New York Senate Bill 1120

Providing small businesses with grants to commercialize energy and environmental technology innovations in-state

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I. Executive Summary

Senate Bill 1120 (S.B. 1120)[i] provides small businesses in New York State (NYS) with grants to commercialize innovative environmental technologies to improve the energy security and economic health of the state. Passage of this bill should alleviate the financial constraints on small businesses lacking early-stage financing. Multiple environmental issues stemming from conventional energy generation (such as greenhouse gas emission) negatively impact global environmental quality, including that of New York State, and also have negative effects on the state's economic future. Though these problems are global, their impacts are felt locally and their steps to their solution can be enacted locally as well. This paper will provide an analysis of these local environmental issues, their sources and impacts, as well as the potential solutions to these problems that are supported by this bill.

New York's primary source of energy is natural gas. While natural gas is abundant and a relatively clean source of energy regarding its emissions compared to coal or oil, there are an array of negative environmental effects associated with its extraction and combustion. Although combustion of natural gas does not lead to significant emissions of sulfur dioxide, nitrous oxide, or particulate matter, it does generate carbon dioxide (CO_2). CO_2 acts as a greenhouse gas, contributing to the trapping of heat within the atmosphere and increasing global temperatures. Increasing temperatures are a root cause of significant changes in physical, biological and geochemical systems. Locally, these effects will be felt via rising average temperatures that can result in significant changes in weather patterns for NYS, with related environmental problems.

Solutions encouraged by S.B. 1120 aim to lower the demand for natural gas and thereby mitigate the associated environmental damage. Two viable solutions involve increasing energy efficiency technologies and renewable energy generation (*e.g.*, solar and wind energy). As a direct result of increased solar and wind power production in NYS, greenhouse gas emissions, water usage rates, and water contamination will decrease. However, increased land use and other externalities associated with solar and wind generation must be considered before implementation.

This paper provides an analysis of both the positive and negative externalities resulting from solar and wind technologies compared to those of natural gas via a lifecycle analysis. The success of S.B. 1120 will be indicated by a decrease in natural gas consumption through maximizing the potential for renewable energy generation and energy efficiency technologies.

II. Legislation Summary of Senate Bill 1120

If passed, Senate Bill 1120 would provide grants of up to $100,000 to small businesses developing innovative energy and environmental technology within New York State to improve energy security and economic health. The bill amends the New York State Urban Development Corporation (NYSUDC) Act in order to achieve two goals. First, it seeks to promote innovative energy and environmental technologies essential to the economic health of NYS. Second, the program should increase employment levels by aiding businesses developing innovative products and procedures related to energy and environmental technology. This support will encourage job growth in small businesses and sustain employment in larger businesses receiving the benefit of the technologies developed through this program. The scarcity of early-stage financing for small businesses currently constrains the development and commercialization of these technologies.

This bill provides general guidelines for program implementation and eligibility:

- Total annual grants shall not exceed $100,000,
- NYSUDC may not enter into more than one grant annually for any individual small business, and
- Grants may only be used for eligible costs related to developing and commercializing the technologies.

The bill encourages two types of technologies:

(a) Innovative energy technologies such as solar, wind, fuel cells, advanced hydroelectric, and biomass power conversion technologies, and

(b) Innovative environmental technologies such as air, water, and soil pollution control; solid and toxic waste management; site remediation; and environmental monitoring and recycling.

Eligible applicants must be independently owned and operated, have principal operations and headquarters located in New York State, and employ less than 100 people, 80% of whom must work in the state full-time. Eligible applicants must also show that comparable funding is not available from another source.

In the grant application, each applicant must detail the product, technique, system, or process being developed, as well as the benefits of and potential for its commercialization. The NYSUDC will evaluate grant applications based upon a number of criteria to be developed in consultation with NYSERDA and the Department of Environmental Conservation including job creation potential, budget feasibility, technical value, and marketability of the technology. As part of the technical review, research will need to be conducted around the efficacy of the energy and environmental technologies. It will also be necessary for these bodies to research the availability of alternative funding and the commercialization potential for these businesses and technologies.

To ensure effective implementation, the NYSUDC must report program results annually including information on each grant's impact on its respective business and an assessment of job creation resulting from the grant. This program does not create a separate funding mechanism, but will be funded through the budget of the NYSUDC and will remain subject to its appropriations.

III. The Environmental Problem Being Addressed

As a major goal of this bill is environmental improvement, it is important to outline the environmental problems that this bill addresses. Several issues negatively impact New York State's environmental quality as well as the state's economic and environmental future. Some of the many environmental issues that can be addressed by this bill include:

- Water contamination from industrial pollutants,

- Management of the large volume of waste generated by New York City, and
- The generation of greenhouse gases generated due to energy demands.

Although the issues addressed in S.B. 1120 have a global reach, this report will focus on the environmental issues within New York State as this is a state bill and concerns local improvements. It should be noted, however, that local improvements in greenhouse gas emissions will also have global benefits. This report will focus on negative environmental effects directly related to energy generation, and specifically on the use of natural gas. Although NYS also uses a variety of other energy sources, natural gas is the major power source. Natural gas comprises 37% of the state's total energy consumption[ii], with nuclear, hydroelectric, and coal as the next largest contributors. Natural gas is used for both residential and industrial use, with uses ranging from cooking and heating to electricity generation.

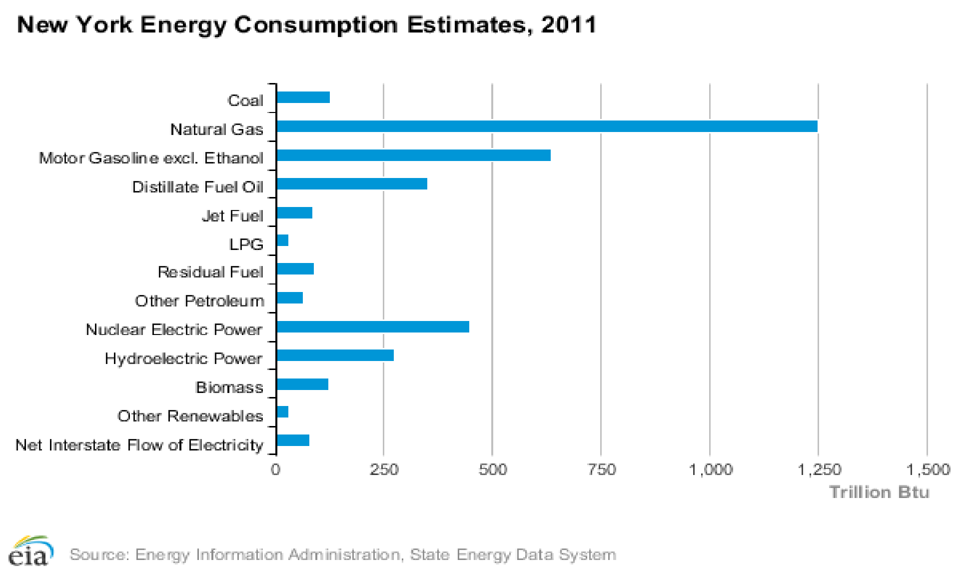

Figure 1. New York State's energy consumption estimates for 2011 (EIA)

In NYS, 87% of CO_2 emissions directly result from fossil fuel combustion, which led the state to contribute 3.8% of the United States' total greenhouse gas emissions in 2010.[iii] Natural gas produces approximately 117 lbs of CO_2 per million BTU equivalent of natural gas. Natural gas use has grown in recent years, serving approximately 4.7 million customers in NYS (0.4 million commercial, industrial, and electric customers; 4.3 million residential customers).[iv] In 2010, New York contributed 64.4 million tons of CO_2 from natural gas out of the total of 172.8 million metric tons of CO_2 released that year.[v]

IV. The Science Behind the Environmental Problem

This section will focus on an analysis of the issues associated with the combustion and extraction of natural gas. The consequences of carbon dioxide emissions have affected the quality of New York's air, water, and land in a variety of ways that will be enumerated below.

1. The Environmental Impact of Carbon Dioxide (CO_2)

The most significant environmental impact from CO_2 emission is related to the greenhouse effect. The Earth receives heat from the sun as electromagnetic radiation. While both land and ocean surfaces absorb this heat, the majority gets reflected back into the atmosphere as long wave, infrared radiation. Greenhouse gases, including carbon dioxide, methane, nitrogen oxides, and sulfur oxides, interfere with this process and contribute to the trapping of heat within the atmosphere through their increased ability to absorb heat radiation at near infrared (IR) wavelengths. This means that the heat energy that would be re-radiated back into the atmosphere is instead absorbed by these gases and re-radiated back towards the Earth. As a result, the temperature of the Earth increases.

The Northeastern states of the U.S. have faced temperature increases of over 1.5°F since 1970.[vi] Following a "business as usual" model, high emissions of carbon dioxide are expected to increase seasonal average temperatures 8°F to 12°F for the winter and 6°F to 14°F in the summer by the year 2100.[vii] These temperature differences will result in significant changes in weather patterns for New York State with corresponding negative effects on the state's environmental and economic future.

A. The Impact of Increasing Temperatures

Nearly 36,000 farms, mainly producing dairy, corn, and cattle,[viii] comprise one quarter of New York State's land, and generate more than $3 billion in revenue.[ix] Increased temperatures may increase stress on food production in future years and may also stress various ecosystems throughout the state. Due to increased greenhouse gas emissions, temperatures have increased without a corresponding increase in summer rainfall, resulting in an increased frequency of short-term, one to three month droughts.[x] Carbon dioxide and other greenhouse gas emissions have been linked to negative impacts on the productivity of agricultural lands, increases in the toxicities of water bodies, and increases in air pollution.

- **Dairy Farms:** Increased temperatures create heat stress on dairy cows, reducing the cows' ability to produce milk. With high CO_2 emissions, modeled by "business as usual" projections, temperature increases will depress milk production up to 15%.[xi]
- **Crops:** Increased levels of CO_2 could increase production of some crops as atmospheric carbon is critical for photosynthesis, and allows plants to create sugars used for growing. Higher atmospheric concentrations of CO_2 would increase availability of CO_2 to plants. The doubling of CO_2 concentrations could increase production of some crops such as wheat and soybeans by as much as 30%. However, other plants would see much smaller increases in yield and increased temperatures would change the climate in state resulting in a need to modify the types of crops currently grown to match environmental characteristics. Other factors linked to CO_2 emissions, such as increased temperature, changes in precipitation patterns and levels, and frequency of extreme weather events, could likely decrease crop yields and increase costs for farmers. Rising temperatures may decrease yields as temperatures exceed crops optimal growing range. Similarly, drought and excessive precipitation may harm crops, decreasing yields, and require more proactive solutions from farmers, raising the costs associated with farming. NYS is a major producer of apples, grapes, sweet corn, and cabbage. Heat stresses will reduce crop yields for some low-value crops but may be beneficial for high-value crops including watermelon, tomatoes, and peaches by extending their growing season.[xii] Increased temperatures and heat stresses will increase pressure from weeds and insects that are harmful to all crop production. Increased temperatures will increase the range suitable for agricultural pests, such as kudzu, to live, increasing the pressure on farmers to make use of pesticides, many of which are toxic.
- **Ecosystems in the Adirondacks:** Short-term droughts are more severe for certain locations in NYS, such as the Adirondacks and Catskill Mountains. These droughts are

expected to affect the habitats of wildlife that depend on diminishing water systems in these locations. Droughts have been estimated to occur yearly toward the end of the 21st century and if carbon emissions continue to follow the "business as usual" model, spruce forests and alpine tundra, upon which species including the Canada lynx and Bicknell's thrush are highly dependent, are expected to reduce in size. Additionally, the alpine tundra of the High Peaks Wilderness is expected to be eliminated by continued climate change.[xiii] An increase in winter temperatures in the Adirondacks will reduce the snow pack in the mountains by causing it to melt earlier than normal, and will create peak stream flows in spring. This will impact the reproductive cycle of various fish, including the native Brook Trout, which spawn at that time. Increased summer temperatures also reduce cold-water refuges available to these fish in the lakes and streams of the Adirondacks increasing their mortality rates.[xiv]

B. The Impact of Increased CO_2 in Marine Environments

As CO_2 emissions increase worldwide, the impact of increased temperatures and carbon dioxide emissions become increasingly complex. The ocean, and other water systems serve as carbon sinks into which CO_2 dissolves. Increases in CO_2 levels in the atmosphere lead to greater amounts of dissolved CO_2 in water systems. Due to the atomic structure of the CO_2 molecule, when it dissolves into bodies of water, it increases the acidity of that system and reduces its pH. This has severely affected marine systems, as described below.

- **Algal blooms:** Algae are photosynthetic organisms, which absorb CO_2 and, with exposure to the sun, release oxygen as a byproduct. Algae have increased in biological efficiency due to increased CO_2 levels in the atmosphere.[xv] Absorbing the readily available CO_2, these photosynthetic organisms are able to thrive and grow at a faster rate at the surface of seawaters. The increased population growth in algae has consequently led to algae-covered surface waters, preventing sunlight from reaching photosynthetic organisms situated at lower depths. As a result, the surface waters have increased in oxygen production, while depriving deeper waters the sunlight needed for photosynthesis and oxygen production. The oxygen produced by these photosynthetic organisms below surfaces waters is essential to marine life. The lack of dissolved oxygen has created both anoxic and hypoxic seawaters, killing off marine populations.

- **Impact on fisheries:** Seawater has an average, historical pH of approximately 8.2. However, recent pH levels have reduced to around 8.1, a 25% increase in acidity since prior to the Industrial Revolution.[xvi] CO_2 dissolves in water to produce a series of reactions that lower the pH of the system as well as the carbonate ion concentration in the water, while also forming calcium carbonate minerals. This increase in acidity has adverse effects on shell-forming organisms such as corals, oysters, shrimp, and some fish by hindering skeletal development of these organisms. This generates a severe impact on fishing industries as seafood comprises approximately 30% of human protein consumption.[xvii] Marine organisms have an optimal temperature range at which they can thrive. With increased ocean temperatures, some organisms like lobsters, which live at cooler temperatures will not be able to survive. Lobster fisheries in the Long Island Sound have not yet recovered from the temperature-driven-die-off of 1999 and if temperatures continue to increase in future years, NYS lobster fisheries will be lost.[xviii]

2. The Impact on Air Systems and Public Health

Natural gas production emits benzene, toluene, ethylbenzene, and xylenes (BTEX) as well as n-hexane and VOC.[xix] Their impacts on humans are summarized below in Table 1. In general, they produce reproductive disorders, birth defects, have led to increased risk of cancer and can affect the nervous system. The effects described in Table 1 are especially dangerous for the most vulnerable populations of NYS; the very young and the elderly.

Contaminant	**Effects**
Benzene	Skin, eyes and upper respiratory tract irritation and blisters; considered a carcinogenic; may cause blood disorders, reproductive and developmental disorders, and cancer.[xx]
Toluene	Skin, eyes and upper respiratory tract irritation, dizziness, headaches, sleep difficulty, birth defects.
Ethylbenzene	Throat and eye irritation, chest constriction, and dizziness, blood disorders
Xylenes	Nose and throat irritants; cause nausea, vomiting, eye irritation and neurological damages
n-Hexane	dizziness, giddiness, slight nausea, and a headache; numbness in extremities, muscular weakness, blurred vision, headaches

Table 1. Health effects related to natural gas emissions during production (EPA).[xxi]

3. The Environmental Impact of Hydraulic Fracturing

Emissions of CO_2 and pollutants are not the only negative externalities associated with natural gas use. Modernized means of natural gas extraction includes hydraulic fracturing, a technique that utilizes large volumes of water mixed with chemicals during the extraction process.[xxii]

It is hard to know the exact composition of fluids used in the fracturing process as they vary from site to site and their disclosure is not required by law. However, a sample fracturing fluid composition supplied by the Department of Energy (DOE) states that fluids are 99.5% composed of water and a proppant, usually sand, which keeps fractures formed in the shale bed open. The other 0.5% of the fracturing fluid is composed of various additives intended to serve secondary functions in the fracturing process, such as killing bacteria in the fracturing fluid, decreasing friction, increasing the viscosity of the fluid, adjusting the fluid pH, or helping to dissolve salts in the shale rock. Various chemicals, such as hydrochloric acid, diesel, mineral salts, and a variety of other chemicals, ranging from innocuous to toxic, are used to achieve these effects.[xxiii]

Critics of the shale gas industry claim that the fracturing fluids are migrating out of the shale formations or the wellbores in which they are applied and into near-surface freshwater aquifers. However, industry experts claim that contamination of drinking water from shale gas operations is unlikely and that the true scale of the problem is being taken out of proportion. To support their claims, they cite previous research that suggests that intermediate layers of rock and saline deepwater should prevent fluid migration.[xxiv]

At this point, there is little unbiased scientific research from which to reach a balanced conclusion about the effects of drilling and potential fluid contamination. Furthermore, the lack of existing laws regarding disclosure make it difficult to understand what contaminants may or may not be linked to fracturing fluid and drilling activities, since many states do not require drillers to disclose the composition of there fluids uses, and only two states require the disclosure of the concentration of compounds used in their fluids.[xxv]

V. Analysis and Description of the Proposed Solution

Given that New York State's largest energy source, natural gas, contributes to environmental pollution, solving our dependence on natural gas will help solve the state's environmental problems.

NYS consumes ~3.6 quadrillion BTUs of energy annually, or 192 million BTUs per capita (ranking 50th among states/DC).[xxvi] Of that energy, 72% (2.6 quadrillion BTUs) is consumed by residential, commercial and industrial users, with the balance used for transportation. Given widely-used public transit systems in the NYC area, transportation energy efficiency is a relative strength for NYS and is not considered further in this paper.

Of the 2.6 quadrillion BTUs consumed for non-transportation related purposes, 1.25 BTUs are generated from natural gas with the balance from nuclear, renewables and other sources. By 2020, it is possible to reduce net energy requirements by 21% to 2.06 quadrillion BTUs through increased energy efficiency (*e.g.*, improved lighting and appliances) and increased renewable energy production. These actions should reduce NYS natural gas consumption by 47%, as summarized in Table 2 below.

New York State Energy (quadrillion BTUs; excludes transportation) (a)

Consumption by consumer category

	Actual 2011	Compounded growth	Projected 2020 (without EE technologies)	Energy efficiency	Projected 2020
Residential	1.07	4%	1.11	-28%	0.80
Commercial	1.18	15%	1.35	-29%	0.96
Industrial	0.35	5%	0.37	-18%	0.30
Total	2.60		2.83		2.06

Energy generation by sources

	Actual 2011	estimated growth		Projected Pro Forma 2020
Nuclear	0.45			0.45
Hydro	0.27	2%	avg. 10% growth	0.28
Biomass	0.12	4%		0.13
Wind/solar	0.03	99%		0.06
Other	0.48			0.48
	1.35			1.39
Natural gas	1.25	-47%		0.67 (b)
Total	2.60			2.06

(a) 2011 data from U.S. Department of Energy. Other figures discussed elsewhere in memo.
(b) Calculated based upon projected pro forma energy consumption (2.06) less amounts available from other sources (1.39).

Table 2. New York State's current and projected energy consumption

Our solution to reducing natural gas consumption focuses on innovations in renewable energy generation, and energy efficiency technologies. Each will be discussed below. To take full advantage of these improvements, it will be necessary to implement changes to NYS infrastructure for the transmission, distribution, and storage of energy, which are currently being addressed by other NYS agencies[1] but are not reviewed here.[xxvii]

1. Renewable Energy Generation

Renewable energy comes from continuously replenished sources like sunlight, wind, hydropower and biomasses, rather than non-renewable sources like coal, oil and natural gas. Nuclear power can be considered renewable in that the chemical energy stored in molecular bonds is infinite for practical purposes, but nuclear power presents other issues (*e.g.*, long-term radioactive waste storage) and is not considered a viable renewable source in this report. Increasing renewable energy production is one way NYS can decrease overall consumption of fossils fuels. By increasing renewable generation, NYS can limit the use of natural gas to periods when renewable energy generation is not available.

Renewable energy can be divided into two types: (a) utility-scale, and (b) small or distributed renewables. Utility-scale renewable projects are large and supply energy to the transmission grid for distribution by local utilities. In comparison, small or distributed renewable projects are intended to supply an individual entity (*e.g.*, a building, campus) with power. These projects reduce purchases of grid-supplied electricity, but do not typically eliminate its need, as the renewable generation source may not operate at all times (*e.g.*, solar panels at night). Excess power from renewable generation can be supplied to the grid where the local utility must buy it and where it can offset a portion of the utility's electricity needs. Our assumptions concern utility scale renewable generation as such scales will be needed to replace comparatively sized natural gas fueled power plants.

[1] NYS Gov. Cuomo recently announced the availability of $10 million to foster smart grid technologies to help strengthen the NYS electric grid to accommodate a diverse supply of power generation sources (including renewable energy) and also enhance grid performance, reduce environmental impacts, boost energy efficiency and lower costs to customers.

Table 3 below summarizes renewable electricity generation sources in NYS. This table shows values for 2010 both in mW (capacity) and mWh (generation/consumption)[xxviii] and the BTU-equivalent. Our estimates of the potential increase in renewable generation that appear in Table 3 will be discussed later in this paper. These figures were incorporated into Table 2 to assess the overall impact of both increased renewable generation and increased energy efficiency on natural gas consumption in NYS.

We predict total renewable generation to increase by 12,103mWh (40%) above 2011 levels. Our analysis results in renewable sources accounting for approximately 31% of 2010 total electricity consumption. This complies with the current NYS "Renewable Portfolio Standard" which requires that 30% of electricity come from renewable energy by 2015.[xxix]

	Current (a)			Additions through 2011-2020 (c)		
	Net Summer	Net Generation		Net Summer	Net Generation	
	Electricity Capacity (mW)	thousand mWh	quadrillion BTU (b)	Electricity Capacity (mW)	thousand mWh (d)	quadrillion BTU (b)
Hydro	4,314	25,472	0.09	325	1,919	0.01
Wind	1,274	2,596	0.01	3,540	7,213	0.02
Solar	0	0	0.00	1,000	1,489	0.01
Biomass:						
Wood/wood waste	86	547	0.00	50	318	0.00
MSW/landfill gas	359	1,671	0.01	250	1,164	0.00
Total biomass	445	2,218	0.01	300	1,482	0.01
Total renewables	6,033	30,286	0.10	5,165	12,103	0.04
2010 Total (all sources)	39,357	136,962	0.47	39,357	136,962	0.47
Renewables % of Total	15%	22%	22%	13%	9%	9%

(a) Data from U.S. Department of Energy
(b) Conversion assumes 1 kWh = 3,412 BTU.
(c) Estimated as discuss in accompanying text.
(d) Based on current NYS factors exc. Solar (estimated at 17% of potential annual output).

Table 3. New York State's current and projected power generation

Although there are other technologies available, this section will discuss four types of renewable energy suitable for technological improvements as these four are relatively easy to deploy in the current marketplace[xxx]: (a) hydroelectricity, (b) wind turbines, (c) solar photovoltaics, and (d) biomass.

A. Hydroelectricity

In the late 19th century, hydropower became a source for generating electricity with the first plant built at Niagara Falls in 1879.[xxxi] NYS is the largest hydroelectric power producer east of the Rocky Mountains with more than 300 hydroelectric generating stations connected to its electric grid and hydroelectric plants typically meet at least 17% of the state's total electricity demand.[xxxii]

Hydropower is one of the most well-developed technologies in NYS, yet newer technologies and retrofits of existing infrastructure present significant opportunities. With improvements to existing generating stations, older stations could be retrofitted at minimal cost, potentially yielding over 30 mW in increased capacity.[xxxiii] Additionally, retrofits to dams and water infrastructure not currently designed for power generation could yield up to 295 mW of capacity without the need to invest in additional dam or water control infrastructure. For purposes of our projections in Table 3, we have assumed 325 mW of net installed capacity will be added prior to 2020.

NYS also has significant capacity to expand local electricity production using small/micro hydroelectric installations in which turbines are placed directly into the flow of a river without the need for dams or redirection of river flow. While it is currently difficult to estimate the impact of these technologies in NYS due to seasonal effects of small hydroelectric installations and the nascency of these technologies, increasing these sources will help build redundancies into the existing power network and decrease the reliance of local areas on grid-supplied electricity, which is critical in times of high-energy demand.

B. Wind Turbines

Although novel designs have been created, traditional turbines are currently the best-developed technology for creating electricity from wind. The basic operation of wind turbines utilizes a rotor that is spun by moving air, connected to a turbine and dynamo by a series of gears. Commercial wind turbines can range from ~400 watts (for individual buildings), to extremely large utility-scale turbines with capacities of over 7 mW. The highest wind velocity in NYS is generally along the Great Lakes and shores of Long Island, with additional pockets upstate. We do not expect significant wind development in New York City given both the weak wind resource and issues with siting large turbines in a highly-developed area.

The American Wind Energy Association ranks NYS 12th in the nation for installed wind power capacity with over 1,403 mW: enough energy to power more than 300,000 homes.[xxxiv] NYS is estimated to have nearly 7,080 mW of installable utility-scale wind capacity, not including small projects for individual buildings. While it is difficult to predict the potential of these small projects, these installations further reduce the need for grid-supplied electricity (generated primarily by natural gas). For purposes of our Table 3 projections, we have assumed 50% of estimated utility-scale capacity (3,540 mW) to be installed prior to 2020.

There are barriers to continued expansion of wind generation resources in NYS, including siting concerns and issues related to permitting. Furthermore, optimal wind resources are often located far from areas where power is most needed, requiring upgrades to existing transmission infrastructure. Finally, there remain some concerns about the availability of project financing given uncertainty around the continuation of financial incentives for wind power.

C. Biomass

Biomass refers to the biological matter in living organisms, including trees and agricultural crops.[xxxv] Biomass is considered a renewable energy source because new plants can be grown and if biomass resources are well-managed, its use can produce minimal environmental impact. Biomass power can be divided into two categories: facilities that use wood or woody products as fuel, and facilities that are powered by methane gas created by decomposing organic matter.

The abundance of sustainably-forested land in upstate NYS already supports biomass-fired steam turbine plants with 96 mW of capacity. There are, however, issues with using woody biomass for power. First, there are negative consequences to the forest if bad forestry management practices are used to provide feedstock. Second, many wood-fired biomass facilities still produce large amounts of particulate emissions, and it is not strictly a zero carbon emission technology.[xxxvi] Third, it may be difficult for facilities to obtain long-term delivery contracts as there is significant competition for woody biomass feedstock. For Table 3, we have assumed 50 mW of installed capacity (~50% of existing capacity) given new installations and/or greater efficiency at existing facilities.

NYS also has significant potential for biogas facilities using fuel from landfill waste and from sewage processing plants. As of 2007, anaerobic digesters (which produce biogas through microbial processes) were installed at over 125 wastewater treatment plants in NYS.[xxxvii] NYS currently has biogas facilities with 359 mW of net summer electricity capacity.[xxxviii] For the purposes of creating Table 3, we have assumed an increase in installed capacity of 250 mW, or ~70% of existing capacity, owing to new installations and/or increased efficiency at existing facilities through 2020.

D. Solar Photovoltaics

Solar power can refer to both utility-scale technologies (*e.g.*, a facility with large contiguous installations of solar panels) and distributed technologies (*e.g.*, rooftop solar panels). It can also refer to technologies that do not generate electricity, but rather, use the sun's energy to displace traditional energy needs (*e.g.*, solar water heaters). This discussion will focus on photovoltaic cells, which are commonly used to convert solar radiation into electricity. While this technology has existed for over 100 years, there continue to be technological improvements[xxxix] to increase its efficiency.[2]

There are promising applications for solar power in NYS. In particular, the roofs of buildings in NYC present an opportunity to create electricity on otherwise marginal space. Studies conducted by the City University of New York (CUNY) indicate nearly two thirds of rooftops in NYC are suitable for solar installations and potential rooftop solar capacity in NYC has been estimated at up to 5,847 mW, of which only 14 mW are currently installed.[xl] If the full potential of this resource was realized, it could provide enough power to meet nearly 50% of the city's peak daytime summer energy demand, and nearly 14% of estimated annual electrical consumption.

Although there are barriers to widespread adoption of rooftop solar (*e.g.*, zoning, engineering, and transmission issues), the CUNY study highlights the potential of this resource. Solar is also

[2] The U.S. Department of Energy's National Renewable Energy Lab (NREL) recently announced a new world record of 31.1% conversion efficiency for a solar power cell.

attractive in that it supplies the most electricity on sunny days when demand is also likely to peak (due to air conditioning load), thereby offsetting peak energy demands. Forecasting future usage amounts is difficult, as NYS has no current utility-scale projects and individual customer panels are not accurately tracked. For purposes of Table 3, we have assumed an incremental 1000 mW of installed capacity by 2020, which attempts to take into account both the large potential (5,847 mW) of the technology and the small base (14 mW) currently in place.

2. Energy-Efficiency Technologies

While renewable energy may reduce pollution and other negative externalities, lowering energy consumption serves as the best way to reducing the burden of energy generation.

One of the most comprehensive reports on energy efficiency was completed by consulting firm McKinsey & Company.[xli] This analysis considered numerous variables to arrive at "business as usual" projections for energy consumption in 2020, and potential energy efficiency savings versus that baseline. For purposes of our analysis, we first developed 2020 energy consumption projections for NYS by customer category (residential, commercial, industrial)[3] based upon projected U.S. growth rates. Consumption projections are shown in Table 3 (1.11, 1.35 and 0.37 quadrillion BTUs for residential, commercial, and industrial customers, respectively). Based on these "business as usual" forecasts for 2020, we applied percentage energy savings from the base case estimates of the McKinsey study (28%, 29% and 18% savings for residential, commercial, and industrial customers, respectively).

What follows is a discussion of the various sources of these energy efficiency savings, an explanation of each, and a discussion of potential barriers to implementation. For purposes of this discussion, we will consider several different types of energy efficiency technologies: (a) lighting, (b) HVAC (heating, ventilation, air conditioning) and building envelope, (c) appliances and equipment, and (d) monitoring/controls.

[3] First, we calculated implied U.S. annual growth rates used in the McKinsey study for years 2008 to 2020 by customer category. Second, we compounded these growth rates over the period 2011 to 2010 and applied the resulting growth rates to 2011 NYS energy consumption figures based on EIA data.

A. Lighting

Lighting has evolved from the traditional incandescent bulb, to the compact fluorescent light (CFL), to LED (light emitting diode) lighting. LEDs use ~75% less energy than incandescent bulbs, emit virtually no heat (reducing cooling loads), last up to 25 times longer, are dimmable, and are cool to the touch.[xlii] Lighting accounts for approximately 15% of an average home's electricity use,[xliii] so converting a home entirely from incandescent to LED bulbs could reduce electric bills by over 10%.

Barriers to implementation have included the quality/externalities of early technologies (*e.g.*, LED bulbs offering weak "bluish" light, CFL bulbs containing mercury, etc.), their historically limited range of applications, and high costs. Continuous technological innovation has improved the quality of lighting and range of applications. While absolute cost remains a barrier to more rapid implementation (*e.g.*, LED bulbs cost 10-20x more than incandescent bulbs), the economic benefits are significant (*e.g.*, a LED bulb can last ~25x longer and use only ¼ the power of an incandescent bulb, producing attractive (<5 year) payback periods).

B. HVAC and Building Envelope

Heating, ventilating, and air-conditioning systems (HVAC) account for ~40% of the electricity used in commercial buildings.[xliv] Energy efficiency improvements include not only more efficient heating and cooling systems, but also improving the building "envelope", the structures which regulate heat loss from a building. These improvements come in many forms including insulation (*i.e.*, wall, foundation, or roof) and high-performance windows and doors.[xlv]

All types of customers can reduce energy consumption through undertaking these retrofits. One of the most visible examples of building energy-efficiency is the recent retrofit of the Empire State Building. This retrofit focused on a variety of technologies but many of the benefits were derived from building envelope and HVAC improvements. The Empire State Building project produced $2.4 million and $2.3 million of energy savings in years one and two, respectively, of its operation post-retrofit.[xlvi]

Barriers to implementation include consumer education and upfront cost (notwithstanding energy cost savings). For many large customers, energy may not be a significant component of operating costs, and so attention and capital are often focused elsewhere. Moreover, landlords often have no incentive to improve building efficiency when tenants pay their own energy costs. Financing programs are now available in NYS to address upfront capital requirements, and innovative lease structures may begin to address the "split incentive" issue.

C. Appliances and Equipment

Items that are plugged in that do not constitute lighting or HVAC equipment fall into the category of appliances and equipment. It is difficult to generalize the potential benefits from energy-efficiency appliances and equipment as customer preferences vary over time and are based upon individual circumstances. Nevertheless, there have been positive developments such as the "Energy Star" program that labels specific items that use less energy than similar products. Technology has had a significant impact in many areas (*e.g.*, current energy-efficient refrigerators use 40% less energy than conventional models did in 2001).[xlvii]

The primary barriers to broader adoption of energy-efficient appliances and equipment include technological and efficacy issues, customer preferences and perceptions, and financial barriers. An additional consideration is the "rebound effect": as items become more efficient to operate, customers often operate them more, thereby minimizing aggregate energy savings.

D. Monitoring/Controls

Monitoring and control systems include systems that track energy consumption on a real-time basis or change heating, lighting or other variables in response to environmental changes or occupant circumstances. This also includes simple devices such as programmable thermostats, timers, and electronic power strips that allow devices to be shut off easily and avoid "phantom loads" (*i.e.*, electricity consumed by a device when it is turned off). In the U.S., phantom loads amount to almost 10% of residential electricity consumption.[xlviii]

Most of these measures have failed to generate savings for homeowners as customer preferences tend to override energy saving considerations. Moreover, the failure of many homeowners to properly use devices has remained an issue. Newer technologies designed to be especially user-friendly (*e.g.*, smartphone integration and operation of thermostatic controls and home alarm/security monitoring systems) may improve the rate of successful adoption by homeowners.

For commercial (and especially for industrial) applications, the use of monitoring and control technologies is more established and likely to remain so given the "bottom line" focus of businesses and the relatively greater incentives to control energy costs.

VI. Science Behind the Proposed Solution

Although S.B. 1120 provides many avenues to lessen the environmental impact of energy production, for the purposes of this discussion, we will focus on renewable energy generation of solar and wind energy, focusing on life cycle analyses for each compared to fossil fuels, particularly natural gas. To best provide the most suitable means of energy, NYS will need to offer energy efficiency technologies and the infrastructure necessary for the transmission, distribution, and storage of energy, neither of which will be discussed as such issues are dependent first upon the growth of renewable energy technologies. Rather, the focus will be primary energy generation that will lower energy demands and the environmental consequences associated with each.

As of 2010 in NYS, solar and wind technologies accounted for less than 1% and 1.9% of total energy production, respectively.[xlix] The 2020 estimate of potential for each renewable is 5,847 MW and 7,080 MW, respectively, which will decrease dependence on natural gas production by 47%.[l] As a direct result of this increased production in solar and wind power, greenhouse gas emissions, water usage, and water contamination will decrease. However, depending on the type of solar and wind technologies implemented in NYS, land use, hazardous wastes and aesthetic issues are possible drawbacks. This section will analyze both the positive and negative externalities that would result from solar and wind power technologies in comparison to natural gas.

Of current solar technologies available on the market, solar photovoltaics will be the focus in this discussion due to its capability to be used for large, contiguous solar panels (*e.g.*, Long Island Solar Farm) and small-scale installations (*e.g.*, rooftop solar panels). Similarly, of current wind technologies available, horizontal axis turbines will be the focus due to their comparative ubiquity and efficiency (*e.g.*, Maple Ridge Wind Farm).[li] In order to fully understand the benefits and disadvantages of the proposed renewables, an analysis on the ecological and human health impacts of photovoltaic cells and wind turbines needs to be understood by examining:

(a) Lifetime energy production,

(b) Greenhouse gas emissions,

(c) Associated pollutants, and

(d) Land use and site suitability.

1. Photovoltaics

A. Overview of the Science

Unlike fossil fuel energy sources, solar energy is Earth's most abundant resource. Present technologies allow us to harness this power with photovoltaic (PV) cell technologies, otherwise known as solar cells. As is implied by its name, PV cells capture the sunlight and convert this energy into usable electrical energy.[4]

Silicon-based (multi-Si & mono-Si) cells are presently the most popular source of PV modules and are currently the most widely used solar technology. However, cadmium telluride-based (CdTe) PV cells have seen an increase in popularity over silicon-based cells recently due to their economic efficiency and lower relative environmental impacts. To provide an appropriate assessment of the feasibility of PV technologies in New York, a life cycle analysis of three major commercial PV modules (mono-Si, multi-Si, and CdTe) will be discussed to compare the environmental viability of these energy sources in New York in comparison to some of the state's traditional energy sources, natural gas, coal, and oil. To put the human health and environmental consequences associated with PV systems into perspective, the life cycle analysis will include a discussion of the energy required for the production, manufacture, and installation of each system, in addition to the greenhouse gas emissions produced, and the pollutant and toxic metal emissions generated.

[4] Note: The terms photovoltaic (PV) and solar modules will be used interchangeably in this discussion.

B. Life Cycle Analysis

i. Energy Lifetime of Installed Photovoltaic System:

Researchers calculate the Energy Payback Time (EPBT) of an energy system to help policymakers understand the economic feasibility and time after installation it will take a PV system to "payback" and balance the energy needed to maintain itself during its lifetime. Because the average lifespan of a PV system is approximately 30 years, researchers have determined that the EPBT of a PV system ranges between 6 months to 6 years.[lii] With a short EPBT, photovoltaic systems are found to be a practical investment, producing 15 to 60 times more energy than they use.[liii]

ii. Greenhouse-Gas Emissions:

There are major greenhouse gas pollutants associated with the photovoltaic system production, manufacture, and installation. Some of these emissions include CO_2, nitrogen oxides (NOx), and sulfur dioxide (SO_2) – all of which contribute significantly to global warming, impact air quality, and affect human health. Photovoltaic systems release these pollutants into the environment during the manufacturing and processing stages. However, post-installation, PV systems do not release any greenhouse-gases or particulate pollution throughout the rest of their lifetime of use. Consequently, the installation of PV systems has been found to be less environmentally damaging in comparison to coal, natural gas, and oil, which also emit these gases during both their manufacturing and post-installation life cycles.

Current research within the scientific community has provided projections for percentage reductions of these pollutants in the future. For instance, in a 2012 report provided by the New York State Energy Research and Development Authority (NYSERDA), researchers have determined that if a 5,000 MW capacity PV system was installed in 2013, which would provide enough energy to power 10,000 homes, we would see a respective 4% and 16% reduction in NOx and SO_2 emissions by 2025. Although an apparently small value, this would amount to approximately $121 million savings in health-related medical costs. In fossil fuel savings, this would reduce NY fuel consumption of coal by 7%, natural gas by 4% and oil by 38%. As a result, this would amount to a reduction of carbon dioxide emissions by 47 million tons – an amount equal to removing an average of 250,000 cars off the streets in NY for each of the 12 years considered in this study.[liv]

iii. Pollutant Emissions:

Heavy metal emissions created from the material processing and manufacture of PV modules include cadmium, arsenic, chromium, lead, nickel and mercury,[lv] each of which are highly toxic to humans. Because cadmium is the main component of CdTe cells; whereas all other heavy metal emissions result from the processing of PV modules through conventional energy sources like coal, oil and natural gas, a comparison of the consequences of cadmium cell production will be discussed in detail. All of these heavy metal emissions are also present during the production, manufacturing and operational life cycles of current natural gas, oil and coal power sources in NYS.

Comparing the energy sources of PV cells, coal, natural gas, and oil, the greatest cadmium emissions arise from oil based power generation, approximately 91.5% of the total, with coal following with 6.55%, PV with 1.50%, and natural gas with 0.42%.[lvi]

iv. Land-Use and Site Selection for Lifetime Operation

There are two main locations for PV systems: on the ground and on rooftops. Rooftop PV installations do not take up any significant land mass since they are placed above buildings; however, ground-mounted PV systems do require significant land mass requiring an assessment of PV feasibility on state land. Site selection studies have been conducted and are based on the insolation or amount of solar radiation reaching a given region. A Cornell University based research study concluded that upstate New York would not be suitable to efficiently capture the most power via PV systems.[lvii] As a result, in order for PV systems to be viable for New York, rooftop installations have been found to be appropriate, otherwise deployment of PV systems onto low value lands such as capped landfills or contaminated sites have been proposed. Other low-value alternative sites include buffer zones such as substations, airports, or power plants.

These site proposals offer a reduced land demand, especially in contrast to natural gas wells, which require approximately 3.5 to 5.33 acres per gas well constructed.[lviii] With 6,157 producing gas wells in place in NYS,[lix] natural gas wells cover approximately 22,000 to 33,000 acres of land. As determined by NYSERDA, a 5,000 MW PV site developed in NYS would require 23,000 acres or 0.08% of NYS's total 30 million acres of land, where 0.02% of land or 3,000 to 6000 acres would utilize more highly valued grasslands.[lx] Use of PV systems can lead to up to 30% less land use than natural gas systems currently in place (see Table 4).

2. Wind Turbines

A. Overview of Science

Similar to solar energy, wind power is an abundant resource even using current technologies. Wind power uses the traditional windmill model relying on lift and drag to power the wind turbine. Essentially, as wind moves across a wind turbine's blade, there is a difference in pressure causing the air underneath the blade to move faster producing a drag force and lift, much like a wing of an airplane.

Although modern wind turbines are made in two different styles, as horizontal axis turbines are the most widely used, they will be the main focus of this report. Wind turbines are made in a variety of different heights and sizes dependent upon geographic location. Typically, an increase in height translates into an increase in efficiency and power. Consequently, the analysis of location and coordination of a wind turbine's dimensions are of utmost importance for highest efficiencies and energy outputs. Wind turbines can be built onshore or offshore; offshore turbines are markedly higher in efficiency and power production, usually by an average of 10%.[lxi] Currently in the United States, wind turbines have only been constructed onshore, so for the purposes of this discussion we will only review onshore wind power.

Additionally, a wind turbine's profitability is equally dependent upon its environmental impact, beginning from mining and manufacturing the turbine's parts to the dismantling and recycling of materials upon the end of its functionality. Consequently, in order to provide an appropriate and responsible assessment of wind production in NYS, a life cycle analysis of wind turbines will be discussed in future sections of this paper. The life cycle analysis will include the wind turbines' environmental impact in NYS compared to fossil fuel resources, particularly natural gas, coal, and oil, from cradle-to-grave. The life cycle analysis will highlight the differences seen in greenhouse gases emitted as well as the pollutants generated. The effect of habitat disruption is a concern in site selection and construction of wind farms, but will not be addressed in this discussion as it does not specifically pertain to energy production.

B. Life Cycle Analysis

i. Energy Lifetime of Installed Wind Turbine System:

As stated in the Solar Photovoltaic Cells section, the term Energy Payback Time (EPBT) is used in the following subsection in order to best illustrate the efficiency and economics of wind turbine systems use. The EPBT of most wind turbine's median range lies between 9 months and 2 years for large-scale wind farms.[lxii] EPBT coupled with the lifespan of a wind turbine expresses the turbine's overall efficiency. The average turbine lifespan ranges from 20 to 30 years; but, most researchers agree that 20 years is the typical lifespan of a turbine for conservative calculation purposes.[lxiii] Subsequently, the average mean of EPBT for wind farms is between 19 and 25 times more energy than they use, and with wind turbines increasing in efficiency and size the EPBT of wind power should continue to climb.[lxiv]

ii. Greenhouse Gas Emissions:

The total amount of greenhouse gas emissions produced in a wind turbine's life cycle is the most accurate data set for use in a comparison of this energy source and traditional fossil fuels. According to National Renewable Energy Laboratory's Life Cycle Assessment Harmonization Project study, the average median range of greenhouse gas emissions for wind-powered electricity generation ranges from 3 to 45 g CO_2-eq/kWh,[lxv] with an approximate average of 10 g CO_2-eq/kWh.[lxvi] About 86% of wind power's greenhouse gas emission occurs during upstream processes (*i.e.*, raw materials extraction, module manufacture, and wind turbine and or wind farm construction and installation). Compared to fossil fuel emissions of coal (758.40 g CO_2-eq/kWh) and natural gas (514.8 g CO_2-eq/kWh), wind power produces 75 times less CO_2-eq/kWh than coal, and 50 times less than natural gas. As for SO_2 and NO_X emissions, studies have shown that wind energy can reduce both by 8.0 lbs/kWh SO_2 and 51.0 lbs/kWh NOx, respectively.[lxvii] This is most applicable to New York State considering the predominance of energy produced via natural gas combustion.

iii. Pollutants:

According to the National Renewable Energy Laboratory roughly 86% of total negative externalities from wind turbine production occur during upstream processes. Materials needed to construct the wind turbine are stainless steel, cast iron, copper, epoxy, plastic, fiberglass, and reinforced concrete. 80% of the material from wind turbines can be recycled. Studies have shown that, given a 2MW turbine, 70% of the energy consumed in the creation of a new turbine can be eliminated with the use of remanufactured parts.[lxviii] The only issue that remains regarding disposal concerns the fiberglass and reinforced plastics used. Both materials are currently placed in landfills or incinerated. In the latter case, this produces flue ash, part of the landfill waste, or a portion of it is reused in the making of cement.[lxix]

iv. Land Use and Site Selection for Lifetime Operation:

The efficiency of a single wind turbine or wind farm, such as Maple Ridge Wind Farm in Martinsburg, NY, is the single most crucial aspect in wind power efficiency. Site suitability of potential wind turbines takes into account the wind speed, consistency of wind production, and height of wind turbine towers. Figure 2 below depicts site suitability for wind turbines of 50m in height. We are reviewing 50m turbine heights in order to review best possible locations for wind power generation.

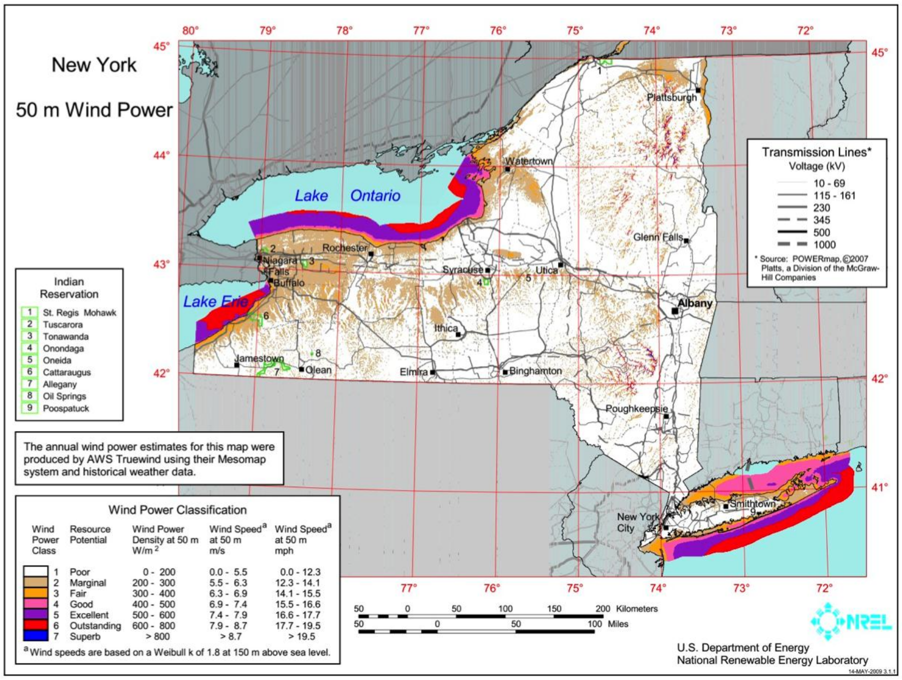

Figure 2. Wind power generated at 50m (height) in New York State[lxx]

Power companies develop site proposals to maximize power potential as well as to lower the disruption of local habitats. Figure 2 illustrates that the highest potential for wind energy generation is found offshore, but as stated earlier, the focus is on onshore wind farms in accord with current NYS protocol. In regards to current onshore wind farms, the average capacity of wind turbines in NYS is roughly 25%.[lxxi] The capacity of wind turbines is necessary in order to properly calculate land use in acres/mWh. Wind needs roughly 0.019 acre/mWh. When compared to natural gas, wind power generation roughly needs 2.5 times more land in order to produce the same amount of energy. However, when reviewing potential sites, NYSERDA and other state agencies attempt to reuse brownfield sites, locations that have been contaminated and are in need of remediation and cleanup. If successful in implementing this strategy, it may lower the amount of acreage needed to produce wind energy generation.

VII. Controversies Behind the Solutions: Land Use Issues

Renewable technologies that exploit the sun, the wind, and geothermal energy are not without some negative related environmental issues. However, most known problems (efficiency issues, intermittency of power generation, heavy metal pollutants, etc.) have foreseeable solutions stemming from technological improvements.

Innovation, however, may not be able to address issues such as increased land requirements. The land requirements of renewable technologies are generally larger than those of conventional energy sources. More land is to be required if renewable energies, namely wind and solar power, are to become major energy sources. NYS has limited land available for such purposing and natural gas requires much less land per unit of energy generation than these energy sources. Since solar and wind technologies don't require high quality soil or particular landscapes, they can occupy places that are currently used for landfills or that have been deserted. However, it is still highly possible that forests, farmland and regions near industries or residential areas will be used to meet a growth in demand for wind and solar power.

Land requirements lead to controversies regarding the development of wind and solar energy due to disagreements regarding whether one kind of land use is more valuable or important than another. The major causes of such controversies are:

a) Different interest groups have conflicting concerns regarding land use, and

b) The impact of renewable power installation on plants and wildlife are not fully understood.

This section measures the potential demand of land by solar and wind power generators assuming NYS plans to adopt them to fulfill 30% of its electricity needs.

1. Measuring Land Demand of Wind and Solar Technologies

According to a report from National Academy of Science (NAS), some renewable energy technologies have heavy land-use requirements. This judgment is based on the impacts on land use by the surface area occupied during the life cycle of these technologies. [lxxii]

According to New York Portfolio Standard, NYS aims to expand the uses of renewable electricity to 30% by 2015[lxxiii] and decrease dependence of natural gas by 47% in 2020.[lxxiv] To fulfill these goals the potential land demand in NYS will be somewhere between 165 km^2 (if all energy needs are fulfilled by solar energy) and 409 km^2 (if all are fulfilled by wind energy) as shown in Table 4. Keeping other variables constant, these land requirements are almost two to four times larger than the amount of land required by natural gas use.

	Natural Gas	Solar	Wind
Land Use (m^2 per MWh/yr)	30	54	136
Projected Energy Generation (MWh/yr)	30% of Electricity Generation in NYS by 2015		
Potential Demand of Land (km^2)	91	165	409

Table 4. Land use assumptions of wind, solar and natural gas in NYS

In order to utilize this amount of land the interest of the original or potential occupants (forests, wild animals, farmers and local residents) must be exchanged for the interests of renewable power generation.

2. Possible Land Options for Renewable Energy Use

A. Agricultural Land

In NYS, 4.3 million acres of land is used for agricultural purposes. According to the U.S. Department of Agriculture, annual output of these croplands is equal to $1997 million.[lxxv] The opportunity cost for replacing this land with renewable energy sources is $2,128/MWh for solar power and $7,664/MWh for wind power. This means, per MWh of renewable electricity generation, using farmland will lose $2,128 to $7,664 of crop output. This results in reduction of not only food supply domestically, but also a reduction in the incomes of local farmers.

B. Forests

In NYS, 18.95 million acres of land area is forest. Forested regions have complex ecosystems with exceptional scenic, recreational, and ecological value and provide a variety of habitats for plants and wildlife. Only 3 million acres of these forests are classified as forest preserves by the New York Department of Environmental Conservation.[lxxvi] Most of other forested regions are classified as “State Forests” which includes reforestation areas meant to provide watershed protection and to offset trends deforestation and restore the land's ability to support vegetation.[lxxvii]

Building large-scale solar plants and wind farms on or near forests will reduce ecological diversity in these regions. This will degrade the stability of habitats as their ability for self-restoration is positively correlated to their ecological complexity.[lxxviii] The quantification of this tradeoff is not studied systematically as the interactions between natural habitats and wildlife are extremely complex. The possible degradation of vegetation in areas disturbed by renewable energy land use may also shrink the natural CO_2 storage capacities of these regions. [lxxix]

C. Residential and Industrial Land

Areas near residential development or industrial sites are favored locations for wind or solar energy plants as they decrease the investment needed for transportation and distribution of energy from the plants to consumers. Among these land types, landfills and other deserted regions cost the least environmentally and economically. However, the occupation of lands close to residential areas will also cause problems because they often involve complicated land ownerships issues, and face opposition from local residents regarding pollution and noise from plant operation and construction.

Quantifiable analysis is not available for this issue as the situations vary in every individual case and are usually layered with emotional and sentimental concerns.

3. Controversies of Land Use and the Measurement of Tradeoffs

In terms of undeveloped land, some areas have higher ecological value than others as they are irreplaceable to certain rare species, or they are necessary for ecological balance (*i.e.*, marshes lands near the coast). Noise pollution from wind farms may disturb wildlife living in marshes and result in the degradation of these ecosystems. Marshes are fragile ecosystems, and it is harder for such ecosystems to recover once destroyed. In this case it may be more important to preserve the ecosystem for the sake of environment rather than replace it with a renewable energy plant.[lxxx]

Large-scale renewable energy plants involving wind turbines and solar panels have many effects on birds, including direct habitat loss or fragmentation, death and injury due to collisions, and disruption of local or migratory transportation routes.[lxxxi] The likelihood of these structures causing significant rates of bird death depends on many factors, such as location in regard to vulnerable species, the surrounding topography, and the nature of the structure itself. The level of bird mortality can also vary greatly, both temporally and spatially, depending on seasonal bird movements, changes in bird behavior, and weather conditions. [lxxxii] Even though bird death is often considered as one of the inevitable tradeoffs of wind power generation, it is actually uncertain whether such effects are significant enough to merit a halt of wind or solar power generation. As admitted by the National Academy of Science (2010): "Research is needed to better understand impacts of renewable power installation development on plants and wildlife and to develop effective methods to mitigate these impacts."[lxxxiii]

When considering urban environments, pollution, noise, and the disruption of scenic views are all factors against power plant development. However, such issues mean more to those living near wind or solar farm sites than people living far from the central operational systems creating a disparity in cost to those benefitting from the power generated.

VIII. Measuring Success

In order to measure the future success of S.B. 1120, we must understand New York's current energy usage in order to know what can be improved. As previously discussed, New York State's primary source of energy is natural gas. Natural gas is considered a "relatively clean" source of energy. This is because, unlike coal and oil, natural gas emits minimal amounts of nitrogen oxides and sulfur dioxides, both of which cause smog and acid rain. Table 5 below summarizes the fossil fuel emissions per type of fossil fuel and pollutant. Because natural gas emits very low levels of nitrogen oxide and sulfur dioxide in relation to coal and oil, the main environmental problem that will be addressed here is the emission of carbon dioxide.

Fossil Fuel Emission Levels - Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Source: EIA - Natural Gas Issues and Trends 1998

Table 5. Fossil fuel emission levels in pounds per billion BTUs of energy input (EIA)

Natural gas is comprised of 90% methane which, when combusted, emits carbon dioxide into the atmosphere. Increases in carbon dioxide and other greenhouse gases into the atmosphere have caused the global temperature to rise 1˚F over the last century, and the warming is expected to continue as our usage of fossil fuels increases.[lxxxiv]

The effects of this temperature increase are visible on a local scale. In New York, the emission of carbon dioxide into the atmosphere due to the state's natural gas consumption leads to environmental and economic consequences. By 2080, sea-level rise along the coast of New York City is estimated to rise from 1 to 3.5 feet, which would result in billions of dollars worth of property losses for the city and state.[lxxxv] Additionally, New York is the fifth largest dairy producer in the country, and an increase in average temperature can cause heat stress on cows and decrease milk yields.[lxxxvi]

1. Quantitative Analysis - Reduced Natural Gas Consumption

Energy efficiency technologies and renewable energy generation are the two major solutions discussed in S.B. 1120. Renewable energy generation possesses huge growing potential and energy efficiency technologies play significant roles in reducing energy consumption in the residential, commercial and industrial sectors.

To quantify how much natural gas will be reduced in 2020 as opposed to 2011, we should first quantify natural gas consumption in 2020. We will project natural gas consumption in 2020 by deducting projected renewable energy generation in 2020 from projected renewable energy generation in 2020. Then by comparing the natural gas consumption in 2020 and natural gas consumption in 2011, we will estimate the reduction in natural gas consumption.

A. Projection of New York State Renewable Energy Generation in 2020

NYS has created a "New York State Renewable Portfolio Standard". In this policy, 30% of NYS energy needs will be derived from renewable energy production by the year 2015. As shown in Table 2, wind and solar energy account for an estimated 0.03 quadrillion BTUs of energy for the state currently. With calculations derived from the NYS plan on reaching its 2020 goal of 30% of its energy consumption coming from renewable sources these renewable energy generation amounts are estimated to double. In 2020, we estimate that wind and solar power will account for 0.06 quadrillion BTUs of energy for NYS (see Table 2). Such increases in renewable energy production will lessen the demand for fossil fuels in NYS, especially the demand for natural gas. As a consequence, this lessened demand will reduce the amount of CO_2 emissions as well.

B. Projection of New York State Natural Gas Consumption in 2020

Natural gas consumption can be predicted by calculating the difference of total energy consumption and renewable energy usage in 2020. As stated above, we have calculated that the total amount of energy to projected to be consumed by NYS in 2020 is 2.06 quadrillion BTUs. The total projections for renewable energy and other energies in NYS is 1.39 quadrillion BTUs, of which wind and solar energy comprise 0.06 quadrillion BTUs. Given these values we can estimate the total consumption of natural gas through a simple equation:

Natural Gas = Total Energy - Renewable Energy (Wind, Solar, Hydro, Biomass) - Other Energy (Nuclear, Coal, etc.)

From our calculations, the total amount of natural gas consumed in 2020 NYS is forecast to be:

= 2.06 quadrillion (Total Energy) - 0.47 quadrillion BTUs (Renewable Energy) - 1.33 quadrillion BTUs (Other Energy)

=0.67 quadrillion BTUs (Natural Gas)

These numbers are shown in Table 6 below.

	Actual 2011	estimated growth		Projected Pro Forma 2020
Wind/solar	**0.03**	99%		**0.06**
Hydro	0.27	2%		0.28
Biomass	0.12	4%	avg. 99% growth	0.13
Nuclear	0.45			0.45
Coal and others	0.48			0.48
Subtotal	1.35			1.39
Natural gas	**1.25**	**-47%**	(b)	**0.67**
Total	2.60			2.06

Table 6. NYS 2011 and 2020 Energy Generation by source (Quadrillion BTUs)

The total amount of energy generated (2.06 quadrillion BTUs) minus all other sources of energy (1.39 quadrillion BTUs) reveals the estimated amount of natural gas consumed in 2020 will be 0.67 quadrillion BTUs (or 47% less than natural gas consumption in 2011).

2. Quantitative Analysis - Reduced CO_2 Emissions

The estimation of natural gas consumption allow for a simple extrapolation of data to show the amount of emissions that are going to be released in 2020. With the reduction in the combustion of natural gas, a reduction in the overall amount of CO_2 produced will follow. One billion BTUs of natural gas produces, on average, 117,000 pounds of CO_2. Since the consumption of natural gas is estimated to be 0.67 quadrillion BTUs in NYS for 2020, it follows that estimated production of CO_2 will be 7.839×10^{10} (670,000 x 117,000) pounds. Comparatively, in 2011 NYS was producing 14.625×10^{10} (1250,000 x 111,700) pounds of CO_2. This comparison shows a reduced NYS carbon footprint with regards to energy as an estimated 6.786×10^{10} pounds of CO_2 will not be released into the atmosphere through the combustion of natural gas, nearly halving the NYS CO_2 footprint in relation to this energy source.

IX. Conclusion/Next Steps

The implementation of S.B. 1120 creates the potential to reduce natural gas consumption in 2020 by 47% versus 2011 levels. This should reduce projected CO_2 emissions by 6.786×10^{10} pounds. This estimate assumes maximum success of the program via swift and broad adoption of renewable generation and energy efficiency measures. Regardless of these assumptions, the potential for reductions in New York's reliance on natural gas and subsequent drops in CO_2 emissions are too great to be ignored. Renewable energy sources and energy efficiency technologies are far less damaging to the environment and have the capability to help New York meet its future energy demands.

Land-use issues associated with these renewable energy sources can be reduced by focusing on previously developed site locations, co-occupation with other land uses, military and government owned sites, and by emphasizing distributed generation technologies to minimize transmission requirements. However, to minimize environmental impacts, renewable power development will need to be restricted regarding areas with sensitive ecosystems or with high cultural or scenic values and communication with the public will prove valuable in the identification of such areas.

The estimated outcomes proposed in this paper are not merely theoretical, but can be achieved with current technologies. However, the widespread adoption of these technologies requires substantial economic support. S.B. 1120 contains the means by which to provide such support and we recommend its passage for the benefit of the current and future residents of the state of New York.

Appendix A. Projection of New York State Energy Consumption in 2020

A comprehensive energy efficiency report from the consulting firm McKinsey & Company will serve the main source of our projection of NYS energy consumption in 2020. This analysis considered numerous variables to conduct "business as usual" projections for energy consumption in 2020, and potential energy efficiency.

We first developed 2020 energy consumption projections for NYS by residential, commercial and industrial sectors based upon projected U.S. natural growth rates. To estimate the natural growth rate, we calculated implied U.S. annual growth rates used in the McKinsey study for the years 2008 to 2020 by consumer category and assumed the annual growth rates to be consistent. By compounding the growth rates over the period from 2011 to 2020 and applying it to 2011 NYS energy consumption figures based on EIA data, we calculated the projected energy consumption in 2020 by consumer category.

U.S. energy use in 2008 was 10,880 trillion BTUs and is projected to be 11,410 trillion BTUs in 2020. Therefore the compounded growth rates from 2011 to 2020 is 4%, as derived from the calculation $(11410/10880)\wedge^{(1/12)}) - 1$. Using the compounded growth rate of the residential sector, we projected the residential energy consumption in 2020, without considering energy efficiency savings, to be 1.11 quadrillion BTUs, which comes from the calculation $1.07*(1+4\%)\wedge^{9}$. The same approach was applied to the commercial and industrial sectors, whose growth rates are 15% and 5% respectively and whose projected energy consumption in 2020, without considering energy efficiency savings, are 1.35 quadrillion BTUs and 0.37 quadrillion BTUs respectively.

When making projections, the McKinsey report takes into account the energy savings through energy efficiency technologies. Thanks to one of the bill's solutions - energy efficiency technologies in fields such as lighting, HVAC (heating, ventilation, air conditioning) and building envelope, appliances/equipment and monitoring/controls, 28%, 29% and 18% energy savings can be achieved for residential, commercial, and industrial sectors, respectively. Therefore, the projected energy consumptions by consumer category are 0.8, 0.96 and 0.3 quadrillion BTUs for residential, commercial and industrial sectors respectively, with the total projected energy consumption in 2020 to be 2.06 quadrillion BTUs.

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