New York State Clean Energy Technology Production Program: The Science Behind AB 1705B

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Columbia University | School of International and Public Affairs | The Earth Institute

Advisor: Dr. Steven Cohen
Manager: Alison Wolters
Deputy manager: Lee Hager
Group Members: Elaine Angeles, Maria Chavez, Stephanie Díaz, Yousef Koutnik, Shao-Chen Lu, Tavo True-Alcala, Cornelia Wu, Shilin Xia, Yu Yen

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Executive Summary

New York State has set ambitious goals to change its energy mix, enhance energy efficiency, and reduce greenhouse gases. As part of the Reforming the Energy Vision (REV) plan, New York State has committed to producing 50% of its energy from renewables by 2030 and reducing its greenhouse gases to 80% of 2005 levels by 2050. Currently, natural gas is New York's largest source of energy. Natural gas usage impairs environmental quality and human health due to:

- *Habitat Fragmentation:* For example, the range of the Allegheny dusky mountain salamander overlaps with 70% of the shale areas in NY and PA. Hydraulic fracturing breaks up its natural habitat.[1]
- *Water Quality:* 82% of drinking water wells in the Marcellus shale region, which runs through New York and Pennsylvania, had methane in it.[2]
- *Carbon Dioxide Emissions and Climate Change:* In 2016, New York State emitted 20.5 million tons of carbon dioxide, a greenhouse gas, from natural gas combustion.[3]
- *Nitrous Oxide Emissions and their Health Effects:* In 2016, New York State emitted almost 7 thousand tons of nitrous oxides, a respiratory irritant, from natural gas combustion.[4]
- *Particulate Matter Emissions and their Health Effects:* Inhalation of particulate matter can exacerbate cardiovascular conditions.[5]

In 2016, New York State produced 43% of its energy through the combustion of natural gas.[6]

As New York State takes steps towards meeting its REV goals, the effects of natural gas usage will be reduced. To meet REV goals, New York will need to address energy generation for commercial and industrial users which account for 63% of the state's energy use.[7] To this effect, Assemblywoman Carrie Woerner and Senator Joseph Griffo proposed a statute entitled "The New York State Clean Energy Technology Production Program" which aims to "stimulate the growth and adoption of more energy-efficient practices, greater use of advanced energy management products, deeper penetration of renewable energy resources, and wider deployment of 'distributed' energy resources."[8] This bill seeks to incentivize large energy users in the state to invest money into energy efficiency and renewable energy projects. Currently, New York State collects money from all energy users based on the electricity usage. These funds are allocated to clean energy programs that fund energy efficiency and renewable energy for small energy users. Large energy users were thought to have no need for assistance and are not eligible to receive funding from these revenues. Under the proposed bill, New York would establish a self-direct program that would make the money that large energy users pay into the fund available to them for energy efficiency and renewable energy projects.

Self-direct programs offer users flexibility to create projects that best suit their energy needs but still adhere to guidelines issued by the state. In New York, large energy users include hospitals, data centers, and chip manufacturers. The ways in which each of these large energy users utilize energy differs, but there are some readily-available technologies that are promoted under this bill:

- *Renewable energy and distributed sources*
- *Energy management systems*

- *Insulation*
- *Light Emitting Diodes*

As part of the bill, large energy users must report on the improvements they made. Success of this program will be measured as follows:

- *Added generation capacity from renewable sources*
- *Energy saved per year by LEUs in KWh*
- *Emissions of carbon dioxide and nitrous oxides reduced per year*

New York State can be a leader in transforming its energy mix. If New York successfully incentivizes companies to participate, the state will be less dependent on natural gas for energy production and therefore experience less of the harmful impacts associated with its usage. This bill would be a step towards a better energy future for New York State.

Introduction: The Science Behind New York's Energy Production

New York State Assembly Bill 1705B (AB 1705B) is designed to increase energy efficiency and reduce greenhouse gas emissions in New York State. The bill is in line with the Reforming the Energy Vision (REV), the comprehensive energy strategy for the State of New York. REV has three strategic pillars—Public Service Commission's Reforming the Energy Vision Regulatory Docket, NYSERDA's Clean Energy Fund, and New York Power Authority (NYPA) operations and programs. These serve as anchors for New York State in reshaping its energy portfolio in the following decades. The bill aims to add to REV by establishing a self-directed, clean energy technology production program for large energy users. The program is intended to stimulate the growth and implementation of energy-efficient practices and products, as well as renewable and locally distributed energy resources.

All energy users in New York State pay an energy tax that is tied to their usage. Many of the current programs under REV are aimed at homeowners and small businesses and fail to influence the behaviors of commercial, industrial, and large energy users because they cannot qualify for these programs. Self-direct programs, like the one proposed in AB 1705B, allow large users to direct how their fees are used, but also require that program participants verify that their energy efficiency measures will successfully meet the thresholds mandated.

In 2015, over 40% of total energy consumed by New York State came from natural gas, making it the single biggest source of energy in the state. While natural gas is often seen as a "cleaner" fossil fuel, problems that arise from the extraction and combustion of natural gas lead to detrimental effects that range from habitat fragmentation, water pollution, particulate pollution, greenhouse gas emissions, and climate change.

AB 1705B proposes several pathways to the goal: improvements to design and technology of buildings, use of advanced energy management products, and increased use of renewables and locally distributed energy resources. Increased use of technology and renewables will decrease reliance on natural gas, reduce the greenhouse effect, and improve human health. AB 1705B is a step in the right direction, and will tap into energy savings that New York State was previously allowing to slip through the cracks.

This report focuses on the science behind both the problem the bill is addressing and the solution it proposes. Energy production is a science-based problem, and it requires science-based solutions. Policy choices, such as the one proposed in AB 1705B, require understanding the problems associated with New York's current energy production and understanding possible paths forward. By incentivizing large energy users to invest in renewable energy production and energy efficiency measures, New York would decrease its dependency on natural gas, a fossil fuel. The science focus of this report highlights the benefits that this bill would bring to New York.

Problems Associated with Natural Gas as an Energy Source

Electricity is a necessity in today's world, and in 2016, the State of New York produced 134 terawatt-hours of energy.[9] Natural gas is the largest source of energy for New York, accounting for 43% of the energy produced.[10] Although there are environmental costs associated with all sources of energy, the environmental costs associated with the use of natural gas, a fossil fuel, are particularly salient to New York and its neighbors. Both the extraction and combustion of natural gas have negative impacts on the environment and human health through habitat fragmentation, water contamination, greenhouse gas emissions, and air pollution. In order to understand the importance of Assembly Bill 1705B, one must first understand the type and severity of the problems that New York's primary energy source produces.

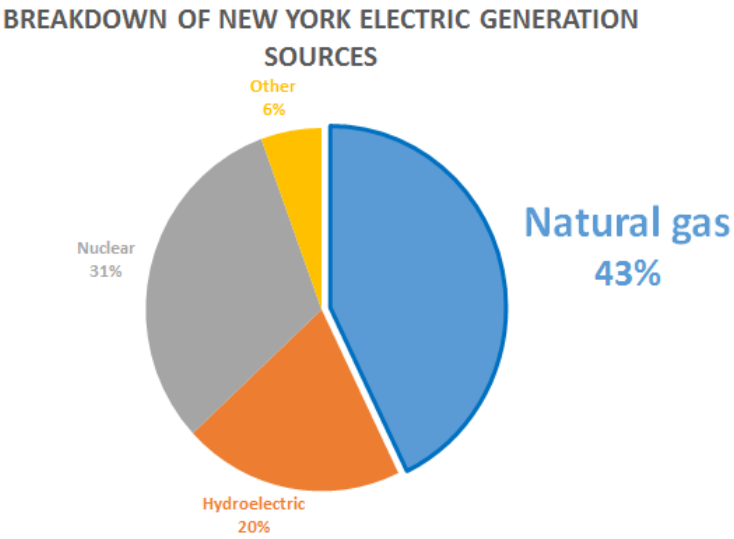


Figure 1-- New York State Energy Production in 2016 by Source. Data from EIA New York State Profile 2016.

New York State government's policy acknowledges the need to address these environmental problems. The proposed bill builds off New York State's "Reforming the Energy Vision" (REV) program, the scope for which is very similar to what is proposed in AB 1705B – that is, promoting energy efficiency practices and effective energy management products, bringing more renewable energy sources to the grid, and curbing carbon emissions.[11]

Extraction of Natural Gas

The first step in using natural gas as an energy source is extracting it from the ground. Natural gas is a fossil fuel consisting of methane. It is naturally found underground and must be brought up to the surface through extractive processes. This report focuses on hydraulic fracturing as the extraction process as hydraulic fracturing has revolutionized US domestic oil and natural gas production. Although New York placed a moratorium on fracking in 2014,[12] the state uses a great deal of natural gas from states like Pennsylvania from which it imports 60% of its natural gas.[13] Since other states that supply New York with natural gas have not imposed bans on fracking techniques, the impacts of such techniques must be considered when discussing the impacts of New York's energy production.

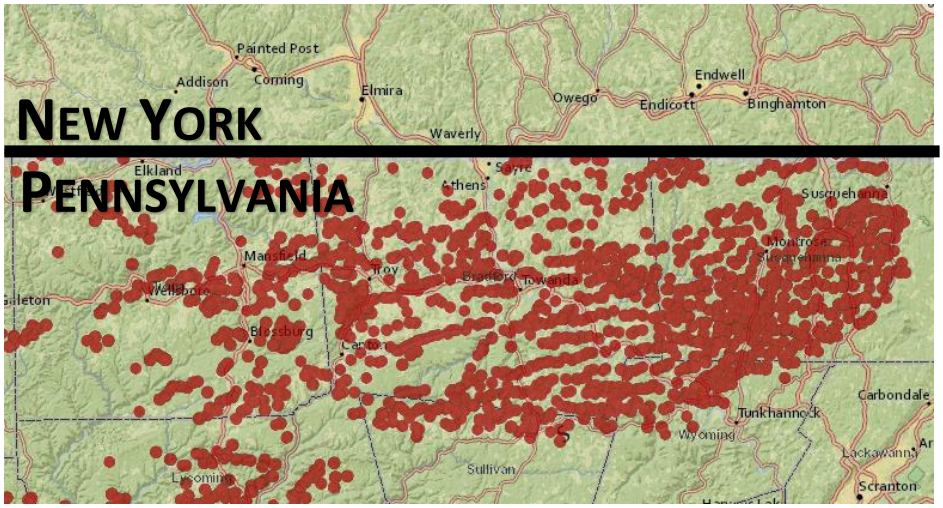


Figure 2--Location of Active Hydraulic Fracturing Wells. Note that the moratorium on fracking in New York does not prevent fracking from occurring near its borders. Image source: PA DEP website.

New York's neighboring states use hydraulic fracturing, also known as unconventional development, as a method of producing oil and natural gas from source rocks that otherwise lack the porosity and permeability to produce hydrocarbons through conventional means. The process involves horizontally drilling through a hydrocarbon-bearing formation and then pumping large amounts of water, sand, and chemicals into the wellbore to fracture the formation and artificially create the porosity and permeability needed to produce hydrocarbons. After wells are fractured, or "fracked," the water, sand, chemicals, and new chemicals from the formation are brought back to the surface before production of oil and natural gas begins. The water must be disposed of properly, or it can become an environmental and public health hazard. While the waste water from oil and gas operations is excluded from federal toxic waste rules, the regulation of waste water is controlled at the state level.

As a new technology to produce natural gas, hydraulic fracturing has become controversial. While some argue fracking is clean and water resources-dependent, others are concerned about groundwater being contaminated with natural gas and the chemicals used in the fracking process. A single hydrofracking treatment may yield 15,000 gallons of chemical waste from the fracking fluids.[14] Additionally, some have argued that fugitive emissions of methane, a highly potent greenhouse gas from fracking, could offset its reduced carbon emissions.[15] The effects of hydraulic fracturing is described below.

Habitat Fragmentation

Figure 3--An example of habitat fragmentation. Image source: Paherps.com

The hydraulic fracturing process requires clearing land for well sites. This process can cut through natural habitats as roads effectively divide the landscape into a mosaic of smaller habitats. These altered conditions affect which species can survive in a given area.[16] For example, the Allegheny Mountain dusky salamander has a range that has 70% overlap with shale areas in New York and Pennsylvania. With a divided landscape, the species may be isolated from important sources of water, causing local extinctions.[17] When factors like the use of access roads, storage tanks, and pipelines are considered, natural gas extraction facilities require large areas of land to operate.[18]

Water Quality

Hydraulic fracturing fluid, which typically has many chemical components, can contaminate water sources via a number of pathways throughout the fracking process.[19] This contamination often involves many different chemical compounds and is the most important form of environmental impact to the public. One study found that of 632 chemicals used in products for natural gas extraction, only 353 could be identified by Chemical Abstracts Services numbers.[20] The chemicals that were not identified are an unknown risk to water quality. Of this, thirty seven percent (37%) were endocrine disruptors, which are contaminants that can affect any system in the body that is controlled by hormone regulation. Its effects include obesity, cardiovascular disease, neurological effects, reproductive issues, and prostate and breast cancer.[21] Developing embryos and young children are particularly susceptible to endocrine disrupting chemicals. A different study with data provided by an oil and gas company list contained 750 chemicals, including 29 that were known carcinogens, regulated by the Safe Drinking Water Act, or classified as hazardous air pollutants.[22] Though many chemicals can be determined through testing or self-submission, companies often list many of the contents of the fracking fluid as “proprietary chemicals” which they are not required to disclose.[23] This lack of transparency adds to the uncertainty in assessing the full extent of water quality impacts that results from hydraulic fracturing.

Despite a ban on fracking in New York, nearby states like Pennsylvania that allow the practice still pose a risk to New York’s water supply near the Pennsylvania border.[24] In addition to chemicals from hydraulic fracturing fluid, stray methane can also leak from fracking sites into

the local water. One study that looked at 141 drinking water wells in the Marcellus shale region detected methane in 82% of samples. The highest methane concentrations were in water supplies within 1 km of a gas well (averaging 6 times higher than the rest).[25] Methane concentrations in the air of over 5% can be explosive or asphyxiating if released quickly from water (like a faucet) in an enclosed environment (like a home),[26] and its presence can make water more likely to dissolve contaminants like iron and arsenic, toxics which negatively impact water quality.[27]

Combustion of Natural Gas

Once natural gas is extracted from the ground, it is transported to energy production facilities. These facilities use natural gas turbines. Natural gas, a fossil fuel, is a hydrocarbon. The bonds between the carbon and hydrogen atoms are a form of stored energy, and when natural gas is burned, this stored chemical energy is turned into mechanical energy as the hot air expands through the turbine. This expansion turns the blades of the turbine which then spins a generator which converts the mechanical energy into electrical energy.

Although this report highlights the negative impacts on human health and the environment associated with natural gas usage, we understand that natural gas is considered a bridge fuel to renewable energy since its production and consumption produces less pollution than other fossil fuels. Natural gas has a lesser impact on the environment as it releases 45% less carbon dioxide than coal and 30% less than oil and has therefore less impact on the environment.[28] Nonetheless, the negative impacts of natural gas are concerning enough to continue efforts to decrease its use.

CO_2 Emissions and Climate Change

The carbon cycle is a naturally occurring phenomenon. Carbon moves between the atmosphere, the oceans, vegetation, and soil, and these processes have a natural balance. In the atmosphere, carbon exists as CO_2. As a greenhouse gas, CO_2 serves a key function in warming the Earth's surface to temperatures that allow life to exist. Heat from the Sun is absorbed by the Earth, and the Earth re-emits this heat. Greenhouse gases trap some of the heat the Earth emits, and global temperatures stabilize when the amount of heat entering the Earth matches the amount of heat leaving the Earth.[29]

Fossil fuels, the product of very old organic matter, are another way in which carbon is stored. When humans extract fossil fuels and burn them, they release stored carbon into the atmosphere as CO_2. The 16 natural gas power plants in New York State cumulatively emitted 20.5 million tons of CO_2 in 2016.[30] By doing so, New York State has contributed to another flow of carbon that was not previously in the cycle. This leads to an accumulation of CO_2 in the atmosphere, meaning more heat is trapped on Earth.[29] Once the amount of CO_2 in the atmosphere surpasses a certain threshold, this disrupts the balance described before, thereby increasing global temperatures and changing the Earth's climate systems. Due to the complexity of the Earth's climate systems and the interactions that occur within it, it is difficult to predict the exact changes that our consumption of fossil fuels will create on the planet. Nonetheless, there is high certainty that humans are driving it through greenhouse gas emissions associated with the usage of fossil fuels like natural gas.[31]

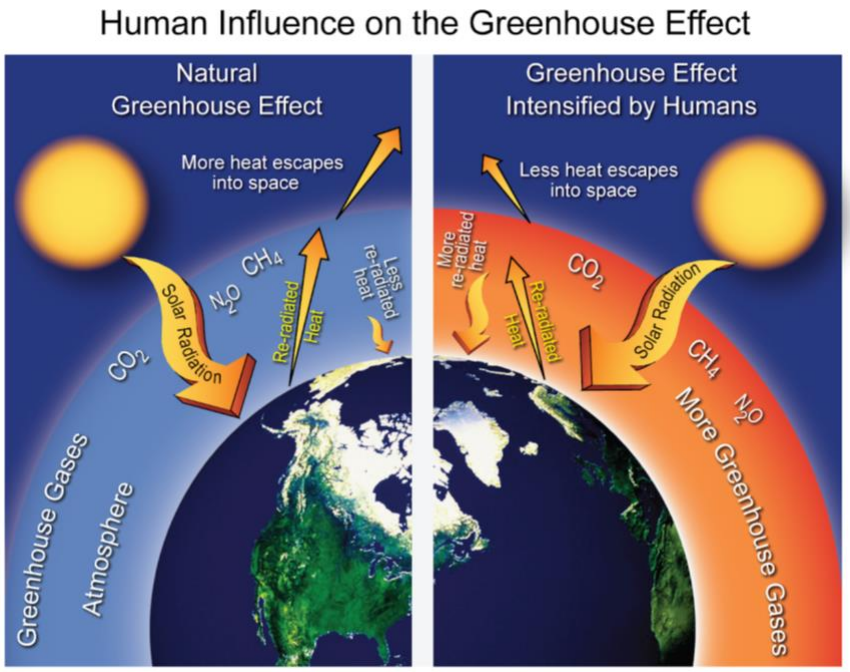


Figure 4--Anthropogenic Changes to the Greenhouse Effect through Carbon Dioxide Emissions. Image Source: Globalchange.gov

Nitrous Oxide Emissions and their Health Effects

In addition to contributing to the greenhouse effect, the combustion of fossil fuels emits compounds into the atmosphere that decrease ambient air quality and harm human health. Nitrogen oxides forms during natural gas combustion primarily through a process known as thermal NO_x production.[32] Thermal NO_x forms near the gas burners, where temperatures are highest, and is a result of the high temperatures leading free nitrogen and oxygen molecules to react with each other. Thermal NO_x production is a direct product of the oxygen concentration at the burner, the peak burner temperature, and the time exposed to peak temperature. An increase in any of these factors will result in an increase of thermal NO_x production, and this applies to virtually all types of natural gas combustion systems.

Nitrogen oxides in high enough concentrations in the atmosphere have the potential to cause respiratory complications in humans.[33] Common symptoms include coughing and difficulty breathing, and individuals with asthma or other pre-existing respiratory issues are at an elevate risk to experience respiratory complications due to high concentrations of nitrogen oxides.[34] Nitrogen oxides can also react with other chemicals in the air to create particulate matter and

ozone, with ozone being the primary component of smog.[35] Additionally, nitrogen oxides can combine with water molecules in the atmosphere to form acid rain,[36] which can significantly harm aquatic ecosystems.[37]

Particulate Matter Emissions and their Health Effects

Another way in which natural gas impacts air quality and human health is through particulate matter emissions. Although particulate matter emissions from natural gas are lower compared to other fossil fuel sources, particulate matter emissions may still "result from poor air/fuel mixing or maintenance problems."[38] Poor air quality can cause severe respiratory illnesses and intensify existing heart conditions.[39] Some analysts have estimated that roughly 6.5 million deaths per year globally due to poor air quality.[40] Most of these deaths are attributable to heart attacks as air pollution is a catalyst for atherosclerosis, a narrowing of the arteries.[41] Air pollution from particulate matter smaller than 2.5 microns in diameter (PM 2.5) is the most concerning to human health. These particles are dangerous because they are too small to be adequately screened by the body and reach the lungs with ease. Once inside, PM 2.5 irritates the lungs and the blood vessels surrounding the heart. The full extent of health impacts is unknown still. The growth of fossil fuel extraction technologies in the last few decades has not left enough time to study lifetime effects on health.

The Proposed Solution and its Policy Framework

Natural gas extraction and combustion have environmental and public health impacts. New York has created a framework by which it will address the energy mix and reduce its natural gas usage. Commercial and industrial users accounted for 63% of the energy was usage in New York State.[42] Though this does not necessarily cover all of the large energy users, from this, it is clear that New York must address the energy production and consumption of its large energy users. Assembly Bill 1705B, proposed by Assemblywoman Carrie Woerner, would establish a clean energy production program that would incentivize renewable energy production and energy efficient practices for large energy users. The current program focuses its efforts on residential consumers and small businesses. The thought is that large businesses have the capital and access to expertise needed to implement energy efficiency measures. While that may be true, many have not done so. It is likely that energy efficiency measures do not compete well with other more lucrative uses of capital. This bill would provide an additional incentive to large users since they would recover some of the energy taxes they would otherwise pay.

Purpose of the Bill

New York Public Service Law (PBS) Section 66 establishes the general powers of commission in respect to gas and electricity. Within PBS§66 are programs with funds dedicated to enhancing energy efficiency and the use of renewable energy resources in the state of New York. Most of the current programs are aimed at homeowners and small businesses, and fail to influence the behaviors of commercial, industrial, and large energy users which are often unable to meet the requirements and transparency demanded of current state programs.[43] Assembly Bill 1705B would change this by adding a new section, PBS§66-p, to establish a clean energy production program for large energy users.

The bill aims to establish a self-directed clean energy technology production program for large users who consumed at least as much energy as 2,000 New York homes. This self-direct program would allow industrial, commercial, or large users to use their energy taxes to implement an energy optimization plan of their own design. This aims to stimulate the growth and implementation of energy-efficient practices and products, as well as renewable and locally distributed energy resources by allowing large businesses and institutions to design and fund their own programs.[44] The energy taxes previously paid by the large users into the general fund would be diverted back to the large users. This makes the bill financially neutral as the energy taxes being collected would go towards energy programs, but the bill can be seen as a loss to the small businesses and residences who would no longer be the sole beneficiaries of these funds.

Key Provisions of the Bill

Section 1: The Goal of the Clean Energy Program

The commission is to create a self-directed clean energy technology program for large energy users. The goals of the program are to:

- Accelerate improvements in energy efficiency

- Increase use of advanced energy management products
- Improve the penetration of renewable energy resources (eg. solar, wind, biomass)
- Expand the application of locally distributed energy resources (eg. micro-grids, rooftop solar panels)

The commission has 45 days following the approval of AB 1705B to establish the clean energy tech program.

Section 2: Requirements of the Clean Energy Program

The commission is to work with utility companies and large energy users to form the guidelines for the clean energy technology program. The required elements of the guidelines are laid out within AB 1705B. Key elements include:

- An allowance for large energy users to treat existing and future clean energy surcharges as dedicated funds to be used to achieve any of the goals listed above.
- A restriction of the program to individual consumers with a 36-month average demand of two megawatts or to customers aggregating a 36-month average demand of four megawatts, provided that at least one of the accounts being aggregated has a 36-month average demand of at least one megawatt.
- A mechanism for the committee to recoup funds that were erroneously or fraudulently spent.
- A method to calculate energy optimization.
- A requirement that participants in the program must create a self-directed optimization plan, and that participants must match 7.5% of the total costs outlined in their self-directed optimization plan.
- A method to measure and verify energy efficiency claims of the self-direct program participants.

Section 3: Annual Reports to the Governor and State Legislature

The commission is to provide an annual report regarding the progress of the clean energy tech program. The report is to be presented on or before January 1st to the governor, the temporary president of the senate, the speaker of the assembly, the minority leader of the senate, and the minority leader of the assembly. The updates serve as another form of accountability for this program.

Self-Direct Programs: Low Administrative Burden, High Flexibility

New York has proposed using a self-direct, clean energy technology production program to address the energy usage of its large energy users. As mentioned above, the bill proposes redirecting existing funds from their system benefits charge. Industrial, commercial, and large users pay energy taxes under the current laws and would continue to do so. However, if they contribute 7.5% and design an energy innovation program, they would get back their tax money to use for improvement of their own facilities. This framework creates little administrative burden, and the money to fund this program already exists. New York would create energy

savings accounts for the large energy users so that the money is accessible, though the exact mechanism for this is not specified in the bill.

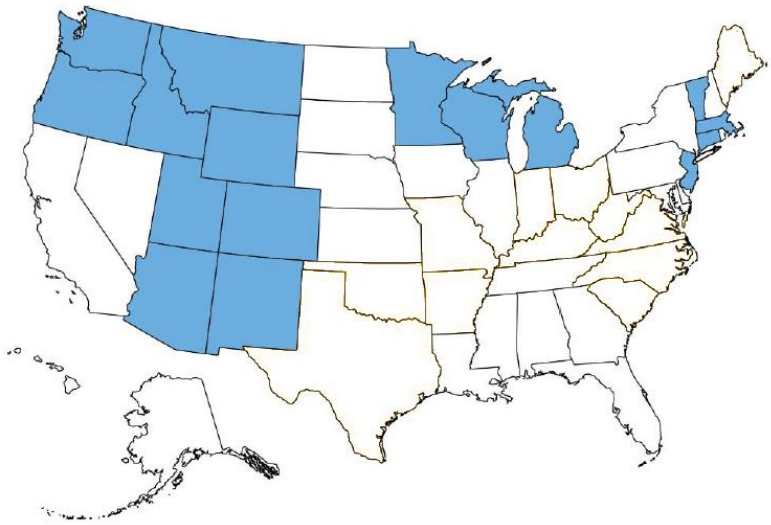


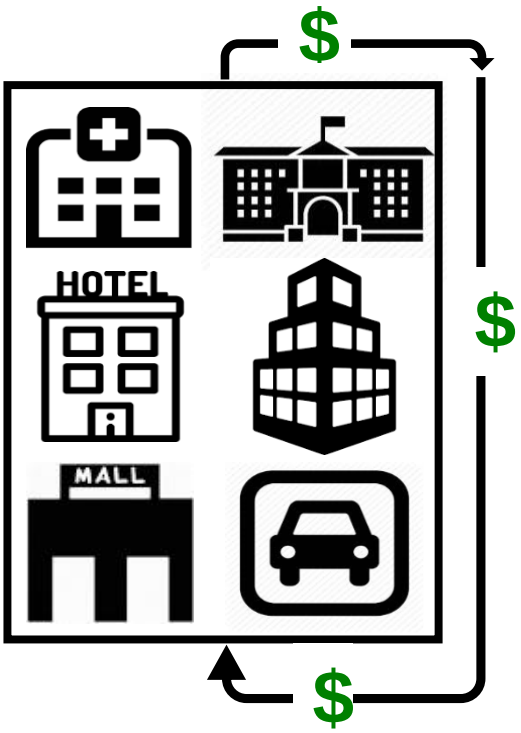
Figure 5--States that currently implement self-direct programs. Image Source: American Council for an Energy-Efficient Economy

As noted above, the self-direct program requires accountability from the energy user that participates in the program. They have to match part of the program costs, and they have to measure and verify the energy efficiency claims. This stands in contrast to opt-out programs which grant large energy users a full exemption on energy efficiency fees for users who maximize their energy efficiency without requiring any verification of results.[45] Self-direct programs, versions of which have already been implemented in several states, allow the same flexibility for large energy users as an opt-out program but ensures that this money will be used for projects in line with New York's REV. Because of its low administrative burden and high flexibility, the proposed self-direct program would be a step forward as New York moves towards a better energy future.

Large Energy Users in New York State

In the state of New York, the largest energy users are primarily hospitals (ex. Northwell Health System), universities (ex. State University of New York) and manufacturing companies (ex. Global Foundries, Quad Graphics, Ball Container), although the manufacturing base has begun to decline in recent years. The large energy users account for a sizeable portion of New York's energy usage. The National Mohawk Power Company, one of the power utilities in New York, reports that 14 large energy users with an average 2.5MW power usage accounts for 3.3% (302,451 MWh) of the energy consumed despite being only 0.001% of the energy users for that utility.[46] Additionally, Multiple Intervenors is an unincorporated association of large energy users in the state of New York with about 60 members all above the 2 MW threshold.[47] If Multiple Intervenor's members also use an average 2.5MW of power, they collectively consume at least 1.3 terawatt-hours of energy. This is a highly conservative and very provisional estimate, but it shows that by incentivizing a few large energy users, New York State could drive a significant impact on energy usage.

Despite the current lack of funds targeting large energy users, they are generally highly interested in self-direct programs, assuming that the structure is correct. In New York, energy funds like the self-direct program being proposed are financed by System Benefit Charges levied on all customers.[48] The System Benefit Charges, which would fund this clean energy technology production program, are applied on a kilowatt hour (kWH) basis and have a disproportionate impact on high-load users. As a result, System Benefit Charges for large energy users tend to be larger than transmission plus delivery costs. Self-direct programs would allow these users to access their own funds and could allow them several years to use the money they have paid in. Justifying the costs of energy efficiency retrofits tends to be straightforward, as this money does not come out of corporations' capital expenditures budgets, and can make financing projects easier and "cheaper" than they might normally be given New York's high costs relative to other states. Multiple Intervenors has advocated for pushing all the goals laid out in REV, not just energy efficiency measures.



Transforming New York's Energy Production and Consumption

New York State wants to reduce its dependency on natural gas, and the bill proposes a self-direct, clean energy production program that promotes energy efficiency and renewable energy. As part of the self-direct program, each participating large energy user will design its own project that will meet the goals of the program. In this section, we provide a glimpse of the types of projects that large energy users might invest in and give a scientific explanation of how they will help transform New York's energy production and consumption.

Renewable Energy and Locally Distributed Energy Resources

The State has a goal that 50% of energy will come from renewable energy sources by 2030. To help achieve that goal, the proposed bill encourages large energy users to utilize renewable energy resources. Solar, wind, hydropower, and biomass all avoid burning natural gas and the associated negative impacts. Investment in micro-grids and locally distributed energy resources such as rooftop solar are specifically targeted by the bill as areas for improvement. Large-scale energy users could supply their own energy by adopting these technologies and developing distributed energy systems.

Traditionally, electricity grids have relied on base power generation, cycling, and peaking facilities. Base load is typically met by a generation technology that efficiently produces flat output at the base load, or base demand, level. Cycling facilities ramp up and down throughout the day to serve usual, expected demand fluctuations. Peaking facilities are generally smaller and typically the least efficient; these are used to meet the highest demand of the day and may only be used on the hottest days of the year.[49]

Wind and solar are intermittent sources of generation that fluctuate in response to factors beyond the control of the system operator, such as available sunlight and wind. The system operator must forecast their availability and have a back-up generation method if power is not produced. Solar, especially, is problematic. The sun shines most brightly at mid-day and solar panels produce the most energy while the sun is shining the brightest.[50] Peak power demand, however, occurs in the evenings. This offset between peak solar production and peak power demand can cause a steeper ramp-up to peak production, known as the duck curve.[51] Steep ramp-up periods are costly to climb without reducing system reliability.[52]

The large-scale implementation of bend-the-meter solar and wind power will impact New York's load profile and may impact essential reliability services.[53]

Technology and innovation are unpredictable and a solution to this problem could take many forms. At present, energy storage appears to be the most viable solution, however, application of energy storage technology is too premature, and its effects are too small at current deployment levels, for the system operator to model.

Solar Power

Solar energy is harnessed through the use of photovoltaic technology. Solar panels are constructed of materials that have the ability to transform light energy into electrical energy. These materials are traditionally silicon, but the materials have been evolving in order to better capture solar energy.[54] Because the energy from solar panels is direct current, solar panels are usually connected to an inverter that converts the electricity into alternating current, allowing it to be transported and used. Solar panels are still an emerging technology. Commercially available solar panels are about 15% efficient,[55] but laboratory solar cells promise efficiencies ranging from 20% to 46%.[56] The amount of solar energy is fairly consistent throughout the state, so this technology can be applied in most of New York.

Wind Power

New York State also has the potential to harness wind power. Most modern wind turbines are horizontal-axis turbines, meaning they have blades that rotate around an axis parallel to the ground. When the wind blows, it rotates the blades of the turbine. The rotational energy of the blades is converted into electrical energy by a generator. Inland wind is considered commercially viable in areas where the wind speed is greater than 6.5 miles per hour on average, and offshore wind is viable at speeds greater than 7.0 miles per hour.[57] In New York, these conditions are located in areas in and around the Great Lakes and Long Island.[58]

Hydropower

Hydropower is the most mature of the renewable technologies described here and has been used in New York State since 1882.[59] While hydropower is not specifically mentioned in the bill, hydropower is the most widely utilized renewable energy source in the state. Hydropower uses the downward flow of water along rivers to spin a turbine. Just like wind power, a generator converts that rotational energy into electrical energy. Despite the widespread usage of hydropower, there is some debate around whether or not the climatic benefits from its zero-emissions energy are outweighed by the local environmental impacts.[60, 61] Proponents of hydropower tend to be people who are particularly concerned with climate change, while opponents tend to be conservationists. The Sierra Club, for instance, opposes large new hydropower projects, and many smaller ones as well.[62] This is a debate that has been going on for a very long time, and it is likely no consensus will be reached.

Biomass and Biogas

Biomass is another renewable form of energy promoted by the bill. Biomass consists of solid hydrocarbons from organic matter. Biomass has chemical energy in the form of stored energy between atoms, and when biomass is burned, that chemical energy is converted into mechanical energy which can be used by a generator to create electrical energy. Biogas works in the same way but uses gaseous hydrocarbons instead.

Biomass and biogas are controversial because unlike most other sources of renewable energy, they involve the combustion of hydrocarbons and the emission of particulate matter and other pollutants, just like fossil fuels.[63] Advocates of biomass and biogas argue that the carbon being

burned would have been emitted to the atmosphere anyway, on relatively short timescales (years to centuries),[64, 65] and therefore the impact is not comparable to fossil fuels, which have had their emission to the atmosphere accelerated by millions of years. In fact, it can be argued that utilizing carbon capture technology makes biomass combustion carbon negative, as the carbon dioxide taken out of the atmosphere is buried into the long-term carbon cycle rather than being emitted through decomposition in a matter of years or centuries.[66] This is also not a disagreement that seems likely to reach a consensus in the short or long term, as there are some people who would argue that any carbon-based fuel is inherently not a clean and sustainable source of energy.

Improvements in Energy Efficiency to Reduce Energy Consumption

Renewable energy production reduces natural gas usage by addressing energy production. Energy efficiency reduces energy demand and, as a result, natural gas demand. Improving energy efficiency means performing the same function while using less energy. This can be achieved by preventing the waste of energy through non-consumable losses during energy conversion. Both new construction and renovations can benefit from better design and technology that reduce energy demands at the source – before the energy is ever even required. Energy efficiency products encompass a broad range of materials, designs and technology, although functionally most are centered around improving insulation and lighting efficiency.[67] Many companies have already undertaken the energy efficiency projects described here, but they are concrete examples of proven technology that could be used by large energy users.

Advanced Energy Management Products

Smart meters and Building Management Systems can be employed to provide feedback and control the energy needs of buildings. Building Management Systems are already in use in many large buildings and updating them would be a good first step. Building Management Systems are tied to heating and cooling systems, lighting sensors and systems, and air quality sensors. This allows the facilities manager to monitor and measure status, ultimately leading to better use of energy. Many older buildings have outdated Building Management Systems. For instance, a building may only have one or two zones even though different parts of a floor may face north or south, and need different zones for optimal efficiency. An upgrade to a Building Management System would be an excellent self-direct project.

Insulation of Window Panes

Insulation is an effective way to improve energy efficiency by preventing unwanted heat from entering a space and preventing wanted heat from leaving a space. One example of using insulation to increase energy efficiency is to install double or triple pane windows in buildings. Double or triple pane window have features such as glass with low emissivity coating and argon/krypton gas fill that can significantly reduce the amount of heat entering or leaving a building. Low emissivity coating is a thick metal or metallic oxide layer that selectively allows visible light to pass through and deflects solar heat and UV rays away from the building.[68] Argon and krypton gases are slow-moving gases that have lower conductivity than air (argon has a conductivity of around 67% that of air), reducing heat transfer by creating fewer convective currents within the window. By reducing changes to indoor temperature, large energy users who utilize insulated window panes can use less energy for heating and cooling.[69]

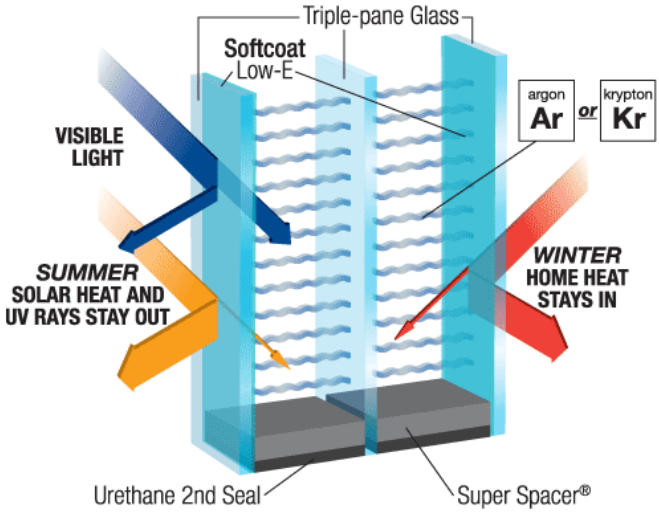


Figure 6--Insulation technology that could be used for energy efficiency. Image Source: Stanek Windows

The production of some standard insulation materials creates upstream emissions resulting from manufacturing, although these tend to be considered negligible.[70]

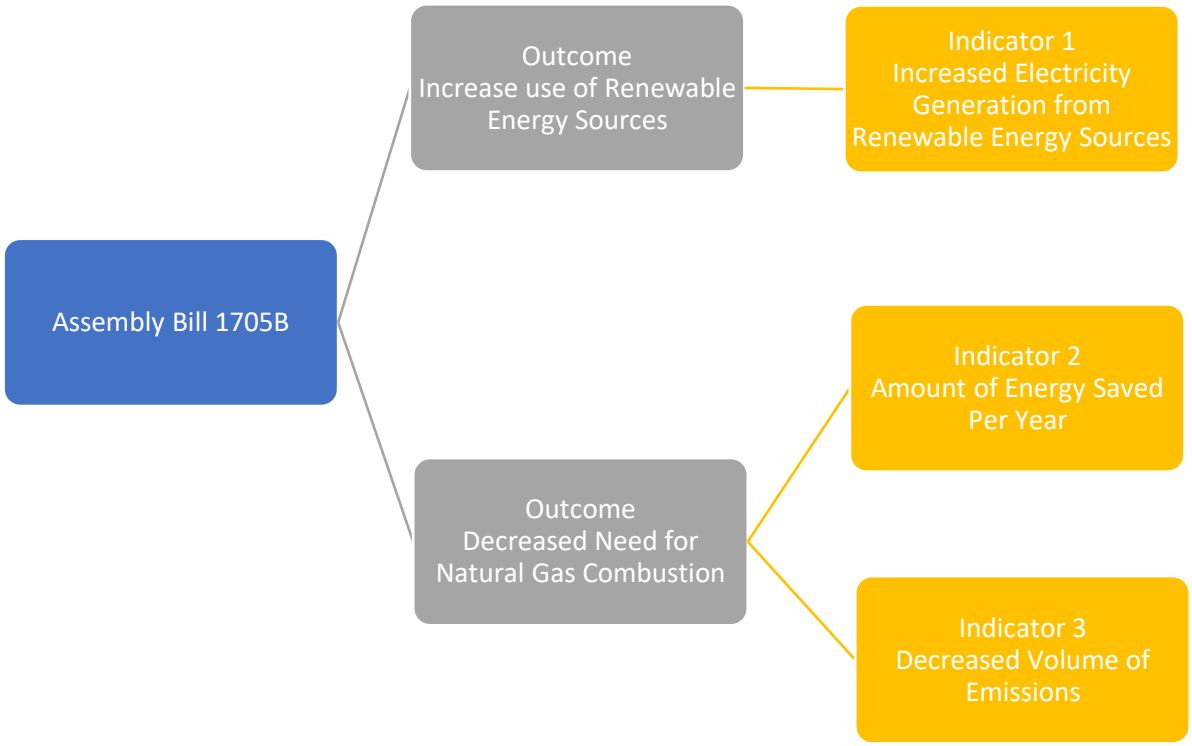
Light Emitting Diodes (LED) Lights

Improved lighting technology, such as light-emitting diodes (LED), is another effective way to improve energy efficiency. LED lights are brighter than traditional incandescent lights while using the same amount of energy. Incandescent lights produce diffuse light that requires reflectors and diffusers to provide directional lights. The use of reflectors and diffusers results in around half of the light never leaving the fixture. In contrast, LED lights are made of tiny clusters of lights that are able to emit light in specific directions. LED lights also dissipate less heat than incandescent lights. The heat produced by LED lights is dissipated through metal heat sinks or liquid cooling whereas incandescent lights dissipate heat directly into the environment. LEDs result in little room heating and can reduce energy spent on air conditioning.[71]

Some energy efficient technologies, such as LED light bulbs, have been shown to contain contaminants such as lead, arsenic, nickel and copper, which can be harmful if ingested or disposed of improperly.[72] However, this waste management issue does not outweigh the benefits that using LED light bulbs could bring to large energy users who are trying to reduce their energy consumption.

Measuring the Successes of Energy Efficiency and Renewable Energy

Assembly Bill 1705B creates a self-direct, clean energy technology production program to stimulate two outcomes: increased use of renewable energy resources and reduced energy usage by large energy users. The bill requires the measurement and verification of the outcomes in order to keep large energy users accountable. Additionally, measurement and verification of outcomes helps us understand how successfully this program is in addressing the environmental problems associated with the extraction and combustion of natural gas for energy production. To this effect, it is important to consider how such results will be verified. New York can use three indicators of success, one corresponding with increased use of renewable energy and the other two corresponding with energy efficiency measures. All three of these measures involve data that is readily available and/or established methods.



Indicator 1: Increased Electricity Generation from Renewable Energy Sources

AB 1705B promotes renewable source of energy and distributed energy systems. Increased use of renewable resources, like use of solar energy and wind energy, can be measured by the 'Calibrated Simulation' method, which build simulations and energy calculations based on detailed modeling to verify the performance of retrofit projects for whole facility or system.[73]

Indicator 2: Amount of Energy (kWh) Saved Per Year

Facilities that successfully implement energy efficiency measures should see a corresponding reduction in their energy usage for the corresponding process. As such, large energy users should report measurements of the amount of energy saved. Though the amount of energy saved cannot be measured directly, there is an established method for how it should be estimated as shown in the equation below.

It is necessary to measure energy savings as it is required for large energy users in the program. The current method to measure the amount of energy use is by using an electric meter. Calculation of savings involves the formula:

$$Savings = Baseline\ Energy\ Use - Post\ Installation\ Energy\ Use +/- Adjustment$$

where baseline energy use refers to the energy use before energy efficiency installation, post installation energy use refers to energy use after energy efficiency installation, and adjustment' involves factors that affect energy use but that are unrelated to equipment performance, like weather.[74]

The baseline energy usage of a large user is readily available information. Facilities have electric meters that measure their energy usage throughout each day. The challenge would be in picking an appropriate baseline period. Electric meters would also provide

Indicator 3: Decreased Volume of Emissions

Natural gas production and combustion emits carbon dioxide, a greenhouse gas, and nitrous oxide. Large energy users' achievements in reducing electricity demand, therefore, can also been seen through their decreased use of natural gas and emissions of these air pollutants. The Federal Clean Air Act requires major facilities, which large users are likely to be, to report emissions in tons every year. As in Indicator 2, the decreased volume of emissions will be determined by comparing emissions during an appropriate baseline period to those after the energy efficiency project has been completed.

Conclusion

Under REV, the State envisions a future where all New Yorkers benefit from higher energy savings, increased access to renewable resources, and reduced greenhouse gas emissions. REV is transformational; within this plan are proposed regulations to ensure that opportunities for growth and improvement in energy production and consumption are maximized. REV facilitates integration of renewable resources into the State's energy mix. It navigates through the transition from natural gas-dependence to better energy options in the face of rapidly increasing energy requirements in New York. It promotes innovation in the way energy is distributed and managed at the state-level, infrastructures are designed, and users consume energy.

The proposed New York State Assembly Bill 1705B, the "Clean Energy Technology Production Program" is an important component of the REV. It is a concrete approach to address the burgeoning demand for energy in New York State, which at present equates to increased natural gas usage. Over 40% of energy supplied to the State comes from natural gas.[75] The extraction and consumption of this fossil fuel puts pressure on the environment because it causes habitat fragmentation, water quality issues, and emissions of carbon dioxide, nitrous oxide, and particulate matter. AB 1705B recognizes that these issues can be reduced if the state changes how energy is produced and lowers how much energy in consumed. As such, AB 1705B promotes renewable sources and distributed energy systems such as solar, wind, hydropower, and biomass. It also promotes energy efficiency measures such as advanced energy management systems, insulted window panes, and light emitted diodes.

Currently, the State assists small energy users by providing funds for energy efficiency programs. Large energy users such as hospitals, universities, and other commercial and industrial users are left out. They are not incentivized to improve their energy consumption practices or facilities. Meeting the REV goals would prove to be a challenge if this persists because large users consume about 63% of all energy supplied to the State. AB 1705B is an initiative to ensure large users' inclusion in the movement to change the State's energy portfolio. It gives large users the opportunity to identify the best or most innovative energy programs based on their own unique requirements and capacities. It makes use of the existing taxation system to allow large users to self-direct, invest in clean energy, and implement cost-effective programs. This is a crucial step towards increasing overall energy efficiency and use of renewable resources in New York State. Ultimately, AB1705B would enable the State to meet its goal of protecting the environment and human health through better energy choices and more efficient energy use.

References

[1] Raphael K. Didham, "Ecological Consequences of Habitat Fragmentation," in *ELS* (American Cancer Society, 2010), https://doi.org/10.1002/9780470015902.a0021904.
[2] Robert B. Jackson et al., "Increased Stray Gas Abundance in a Subset of Drinking Water Wells near Marcellus Shale Gas Extraction," *Proceedings of the National Academy of Sciences of the United States of America* 110, no. 28 (2013): 11250–55.
[3] "Summary 2016 Emission Inventory," New York State Department of Environmental Conservation, accessed July 20, 2018, https://www.dec.ny.gov/chemical/113619.html.
[4] "Summary 2016 Emission Inventory."
[5] "Air Pollution and Heart Disease, Stroke," June 15, 2018, http://www.heart.org/HEARTORG/Conditions/More/MyHeartandStrokeNews/Air-Pollution-and-Heart-Disease-Stroke_UCM_442923_Article.jsp#.WyRA8xIzrox.
[6] "New York State Energy Profile 2016," January 25, 2018, https://www.eia.gov/electricity/state/newyork/index.php.
[7] "New York State Energy Profile 2016."
[8] Carrie Woerner, "New York State Clean Energy Tech Production Program" (2017), http://assembly.state.ny.us/leg/?default_fld=&bn=A01705&term=2017&Summary=Y&Actions=Y&Text=Y&Committee%26nbspVotes=Y&Floor%26nbspVotes=Y.
[9] "New York State Energy Profile 2016."
[10] "New York State Energy Profile 2016."
[11] Ian M Hoffman et al., "The Total Cost of Saving Electricity through Utility Customer-Funded Energy Efficiency Programs: Estimates at the National, State, Sector, and Program Level" (Berekely Lab, Electricity Markets & Policy Group, April 2015).
[12] Lucia Graves, "On the Faultline: New York Fracking Ban Leaves State Divided as Primary Looms," *The Guardian*, April 16, 2016, sec. Environment, http://www.theguardian.com/environment/2016/apr/16/fracking-new-york-primary-bernie-sanders-hillary-clinton-donald-trump.
[13] "New York - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)," July 20, 2017, https://www.eia.gov/state/analysis.php?sid=NY.
[14] "How It Works: Water for Natural Gas," Union of Concerned Scientists, accessed August 6, 2018, https://www.ucsusa.org/clean-energy/energy-water-use/water-energy-electricity-natural-gas.
[15] Matthew Harrison et al., "Methane Emissions from the Natural Gas Industry," Project Summary (National Risk Management Research Laboratory: United States Environmental Protection Agency, June 1997), https://permanent.access.gpo.gov/websites/epagov/www.epa.gov/ORD/WebPubs/projsum/600sr96080.pdf.
[16] Didham, "Ecological Consequences of Habitat Fragmentation."
[17] Didham.
[18] Brady W. Allred et al., "Ecosystem Services Lost to Oil and Gas in North America," *Science* 348, no. 6233 (April 24, 2015): 401–2, https://doi.org/10.1126/science.aaa4785.
[19] Madelon L. Finkel and Madelon L Finkel, *Human and Environmental Impact of Fracking: How Fracturing Shale for Gas Affects Us and Our World* (Santa Barbara, CA, UNITED STATES: ABC-CLIO, LLC, 2015), http://ebookcentral.proquest.com/lib/columbia/detail.action?docID=1963714.
[20] Theo Colborn et al., "Natural Gas Operations from a Public Health Perspective," *Human and Environmental Risk Assessment* 17, no. 5 (2011): 1039–56, https://doi.org/10.1080/10807039.2011.605662.
[21] Colborn et al.
[22] Henry A Waxman, Edward J Markey, and Diana DeGette, "Chemicals Used in Hydraulic Fracturing" (United States House of Representatives, Committee on Energy and Commerce, n.d.), http://www.conservation.ca.gov/dog/general_information/Documents/Hydraulic%20Fracturing%20Report%204%2018%2011.pdf.
[23] Waxman, Markey, and DeGette.
[24] "New York - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)."
[25] Jackson et al., "Increased Stray Gas Abundance in a Subset of Drinking Water Wells near Marcellus Shale Gas Extraction."

[26] William M Kappel and Elizabeth A Nystrom, "Dissolved Methane in New York Groundwater," n.d., 6.
[27] Finkel and Finkel, *Human and Environmental Impact of Fracking*.
[28] Rinkesh, "Pros and Cons of Natural Gas," *Conserve Energy Future* (blog), January 28, 2015, https://www.conserve-energy-future.com/pros-and-cons-of-natural-gas.php.
[29] Williams, P., (2018). ENVP U6115: Climatology. [PowerPoint Slides]. Retrieved from https://courseworks2.columbia.edu/courses/64649
[30] "Summary 2016 Emission Inventory."
[31] "Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change" (IPCC, 2013, Cambridge University Press, n.d.), 1535, https://doi.org/10.1017/CBO9781107415324.
[32] Office of Air Quality Planning and Standards, Office of AIr and Radiation, U.S. Environmental Protection Agency, "Natural Gas Combustion," in *AP-42: Compilation of Air Emission Factors*, 5th ed. (Research Triangle Park, NC 27711: U.S. Environmental Protection Agency, 1998).
[33] Office of Air and Radiation United States Environmental Protection Agency, "Basic Information about NO2," Overviews and Factsheets, Nitrogen Dioxide (NO2) pollution, July 6, 2016, https://www.epa.gov/no2-pollution/basic-information-about-no2.
[34] United States Environmental Protection Agency.
[35] "Nitrogen Oxides (NOx), Why and How They Are Controlled," Technical Bulletin (United States Environmental Protection Agency, November 1999).
[36] "Nitrogen Oxides (NOx), Why and How They Are Controlled."
[37] Office of Air and Radiation United States Environmental Protection Agency, "Effects of Acid Rain," Overviews and Factsheets, US EPA, March 16, 2016, https://www.epa.gov/acidrain/effects-acid-rain.
[38] Office of Air Quality Planning and Standards, Office of AIr and Radiation, U.S. Environmental Protection Agency, "Natural Gas Combustion."
[39] "Air Pollution and Heart Disease, Stroke."
[40] "Air Pollution and Heart Disease, Stroke."
[41] "Air Pollution and Heart Disease, Stroke."
[42] "New York State Energy Profile 2016."
[43] "A01705 Memo," New York State Assembly, accessed August 1, 2018, http://assembly.state.ny.us/leg/?default_fld=&leg_video=&bn=A01705&term=2017&Memo=Y.
[44] Carrie Woerner, New York State Clean Energy Tech Production Program; Joseph A. Griffo, "New York State Clean Energy Tech Production Program" (2017), https://www.nysenate.gov/legislation/bills/2017/s1225/amendment/b.
[45] American Council for an Energy Efficient Economy, "Self-Direct Programs for Large Energy Users," ACEEE, April 27, 2012, https://aceee.org/sector/state-policy/toolkit/industrial-self-direct.
[46] George Carlin, "Electric and/or Gas Utilities Classes A and B Annual Report of Niagara Mohawk Power Corporation" (Niagara Mohawk Power Corporation, 2018), http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=10-01665; Thomas B. King, "Niagara Mohawk Power Corporation d/b/a National Grid Schedule for Electric Service Applicable in All Territory Served by This Company" (Niagara Mohawk Power Corporation, April 27, 2009), https://www2.dps.ny.gov/ETS/jobs/display/download/6262624.pdf.
[47] "About MI," Multiple Intervenors, accessed August 7, 2018, http://www.multipleintervenors.com/about-mi/.
[48] "System Benefits Charge," New York State Department of Public Service, June 3, 2014, http://www3.dps.ny.gov/W/PSCWeb.nsf/All/58290EDB9AE5A89085257687006F38D1?OpenDocument.
[49] "Solar Impact on Grid Operations - An Initial Assessment" (NYISO, June 30, 2016), http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Documents_and_Resources/Special_Studies/Special_Studies_Documents/Solar%20Integration%20Study%20Report%20Final%20063016.pdf.
[50] Toby D. Couture, "Introducing the Shark Curve," May 22, 2018, https://www.greentechmedia.com/articles/read/introducing-the-shark-curve.
[51] Couture.
[52] "Solar Impact on Grid Operations - An Initial Assessment."
[53] "Solar Impact on Grid Operations - An Initial Assessment."
[54] "Solar Photovoltaic Technology Basics," National Renewable Energy Laboratory, accessed July 30, 2018, https://www.nrel.gov/workingwithus/re-photovoltaics.html.

[55] "Photovoltaics and Electricity - Energy Explained, Your Guide To Understanding Energy," Energy Information Adminsitration, July 30, 2018, https://www.eia.gov/energyexplained/index.php?page=solar_photovoltaics.
[56] "Research Cell Efficiency Records," United States Department of Energy, September 2015, https://www.energy.gov/eere/solar/downloads/research-cell-efficiency-records.
[57] "Energy Efficiency and Renewable Energy Potential Study of New York State" (New York State Energy Research and Development Authority, April 2014), https://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/EERE-Potential-Studies.
[58] "New York 80-Meter Wind Resource Map | WINDExchange," United States Department of Energy Office of Energy Efficiency and Renewable Energy, accessed August 7, 2018, https://windexchange.energy.gov/maps-data/95.
[59] "Energy Efficiency and Renewable Energy Potential Study of New York State."
[60] "Hydropower and the Environment - Energy Explained, Your Guide To Understanding Energy - Energy Information Administration," July 12, 2017, https://www.eia.gov/energyexplained/index.php?page=hydropower_environment.
[61] "Hydropower Facts and Information," October 9, 2009, https://www.nationalgeographic.com/environment/global-warming/hydropower/.
[62] "Energy Resources Policy" (Sierra Club, July 25, 2011), https://www.sierraclub.org/sites/www.sierraclub.org/files/energy.pdf.
[63] "Carbon Emissions from Burning Biomass for Energy," Parnership for Policy Integrity, March 17, 2011, http://www.pfpi.net/carbon-emissions.
[64] "Why Biomass - Energy and Environment, Facilities Management," The University of Iowa Facilities Management, 2009, https://www.facilities.uiowa.edu/uem/renewable-energy/biomass.html.
[65] Renee Cho, "Is Biomass Really Renewable?," *State of the Planet* (blog), August 18, 2011, https://blogs.ei.columbia.edu/2011/08/18/is-biomass-really-renewable/.
[66] Daniel L. Sanchez et al., "Biomass Enables the Transition to a Carbon-Negative Power System across Western North America," *Nature Climate Change* 5, no. 3 (March 2015): 230–34, https://doi.org/10.1038/nclimate2488.
[67] "Energy Efficiency and Conservation - Energy Explained, Your Guide To Understanding Energy," Energy Information Adminsitration, March 7, 2018, https://www.eia.gov/energyexplained/index.php?page=about_energy_efficiency.
[68] "Low-E Windows - Int'l Association of Certified Home Inspectors (InterNACHI)," July 30, 2018, https://www.nachi.org/low-e-windows.htm.
[69] "Window Gas Fills: What Inspectors and Consumers Should Know - InterNACHI," July 30, 2018, https://www.nachi.org/window-gas-fills.htm.
[70] Jonathan I Levy et al., "Carbon Reductions and Health Co-Benefits from US Residential Energy Efficiency Measures," *Environmental Research Letters* 11, no. 3 (March 1, 2016): 034017, https://doi.org/10.1088/1748-9326/11/3/034017.
[71] "LED Lighting," United States Department of Energy, accessed July 30, 2018, https://www.energy.gov/energysaver/save-electricity-and-fuel/lighting-choices-save-you-money/led-lighting.
[72] Roddy Scheer and Doug Moss, "The Dark Side of LED Lightbulbs," Scientific American, accessed August 6, 2018, https://www.scientificamerican.com/article/led-lightbulb-concerns/.
[73] "Calibrated Building Energy Simulation," Centre for Advanced Research in Building Science & Energy, August 6, 2018, http://www.carbse.org/calibrated-building-energy-simulation/.
[74] Lea Webster et al., "M&V Guidelines: Measurement and Verification for Performance-Based Contracts Version 4.0" (Federal Energy Management Program, November 2015), https://www.energy.gov/sites/prod/files/2016/01/f28/mv_guide_4_0.pdf.
[75] "New York State Energy Profile 2016."