State Energy Strategy Revisions- Dublin Public Comment Session
Dublin Town Hall – October 18, 2017

Anne Huberman – Peterborough

- Secretary for Monadnock citizens climate lobby
- Energy plan as it stands is thoughtful
- OSI should add support for a carbon fee and dividend program to add hasten good things in plan.
- The proposal: fee is placed on carbon at source. $15 a ton, ups by $10 a year. Net fees are returned to households on an equal basis.
- Border tariffs added to countries without a tax on carbon
- Sends a clear market signal.
- 2014 plan recognizes all carbon fuels must be imported into the state.
- If OSI supported it, the congressional delegation would support it.

Sharon Malt – Peterborough

- Mothers Out front Monadnock, trustee of Conservation Law Foundation.
- Moms and grandmothers to ensure transition away from fossil fuels.
- Urges Governor Sununu to join Paris Climate Agreement. NH is one of 2 New England states that haven't.
- Self-sufficiency and energy independence are New Hampshire traditions.
- Urge Governor Sununu to act with children's future in mind.

Pat Martin –

- Mothers Out Front and Ready for 100. Ceding time to Phil Suter.

Phil Suter – Keene Chamber President

- Really good people in this room
- There is an increasing interest for developing a comprehensive regional strategy in Monadnock.
- As a business member, you will hear that energy costs are too high. That piece has not been connected to any of these recommendations.
- The energy you don't use is just as valuable as the energy you bring in. Energy efficiency is very important.
- It will be helpful to hear from the state that a transition to renewable energy is inevitable and is going to happen. Where is New Hampshire in that process? At the end of the line or the front of the line. We have opportunity to be bold.

Representative Marjorie Shepardson – Marlborough

- Was pleased when strategy came out.
- Wanted more measurable goals in the strategy. That could be added.
- Strategy is creating healthier land, creating jobs, and making our grid more resilient.

- PUC opened grid modernization docket based on recommendations.
- Promote energy efficiency.
- We were encouraged to add more distributed generation.
- Sb129 has allocated funds to help pay for solar.
- There is a lot more that needs to be done, we need to strengthen the program not weaken it.
- Use Volkswagen Settlement money for Electric Vehicle infrastructure
- Improve financing for energy efficiency.
- Strengthen RPS.
- Consolidate resources, maybe have an energy agency?
- Expand mass transit.
- Delete goal of trying to convert more people to natural gas. More renewables.

Peter Wotowiec - Langdon

- Farmer and a carpenter
- Standing up and discussing these issues
- Used to think thanks heavens for clean natural gas. Bridge fuel. Thank heavens for fracking. That is yesterday's way of thinking.
- Methane is a very potent greenhouse gas. Huge leakage through well heads and distribution system. Makes it as bad as or worse than coal.
- Fracked gas uses tremendous amounts of water. Precious resource. Creates a lot of pollution.
- Chemicals put into ecology. Makes the water that comes back out a hazardous waste.
- Need to stop promoting a dirty fuel. It's not helpful it's taken us backwards.
- Recommendation is not to promote gas.
- We need leadership.
- Plan looks good as is.
- Recognize these issues now

Douglas Whitbeck – mason NH

- The energy strategy in 2014 wisely recommends diverse portfolio.
- We need to avoid new fracked gas.
- Don't invest in fossil fuel infrastructure.
- Anything done to reduce peak demand saves us from having to invest in new gas infrastructure.
- Insurance companies recognize climate change, we should do.
- 2 million increase in health care costs from Kinder Morgan project.

Emily Manns – Peterborough

- Mothers out front, background in energy.
- Climate change approaching, no time to waste, hasten our move to modern sustainable economy
- Keep our energy payments here. Good for business ratepayers and citizens.

- Learned a lot since 2014. Local sustainable energy economy.
- Modernize the electrical grid
- Increase efficiency
- Protect ratepayers- long-term PPA's become stranded costs
- Keep energy payments in new Hampshire
- Claw back profits from market manipulation by Eversource. Find out what they've been doing and get that money back.

Dori Drachman – Peterborough

- Mothers out front.
- Co-housing community only in NH. They try to be as sustainable as possible.
- Would like to see NH be a leader in renewable energy it's not just for our children and grandchildren it's for us.
- No more infrastructure for fossil fuels. The bridge time is over. Another pipeline would commit us to a lifetime of fossil fuels. Their community would like to produce energy and sell to neighbors, but they can't. They want to make it easier to create a micro grid.

Kathy Conover – Alstead

- Monadnock region wants to move to 100% renewable energy.
- Keene has made great strides.
- Aging population in New Hampshire we hear about a lot. A green energy economy is the best thing to attract young workers and families.
- Works towards being a state that is the first in the nation to be 100% renewable.

John Kondos- Chesterfield

- Plan must acknowledge a warming planet based on carbon in atmosphere with severe consequences.
- Solar increases resilience. Strat must reduce risks and costs associated with fossil fuels.
- Must prevent stranded costs.
- No need for new natural gas.
- Must promote efficiency. NH ranks #21
- Offshore wind
- Keep NH money and investment in the state.
- Insist on us using a proxy price for carbon.
- Thankful that he's a retired solar contractor. NH is slowly strangling the solar industry and the industry is on thin ice. Rebate is gone and we are lagging behind our neighbors.

John Kieley – chesterfield

- Was at energy summit.
- Jeb Bradley summarized things his committee has done. Dan weeks added a pointed question asking if NH has less than .4 % energy coming from renewable sources. Bradley said don't worry it will go up to .7%.

- 2 consultants showed a map that some states have joined Massachusetts Clean Energy RFP and who is going out for bid. Tons of projects could be built in NH.
- Do we want to be at the front of the line or the end?
- The best sites are going to be taken and be sent to Massachusetts.
- Don't become the Houston of the east of energy production.
- The price we pay for fracked gas isn't only the air. It's the people who lose property to eminent domain.

Nancy Nolan – Dublin

- 40 people are here and not one is pro fossil fuels
- Live in solar home.
- Urge governor to promote renewables.
- Climate is rapidly degrading.
- Risks to ignoring scientists.
- Climate provides foliage, maple syrup, ski season, tourism.
- Suggestions: promote efficiency everywhere
- Prioritize Electric Vehicles
- Address climate change by making sustainability a consideration in all permitting.
- Do more offshore wind
- Halt fossil fuel infrastructure projects
- Stay in the Paris climate accord
- Stay in RGGI.

Josh Maua -Alstead

- Emphasize efficiency
- A lot can be done if you take it seriously

Jennifer Runyon -Peterborough

- Three points, things not to do
- Notice of proposed ruling from FERC to DOE – resilient grid propping up coal and nuclear
- Renewable energy is a job creator. She works for a media company that writes about renewables
- We should be investing in distributed energy resources.
- Look at micro-grids and offshore wind – look at floating offshore wind turbines

Liz Fletcher- Mason

- Mason conservation commission
- Strategy was quite decent
- Wind energy is competitive with natural gas with affordability. Level-ized rates in certain parts of the country. Gas is a loser.
- Solar price is also coming down quickly.

- National renewable energy lab sees solar price dropping. Energy plan must reflect changes like wind and solar. NH is dependent on gas for more than half of our energy.
- There are tremendous risks of stranded costs in new gas projects. Renewables have much less risk. Our state should do a rigorous analysis of natural gas.

Lisa Murphy – southwest region planning commission

- Monadnock region commission.
- We have a high cost of energy but it doesn't mean we should pursue all projects.
- The people of this region want clean energy. Several towns pursue municipal renewables and are attacking barriers to clean tech.
- Towns are getting many requests on how to get clean energy set up. We should use them as a resource as well as their regional plans
- Encourage transition to Electric Vehicles, listen to comments here tonight about renewables.

Kaela Law –Francestown

- Further emphasis on energy efficiency
- Factor in the towns master plans and use that as a consideration for new projects.
- Energy efficiency is a logical first step, no one fights it, and every one fights new projects

Bob King – Keene

- Professional engineer
- Recently went to Marco Island where hurricane made landfall. We have had 3 major hurricanes this year.
- Tell Governor Sununu to join Paris Climate Accord.
- PUC testifying that transmission costs are going up and driving up the cost of electricity.
- Behind the meter energy will help keep the transmission costs down, this is a fact.
- It's not the price per energy. It's the bill. Promote energy efficiency.
- If you are over a mw you can't net meter. These people get crushed by having to take wholesale energy.
- We need more than anything a carbon tax.

Olivia Wolpe –Dublin

- Has grown up in NH
- Embarrassed by the state.
- Lag in several areas. Education, technology, energy stuff, healthcare, gun laws,
- Find it baffling that these are discussions that are happening about science.
- Climate change is a repeated across political spectrum. Wants our governor to embrace this idea like people in small towns. Scared of governor Sununu "curveballing" this strategy.

Stephanie Schern – Fitzwilliam

- As an environmental educator, adults need to model to our young people how to behave and act. Right now they are doing that to us.
- Greenschools
- Governor Sununu's picture is on the wall. His wife has commended the schools on their work.
- She is concerned that he brought head of EPA to NH to discuss putting a pipeline through. Top comment to FERC is that people want renewable energy.
- Many people were disappointed that concord steam biofuel plant was allowed to close.
- No more giant infrastructure coming into this state destroying everything.
- Shouldn't have to come into competition with businesses.
- Other states are building beautiful communities for the future. State really needs to change its image. Pull up to standards of surrounding states.
- Put offshore wind in the gulf of Maine.
- Look where our state needs to go and take us there.
- Please make the right decisions.

Darrell Scott from mason

- Poor track record of maintaining our infrastructure. Pipelines leak, often catastrophically. Don't leave our grandchildren with this infrastructure.
- It's hypocritical to say we want solar and wind but not near us. We need to encourage people to have solar and wind in towns all over.
- Demand level - - we need to change the rate structure at the PUC.

Marjorie Shepardson

- We have 9% of the share of the energy grid. Other states demand is going down, decreasing. Ours is going up a little, because we don't do enough energy efficiency. Will save us money in the end.

(1)

SPEAKING SIGN-IN SHEET

Project:	Dublin Public Comment Session	**Meeting Date:**	10/18/17
Facilitator:	Office of Strategic Initiatives	**Place/Room:**	Town Hall

Name (Please Print)	Town/City
✓ Anne Huberman	Peterborough, NH
✓ SARA TIMMONS	Greenfield, NH 03047
✓ Sharon Malt	Peterborough, NH
✓ Terry Reeves	Peterborough NH
~~Rosemary Wolfe~~	~~Dublin NH~~
✓ DAVID Wolpe	Dublin
✓ Olivia Wolpe	Dublin NH.
✓ Pat Martin	Rindge NH
✓ Marjorie Shepardson	Marlborough, NH
✓ PETER WOTOWIEC	LANGDON, NH
✓ DOUGLAS WHITBECK	MASON, NH
✓ Emily Manns	Peterborough - NH
✓ Dori Drachman	Peterborough, NH
✓ TRISH STEFANKO (PATRICIA A)	LANGDON, NH
✓ Kathy Conover	Alstead, NH 03602
✓ John Kondos	Chesterfield, NH 03462
✓ John Kieley	Temple NH 03084
✓ Nancy Nolan	Dublin 03444
✓ John Mann (maybe)	Alstead

②

Speaking Sign-In Sheet

Project:	Dublin Public Comment Session	**Meeting Date:**	10/18/17
Facilitator:	Office of Strategic Initiatives	**Place/Room:**	Town Hall

Name (Please Print)	Town/City
✓ Jennifer Runyon	Peterborough, NH
✓ Liz Fletcher	Mason NH
✓ Lisa Murphy	SWRPC
✓ MARCIA KAYSER	KEENE
✓ Kaela Law	Francestown, NH
✓ Phil Suter	GKCC
✓ Bob King	Keene
✓ Olivia Wolpe	Dublin
✓ Stephanie Scherr	Fitzwilliam

③

SPEAKING SIGN-IN SHEET

Project:	Dublin Public Comment Session	**Meeting Date:**	10/18/17
Facilitator:	Office of Strategic Initiatives	**Place/Room:**	Town Hall

Name (Please Print)	Town/City
✓ Darrell Scott	Mason
✓ Marge Shepardson (2nd time)	Marlborough
✓ Pat Martin (2nd Time)	Rindge

5 FUEL DIVERSITY

Like other states in the Northeast, New Hampshire has limited energy resources of its own, importing most fuels used in the state. As the sources and supply chains for these fuels become increasingly global, the state has seen volatility in both price and supply. The New England region is even more susceptible to these volatile conditions because it is at the end of fuel distribution networks. As demand for all fuels increases on a global scale, these challenges are not expected to ease, and prices are predicted to continue increasing. As a result, there is a need for focused efforts to reduce New Hampshire's vulnerability to price volatility and supply disruptions, and increase our flexibility and resiliency. Diversifying our fuel portfolio and increasing the use of in-state resources will be critical tools in achieving those goals, in combination with increased efficiency. Better utilizing New Hampshire's in-state resources will also provide an important economic boost, as more energy dollars are retained in state rather than spent on imported fuels, and the industries associated with building and installing systems that use these resources create local jobs.

This chapter makes recommendations for action to achieve New Hampshire's energy goals related to diversity, fuel choice, and increasing energy independence.

5.1 NEW HAMPSHIRE'S RPS PROGRAM

Given that all of New Hampshire's in-state energy resources are renewable, the most effective policy to increase deployment of those resources could be one that already exists—the Renewable Portfolio Standard (RPS). The RPS was established in 2007 as a tool to increase the use of renewable energy for producing electricity and to protect and enhance fuel diversity.[103] The RPS requires that electric service providers, including distribution utilities and competitive suppliers, must acquire a certain percentage of supply from renewable energy sources. In total, 25% of electricity sold to retail electric customers must be generated by renewable energy sources by 2025. Under the NH RPS structure, applicable renewable energy sources are organized into four classes:[104]

- Class I: New (after 2008): wind; hydrogen derived from biomass fuel or methane gas; ocean thermal, wave or tidal energy; methane gas; or biomass. Thermal energy from biomass, solar, and ground source heat pumps (geothermal) was recently added to this class.
- Class II: New solar electric (PV) generation.
- Class III: Existing biomass or methane facilities that meet air emission criteria.
- Class IV: Existing small hydroelectric facilities that meet fish passageway criteria.

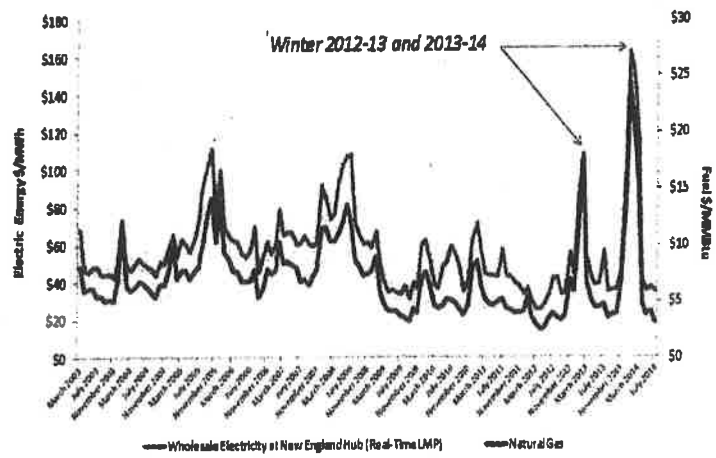
FROM DOUGLAS WHITBECK
MASON, NH
DWHITBECK
@HOTMAIL.COM

The *real* story behind utility rate hikes

Electric market policies and practices manufacture price spikes

- **ISO-NE chose a policy that would cause price spikes.** For the winter of 2013-14, ISO New England – the region's electrical grid manager – did not support using liquefied natural gas (LNG) to keep winter gas and electricity prices down; ISO-NE sought to avoid a solution that ***"would lower gas prices and send the wrong signal about the relative scarcity of natural gas."***[1] Instead, ISO-NE promoted the use of expensive oil reserves.
- **ISO-NE overstates the need for additional electricity supply.** In fact, "ISO-NE ... ignores its [own] interim, conservative forecast of hundreds of MWs of solar PV projected to come on-line in the next three years. ... By excluding these resources from [ISO's] calculation, ***consumers are paying for unneeded future capacity***".[2]
- **Electric generators buy natural gas on the spot market.** Unlike home heating companies that buy gas under longterm contracts, power companies subject themselves to the daily fluctuations of the market, and high prices get passed on to the consumer.

Over-Reliance on Natural Gas is Making Price Fluctuations Worse

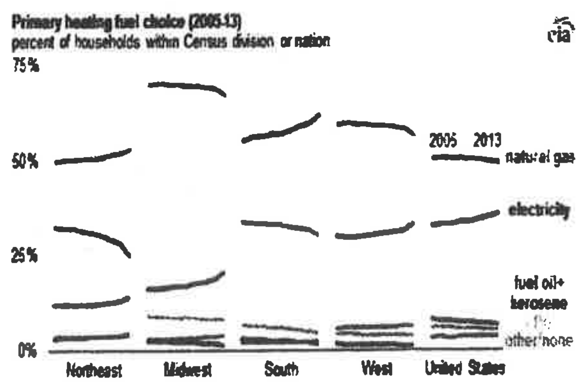


About 67% of the electricity used in MA is from natural gas, up from about 40% just six years ago. (Boston Globe)

- Heavy reliance on this single fuel source subjects electric ratepayers to natural gas market volatility – wholesale electric prices in New England closely track natural gas prices (see chart at left from ISO-NE).
- Better management of existing pipeline capacity through market reforms could reduce this price volatility.

Fewer homes are choosing natural gas as a heating source – except in the Northeast. (US EIA)

- State policies that incentivize switching to natural gas should be eliminated.
- New high-efficiency heat pumps are now available that work in New England winter conditions (Boston Globe); new grants help make the initial investment more affordable.



massPLAN
Massachusetts PipeLine Awareness Network

Full Citations available at www.massPLAN.org

[1] ISO New England, June 28, 2013, p.7.
[2] New England States Committee on Electricity, October 3, 2014.

New Gas Pipelines Could Cause Prices to Rise.

- Kinder Morgan has not and cannot promise that their pipeline would result in lower prices.
- While natural gas is cheap now, a number of factors make an increase in prices likely:
  - ***Export:*** The proposed pipeline would link up to Canadian LNG export facilities. Export would subject domestic wholesale gas purchasers to global markets, where prices are 2-5 times higher.
  - ***Gas supply is not limitless:*** Estimates of available shale gas have revised downward; many people believe we are experiencing a "shale gas bubble", and prices will rise dramatically when it becomes clear that we are running out of drillable gas.
  - ***Regulation:*** The fracking industry is becoming more regulated with measures to protect human health, the local environment and the climate; this will increase production costs.

How do we replace power plants that are being retired? *Policy decisions made now will shape how New England is powered for decades to come.*

- Ending the reign of nuclear, coal, and oil plants is a positive step, but replacing them with natural gas creates more vested interest in fossil fuels and gets in the way of renewables.
- Many old plants are mostly used only 10-40 days a year; ***peak*** energy needs can be met with other energy sources and market reforms for better utilization of existing pipeline capacity.
- Not all of the coal, oil, and nuclear energy sources retiring need to be replaced; there are cost-effective solutions to ***reduce*** the need – e.g., energy efficiency measures now being deployed in Massachusetts are projected to eliminate the need for 1,200 MW of capacity. (EEA, p.3)
- Renewables are now economically competitive with gas; the cost of utility-scale solar has dropped 78% in the past five years; renewable energy storage is rapidly improving.
- The Massachusetts Department of Energy Resources is analyzing cost-effective alternatives to pipeline expansion in a study due to be released in December.

What you can do about your utility bills now:

- Contact MassSave for a free energy audit and information about available rebates on energy efficient appliances, insulation and weatherization.
- Swap in LED lightbulbs wherever you can – they are now available at low cost (and MassSave gives them away with their audits).
- Save on heating oil though the Mass Energy Consumers Alliance Discount Heating Oil Service (available regardless of your income level).
- If you will struggle to pay for heating this winter, apply for fuel assistance.

Other ways to fight the push for more gas pipelines as a consumer:

- Change how you power and heat your home: Photovoltaic systems are more affordable than ever; high efficiency heat pumps use far less energy than traditional electric heat; micro wind and geothermal are good options for some locations – just don't switch to gas!
- Sign up for Mass Energy's New England GreenStart Program so that you are supporting renewable energy sources every time you pay your electric bill.
- Join your town's energy committee; help your town become a Green Community. The Green Communities Designation and Grant Program helps municipalities navigate and meet the five criteria required to become a Green Community, in turn qualifying them for grants that finance additional energy efficiency and local renewable energy projects.

ENE Comments to the New Hampshire State Energy Advisory Council on Policy Prioritization

March 28, 2014

ENE is a non-profit organization that researches and advocates innovative policies that tackle our environmental challenges while promoting sustainable economies. ENE is at the forefront of efforts to combat global warming with solutions that promote clean energy, clean air and healthy forests.

ENE thanks the Energy Advisory Council for the opportunity to present our recommendations for policies that will help New Hampshire achieve its energy vision for 2025. The policy prioritization process is an important step in developing a coherent, deliberate, and comprehensive energy policy for New Hampshire. We present key policies for each of the three sectors: electric, thermal and transportation.

I. ENE's Electricity Sector Strategy Recommendations

Energy Efficiency

Expanding energy efficiency for all fuels – electric, gas, and oil customers – will deliver multiple benefits to New Hampshire. Strategic investments in energy efficiency help reduce consumer and business energy costs while avoiding greenhouse gas emissions. In addition to lower energy bills, reduced energy demand means less money leaving the state to import carbon-intensive fossil fuels. Energy efficiency investments generate significant local economic benefits, including increased Gross State Product and thousands of new jobs.[1]

New Hampshire should adopt multi-year energy savings targets for the utilities' customer energy efficiency programs. Electric and natural gas savings targets should be established on a statewide basis, and be subject to approval by the Public Utilities Commission (PUC). Utility program administrators would be required to meet the targets. Multi-year targets provide greater market certainty for sustained energy efficiency investments. The charts in Figure 1 and Figure 2 depict the multi-year energy savings goals in place in Massachusetts and Rhode Island.

Multi-year targets should be complemented by a requirement for utilities to procure all cost-effective energy efficiency that is less expensive than supply. Energy efficiency investments deliver real energy savings that can displace generation from supply-side resources. An all cost-effective efficiency requirement would require the utility to consider all available energy resources, including energy efficiency, and to invest in efficiency whenever it is cheaper than traditional supply. Energy efficiency can also play an important role in addressing grid reliability and high fuel prices. Regional electricity prices closely track natural gas prices, thus escalating natural gas prices and pipeline constraints affect both electric and natural gas customers. Energy efficiency is a resource that can be quickly deployed to reduce system price and reliability challenges, and can be targeted to specific geographic areas to defer expensive system upgrades and lessen seasonal peaks.

[1] http://www.env-ne.org/resources/open/p/id/964

Figure 1. Massachusetts Electric Energy Savings Targets[2]

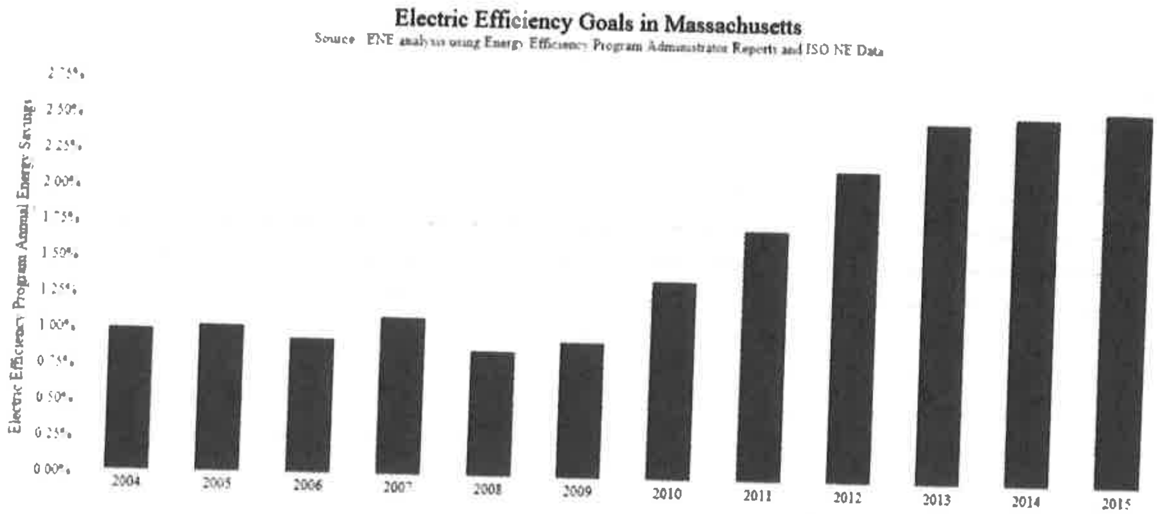
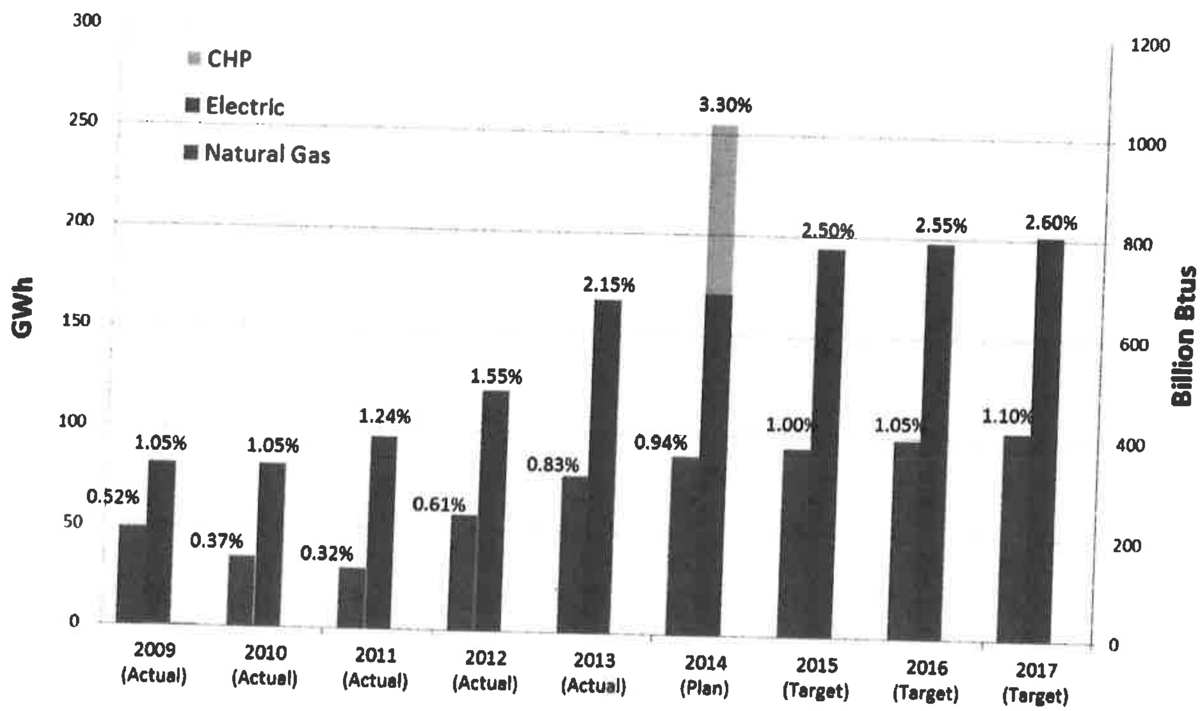


Figure 2. Rhode Island Electric, Natural Gas, and CHP Energy Savings Targets[3]



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[2] http://eneclimatevision.org/policy-successes/energy-efficiency-investments

[3] "2015-2017 Savings Targets Recommendations" presentation by the Rhode Island Energy Efficiency & Resource Management Council, Rhode Island Public Utilities Commission Technical Session, February 25, 2014.

Financing mechanisms should not be considered standalone alternatives to comprehensive energy efficiency programming. Property Assessed Clean Energy (PACE) funding, revolving loan programs, and other financing vehicles are a complementary element of comprehensive energy efficiency programs. Financing alone will not capture all cost-effective energy efficiency, and will not deliver the same results as well-designed energy efficiency programs.

ENE recommends establishing a stakeholder council to oversee and guide the development of statewide energy savings targets, and ensure the program administrators are pursuing all cost-effective energy efficiency that is cheaper than supply. The stakeholder council would not diminish the authority of the PUC, but would rather serve as an advisory body throughout the planning and implementation phases. The stakeholder council would include key parties who are engaged in energy policy in the state. Ideally, council decisions would be consensus-based and informed by objective analysis. Three states at the top of the American Council for an Energy-Efficient Economy's *2013 State Energy Efficiency Scorecard* – Massachusetts (#1), Connecticut (#5), and Rhode Island (#6) – have efficiency stakeholder councils in place.

New Hampshire should explore revenue decoupling mechanisms that eliminate the utilities' financial incentive to promote electric and gas sales, to make them stronger allies in promoting efficiency.

New Hampshire should adopt the most recent edition of the International Energy Conservation Code (IECC) for residential and commercial buildings. In addition, ENE recommends a legislative requirement to adopt each new IECC edition within one year of its publication. Updated on a three-year cycle, each new edition of the IECC builds upon the efficiency requirements of the prior version. The 2012 IECC is approximately 30% more efficient than the 2006 IECC edition. The 2015 IECC raises efficiency requirements by 45-50% over the 2006 IECC.[4]

Extending and Expanding Support for Renewable Energy

Cleaning up New Hampshire's energy supply will reduce greenhouse gas emissions, improve the stability and sustainability of the current energy system, and promote jobs and economic development in the state and region. Supporting both grid scale and distributed renewable energy through incentives and policies will reduce air and water pollution and enhance price stability by reducing exposure to volatile fossil fuel prices.

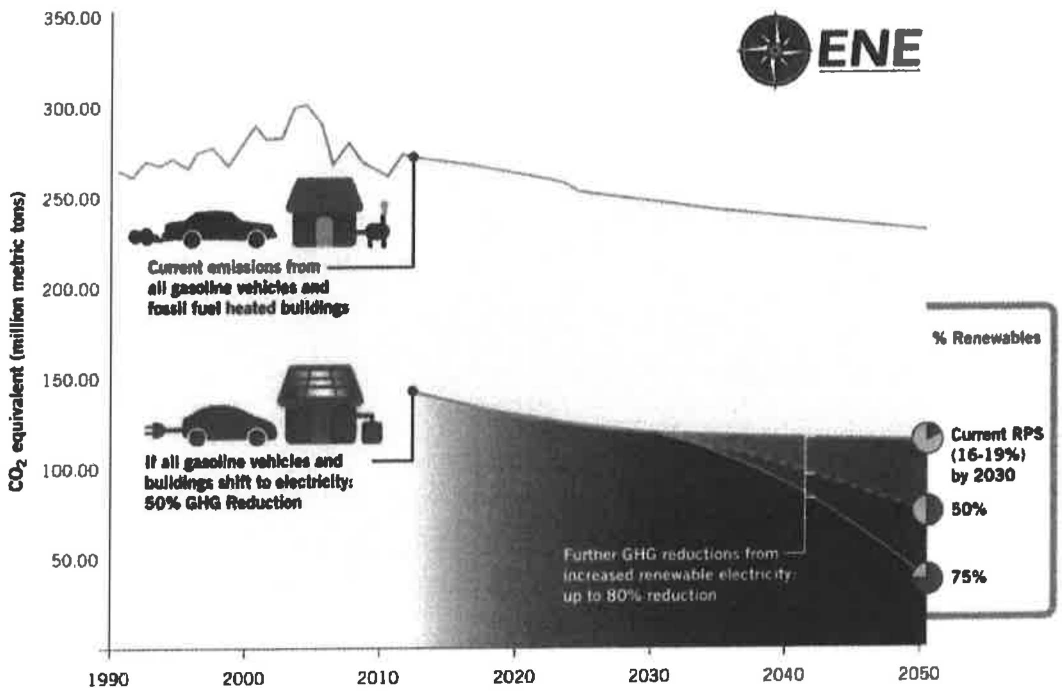
New Hampshire's existing renewable portfolio standard (RPS) should be extended and expanded from current requirements in order to provide financial support for sustainable, low-carbon power sources that can help the state meet climate targets while promoting economic growth. In order to provide clarity to investors, RPS targets should be increased to at least 75% renewable energy by 2050, with potential revisions to 2025 and other interim targets to support the 2050 goal.

Advanced consumer technologies that are increasingly available to provide heat and transport to New Hampshire citizens will increase the state's reliance on electricity to meet a growing share of its energy needs. Electric vehicles operate at greater efficiency and lower cost than gasoline-powered vehicles, and produce fewer GHG emissions. Air sourced heat pumps are capable of heating and cooling buildings at lower cost to consumers and the climate. While electrification in and of itself will help reduce GHG emissions from the heat and transport sector, supplying a greater percent of New Hampshire's electricity from clean generation sources will be needed to meet greenhouse gas (GHG) reduction goals. If

[4] U.S. Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program. "Building Energy Codes – IECC 2012 and Beyond." http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/ns/webinar_residential_energycodes_20110222.pdf

renewable thermal technologies are supported through the RPS, heat pumps should also be allowed to generate credits. Realizing the full GHG reduction benefit of electric vehicles and heat pumps will require that electricity supply come from clean power sources. If 75% of electricity supply is provided by renewables, GHG emissions from cars and buildings in the region would drop by 80% (see Figure 3) and help the state meet its GHG reduction goals.

Figure 3: GHG Emissions Benefit Achieved by Supplying Renewable Power to Electric Vehicles and Heat Pumps



Economy-wide Carbon Pricing

A market-based mechanism that puts a price on carbon will spur innovation and drive a cost-effective transition to a more sustainable, low-emissions future. New Hampshire should build on the successful Regional Greenhouse Gas Initiative (RGGI) to extend carbon pricing across the state economy in order to capture least-cost emissions reductions and support the transition to a sustainable energy system.

Market-based environmental programs achieve outcomes at lowest cost by leading businesses and consumers to account for the societal cost impacts and adjust behavior accordingly. Under RGGI, emissions across the region have dropped significantly since the program was launched, even as electricity prices dropped (coming down by 8% from before the program launched in 2008 to 2012[5]). Extending RGGI beyond the power sector or establishing a carbon tax in other sectors of the economy would create incentives to reduce emissions, while at the same time raising revenue for the state to cut taxes or invest in additional emissions reductions.

Markets are able to react quickly and can deliver reductions in pollution cost-effectively. If revenue from carbon pricing is returned to consumers or invested in energy efficiency, carbon pricing can also

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[5] See ENE Emissions Trends Report at: http://www.env-ne.org/public/resources/ENE_RGGI_Past__Future_121210.pdf

promote economic growth – particularly in states like New Hampshire that do not produce fossil fuels. For example, since establishing a revenue-neutral carbon tax in 2008 British Columbia's consumption of fossil fuels has dropped faster than the rest of Canada, without damaging the Provincial economy. British Columbia was also able to reduce income taxes to the lowest level in Canada,[6] though revenue could also be used to lower sales taxes or other taxes. Investing carbon revenue in energy efficiency could create even greater benefits, as consumer savings on energy bills are reinvested in the local economy. Independent analysis found that New Hampshire's investment of RGGI revenue in energy efficiency over the program's first 2.5 years of operations will generate $17 million in net benefits over ten years.[7]

Reforming the Electric Grid

The transmission and distribution (T&D) planning and investment policies that exist today in New England were developed in a different era, when large fossil-fueled power plants were constructed to energize the region's population centers. Electric T&D planning and cost allocation has not kept pace with changes in energy technologies and environmental and consumer goals. While the New England states have set aggressive targets for meeting our energy needs with demand-side resources- including energy efficiency, demand response, distributed generation, and combined heat and power- the outdated processes used to determine new grid investments are barriers to pursuing and integrating clean energy resources. Realizing the potential of new technologies, strategies and tools that help consumers control energy use, such as time-varying rates and advanced meters, and technologies that help the utility manage the grid system, such as energy storage and clean distributed generation, will require a new way of thinking about the grid. The goal is to transform the grid from a centralized network run by the electricity producers, distributors, and system operators to a more decentralized consumer interactive network. A smarter system would be better able to take advantage of energy efficiency, clean distributed resources, and energy storage (including electric vehicles) to meet our energy needs. The challenge is to construct a system that facilitates development of new clean heat and power sources, energy efficiency, and electric vehicles through policy and planning reform at the state and regional levels to maximize consumer value and environmental benefit.

In ENE's vision of the modern grid system, the home and business are the centerpieces of the energy system. Consumers will have greater control over energy use within and around buildings through technologies such as rooftop solar water heating and photovoltaic systems, advanced meters that help consumers control and monitor power usage, and technologies such as smart appliances, heat pumps, and electric vehicles that can help power the home or office when not being driven. Community energy systems will also play an important role in a decentralized power grid. Energy efficiency is a "first resource" through targeted deployment that offers a cost-effective alternative to building more poles and wires to supply additional power.

The modern grid should have the following characteristics:

- Fully integrated, flexible, low carbon energy network
- Smart and dynamic electric system
- Widespread clean energy supply, distributed generation, deep energy efficiency
- Increasingly electrified buildings and vehicles
- Incorporation of new, customer-side energy resources

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[6] Based on analysis of data from Statistics Canada by Professor Steward Elgie, see: http://www.sustainableprosperity.ca/article3685

[7] Analysis Group, 2011, *The Economic Impact of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States*, available at: http://www.analysisgroup.com/rggi.aspx

- Consumer-centered system
- Connecting to local, distributed generation
- Incentives for off-peak consumption
- Homes and businesses as micro-utilities
- Efficient, clean technologies
- Two-way power flow for distributed generation and electric vehicles
- Rates that incentivize energy efficiency, conservation, load shifting
- Infrastructure that supports energy efficiency, DG, storage, vehicles
- Energy efficiency, DG, EVs, etc. utilized as grid resources

Existing regulatory policies for grid planning and financing risk perpetuating the status quo. To achieve this future, existing policies and rules at the state and regional levels need significant reform in the following areas:

Planning barriers- *current planning processes fail to include non-transmission alternatives*

- Existing T&D planning processes largely ignore the proven ability of non-transmission alternatives (i.e., energy efficiency, demand response, distributed generation, storage) that would help forestall and/or avoid construction of new transmission and distribution lines
- The existing planning process also does not account for the likely impact of new advanced electric technologies on the grid, and strategies for grid modernization that would minimize any adverse impacts.
- Planning process is reactive and primarily focused on traditional utility solutions.
- Incongruity of a regulatory model for traditional "poles & wires" solutions and market model for non-wires solutions has resulted in an un-level playing field for new technologies and resources.
- Planning mindset is focused on long-lived, predictable assets that are part of a centrally-controlled network.
- Current planning schedule is often too late for the incorporation of non-traditional solutions; however some states, such as Maine and Vermont, have taken steps to ensure that non-transmission alternatives are examined in a timely fashion.

Cost allocation barriers- *current regulatory framework creates an un-level playing field*

- Utilities and transmission companies are able to earn a higher return on equity for traditional poles & wires solutions, but non-transmission alternatives are not eligible for the same return.
- Regional rules on the cost allocation of new transmission infrastructure significantly disadvantages non-transmission alternatives because the costs of new wires are divided among the ratepayers of all of the states based on the state's contribution to the ISO-NE load, while the cost of non-transmission alternatives are spread over the ratepayers of the individual state in which the project is located.
- State regulators determine whether distribution utilities receive cost recovery and a return on equity for distribution-level system investments. The utility has the burden of proving that investments are prudent, valuable, used, and useful.
- Utilities, seeking to retain a familiar level of financial risk, will not adopt new technologies or strategies for modernizing the grid until state regulators clarify and

establish clear guidelines for determining whether utilities can recover investments in new technologies/strategies.

- Regulators point to uncertainty about costs, benefits, and risks.

ENE recommends that New Hampshire enact policies to modernize the grid that achieve the following:

1. Utilities should be provided clear incentives (e.g., revenue decoupling mechanism) to promote and prioritize energy efficiency, renewable energy, combined heat and power, and demand response strategies over traditional transmission and generation.
2. Reward utilities for taking a coordinated approach to improving the efficient use of the distribution system, including providing capacity for strategic electrification of buildings and transportation.
3. Ensure that investments in advanced metering infrastructure maximize consumer benefits from energy efficiency, distributed generation, demand response, load management and automation, and electric vehicles.
4. Reward utilities for deploying high-value, targeted non-transmission alternatives to provide capacity on the transmission and distribution network, potentially deferring or avoiding costly infrastructure upgrades.
5. Ensure that utilities support and are equipped to receive and deliver net-metered energy on a large scale, including stored power from electric vehicles. Utility planning processes must anticipate the impacts to the grid of consumer engagement with energy efficiency and distributed generation resources.

II. ENE's Thermal Sector Strategy Recommendations

Natural Gas

ENE recommends that before any natural gas expansion is considered in New Hampshire, all alternatives are explored, including installation of air source heat pumps and/or solar PV combined with efficiency. Any expansion of natural gas infrastructure should be incremental and cost-effective. Expansion of distribution should take a 'near main' approach as it reflects an efficient strategy of expanding with only low capital investment. Consideration should also be given to requiring coordination of any natural gas conversions with NH's greenhouse gas emission reduction goals and ongoing energy efficiency efforts. ENE believes that increasing natural gas usage will conflict with state goals to reduce carbon pollution.

Thermal Efficiency

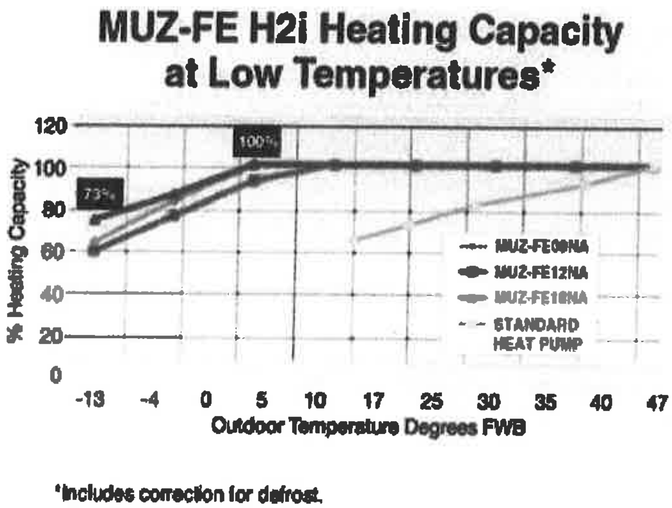
ENE supports analyzing an expanded energy efficiency future that includes heating oil and other delivered fuels, including propane and kerosene. Energy efficiency, especially improving the efficiency of the building envelope through weatherization, should be the first choice of every home owner and business since it is the least expensive option to reduce home heating bills, and avoids the need to purchase imported, carbon-emitting fuels. Considerable environmental and macroeconomic benefits will accrue to New Hampshire and its residents and businesses by giving comprehensive, all-fuels energy efficiency top policy priority.

ENE recommends designing incentives and rebates to support adoption of energy efficiency improvements to both heating equipment, the building envelope and clean heating technologies such as air source heat pumps to overcome the barrier of upfront cost of weatherization, equipment upgrades, and replacing existing heating systems.

Renewable Thermal

New Hampshire's support for renewable thermal technologies through the RPS creates an important incentive for the adoption of technologies that can reduce energy costs and greenhouse gas emissions, and air source heat pumps designed for cold climates should be included with other technologies eligible to generate credit under the RPS. Heat pumps are advancing rapidly and are increasingly able to operate at extremely low temperatures in the northeast. Whereas natural gas and oil systems have a maximum potential efficiency of 100%, heat pumps are already 200% to 400% more efficient than combustion technologies – even in Northeast winters – and the efficiencies are likely to continue improving (see Figure 4 below)[8]. HPs are able to achieve this efficiency because they move heat from outside a building to inside rather than directly create it from another energy source.

Figure 4. Heating capacity for advanced heat pumps



Cold climate air source heat pumps (ccASHPs) are furthermore capable of being installed in buildings at fairly low costs, and are more widely applicable than some other renewable thermal technologies. Specifically, ccASHPs do not require the land or vertical drilling of ground source heat pumps, and can thus be installed at lower cost. Additionally, ccASHPs are ductless and require no modifications to existing oil, gas, or propone heating systems, but can significantly offset use of these more expensive heating fuels.

III. ENE's Transportation Sector Strategy Recommendations

The current transportation system is unsustainable. The transportation sector is the second largest source of U.S. GHG emissions, responsible for 28% of emissions nationally, and nearly 40% in Northeast and Mid-Atlantic states. In New Hampshire, transportation is responsible for 41% of emissions. Additionally, the current transportation system is almost entirely dependent on gasoline and diesel,

[8] Available at: http://www.mitsubishipro.com/media/382145/m-series_revised_july13.pdf

resulting in a transfer of wealth from New Hampshire to other regions and countries. Electrifying the transport sector will also save drivers money. At recent electricity and gasoline prices, the fuel costs of a battery-electric vehicle like the Nissan Leaf are approximately 65 percent lower than the fuel costs of a conventional medium sedan.[9] Shifting a greater portion of driving to electric vehicles will reduce our total expenditure on transportation fuels and slow the flow of wealth out of the state.

The suite of policies and actions outlined below can begin the process of bringing additional choice to consumers and speeding the transition off of petroleum-based fuels.

Establish 2025 Target for Electric Vehicles

Electric vehicles (EVs) provide significant reductions in greenhouse gas emissions compared to existing vehicles on the road. Replacing only ten percent of the 600,000 conventional automobiles in New Hampshire with electric vehicles could reduce New Hampshire's greenhouse gas emissions by nearly a quarter of a million tons with the current electricity mix.[10] As we continue to clean our electric sector over the coming decades, the greenhouse gas benefits of electric vehicles will increase and can represent a substantial percentage of the proportional reductions from the transportation sector.

Provide Consumer Incentives to Accelerate EV Adoption

Electric vehicles purchased in or after 2010 may be eligible for a federal income tax credit of up to $7,500.[11] New Hampshire should capitalize on this by further reducing costs to encourage electric vehicle adoption. Other states, such as Massachusetts and California, have enacted financial incentives for EV buyers that could serve as models. New Hampshire should:

1. Establish a long-term rebate program for qualified electric vehicles, with a framework for determining rebate levels as battery costs change over time.
2. Exempt charging equipment and relevant electric vehicle parts from the state excise tax.

Regulatory Framework to Maximize Benefits of EV Adoption

Public utilities commissions need to make structural reforms to ensure that electric vehicles are integrated into the electric system in a manner that enhances system reliability, minimizes costs, and protects consumers.

1. Establish and publicize mechanisms to incentivize EV owners to charge vehicles during low-cost off-peak periods. These mechanisms may include, but not be limited to, time-varying electricity rates.
2. Adopt rules that encourage utilities to support the integration of electric vehicles into the electric grid to increase asset utilization, load management, and energy storage.
3. Integrate electric vehicles into short and long term distribution-level system planning and load forecasting. Provide for reporting of EV charging station location and capacity and direct the registry of motor vehicles to share EV registrations with the electric distribution utilities.

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[9] ENE analysis assumes gasoline price of $3.63 per gallon of gasoline and $0.15 per kWh of electricity. The conventional vehicle fuel efficiency (miles per gallon) and electric efficiency (kWh/100 miles) from U.S. DOE. Fuel efficiency of the "medium sedan" category is the average of MY 2012 Chevrolet Impala, Ford Fusion, Honda Accord, Nissan Altima, and Toyota Camry. Available from: http://www.fueleconomy.gov/.
[10] Based upon reductions per vehicle shown in Chart 2.
[11] The Internal Revenue Service maintains an index of qualified electric drive motor vehicles eligible for the federal tax credit. Available from: http://www.irs.gov/Businesses/Qualified-Vehicles-Acquired-after-12-31-2009

4. Require electric utilities to provide consumer education on electric vehicle charging rates and costs of residential charging infrastructure installation.

Facilitate Build-out of EV Charging Infrastructure

A significant build-out of electric charging infrastructure is needed to support widespread electric vehicle adoption. New Hampshire can facilitate deployment by providing guidance and standards for infrastructure site selection and integration of charging infrastructure into the built environment:

1. Establish targets for charging infrastructure to accommodate the electric vehicle target.
2. Develop statewide guidelines for public electric vehicle charging stations that inform technical design and optimal site selection to serve diverse consumer groups.
3. Clarify that 1) non-utilities are allowed to own and operate EV charging stations, and 2) all owners of EV charging stations will be able to purchase electricity on fair terms.[12]
4. Make charging costs easily visible in a format understandable to consumers and prohibit member-only public charging stations.
5. Require state and local building code officials to implement standards related to electric vehicle charging and provide expedited inspection of home charging infrastructure.
6. Recommend standardized signage for use by cities and towns to identify EV parking and charging locations.

Lead by Example

New Hampshire can accelerate transportation electrification and prime the market for vehicles and infrastructure by committing to electric vehicle usage and providing guidance and incentives for municipalities.

1. Establish a yearly minimum percentage of electric vehicles for state fleet purchases and increase the percent of vehicles that must be zero emissions over time.
2. Develop model RFPs or procurement standards for vehicle and charging equipment by state agencies and municipalities.[13]

[12] Retail rate structures should be designed to avoid discriminating against electric vehicle charging stations. Charging station owners should be able to act as a supplier of generation services but must be subject to the same requirements, such as renewable portfolio standards, as other entities providing electric energy from the wholesale markets.

[13] Rhode Island recently added the all-electric Ford Focus, Nissan Leaf, and Honda Fit to its list of eligible alternative fuel vehicles. Plug-in gas-electric models include the Chevrolet Volt, Ford C-Max, Toyota Prius Hatchback, and Ford Fusion. For additional information, see: https://www.purchasing.ri.gov/RIVIP/StateAgencyBids/7458316.pdf.

InDepthNH.org | (http://indepthnh.org/2017/10/11/study-unusual-practices-by-eversource-avangrid-cost-ne-consumers-3-6b-over-three-years/)

FEATURED IN CATEGORY

Study: 'Unusual' Practices By Eversource, Avangrid Cost NE Consumers $3.6B Over 3 Years

By **Nancy West** October 11, 2017

The Algonquin Gas Transmission Pipeline delivers natural gas to New England.

Vertical Market Power in Interconnected Natural Gas and Electricity Markets (https://www.edf.org/sites/default/files/vertical-market-power.pdf)

By Nancy West
InDepthNH.org

A new study says Eversource and Avangrid artificially inflated electricity prices costing New England consumers $3.6 billion over three years by scheduling deliveries on the Algonquin Gas Transmission Pipeline, then not flowing the gas.

The study, which Eversource called "completely fabricated" by pipeline opponents, noted the severe, simultaneous spikes in the region's wholesale natural gas and electricity markets.

"While frequently attributed to limited pipeline capacity serving the region, we demonstrate that such price spikes have been exacerbated by some gas distribution firms scheduling deliveries without actually flowing gas," the study said.

By doing so, other firms are blocked from utilizing pipeline capacity. These "unusual scheduling practices" artificially limit gas supply to the region and drives up gas and electricity prices, the study said.

"We find clear patterns of withholding at a subset of delivery nodes operated by Avangrid and Eversource ..., the only two firms operating on the pipeline with substantial assets and operations in both the gas distribution market and the electricity generation market," the study said.

Capacity withholding

Capacity withholding increased average gas and electricity prices by 38% and 20%, respectively, over the three-year study period, according to the study, "Vertical Market Power in Interconnected Natural Gas and Electricity Markets. (https://www.edf.org/sites/default/files/vertical-market-power.pdf)" It was posted Wednesday by the Massachusetts Institute of Technology.

Eversource provided InDepthNH.org a written response to the study saying the company never artificially constrains capacity.

"Our focus and actions are driven by our responsibility to ensure our customers have enough gas – we can't run the risk that they are left in the cold," Eversource said.

"It appears to be fabricated by anti-pipeline proponents who are trying to make the case that pipeline shortages in New England are due to capacity withholding. To the contrary – it is well documented that New England pipeline demand greatly exceeds the supply on cold days," Eversource said.

Consumer advocate

The state's consumer advocate, D. Maurice Kreis, wasn't surprised by the study's findings.

"I have been saying all along that when it comes to making sure there's enough natural gas in New England to keep everyone warm and the electricity grid from failing during the coldest hours of a very cold winter, there has to be a more creative and cost-effective solution than having an electric distribution utility invest in natural gas pipeline capacity and force its electric customers to pay for it," Kreis said.

Kreis added: "The whole idea of restructuring the electric industry was to let the marketplace, rather than ratepayers, take on these risks. This study seems to suggest that we need to make sure we have better market rules in place before we turn the clock back on restructuring."

Supreme Court appeal

Eversource, most recently at the New Hampshire Supreme Court, is seeking the right to invest in natural gas pipeline capacity while passing the costs along on a non-bypassable basis to electric customers in New Hampshire.

The Public Utilities Commission ruled against Eversource's attempt to use money from electric rates for a new natural gas pipeline, which Eversource has appealed to the state Supreme Court.

Avangrid's website says it is a diversified energy and utility company with two primary lines of business in 27 states.

More regulation?

The study called for improved regulation.

"While the studied behavior may have been within the firms' contractual rights, the significant impacts in both the gas and electricity markets underscore the need to improve regulation and coordination as these two energy markets become increasingly interlinked," the study said.

"Our simulation predicts that underutilized pipeline capacity ultimately resulted in a transfer from New England electricity ratepayers to generators (and their fuel suppliers) of about $3.6 billion over the course of our study period, about half of which occurred during the particularly cold winter of 2013-14," the study said.

Utility Dive posted a story about the study on Wednesday quoting researchers saying it doesn't appear that Eversource or Avangrid broke any contract laws or market. UtilityDive wrote: "But if the report's findings are accurate, industry lawyers say they could amount to violations of federal law — and become one of the biggest price manipulation scandals since the California energy crisis."

Eversource's position

The Eversource statement said revenue related to the regulated electric generation facilities they own and operate in New Hampshire is the same no matter how often the power plants run.

"The plants would not produce more revenue for Eversource as a result of gas capacity issues, as the report falsely alleges," Eversource said.

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Report: Natural Gas Companies Artificially Constrained Supply, Costing New Englanders Billions 04:23

October 17, 2017 *Updated October 17, 2017 3:07 PM* | By Fred Bever, Maine Public

New England electricity customers paid billions of dollars more than necessary over a three-year period, according to a report by a national environmental group.

It's prompted a review by Massachusetts Attorney General Maura Healey, but one utility named in the report is calling it an outright fabrication.

The Environmental Defense Fund report's findings stem from the complicated dynamics of gas and electricity markets.

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It says that on hundreds of occasions, gas distributors Avangrid and Eversource reserved a certain amount of natural gas pipeline capacity, and then at the very end of the day decided not to use it. The lead author, Vanderbilt University economist Matthew Zaragoza-Watkins, says that "artificially" constricted supplies on cold days when natural gas was in high demand, particularly during the polar vortex four winters ago.

"They had reserved it like a table at a restaurant and then that table sat empty all day long and then at the last minute they said actually we never needed that table anyway," he said.

So why does that matter? Well, it can make gas more scarce, which drives up its price. That raises the price of electricity fueled by natural gas, in turn making non-gas fired electricity -- from coal, oil, or renewables — more competitive in the marketplace. So when Avangrid and Eversource withheld gas capacity, non-gas units throughout New England benefited, according to Zaragoza-Watkins.

"When it's more expensive for gas powered power plants to run, everybody earns higher revenues," he said. "And what that resulted in over the three-year span of our data was about a 20 percent higher price on average for electricity, or about a $3.6 billion transfer from electricity customers, to electricity generators."

Tricia Modifica, a spokeswoman for Boston-based Eversource, calls the report "a fabrication." She said the analysts don't understand gas and electricity markets.

"The pipeline capacity we reserve is done so to meet the needs of our customers and no other purpose," she said in a statement. "We do not engage in any behavior to artificially constrain capacity. Our focus and actions are driven by our responsibility to ensure our customers have enough gas, because we can't run the risk that they are left out in the cold."

A spokesman for Avangrid also said that company is following all rules and regulations.

The report's authors and its sponsor defend the analysis. Environmental Defense Fund spokesman Jon Coifman says it raises important questions about whether New England's gas supply issues are or were as dire as they've been painted by would-be pipeline developers -- including Eversource -- who were pushing regulators to make electricity consumers pay for new gas pipelines.

"Nobody is arguing that New England doesn't have tight capacity right now," Coifman said. "The question is, how tight is that capacity and what's the best way to most quickly meet it at the lowest cost?"

Several industry observers said they are perplexed by the report.

Tony Buxton is a lobbyist for paper mills and other large industrial energy users in Maine, and he has worked to add gas pipeline infrastructure serving this region, including the now-shelved Kinder-Morgan project. Buxton says the report's accuracy needs to be established. But he said it raises legitimate questions about the transparency and effectiveness of gas and electricity market operations.

"If it is correct that otherwise lawful behavior in New England has increased the cost of gas to consumers and thereby the price of electricity, then we need to be certain that's the case, and to fight hard to fix it," Buxton said.

Some state-level officials are already calling for new regulatory scrutiny, and in a statement, Massachusetts AG Healey's office called the allegations in the report "concerning," and will require "careful assessment and analysis."

Representatives of the regional grid operator, ISO-New England, and the Federal Energy Regulatory Commission declined comment. The report's authors, meanwhile, say they soon will submit it to a scientific journal for peer-review.

This report comes from the New England News Collaborative. It was first published by Maine Public Radio.

This segment aired on October 17, 2017.

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PERSPECTIVE

A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas

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Abstract

In April 2011, we published the first peer-reviewed analysis of the greenhouse gas footprint (GHG) of shale gas, concluding that the climate impact of shale gas may be worse than that of other fossil fuels such as coal and oil because of methane emissions. We noted the poor quality of publicly available data to support our analysis and called for further research. Our paper spurred a large increase in research and analysis, including several new studies that have better measured methane emissions from natural gas systems. Here, I review this new research in the context of our 2011 paper and the fifth assessment from the Intergovernmental Panel on Climate Change released in 2013. The best data available now indicate that our estimates of methane emission from both shale gas and conventional natural gas were relatively robust. Using these new, best available data and a 20-year time period for comparing the warming potential of methane to carbon dioxide, the conclusion stands that both shale gas and conventional natural gas have a larger GHG than do coal or oil, for any possible use of natural gas and particularly for the primary uses of residential and commercial heating. The 20-year time period is appropriate because of the urgent need to reduce methane emissions over the coming 15–35 years.

Introduction

Natural gas is often promoted as a bridge fuel that will allow society to continue to use fossil energy over the coming decades while emitting fewer greenhouse gases than from using other fossil fuels such as coal and oil. While it is true that less carbon dioxide is emitted per unit energy released when burning natural gas compared to coal or oil, natural gas is composed largely of methane, which itself is an extremely potent greenhouse gas. Methane is far more effective at trapping heat in the atmosphere than is carbon dioxide, and so even small rates of methane emission can have a large influence on the greenhouse gas footprints (GHGs) of natural gas use.

Increasingly in the United States, conventional sources of natural gas are being depleted, and shale gas (natural gas obtained from shale formations using high-volume hydraulic fracturing and precision horizontal drilling) is rapidly growing in importance: shale gas contributed only 3% of United States natural gas production in 2005, rising to 35% by 2012 and predicted to grow to almost 50% by 2035 [1]. The gas held in tight sandstone formations is another form of unconventional gas, also increasingly obtained through high-volume hydraulic fracturing and is growing in importance. In 2012, gas extracted from shale and tight-sands combined made up 60% of total natural gas production, and this is predicted to increase to 70% by 2035 [1]. To date, shale gas has been almost entirely a North American phenomenon, and largely a U.S. one, but many expect shale gas to grow in global importance as well.

In 2009, I and two colleagues at Cornell University, Renee Santoro and Tony Ingraffea, took on as a research challenge the determination of the GHG of unconventional gas, particularly shale gas, including emissions of methane. At that time, there were no papers in the peer-reviewed literature on this topic, and there were relatively few papers even on the contribution of methane to the GHG of conventional natural gas [2–4]. At the end of 2009, the U.S. Environmental Protection Agency (EPA) still did not distinguish between conventional gas and shale gas, and they estimated methane emissions for the natural gas industry using emission factors from a 1996 study conducted jointly with the industry [5]; shale gas is not mentioned in that report, which is not surprising since significant shale gas production only started in the first decade of the 2000s.

We began giving public lectures on our analysis in March 2010, and these attracted media attention. One of our points was that it seemed likely that complete life cycle methane emissions from shale gas (from well development and hydraulic fracturing through delivery of gas to consumers) were greater than from conventional natural gas. Another preliminary conclusion was that the EPA methane emission estimates (as they were reported in 2009 and before, based on [5]) seemed at least two- to three-fold too low. In response to public attention from our lectures, the EPA began to reanalyze their methane emissions [6], and in late 2010, EPA began to release updated and far higher estimates of methane emissions from the natural gas production segment [7]. In April 2011, we published our first paper on the role of methane in the GHG of shale gas [8]. We concluded that (1) the amount and quality of available data on methane emissions from the natural gas industry were poor; (2) methane emissions from shale gas were likely 50% greater than from conventional natural gas; and (3) these methane emissions contributed significantly to a large GHG for both shale gas and conventional gas, particularly when analyzed over the timescale of 20-years following emission. At this shorter timescale – which is highly relevant to the concept of natural gas as a bridge or transitional fuel over the next two to three decades – shale gas appeared to have the largest greenhouse warming consequences of any fossil fuel (Fig. 1). Because our conclusion ran counter to U.S. national energy policy and had large implications for climate change, and because the underlying data were limited and of poor quality, we stressed the urgent need for better data on methane emissions from natural gas systems. This need has since been amplified by the Inspector General of the EPA [9].

Our paper received immense media coverage, as evidenced by Time Magazine naming two of the authors

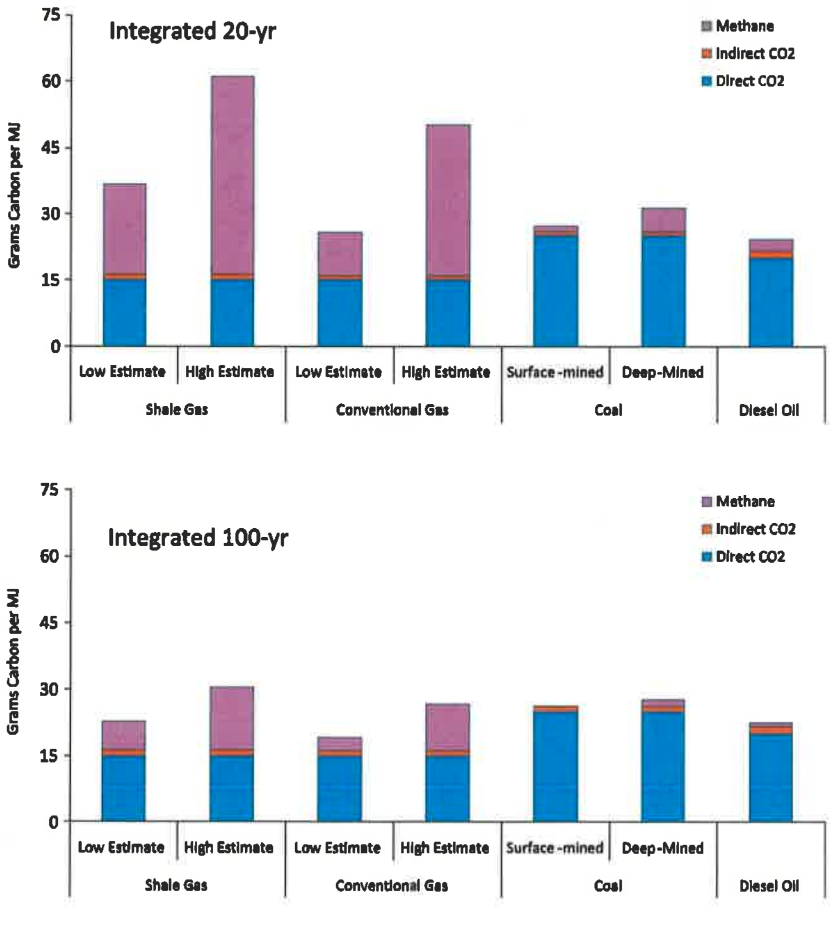

Figure 1. Comparison of the greenhouse gas footprint of shale gas, conventional natural gas, coal, and oil to generate a given quantity of heat. Two timescales for analyzing the relative warming of methane and carbon dioxide are considered: an integrated 20-year period (top) and an integrated 100-year period (bottom). For both shale gas and conventional natural gas, estimates are shown for the low- and high-end methane emission estimates from Howarth et al. [8]. For coal, estimates are given for surface-mined and deep-mined coal, since methane emissions are greater for deeper mines. Blue bars show the direct emissions of carbon dioxide during combustion of the fuels; the small red bars show the indirect carbon dioxide emissions associated with developing and using the fuels; and the magenta bars show methane emissions converted to g C of carbon dioxide equivalents using period-appropriate global warming potentials. Adapted from [8].

(Howarth and Ingraffea) "People who Mattered" to the global news in the December 2011 Person of the Year Issue [10]. The nine months after our paper was published saw a flurry of other papers on the same topic, a huge increase in the rate of publication on the topic of methane and natural gas compared to prior years and decades. While some of these offered support for our analysis, most did not and were either directly critical of our work, or without referring to our analysis reached conclusions more favorable to shale gas as a bridge fuel. Few of these papers published in the 9 months after our April 2011 paper provided new data; many simply offered different interpretations of previously presented information (as is reviewed briefly below). However, in 2012 and 2013 many new studies were published with major new insights and sources of data. In this paper, I briefly review the work on methane and natural gas published between April 2011 and February 2014, concentrating on those studies that have produced new primary data.

There are four components that are central to evaluating the role of methane in the GHG footprint of natural gas: (1) the amount of carbon dioxide that is directly emitted as the fuel is burned and indirectly emitted to obtain and use the fuel; (2) the rate of methane emission from the natural gas system (often expressed as a fraction of the lifetime production of the gas well, normalized to the amount of methane in the gas produced); (3) the global warming potential (GWP) of methane, which is the relative effect of methane compared to carbon dioxide in terms of its warming of the global climate system and is a function of the time frame considered after the emission of the methane; and (4) the efficiency of use of natural gas in the energy system. The GHG is then determined as:

$$\text{GHG footprint} = [\text{CO}_2\text{emissions} + (\text{GWP} \times \text{methane emissions})]/\text{efficiency}$$

There is widespread consensus on the magnitude of the direct emissions of carbon dioxide, and the indirect emissions of carbon dioxide used to obtain and use natural gas (for example, in building and maintaining pipelines, drilling and hydraulically fracturing wells, and compressing gas), while uncertain, are also relatively small [8]. In this paper, I separately consider each of the other three factors (methane emissions, GWP, and efficiency of use) in the context of our April 2011 paper [8] and the subsequent literature.

How Much Methane is Emitted by Natural Gas Systems?

We used a full life cycle analysis in our April 2011 paper, estimating the amount of methane emitted to the atmosphere as a percentage of the lifetime production of a gas well (normalized to the methane content of the natural gas), including venting and leakages at the well site but also during storage, processing, and delivery to customers. For conventional natural gas, we estimated a range of methane emissions from 1.7% to 6% (mean = 3.8%), and for shale gas a range of 3.6% to 7.9% (mean = 5.8%) [8]. We attributed the larger emissions from shale gas to venting of methane at the time that wells are completed, during the flowback period after high-volume hydraulic fracturing, consistent with the findings of the EPA 2010 report [7]. We assumed all other emissions were the same for conventional and shale gas. We estimated that downstream emissions (emissions during storage, long-distance transport of gas in high-pressure pipelines, and distribution to local customers) were 1.4–3.6% (mean = 2.5%) of the lifetime production of a well, and that the upstream emissions (at the well site and for gas processing) were in the range of 0.3–2.4% (mean = 1.4%) for conventional gas and 2.2–4.3% (mean = 3.3%) for shale gas (Table 1).

Table 1. Full life cycle-based methane emission estimates, expressed as a percentage of total methane produced in natural gas systems, separated by upstream emissions for conventional gas, upstream emissions for unconventional gas including shale gas, and downstream emissions for all natural gas. Studies are listed chronologically, and our April 2011 study is boldfaced.

	Upstream conventional gas	Upstream unconventional gas	Downstream
EPA 1996 [5]	0.2%	–	0.9%
Hayhoe et al. [2]	1.4	–	2.5
Jamarillo et al. [4]	0.2	–	0.9
Howarth et al. [8]	**1.4**	**3.3**	**2.5**
EPA [11]	1.6	3.0	0.9
Ventakesh et al. [12]	1.8	–	0.4
Jiang et al. [13]	–	2.0	0.4
Stephenson et al. [14]	0.4	0.6	0.07
Hultman et al. [15]	1.3	2.8	0.9
Burnham et al. [16]	2.0	1.3	0.6
Cathles et al. [17]	0.9	0.9	0.7

Total emissions are the sum of the upstream and downstream emissions. Studies are listed chronologically by time of publication. Dashes indicate no values provided. The full derivation of the estimates shown here is provided elsewhere [18, 19].

Although there were no prior papers on methane emissions from shale gas when our paper was published, we can compare our estimates for conventional natural gas with earlier literature (Table 1). Our mean estimates for both upstream and downstream emissions were identical to the "best estimate" of Hayhoe et al. [2], although that paper presented a wider range of estimates for both upstream and downstream. It is important to note that we used several newer sources of information not available to Hayhoe et al. [2], making the agreement all the more remarkable. The Howarth et al. [8] estimates were substantially higher than the emission factors used by the EPA through 2009 based on the 1996 joint EPA-industry study [5], which were only 1.1% for total emissions, 0.2% for upstream emissions, and 0.9% for downstream emissions. In the only other peer-reviewed paper on life cycle methane emissions from conventional gas published in the decade or two before our paper, Jamarillo et al. [4] relied on these same EPA emission factors, although new data on downstream emissions had already shown these emission factors to be too low [3].

Through late 2010 and the first half of 2011, the EPA provided a series of updates on their methane emission factors from the natural gas industry, giving estimates for shale gas for the first time as well as substantially increasing their estimates for conventional natural gas. These are discussed in detail by us elsewhere [18, 19]. Note that the EPA did not and still has not updated their estimates for downstream emissions, still using a value of 0.9% from a 1996 study [5]. For upstream emissions, the revised EPA estimates gave emission factors of 1.6% (an increase from their earlier value of 0.2%) for conventional natural gas and 3.0% for shale gas [18, 19]. Note that the EPA estimates for upstream emissions presented in 2011 [11] were 14% higher than ours for conventional gas and 10% lower than ours for shale gas. Total emissions were more divergent, due to the large difference in downstream emission estimates (Table 1).

In addition to the revised EPA emission factors, many other papers presented life cycle assessments of methane emissions from shale gas, conventional gas, or both in the immediate 9 months after April 2011 (Table 1). We and others have critiqued these publications in detail elsewhere [18–20]. Here, I will emphasize four crucial points:

1. For the upstream emissions in Table 1, all studies relied on the same type of poorly documented and highly uncertain information. These poor-quality data led us in Howarth et al. [8] to call for better measurements on methane fluxes, conducted by independent scientists. Several such studies have been published in the past 2 years, as is discussed further below, and these provide a more robust approach for estimating methane emissions.
2. At least some of the differences among values in Table 1 are due more to different assumptions about the lifetime production of a shale gas well than to differences in emissions per well [18, 20]. Note that the upstream life cycle emissions are scaled to the lifetime production of a well (normalized to the methane content of the gas produced for the estimates given in Table 1), and this was very uncertain in 2011 since shale gas development is such a new phenomenon [21]. A subsequent detailed analysis by the U.S. Geological Survey has demonstrated that the mean lifetime production of unconventional gas wells is in fact lower than any of papers in Table 1 assumed [22], meaning that upstream shale gas emissions per production of the well from all of the studies should be higher, in some cases substantially so [18, 20].
3. The downstream emissions in Table 1 are particularly uncertain, as highlighted by both Hayhoe et al. [2] and Howarth et al. [8]. Note that all of the other papers listed in Table 1 base their downstream emissions on the EPA emission factors from 1996 [5], and none are higher than those EPA estimates, even though a 2005 paper in *Nature* demonstrated higher levels of emission from long-distance pipelines in Europe [3]. Several of the papers in Table 1 have downstream emissions that are lower than the 1996 EPA values, as they are focused on electric power plants and assume that these plants are drawing on gas lines that have lower emissions than the average, which would include highly leaky low-pressure urban distribution lines [12–14, 16]. Some recent papers have noted a high incidence of leaks in natural gas distribution systems in two U.S. east coast cities [23, 24], but these new studies have yet placed an emission flux estimate on these leaks. Another study demonstrated very high methane emissions from fossil fuel sources in Los Angeles but could not distinguish between downstream natural gas emissions and other sources [25]. Given the age of gas pipelines and distribution systems in the United States, it should come as no surprise that leakage may be high [8, 18, 19]. Half of the high-pressure pipelines in the United States are older than 50 years [18], and parts of the distribution systems in many northeastern cities consist of cast-iron pipes laid down a century ago [24].
4. While one of the papers in Table 1 by Cathles and his colleagues [17], characterized our methane emission estimates as too high and "at odds with previous studies," that in fact is not the case. As noted above, both our downstream and upstream estimates for conventional gas are in excellent agreement with one of the few previous peer-reviewed studies [2]. Furthermore, our upstream emissions are in good agreement with the majority of the papers published in 9 months after

ours: for conventional gas, our mean estimate of 1.4% compares with the mean for all the other studies in Table 1 of 1.33%; if we exclude the very low estimate from Stephenson et al. [14], which was based on an analysis of what the gas industry is capable of doing rather than on any new measurements, and also the relatively low estimate from Cathles et al. [17], which was based on the assumption that the gas industry would not vent gas for economic and safety issues (see critique of this in [18]), the mean of the other four studies is 1.7, or almost twice as high as the Cathles et al. [17] estimate and 20% higher than our estimate. For shale gas, again excluding Stephenson et al. [14] and Cathles et al. [17] as well as our estimate, the other four studies in Table 1 have a mean estimate of 2.3, a value 2.5-fold greater than that from Cathles et al. [17] and 30% less than our mean estimate. From this perspective, the estimates of Cathles et al. [17] appear to be greater outliers than are ours.

Since 2012, many new papers have produced additional primary data (Fig. 2). Two of these found very high upstream methane emission rates from unconventional gas fields (relative to gross methane production), 4% for a tight-sands field in Colorado [26] and 9% for a shale gas field in Utah [27], while another found emissions from a shale gas field in Pennsylvania to be broadly consistent with the emission factors we had published in our 2011 paper [28]. All three of these studies inferred rates from atmospheric data that integrated a large number of wells at the basin scale. The new Utah data [27] are much higher than any of the estimates previously published for upstream emissions from unconventional gas fields (Fig. 2), while the measurement for the Colorado tight-sands field [26] overlaps with our high-end estimate for upstream unconventional gas emissions in Howarth et al. [8]. The Utah and Colorado studies may not be representative of the typical methane emissions for the entire United States, in part, because they focused on regions where they expected high methane fluxes based on recent declines in air quality. But I agree with the conclusion of Brandt and his colleagues [29] that the "bottom-up" estimation approaches that we and all the other papers in Table 1 employed are inherently likely to lead to underestimates, in part, because some components of the natural gas system are not included. As one example, the recent Pennsylvania study, which quantified fluxes from discrete locations on the ground by mapping methane plumes from an airplane, found very high emissions from many wells that were still being drilled, had not yet reached the shale formation, and had not yet been hydraulically fractured [28]. These wells represented only 1% of the wells in the area but were responsible for 6–9% of the regional methane flux from all sources. One explanation is that the drill rigs encountered pockets of shallower gas and released this to the atmosphere. We, the EPA, and all of the papers in Table 1 had assumed little or no methane emissions from wells during this drilling phase.

Allen and colleagues [30] published a comprehensive study in 2013 of upstream emissions for both conventional and unconventional gas wells for several regions in the United States, using the same basic bottom-up approach as the joint EPA-industry study of 1996 used [5]. As with that earlier effort, this new study relied heavily on industry cooperation, and was funded largely by industry with coordination provided by the Environmental Defense Fund. For the United States as a whole at the

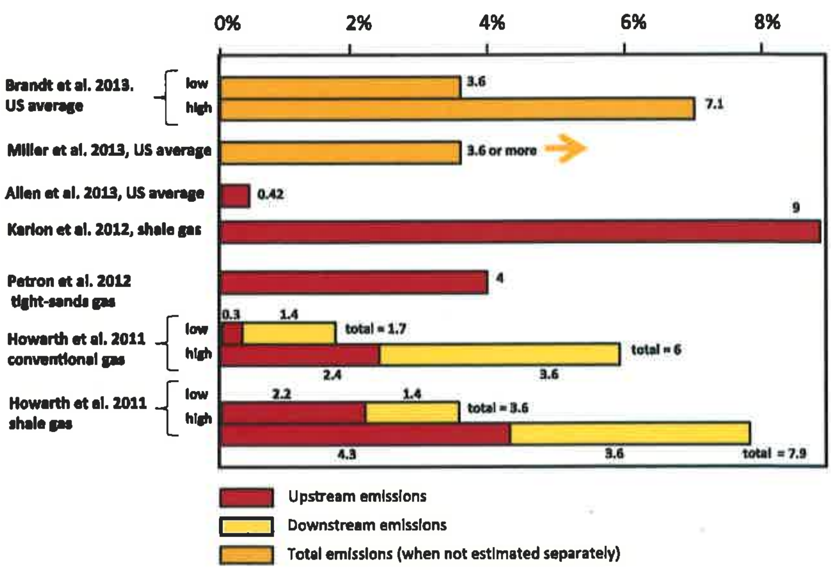

Figure 2. Comparison of recent new data on methane emissions compared to the estimates published in Howarth et al. [8]. Some of the new data are for upstream emissions, while others give only averages for natural gas systems in the United States. No new measurements for downstream emissions alone have been published since 2005 [8, 26, 27, 29, 30, 32].

time of their study, Allen et al. [30] concluded that upstream methane emissions were only 0.42% of the natural gas production by the wells (Fig. 2), a value at the low end of those seen in Table 1. Using the low-end estimates, "best-case" scenarios for upstream emissions from Howarth et al. [8] and the mix of shale gas and conventional gas produced in the United States in 2012, I estimate the U.S. national best-case emission rate would be 0.5%, or similar to that observed by Allen and colleagues. It should not be surprising that their study, in relying on industry access to their sampling points, ended up in fact measuring the best possible performance by industry.

In 2013, the EPA reduced their emission estimates for the oil and gas industry, essentially halving their upstream emissions for average natural gas systems from 1.8% to 0.88% for the year 2009 (with the mix of conventional and unconventional gas for that year) from what they had reported in 2011 and 2012; the EPA estimate for downstream emissions remained at 0.9%, giving a total national emission estimate of 1.8%. EPA took this action to decrease their emission factors for upstream emissions despite the publication in 2012 of the methane emissions from a Colorado field [26] and oral presentations at the American Geophysical Union meeting in December 2012 of the results subsequently published by Karion and colleagues [27] and Caulton and colleagues [28], all of which would have suggested higher emissions, perhaps spectacularly so. As is discussed by Karion et al. [27], the decrease in the upstream methane emissions by EPA in 2013 was driven by a non-peer-reviewed industry report [31] which argued that emissions from liquid unloading and during refracturing of unconventional wells were far lower than used in the EPA [11] assessment. At least in part in response to these changes by EPA, the Inspector General for the EPA concluded that the agency needs improvements in their approach to estimating emissions from the natural gas industry [9].

An important paper published late in 2013 [32] indicates the EPA made a mistake in reducing their emission estimates earlier in the year. In this analysis, the most comprehensive study to date of methane sources in the United States, Miller and colleagues used atmospheric methane monitoring data for 2007 and 2008 – 7710 observations from airplanes and 4984 from towers from across North America – together with an inverse model to assess total methane emissions nationally from all sources. They concluded that rather than reducing methane emission terms between their 2011 and 2013 inventories, EPA should have increased anthropogenic methane emission estimates, particularly for the oil and gas industry and for animal agriculture operations. They stated that methane emissions from the United States oil and gas industry are very likely two-fold greater or more than indicated by the factors EPA released in 2013 [32]. This suggests that total methane emissions from the natural gas industry were at least 3.6% in 2007 and 2008 (Fig. 2).

In early 2014, Brandt and his colleagues [29] reviewed the technical literature over the past 20 years on methane emissions from natural gas systems. They concluded that "official inventories consistently underestimate actual methane emissions," but also suggested that the very high estimates from the top–down studies in Utah and Colorado [26, 27] "are unlikely to be representative of typical [natural gas] system leakage rates." In the supplemental materials for their paper, Brandt et al. [29] state that methane emissions in the United States from the natural gas industry are probably greater than the 1.8% assumed by the EPA by an additional 1.8–5.4%, implying an average rate between 3.6% and 7.1% (mean = 5.4%) [33] (Fig. 2).

This recent literature suggests to me that the emission estimates we published in Howarth et al. [8] are surprisingly robust, particularly for conventional natural gas (Fig. 2). The results from two of the recent top–down studies [26, 27] indicate our estimates for unconventional gas may have been too low. Partly in response to our work and their own reanalysis of methane emissions from shale gas wells, EPA has now promulgated new regulations that will as of January 2015 reduce methane emissions at the time of well completions, requiring capture and use of the gas instead in most cases. Some wells are exempt, and the regulation does not apply to venting of methane from oil wells, including shale oil wells, which often have associated gas. Nonetheless, the regulations are an important step in the right direction, and will certainly help, if they can be adequately enforced. Even still, though, results such as those from the Pennsylvania flyover showing high rates of methane emission during the drilling phase of some shale gas wells [28] suggest that methane emissions from shale gas may remain at levels higher than from conventional natural gas.

The GWP of Methane

While methane is far more effective as a greenhouse gas than carbon dioxide, methane has an atmospheric lifetime of only 12 years or so, while carbon dioxide has an effective influence on atmospheric chemistry for a century or longer [34]. The time frame over which we compare the two gases is therefore critical, with methane becoming relatively less important than carbon dioxide as the timescale increases. Of the major papers on methane and the GHG for conventional natural gas published before our analysis for shale gas, one modeled the relative radiative forcing by methane compared to carbon dioxide continuously over a 100-year time period following emission [2], and two used the global warming approach (GWP) which compares how much larger the integrated global warming from a given mass of methane is over a specified period of time compared to the same mass of carbon dioxide. Of the two that used the GWP approach, one showed both 20-year and 100-year GWP analyses [3] while another used only a 100-year GWP time frame [4]. Both used GWP values from the Intergovernmental Panel on Climate Change (IPCC) synthesis report from 1996 [35], the most reliable estimates at the time their papers were published. In subsequent reports from the IPCC in 2007 [36] and 2013 [34] and in a paper in *Science* by workers at the NASA Goddard Space Institute [37], these GWP values have been substantially increased, in part, to account for the indirect effects of methane on other radiatively active substances in the atmosphere such as ozone (Table 2).

In Howarth et al. [8], we used the GWP approach and closely followed the work of Lelieveld and colleagues [3] in presenting both integrated 20 and 100 year periods, and in giving equal credence and interpretation to both timescales. We upgraded the approach by using the most recently published values for GWP at that time [37].

Table 2. Comparison of the timescales considered in comparing the global warming consequences of methane and carbon dioxide.

Publication	Timescale considered	20-year GWP	100-year GWP
IPCC [35]	**20 and 100 years**	**56**	**21**
Hayhoe et al. [2]	0–100 years	NA	NA
Lelieveld et al. [3]	20 and 100 years	56	21
Jamarillo et al. [4]	100 years	–	21
IPCC [36]	**20 and 100 years**	**72**	**25**
Shindell et al. [37]	**20 and 100 years**	**105**	**33**
Howarth et al. [8]	20 and 100 years	105	33
Hughes [20]	20 and 100 years	105	33
Venkatesh et al. [12]	100 years	–	25
Jiang et al. [13]	100 years	–	25
Wigley [38]	0–100 years	NA	NA
Stephenson et al. [14]	100 years	–	25
Hultman et al. [15]	20 and 100 years	72, 105	25, 44
Skone et al. [39]	100 years	–	25
Burnham et al. [16]	100 years	–	25
Cathles et al. [17]	100 years	–	25
Alvarez et al. [40]	0–100 years	NA	NA
IPCC [34]	**10, 20, and 100 years**	**86**	**34**
Brandt et al. [29]	100 years	–	25

Studies are listed chronologically by time of publication. Values for the global warming potentials at 20 and 100 years given, when used in the studies. NA stands for not applicable and is shown when studies did not use the global warming potential approach. Dashes are shown for studies that did not consider the 20-year GWP. Studies that are bolded provided primary estimates on global warming potentials, while other studies are consumers of this information.

These more recent GWP values increased the relative warming of methane compared to carbon dioxide by 1.9-fold for the 20-year time period (GWP of 105 vs. 56) and by 1.6-fold for the 100-year time period (GWP of 33 vs. 21; Table 2). Our conclusion was that for the 20-year time period, shale gas had a larger GHG than coal or oil even at our low-end estimates for methane emission (Fig. 1); conventional gas also had a larger GHG than coal or oil at our mean or high-end methane emission estimates, but not at the very low-end range for methane emission (the best-case, low-emission scenario). At the 100-year timescale, the influence of methane was much diminished, yet at our high-end methane emissions, the GHG of both shale gas and conventional gas still exceeded that of coal and oil (Fig. 1).

Of nine new reports on methane and natural gas published in 9 months after our April 2011 paper [8], six only considered the 100-year time frame for GWP, two used both a 20- and 100-year time frame, and one used a continuous modeling of radiative forcing over the 0–100 time period (Table 2). Of the six papers that only examined the 100-year time frame, all used the lower GWP value of 25 from the 2007 IPCC report rather than the higher value of 33 published by Shindell and colleagues in 2009 that we had used; this higher value better accounts for the indirect effects of methane on global warming. Many of these six papers implied that the IPCC dictated a focus on the 100-year time period, which is simply not the case: the IPCC report from 2007 [36] presented both 20- and 100-year GWP values for methane. And two of these six papers criticized our inclusion of the 20-year time period as inappropriate [14, 17]. I strongly disagree with this criticism. In the time since April 2011 I have come increasingly to believe that it is essential to consider the role of methane on timescales that are much shorter than 100 years, in part, due to new science on methane and global warming presented since then [34, 41, 42], briefly summarized below.

The most recent synthesis report from the IPCC in 2013 on the physical science basis of global warming highlights the role of methane in global warming at multiple timescales, using GWP values for 10 years in addition to 20 and 100 years (GWP of 108, 86, and 34, respectively) in their analysis [34]. The report states that "there is no scientific argument for selecting 100 years compared with other choices," and that "the choice of time horizon .... depends on the relative weight assigned to the effects at different times" [34]. The IPCC further concludes that at the 10-year timescale, the current global release of methane from all anthropogenic sources exceeds (slightly) all anthropogenic carbon dioxide emissions as agents of global warming; that is, methane emissions are more important (slightly) than carbon dioxide emissions for driving the current rate of global warming. At the 20-year timescale, total global emissions of methane are equivalent to over 80% of global carbon dioxide emissions. And at the 100-year timescale, current global methane emissions are equivalent to slightly less than 30% of carbon dioxide emissions [34] (Fig. 3).

This difference in the time sensitivity of the climate system to methane and carbon dioxide is critical, and not widely appreciated by the policy community and even some climate scientists. While some note how the long-term momentum of the climate system is driven by carbon dioxide [15], the climate system is far more immediately responsive to changes in methane (and other short-lived radiatively active materials in the atmosphere, such as black carbon) [41]. The model published in 2012 by Shindell and colleagues [41] and adopted by the United Nations [42] predicts that unless emissions of methane and black carbon are reduced immediately, the Earth's average surface temperature will warm by 1.5°C by about 2030 and by 2.0°C by 2045 to 2050 whether or not carbon dioxide emissions are reduced. Reducing methane and black carbon emissions, even if carbon dioxide is not controlled, would significantly slow the rate of global warming and postpone reaching the 1.5°C and 2.0°C marks by 15–20 years. Controlling carbon dioxide as well as methane and black carbon emissions further slows the rate of global warming after 2045, through at least 2070 [41, 42] (Fig. 4).

Why should we care about this warming over the next few decades? At temperatures of 1.5–2.0°C above the 1890–1910 baseline, the risk of a fundamental change in the Earth's climate system becomes much greater [41–43], possibly leading to runaway feedbacks and even more global warming. Such a result would dwarf any possible benefit from reductions in carbon dioxide emissions over the next few decades (e.g., switching from coal to natural gas, which does reduce carbon dioxide but also increases methane emissions). One of many mechanisms for such catastrophic change is the melting of methane clathrates in the oceans or melting of permafrost in the Arctic. Hansen and his colleagues [43, 44] have suggested that warming of the Earth by 1.8°C may trigger a large and rapid increase in the release of such methane. While there is a wide range in both the magnitude and timing of projected carbon release from thawing permafrost and melting clathrates in the literature [45], warming consistently leads to greater release. This release can in turn cause a feedback of accelerated global warming [46].

To state the converse of the argument: the influence of today's emissions on global warming 200 or 300 years into the future will largely reflect carbon dioxide, and not

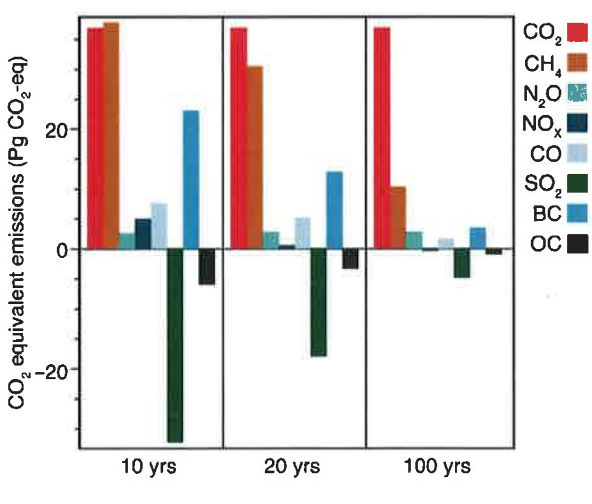

Figure 3. Current global greenhouse gas emissions, as estimated by the IPCC [34], weighted for three different global warming potentials and expressed as carbon dioxide equivalents. At the 10-year time frame, global methane emissions expressed as carbon dioxide equivalents actually exceed the carbon dioxide emissions. Adapted from [34].

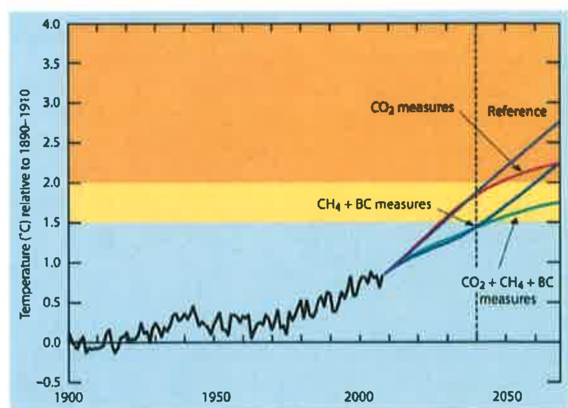

Figure 4. Observed global mean temperature from 1900 to 2009 and projected future temperature under four scenarios, relative to the mean temperature from 1890 to 1910. The scenarios include the IPCC [36] reference, reducing carbon dioxide emissions but not other greenhouse gases ("CO_2 measures"), controlling methane, and black carbon emissions but not carbon dioxide ("CH_4 + BC measures"), and reducing emissions of carbon dioxide, methane, and black carbon ("CO_2 + CH_4 + BC measures"). An increase in the temperature to 1.5–2.0°C above the 1890–1910 baseline (illustrated by the yellow bar) poses risk of passing a tipping point and moving the Earth into an alternate state for the climate system. The lower bound of this danger zone, 1.5° warming, is predicted to occur by 2030 unless stringent controls on methane and black carbon emissions are initiated immediately. Controlling methane and black carbon shows more immediate results than controlling carbon dioxide emissions, although controlling all greenhouse gas emissions is essential to keeping the planet in a safe operating space for humanity. Adapted from [42].

methane, unless the emissions of methane lead to tipping points and a fundamental change in the climate system. And that could happen as early as within the next two to three decades.

An increasing body of science is developing rapidly that emphasizes the need to consider methane's influence over the decadal timescale, and the need to reduce methane emissions. Unfortunately, some recent guidance for life cycle assessments specify only the 100-year time frame [47, 48], and the EPA in 2014 still uses the GWP values from the IPCC 1996 assessment and only considers the 100-year time period when assessing methane emissions [49]. In doing so, they underestimate the global warming significance of methane by 1.6-fold compared to more recent values for the 100-year time frame and by four to fivefold compared to the 10- to 20-year time frames [34, 37].

Climate Impacts of Different Natural Gas Uses

In Howarth et al. [8], we compared the greenhouse gas emissions of shale gas and conventional natural gas to those of coal and oil, all normalized to the same amount of heat production (i.e., g C of carbon dioxide equivalents per MJ of energy released in combustion). We also noted that the specific comparisons will depend on how the fuels are used, due to differences in efficiencies of use, and briefly discussed the production of electricity from coal versus shale gas as an example; electric-generating plants on average use heat energy from burning natural gas more efficiently than they do that from coal, and this is important although not usually dominant in comparing the GHGs of these fuels [8, 18–20]. We presented our main conclusions in the context of the heat production (Fig. 1), though, because evaluating the GHGs of the different fossil fuels for all of their major uses was beyond the scope of our original study, and electricity production is not the major use of natural gas. This larger goal of separately evaluating the GHGs of all the major uses of natural gas has not yet been taken on by other research groups either.

In Figure 5 (left-hand panel), I present an updated comparison of the GHGs of natural gas, diesel oil, and coal based on the best available information at this time (April 2014). Values are expressed as g C of carbon dioxide equivalents per MJ of energy released as in our 2011 paper [8] and Figure 1. The methane emissions in Figure 5 are the mean and range of estimates from the recent review by Brandt and colleagues [29] (see Fig. 2), normalized to carbon dioxide equivalents using the 20-year mean GWP value of 86 from the latest IPCC assessment [34]. As noted above, I believe the 20-year GWP is

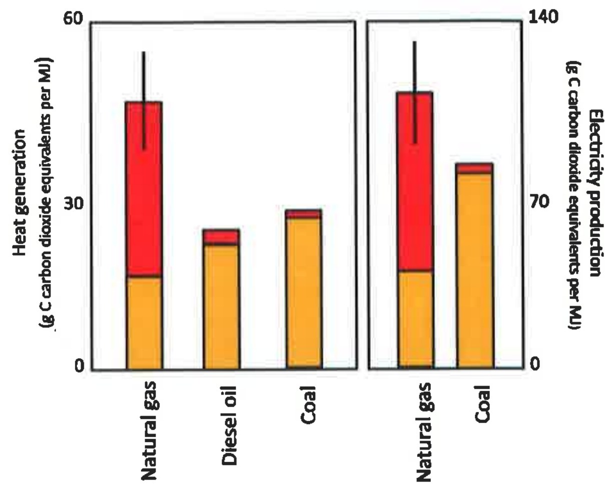

Figure 5. Comparison of the greenhouse gas footprint for using natural gas, diesel oil, and coal for generating primary heat (left) and for using natural gas and coal for generating electricity (right). Direct and indirect carbon dioxide emissions are shown in yellow and are from Howarth et al. [8], while methane emissions shown as g C of carbon dioxide equivalents using the 2013 IPCC 20-year GWP [34] are shown in red. Methane emissions for natural gas are the mean and range for the U.S. national average reported by Brandt and colleagues [29] in their supplemental materials. Methane emissions for diesel oil and for coal are from Howarth et al. [8] For the electricity production, average U.S. efficiencies of 41.8% for gas and 32.8% for coal are assumed [20]. Several studies present data on emissions for electricity production in other units. One can convert from g C of CO_2-equivalents per MJ to g CO_2-equivalents per kWh by multiplying by 13.2. One can convert from g C of CO_2-equivalents per MJ to g C of CO_2-equivalents per kWh by multiplying by 3.6.

an appropriate timescale, given the urgent need to control methane emissions globally. Estimates for coal and diesel oil are from our 2011 paper [8], using data for surface-mined coal since that dominates the U.S. market [20]. The direct and indirect emissions of carbon dioxide are combined and are the same values as in Howarth et al. [8] and Figure 1. Direct carbon dioxide emissions follow the High Heating Value convention [2, 8]. Clearly, using the best available data on rates of methane emission [29], natural gas has a very large GHG per unit of heat generated when considered at this 20-year timescale.

Of the studies listed in Tables 1 and 2 published after our 2011 paper [8], most focused just on the comparison of natural gas and coal to generate electricity, although one also considered the use of natural gas as a long-distance transportation fuel [40]. For context, over the period 2008–2013 in the United States, 31% of natural gas has been used to generate electricity and 0.1% as a transportation fuel [50]. None of the studies listed in Tables 1 and 2, other than Howarth et al. [8], considered the use of natural gas for its primary use: as a source of heat. In the United States over the last 6 years, 32% of natural gas has been used for residential and commercial heating and 28% for industrial process energy [50]. The focus on electricity is appropriate if the only question at hand is "how does switching out coal for natural gas in the generation of electricity affect greenhouse gas emissions?" However, policy approaches have pushed other uses of natural gas – without any scientific support – as a way to reduce greenhouse gas emissions, apparently on the mistaken belief that the analysis for electricity generation applied to these other uses. Before exploring some of these other uses of natural gas, I would like to further explore the question of electricity generation.

Many of the papers listed in Tables 1 and 2 concluded that switching from coal to natural gas for generating electricity has a positive influence on greenhouse gas emissions. Note, though, that for almost all of these papers, the conclusion was driven by a focus on only the 100-year timescale [4, 12–14, 16, 17, 29, 39], on a very low assumed level of methane emission [4, 12–14, 17, 39], or both. The differences in efficiency of use in electric power plants, comparing either current average plants or best possible technologies, are relatively small compared to the influence of the GWP on the calculation [8, 18, 20, 40]. Using a 20-year GWP framework and the methane emission estimates from Howarth et al. [8], the GHG from generating electricity with natural gas is larger than that from coal [8, 18–20]. Alvarez and colleagues [40] concluded that for electricity generation, the GHG of using natural gas was less than for coal for all time frames only if the rate of methane leakage was less than 3.2%. Their analysis used the estimates for the radiative forcing of methane from the IPCC 2007 synthesis [36], and if we correct their estimate for the data in the 2013 IPCC assessment [34], this "break-even point" becomes 2.8%. If we further consider the uncertainty in the radiative forcing of methane of 30% or more [34], this "break-even" value becomes a range of 2.4–3.2%.

In Figure 5 (right-hand panel), I compare the GHGs of natural gas and coal when used to generate electricity, again using the High Heating Value convention [2, 8], the latest IPCC value for the 20-year GWP [34] and the range of methane emission estimates reported by Brandt and colleagues [29]. No distinction is made for less downstream emissions for the pipelines that feed electric power plants, as is assumed in several other studies [12–14, 16], simply because no data exist with which to tease apart downstream emissions specific for electric power generation [51]. This analysis uses the average efficiency for electric power plants currently operating in the United States, 41.8% for gas and 32.8% for coal [20]. The emissions per unit of energy produced as electricity are higher than for the heat generation alone, due to these corrections for efficiency. Although the difference in the footprints for using the two fuels is less for the electricity comparison than for the comparison for heat generation, at this 20-year timescale the GHG of natural gas remains greater than that of coal, even at the low-end methane emission estimate. This conclusion still holds when one compares the fuels using the best available technologies (50.2% efficiency for natural gas and 43.3% for coal [20]); the emissions per unit of electricity generated decrease for both by approximately the same amount.

For the dominant use of natural gas – heating for water, domestic and commercial space, and industrial process energy – the analysis we presented in our 2011 paper [8] and shown in Figure 1 remains the only published study before this new analysis shown in Figure 5 (left-hand panel). The updated version shown here compellingly indicates natural gas is not a climate-friendly fuel for these uses. However, the greenhouse gas consequences may in fact be worse than Figure 5 or Howarth et al. [8] indicate, as I discuss next.

A recent study supported by the American Gas Foundation promoted the in-home use of natural gas over electricity for appliances (domestic hot water, cooking) because of a supposed benefit for greenhouse gas emissions [52]. The report argues that an in-home natural gas appliance will have a higher efficiency in using the fuel (up to 92%) compared to the overall efficiency of producing and using electricity ("only about 40%," according to this study). However, they did not include methane emissions in their analysis, nor did they consider the extremely high efficiencies available for some electrical appliances, such as in-home air-sourced heat pumps for domestic hot water. For a given input of electricity, such heat pumps can produce 2.2-times more heat energy, since they are harvesting and concentrating heat from the local environment [53]. In a comparison of using in-home gas-fired water heaters or in-home high-efficiency electric heat pumps, with the electricity for the heat pumps generated by burning coal, the heat pumps had a lower GHG than did in-home use of gas if the emission rate for methane was greater than 0.7% for a 20-year GWP or 1.3% for a 100-year GWP [51]. Using the mean methane emission estimate from Howarth et al. [8] for conventional natural gas (Fig. 2) and a 20-year GWP, the in-home natural gas heater had a GHG that was twice as large as that of the heat pump [51]. Of course, an in-home heat pump powered by electricity from renewable sources such as wind and solar would have a far smaller GHG yet [54].

What about other uses of natural gas? The "Natural Gas Act," a bill introduced in the United States Congress in 2011 with bipartisan support and the backing of President Obama, would have provided tax subsidies to encourage the replacement of diesel fuel by natural gas for long-distance trucks and buses; the bill did not pass, in part because conservatives opposed it as "market distorting" [55, 56]. In Quebec, industry has claimed that this replacement of diesel by shale gas would reduce greenhouse gas emissions by up to 30% [57]. However, in contrast to a possible advantage in replacing coal with natural gas for electricity generation (if methane emissions can be kept low enough), using natural gas to replace diesel fuel as a long-distance transportation fuel would greatly increase greenhouse emissions [29, 40]. In part, this is because the energy of natural gas is used with less efficiency than diesel in truck engines. Furthermore, although methane emissions from transportation systems have not been well measured, one could imagine significant emissions during refueling operations for buses and trucks, as well as from venting of on-vehicle natural gas tanks to keep gas pressures significantly safe during warm weather. Despite the findings of Alvarez and colleagues published in 2012 [40], the EPA continues to indicate that switching buses from diesel fuel to natural gas reduces greenhouse gas emissions [58].

Concluding Thoughts

By 1950, which is about the time I was born, human activity had contributed enough greenhouse gases to the atmosphere to cause a radiative forcing – the driving factor behind global warming – of 0.57 watts m^{-2} compared to before the industrial revolution [34]. Thirty years later, in 1980 when I taught my first course on the biosphere and global change, this human influence had doubled the anthropogenic radiative forcing, to 1.25 watts m^{-2} [34]. And another 30 years later, the continued release of greenhouse gases by humans has again doubled the forcing, now at 2.29 watts m^{-2} or fourfold greater than just 60 years ago [34]. The temperature of the Earth continues to rise in response at an alarming rate, and the climate scientists tell us we may reach dangerous tipping points in the climate system within just a few decades [34, 41, 42]. Is it too late to begin a serious reduction in greenhouse gas emissions? I sincerely hope not, although surely society has been very slow to respond to this risk. The use of fossil fuels is the major cause of greenhouse gas emissions, and any genuine effort to reduce emissions must begin with fossil fuels.

Is natural gas a bridge fuel? At best, using natural gas rather than coal to generate electricity might result in a very modest reduction in total greenhouse gas emissions, if those emissions can be kept below a range of 2.4–3.2% (based on [40], adjusted for the latest information on radiative forcing of methane [34]). That is a big "if," and one that will require unprecedented investment in natural gas infrastructure and regulatory oversight. For any other foreseeable use of natural gas (heating, transportation), the GHG is larger than if society chooses other fossil fuels, even with the most stringent possible control on methane emissions, if we view the consequences through the decadal GWP frame. Given the sensitivity of the global climate system to methane [41, 42], why take any risk with continuing to use natural gas at all? The current role of methane in global warming is large, contributing 1.0 watts m^{-2} out of the net total 2.29 watts m^{-2} of radiative forcing [34].

Am I recommending that we continue to use coal and oil, rather than replace these with natural gas? Not at all. Society needs to wean itself from the addiction to fossil fuels as quickly as possible. But to replace some fossil fuels (coal, oil) with another (natural gas) will not suffice as an approach to take on global warming. Rather, we should embrace the technologies of the 21st Century, and convert our energy systems to ones that rely on wind, solar, and water power [59, 60, 61]. In Jacobson et al. [54], we lay out a plan for doing this for the entire state of New York, making the state largely free of fossil fuels by 2030 and completely free by 2050. The plan relies only on technologies that are commercially available at present, and includes modern technologies such as high-efficiency heat pumps for domestic water and space heating. We estimated the cost of the plan over the time frame of implementation as less than the present cost to the residents of New York from death and disease from fossil fuel caused air pollution [54]. Only through such technological conversions can society truly address global change. Natural gas is a bridge to nowhere.

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Conflict of Interest

None declared.

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BY JOHNABRAHAMAND DANANUCCITELLI
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Is climate change humanity's greatest-ever risk management failure?

Humans are very good at managing risks, except when it comes to the greatest risk we've faced - climate change

Our gamble may lead to an unstable future climate. Photograph: Don Mcphee

Humans are generally very risk-averse. We buy insurance to protect our investments in homes and cars. For those of us who don't have universal health care, most purchase health insurance. We don't like taking the chance - however remote - that we could be left unprepared in the event that something bad happens to our homes, cars, or health.

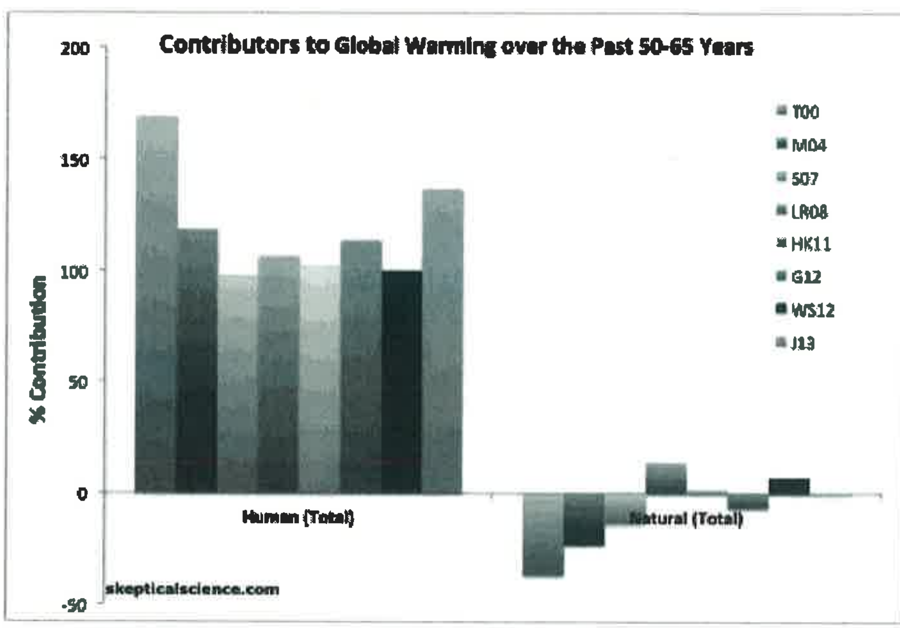
Climate change seems to be a major exception to this rule. Managing the risks posed by climate change is not a high priority for the public as a whole, despite the fact that a climate catastrophe this century is a very real possibility, and that such an event would have adverse impacts on all of us.

For example, in my job as an environmental risk assessor, if a contaminated site poses a cancer risk to humans of more than 1-in-10,000 to 1-in-1 million, that added risk is deemed unacceptably high and must be reduced. This despite the fact that an American man has a nearly 1-in-2 chance of developing and 1-in-4 chance of dying from cancer (1-in-3 and 1-in-5 for an American woman, respectively).

To that 42 percent chance of an average American developing cancer in his or her lifetime, we're unwilling to add another 0.001 percent. The reason is simple - we really, really don't want cancer, and thus consider even a small added risk unacceptable.

Yet we don't share that aversion to the risks posed by human-caused climate change. These risks include more than half of global species potentially being at risk of extinction, extreme weather like heat waves becoming more commonplace, global food supplies put at risk by this more frequent extreme weather, glaciers and their associated water resources for millions of people disappearing, rising sea levels inundating coastlines, and so forth.

This isn't some slim one-in-a-million risk; we're looking at seriously damaging climate consequences in the ***most likely***, business-as-usual scenario. The forthcoming fifth IPCC report is likely to state with 95 percent confidence that humans are the main drivers of climate change over the past 60 years, and the scientific basis behind this confidence is quite sound. It's the result of virtually every study that has investigated the causes of global warming.



The percentage contribution to global warming over the past 50-65 years is shown in two categories, human causes (left) and natural causes (right), from various peer-reviewed studies (colors).

Yet in a recent interview with NPR, climate scientist Judith Curry, who has a reputation for exaggerating climate science uncertainties, claimed that based on those uncertainties,

> "I can't say myself that [doing nothing] isn't the best solution."

This argument, made frequently by climate contrarians, displays a lack of understanding about risk management. I'm uncertain if I'll ever be in a car accident, or if my house will catch fire, or if I'll become seriously ill or injured within the next few years. That uncertainty won't stop me from buying auto, home, and health insurance. It's just a matter of prudent risk management, making sure we're prepared if something bad happens to something we value. That principle should certainly apply to the global climate.

Uncertainty simply isn't our friend when it comes to risk. If uncertainty is large, it means that a bad event might not happen, but it also means that we can't rule out the possibility of a catastrophic event happening. Inaction is only justifiable if we're certain that the bad outcome won't happen.

Curry is essentially arguing that she's not convinced we should take action to avoid what she believes is a very possible climate catastrophe. That's a failure of risk management. I wonder if she would also advise her children not to buy home or auto or health insurance. Maybe they'll be a wasted expense, or maybe they'll prevent financial ruin in the event of a catastrophe.

Climate change presents an enormous global risk, not in an improbable one-in-a-million case, but rather in the most likely scenario. From a risk management perspective, our choice could not be clearer. We should be taking serious steps to reduce our impact on the climate via fossil fuel consumption and associated greenhouse gas emissions. But we're not. This is in large part due to a lack of public comprehension of the magnitude of the risk we face; a perception problem that social scientists are trying to determine how to overcome.

At the moment, climate change looks like humanity's greatest-ever risk management failure. Hopefully we'll remedy that failure before we commit ourselves to catastrophic climate consequences that we're unprepared to face.

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NH 10-Year Energy Strategy

New Hampshire's 2014 10-Year Energy Strategy has been very helpful in steering the state toward a cleaner energy future. This is also creating a healthier place in which to live with less air pollution. It's creating more jobs in the renewable energy sector, especially in the solar and biomass industries. And as we have more distributed energy, our grid becomes more resilient to interruptions from storms or other causes.

I would like to see measurable goals in our energy strategy so we know where we are going and when we've achieved our goals. The legislature has helped implement some of the suggestions in the 2014 Strategy:

- "Open a PUC docket on grid modernization" – that docket was completed this year and will lead to an ajudicative docket on grid modernization in the next year.
- The legislature adopted the Energy Efficiency Resource Standard in an effort to "capture all cost effective energy efficiency savings." It is just being fully implemented this January but already I question whether it will be effective enough or if it needs to be strengthened.
- "Encourage distributed generation" – the PUC completed a docket on net metering which resulted in lifting the cap on net metering and deciding on an interim price for the excess electricity. They have initiated pilot studies that will look into Time Of Use pricing and other changes, and they will report back in 2 years. As the Strategy says, "DG supports a system that is more resilient, flexible, and efficient." It also "creates jobs that are difficult to outsource, and money spent on the projects circulates within the state's economy."
- "Towns should be encouraged to adopt Renewable Energy Property Tax Exemptions." Some towns have done so and others are considering it.
- "Do more to reduce costs for our low income neighbors." This year we passed SB 129 which allocates 15% of the REF to do energy efficiency for low income households. But it still doesn't cover the need across the state and I hope we can find a way to fund many more projects so people don't have to wait years to get work done on their house.
- "Adjust the ACP price" to be more in line with neighboring states. SB 129 raised the price back to its original amount of $55. This will help as long as the PUC doesn't lower the requirements for RECs as they've done the past few years.

Much more still waits to be done. This year I hope we will use some of the VW settlement money to build more EV infrastructure, to create charging corridors along our major highways so that the growing number of electric vehicles can travel in our state. Our state can also implement goal 14.B to incent development of public charging stations. Car makers are looking to the future and that future involves different versions of electric vehicles. We need to start investing in the future too, or we'll be left behind.

We need to improve consumer access to financing, perhaps with green banks as some states are trying.

We need to "strengthen and stabilize the RPS", not try to weaken it as legislation tried to do again this year.

We need to "improve coordination and design of existing efficiency programs." I would like to see an Energy Department at the state level where all programs and information can be better coordinated for the consumer, a "one-stop shop" as the Strategy says.

We need to expand mass transit where possible. For example, the train project from Massachusetts to southeastern NH has been talked about for years but still hasn't happened.

I would also like to delete the goal of converting customers to natural gas and trucked CNG. This was considered a bridge fuel but we should be moving beyond gas to more renewables and more energy efficiency.

Thank you for your attention.

Marjorie Shepardson
Representative, Cheshire 10

94 Pleasant St.
Marlborough, NH 03455

I would like to see a new goal of putting a price on carbon, or at least position our state to be ready for a national carbon fee by investing in renewable energy and energy efficiency rather than fossil fuel infrastructure.

My name is Nancy Nolan and I am a resident of Dublin. I'd like to urge the Governor to promote the development of renewable energy, not dirty fossil fuels, in New Hampshire.

Science has made America great over the past century. But recently, climate scientists have loudly declared that the climate change issue is rapidly worsening, and that we must quickly switch to renewable energy in order to reduce harmful emissions. By ignoring the scientists' warnings about climate change, we are taking an unnecessary risk. There is much we can do to reduce the harmful effects of climate change.

There is too much at stake, namely a safe and healthy future for our children and grandchildren. I agree with the 97 percent of climate scientists who say that we must move away from fossil fuels quickly in order to preserve a reliable climate, which provides New Hampshire with a brilliant foliage season, a profitable maple sugaring season, an economically beneficial ski season, and a healthy summer tourism season. If we don't move quickly, we are destined to have the climate of South Carolina within this century, destroying much of what we love in our state.

With this in mind, here are my suggestions for a clean energy plan in 21st century New Hampshire:

1. Promote energy efficiency in homes, municipal buildings and businesses, which saves money and reduces emissions.

2. Prioritize electric vehicles so that New Hampshire doesn't fall behind on the transportation revolution that is happening in the country, or lose tourism dollars. Install electric charging stations around the state, and assist municipalities in switching to electric/hybrid vehicles.

3. Address climate change by considering the sustainability of every project approved on a state level, and working to reduce the State's carbon footprint at every level. Any project being proposed should include renewable energy if possible.

4. Consider off-shore wind projects and ask the federal government for assistance in assessing New Hampshire's suitability.

5. Halt fossil fuel infrastructure projects in the state.

6. The Governor ~~should~~ MUST encourage the President to stay in the Paris Climate Accord.

7. Stay in the Regional Greenhouse Gas Initiative (RGGI) with other NE states, to help reduce CO2 emissions in the Northeast, while furthering the development of renewable energy in homes and businesses.

Climate change is the most urgent issue of our lives, an experiment that could wreak havoc on our world. In our small state, we have a chance to make a difference. But we have to move quickly, and cleanly, into the future. Thank you.

Nancy Nolan
10-18-17

MOTHERS OUT FRONT
MOBILIZING FOR A LIVABLE CLIMATE

MEET MOTHERS OUT FRONT

We are mothers, grandmothers, and other caregivers coming together to make climate change an issue that our leaders can no longer ignore.

We are building a powerful grassroots movement to ensure a swift, complete, and just transition away from fossil fuels and toward clean and renewable energy. We need your help. Together, we can create a healthy climate today and a livable future for all children.

Why Now?

The world is starting to understand that we must act now to address climate change.

No matter where we each stand on the political spectrum, **we are united in our belief that our work is more important now than ever.** The President has vowed to:

- Pull out of the Paris Climate Agreement.
- Dismantle the Clean Power Plan.
- Double-down on building new fossil fuel infrastructure.

We have a short but real window of time to act. We have the knowledge, skills, and much of the technology we need to keep the Earth's temperature from rising to catastrophic levels.

Join a Local Team

Our movement is led by our local teams of dedicated volunteers, who determine their community's needs and choose their own goals. We empower them with training, coaching, and ideas to move their communities and states from dirty to clean energy.

Team members come together to learn, strategize, meet with elected and business leaders, testify at hearings, and plan and show up at rallies and other events. At the same time, they add to their team – and their power – by hosting house parties and engaging new people.

Our teams welcome volunteers at all levels - from those who feel called to help build a local team to those who only have time to sign a petition or attend an event. Knowing that it will take everyone to create a sustainable future for all children, we all do what we can.

JOIN MOTHERS OUT FRONT MONADNOCK

Our movement is made strong by our volunteers' interests, skills, talents, and energy. To learn about upcoming projects and meetings, contact:

Monica Lehner at 603 345 2479. monica@lehner.us

Or

Sharon Malt at 617 840 3519. Smalt62@gmail.com

MOTHERS OUT FRONT
MOBILIZING FOR A LIVABLE CLIMATE

We are mothers, grandmothers, and other caregivers who can no longer be silent and still about the very real danger that climate change poses to our children's and grandchildren's future.

To: NH Office of Strategic Initiatives & Governor Sununu
BULFINCH ENTRANCE
MASSACHUSETTS STATE HOU
MOTHERS OUT FRONT
Less Oil More Peace
CHILDRENS FUTURE
THE TIME IS NOW

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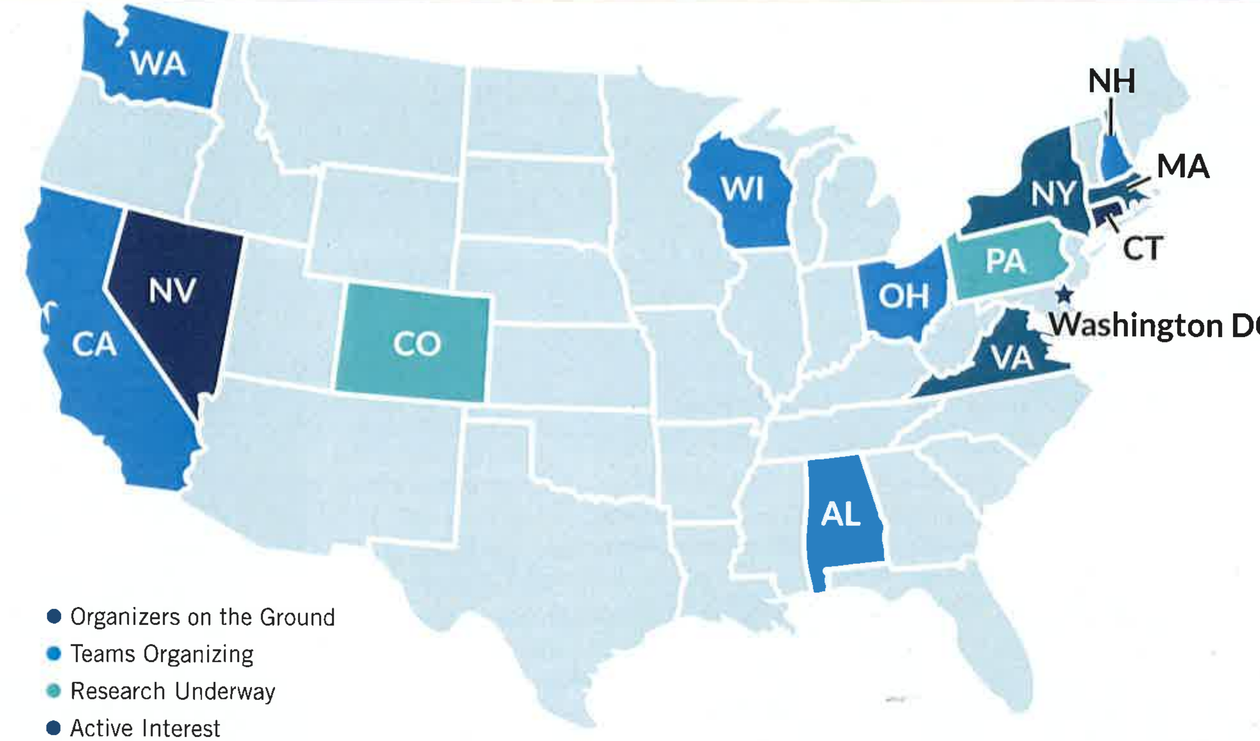

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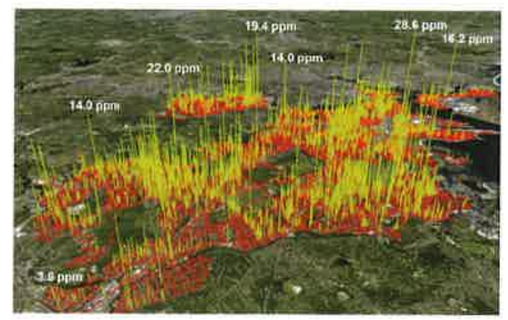

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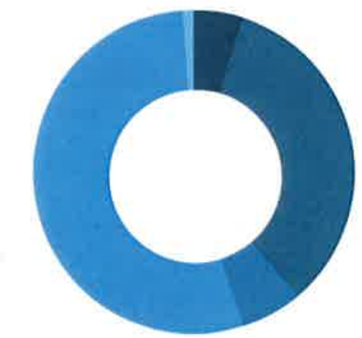
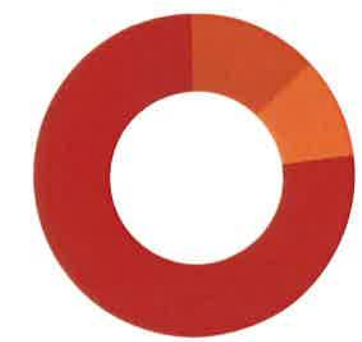


EXPENSES		
Program Services	$836,934	76%
Management and General	$146,389	13%
Fundraising	$111,038	10%
Total Expenses	**$1,094,361**	



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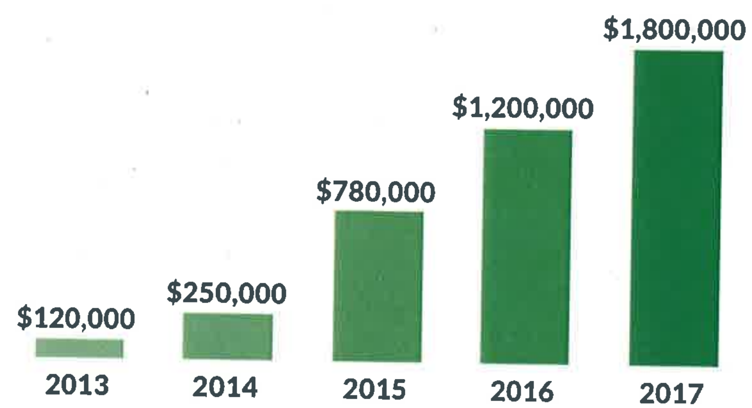

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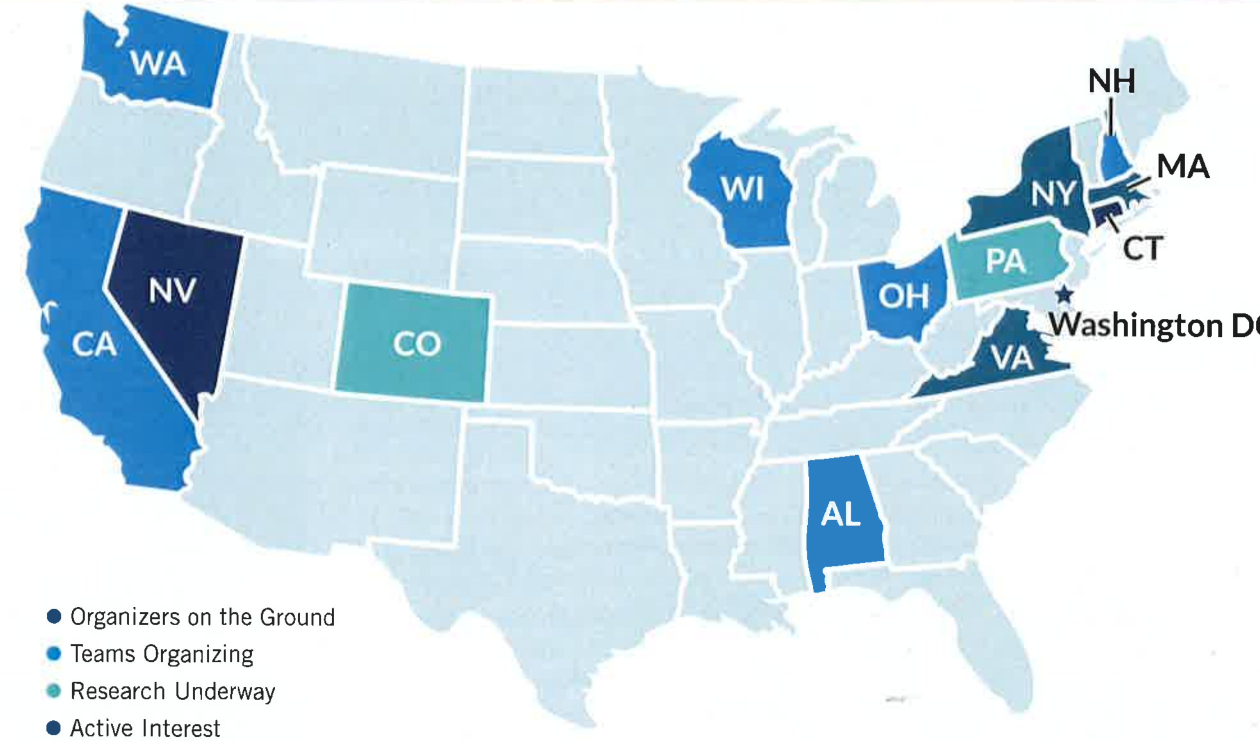

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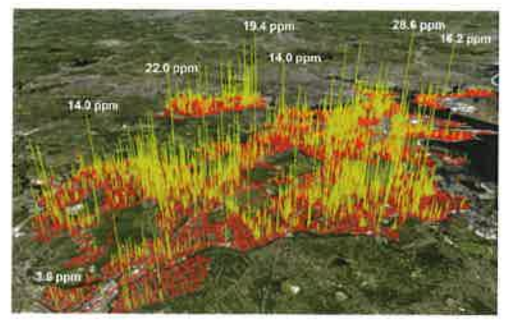

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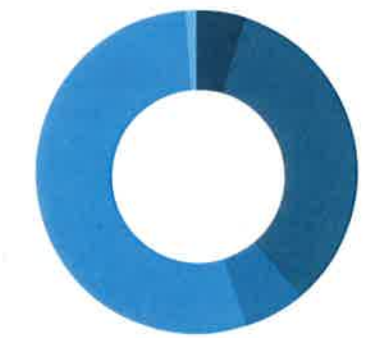

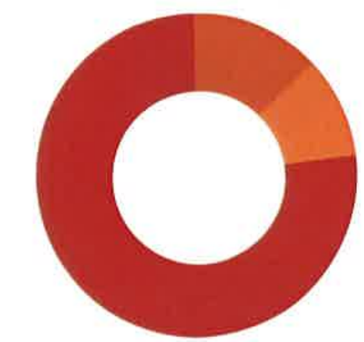

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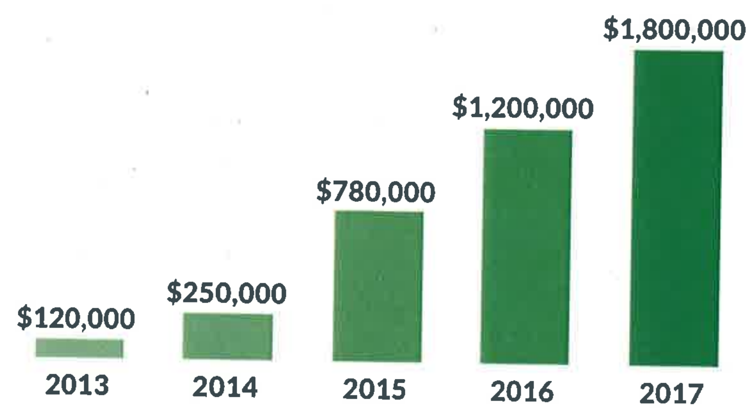

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