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House of Representatives
COMMONWEALTH OF PENNSYLVANIA
HARRISBURG

HOUSE DEMOCRATIC POLICY COMMITTEE HEARING
Topic: Should Pennsylvania Incentivize Natural Gas?
418 Main Capitol Building – Harrisburg, PA
March 21, 2016

AGENDA

10:00 a.m. Welcome and Opening Remarks

10:10 a.m. Panel on State Policies Which Incentivize Natural Gas:
- David Althoff, Jr., Manager of Office of Pollution Prevention and Energy Assistance, Pennsylvania Department of Environmental Protection
- Denise Brinley, Special Assistant to the Secretary-Strategic Industry Initiatives, Pennsylvania Department of Community and Economic Development

10:45 a.m. Panel on Whether Some Natural Gas Incentives Are Better Than Others:
- Robert Altenburg, Director, PennFuture Energy Center
- Michael Griffin, Associated Research Professor of Engineering and Public Policy, Carnegie Mellon University
- Tom Peterson, President and CEO, Center for Climate Strategies

11:35 a.m. Panel on Natural Gas Incentives and Our Carbon Budget:
- Donald Brown, Scholar in Residence, Widener University Commonwealth Law School
- Robert Howarth, David R. Atkinson Professor of Ecology and Environmental Biology, Cornell University
- Mark Szybist, Senior Program Advocate for Energy and Transportation, Natural Resources Defense Council

12:25 p.m. Closing Remarks

Testimony of

David Althoff Jr.

Environmental Group Manager

Department of Environmental Protection

Natural Gas Fuel Use Incentives in Transportation

House Democratic Policy Committee Hearing

March 21, 2016

Good Morning Chairman Sturla, Chairman Vitali, and Members of the Committee. Thank you for the opportunity to appear before you today and present information about the ongoing activities regarding natural gas use incentives in Pennsylvania managed by the Office of Pollution Prevention and Energy Assistance in Pennsylvania's Department of Environmental Protection.

My name is David Althoff Jr. and I've worked in for the Office of Pollution Prevention and Energy Assistance helping to oversee and deploy Alternative Energy Programs for PADEP for the past 17 years.

DEP is currently managing active projects from two previous natural gas incentive programs, the Act 13 Natural Gas Energy Development Program, designed to incentivize the purchase and use of heavy duty natural gas using vehicles, and the 2013 and 2014 Alternative Fuels Incentive Grant (AFIG) program, which was modified in those years to be a companion program to the Act 13 natural gas program to incentivize the use of natural gas use in medium duty and light duty vehicles.

I will provide to you today a brief status of the two aforementioned programs and then detail for you the recently announced the Alternative Fuels Incentive Grant Program for 2016, which also includes incentives for natural gas use in the transportation sector along with other alternative fuels.

In 2012, Chapter 27 of Title 58 (Oil and Gas) authorized DEP to develop program guidelines and to distribute up to $20 million in grants from the Marcellus Legacy Fund over a period of three years to help pay for the incremental purchase and conversion costs of natural gas fleet vehicles weighing greater than 14,000 lbs.

In total, for all three rounds of the Natural Gas Energy Development Program, 134 Applications were received. Sixty-two projects were competitively selected which resulted in the awarding of all funding which was available. As per the statute, the Natural Gas Energy Development Program ends December 31, 2016 and all awarded funds must be expended by that time.

The 62 Natural Gas Energy Development Program awards provided incentive for the planned the purchase or conversion of:

- 987 Compressed Natural Gas (CNG) vehicles weighing greater than 14,000 lbs.
- 119 Liquefied Natural Gas (LNG) vehicles weighing greater than 14,000 lbs.
- An estimated 13.9 million gasoline gallon equivalents (GGE) of natural gas fuel used annually, displacing petroleum fuel.
- Vehicles supporting 41 new natural gas fueling stations built in PA (38 CNG & 3 LNG). This break down to 20 fueling stations with full public access, 14 fueling

stations with limited/restricted public access, and 7 fueling stations with private access only.

- Vehicles supporting 34 existing stations in PA (30 CNG & 4 LNG). This breaks down to 14 fueling stations with full public access, 13 fueling stations with limited/restricted public access, and 7 fueling stations with private access only

As of the beginning of the year, DEP has reimbursed grantees for the purchase or conversion of 434 heavy duty vehicles under the Act 13 program totaling more than $8.7 million in program funds disbursed. The 434 vehicles supported to date with grant funds are estimated to be displacing over 5.2 million gasoline gallon equivalents per year. Over $23.5 million in actual incremental costs have been expended on alternative fuel vehicles due to this program.

DEP will be receiving reports annually for 3 years after project completion to track actual vehicle miles traveled for all vehicles supported with grant funds.

DEP also administers the Alternative Fuels Incentive Grant Program grant to promote the use of alternative fuels in Pennsylvania under the Alternative Fuels Incentive Act, Act no. 178 of 2004. (Act of Nov. 29, 2004, P.L. 1376, No. 178).

As a complimentary program, DEP through the Alternative Fuels Incentive Grant Program provided a grant program in 2013 utilizing the same format as the Natural Gas Energy Development Program only for CNG vehicles weighing less than the 14,000 lbs. gross vehicle weight threshold in the Act 13 Program AFIG also provided incentives for all other alternative fuel vehicles (propane, electric, etc.) of any weight or size.

The Alternative Fuels Incentive Act requires DEP to establish a formula and method to award Alternative Fuels Incentive Grants and to establish a method to prioritize the grant applications to so as to achieve certain goals and criteria, including the following:

- The improvement of Pennsylvania's air quality.
- The fulfillment of Pennsylvania's responsibilities under the Clean Air Act (69 Stat. 322, 42 U.S.C. § 7401 et seq.).
- The protection of Pennsylvania's natural environment, including land, water and wildlife.
- The advancement of economic development in Pennsylvania and the utilization of the state's indigenous resources.
- The reduction of Pennsylvania's dependence on imported crude oil and other petroleum products.
- The most cost-effective use of private and public funding.
- The transfer and commercialization of innovative alternative energy technologies.

Combined for the 2013 and 2014 years, DEP awarded 63 alternative fuel vehicle purchase or conversion projects resulting in a total award amount of $6.8 Million. All projects supported no more than 50 percent of the incremental purchase or conversion costs for the vehicles proposed.

The projects awarded resulted in the planned support for the purchase or conversion of:

- Deployment of 649 compressed natural gas fueled vehicles (medium and light duty vehicles).

- Deployment of 559 propane fueled vehicles deployed with no weight limits.

- Deployment of 18 electric fueled vehicles including both plug-in hybrid electric and fully electric vehicles.
- Vehicles supporting 38 new and 64 existing refueling stations in PA (gas, propane and electric).
- Over 3.1 million gasoline gallon equivalents displaced annually.

As of the beginning of this year, DEP has reimbursed grantees for the purchase or conversion of 264 vehicles totaling just over $1.5 million in program funds disbursed. The 264 vehicles are estimated to be displacing approximately 650,845 gasoline gallon equivalents per year. Over $3.1 million in actual incremental costs have been expended on alternative fuel vehicles due to this program. DEP will also be receiving reports annually for 3 years after project completion to track actual vehicle miles traveled for all vehicles supported with grant funds. Most remaining projects will be completed within this calendar year.

In February of this year, DEP announced a new round of incentives from the Alternative Fuel Incentive Grant program.

- Eligible Applicants include: School districts, Municipal authorities, and Political subdivisions incorporated nonprofit entities, Corporations, Limited liability companies or partnerships registered to do business in the Commonwealth.

Through the experience of the last several years, we have made some modifications to the Alternative Fuel Incentive Grant program to continue to support natural gas use as an alternative transportation fuel as well as other alternative fuels. One major modification is that we have opened the program for applications to be received throughout the calendar year and have defined three submission due dates at which projects submitted will be reviewed, scored and awarded. This is in place of one two-month application period/opportunity for potential applicants to arrange and scope projects. Applicants who are not determined to be best, will be notified, given feedback and hopefully will apply again in time for the next submission period with a more robust project. Submission periods are 4 months apart. It is our hope that we will here-to-fore operate the Alternative Fuel Incentive Grant Program as a continuously open program for years to come providing a funding opportunity that is always open and ready to provide assistance to the best project when they are ready to receive assistance which pushes the project over the top with assurances the project will get built.

AFIG will continue providing incentives for natural gas vehicles with some slight modifications as well as offer incentives for natural gas dispensing infrastructure aimed at segments of the transportation sector that we believe are more strategic and local.

The program changes for the Natural Vehicle Retrofit and Purchase projects category are:

- There is no gross vehicle weight rating (GVWR) limit. Vehicles of any size operating on alternative fuels are eligible and there is no minimum number of vehicles required to apply. Previously, there was a minimum project size of 5 vehicles.
- The funding cap for any alternative fuel vehicle project is set at $200,000. Previous Act 13 projects were capped at $500,000 and the 2013 and 2014 caps were set at $300,000 and $250,000 respectively. No individual vehicle may receive more than $20,000, as opposed to $25,000 in prior programs.
- We will support vehicles recently purchased or projects that will guarantee purchase of vehicles within 12 months of the application submission.

- Retrofit and purchase cost incentives will all be 50% of the incremental cost as long as the total grant award is not exceeded.

The Alternative Fuel Incentive Grant Program also plans to support Alternative Fuel Refueling Infrastructure projects (including Natural Gas) including the cost to purchase and install refueling equipment for alternative fuel fleet vehicles and the cost to purchase and install refueling equipment at a vehicle or vehicles' home location.

Fleet Refueling Projects are:

- Installation of refueling equipment which must service at least one existing fleet of alternative fuel vehicles by the end of the period of performance. (24 months)
- A fleet of alternative fuel vehicles must be a group of ten or more vehicles comprised of passenger cars, buses and trucks with a gross vehicle weight rating up to 26,000 lbs. (Class 1 through Class 6 vehicles) owned by a single entity.

Home-Based Refueling Projects are:

- Projects which are deployed at the alternative fuel vehicle(s) home location or base of operation and service at least one alternative fuel vehicle. Home location can be defined as the property location of the owner of the vehicle or the base of operation for the vehicle(s) using the refueling facility.
- Alternative fuel vehicles supporting a home based refueling project may only be passenger cars, light duty trucks, or light heavy duty trucks up to 10,000 lbs. in GVWR (Class 1 and Class 2a and Class 2b)

New refueling facilities and expansion of existing refueling facilities for both Fleet and Home-based location refueling projects will be considered.

These specific funding opportunities and the adjustments identified were to fill critical gaps in the expanding marketplace for natural gas fueling and vehicles which has been growing since 2011, but also has seen a slow down for those who are not the heavy duty and super large fuel consumers due to the price fall of diesel.

From an emissions standpoint, it is important that natural gas vehicles funded by these programs continue to provide emissions benefits, especially when replacing an older conventional vehicle.

An additional opportunity resultant of varied and widespread decentralized alternative fuel refueling capabilities is that other potential uses of alternative fuels then tend to occur such as the replacement of conventional fuel use in smaller applications, such as in forklifts and/or commercial lawn equipment, generators, etc. Because natural gas, propane etc. is a lower-carbon, cleaner-burning fuel, a switch to natural gas and alternative fuels in these applications can result in substantial reductions of hydrocarbon, carbon monoxide, oxides of nitrogen, and greenhouse gas emissions. Emissions from this this class of smaller equipment does not have the same tailpipe emissions standards as on-road vehicles and added up, their impacts could be significant

In addition, increasing the use and infrastructure and the number of vehicles consuming this alternative fuels may increase opportunities for renewable natural gas as well. Renewable natural gas, also known as bio methane, is chemically identical to fossil natural gas, yet may yield far fewer GHG emissions during the production process, the blending of relatively small quantities of RNG with fossil natural gas can provide significant life cycle GHG emission benefits and

Overall, CNG, LNG, Propane etc. are both cleaner-burning fuels and perform well against current vehicle emissions standards. The support of the use of Natural Gas in on road vehicles through the Natural Gas Energy Development Program and the past and current Alternative Fuels Incentive Grant Program will have resulted in millions of gallons of gasoline and diesel fuel displaced in Pennsylvania by the dispensing of cleaner burning indigenous fuels as well as supporting significant alternative fuel infrastructure growth.

I'd like to thank the committee members for their time and the opportunity to present information on our current programs and welcome any questions you may have.

House Democratic Policy Committee

March 21, 2016

Good morning, Chairman Sturla, Chairman Vitali, and members of the House Democratic Policy Committee.

My name is Denise Brinley and I serve as the Special Assistant to Secretary Davin of the Department of Community and Economic Development (DCED). In this role, I assist Secretary Davin in leading strategic industry initiatives, with a laser beam focus on the energy and advanced manufacturing sectors.

The Commonwealth is a leader in natural gas production due to our prolific shale gas resource. At DCED, we are working to broaden the benefits of the extraction, processing, and transmission of this natural resource to our economy and the communities that go with it. We are working to foster opportunities across the state that represent an intersection of our energy and manufacturing sectors. We are also working to capitalize on the global focus on Pennsylvania due to natural gas production to increase facilitated exports and DCED-facilitated Foreign Direct Investment.

We are at a critical inflection point with this resource that could power Pennsylvania's economy for the foreseeable future. There are currently more than $10 billion in transmission pipeline projects proposed for the Marcellus Shale that will transport our state's resource to end use markets. DCED is working with the Governor's Office and other state agencies to coordinate these large scale pipeline projects. We must focus our resources on the energy economy by putting the infrastructure in place to use the energy we have and capture downstream shale gas manufacturing-related opportunities.

But Pennsylvania needs to become more than a producer of natural gas. The commonwealth also needs our businesses and residents to become consumers. Now is the time for our state to harness our resources to drive economic progress beyond the boundaries of the resource development itself.

To tap the vast resources of the Marcellus Shale for economic growth, we must focus on expanding the use and delivery of natural gas to residential, commercial and industrial facilities. We can use natural gas in Pennsylvania to:

- heat and power manufacturing plants;
- manufacture chemicals and plastics;
- power more of our electric generating plants;
- heat our homes;
- fuel our school buses and fleet vehicles; and
- manufacture, distribute, and apply fertilizers to grow food.

DCED wants to maximize opportunities for natural gas projects that have a direct impact on workforce and economic development in Pennsylvania.

We want to maximize economic development opportunities through a targeted business recruitment strategy that encourages 1) the expansion of existing companies, and 2) the attraction of new facilities that are large consumers of natural gas for energy and/or natural gas liquids and their derivatives as raw materials in their manufacturing processes. DCED is developing a coordinated marketing strategy to encourage and promote Pennsylvania as a strategic location based on our prolific natural gas resource, world class university system, strong workforce, and strategic location. Our 21st century economy will be built upon these assets. The Secretary, the Governor's Action Team (GAT), and the Office of International Business Development, in particular, have been proactively targeting natural gas end users nationally and internationally and recruiting downstream companies to the state.

Part of this strategy includes cross border collaborations with our neighboring producing states, where appropriate. In October 2015, Governor Wolf signed the Tri-State Shale Agreement, a three-year cooperative agreement with West Virginia and Ohio to collaborate on maximizing economic growth in the shale gas region. As part of this agreement, we will work with these states to cooperate in marketing efforts to attract new businesses, strengthen workforce development programs, spur investments in expanding infrastructure and delivery of natural gas and liquids, and encourage our academic institutions to expand and collaborate on research related to natural gas uses and energy-related opportunities.

We are also working with the Greater Philadelphia Chamber of Commerce, which has created the Greater Philadelphia Energy Action Team, to establish an "energy hub" in the Philadelphia region, where there is potential for billions of dollars of investment. We want to help grow our chemical manufacturing base, liquid natural gas (LNG) production opportunities, and other downstream end uses of our natural gas.

We are also encouraging the use of natural gas at ports in Pennsylvania, where small scale LNG facilities can be developed and operated to serve maritime vessels.

In other parts of the state, we are encouraging the implementation of natural gas "virtual pipeline" delivery systems, which can provide natural gas to users that are too far from existing pipelines and where extensions are not economically feasible.

We are working on coordinating and collaborating with economic development stakeholders across the state. We also are working at the federal level with the Appalachian Regional Commission and the Economic Development Agency to help coal impacted communities through President Obama's Partnerships for Opportunity and Workforce and Economic Revitalization (POWER) initiative. As the coal industry declines, we recognize that some of these jobs may shift to the natural gas industry and we play a key role in assisting impacted businesses and dislocated workforce.

DCED wants to maintain Pennsylvania's economic position as an energy producing state and net energy exporter, but ensure we are doing so in an environmentally-conscious way. We are looking at natural gas-fired power plants and combined heat and power systems as economical options. We recognize the environmental benefits can be significant when utilizing natural gas instead of other fossil fuels. We must stress, however, that we understand that we must balance natural gas and renewable energy production to ensure we have a diverse energy economy and a sustainable future.

One of the few programs that provide funding for natural gas projects is the Alternative and Clean Energy program under the Commonwealth Financing Authority. This program provides loans of up to $5 million and grants of up to $2 million to alternative and clean energy projects in the state. This program is currently open and we are accepting applications until April 1, 2016. In the past, this program has funded natural gas projects such as the construction of compressed natural gas filling stations.

We understand that we cannot do many of our economic development initiatives without the necessary workforce. DCED will continue workforce training efforts that effectively meet the needs of our businesses and maintain a strong worker pipeline. We will promote additional industry partnership and apprenticeship opportunities so that students are increasingly matched with open industry positions and trained in critical skills necessary for a career in advanced manufacturing or energy.

DCED believes the most important step in promoting the right investments in our energy economy is to position Pennsylvania as **THE** energy state in North America. With focused attention and impactful investments in the energy and advanced manufacturing sectors, DCED is determined to harness the next era of business growth.

Thank you for the opportunity to testify today. DCED looks forward to any input you may have as we continue to move forward with efforts to retain, expand, and attract energy-related businesses to the state.

Before the House Democratic Policy Committee:
Are Some Natural Gas Subsidies Better Than Others?
Testimony of Robert C. Altenburg
Director, PennFuture Energy Center
March 21, 2016

Good afternoon Chairman Sturla and members of the Committee.

My name is Robert Altenburg and I'm the director of the Energy Center at Citizens for Pennsylvania's Future (PennFuture). We are a statewide non-profit environmental advocacy organization focusing on land, air, water, and energy issues that impact Pennsylvania. I'm very happy to be here today to discuss fossil fuel subsidies.

Last year, PennFuture released a report identifying **over $3.2 billion dollars in fossil fuel subsidies provided by Pennsylvania** during fiscal year 2012 – 2013.[1] Although a large number, this is still a conservative estimate because we limited our calculations to subsidies for which data was readily available. We also excluded federal fossil fuel subsidies, which are large, numerous, and have been in place for decades.

We recognize that energy subsidies present complex issues, and have been implemented for different reasons. To be clear, we are not calling for a blanket end to all energy subsidies as some analysts and media sources have suggested. Instead, as our report indicates, **we need greater transparency and ongoing evaluation to ensure these subsidies provide the Commonwealth overall benefit.** This is particularly true in the case of fossil fuel subsidies.

Pennsylvania's Constitution states that "Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."[2] At the very minimum, **the Legislature has a duty to ensure that any fossil fuel subsidy enacted upholds both the letter and the spirit of this Constitutional guarantee.**

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[1] PennFuture, Fossil Fuel Subsidy Report for Pennsylvania, (April, 2015), *available at: http://www.pafossilfuelhandouts.org/*
[2] Pa. Const. Art. I § 27.

How do we define subsidies and why are they an issue?

According to the International Energy Agency, a subsidy occurs when a government makes a financial contribution that confers a benefit on energy producers.[3] In Pennsylvania, this may include grants, loan guarantees, the assumption of environmental liability, tax expenditures, or other preferential policy treatment. Some of these lower the cost of production or raise prices, others lower consumer prices or otherwise influence purchasing decisions.

Subsidies may be effective tools to achieve particular objectives, but like any tool we must be aware of the risks. We can divert limited resources to favored recipients based on political influence rather than a well-reasoned justification, or we find that by masking the real price of goods and services there are unintended consequences resulting in more harm than good.

Examples of Pennsylvania fossil fuel subsidies

Tax expenditures

The majority of fossil fuel subsidies in Pennsylvania come in the form of tax expenditures. This is government spending through the tax code in a manner that favors or promotes fossil fuel use over other alternatives. Rather than the government appropriating money through the budget to promote a result, the government achieves the same goal by forgoing revenue. For example, instead of appropriating additional funds to support volunteer fire and rescue squads, Pennsylvania choose to forgo revenue by providing an exemption from taxes on motor fuel.

Sales tax

Tax expenditures can be revenue neutral, but favoring one product over another often has side effects that work against our policy goals. **Pennsylvania's sales tax rules provide incentives for fossil fuel based energy use rather than conservation.** For example, practically all purchases of electricity are exempt from sales and use tax. Yet, purchases of items that save electricity like LED light bulbs, insulation, and solar panels are taxed. While we want to ensure that citizens have access to affordable energy, promoting energy efficiency furthers that same goal of making energy less expensive to the consumer. **Providing a tax exemption for energy purchases and not energy efficiency favors energy consumption over conservation**, which incentivizes the waste and pollution associated with energy production.

[3] World Trade Organization (WTO), *Uruguay Round Agreement on Subsidies and Countervailing Measures*, Definition of a Subsidy, 1.1, *available at*: https://www.wto.org/english/docs_e/legal_e/24-scm_01_e.htm.

Property tax

Pennsylvania's property tax rules also favor particular fossil fuel energy sources over others. While property taxes are a key source of revenue for our counties, municipalities, and schools, we have made policy decisions to exempt churches, hospitals, schools and nonprofits. These exemptions subsidize non-commercial entities that provide critical services to our communities. Pennsylvania property taxes also subsidize some energy sources over others. For example, oil and gas reserves and operating wells are exempt from property taxes, whereas coal reserves and coal mines are subject to these taxes. As a result, Pennsylvania property tax policy directly favors the development of natural gas over coal and, as a result, makes it more difficult for clean energy alternatives to compete.

The natural gas industry is currently facing financial challenges caused by oversupply and record-high stockpiles, resulting in low market prices.[4] In this situation, **additional incentives to further expand natural gas production are counterproductive.**

Lack of a natural gas severance tax

If the natural gas industry does not fully compensate state and local governments for the external cost of their activities, a subsidy exists equal to the costs to the government to pay for those externalities. The Pennsylvania Budget and Policy Center has calculated that the effective rate of the current impact fee may be the equivalent of a severance tax of less than 2 percent.[5] That combined with a very low effective corporate tax rate for drillers[6] means that there is significant risk that the public is subsidizing external costs associated with natural gas development, including enforcement, road damage, housing shortages, and harm to public health and the environment.

Plainly, in the energy field as in other areas, Pennsylvania's tax expenditures reflect specific policy choices that promote particular items and activities. PennFuture believes that it is good public policy to **periodically evaluate the billions of dollars in tax expenditures** being made under existing tax policy, and reassess the effects of those choices to determine if they continue to further reasonable policy choices, or whether there are better choices available.

Preferential Policy Treatment

In addition to tax expenditures, there are laws on the books that create other forms of preferential treatment that effectively subsidize fossil fuels.

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[4] C. Buurma, M. Shenk, *Natural gas slides to 17-year low as glut widens,* Bloomberg News (Feb. 25, 2016).
[5] Penn. Budget and Policy Center, *Pa's Marcellus Impact Fee Comes up Short* (June 18, 2013).
[6] Penn. Budget and Policy Center, *Gas Production Booms, Drillers; Corporate Tax Payments Plummet*, (June 6, 2013).

In 1990, two years after Dr. James Hansen made his address to Congress saying global warming had already begun,[7] Pennsylvania passed a law that said "**Any heating system or heating unit installed in a facility owned by the State...shall be fueled by coal**."[8] The law allows the Department of General Services (DGS) to use other fuels in some cases, but there remains a clear bias towards use of fossil fuels. Scientists from Stanford and UC Berkeley have shown that with each degree of warming that a country experiences, its economic production drops, and if it begins at a warmer temperature, then it suffers a greater drop in economic performance for each degree of warming.[9] Considering the current state of knowledge about the economic impact of climate change, **it is ludicrous for the state to perpetuate a policy mandating that DGS use coal fired heat or fossil fuels** in state-owned buildings.

Most business owners in the state, understand that if they cannot afford liability insurance, to protect their neighbors and community, they cannot afford to be in business. Unfortunately, this does not always apply to possible environmental damage. When activities are too risky for private insurers, the government may step in with bonding programs or other mechanisms where the government assumes risk and responsibility for mitigating harms associated with the activity. If the government is not fully compensated for its expenses, a direct transfer of wealth exists. If the government provides insurance below market rates for certain industries, that once again creates a situation where it is more difficult for other alternatives to compete.

Conclusion

Pennsylvania has a legacy of environmental damage from extractive industries including timber, oil, coal, and gas. In response, we passed a Constitutional amendment requiring that the government act as a trustee with the duty to conserve and maintain our environment and our resources. The threats associated with climate change only add to the urgency of this duty.

Pennsylvania must work to reduce dependence on fossil fuels and promote alternatives such as energy efficiency and clean renewable energy. To do so, we must align our investments with our goals and avoid unintended side effects that promote pollution. This is a significant undertaking, but as a start PennFuture recommends the following:

- **Greater Transparency**: To make informed decisions, policymakers and the public need to have ready access to the magnitude of existing subsidies and their impacts. We recommend that a non-partisan, governmental organization should develop and periodically update a comprehensive report on Pennsylvania's energy subsidies.

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[7] P. Shabecoff, *Global Warming Has Begun, Expert Tells Senate*, New York Times, (June 24, 1988).
[8] Act of Apr. 9, 1990, P.L. 115, No. 28.
[9] Thomas Sterner, *Higher Costs of Climate Change*, Nature, Volume 527 (November 12, 2015).

- **Regular and ongoing evaluation of the costs and benefits of the subsidies:** As time and technology changes, subsidies that were once justified may no longer make sense. Regular reconsideration of existing subsidies is needed to ensure we are spending money wisely and working towards our goals.

We believe Pennsylvania can build a vibrant and growing economy on clean and renewable energy. We ask our Legislature to help lead us to that future.

Should Pennsylvania Incentivize Natural Gas?
House Democratic Policy Committee Hearing

W. Michael Griffin
Associate Research Professor
Engineering and Public Policy
Carnegie Mellon University

March 21, 2016

Good morning. Thank you Chairman Sturla and Representative Vitali and distinguished members of the House Democratic Policy Committee for the gracious invitation to discuss the idea of incentives for natural gas use. I will concentrate on incentivizing transportation use of natural gas. But let's establish two points for a common understanding. First, natural gas is NOT a bridge fuel to a renewable energy system, it is a simply bridge to nowhere.

There has been a series scenarios of natural gas use developed to seed climate models and these efforts suggest that, the availability of low priced abundant natural gas displaces more than just coal fired electricity production and substantially increases economic activity in general. The combined effect is that there is no discernible reduction in fossil fuel GHG emissions out to 2050. If a high fugitive emissions rate for natural gas production is assumed, climate forcing increases by 5%. To meet the IPCC AR5 goal of limiting warming to 2°C we need to immediately transition to low-carbon renewables (wind, solar and nuclear) and move transportation to the grid. Some see the natural gas transition as an impediment to these climate goals.

Second, natural gas IS a cleaner burning fuel compared to its other fossil counterparts. Less criteria pollutants are emitted on combustion. Compared to coal plants, natural gas plants emit less sulfur dioxide (SO_2) and nitrogen oxides (NO_x), both of which are precursors of particulate matter. Natural gas also has lower primary emissions of particulate matter up to 2.5 microns in size ($PM_{2.5}$) compared to coal combustion. Exposure to $PM_{2.5}$ has been conclusively been linked to human mortality and morbidity.

My colleagues and I have recently had a paper accepted in the journal *Energy* that shows a complete switch to natural gas from coal can result in a reduction of monetized health and environmental damages of between $20 and 50 billion annually. The majority of this reduction is in the PJM ISO region – PA!

Do we need subsidies/ Incentives to make this transition? I can't imagine the Commonwealth can do much at re-work the entire electricity system as this is a massive change but the adoption of the Clean Power Plan will be a step towards this transition. We should expect similar health benefits (but not as large) can be expected for natural gas replacement of diesel fuel because of the particulate emissions associated with diesel combustion.

The use of natural gas in transportation can take the form of compressed natural gas (CNG) or liquefied natural gas (LNG). It is commonly thought that natural gas life cycle greenhouse gas emissions are less than its fossil counterparts for transportation, gasoline or diesel. The often quoted GREET modeling system developed at Argonne National Laboratories shows that there is between a 6 to 11% reduction in these emissions.

However, two recent peer-reviewed publications by two of my colleagues at CMU and graduate student Fan Tong (the lead author) documented an extensive study of natural gas use in the light duty fleet (the cars and trucks we normally drive) and commercial vehicles (delivery vans, trucks, buses, garbage trucks and tractor trailers). They showed that the vehicles using natural gas fuels have slightly higher greenhouse gas emissions based on a delivery of the intended service, a distance traveled (per km) or "freight" movement (per tonne-km). The authors conclude that within the limits of the uncertainty of the life cycle model, natural gas emits the same level of GHG emissions as gasoline or diesel. As I said before there is really no GHG emissions advantage for natural gas use.

Any alternative fuel must compete against the incumbent in the marketplace. Like in politics, the incumbent has some built in advantages. For diesel and gasoline these include vehicles that use the fuel, an extensive infrastructure designed to deliver the fuel, produce and maintain the vehicles, and the entire system is well known and "comfortable" for the general public.

Natural gas starts with an extensive delivery infrastructure of hundreds of thousands of miles of pipelines, some 150,000 natural gas vehicles nationwide, but the end use fueling infrastructure is very limited. I have seen estimates 7 to 61 CNG refueling stations in PA. To put the vehicle numbers into perspective, there are about 600,000 Flexible Fuel Vehicles (FFV) capable of using the alternative fuel E85 in PA. There is four times more PA FFV than natural gas vehicles in the national fleet. So one can assume the number of vehicles to support early use of natural gas in PA is likely very small.

Any alternative fuel has a difficult marketplace entry because of the chicken and egg perspective. The fuel needs to be available to run the vehicles and the vehicles need to be available to use the fuel. There is an infrastructure threshold where fuel availability no longer enters into the buying decision. This is generally thought to be around 10% of the stations offering the fuel. We estimate that there are between 2,000 to 3,000 refueling stations in PA and thus one can envision the need for 200 to 300 stations offering the fuel to reach this milestone. This would be a transition that would be difficult to incentivize with any degree of success, mainly due to costs.

I will point out that after years of federal incentives dating back to the 70's, E85 use in PA is less than a tenth of 1% of fuel sales and there are only 37 refueling stations in the State. The impediment is simply fuel costs. E85 costs more on a gallon of gasoline equivalent basis than gasoline (now E10).

Natural gas has been shown at times to provide transportation services at less cost than its petroleum competitors. This is good. Comparing the price of diesel and gasoline from 2012 to 2014 about ¾ of the time the petroleum fuels were cheaper. Without the cost difference the luster of natural gas as a fuel is lost.

New fuel vehicles having not yet achieved economies of scale, generally have a premium price. Because cost benefits are usually small between the alternative and incumbent proponents look early on to fleet use. The high mileage use allows the initial capital outlay to be rapidly recovered.

Natural gas has been adopted by many fleets, return to base delivery vans are a prime example. The advantage of this strategy is multifold: the fueling infrastructure can be right sized to the use, vehicles can be refueled overnight, and return to base vehicles do not need to be bi-fueled or dual fueled vehicles reducing costs. We should note that within the last year UPS has announced the addition of 15 CNG fueling stations and 1,400 new CNG vehicles. One of those stations is intended for New Stanton.

Although I have been discussing the problems/issues to adopting the alternative fuel there is a sweet spot for a targeted incentive. When I think of public policy issues, I try to imagine policies that can hedge the bets. So if one adopts incentives in hopes of helping the PA economy, creating general prosperity, and potentials jobs, why not target the incentive where we know there are additional benefits that can accrue so that no matter the ultimate economic outcomes there will be a positive benefit-cost balance sheet.

Remember natural gas is a clean burning fuel, we should take advantage of this. The literature is clear that CNG compared to diesel use results in less hydrocarbon, VOC, SOx, NOx and particulate emissions, even with after treatment. These pollutants result in health impacts such as cardiovascular disease and infant mortality. The exact health impacts need to determined based on a specific program but currently, diesel transit buses, return to base delivery trucks, garbage trucks, and school buses all operate in densely populated areas of the Commonwealth. Health impacts are the highest where exposure is the highest. These are the streets of our heavily populated cities and suburbs. A program targeted at these vehicles to aid in switching from diesel to natural gas will likely have monetized health impacts larger than the associated economic benefits. Thus, if one must incentivize do so where it can do the most good.

THE CENTER FOR
CLIMATE STRATEGIES

To: Pennsylvania House Democratic Policy Committee Hearing

From: Tom Peterson and Nikola Pilipovic, The Center for Climate Strategies

Subject: Should Pennsylvania Incentivize Natural Gas?

Date: March 21, 2016

Background

The question of whether and how to provide public incentives for production and delivery of natural gas and other energy resources involves an understanding of: 1) *justifications for market intervention* and where they might apply, and 2) the *comparative return on investment* for policy and investment mechanisms related to energy, whether they are budget priorities, and if they are otherwise feasible for application.

Generally, market intervention may be justified where markets fail to efficiently or equitably distribute resources for one or more of the following reasons:

1) imperfect competition or collusion
2) imperfect information
3) nonmarket values, such as health
4) common property resources where controls do not exist for resource use and conservation due to lack of private ownership rights; and 5) distributional impacts, such as poverty or other forms of inequality
5) economic rents (windfall profits), where an increase in market value is caused by exogenous conditions, and producers gain higher profits not "earned" by them
6) split incentives, sometimes known as moral hazard, where one party fails to act efficiently because the rewards for doing so fall uncontrollably to another party (the "landlord-tenant" problem)

In terms of these potential justifications for intervention through incentives (or disincentives), natural gas falls under some of these categories. With respect to health and environment, often not valued adequately through market pricing, natural gas can be can be considered as a "clean" or low carbon, low emitting energy resource in comparison to higher emitting alternatives, such as conventional coal based power generation or home heating oil. To the extent that natural gas displaces higher carbon alternatives, it may correct for the lack of a natural market incentive for the reduction of public risk.

While natural gas is not as clean as renewable energy, nuclear energy, or energy efficiency in terms of carbon emissions, it does provide lower carbon impacts and negative externalities than conventional fossil alternatives. It may also reduce other pollutant loadings, such as fine particulate matter (PM). The shift from higher polluting alternatives to natural can gas provide a significant shift to less harmful energy supplies. As such, it may justify public intervention for health and environmental benefit. This does not hold if natural gas displaces cleaner alternatives, such as renewable energy or energy efficiency.

However, choices between natural gas and other forms of low carbon and low emitting energy may not be mutually exclusive. Expanded natural gas production can be used to expand renewable and efficient energy through the provision of indigenous, low cost feed stocks for advanced chemicals and materials inputs to renewable and efficient technology development and production with the net effect of reducing pubic risk associated with pollutants. Other benefits may result from this linkage, including economic stimulus.

An industrial strategy the overtly links natural gas with renewable and efficient energy is an important option for Pennsylvania given its production, domestic consumption, and export potential. The public benefits that can be provided by clean energy may justify public incentives that are an important inducement to the flow of private capital. This include health environmental protection, and also macroeconomic benefits that can address inequities (distributional impacts), particularly jobs, economic growth and personal income. Economic design strategies and mechanisms are critical to this potential benefit. Clean energy may also provide energy security benefits if domestic supplies replace energy imports and supply chains, or if they expand source and use diversity.

If justifications exist, potentially, for natural gas incentives, the next question becomes their comparative return on investment for public benefits not naturally provided by the marketplace. This is where the use of appropriate analysis can be helpful. Health, environment, and energy security effects of clean energy choices, and their direct economic impacts, can be estimated through state of the art energy and resource systems analysis.[1] Economic equity issues can be evaluated via indirect economic system effects (macroeconomic) modeling, including use of advanced tools such as the REMI, Inc. model.[2] Analysis is most helpful when

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[1] Delaquil, P., Goldstein, G., Nelson, H., Peterson, T., Roe, S., Rose, A., Wei, D., & Wennberg, J. (2014). Developing and Assessing Investment Options for Economic, Energy, and Climate Security Gains in the United States. *Low Carbon Economy, Scientific Research, 5(1)*

[2] Dernbach, J. C., McKinstry, R. B., & Peterson, T. D. (2010). Making the States Full Partners In a National Climate Change Effort: A Necessary Element for Sustainable Economic Development. *Environmental Law Reporter*, *10*(08)

McKinstry, R. B., Peterson, T. D., Rose, A. Z., & Wei, D. (2009). The New Climate World: Achieving Economic Efficiency In a Federal System for Greenhouse Gas Control Through State Planning Combined with Federal Programs. North Carolina *Journal of International Law & Commercial Regulation*, *34* (102)

Peterson, T. D., Rose, A., & Wei, D. (2010). Impacts of Comprehensive Climate and Energy Policy Options on the US Economy. *Center for Climate Strategies & John Hopkins University* applied at a highly specific level on policy options and mechanisms and the returns of benefits to funding outlays (cost, or investment).

The Center for Climate Strategies (CCS) has conducted many such analyses of direct and indirect effects of policy options over the past decade, including numerous assessments of state level energy policy and mechanism alternatives designed to improve economic, energy, economic, and equity conditions at the same time, and consistent with justifications for market intervention described above. The selection and design of alternative choices used in policy planning and development by states can be guided by a sharp understanding of how these choices affect outcomes, particularly macroeconomic impacts, and how their return on investment compares across other options.

Because of the primary importance of economic issues in the stakeholder and leadership community, CCS has focused heavily on understanding successful design and implementation of macroeconomic strategies as they related to climate mitigation and sustainable energy. To understand general patterns of macroeconomic impacts and design strategies more clearly, members of the CCS analytical team conducted a meta analysis of macroeconomic studies of state climate plans. This involved statistical (multivariate regression) analysis of many REMI modeling evaluations of highly specific policy options and mechanisms in the energy supply and use sectors.[3] Results may be helping in guiding Pennsylvania choices on clean energy incentives.

Six key macroeconomic impact and design strategies emerged from the meta analysis. These include the following empirical findings:

1. Cost-effective actions increase economic efficiency and expansion. Policies with an overall net cost that is lower than alternatives, or negative (indicating greater total societal savings than total costs), enable reinvestment of savings and expansion of growth, employment, and income. Where reinvestment is targeted to labor intensive activities, it may further expand employment.
2. Energy savings cut costs and stimulate labor investment. Similarly, when households, industries and government entities can spend less in order to achieve the same outcome, this expands reinvestment and has a macroeconomic stimulus effect.
3. Shifts to indigenous vs. imported resources tend to cut job outflows. The shift to indigenous sources can also have significant positive local growth, employment, and income impacts by shifting associated activities to local sourcing and reducing the flow of private and public funds out of the region.
4. Actions supported by local vs. distant supply chains tend to shift economic growth, employment, and income outflows from external to local areas.
5. New investment from outside versus inside jurisdiction sources has an expansionary effect and stimulates growth, employment, income, and investment at home. It expands

[3] Rose, A., & Dormady, N. (2011a). A meta-analysis of the economic impacts of climate change policy in the United States. *The Energy Journal*, 32(2), 143-166

the total amount of business spending within the region, and reduces or eliminates tradeoffs involving shifts of existing investment to new policy and market actions.

6. Increasing labor-intensive activities tends to create more jobs, even if at higher cost (up to a point). Investment in labor intensive activities increases direct employment. In particular, renewable energy tends to have significantly higher labor multipliers than conventional energy alternatives. However, indirect losses of jobs can occur when new sources of energy are more costly than existing sources, and increase the prices of goods and services in the economy, and leads to economic contraction and indirect job loss. As a result, cost differentials and controls may be critical to evaluation of the return on investment for incentives used for job creation.

These strategies help us understand where energy incentives might be most productive, how best to design them, and how they might be targeted within and across sectors when combined with an understanding of barriers to investment and market expansion of clean energy.

In general, three major clean energy barriers exist and include: cost, technology, and investment. Incentives may be targeted to any or all of these areas.

Cost differentials for renewable energy, for instance, have been addressed by focus on so called "hard" and "soft" costs as means to accelerate technology development and deployment.

Hard costs involve technology development and acquisition, such as solar, wind, biomass, hydro, and waste recovery or conversion technologies. While these costs are falling, they are not as low as needed to support full scale up of renewable energy to levels needed to meet environmental, energy, and economic goals in some cases. Technology needs include both energy conversion (e.g. solar or wind conversion to electricity) and energy distribution through centralized (grid based) or decentralized (on site, off grid) systems. Grid modernization and distributed generation links are particularly important areas for renewable energy.

Soft costs involve the installation and use of energy supply or savings technology, such as regulatory and siting approvals, financing and rate approvals, linkage to centralized power systems, and other deployment costs. These are often the largest and most controllable components of cost.[4]

Cost controls have a corollary effect on investment. As cost differentials fall, clean energy markets become more competitive and naturally attractive for investment. At the same time, they become more capable of generating macroeconomic benefits such as jobs that are of interest to public policy makers and social impact investors.

Table 1 below summarizes areas where public incentives in Pennsylvania might be justified for natural gas, renewable energy, and energy efficiency in Pennsylvania and designed to maximize macroeconomic returns to investment through incentives or disincentives.

[4] http://www.nrel.gov/docs/fy12osti/54574.pdf

Table 1. Pennsylvania Clean Energy Incentive Options

Macroeconomic Design Strategy	Natural Gas	Renewable Energy	Energy Efficiency
1. Cost-effective actions increase economic efficiency and expansion	Capitalize on low costs and maintain competitive markets	Address hard costs via technology development Address soft costs through best practices and management	Address hard costs via technology development Address soft costs through best practices and management
2. Energy savings cut costs and stimulate labor investment	Pair shifts to gas with expansion of energy efficiency	Pair shifts to renewables with expansion of energy efficiency	Expand savings and targeted reinvestment
3. Shifts to indigenous vs. imported resources tend to cut job outflows	Focus on domestic resource development and use (supply); capitalize on domestic resources	Focus on domestic resource development and use (supply); capitalize on domestic feed stocks for technology	Reduce demand for imports while shifting to domestic supply
4. New investment from outside sources stimulates labor and investment at home	Export resources for energy and technology use; maintain attractive investment climate	Export technology and secondary and tertiary inputs to production (second and thirds stage materials and chemicals); create and maintain attractive investment climate	Export technology and secondary and tertiary inputs to production (second and thirds stage materials and chemicals); create and maintain attractive investment climate
5. Actions supported by local vs. distant supply chains tend to avoid job outflows	Focus on domestic technology and services use	Focus on domestic technology and services use	Focus on domestic technology and services use
6. Increasing labor-intensive activities tends to create more jobs, even if at higher cost	Identify and support high ROI areas for labor, income	Identify and support high ROI areas for labor, income; reduce price and cost differentials to maximize	Identify and support high ROI areas for labor, income

Table 1 also raises the question of whether evidence exists to support linkage between clean energy and economic stimulus. Various state level clean energy studies have documented the potential for macroeconomic stimulus from clean energy investments. For instance, CCS recently completed evaluation of energy supply and demand policy options for the state of Minnesota.[5] This included options to strengthen the state's renewable energy standard as well as retiring and or converting coal plants to natural gas use.

Results in Figures 1-5 below show macroeconomic evaluations for a range of state policy options related to clean energy and resource use. The first set of figures show impacts of energy supply (ES) policy options. In Figure 1, Policy Option ES-1 is an expansion of renewable energy through a flexible target and creates significant macroeconomic benefits, whereas ES-2 is an option for coal plant retirement and or conversion. It does not have the same positive effect. Figure 1 shows sector wide impacts for both policy options for base and aggressive renewable energy target scenarios in the last two columns.

Figure 2 shows changes in employment over time, and reinforces the finding of stronger effects of expanding renewable energy in comparison to coal plant retirement or conversion to natural gas. Figure 3 shows the effect of stringency of the higher renewable energy standard on jobs in Minnesota, with stronger job growth associated with more stringent standards.

Figures 4-5 show additional evaluation of macroeconomic effects of energy efficiency policy options in the Residential, Commercial, Industrial, and Institutional (RCII) sector. Only one option does not show strong performance, in this case due to high costs. Overall, the energy efficiency sector shows strong returns for jobs, growth, and income.

Key differences may exist between Pennsylvania and Minnesota. In Minnesota, domestic natural gas supplies are more limited than in Pennsylvania, and less potential exists for vertical integration and horizontal diversification within the state through use of indigenous resources. Results do suggest that the renewable energy resource is potent as an economic stimulant, and should not be compromised by natural gas expansion if economic growth, employment, and income are important. The same can be said for the energy efficiency resource. As a result, it may be valuable in Pennsylvania to evaluate the potential for all clean energy resources, including natural gas and renewables as well as efficiency, and to link them where strategic. See Figures 7-9 for resource potential for renewable energy in Pennsylvania and other states, and note similarities with Minnesota.

[5] http://www.climatestrategies.us/policy_tracker/policy/index/24

Figure 1. MN ES Policy Options, Macroeconomic Indicators, Cumulative Impact Indicators, 2015-2030

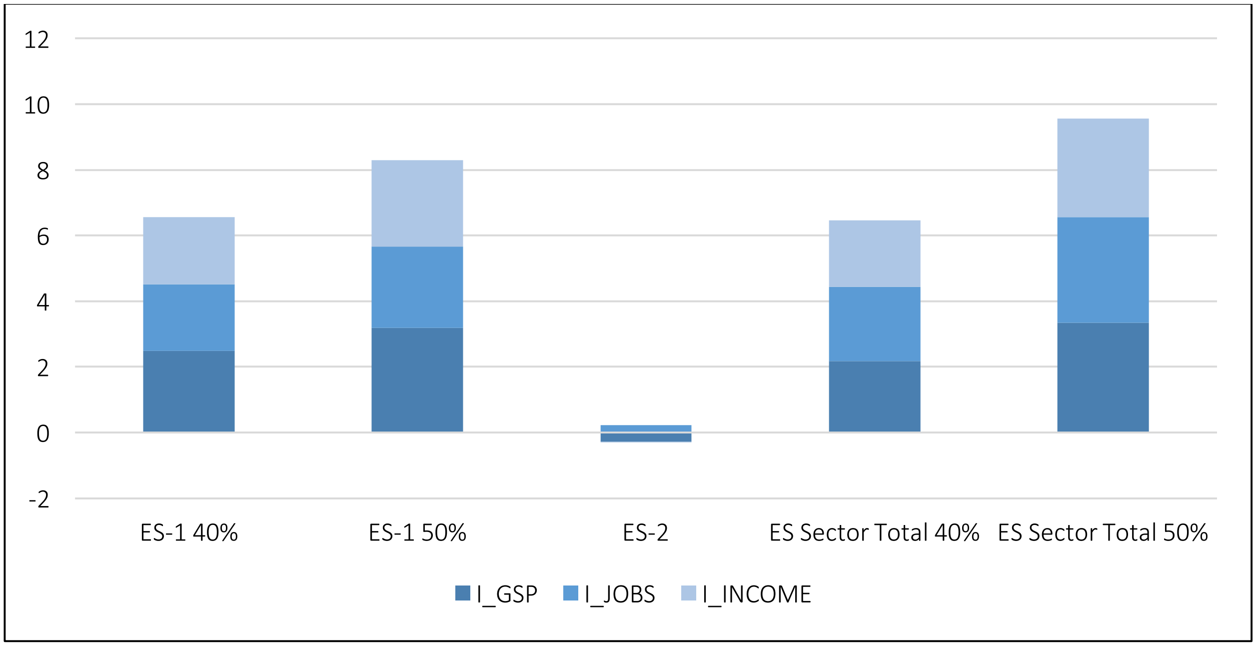


Figure 2. MN ES Policy Options, Employment Impacts (Jobs)

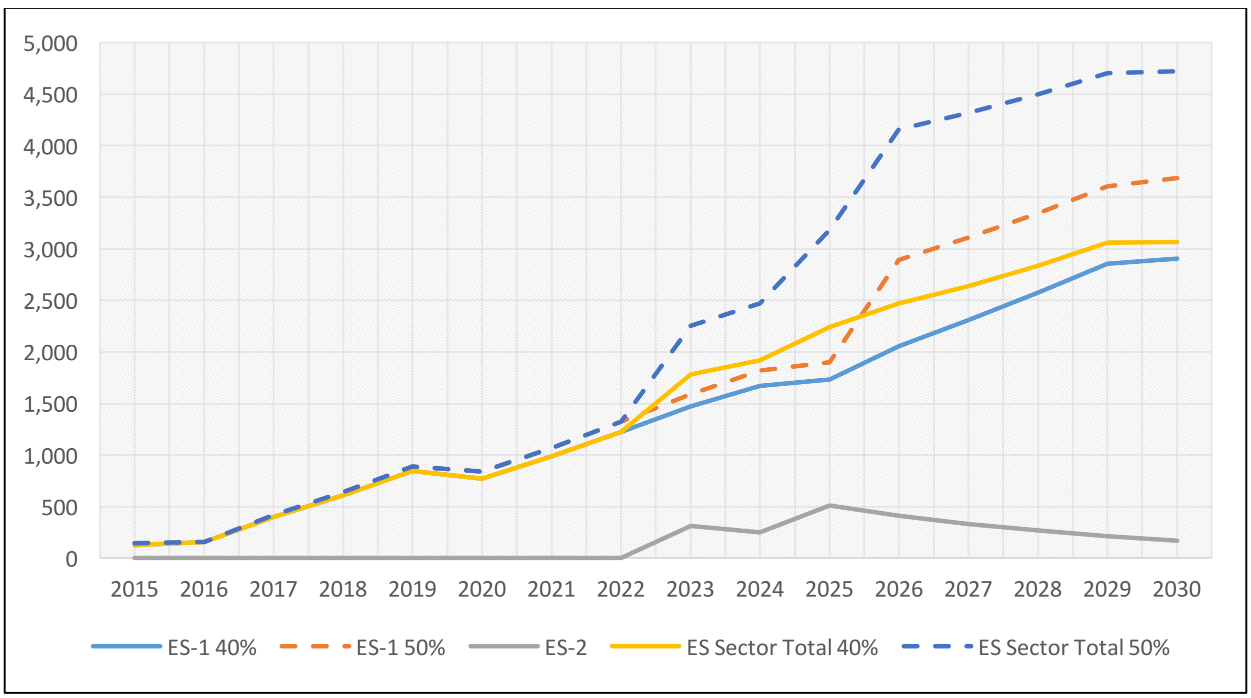


Figure 3. MN ES Policy Options, Macroeconomic Impacts of 40% Versus 50% Targets for Renewable Electricity Use

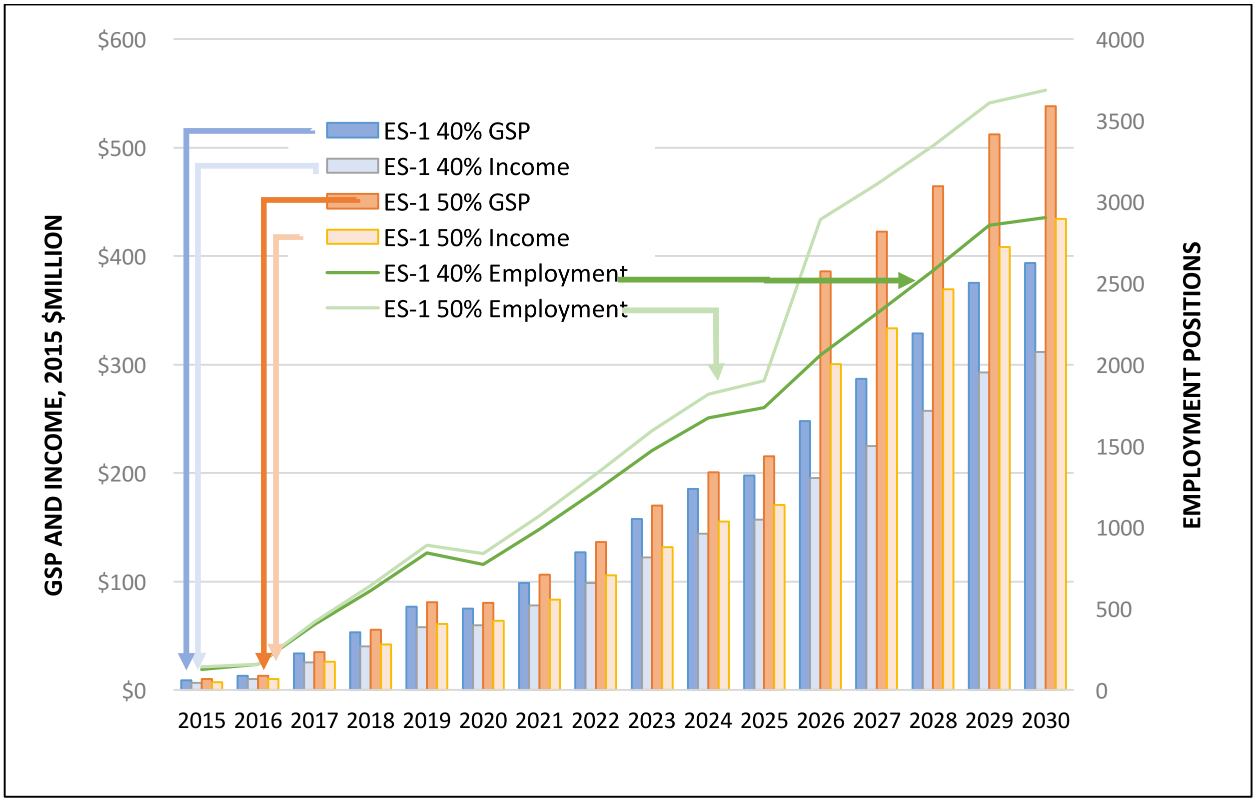


Figure 4. MN RCII Policy Options Macroeconomic Indicators, 2015-2030

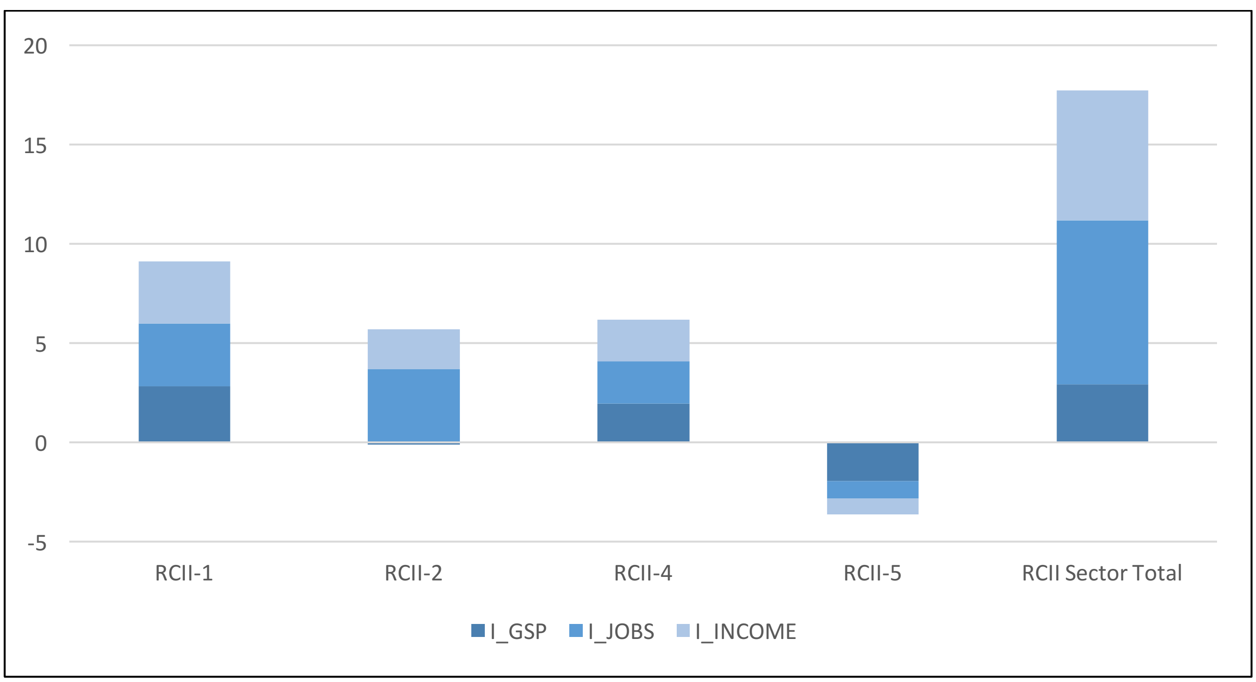


Figure 5. RCII CSEO Policy Options Employment Impacts (Jobs)

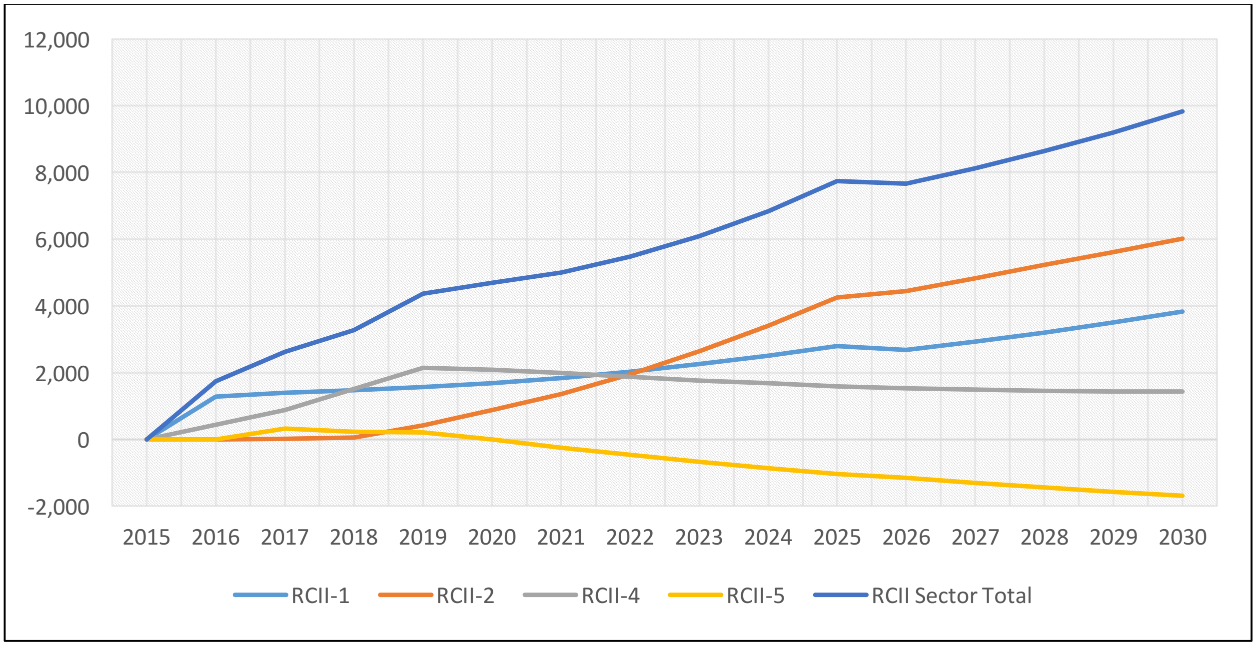


Figure 6 shows the relative distribution of energy consumption in Pennsylvania and the dominance of fossil fuel. Tables 2-3 show comparisons with national energy statistics, and illustrate Pennsylvania's emphasis on hydro carbon fuel and nuclear energy sources.

Figure 6. Inventory of Pennsylvania Energy Consumption, 2013

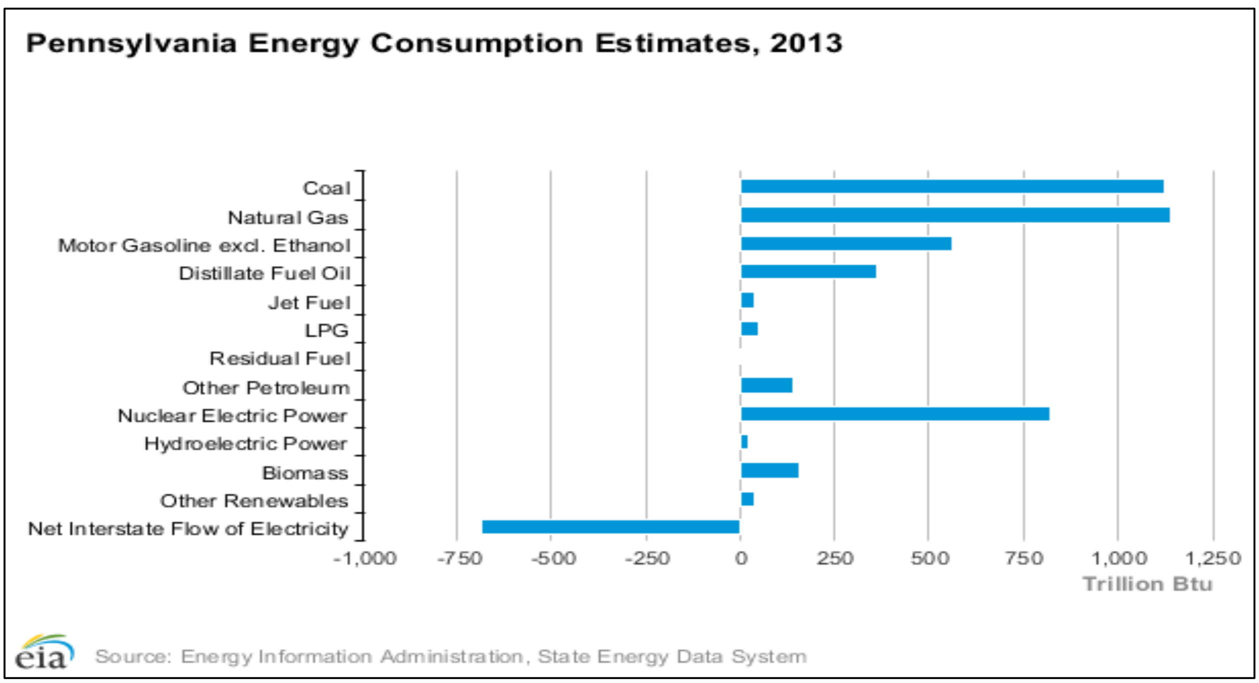


Table 2. Energy Price Comparisons, Pennsylvania Versus US

Natural Gas Prices ($/1000 cu feet)	National Statistics			
	Average	Max	Min	Pennsylvania
City Gate	4.24	14.81	2.22	4.15
Residential	10.52	38.2	5.61	9.85
Electricity Prices (cents/kWh)	National Statistics			
	Average	Max	Min	Pennsylvania
Residential	12.83	26.86	8.7	14.12
Commercial	10.50	24.96	6.85	9.53
Industrial	7.45	21.08	4.17	6.93

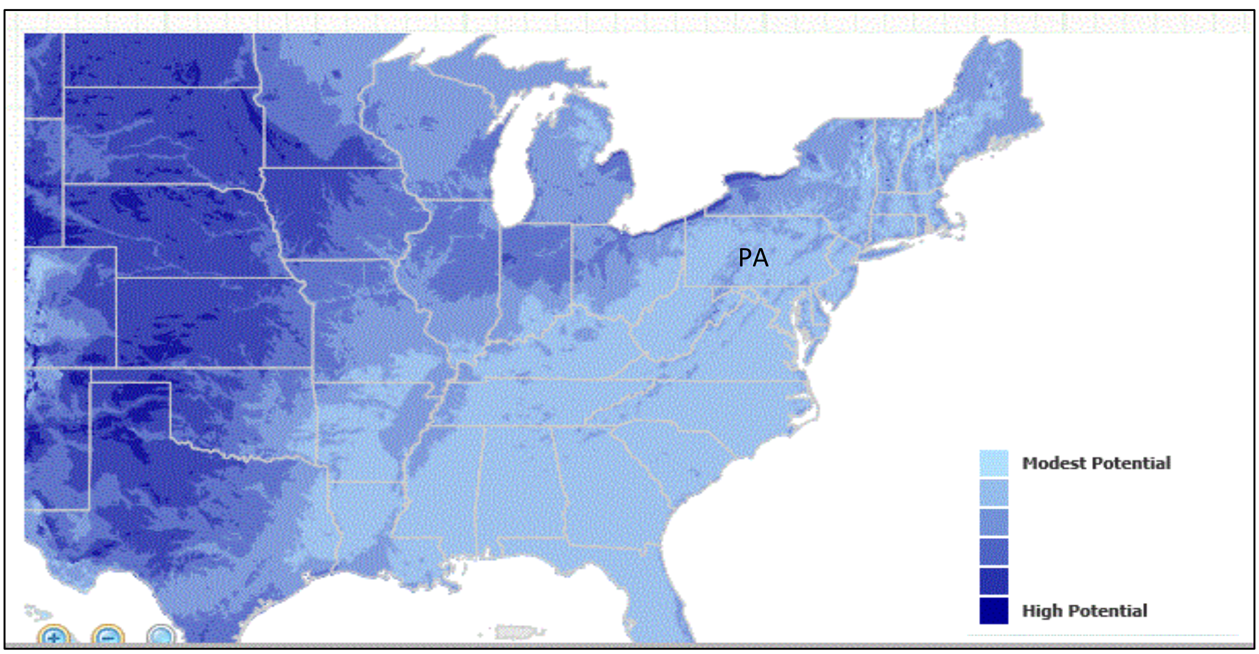
Source: Annual Energy Outlook, 2015, Energy Information Administration

Table 3. Renewable and Nuclear Energy Source Comparisons, Pennsylvania Versus US

Electricity Generation (% of total)	National Statistics			
	Average	Max	Min	Pennsylvania
Renewable Electricity	10.53	39.9	0.6	3.5
Nuclear	29.41	59	8.5	42.9

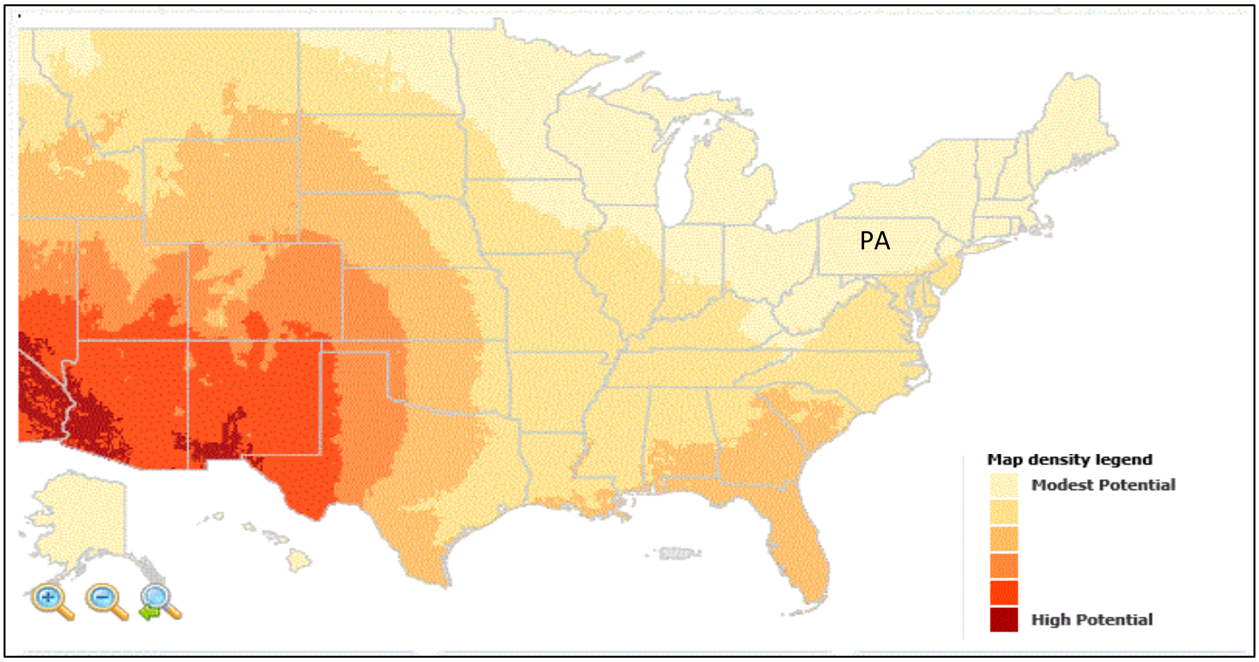
Source: Annual Energy Outlook, 2015, Energy Information Administration

Figure 7. Pennsylvania Wind Resource Potential



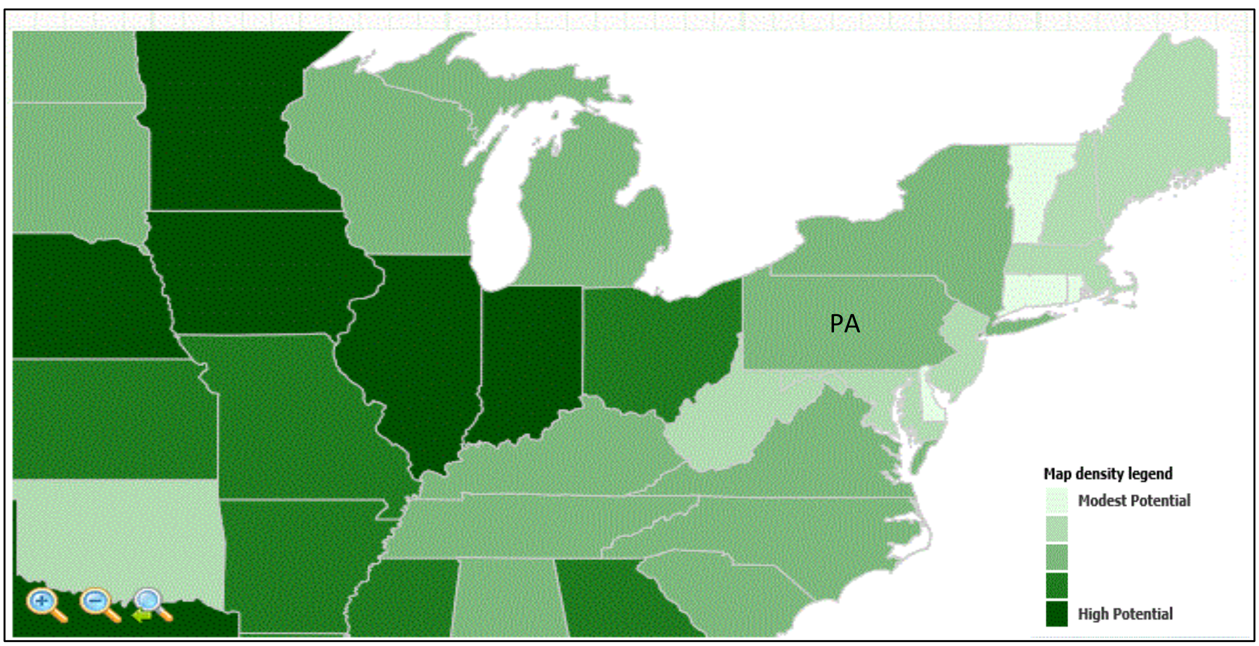
http://www.nrdc.org/energy/renewables/map_penn.asp#map

Figure 8. Pennsylvania Solar Resource Potential.



http://www.nrdc.org/energy/renewables/map_penn.asp#map

Figure 9. Pennsylvania Biomass Resource Potential

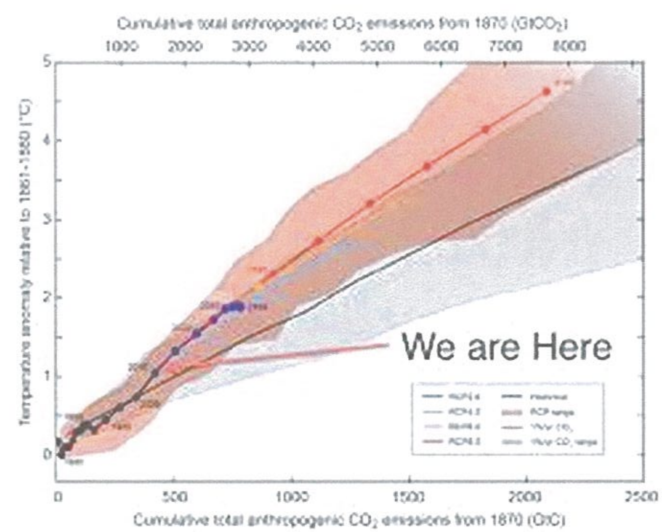


http://www.nrdc.org/energy/renewables/map_penn.asp#map

Conclusions, of the matrix of justifications for market intervention combined with macroeconomic evidence and strategy suggests that incentives for natural gas in Pennsylvania might be most productive under the following guidelines:

- Using Pennsylvania's natural gas advantage to expand the competitiveness of renewable and efficient energy, not as competition against it
- Linking Pennsylvania natural gas supplies to reduction of cost for technology development and production for renewable and efficient energy, particularly in support of vertical integration and horizontal diversification of clean energy
- Stimulating expanded energy efficiency to support upward spiral effects of energy and resource savings and reinvestment in high return areas, including targeting to consumers negatively affected by higher costs of clean energy (where applicable) and expanded clean energy production and cost controls (where needed)
- Investing of incentives into labor intensive renewable energy production and distribution on a targeted basis, including vertical integration strategies, to stimulate job and personal income growth for state residents
- Providing incentives to reduce both hard and soft costs for renewable and efficient energy and expand market investment from external sources
- Expanding exchange programs with other regions inside and outside the US to capitalize on peer knowledge and technical assistance
- Establishing or improving policies to ensure full information and competition for natural gas to ensure low prices and prices that are critical to its direct and indirect economic performance
- Establishing or improving policies and incentives to mitigate negative externalities associated with natural gas extraction, distribution, and combustion including establishment of best practices and program funding sources
- Establishing or improving the full costing of negative externalities associated with natural gas production effects to incentivize market adjustments toward low footprint production, and through mechanisms that enable reinvestment of price adders to help renewable and efficient technology expansion
- Reinvesting proceeds of natural gas exports to domestic expansion of clean energy sources and uses that are more highly leveraged through local supply chains.
- Design state incentives for export of locally manufactured components for solar and other renewable energy technologies

How to set National GHG Emissions Reduction Target After the 2015 Paris Climate Agreement



Donald A. Brown

Scholar In Residence and Professor

Widener University School Of Law

Major Positive Developments in Paris

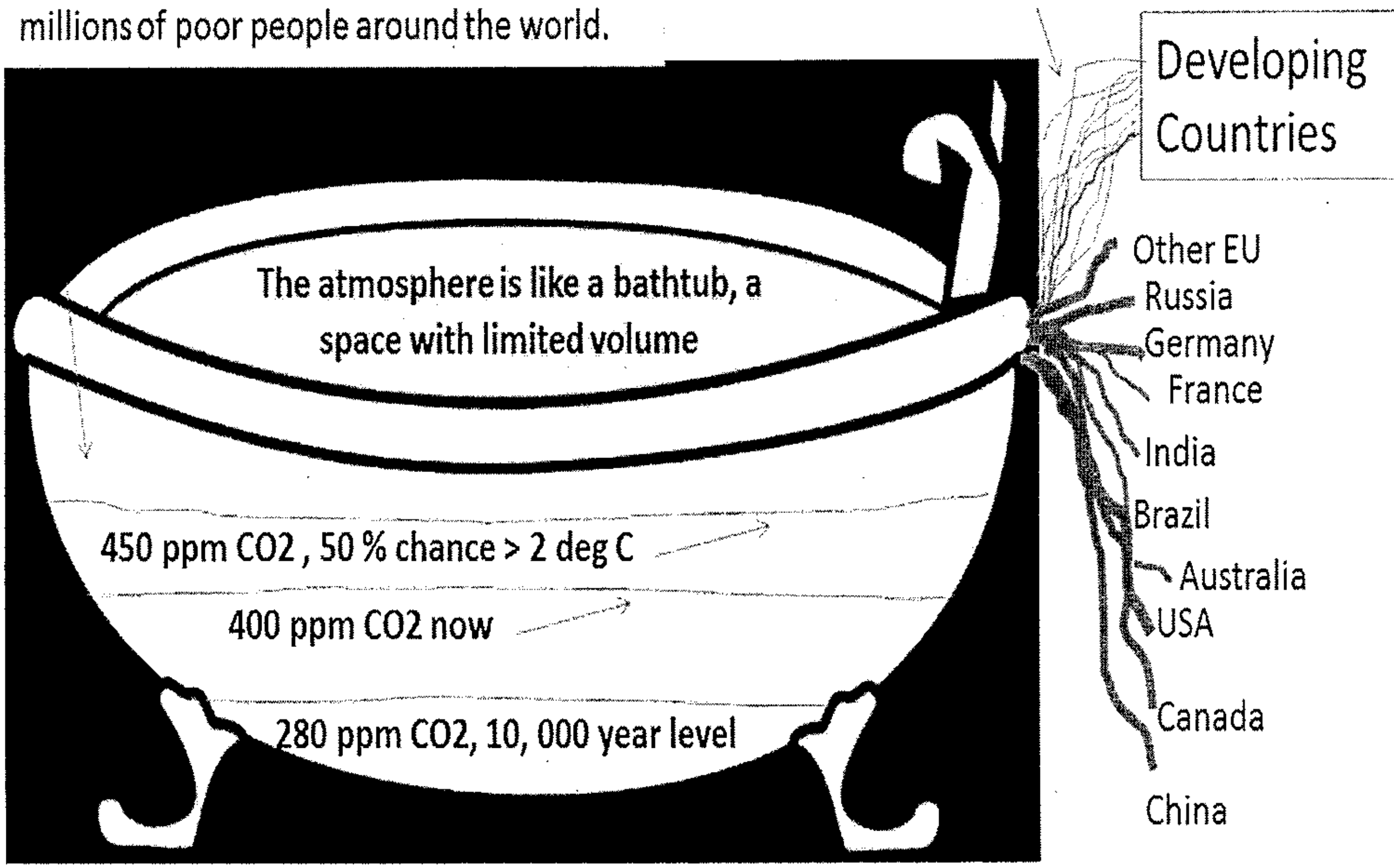
PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21 CMP11

- 186 nations made commitments to reduce ghg emissions, far short of 2° C goal
- Nations agreed to limit the increase in global average temperatures to "well below 2° C" and to "pursue efforts" to limit temperature increase to 1.5 ° C.

- The Paris Agreement, **GHG emissions must be no greater than sinks by the second half of this century**

The Justice Question: What levels of GHGs will be permitted in the bathtub given that the higher the levels-- the greater the harms to those countries and millions of poor people that have done little to fill the bathtub and given some levels of warming are an existential threat to millions of poor people around the world.

The Equity Question: Who gets to fill the rest of the atmospheric bathtub given limited remaining space to limit atmospheric GHG concentrations to safe levels, different historical and per capita emissions that have filled the bathtub to current levels, and the needs of poor countries to grow economically.



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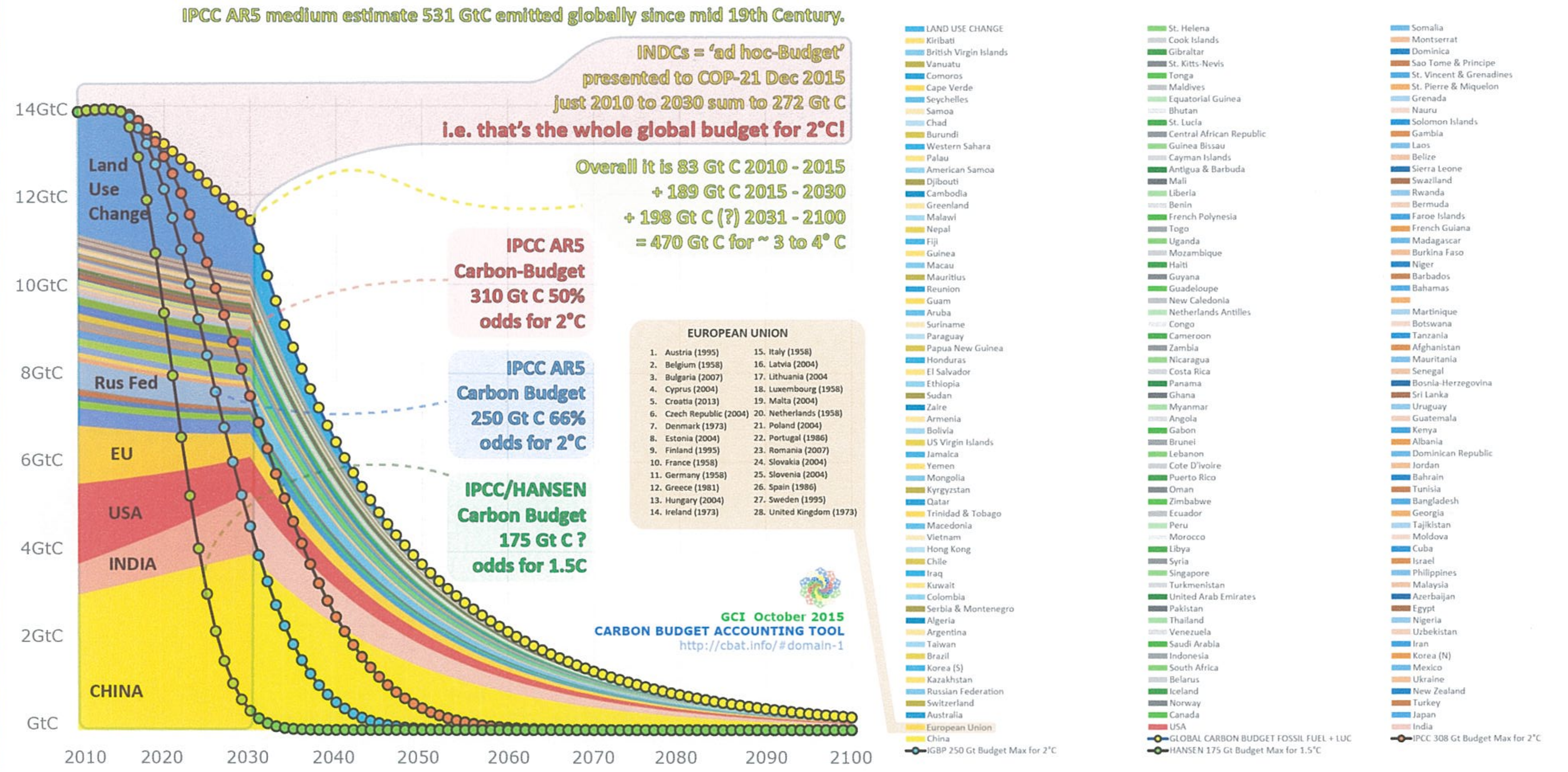
COP-21 International INDCs 20 2030, compared with Global Carbon Budgets for 1.5° & 2.0°C



Pg 38 2015 UNEP Emmissions Gap Report

Box 2.1: The global carbon dioxide (CO_2) budget, non-CO_2 GHGs and the link to global warming

Limiting warming to any desired level requires a cap on total, cumulative anthropogenic CO_2 emissions. Working Group I of the IPCC (IPCC, 2013) showed that global mean temperature increases are almost directly proportional to cumulative carbon dioxide emissions since the pre-industrial period. This leads to the important conclusion that there is a maximum amount of carbon dioxide emissions, or a CO_2 budget, that can be discharged to the atmosphere over time if society wishes to stay within a 2°C or other global warming limit. The IPCC indicated that to limit warming to below 2°C with a 'likely chance' (that is >66% chance) by the end of the century, about 1 000 $GtCO_2$ of CO_2 emissions remained 'in the budget' from 2011 onward* (IPCC, 2014b; Knutti and Rogelj, 2015). To keep CO_2 emissions within such a budget allowance, annual global CO_2 emissions have to become zero at some point during the 21[st] century. This is a geophysical requirement that applies regardless of the budget level chosen. For non-CO_2 GHGs with a shorter lifetime in the atmosphere, such as methane, the levels of emissions that are emitted per year are more important than the cumulative amount**. Reducing their annual emissions is also important to limit global mean temperature increase to low levels. Table 2.1 indicates the year of global annual emissions becoming net zero for each of the pathways considered.

* This number is accompanied by an uncertainty range, which depends on the concurrent mitigation of non-CO_2 GHGs.
** This is approximately true, as for non-CO_2 GHGs that stay in the atmosphere for quite a while (for example, N_2O has an atmospheric lifetime of 121 years) there is also a more limited cumulative effect. See, for example, Smith *et al.* (2012).

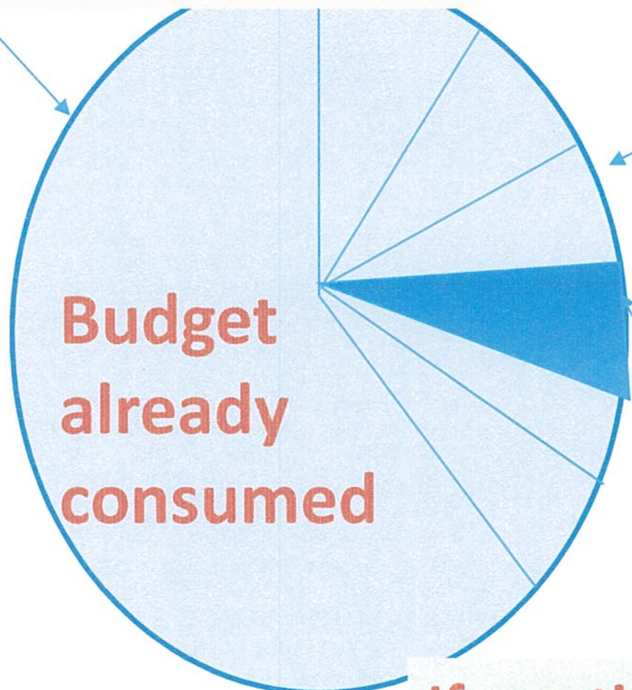
Table 2.1: Overview of pathway characteristics of 1.5°C and 2°C scenarios based on a re-analysis of the IPCC AR5 Scenario Database and a recent study on 1.5°C scenarios[15].
All scenarios have prescribed 2020 emissions consistent with the GHG pledges made by Parties in Cancun in 2010, and hence do not represent least-cost emission levels until then. All available scenarios with limited action until 2020 rely on net negative CO_2 emissions from energy and industry during the 21[st] century. Most scenarios with such specifications were contributed to the IPCC AR5 Scenario Database by the LIMITS intercomparison project[16]. Note that this table provides data for limiting warming below 1.5°C and 2°C in 2100. Further information is provided in the Tables of Annex A (available online)

Limiting warming in 2100 (allowing for overshoot)					
1.5°C (>50% in 2100)	Pathways limiting warming to below 1.5°C by 2100 with >50% chance Limited action until 2020 and least-cost mitigation afterwards				
Number of available scenarios: 6; Number of contributing modelling frameworks: 2 Year of global annual emissions becoming net zero† for: Kyoto-GHGs: **(2060-2080)**; total CO_2 (including LULUCF): **(2045-2050)**; CO_2 from energy and industry: **(2045-2055)**					
	Annual emissions of global total greenhouse gases [$GtCO_2e/yr$]				
Year	2020	2025	2030	2050	2100
median*	**56**	**47**	**39**	**8**	**-5**
range and spread**	53(-/-)56	46(-/-)48	37(-/-)40	4(-/-)14	-5(-/-)-3
2°C (>66% in 2100)	Pathways limiting warming to below 2°C by 2100 with >66% chance Limited action until 2020 and least-cost mitigation afterwards				
Number of available scenarios: 10; Number of contributing modelling frameworks: 4 Year of global annual emissions becoming net zero† for: Kyoto-GHGs: **2085 (2080-2090)**; total CO_2 (including LULUCF): **2070 (2060-2075)**; CO_2 from energy and industry: **2070 (2060-2075)**					
	Annual emissions of global total greenhouse gases [GtCO2e/yr]				
Year	2020	2025	2030	2050	2100
median*	**52**	**48**	**42**	**23**	**-3**
range and spread**	49(49/53)55	44(46/50)53	29(31/44)44	17(18/27)29	-11(-9/-1)0
2°C (50-66% in 2100)	Pathways limiting warming to below 2°C by 2100 with 50-66% chance Limited action until 2020 and least-cost mitigation afterwards				
Number of available scenarios: 4; Number of contributing modelling frameworks: 2 Year of global annual emissions becoming net zero† for: Kyoto-GHGs: **(2095-2095)**; total CO_2 (including LULUCF): **(2065-2070)**; CO_2 emissions from energy and industry: **(2070-2080)**					
	Annual emissions of global total greenhouse gases [$GtCO_2e/yr$]				
Year	2020	2025	2030	2050	2100
median*	**53**	**50**	**47**	**28**	**-1**
range and spread**	50(-/-)55	49(-/-)51	46(-/-)48	27(-/-)29	-2(-/-)-1

† Rounded to nearest 5 years. Explanation of format: 'median (20[th] percentile – 80[th] percentile)' – for example, '2085 (2080-2090)'; no median is provided if fewer than 10 scenarios are available '(minimum–maximum)' – for example, '(2060-2080)'.
* Rounded to the nearest 1 $GtCO_2e/yr$.
** Rounded to the nearest 1 $GtCO_2e/yr$. Explanation of format: 'minimum value (20[th] percentile/80[th] percentile) maximum value' – for example, '44(46/50)53'. No percentiles are provided if fewer than 10 scenarios are available – for example, '46(-/-)48'.

15 See Rogelj et al. (2015a)

Total Carbon Budget To LIMIT warming to 2 or 1.5 degrees C measured in gigatons (1 billion tons)

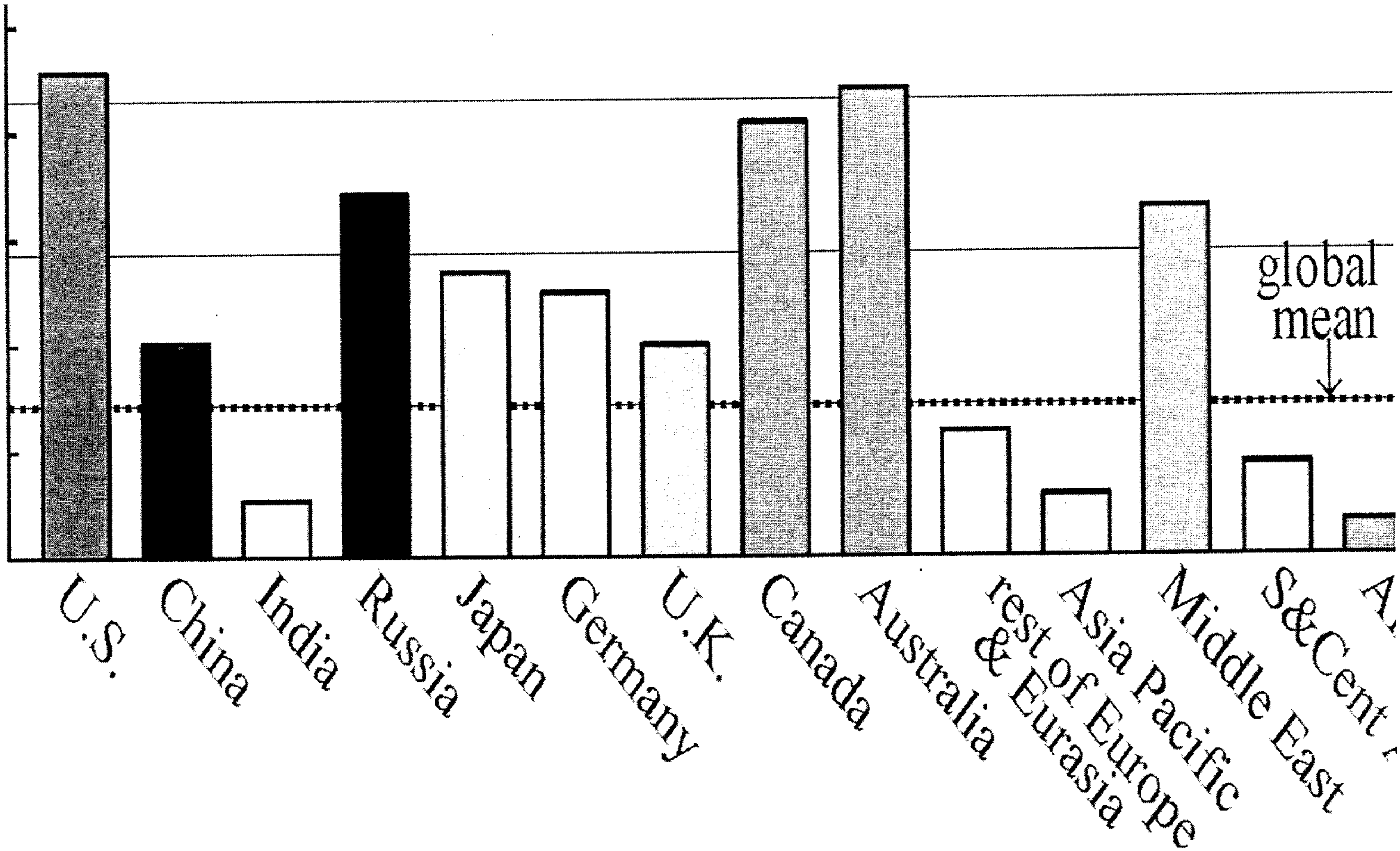


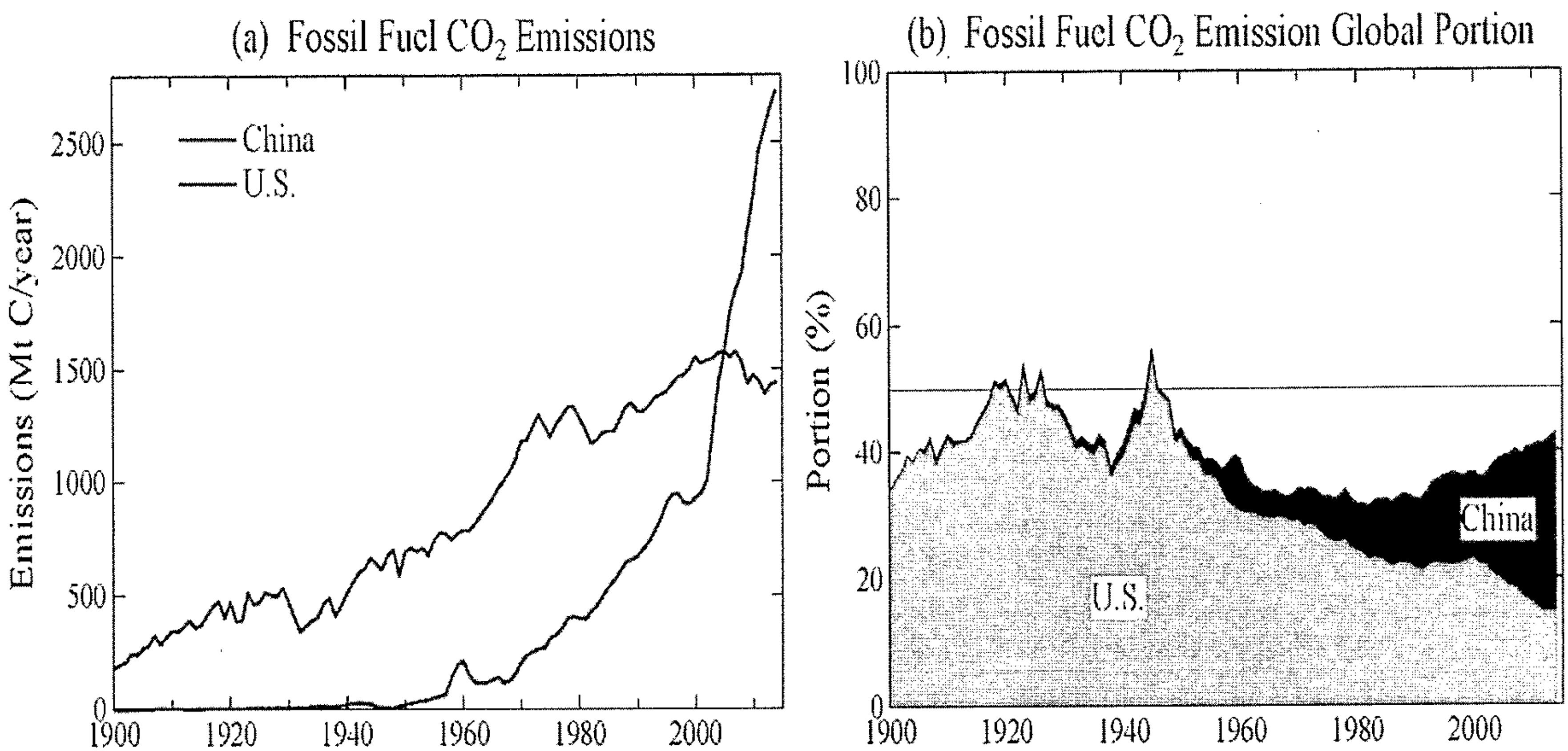
Remaining Carbon Budget

Each National GHG Reduction Target is implicitly a position on the nation's fair share of the remaining carbon budget

If a nation emits more than its fair share of the remaining carbon budget, it will either require other nations to reduce their GHG emissions to levels smaller than their fair share of the remaining budget or guarantee dangerous climate change

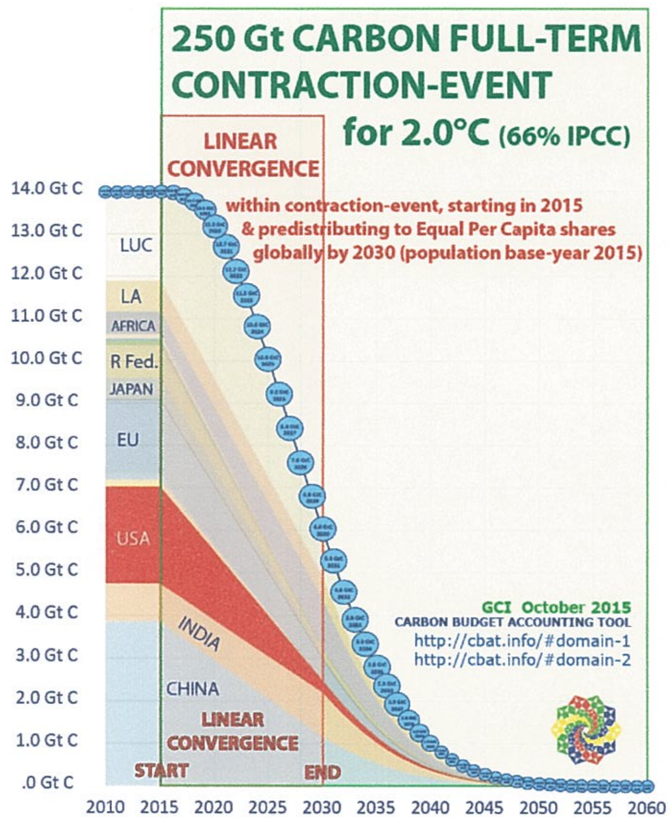
D. Brown,
Ethicsandclimate.o


global mean
U.S.
China
India
Russia
Japan
Germany
U.K.
Canada
Australia
rest of Europe & Eurasia
Asia Pacific
Middle East

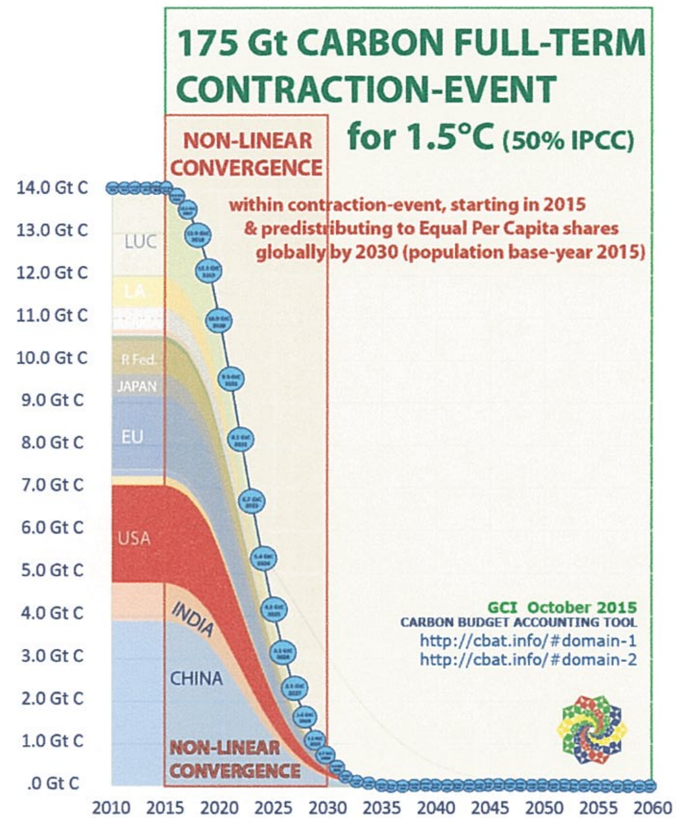


(a) Fossil Fuel CO_2 Emissions
China
U.S.
Emissions (Mt C/year)
0
500
1000
1500
2000
2500
1900
1920
1940
1960
1980
2000
(b) Fossil Fuel CO_2 Emission Global Portion
Portion (%)
0
20
40
60
80
100
U.S.
China
1900
1920
1940
1960
1980
2000

Emissions Reductions with contraction to equal per capita emissions in 2030



250 GtC Global	
YEAR	US
2010	2.3 Gt C
2011	2.3 Gt C
2012	2.3 Gt C
2013	2.3 Gt C
2014	2.3 Gt C
2015	2.3 Gt C
2016	2.1 Gt C
2017	2.0 Gt C
2018	1.9 Gt C
2019	1.7 Gt C
2020	1.6 Gt C
2021	1.5 Gt C
2022	1.3 Gt C
2023	1.2 Gt C
2024	1.1 Gt C
2025	.9 Gt C
2026	.8 Gt C
2027	.7 Gt C
2028	.5 Gt C
2029	.4 Gt C
2030	.3 Gt C
2031	.2 Gt C
2032	.2 Gt C
2033	.2 Gt C
2034	.1 Gt C
2035	.1 Gt C
2036	.1 Gt C
2037	.1 Gt C
2038	.1 Gt C
2039	.1 Gt C
2040	.0 Gt C
2041	.0 Gt C
2042	.0 Gt C
2043	.0 Gt C
2044	.0 Gt C
2045	.0 Gt C
2046	.0 Gt C
2047	.0 Gt C
2048	.0 Gt C
2049	.0 Gt C
2050	.0 Gt C
2051	.0 Gt C
2052	.0 Gt C
2053	.0 Gt C
2054	.0 Gt C
2055	.0 Gt C
2056	.0 Gt C
2057	.0 Gt C
2058	.0 Gt C
2059	.0 Gt C
2060	.0 Gt C
TOTAL	33.1 Gt C



175 GtC Global	
YEAR	US
2010	2.3 Gt C
2011	2.3 Gt C
2012	2.3 Gt C
2013	2.3 Gt C
2014	2.3 Gt C
2015	2.3 Gt C
2016	2.2 Gt C
2017	2.2 Gt C
2018	2.1 Gt C
2019	2.0 Gt C
2020	1.8 Gt C
2021	1.5 Gt C
2022	1.3 Gt C
2023	1.1 Gt C
2024	.9 Gt C
2025	.7 Gt C
2026	.5 Gt C
2027	.4 Gt C
2028	.3 Gt C
2029	.2 Gt C
2030	.1 Gt C
2031	.1 Gt C
2032	.0 Gt C
2033	.0 Gt C
2034	.0 Gt C
2035	.0 Gt C
2036	.0 Gt C
2037	.0 Gt C
2038	.0 Gt C
2039	.0 Gt C
2040	.0 Gt C
2041	.0 Gt C
2042	.0 Gt C
2043	.0 Gt C
2044	.0 Gt C
2045	.0 Gt C
2046	.0 Gt C
2047	.0 Gt C
2048	.0 Gt C
2049	.0 Gt C
2050	.0 Gt C
2051	.0 Gt C
2052	.0 Gt C
2053	.0 Gt C
2054	.0 Gt C
2055	.0 Gt C
2056	.0 Gt C
2057	.0 Gt C
2058	.0 Gt C
2059	.0 Gt C
2060	.0 Gt C
TOTAL	31.0 Gt C

What Should The US and Pa GHG Emissions ReductionTarget Be?

Carbon Neutral As Soon As Possible But No Later Than 2040.

This is based on converging on equal per capita shares after 2030 and achieving global reductions necessary to limit warming to 1.5 degrees. According to UNEP, the electricity and energy sector for the entire world must be carbon neutral between 2045 and 2050.

What questions should be asked of proponents of continued use of natural gas on the record.

1. How is the United States and Pennsylvania going to assure that carbon emissions are no greater than carbon sinks by no later then 2040 if governments continue to rely on natural gas?
2. Do proponents of natural gas agree that the US and Pennsylvania must as quickly as possible replace fossil fuel with non-fossil fuel to limit warming to non-dangerous levels?
3. Will proponents of continued increase use of natural gas work with the State to replace fossil fuel with non-fossil fuel as quickly as possible?

Cornell University

Statement of Robert W. Howarth, Ph.D.

House Democratic Policy Committee Hearing
"Should Pennsylvania Incentivize Natural Gas?"

March 21, 2016

Thank you for the opportunity to address you today. My name is Robert Howarth. I am an Earth systems scientist with a Ph.D. jointly from MIT and the Woods Hole Oceanographic Institution. I have been a tenured member of the faculty of Cornell University since 1985 and have held an endowed position as the *David R. Atkinson Professor of Ecology & Environmental Biology* at Cornell since 1993. I also serve as an Adjunct Senior Scientist at the Ecosystems Center in Woods Hole, MA. I am the Editor in Chief of the academic journal *Limnology & Oceanography* and previously served as Editor in Chief of the academic journal *Biogeochemistry* for over 20 years. I have published more than 200 peer-reviewed research articles and am the editor or author of 8 scholarly books.

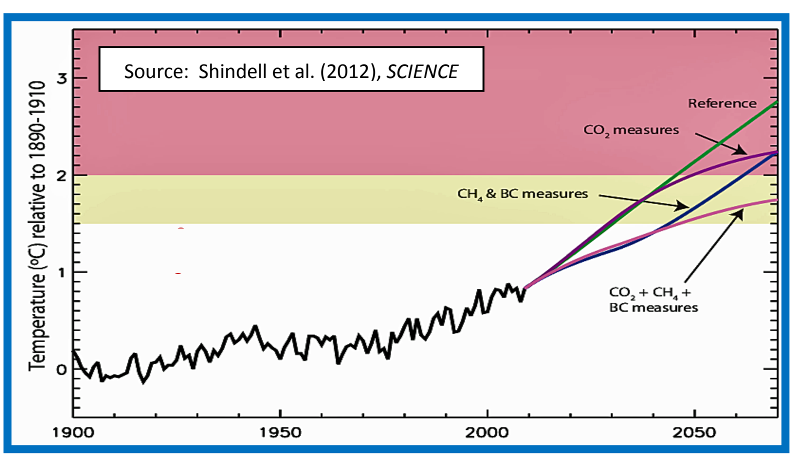
I have conducted research and taught on several aspects of global change for over 35 years. In 2011, I published the first ever peer-reviewed analysis of the greenhouse gas footprint of shale gas. Since then, I have published an additional 6 peer-reviewed papers as well as a background report for the US Climate Change assessment on the topic of greenhouse gas emissions from the development and use of shale gas. I also have published 2 peer-reviewed articles laying out plans for the states of New York and California to become free of all fossil fuel use. I served as a delegate to the United Nations COP21 negotiations on climate change in Paris this past December, and while there participated in several discussions on the role of methane and shale gas in climate change. My most recent peer-reviewed publication on the role of methane emissions in the greenhouse gas footprint of shale gas (Howarth 2015), published in October of last year, is appended at the end of this testimony. The statements and conclusions I draw here are all well documented in that paper.

In the past, industry as well as many politicians promoted natural gas, including shale gas, as a "bridge fuel" that would allow society to continue to use fossil fuels for the next few decades while reducing carbon dioxide emissions. While less carbon dioxide is produced while burning natural gas than is true for coal for a given amount of energy, methane emissions from the use of natural gas are far higher than from coal. Methane is a potent greenhouse gas, one that is more than 100 times as effective as carbon dioxide in trapping heat in the atmosphere for the decade or so following emission when both gases remain in the atmosphere. Using the best available evidence on rates of methane emissions, shale gas is seen to have a greenhouse gas footprint that is 2.5-fold greater than that of coal when compared over a 20-year averaged period following the burning of the two fuels. Conventional natural gas also has a larger footprint than does coal, although only slightly so.

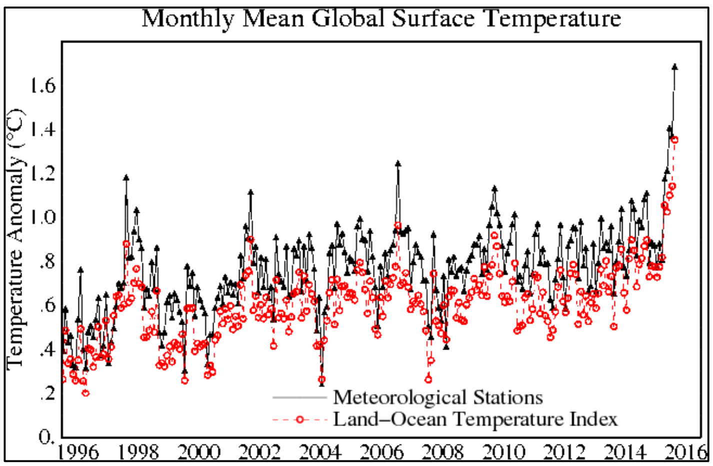
Before the shale gas revolution began in earnest in 2009, the scientific literature ignored methane emissions from this fuel. We first suggested in our 2011 paper that methane emissions from shale gas may be far larger than from conventional natural gas. The available evidence at that time was limited, and so one of our major conclusions was to point for the need for better studies. Our suggestion of high methane emissions was hotly contested by industry and by some academics, but extensive subsequent research has indicated that indeed the methane emissions are far higher than for shale gas. This is particularly evident in the study by Schneising and colleagues published in 2014 that used satellite data, comparing methane levels in the atmosphere for a few years before the shale gas revolution (2006-2008) with levels in the first few years after heavy shale gas and oil development began (200-2011). During this time, the methane concentration in the atmosphere increased globally, and the satellite data indicate the shale gas and shale oil plays of the United States are the likely source of most if not all of this increased methane.

These methane emissions from shale gas have had a major impact on the greenhouse gas inventory of the United States. Beginning in 2007, carbon dioxide emissions from fossil fuel use in the US fell, in part due to recession but also due to some switching of natural gas for coal in electricity generation. However, as shale gas became an increasingly large percentage of natural gas production, methane emissions began to rise sharply. As a result, the total greenhouse gas inventory of the US has been rising rapidly since 2008, and in fact this has been the most rapid rate of increase in greenhouse gas emissions seen in many decades. Clearly natural gas is no bridge fuel.

Note that my analysis differs from the position of the US EPA in their inventory reporting, for two reasons: 1) the EPA continues to underestimate the extent of methane emissions, as noted by a growing number of critics including the inspector general of the US EPA; and 2) the EPA continues to use outdated science to compare the influence of methane and carbon dioxide, despite the guidance to the contrary given by the Inter-Governmental Panel on Climate Change in their most recent synthesis report from 2013. For more discussion on these problems with the EPA analysis, please refer to my 2015 paper, appended below.



I would like to provide one update on the importance of methane to global warming based on events since my most recent paper was published 6 months ago: in Paris 3 months ago, the 195 nations of the world came together and agreed to keep the temperature of the Earth well below 2° C compared to the pre-industrial baseline; they also acknowledged the increasing risk of climate catastrophe should the planet warm above 1.5° C. Some climate models tell us we are on a trajectory to reach this 1.5° C target in 12 years, with warming above 2° C just 35 years away. Because of lags in how the climate system responds to carbon dioxide, it simply is not possible to avoid these dangerous levels of global warming over the coming decades through reductions in carbon dioxide emissions. On the other hand, the planet responds very quickly to reductions in methane emissions: reductions in methane emissions would immediately slow the rate of global warming, buying several decades of time with the Earth at lower temperatures. The oil and gas industry is the largest source of methane emissions in the United States, and shale gas development has greatly increased these emissions.



Global warming reaches all-time new high in February 2016. Source: NASA Goddard Space Sciences Institute, downloaded March 13, 2016.

Unfortunately, the very latest evidence shows that the planet is warming even more quickly than model predictions. Last month, the temperature of the Earth spiked above 1.6° C, according to data from the NASA Goddard Space Institute. The temperature increase from a year ago is the fastest ever observed. This high temperature for February 2016 is driven both by *el nino* and by human-caused global warming, and we can expect the temperature to decrease some over the coming months. Nonetheless, the accelerating upward general trend of global warming is alarming.

Given the role of methane in global warming, and the large emissions of unburned methane to the atmosphere as shale gas is developed, I strongly recommend that society more as quickly as possible away from using shale gas a fuel. We have alternatives: embrace wind, solar, and highly efficient 21st Century technologies for using electricity for transportation and for heating. I urge that the House Democratic Policy Committee show leadership and help move the Commonwealth of Pennsylvania to this alternative energy future.

Energy and Emission Control Technologies

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REVIEW

Methane emissions and climatic warming risk from hydraulic fracturing and shale gas development: implications for policy

This article was published in the following Dove Press journal:
Energy and Emission Control Technologies
8 October 2015
Number of times this article has been viewed

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Abstract: Over the past decade, shale gas production has increased from negligible to providing >40% of national gas and 14% of all fossil fuel energy in the USA in 2013. This shale gas is often promoted as a bridge fuel that allows society to continue to use fossil fuels while reducing carbon emissions since less carbon dioxide is emitted from natural gas (including shale gas) than from coal and oil per unit of heat energy. Indeed, carbon dioxide emissions from fossil fuel use in the USA declined to some extent between 2009 and 2013, mostly due to economic recession but in part due to replacement of coal by natural gas. However, significant quantities of methane are emitted into the atmosphere from shale gas development: an estimated 12% of total production considered over the full life cycle from well to delivery to consumers, based on recent satellite data. Methane is an incredibly powerful greenhouse gas that is >100-fold greater in absorbing heat than carbon dioxide, while both gases are in the atmosphere and 86-fold greater when averaged over a 20-year period following emission. When methane emissions are included, the greenhouse gas footprint of shale gas is significantly larger than that of conventional natural gas, coal, and oil. Because of the increase in shale gas development over recent years, the total greenhouse gas emissions from fossil fuel use in the USA rose between 2009 and 2013, despite the decrease in carbon dioxide emissions. Given the projections for continued expansion of shale gas production, this trend of increasing greenhouse gas emissions from fossil fuels is predicted to continue through 2040.

Keywords: shale gas, natural gas, methane, greenhouse gases, global warming, bridge fuel

Introduction

Shale gas is natural gas tightly held in shale formations, and as for conventional natural gas, shale gas is composed largely of methane. The difference between shale gas and conventional natural gas is the mode of extraction. Shale gas cannot be obtained commercially using conventional techniques and has entered the market only recently as industry has used two relatively new technologies to extract it: high-precision horizontal drilling with high-volume hydraulic fracturing. Over the past decade, shale gas development in the USA has increased rapidly, a trend that both the Energy Information Agency (EIA) of the US Department of Energy and the industry expect to continue[1–3] (Figure 1). To date, almost all shale gas production in the world has occurred in the USA, a condition likely to continue for at least another decade.[2] The EIA projections for future growth in shale gas development may well be too rosy because both the expense of developing shale gas and the pattern of production from a shale gas well have proven to differ dramatically from that seen in conventional gas wells, with very rapid declines over the first year or two.[4] An independent assessment concludes that

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http://dx.doi.org/10.2147/EECT.S61539

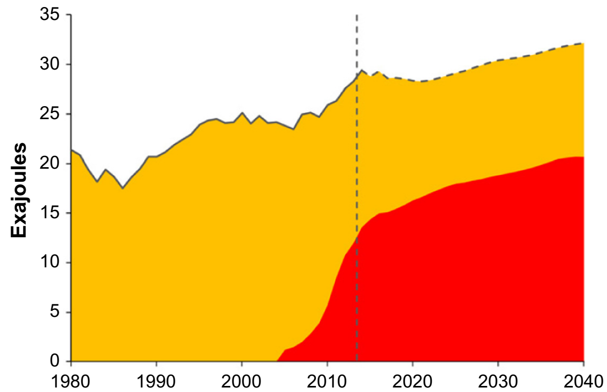

Figure 1 Natural gas production in the USA from 1980 to 2013 and future natural gas production until 2040 as predicted by the US Department of Energy in the *Annual Energy Outlook 2015*.[1] Conventional gas is indicated in yellow, shale gas in red.

shale gas production in the USA is likely to underperform the EIA estimates by almost 40% between now and 2040.[5] However, all these estimates are highly uncertain. If the EIA projections prove true, what might some of the environmental and public health consequences be?

Since shale gas development is a recent phenomenon, scientific investigations on its environmental and public health consequences are also quite new, with the first peer-reviewed studies published only in 2011.[6,7] Nonetheless, the literature has quickly grown, and evidence is accumulating of many adverse effects, including surface and groundwater contamination,[8] degraded air quality,[9,10] increased release of greenhouse gases,[11,12] increased frequency of earthquakes,[13] and evidence of harm to the health of humans and domestic animals, including farm livestock.[7,14–18]

The natural gas industry often points out that hydraulic fracturing has been in use for >60 years, implying that there is little new about shale gas development.[19] The scale of hydraulic fracturing used to develop shale gas, however, is far greater than the fracturing employed in previous decades for conventional gas, with two orders of magnitude increase in the volume of water and chemicals used from the hydraulic fracturing and even proportionally greater return of fracturing wastes to the surface.[6] Further, the use of high-volume hydraulic fracturing with high-precision directional drilling to develop shale gas leads to an intensity of development not generally seen with conventional natural gas and to the redevelopment of regions where conventional gas has largely played out, which may intensify some effects such as air emissions due to interactions with old wells and formations.[20] The appropriate focus when considering the environmental and public health effects of shale gas development is on the entire enterprise and use of the gas and not merely on the process of hydraulic fracturing.

This paper focuses on the role of methane emissions in determining the greenhouse gas footprint of shale gas. Natural gas, including shale gas, is often promoted as a bridge fuel that will allow society to continue to use fossil fuels over the coming decades while reducing carbon emissions. This was highlighted, for example, by President Obama in his State of the Union speech in January 2014.[21] For a given unit of energy consumed, the emissions of carbon dioxide from natural gas are substantially lower than from oil or coal,[11,22] which is the basis for the bridge fuel concept. However, natural gas is composed mostly of methane, a greenhouse gas that on a mass-to-mass basis is >100 times more powerful than carbon dioxide as an agent of global warming for the time when both gases persist in the atmosphere.[23] Consequently, even small releases of methane to the atmosphere from the development and use of shale gas can greatly influence the greenhouse gas footprint of shale gas.

How much methane is emitted?

My coauthors and I published the first peer-reviewed assessment of methane emissions from shale gas development in 2011.[11] We concluded that 3.8% (±2.2%) of the total lifetime production of methane from a conventional gas well is emitted into the atmosphere, considering the full life cycle from well to final consumer.[11] The data available for estimating emissions from shale gas were more scarce and more poorly documented at that time, but we estimated that the full life cycle emissions of shale gas were ~1.5-fold higher than that of conventional natural gas, or 5.8% (±2.2%).[11] We attributed the higher emissions to venting of gas during the flowback period following high-volume hydraulic fracturing, although a subsequent study identified other sources as well, such as drilling through strata previously developed for coal and conventional natural gas.[20] For both conventional gas and shale gas, we estimated the "downstream" emissions associated with storing gas and delivering it to market to be 2.5% (±1.1%), so our estimates for "upstream" emissions at the well site and from gas processing averaged 1.3% for conventional natural gas and 3.3% for shale gas.[11,12]

Through 2010, the US Environmental Protection Agency (EPA) continued to estimate emissions for conventional natural gas as 1.1%, with 0.9% of this from downstream emissions and 0.2% from upstream emissions, based on a joint EPA and industry study from 1996, as I discuss elsewhere.[12]

They did not separately consider shale gas emissions. Soon after our paper was published in 2011, the EPA released new estimates that were very similar to ours in terms of upstream emissions: 1.6% for conventional natural gas and 3.0% for shale gas.[12] They kept their downstream emission estimates at 0.9%, yielding full life cycle emissions of 2.5% and 3.9%, respectively, for conventional gas and shale gas. EPA subsequently reduced their estimates for upstream emissions, cutting them approximately in half, relying on a non-peer-reviewed industry report[24] asserting that the 2011 estimates had been too high.[12,25] This yielded a full life cycle emission estimate for all natural gas in the USA, considering the contributions from both conventional and shale gas as of 2009, of 1.8%.[12] The inspector general of the EPA has called for improvements in the agency's approach in estimating emissions,[26] at least in part because of the 2013 decision to lower emission estimates.[12,25]

In our original 2011 paper, we called for new and better studies of methane emissions from the natural gas industry,[11] and in fact, many studies have been published in the subsequent 4 years. In 2014, I published a review of the new studies that had come out through February 2014.[12] One of these studies evaluated a large set of data from monitoring stations across the USA for the period 2007–2008, before the large increase in shale gas production, and concluded that the EPA estimate of 1.8% emission was clearly too low by a factor of at least 2 and that full life cycle emissions from conventional natural gas must be ≥3.6% on average across the USA.[27] Other, shorter term studies evaluated upstream emissions from shale gas and other unconventional gas development (ie, tight sands), with two finding high emissions (4%–9%)[25,28] and one published by Allen et al finding low emissions (0.4%).[29] In a summary published in early 2014, Brandt et al concluded that emissions from the natural gas industry, including both conventional gas and shale gas, could best be characterized as averaging 5.4% (±1.8%) for the full life cycle from well to consumer.[30] I accepted that conclusion and presented it as the best value in my 2014 review.[12]

Further thought and subsequent studies published since February 2014 have led me to reconsider. I now believe that emissions from conventional natural gas are somewhat <5.4%, based on the ^{14}C content of atmospheric methane globally, and emissions from shale gas are likely substantially more, based on global trends observed from satellite data and new evidence that the 2013 report by Allen et al of only 0.4% emissions[29] is likely to be flawed.

^{14}C content of methane and emissions from conventional natural gas

The ^{14}C radiocarbon content of methane in the planet's atmosphere provides a constraint on the emission rate from conventional natural gas systems. On average during the years 2000–2005, 30% of atmospheric methane was ^{14}C "dead", indicating that it came from fossil sources.[31,32] During this time period, the total global flux of methane to the atmosphere was probably in the range of 548 (±22) Tg CH_4 per year.[33] Therefore, the flux from fossil sources, 30% of the total flux, would have been ~165 Tg CH_4 per year. These fossil sources include fluxes associated with coal, oil, and natural gas development as well as natural seeps. Using global production data for coal and oil[34] and well-accepted methane emission factors for these two fuels as described elsewhere,[11] I estimate the combined methane emissions from oil and coal as ~50 Tg CH_4 per year. Using the 5.4% emission rate and global natural gas production estimates[34] for the years 2000–2005 yields a methane emission of 130 Tg CH_4 per year from the natural gas industry or 180 Tg CH_4 per year from all fossil fuels. This is too high compared to the ^{14}C constraint, suggesting that an emission rate of 5.4% for conventional gas is too high, even if natural seeps are negligible, as assumed by the Intergovernmental Panel on Climate Change (IPCC) in 2007 in their fourth assessment report.[35] Flux estimates from natural seeps are poorly constrained, but these natural emissions may be as great as 50 Tg CH_4 per year or higher.[31] If we instead use the mean emission factor from our 2011 paper for conventional natural gas of 3.8%,[11] the global flux from natural gas emissions is estimated as 91 Tg CH_4 per year, giving an emission flux from all fossil fuels of ~140 Tg CH_4 per year and an estimate of emissions from natural seeps of 15 Tg CH_4 per year. This combination is plausible, if uncertain, and the 3.8% factor agrees well with the robust conclusion from Miller et al that emissions from conventional natural gas systems in the USA, from before the shale gas boom, must have been at least 3.6% of production.[27]

How high are methane emissions from shale gas?

A paper published by Schneising et al in the fall of 2014 used satellite data to assess global and regional trends in atmospheric methane between 2003 and 2012.[36] Methane concentrations rose dramatically in the northern hemisphere, particularly after 2008. In a detailed comparison across the

USA for the time periods 2006–2008 (before there was much shale gas or shale oil development) and 2009–2011 (after shale gas and oil production began in earnest), atmospheric methane concentrations rose dramatically in many of the major shale-producing regions. By evaluating trends in drilling and hydraulic fracturing activity, Schneising et al estimated methane emission rates of 9.5% (±7%) in terms of energy content during the 2009–2011 period for the two large shale regions – the Eagle Ford in Texas and the Bakken in North Dakota – where they felt most comfortable in estimating emissions.[36] They reported similar methane emissions for the Marcellus shale, but with much greater uncertainty in the analysis of the satellite data because of sparser spacing of wells, the mountainous terrain, and the proximity of the region to the Great Lakes. For the Bakken, shale oil production was far greater than gas production during this time period,[37] and the methane emissions may have been more associated with the oil production. However, natural gas was the dominant form of shale energy produced in the Eagle Ford formation between 2009 and 2011, contributing 75% of all shale energy with oil contributing 25%.[37] For the Marcellus shale, virtually all shale energy production through 2011 came from shale gas and not oil.[37] Therefore, it seems reasonable to attribute a methane emission rate of ~9.5% to shale gas development in the Eagle Ford and Marcellus formations.

The satellite methane emission estimate is largely for upstream emissions and does not fully account for downstream emissions during storage and delivery of gas to customers, which may on average add another 2.5% of methane emission.[11,12,22] The conclusion is that shale gas development during the 2009–2011 period, on a full life cycle basis including storage and delivery to consumers, may have on average emitted 12% of the methane produced. This is more than twice what we had estimated for shale gas in our 2011 analysis,[11] but the satellite-based estimate is based on more robust data and integrates across a period of 2 years. These shale gas emissions already may have a globally observable effect on methane in the atmosphere.[36]

The satellite-based estimate is ~20-fold greater than the estimate presented by Allen et al,[29] a study that worked closely with industry to measure emissions from various component processes of shale gas development. In my 2014 review, I suggested that the study by Allen et al may represent a best-case scenario for low emissions, given that measurements were made only at sites where industry allowed.[12] Since then, two papers published in 2015 have indicated that in fact the data in the Allen et al's paper may be flawed. Allen et al used a high-flow analyzer that employs two independent sensors, switching between a catalytic oxidation detector when methane levels are low and a thermal conductivity detector when methane concentrations are greater. Howard et al noted that the high-flow analyzer is prone to underestimating methane fluxes when switching between detectors.[38] A follow-up paper by Howard et al carefully evaluated the use of a high-flow analyzer by Allen et al and concluded that "the data reported by Allen et al. (2013) suggest their study was plagued by such sensor failure", and as a result "their study appears to have systematically underestimated emissions."[39] The sensor failure issue may well have affected other data reported by industry to the EPA and used by the EPA in their assessment of methane emissions, leading to serious underestimation.[38,39]

Several other recent studies have estimated upstream methane emissions from shale gas and other unconventional natural gas development (ie, from tight-sand formations) using more robust and more integrated measurement techniques such as airplane flyovers, but still with highly variable results. Estimates were ~30% greater than the satellite-derived data for one gas field,[40] were comparable in two other cases,[20,25] were only about half as much for two sets of measurements in another gas field,[28,41] and were substantially less in three other cases.[40] Peischl et al have suggested that higher emissions are associated with wet-gas fields and lower emissions with dry-gas fields.[40] Alternatively, the variation in emissions may simply reflect variance in space and/or in time: many of these studies were quite short in duration, for example, based on measurements made during airplane flyovers of just 1–2 days.[20,40] It is also important to note that these emission estimates are given as percentages of the gas production rates. The activity of the natural gas industry and rates of production in various gas fields are quite variable in time, and some of the differences in percentage emission rates may reflect this variability. For instance, Caulton et al reported high emission rates in the southwestern Pennsylvania portion of the Marcellus shale based on a June 2012 flyover,[20] while Peischl et al reported a very low percentage of emission rate in the northeastern Pennsylvania portion of the Marcellus shale from a July 2013 flyover.[40] Between these two flights, gas drilling activity for shale gas fell by 64% due to low prices for gas,[42] yet shale gas production remained high based on prior drilling and hydraulic fracturing.[1] If methane emission is more related to drilling and hydraulic fracturing activity than to production, these rapid changes in activity may explain at least part of the differences between the two estimates for Marcellus shale.

I therefore conclude that the satellite data[36] provide the most robust estimates for upstream methane emissions from shale gas operations to date.

Is natural gas a bridge fuel?

Natural gas is widely promoted as a bridge fuel, a source of energy that allows society to continue to use fossil fuels while reducing greenhouse gas emissions over the next 2 decades or so, until renewable energy sources can more fully come on line. Our 2011 paper challenged that view because of methane emissions from natural gas, although we tempered our conclusion because of the uncertainty in methane emissions from shale gas development.[11] We also observed that the time frame over which one compares the consequences of emissions of carbon dioxide and methane is important in determining the overall greenhouse gas footprint of natural gas. While many studies have made this comparison only by averaging the radiative forcing of the two gases over a time of 100 years following emission, we compared on a 20-year timescale as well, following the lead of Hayhoe et al[22] and Lelieveld et al.[43] Methane has a residence time in the atmosphere of only 12 years,[23,33] while the influence of carbon dioxide emissions persists in the atmosphere for many hundreds of years or longer.[23] While both gases are in the atmosphere, the greenhouse warming effects of methane are >100-fold greater than for carbon dioxide on a mass-to-mass basis.[23] When compared on a 100-year average time after emission, the emitted methane is largely absent from the atmosphere for almost 90% of that time, which greatly underplays the importance of methane while it is in the atmosphere.

Our 2011 paper was criticized for comparing the consequences of methane and carbon dioxide over a 20-year period in addition to the 100-year period, with some authors stating that only a 100-year period should be used under the guidance of the IPCC.[44,45] This was never the case, and in the fourth synthesis report in 2007, the IPCC presented analyses based on both 20- and 100-year time periods.[35] Further, in the fifth synthesis report in 2013, the IPCC explicitly weighed in on this controversy, stating that "there is no scientific argument for selecting 100 years compared with other choices", and "the choice of time horizon […] depends on the relative weight assigned to the effects at different times".[23]

So what is the best choice of timescale? Given current emissions of greenhouse gases, the Earth is predicted to warm by 1.5°C above the preindustrial baseline within the next 15 years and by 2°C within the next 35 years.[46,47] Not only will the damage caused by global warming increase markedly but also at these temperatures, the risk of fundamentally altering the climate system of the planet becomes much greater.[48,49] Further, reducing emissions of carbon dioxide will do little if anything to slow the rate of global warming over these decadal time periods.[47] On the other hand, reducing emissions of methane has an immediate effect of slowing the rate of global warming.[47] For these reasons, comparing the global warming consequences of methane and carbon dioxide over relatively short time periods is critical. The use of a global warming potential (GWP) estimate for the 20-year time period from the IPCC fifth assessment report provides a convenient approach for doing so.[23] This GWP value of 86 is the relative radiative forcing for methane compared to that of carbon dioxide, averaged over 20 years, for two equal masses of the gases emitted into the atmosphere today.

Figure 2 compares the greenhouse gas footprint of shale gas with that of conventional natural gas, oil, and coal. Methane emissions of shale gas are derived from the satellite-based estimates of Schneising et al[36] with an additional 2.5% emission rate assumed from downstream transport, storage, and distribution systems.[11,12,22] Methane emissions for the other fuels are those used in our 2011 paper, which is 3.8% (±2.2%) for conventional natural gas.[11] Methane emissions are converted to carbon dioxide equivalents using the 20-year GWP value of 86 from the IPCC assessment.[23] While for a

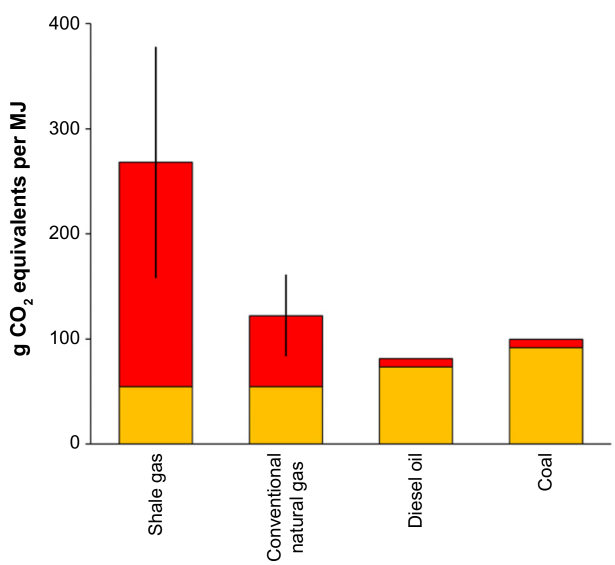

Figure 2 The greenhouse gas footprints of shale gas, conventional natural gas, oil, and coal expressed as g CO_2 equivalents per MJ of heat produced.
Notes: Yellow indicates direct and indirect emissions of carbon dioxide. Red indicates methane emissions expressed as CO_2 equivalents using a global warming potential of 86. Vertical lines for shale gas and conventional natural gas indicate the range of likely methane emissions. Emissions for carbon dioxide for all fuels and for methane from conventional natural gas, oil, and coal are as in Howarth et al.[11] Mean methane emission estimate of shale gas is taken as 12% based on Schneising et al[36] as discussed in the text.

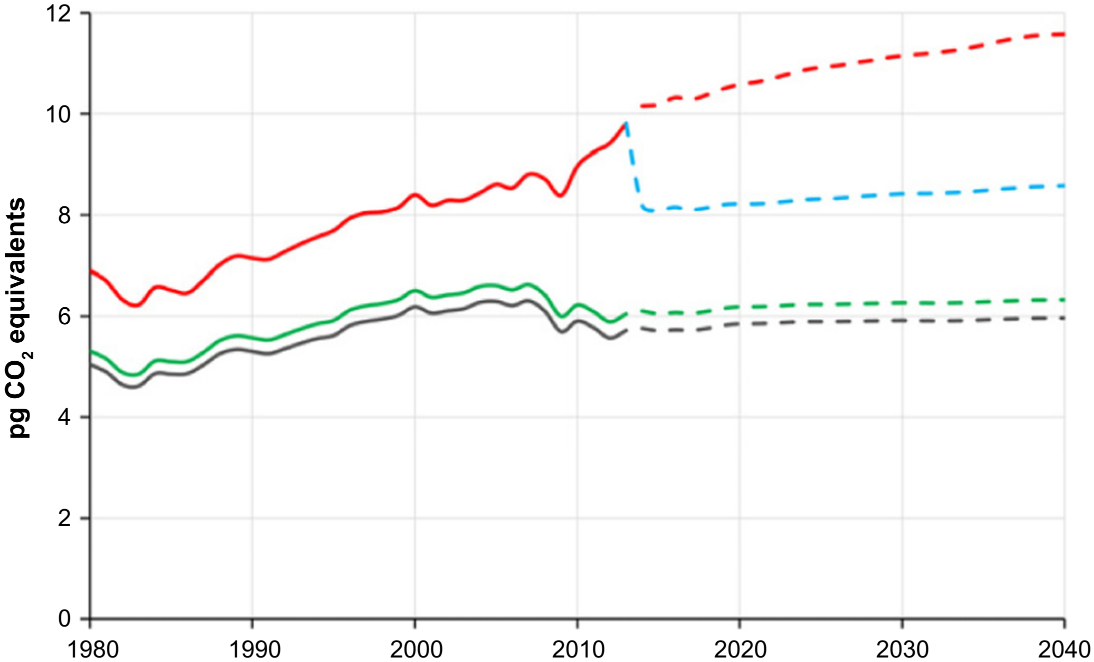

Figure 3 Trends in greenhouse gas emissions from fossil fuel use in the USA from 1980 to 2013 and future trends predicted until 2040 based on historical energy use and energy predictions in the *Annual Energy Outlook 2015*.[1] Shown are: emissions just for carbon dioxide (gray line); emissions for carbon dioxide and for methane using EPA assumptions, which undervalue the importance of methane (green line); emissions for carbon dioxide and methane based on emission factors for conventional natural gas, oil, and coal from Howarth et al,[11] mean methane emission estimates for shale gas of 12% based on Schneising et al[36] as discussed in the text, and a global warming potential for methane of 86 (red line); and future emissions for carbon dioxide and methane based on the same assumptions as for the red line, except assuming that shale gas emissions can be brought down to the level for conventional natural gas (blue line). Historical data are shown by solid lines; dashed lines represent future predictions.
Abbreviation: EPA, Environmental Protection Agency.

given unit of energy produced, carbon dioxide emissions are less for shale gas and conventional natural gas than those for oil and coal, the total greenhouse gas footprint of shale gas is substantially greater than that of the other fossil fuels when methane emissions are included (Figure 2). Note that this is true even for the low-end estimates of methane emissions from the Schneising et al study. The greenhouse gas footprint of conventional natural gas is also higher than that of conventional oil and coal for the mean estimate of methane emissions and still greater than or comparable to that of these other fuels even at the low-end estimate for methane emissions. Natural gas – and shale gas in particular – is not a bridge fuel when methane emissions are considered over an appropriate timescale.

Trends in greenhouse gas emissions from fossil fuels in the USA

Figure 3 shows the greenhouse gas emissions from all use of fossil fuels in the USA from 1980 to 2013 and projections for emissions through 2040, based on data for fossil fuel use and projections of future use from the EIA *Annual Energy Outlook 2015* report[1] and carbon dioxide emissions per unit of energy produced for each fuel.[11,22] Total carbon dioxide emissions fell in the early 1980s due to economic recession, but as the economy recovered, emissions rose steadily until the great recession of 2008. Carbon dioxide emissions continued to fall from 2008 to 2013 and are predicted to remain relatively flat through 2040.[1] President Obama and others have attributed the decrease in carbon dioxide emissions since 2008 to a switch from coal to shale gas,[21,50] although a recent analysis by Feng et al concludes that the sluggish economy was the more significant cause.[51]

When methane emissions are included in the analysis, we see some important differences in trends in national greenhouse gases. For the top line in Figure 3, methane emissions are included as carbon dioxide equivalents using the 20-year GWP of 86 from the IPCC fifth assessment[23] and methane emission factors from the 2011 study by Howarth et al[11] for coal, conventional oil, and conventional natural gas and a factor of 12% based on the satellite data discussed earlier for shale gas. In this analysis, methane contributes 28% of total fossil fuel emissions for the USA in 1980 and 42% in 2013 (Figure 3). The increasing trend in the relative importance of methane in the greenhouse gas emissions of the USA is due to an increasingly large portion of the nation's fuel mix coming from natural gas and particularly from shale gas for the time since 2009.[1] Shale gas production was negligible before 2005 (Figure 1) but rose to contribute 14% of all fossil fuel energy used in the USA in 2013.[1] Importantly, while carbon dioxide emissions fell between 2008 and 2013, total greenhouse gas emissions including methane fell only briefly in 2008 before beginning a rapid increase that lasted through 2013 and are projected to continue to rise through 2040.

The US EPA includes methane emissions in the natural gas inventory, but they do so in a manner that greatly undervalues their importance. This can be seen in Figure 3, where the green line that is just above and closely tracks the gray line for carbon dioxide emissions is based on EPA assumptions: a methane emissions rate of only 1.8% from natural gas and a GWP of 21 based on the 100-year time period from the second IPCC assessment from 1996.[52] Note that the EPA used this GWP value of 21 for many years, through 2013, before switching to the 100-year value of 25 in 2014 from the IPCC fourth assessment from 2007. The 2013 assessment of the IPCC gives a GWP value of 34 for the 100-year period but, as noted earlier, also states that the 100-year time frame is arbitrary. A shorter time frame, such as the 20-year GWP of 86 used in the top line in Figure 3, far better accounts for the importance of methane to global warming in the critical next few decades as the temperature is predicted to reach 1.5°C–2°C above the preindustrial baseline if methane emissions are not reduced.

Implications for policy on shale gas

As of January 2015, the US EPA has taken some steps to reduce emissions from shale gas, but how effective these will be in reducing methane emissions remains unclear. A draft regulation proposed in 2012 would have prevented the venting of methane during the flowback period following hydraulic fracturing, with some exceptions such as for wells in frontier regions not yet serviced by pipelines.[53] This would be important, since such venting can emit a large amount of methane.[11] However, the final regulation distinguishes between two phases of flowback, an "initial flowback stage" and a "separation flowback stage". Venting of methane and other gas is explicitly allowed during the initial stage, and recovery of the gas is only required during the separation stage.[53] The separation stage is supposed to commence as soon as it is technically feasible to use a flowback gas separator. At this stage, EPA requires that the gas be sold to market, reinjected into the ground, used as an onsite fuel, or, if none of these are possible, flared (ie, burned). No direct venting of gas is allowed during this separation flowback stage, "except when combustion creates a fire or safety hazard or can damage tundra, permafrost or waterways".[53] Much is left to operator judgment as to when the shift from the initial stage to the separation stage occurs and whether an exception is necessary, which would seem to make enforcement of these regulations difficult.

Further, EPA continues to ignore some methane emission sources, such as during the drilling phase. Caulton et al identified many wells that were emitting high levels of methane during this drilling phase, before the drillers had even reached the target shale, and long before hydraulic fracturing,[20] perhaps because drillers were encountering pockets of methane gas from abandoned conventional gas wells or abandoned coal mines. Our understanding of emission sources remains uncertain, with the study of shale gas methane emissions commencing only in the past few years.[6] Adequate regulation to reduce emissions requires better knowledge of sources, as well as better oversight and enforcement.

Nonetheless, methane emissions from shale gas can be reduced to some extent. I suggest that the best-case scenario would have these emissions reduced to the level for conventional natural gas, or ~3.8% for the full well-to-consumer life cycle. This best-case scenario is explored in Figure 3 (dashed blue line), where it is assumed that shale gas methane emissions are reduced from 12% to 3.8% as of 2014. Even still, methane accounts for 30% of total greenhouse gas emissions from fossil fuels in the USA throughout the period from 2014 to 2040 under this scenario, and total emissions continue to rise, albeit more slowly than without the aggressive reduction in shale gas methane emissions. This best-case scenario seems unlikely, and actual emissions from shale gas are likely to range between 3.8% and 12%, giving total greenhouse gas emissions for all fossil fuels that lie between the dashed red and blue lines in Figure 3.

Methane emissions severely undercut the idea that shale gas can serve as a bridge fuel over the coming decades, and we should reduce our dependence on natural gas as quickly as possible. One of the most cost-effective ways to do so is to replace in-building use of natural gas for domestic space and water heating with high-efficiency heat pumps. Even if the electricity that drives these heat pumps comes from coal, the greenhouse gas emissions are far less than from the direct use of natural gas.[12] Heating is the major use for natural gas in the USA, making this change of use imperative.

Concluding thoughts and a path forward

Should society continue to use coal rather than convert toward more electricity production from shale gas? Absolutely not. The carbon dioxide emissions from burning any fossil fuel will continue to influence the climate for hundreds of years into the future, and coal is the worst of the fossil fuels in terms of carbon dioxide emissions. Given the imperative of also reducing methane emissions to slow global warming over the coming few decades, though, the only path forward is to reduce the use of all fossil fuels as quickly as possible. There is no bridge fuel, and switching from coal to shale gas is accelerating rather than slowing global warming.

Fortunately, society does have a path forward: recent studies for the State of New York[54] and for the State of California[55] have demonstrated that we can move from a fossil fuel-driven economy to one driven totally by renewable energy sources (largely solar and wind) in a cost-effective way using only technologies that are commercially available today. The major part of the transition can be made within the next 15 years, largely negating the need for shale gas, with a complete transition possible by 2050. A critical part of these plans is to use modern, efficient technologies such as heat pumps and electric vehicles, which greatly reduce the overall use of energy. The cost of the transition is less than the cost currently paid for death and illness related to air pollution from using fossil fuels.[54] The costs of renewable energy today are equal to or lower than those from using fossil fuels, when the external costs to health and the climate are considered.

In June 2015, six of the largest oil and gas companies in Europe including BP and Shell called for a carbon tax as a way to slow global warming.[56] An editorial in the *New York Times* endorsed this idea,[56] and indeed, a carbon tax is perhaps the best way to equalize the playing field for renewable energy technologies. The International Monetary Fund estimates that subsidies to fossil fuels globally are in the range of $5 trillion per year, with much of this due to the effects of global warming and consequences on human health.[57] A carbon tax would help rectify these subsidies and help promote renewable energy. However, the editorial in the *Times* made a fundamental error by ignoring methane emissions when they wrote "this tax would reduce demand for high-carbon emission fuels and increase demand for lower emission fuels like natural gas".[56]

Any carbon tax should recognize the two faces of carbon: the two major greenhouse gases, carbon dioxide and methane, are both carbon gases. Both of these carbon gases are critically important, and the 2013 IPCC synthesis report tells us that the effects of global methane being emitted today matches the consequences of carbon dioxide emissions as drivers of global warming.[23] The modes of interaction with the planetary climate system are dramatically different, though. The climate is slow to respond to changes in carbon dioxide emissions, and so immediate reductions in emissions would take 30–40 years before having an influence on slowing warming, but the emissions have a warming effect on the climate that will persist for hundreds of years.[23,46,47] The climate responds quickly to changes in methane emissions, and reducing methane emissions is essential for slowing climate change over the coming 30–40 years; however, the methane remains in the atmosphere for little more than 1 decade, and methane emissions have no lasting influence on the Earth's climate systems in future centuries, unless global warming over the coming decades leads to fundamental thresholds and changes in the climate.[12,23,46,47]

A carbon tax that adequately addresses the immediacy of global climate change must include both carbon gases. Methane emissions should be taxed using the best available information on methane emissions. And the tax on methane should adequately reflect the importance of methane in current global warming and its influence in global warming over the critically important next few decades. Taxing methane emissions at 86 times the tax for carbon dioxide emissions, using the 20-year GWP from the most recent IPCC synthesis report,[23] would accomplish this.

Acknowledgments

The author thanks Tony Ingraffea for his continued support and collegial interaction over the past 6 years in the joint work that has helped to lead to this paper. Funding was provided by the Park Foundation and an endowment given by David R Atkinson to Cornell University to support my position. Roxanne Marino and Melanie Hayn assisted with drafting the figures, and the manuscript benefited from advice and input from Roxanne Marino, my wife and long-term colleague. Two anonymous reviewers provided very helpful comments.

Disclosure

The author reports no conflicts of interest in this work.

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Testimony of Mark Szybist
House Democratic Policy Committee
Harrisburg, March 21, 2016

Representative Vitali, Chairman Sturla, Honorable Members of the Committee: good morning, and thank you for the invitation to testify today on the question of natural gas incentives in Pennsylvania.

My name is Mark Szybist; I am an attorney by training, and I work as a Senior Program Advocate for the Natural Resources Defense Council. NRDC is a national environmental organization with more than 90,000 members and online activists in Pennsylvania, and offices in New York, Washington, D.C., Chicago, Santa Monica, San Francisco, Montana, and Beijing.

I am based in NRDC's Washington, D.C. office, but my work focuses on Pennsylvania environmental issues, especially implementation of the Clean Power Plan. I grew up in Williamsport, went to Temple Law School, and from 2011 until early 2015 served as a staff attorney for PennFuture in Wilkes-Barre. At PennFuture, I worked on various natural gas production issues, from stormwater pollution to State Forest drilling to waste disposal.

My testimony today will address the question of today's hearing – whether Pennsylvania should incentivize natural gas – as applied to the Clean Power Plan, the federal initiative to reduce carbon pollution from power plants. In terms of the Clean Power Plan, the question is this: whether the Commonwealth should incentivize new natural gas power plants by exempting those plants from its State Plan to implement the Clean Power Plan. My answer to this question is: no. Pennsylvania should cover new plants in its State Plan in order *not* to incentivize them.

The Clean Power Plan is an example of a kind of lawmaking that lawyers call cooperative federalism, in which the federal government and state governments work together to address problems that are too complex for either to address alone. In the case of the Clean Power Plan, the EPA has established a series of carbon pollution reduction targets for the states. These targets will be phased in over time, and the states have an extraordinary range of tools to meet them – from expanding consumer-side energy efficiency in homes, factories, and government buildings; to generating more electricity from zero-emitting sources like the wind and the sun; to utilizing the full capacity of existing but underutilized natural gas plants; to burning coal more efficiently at coal plants.

Several coal companies and other parties, including 27 states, have sued the EPA over the Clean Power Plan, claiming that it is illegal. (Sixteen other states, and many generators, business groups, and environmental organizations, have also intervened on the side of the EPA; Pennsylvania is one of three states that is not participating in the lawsuit). The opponents' claims will be decided by the federal Court of Appeals for the District of Columbia after oral arguments in June. Meanwhile, last month the U.S. Supreme Court issued a "stay" order that prohibits the EPA from enforcing the Clean Power Plan until the litigation is over. During the stay, states can continue working on their state plans, and Governor Wolf's administration has wisely committed to doing so. As DEP Secretary Quigley pointed out to the House Appropriations Committee a couple weeks ago, continuing work on the State Plan is the prudent course for Pennsylvania. On the one hand, given the way that cheap, oversupplied natural gas and other factors are transforming its power sector, Pennsylvania needs to do this work anyway. On the other hand, failing to plan would leave the state flat-footed if the Clean Power Plan is ultimately withheld – and NRDC is confident that it will be.

For the purposes of the Clean Power Plan, a new gas power plant is a plant that started construction after January 8, 2014. One of the decisions that states have to make in their State Plans is whether to include new plants, and thereby make them compete against existing plants on an equal footing, or to leave them out and thereby give them a competitive advantage. Inclusion and exclusion are both options for states, because existing power plants and new power plants are respectively covered by two different sections of the Clean Air Act.

If Pennsylvania's State Plan covers new power plants, all fossil-fuel plants of 25 megawatts (MW) or more will be covered by a reasonable, growth-based cap on carbon pollution. This cap will not only cut carbon pollution; it will also cut emissions of harmful co-pollutants like sulfur dioxides and particulate matter; incentivize the use of energy efficiency to lower both emissions and electricity bills; and allow Pennsylvania's economy to prosper. Based on comments that generators and other stakeholders made during the DEP's listening sessions on the Clean Power Plan last fall, the Commonwealth is likely to choose is a mass-based compliance approach in which power plants have to buy carbon "allowances" to cover their pollution. In practical terms, covering new as well as existing power plants would mean that *all* coal and gas power plants have to buy allowances to cover the carbon pollution they emit, and all are subject to the growth-based cap. If this sounds like common sense, it is. It will ensure a level playing field for existing plants and new plants, and ensure that pollution reductions from existing plants are not compromised by huge pollution increases from new plants.

By contrast, if Pennsylvania leaves new gas power plants out of the state plan, so that only plants built before 2014 would have to stay under the cap and buy carbon allowances, it would create an incentive for new power plants. New plants could operate without carbon pollution limits and carbon pricing and this would give them a built-in, competitive advantage over existing plants. In this kind of distorted market, we would likely see the premature closure of existing gas plants and the unnecessary construction of new plants, with the construction costs passed on to electricity ratepayers. We would see pollution "leak" to new plants from the existing plants that are covered by the state cap. The new plants would have to be supplied by new pipelines, and the extra gas they burned would be produced by more hydraulic fracturing. A greater number of coal plants would probably retire.

Right now, there are at least five new natural gas power plants in the Commonwealth that are either under construction or recently finished construction – in Jessup, in Lackawanna County (1,500 MW); Shamokin Dam, Snyder County (1,224 MW); Clinton Township, Lycoming County (825 MW); Asylum Township, Bradford County (825 MW); and Salem Township, Luzerne County (1,029 MW). The combined planned capacity for these plants is more than 5,000 MW. In addition, Talen Energy has announced that it will convert its Brunner Island coal-fired power plant to fire gas as well as coal. Other new gas plants have been proposed in Clinton County and Lawrence County.

What the construction of these new power plants tells us is that Pennsylvania does not need incentives for new natural gas power plants. Those plants are being built because Pennsylvania is sitting on top of the most productive shale gas formations in the United States, because natural gas is oversupplied and cheap, and because none of those things will change any time soon. What Pennsylvania should incentivize is energy efficiency – for instance, by improving its building codes and removing the arbitrary limits on efficiency in Act 129 – and zero-emitting renewable energy from the wind and the sun.