling and performance testing (e.g tensile strength)

INTEGRATION REQUIRED

Task 3 – Coating Deposition Tool

- **Scope**
  - Develop coating deposition tool
  - Design and test robotic crawler integrated with deposition tool:
    - Operate 500 m in each direction from pipe launch point
    - Deposit coating at 15 m/hr or greater
    - Capable of operating 10-inch diameter pipe and larger
    - Capable of operating in pipe with minimal cleaning
    - On-board diagnostics for coating deposition QA/QC
    - Preference for ability to operate with pipe on-line

INTEGRATION REQUIRED

Task 4 – Pipe Integrity/Testing Tool

- **Scope**
  - **4.1** Pre-coating integrity/inspection
    - Identify any gross features that could hinder pipe rehabilitation (e.g. obstruction such as debris, liquids, pipe joints, tight bends, reducers, valves, etc.)
    - Identify pipe defects that would limit the operation of the coating deposition tool (e.g. cracks, excessive corrosion, dents, etc.)
    - Provide real-time information with data visualization for operators.
  - **4.2** Post-coating integrity/inspection
    - Above requirements in addition to testing the integrity of the newly deposited coating

INTEGRATION REQUIRED

Task 5 – Integrated Task 2,3,4 Pipe Test

- Scope
  - Commercial success requires system integrators to develop “turnkey” offerings for gas utilities
  - Responsible for selecting and integrating system components
  - Final tests will be run on a 10- to 20-inch diameter segment of field pipe removed from service
  - Applicants will demonstrate pre-coating inspection, coating deposition, and post-coating inspection to verify coating integrity

Task 6 – Pipeline Mapping/Inspection Data Integration

- **Scope**
  - **6.1** In-pipe mapping
    - In-pipe mapping tools deployed on the coating robot and/or inspection robot preferred
    - Tools deployed independently require Applicants to provide the target operating ranges
  - **6.2** Surface mapping
    - Develop 3D sub-surface imaging tool
      - Real-time data visualization
      - Capable of identifying sub-surface infrastructure
      - Ideally capable of measuring pipe properties (i.e. materials, diameter, and wall thickness)
  - **6.3** Data integration and data management/visualization
    - Create unified data management tool to integrate all REPAIR information into 3D pipeline maps
    - Provide an interface that allows users to manage and visualize the data in real time.

Funding Opportunity Announcement (FOA)

- Expect February Release
- 60 day response time
- Straight to full applications (eliminating concept paper phase)
- Key review areas
    1. Impact of proposed technology (30%)
    2. Overall scientific and technical merit (30%)
    3. Qualifications, experience, and capabilities of the project team (30%)
    4. Soundness of management plan (10%)

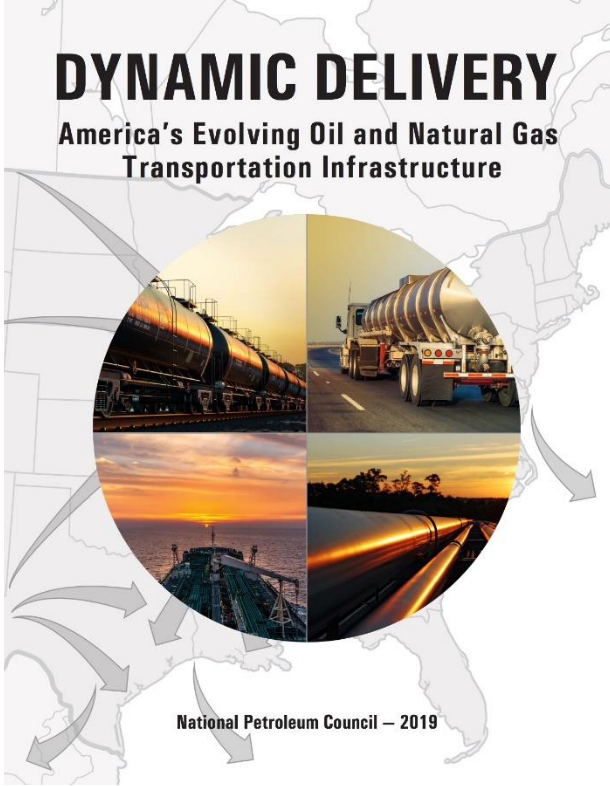
NARUC Winter Policy Summit

Staff Subcommittee on Gas

Sunday, February 9, 2020

National Petroleum Council

Dynamic Delivery –
America's Evolving Oil and Natural Gas Transportation Infrastructure



National Association of Regulatory Utility Commissioners

Natural Gas Staff Subcommittee

February 9, 2020

National Petroleum Council (NPC)

Organization	A Federally chartered, self-funded Advisory Committee; not an advocacy group, does not lobby
Purpose	Sole purpose of NPC is to advise U.S. Secretary of Energy and Executive Branch by conducting studies at their request
Origins	Continuation of WWII government / industry cooperation
Membership	Broad and balanced. Approximately 200 members from all segments of the oil and gas industries and many outside interests
Study Participants	Diverse interests and expertise relating to the topic being addressed
Study Reports	All NPC advice is provided in reports approved by its members and is available to the public. Reports can be viewed and downloaded at no cost from the NPC website – www.npc.org

Secretary's Request

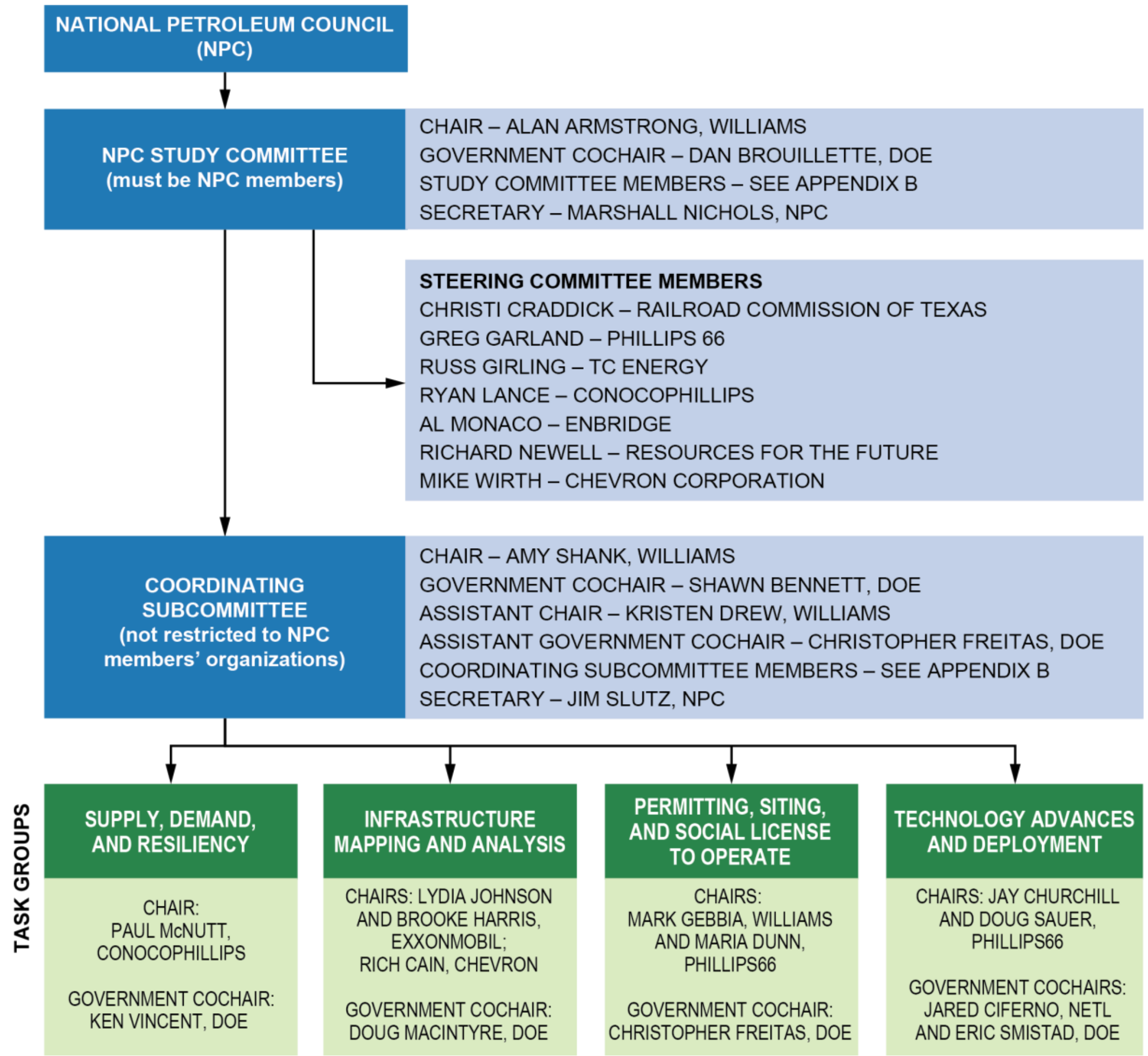
A study that would:

- Explain the extent of the transportation infrastructure today and the United States' infrastructure needs under varying demand assumptions.
- Include a review of any constraints to growing domestic oil and natural gas production caused by infrastructure limitations that reduce domestic demand or energy exports.
- Evaluate technology and policy options for improving infrastructure siting and related permitting processes, and which in turn could improve safety, environmental performance, and resilience of the system.

Key Questions:

- What are the important changes in future supply and demand patterns, and what transportation infrastructure improvements are required to leverage the regional and national opportunities offered by these changes?
- What advances in technology could improve the U.S. oil and natural gas transportation system, in terms of safety, reliability, efficiency, and environmental performance? In what new technology areas should research be progressed?
- How can state and federal governments leverage efforts to support U.S. petroleum and natural gas supply and transportation infrastructure capacity improvements?
- Are there regulatory requirements or policies that may be causing unintended consequences on energy system resilience? If so, what solutions can accomplish the regulatory objective more effectively?
- What emerging issues should policy makers be aware of and what actions should be considered to address these issues?

Infrastructure Study Organization



Study Team Diversity

STUDY COMMITTEE
55 team members

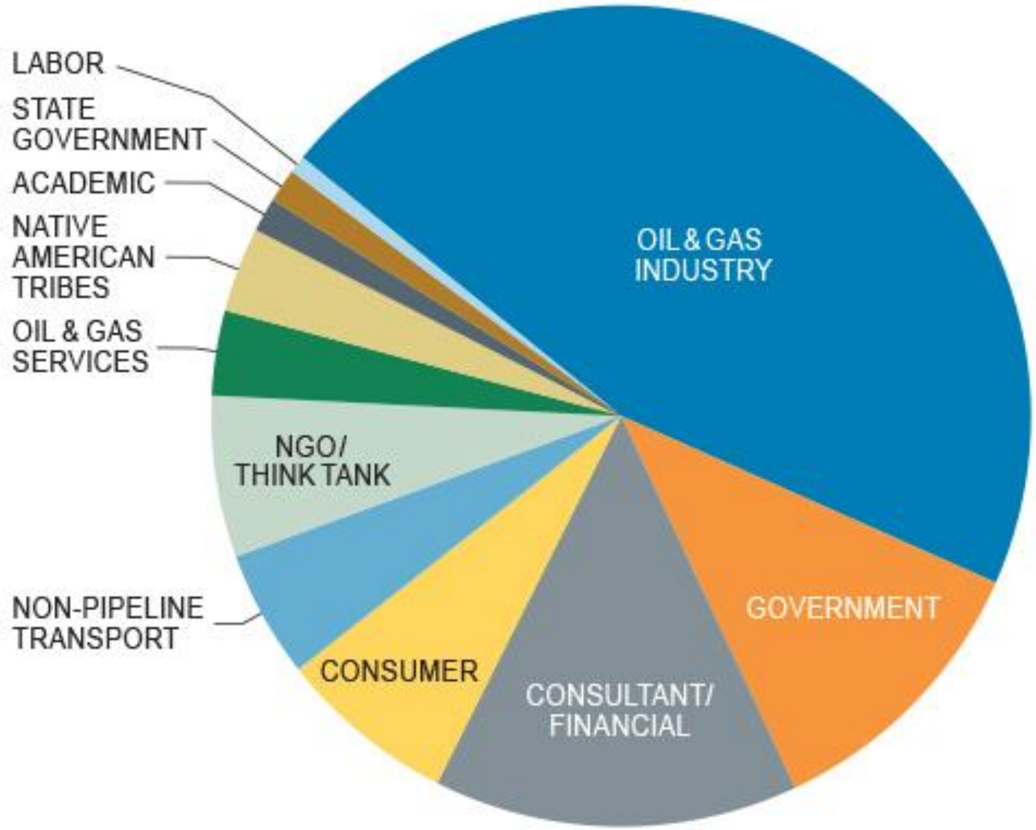
COORDINATING SUBCOMMITTEE
41 team members

SUPPLY AND DEMAND TASK GROUP
49 team members

INFRASTRUCTURE RESILIENCY, MAPPING AND ANALYSIS TASK GROUP
32 team members

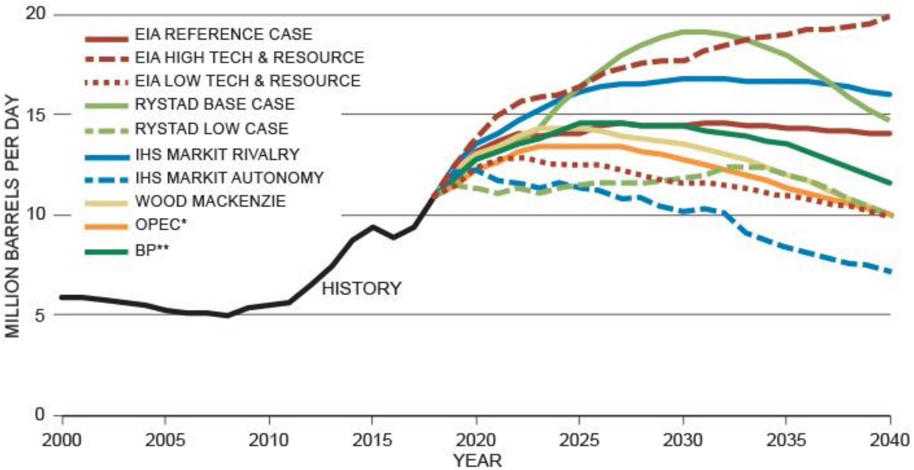
PERMITTING, SITING, AND SOCIAL LICENSE TO OPERATE TASK GROUP
45 team members

TECHNOLOGY ADVANCES AND DEPLOYMENT TASK GROUP
126 team members



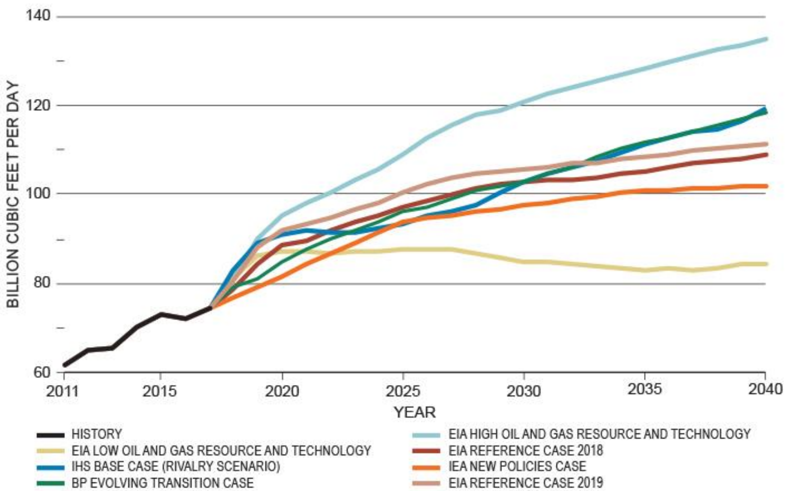
Supply and Demand

Key Finding 1: The United States has become the largest producer of both oil and natural gas in the world, which has provided the nation with increased employment and economic growth, reduced energy imports, and reduced greenhouse gas emissions. Increased natural gas use replacing coal to generate electricity has been the single largest contributor to reducing U.S. CO_2 emissions by 15% since 2005.



* OPEC outlook released in 2018. Other outlooks from 2019. ** BP 2019 Energy Outlook, Evolving Transitions scenario.

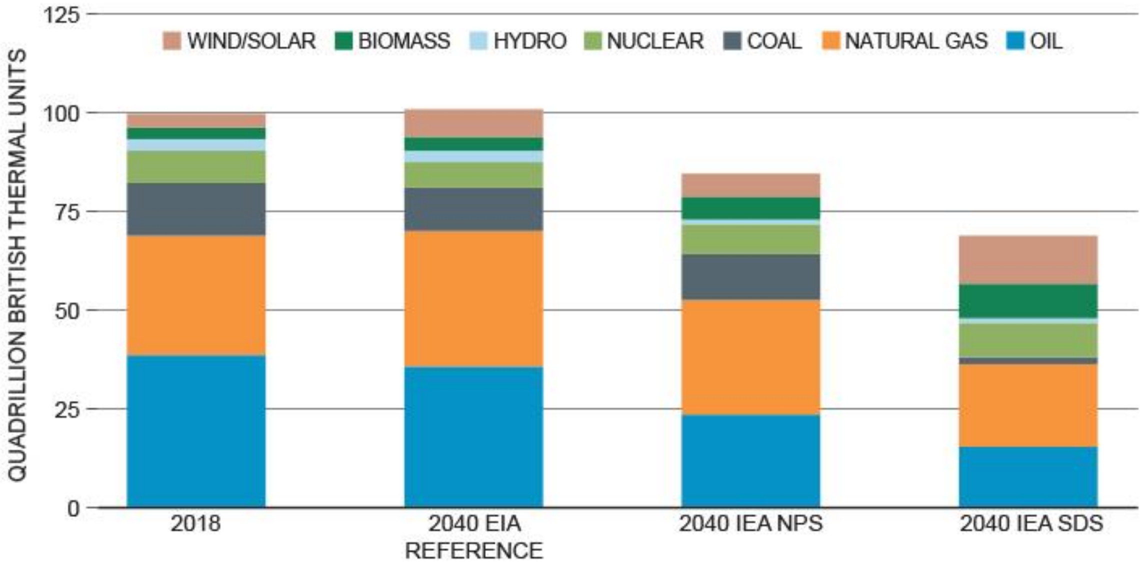
Sources: IHS Markit; EIA *Annual Energy Outlook* 2019, Rystad Energy, IHS Markit, BP, OPEC, and Wood Mackenzie Q1 2019.



Sources: EIA *Annual Energy Outlook* 2018 and 2019; IHS Markit; *BP Energy Outlook* 2019; and International Energy Agency, *World Energy Outlook* 2018.

Supply and Demand

Even in energy forecasts designed to meet climate change targets, the largest energy sources continue to be oil and natural gas through at least 2040 to provide reliable and affordable energy.



Note: "Consumption" as used here does not include net exports, such as export of LNG.

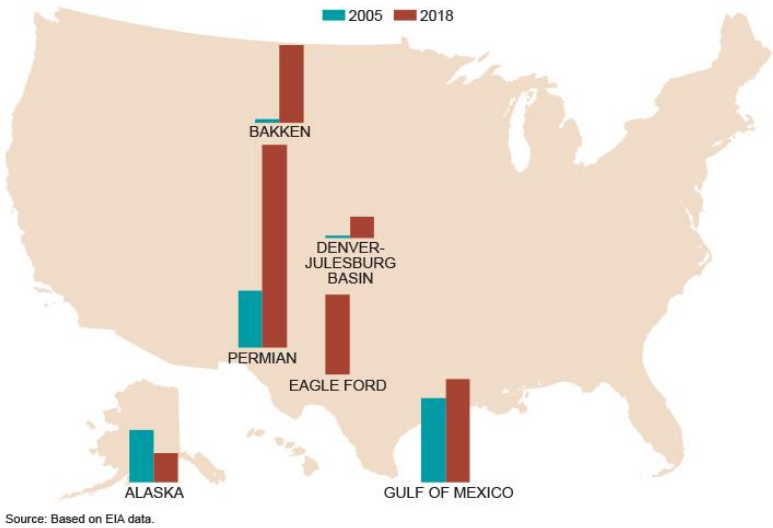
Source: The IEA New Policy Scenario and Sustainable Development Scenario are based on IEA data from International Energy Agency, *World Energy Outlook* 2018; as modified by the National Petroleum Council.

IEA New Policies Scenario – Incorporates existing energy policies as well as an assessment of the results likely to stem from the implementation of announced policy intentions. These policies include the Nationally Determined Contributions countries agreed to under the Paris Agreement.

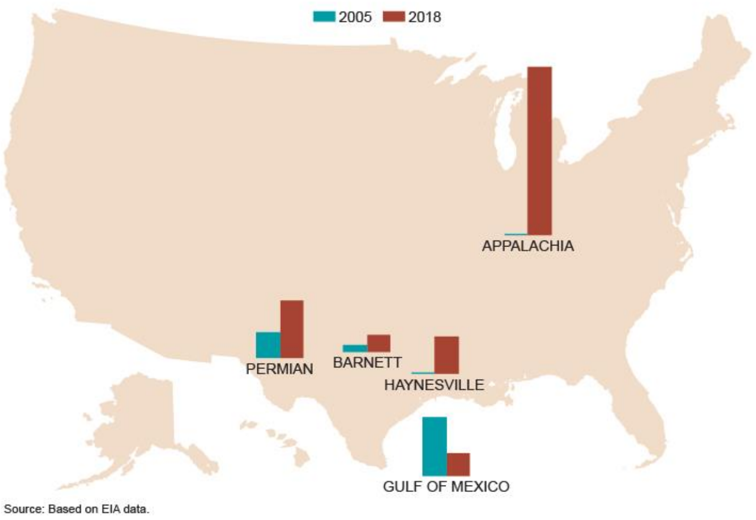
Infrastructure Analysis

Key Finding 3: The benefits of the unprecedented increase in oil and natural gas production could not have come about without the significant expansion and adaptation of transportation infrastructure capacity.

Oil and Natural Gas Production Shifts

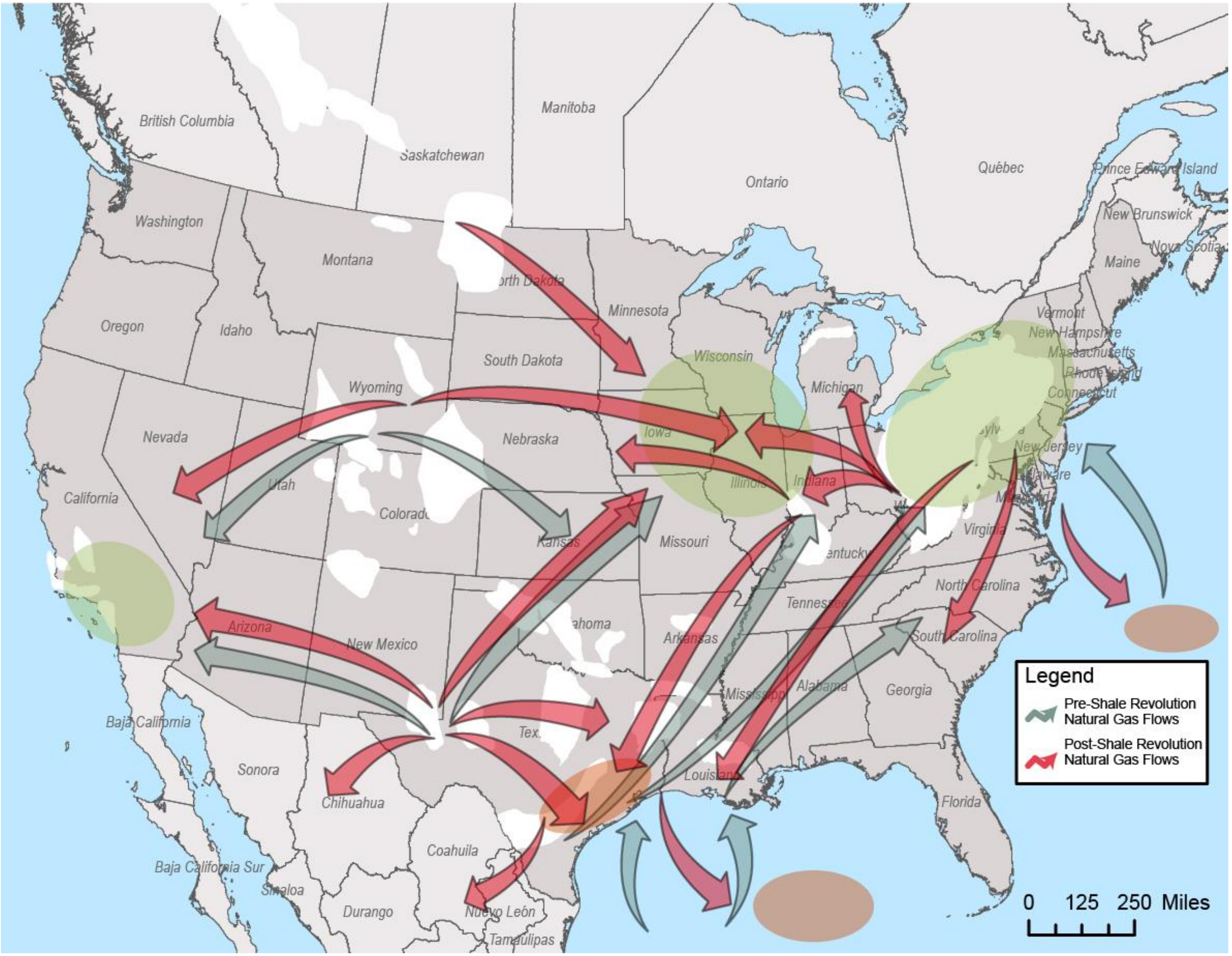


Crude Oil



Natural Gas

Natural Gas Flows Pre- and Post-Shale



Source: RBN Energy and Hart Energy

Infrastructure Analysis

Key Finding 4: The U.S. economy can benefit even further from increased export of oil and natural gas.

Key Finding 5: Existing infrastructure has been modified and adapted to near-maximum capacity. To connect America's abundant energy supplies with domestic and global demand, significant public and private investment in new and existing pipelines, ports, rail facilities, and inland waterways will be essential.

Key Finding 6: Several critical infrastructure bottlenecks exist: natural gas pipeline access to New England/New York, Port of Houston capacity, and oil and natural gas export capability.

Key Finding 7: It is becoming increasingly challenging to keep pace with hiring and developing a well-qualified workforce to build and maintain existing and future infrastructure. A skilled labor shortage exists in the United States and will continue to grow as the current workforce continues to retire.

Value of Oil and Natural Gas Infrastructure

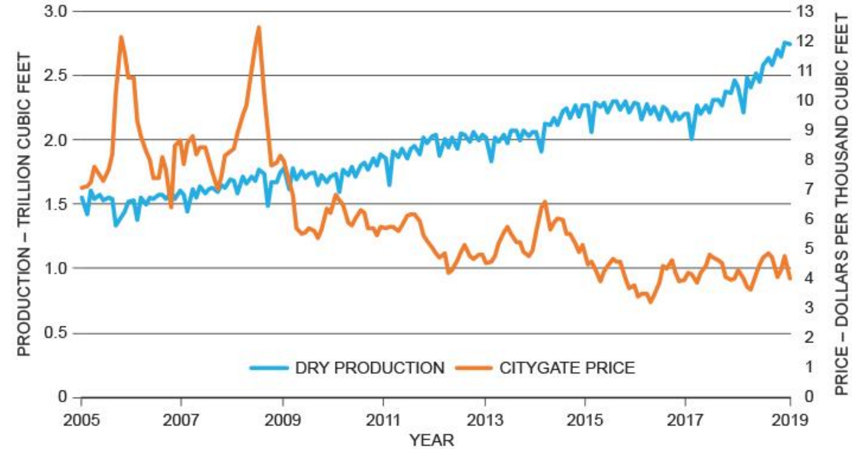
Economic Contributions of Oil and Natural Gas

JOBS
10.3 MILLION

INCOME
$714 BILLION

ECONOMIC
BENEFIT
$1.3 TRILLION

Lower Energy Costs Benefit Consumers

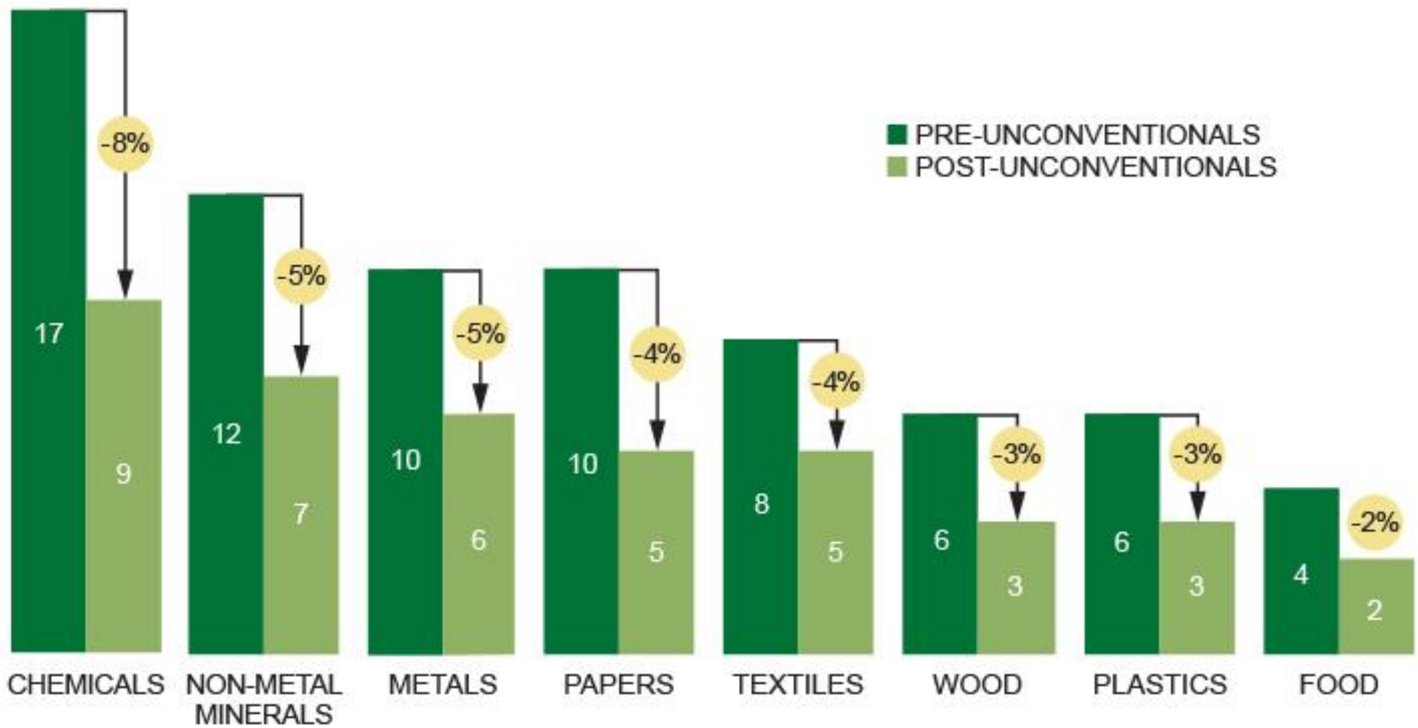


Source: EIA, *Natural Gas Monthly*, June 2019.

PriceWaterhouseCoopers, “Impacts of the Oil and Natural Gas Industry on the US Economy in 2015,” July 2017.

Source: EIA, Natural Gas Monthly, June 2019.

Value of Oil and Natural Gas Infrastructure



Source: Michael E. Porter, David S. Gee, and Gregory J. Pope, America's Unconventional Energy Opportunity, Harvard Business School & Boston Consulting Group, June 2015; https://www.hbs.edu/competitiveness/Documents/america-unconventional-energyopportunity.pdf.

Natural Gas and Electricity Costs as a Percentage of Total
Pre-Unconventional Oil and Natural Gas Manufacturing Costs

Improving Infrastructure Investment

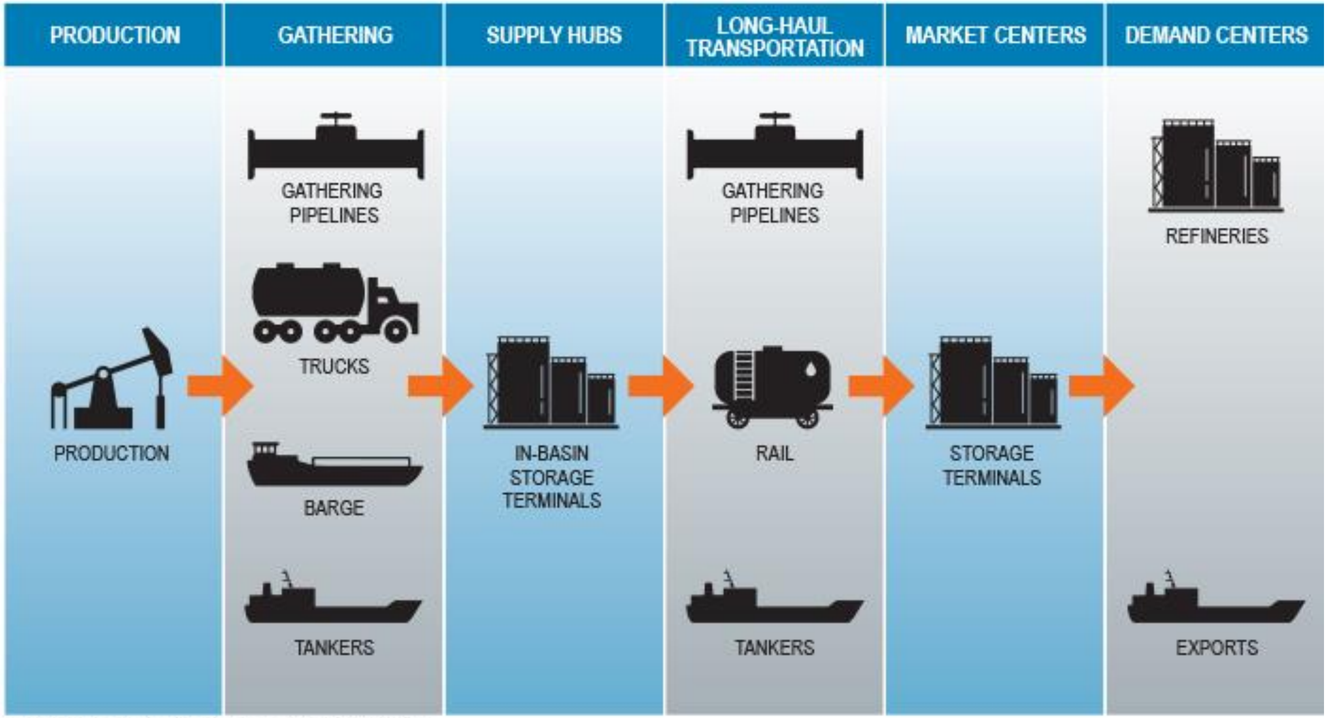
The NPC recommends:

- To mitigate negative impacts on interstate commerce, all levels of government should have constructive dialogue about the overall economic benefits from the nation's energy resources and effectively engaging stakeholders and minimizing local impacts and risks.
- Congress should fully appropriate the revenue coming into the Harbor Maintenance Trust Fund and the Inland Waterways Trust Fund funds to restore and fully maintain all U.S port and waterways infrastructure at their authorized dimensions.
- The U.S. government, states, local communities, secondary schools, and industry should promote vocational career education and technical training of their constituents, members, and communities.
- Industry, along with secondary and technical schools, should advocate for and support registered and accredited apprenticeship programs to ensure an adequate supply of skilled industrial construction, operations, and maintenance workers.

Resiliency

Key Finding 8: An interdependent infrastructure system of pipeline, truck, rail, and marine transport working together with storage ensures the delivery of reliable and affordable energy.

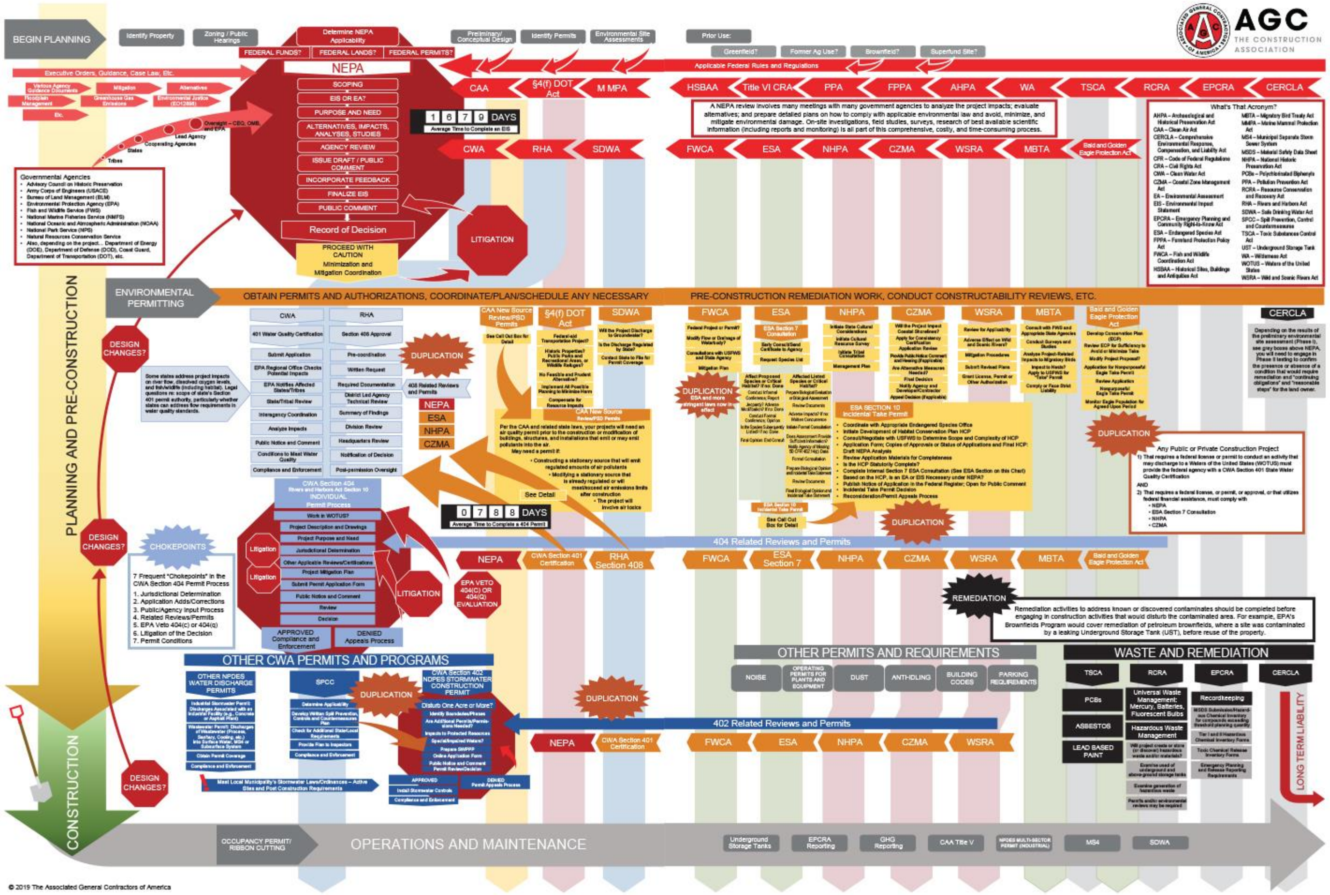
Crude Oil Supply Chain Example



Source: Plains All American, adapted by NPC.

Permitting

Key Finding 9: Overlapping and duplicative regulatory requirements, inconsistencies across multiple federal and state agencies, and unnecessarily lengthy administrative procedures have created a complex and unpredictable permitting process.



Permitting

The NPC recommends:

- States should consider utilizing the Environmental Council of the States' relationships with state officials and knowledge of the federal process, to facilitate a common agreement between federal and state jurisdictions when there are potential conflicts between a NEPA review and a SEPA review to avoid delay, confusion, and legal vulnerability.
- A national organization made up of state regulatory agencies, such as the Interstate Oil and Gas Compact Commission or the Environmental Council of the States, and representatives of local governments, communities, interested nongovernmental organizations (NGOs), and industry should collaborate to develop a model master structure for state permitting and coordination of approvals for infrastructure, to provide for efficient collaboration with operators and better coordination with federal agencies.
- States should adopt a single point of contact for permit coordination.

Permitting

The NPC recommends: The U.S. Army Corps of Engineers should:

- Implement rulemaking to provide procedural consistency among nationwide permit programs, potentially requiring pre-application to identify Lead Districts, points of contact, and variations in requirements across watershed and political boundaries.
- Continue working and implementing One Federal Decision process initiatives to improve the efficiencies of the USACE regulatory processes, including a lead district for projects crossing multiple districts and a single point of contact for One Federal Decision and any project crossing District boundaries.
- Clarify when the pre-construction notifications requirements for use of NWP12 are required, e.g., when there are public water supply intakes downstream of the activity, or when the activity may affect listed species or officially designated critical habitat.
- Implement consistent approaches to permit interpretation among its field offices to minimize variation of nationwide permit programs.

Permitting

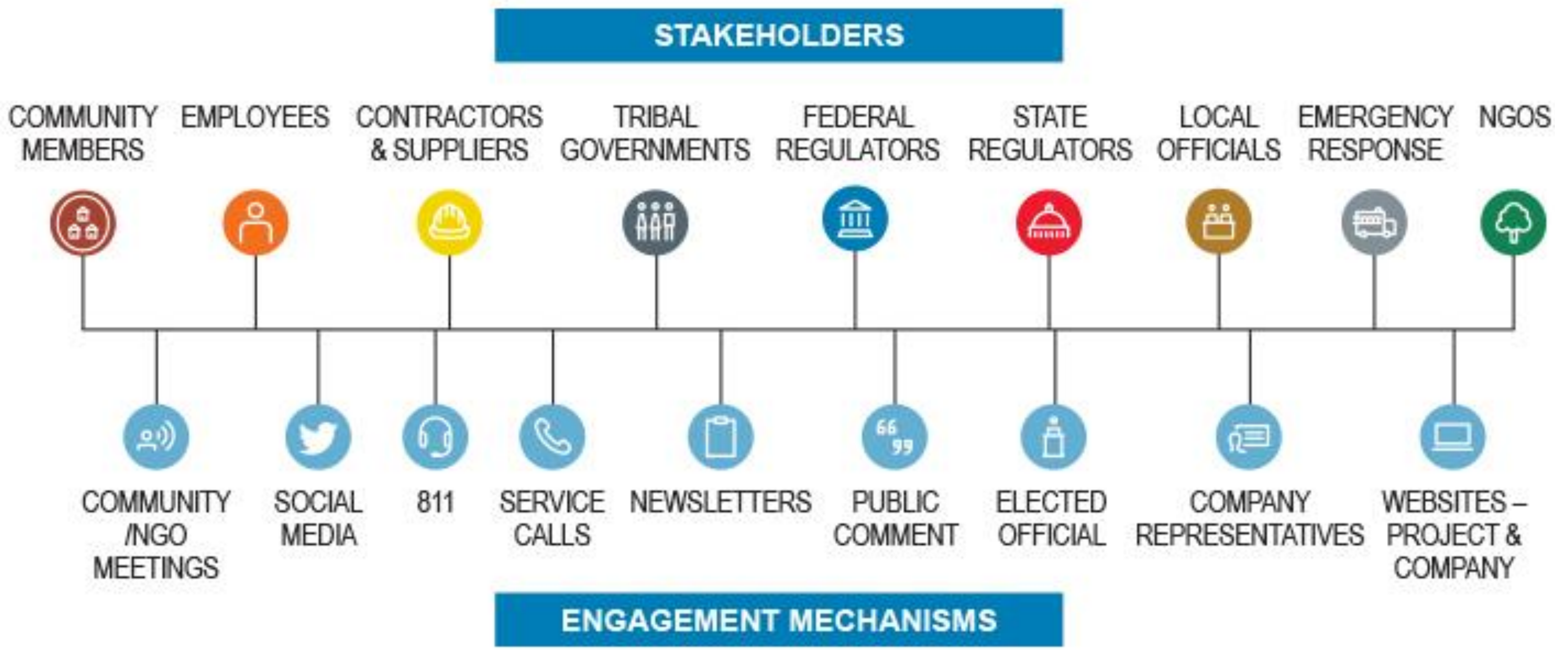
Key Finding 10: Bipartisan actions by Congress and the Executive Branch, including mechanisms to expedite the permitting process for large infrastructure projects, represent positive steps; however, further improvements are necessary.

The NPC recommends:

- A federal agency should consult with FAST-41 project sponsors and other stakeholders to obtain feedback to improve FAST-41 before reauthorization.
- Congress should reauthorize FAST-41 for an additional 7 years and include the following improvements:
  - Expand FAST-41 to include eligibility for all federal energy infrastructure projects and continuing staffing of FPISC.
  - For federal permits or decisions delegated to the states (CZMA, CWA, CAA), states should be incentivized to comply with FAST-41 and One Federal Decision and make decisions in conjunction with federal NEPA process timeline.
  - FPISC should be leveraged to drive concurrent review by the states during federal permitting processes.
- Further reauthorizations by Congress of FAST-41 should consider eliminating sunset provisions.

Stakeholder Engagement

Key Finding 11: Successful infrastructure projects depend upon early, effective, and continuous stakeholder engagement and collaboration.



Stakeholder Engagement

The NPC recommends: Infrastructure companies should:

- Implement existing best practices (e.g. FERC, INGAA, API, AOPL) for early and effective engagement with local governments, communities, private citizens, public interest groups, and American Indian and Alaska Native Tribes to understand and address stakeholder concerns. Infrastructure companies should strive to incorporate stakeholder input into a proposed action wherever practicable and collaborate on finding solutions or conveying reasons in those circumstances where an interest is difficult to accommodate.
- Engage in educational and awareness efforts with communities and stakeholders to increase understanding of the need for infrastructure, the steps to be taken to construct and operate it safely, and how they will be engaged throughout the siting and development process.
- Work collectively towards more effective engagement practices regarding energy, environmental, and related public policies that encourage responsible energy development and transport.

Permitting and Climate Change

Key Finding 12: The nation faces the dual challenge of providing affordable energy to support economic growth and human prosperity while addressing the environmental effects including the risks of climate change. Industry shares the public's concerns that climate change is a serious issue that must be addressed. Litigation of individual projects to address climate concerns is an ineffective approach.

The NPC recommends:

- All infrastructure companies should strive for an outstanding environmental compliance record and to reduce the intensity of greenhouse gas emissions from their operations. Emissions reduction programs, such as One Future, The Methane Challenge, The Environmental Partnership, and EPA's Natural Gas Star Program are all means of demonstrating a company's efforts to reduce methane emissions.

Permitting and Climate Change

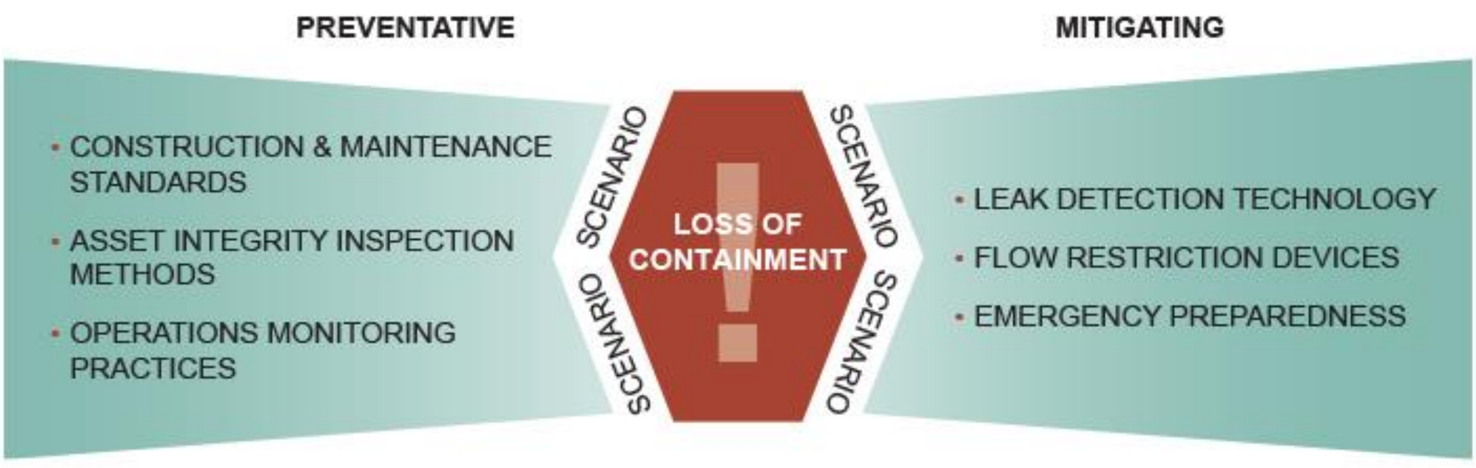
Key Finding 13: The permitting and construction of some energy infrastructure projects has been challenged, delayed, or stopped as a result of litigation by stakeholders concerned about climate change and the associated policy debate.

The NPC recommends: Congress should:

- Clarify that greenhouse gas assessments under NEPA, for oil and natural gas infrastructure projects, are confined to emissions that are (1) proximately caused by the federal action (see Dep't. of Transportation v. Public Citizen, 541 U.S. 752 (2004)), and (2) are reasonably foreseeable.
- Enact a comprehensive national policy to reduce greenhouse gas emissions and seek to harmonize federal, state, and sectoral policies to enhance efficiency and effectiveness. Congress should ensure that the enacted national policy is economy wide, applicable to all sources of emissions, market-based, transparent, predictable, technology agnostic, and internationally competitive.

Technology Advancements – Safety

Key Finding 14: Crude oil, petroleum products, and natural gas moved by the nation's infrastructure reach their destinations with a high degree of safety, resiliency, and environmental performance. However, incidents have occurred, and oil and gas companies are committed to continuous improvement.



Technology Deployment

Key Finding 15: Advancements in new technologies have been an important contributor to industry's safety, reliability, and environmental performance. Overcoming challenges and barriers to new technology development and deployment would accelerate these improvements.

The NPC recommends:

- While working with DOE, EPA, and the U.S. Coast Guard, DOT should lead creation of an agile pathway for evaluation and regulatory acceptance of new technologies that can improve transportation safety and shorten the research, deployment, and adoption cycle time.
- Congress should authorize DOT to lead a collaborative effort, with support from industry, to develop and prioritize pilot programs that can accelerate pipeline, storage, and LNG technology adoption based on performance-based rules with a goal of enhancing public safety. Upon successful completion of pilot programs, regulators should promptly update regulations to allow use of new technology.
- Oil and natural gas transportation companies should establish a collaborative effort with participation from DOT, DOE, EPA, and industry research consortiums to prioritize promising, risk-based research opportunities, establish consistent technical readiness processes, and prioritize field validation testing needs.
- FERC and state regulatory agencies should work with DOT, DOE, and others to promote laws, regulations, and public-private partnerships that support cost recovery for natural gas and oil pipeline safety research.

Cybersecurity

Key Finding 16: Cyber threats to energy infrastructure control systems are increasing and security protections are being challenged due to increasing connectivity and growing malicious cyber activity.

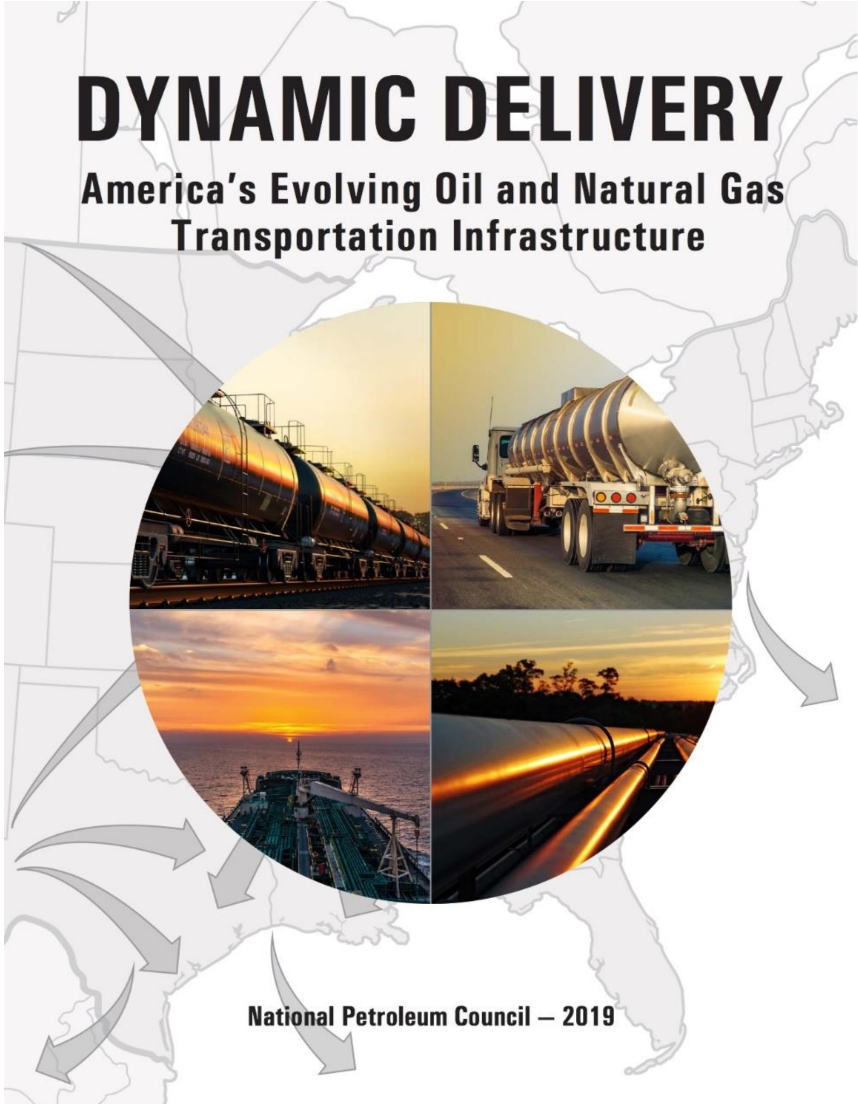
The NPC recommends: Cybersecurity protections should be advanced through:

- Industry, in collaboration with trade associations and federal government agencies, should adopt and maintain up-to-date performance-based Cyber Security Management Standards.
- Increased DHS and DOE capabilities and resources to support independent and secure cyber security assessments and audits prioritized on critical infrastructure.
- DOE, working with industry, DOD, DHS, and DOT, to establish a collaborative process to identify and prioritize research and development aimed at sector-wide protection against nation-state and advanced persistent threat actors.

Dynamic Delivery: America's Evolving Oil and Natural Gas Transportation Infrastructure

Full draft report available at
dynamicdelivery.npc.org

For more information,
email info@npc.org



NARUC Winter Policy Summit

Staff Subcommittee on Gas

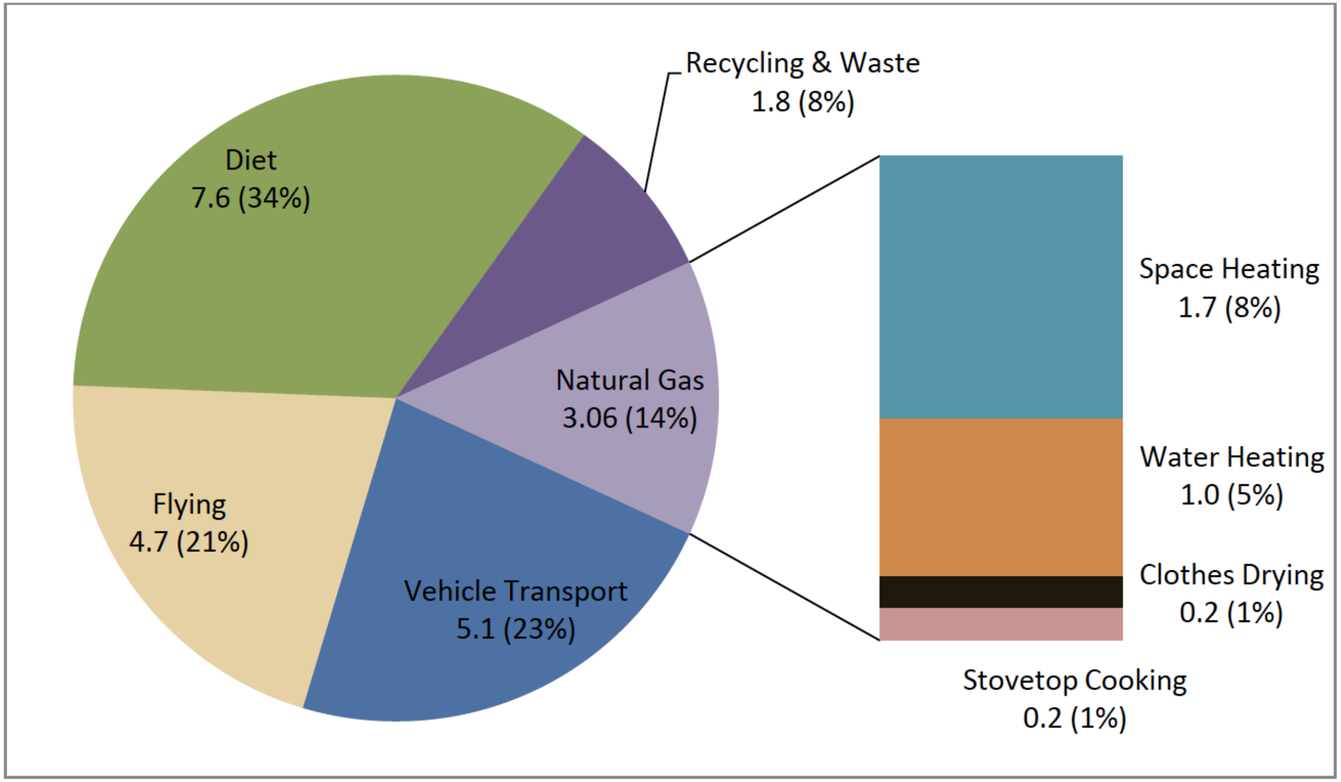
Sunday, February 9, 2020

In 2019, Palo Alto, California adopted a ban on natural gas connections in new construction

Gas network map of Palo Alto

Residential Electrification Opportunities in Palo Alto, CA

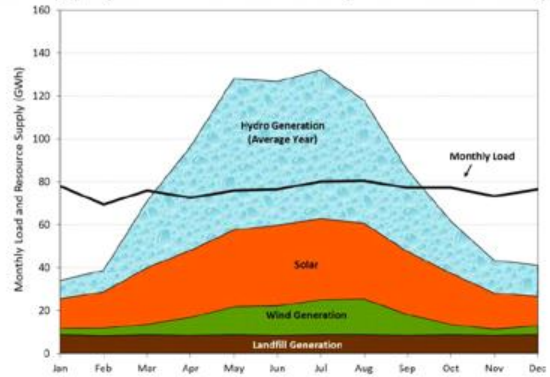
FIGURE 21: ESTIMATED ANNUAL HOUSEHOLD GREENHOUSE GAS EMISSIONS IN CO2 EQUIVALENT (MT)



Palo Alto Electricity is 100% Carbon Neutral on **Annual** Basis

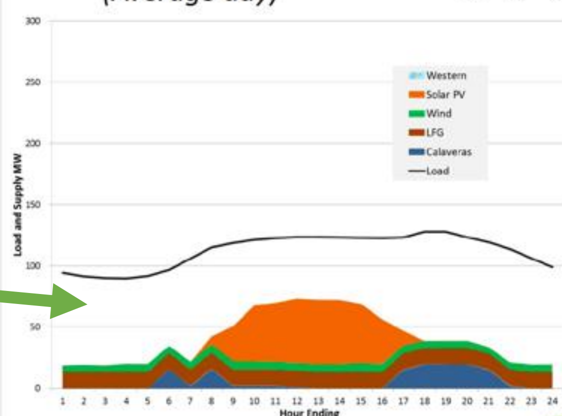
- Palo Alto's electric supply resources vary both hourly and seasonally

Monthly Totals →



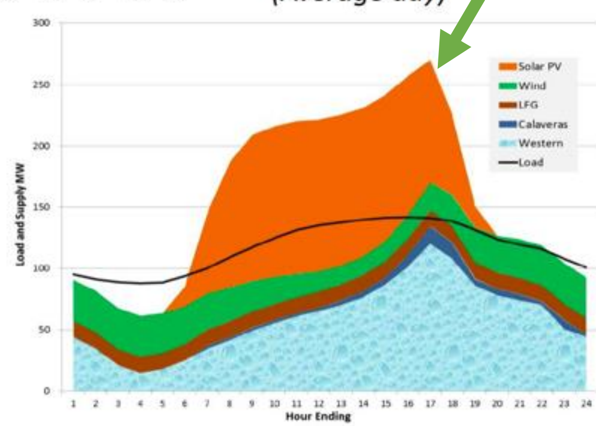
Overgeneration must be curtailed or sold

January
(Average day)



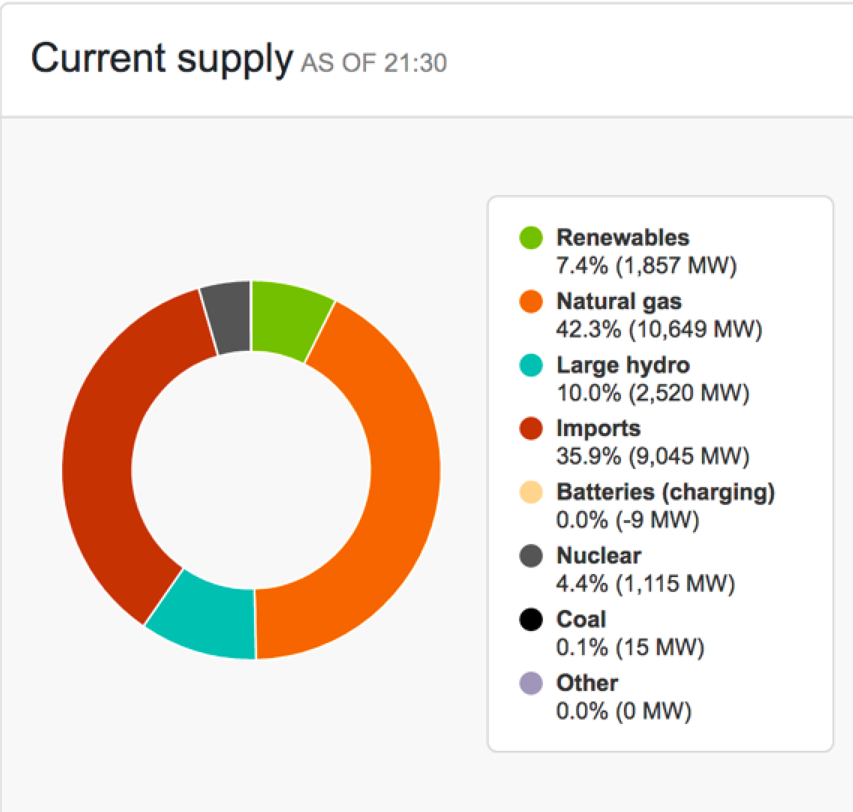
Natural gas and imports make up short fall

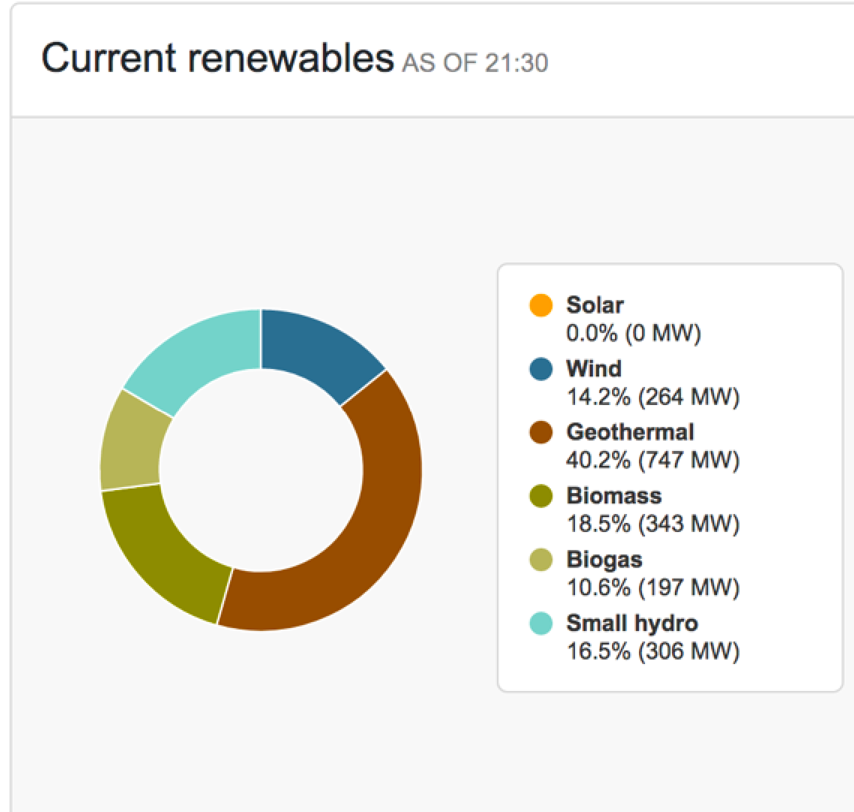
July
(Average day)



CITY OF PALO ALTO

Overnight Electricity Supply in California





CAISO November 22, 2019 9:35 PM

NARUC Winter Policy Summit

Staff Subcommittee on Gas

Sunday, February 9, 2020

NW Natural: Effectively Addressing Climate Change in the Pacific Northwest

Zach Kravitz, Director of Rates & Regulatory Affairs

February 9, 2020

NW Natural®

NW NATURAL OVERVIEW

- 161 year old gas utility serving, 2.5 million people through more than 750,000 meters
- Water utilities serve 46,000 people through 18,000 connections with several acquisitions pending

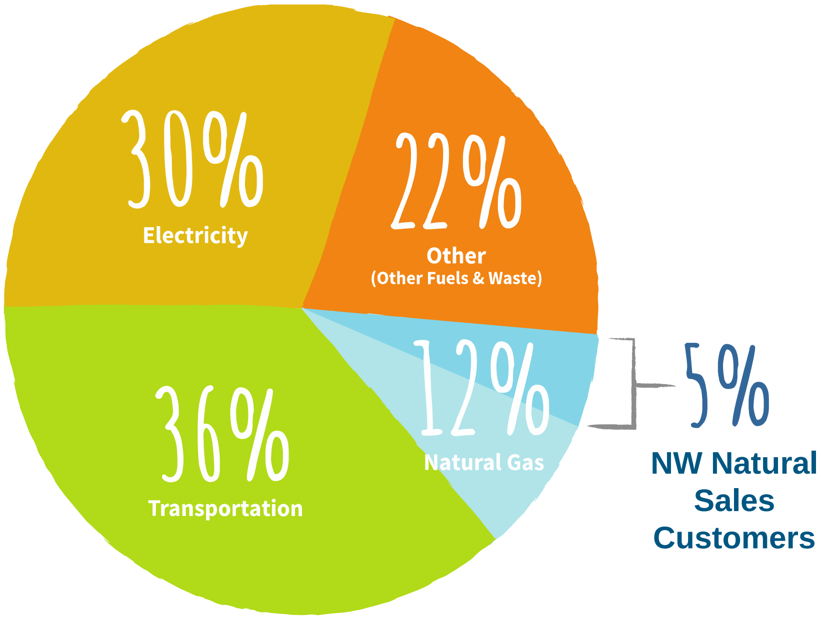
NW Natural HOLDINGS™

ROLE OF OUR SYSTEM NOW

NW Natural's System

- Delivers more energy than any other utility in Oregon
- Heats 74% of residential square footage in the areas we serve
- Provides 90% of energy needs for our residential space and water heat customers on the coldest winter days
- One of the tightest, newest systems in the country

Oregon Greenhouse Gas Emissions



Source: ODEQ In-Boundary GHG Inventory 2015

NW NATURAL SERVES 2.5 MILLION PEOPLE IN 140 COMMUNITIES

HOLISTIC VIEW IS NEEDED

Electrification of space heating is not an effective decarbonization strategy

- Roughly 2 out of 3 Oregonians rely on natural gas for home heating, yet it's 3% of greenhouse gas emissions
- E3 study analyzed how to serve buildings in 2050 and showed that leveraging our system is the least costly option[1]
- All pathways rely on natural gas to decarbonize by 2050.
- Do we leverage the billions of dollars in pipeline infrastructure or do we build new gas peaker plants?
- We can achieve deep decarbonization by changing the product in our pipes.

Bans would be ineffective

- There is no such thing as banning natural gas, not now and not for decades to come
- Up to 45% of natural gas use for Oregon annually is for power generation - and that's before the coal plants close
- Most citizens don't want bans, they want choice and a diversified set of solutions

We must look at energy system risks in evaluating solutions

- There is a serious capacity shortfall that's forecasted for the Northwest electric grid – with current loads
- Gas system is designed to serve winter; existing system already has 3x the peak capacity of electric grid

[1] E3 "Pacific Northwest Pathways to Decarbonization," http://lesswecan.com/what-were-doing/pathways2

OUR LOW-CARBON PATHWAY

VOLUNTARY GOAL: 30% CARBON SAVINGS BY 2035

Baseline: 2015 emissions associated with customer use

RENEWABLE NATURAL GAS (RNG)

- Closes the loop on waste –renewable fuel from organic waste streams
- Substantially reduces CO_2 – used directly in appliances or in vehicles
- Turns costly waste into revenue generator with resiliency benefits for cities

ODOE STUDY POTENTIAL: 48 Bcf

Equals All Oregon Residential Gas Use

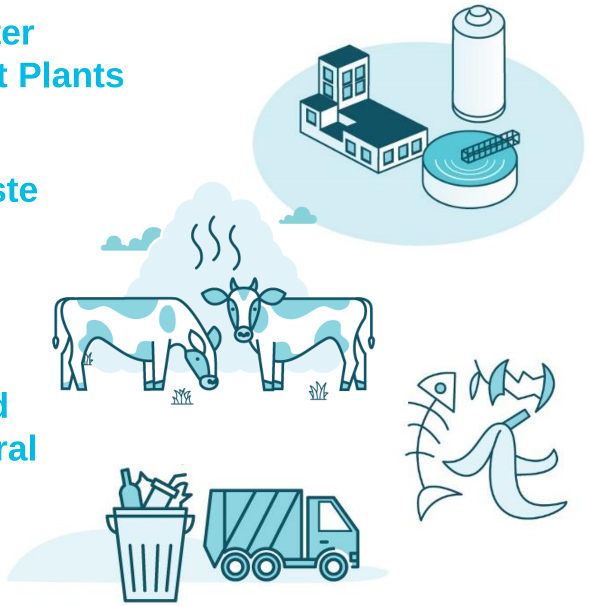
Wastewater Treatment Plants

Municipal Solid Waste

Landfills

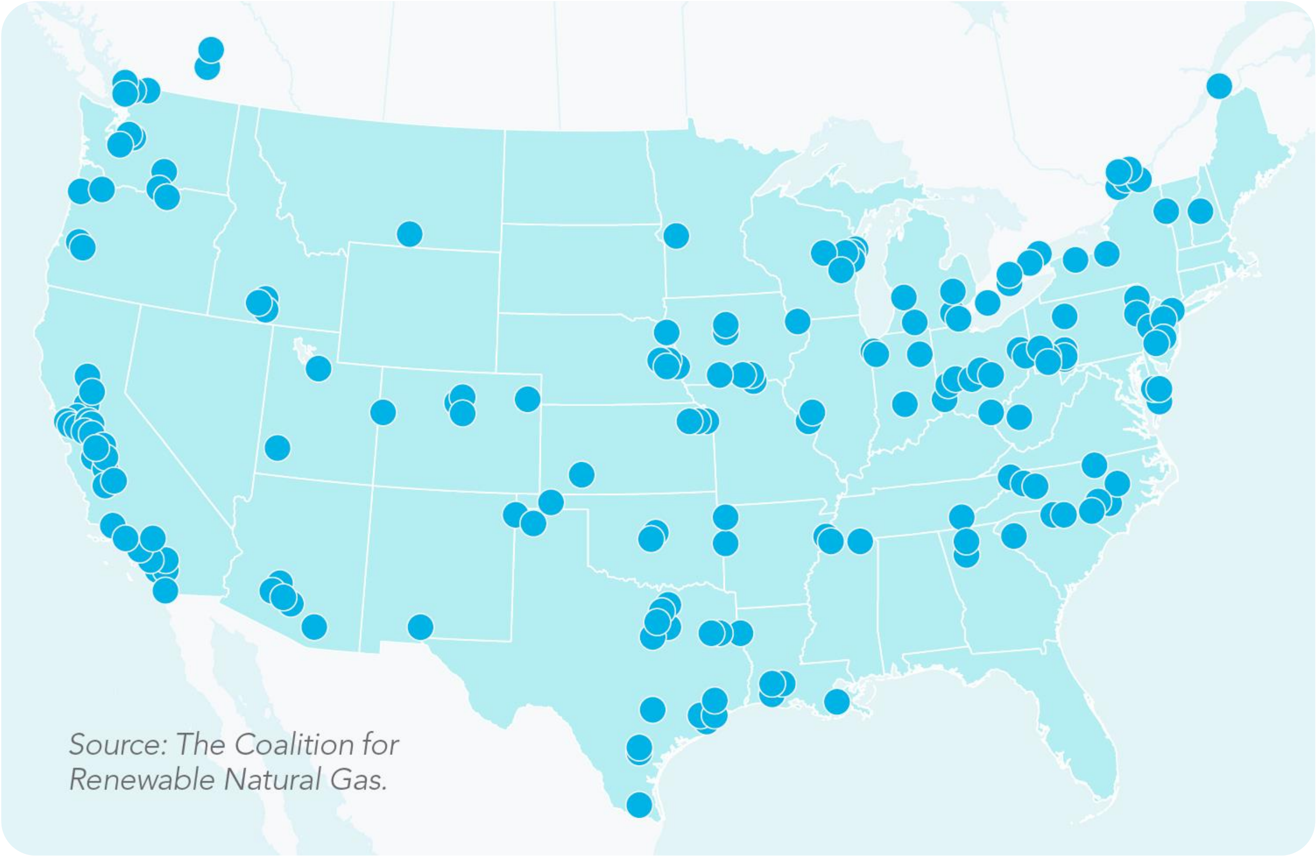
Dairies

Wood and Agricultural Residues



Turning the problem of waste into renewable energy.

FROM WASTE TO RENEWABLES



- 110 RNG facilities operating today in the U.S. and Canada
- Nearly 100 more are in development or under construction
- We are interconnecting 3 projects onto our system in 2020
- Several more in discussions

POWER TO GAS

Excess wind, solar or hydro converted to renewable hydrogen for use in our pipeline system

excess renewable energy → goes through electrolysis → which splits the molecule → hydrogen & carbon combine through methanization → methane can be stored in pipeline for future use

40+ projects in Europe

3 projects in North America

THANK YOU

NARUC Winter Policy Summit

Staff Subcommittee on Gas

Sunday, February 9, 2020