

**S. 1205 The Local Energy Supply and Resiliency
Act of 2013**

**Scientific Analysis of The Local Energy
Supply and Resiliency
Act of 2013**

Columbia University
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Executive Summary

The United States Congress will consider S. 1205, the Local Energy Supply and Resiliency Act of 2013, a legislative approach to reduce energy waste and strengthen energy system resiliency in the United States. This policy framework addresses the inefficiency of the current infrastructure and its environmental impact and proposes several technological solutions. The Act seeks to promote local economic development throughout the country by helping public and private entities assess and implement energy systems that recover and use waste heat and local renewable energy resources. In order for this country's current energy system practices of generation, transmission, and distribution to become more efficient, particularly in the face of increasing vulnerabilities, improvements to infrastructure and development of new and available technologies are necessary.

Two innovative technology solutions currently exist to capture waste heat to be reused for electricity, heating and cooling purposes: combined heat and power (CHP) and smart microgrids, also known as smartgrids. New York City currently boasts one example of successful implementation of these technologies. These two complex systems are often used in conjunction, and the scientific indicators identifying the positive impacts of these technologies are reliable and indisputable. Reducing wasted energy resulting from inefficient infrastructure is at the forefront of a national movement that seeks to promote energy efficiency and the switch to a low-carbon economy. This report will summarize the legislative background of the Local Energy Supply and Resiliency Act of 2013. A thorough analysis of the science associated with waste heat and its recovery

will be explored, followed by an analysis of the technological solutions that the Act recommends and examples of their application. Finally, this report will explore the scientific indicators used to measure the success of the technologies and discuss some of the advantages and disadvantages of the policy and its mandate for technical assistance. This Act is a paramount step towards reducing energy waste and promoting resiliency in the United States through the use of technology that captures and reuses waste heat.

I. Introduction

The Local Energy Supply and Resiliency Act of 2013 was introduced on June 20, 2013 to the 113th Congress of the United States. The proposed bill addresses wide-scale inefficiency and vulnerability of energy systems across the country. Though the waste of excess heat energy from current energy generation methods is typically a local municipal problem, the Act is concerned with national impacts as well as it contributes both directly and indirectly to the larger challenges of air pollution, climate change, dependency on fossil fuels, and inefficient infrastructure. A solution to energy waste is to recover the heat lost in order to reuse it towards the local energy supply that provides electricity, heating, and cooling needs to buildings and industry. The Act identifies combined heat and power (CHP) generating systems, district energy systems, and smartgrids as examples of technologically efficient, resilient, and reliable energy systems.

The mandates contained in the Act are comprised of a technical assistance program and loan guarantee program to aid local entities in deploying these types of technologies to meet their energy requirements. This report takes a deeper look into the science behind the problems associated with wasted energy and the scientific foundations of the solutions for integrated, localized, and reliable energy systems. We provide an analysis of the financial programs, as well as outline scientific measurements for the successful implementation of these technologies.

II. What is Our Current Energy Infrastructure?

The current electrical infrastructure that dominates energy systems across the United States is inefficient. Standard power plants waste energy during generation, transmission and distribution. Up to 36% of heat is lost during energy generation in the form of steam and dispersed into lakes, the atmosphere and other ecosystems; additionally, energy is lost during transmission and distribution, caused by physical resistance between the electric current and wires.¹ Furthermore, energy infrastructure spans widespread over several different regions of the United States, creating inefficiencies attributed to the amount wasted during power delivery. A major grid such as the Western North American grid consists of large interconnected networks with over 1,600 connection points. Due to the long distance that electricity must travel to reach substations or end users, a large amount of energy can be lost.² Furthermore, a malfunction or a system failure may trigger a series of failures across the grid. For instance, the 2003 Northeastern blackout left over 50 million people without power.

Infrastructure Vulnerability

The current energy infrastructure is highly vulnerable to environmental problems and shocks. Cities will become increasingly vulnerable as incidences of more frequent and more intense natural disasters are expected to occur as a result of global climate change. All U.S. Senate Committee on Energy and Natural Resources

¹ "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." How Much Electricity Is Lost in Transmission and Distribution in the United States? US Department of Energy, n.d. Web. 15 July 2014.

² "Research: Microgrids Better than One Massive Grid." *Latest News*. N.d., n. Web. 14 July 2014.

Subcommittee on Energy agree that resilience of energy supplies is an important environmental problem needing to be addressed. The senators also recognize that the lack of energy resiliency becomes more problematic with the increase of irregular weather patterns due to climate change, and the harmful impacts of these challenges will only continue to be exacerbated if not addressed.³

³ U.S. Committee on Energy and Natural Resources. S. HRG. 113-70. Energy Efficiency Bills Hearing, Washington: Government Printing Office, June 25th, 2013.

III. Overview of the Bill

The main purpose of the Local Energy Supply and Resiliency Act is to encourage the development and integration of less wasteful energy systems that recover and reuse waste heat to meet local energy requirements (including electricity, heating and cooling). The Act identifies combined heat and power and smartgrids as the most effective technological solutions. In addition to establishing greater energy efficiency and reliability of infrastructure, the objectives of the Act include the reduction of air pollutants and greenhouse gas emissions, the promotion of local economic development and the strengthening of United States' industrial competitiveness.

The proposed legislation will enable cities, communities, hospitals, universities or other local institutions to apply for loans and grants for the start-up of efficient infrastructure development, from evaluation and design to low-cost financing for construction. The Act tasks the Secretary of Energy with approving applications based on an eligibility criterion--to prioritize projects with the greatest potential for minimizing environmental impact and utilizing local renewable energy supplies.

IV. The Science of the Problem of Waste Heat and Its Impacts

What is Waste Heat?

Waste heat is a byproduct of the natural process of energy conversion. When primary fuels are used for energy or heat production, they are being converted from one form of energy to another. The mechanisms related to the releasing of energy from fuels are held true by the Second Law of Thermodynamics, which dictates that a heat engine can never reach 100% efficiency. Therefore, high energy thermal combustion will always naturally produce a surplus of low-temperature heat that is later discarded to the surrounding environment.⁴ This discarded energy, known as waste heat, is seen in many of our energy infrastructure processes, from transmission and distribution lines to power plants and boilers and represents the inherent inefficiency associated with our current energy infrastructure.

Why is Waste Heat a Problem?

In traditional energy generation processes, waste heat is produced and lost or dissipated to the surrounding environment. In traditional power plants, up to 60% of the energy inputs may be lost in the form of waste heat. This requires that even more fuel be burned to make up for this loss, which contributes to human health issues, climate change, and decreased infrastructure reliability.

⁴ Dincer and Y.A. Cengel. Energy, Entropy and Energy Concepts and Their Roles in Thermal Engineering. *Entropy* 2001, 3, 116-149

Human Health Problems

The loss of waste heat contributes to the problems associated with fossil fuel combustion—in particular, emissions pollution may result in human health issues, including aggravated asthma, acute respiratory symptoms, decreased lung function and even premature death. The health risks are associated with atmospheric contaminants, such as water vapor, carbon dioxide (CO₂), oxygen (O₂), nitrous oxide (NO₂), and sulfur dioxide (SO₂), which are associated with these human health risks.⁵ The fuel used in domestic heating, car combustion, and power plants also produces vast amounts of small particles and droplets known as particulate matter (PM) or particle pollution, which include acids, organic chemicals, metals, and soil or dust particles. The U.S. Environmental Protection Agency (USEPA) states that the potential of disease caused by particulate matter is correlated with the size of particles. A particle with a diameter smaller than 10 micrometers is considered to easily travel through the nose and throat and eventually enter the lungs.⁶ Fine particles (2.5 micrometers in diameter) cause haze and reduce visibility. These particles negatively impact the cardiovascular and respiratory system function.

Contribution to Climate Change

Excess waste heat loss is a small part of the larger problem of the United States' dependency on fossil fuels. Among many detrimental environmental effects, burning fossil fuels contributes to air and water pollution, soil contamination, and climate change. The excessive release of greenhouse gases into the atmosphere as a result of

⁵ D.Wang, A. Bao, W. Kunc, W. Liss. Coal power plant flue gas waste heat and water recovery. *Applied Energy* 91 (2012) 341–348

⁶ USEPA. Particulate matter. <http://www.epa.gov/airquality/particulatematter/>. 18 March 2013.

anthropogenic activities such as fossil fuel combustion is widely acknowledged to be the principal driver of climate change. As higher concentrations of greenhouse gases accumulate in the atmosphere, elevated amounts of infrared radiation that would otherwise be released back into space is absorbed by greenhouse gases and retained in the earth's surface and lower atmosphere, causing a heating effect. In 2010, the National Research Council concluded that "climate change is occurring, is very likely caused by human activities, and poses significant risks for a broad range of human and natural systems."⁷ The Intergovernmental Panel on Climate Change (2013) points out that since the 1950s, the atmosphere and ocean have warmed, sea levels have risen, and atmospheric greenhouse gas concentrations have increased.

⁷ National Research Council. America's Climate Choices. Washington, DC: The National Academies Press, 2011.

V. Science and Technology Solutions

The Act promotes the use of energy efficient technologies that reduce the loss of waste heat. Two solutions are examined in this report: combined heat and power systems and microgrids.

Combined Heat and Power Systems

Combined heat and power, also known as cogeneration, refers to a group of technologies that operate together to generate electricity and useful heat, often close in proximity to the point of consumption. Cogeneration is considered superior to separate generation of heat and electricity--a prevalent practice across the U.S--because of its inherent higher efficiency and the ability to reduce transmission losses. Combined heat and power systems are even more efficient when used in conjunction with district energy technology.

District energy systems are essential for the expansion of combined heat and power systems as they provide the infrastructure for delivering thermal energy to a substantial base of end users. It has been estimated that this application will enable power plants to achieve as much as 80 percent efficiency as compared to the current rate of 40 percent.⁸

A combined heat and power plant may generate electricity and heat from both single and multiple fuel sources. Energy recovery is achieved through a heat waste recovery boiler, where the heat that travels through the boiler heats water and generates steam. The steam then travels through pipes and supplies district heating directly, or

⁸ Office of Fossil Energy. Energy.gov. n.d. 12 August 2014. <http://energy.gov/fe/office-fossil-energy>

more electricity can be produced by a steam turbine.⁹ Figure 1 below shows a prime example of combined heat and energy already in use at the Avedøre CHP station in Copenhagen.

Figure 1: Avedøre Combined Heat and Power Plant

Avedøre CHP in Copenhagen, Denmark:

The Avedøre power station, is located in Copenhagen, is considered one of the world's most energy-efficient combined heat and power plants. It generates 485 MW of electricity for the Nordic power grid, meeting the needs of 800,000 homes. The station also generates 570 MW of district heat for 180,000 houses in the Copenhagen city area. It has replaced three older and less efficient coal-fired power plants.



Source: DONG Energy

Microgrids and Smartgrid Technology

Microgrids are localized and connected energy distribution systems, which are comprised of electricity control, protection, and management systems. Microgrids can remain connected to the main grid or function autonomously to provide local electricity.

⁹ "Understanding Combined Heat and Power, Also Known as Cogeneration." *Combined Heat and Power (CHP) & Cogeneration*. Recycled Energy Development, n.d. Web. 15 July 2014

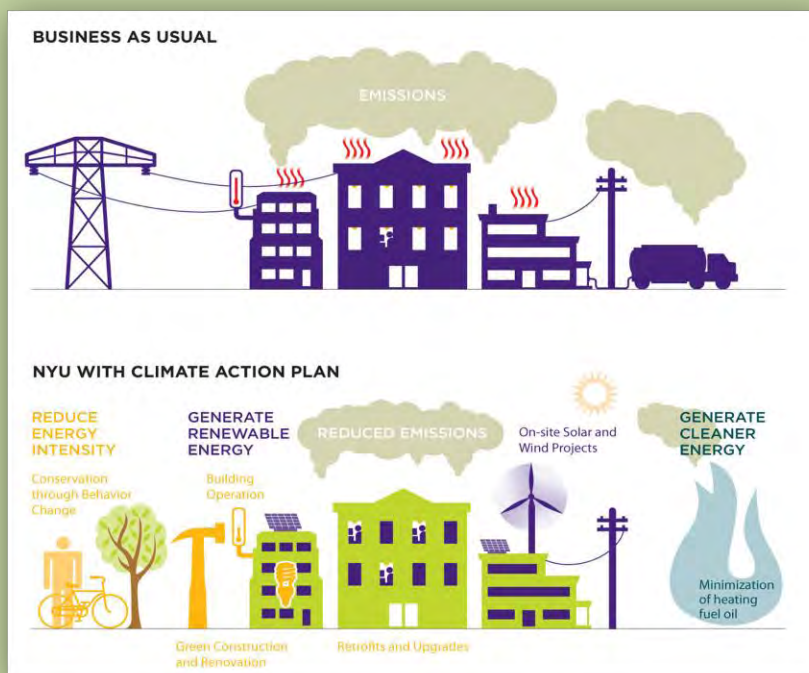
The collection of smaller microgrids covering a large area can lead to higher efficiency as blackouts are contained to one small network without compromising the electricity supply to the entire area. Smaller localized grids also have the potential to minimize energy loss as a result of shorter distribution distances.¹⁰ Microgrid technology is already being used by many organizations in the United States. New York University (NYU) is an example of combined heat and power technology used in conjunction with microgrid technology. During Hurricane Sandy, NYU's interconnected campus remained the only buildings with power south of 42nd street. For a closer look at NYU's district energy system, see Figure 2 below.

¹⁰ "Research: Microgrids Better than One Massive Grid." *Latest News*. N.d., n. Web. 14 July 2014.

Figure 2: NYU District Energy System

New York University's district energy system:

NYU recently made a transition from producing on-site power through oil-fired technology towards a modern natural gas fired combined heat and power facility connected to a microgrid. The system supplies electricity to 22 buildings and heat to 37 buildings across its vast campus. It has two 5.5 MW gas turbines to produce electricity along with steam generators to recover heat. There is also a 2.4 MW steam turbine. The best feature of the system is that it has the ability to work as an island or remain connected to the Con Edison distribution grid.



Source: New York University

Smartgrids are technologically advanced electrical grid systems that will likely become an integral part of our future electricity infrastructure. These systems, rather than simply having an on and off switch to control the flow of energy from suppliers to consumers, have built-in information technology and telecommunication functions that

allow remote control of energy distribution based on real-time consumption patterns that are constantly in flux. Smartgrids are automated systems, reacting to consumer demands and the availability of energy supplies from multiple sources; the objective is to maximize efficiency in energy distribution. For instance, when real-time monitoring indicates that user demand is low in a specific area, less energy will be transmitted to that area, decreasing energy losses during transmission. Smartgrid technology also allows consumers to adjust their energy use relative to current prices of energy (based on generation capacity and sourcing) in real-time for residential, industrial and commercial users.^{11,12}

Smartgrids are decentralized systems and can operate independently from traditional grid infrastructure, with the ability to function continuously without having to draw from a central source. This increases energy resiliency in local areas that are running off of a smartgrid, with the ability to prevent potential blackouts from sudden interruptions in energy supplies (e.g. malfunctions in traditional grid infrastructure, extreme weather events, physical or cyber-attacks). Improved energy reliability will guarantee increased security across many sectors that require a constant energy supply (e.g., banking, traffic systems, and medical centers).

Real-time consumption level data can assist in determining from where energy supplies should be drawn. As shown in Figure 3 below, smartgrids can connect to a diverse portfolio of energy resources, including renewables (e.g. wind, solar, and biomass) as well as traditional fossil fuel burning systems. Forecasting mechanisms are

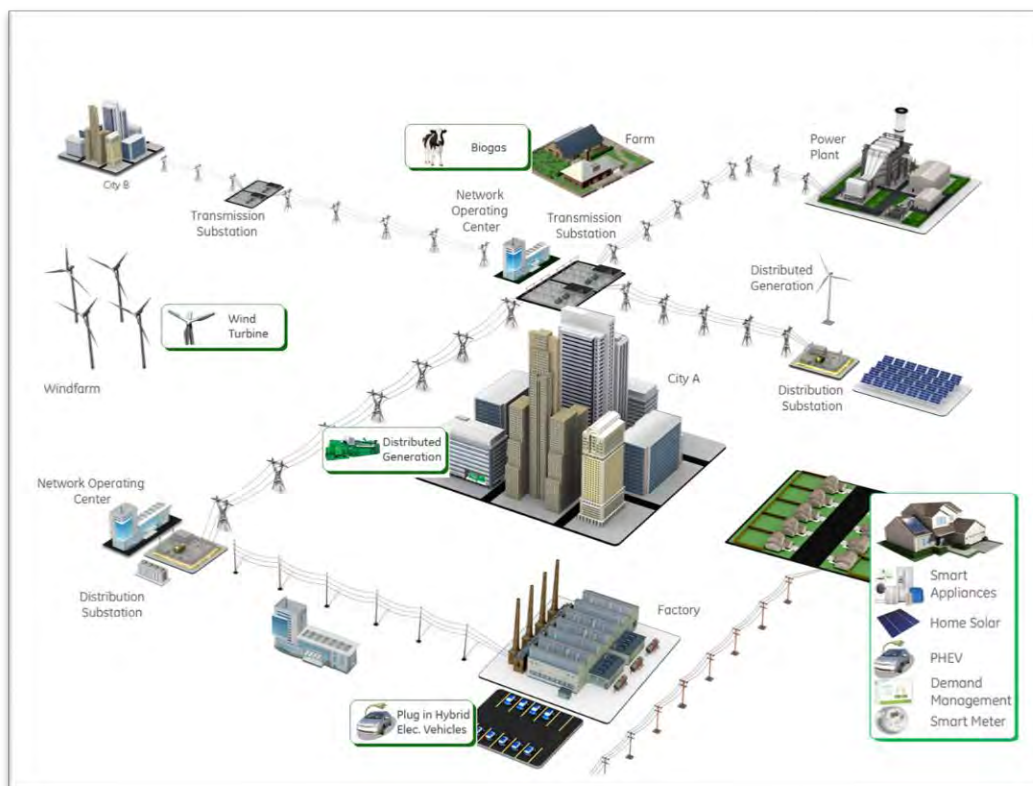
¹¹ "What Is the Smart Grid?" *Smart grid.gov*. US Department of Energy, n.d. Web. 7 July 2014. <https://smartgrid.gov/the_smart_grid>.

¹² "Smart Grid." *Smart Grid*. US Department of Energy, Office of Electricity Delivery and Energy Reliability, n.d. Web. 7 July 2014. <<http://energy.gov/oe/services/technology-development/smart-grid>>.

built into smartgrids to anticipate supply shortages, and storage capabilities can allow coverage for periods of decreased supply (e.g. weakened winds) or supply interruptions.

Aging electrical grid infrastructure will eventually need to be replaced, and there is an opportunity to improve energy resiliency and efficiency in localized areas if the smartgrid technology is widely adopted across American communities. Increasing atmospheric concentrations of greenhouse gases are exacerbating climate change; hence, the shift from fossil fuel energy resources to renewables is an absolute necessity. As smartgrids have the ability to smoothen the fluctuating supply levels from renewable energy resources, implementing these systems can heighten consumer confidence in them.

Figure 3: Diagram of a Potential Smartgrid



Source: Purdue University

VI. The Proposed Policy Solutions

The current approach dominating energy policy is geared towards immediate gain in order to satisfy the increasing energy supply and demand. The formulation of a longer-term strategy for United States' energy systems is crucial for a sustainable future. Local energy systems, as described in this report, are more energy efficient and contribute to this long-term strategy. While these systems can be initially capital intensive, the energy savings will offset the original investment costs over time. To invigorate the investment process, the Act mandates the establishment of a technical and financial assistance program. Technical assistance is provided to facilitate the use of the technologies in local districts. Grants are given for pre-construction costs, and low cost financing is facilitated for construction.

Grants

Technical assistance is provided in this Act for the identification, evaluation, planning and design consultation for installing the new technology and implementing its local use. \$15million will be authorized as planning grants for this purpose from 2014 to 2018. The parameters of the funds allocated are outlined in Table 1 below.

Table 1: Technical Assistance Program Funding Parameters

Percentage Cost Covered	Type of Assistance
100%	Initial assessment to identify opportunities
75%	Feasibility studies to assess infrastructure
60%	Guidance on overcoming barriers to the implementation
45%	Detailed engineering of local energy infrastructure

Low-cost Financing

The bill amends Title XVII of the Energy Policy Act of 2005 to include a \$4 billion loan guarantee program. The loan guarantee program originally gave authority to the Department of Energy to disburse loans for projects that either reduced or avoided air pollutants and greenhouse gases by employing new technologies in place of the original inefficient technologies.¹³ This Act proposes a new section, Sec. 1706, titled “Local Energy Infrastructure Loan Guarantee Program” to be added to the Energy Policy Act to establish loans that will provide for the construction costs of the energy systems. Based on the Federal Credit Reform Act of 1990, all loans are distributed from the government to non-federal borrowers in the form of contracts.

Costs and Benefits of the Legislation

The proposed policy solutions in this Act have both costs and benefits. The Act provides eligible parties with the ability to obtain energy saving technologies at a lower cost. This provides the benefit of greater control over energy production on a local scale. Likewise, combined heat and power, district energy, and smartgrids have low lifecycle costs relative to current energy systems, which provide for economies of scale. Most importantly, the integration of these technologies could lead to reduction of emissions and an aggregation of small renewable energy sources.

The Committee of Energy and Natural Resources recognizes the drawbacks of the Local Energy Supply and Resiliency Act. The allocation of \$15 million dollars as grants is minor, especially relative to the ultimate goal of replacing current functioning energy infrastructure across the country. Moreover, the technology is most suitable in areas

¹³ U.S. Department of Energy – Loan Guarantee Program. Energy.gov. 10 August 2014. <http://energy.gov/savings/us-department-energy-loan-guarantee-program>

with high population densities, due to the fact that urban planning allows for efficient energy transmission and distribution. A dense urban environment such as New York City can apply co-generation technologies more effectively than what is possible in suburban or rural areas. Additionally, combined heat and power systems are still dependent on fossil fuels. Although the system leads to a more efficient use of this energy source and can serve as an important step in a gradual phase-out of fossil fuels, it is important to note that this technology does not offer an alternative to fossil fuel use.

Table 2 below shows the pros and cons of the technologies and provisions emphasized in the bill. While the energy efficient technologies promoted in the bill are undoubtedly positive, there remains several shortcomings.

Table 2: Pros and Cons of S.1205 Local Energy Supply and Resiliency Act Provisions

Pros	Cons
• Greater control over the production of energy consumed by public and private institutions. • Higher economies of scale, when compared to small distributed generators of energy. • Reduction of fossil fuel emissions through improved thermal and electrical efficiency and aggregation of smaller renewable energy sources.	• Allocated amount of \$15 million as grants too small for a nation-wide program. • Suitable for areas with high population densities to achieve efficiency. • Combined Heat and Power systems not a complete alternative to power plants that use fossil fuel.

VII. Scientific and Environmental Measure of the Program's Success

Energy Savings

Because the bill provides for the implementation of energy efficient technologies, a crucial measure of the success of the proposed program is the measurement of the actual amount of energy saved as a result of implementation. The International Performance Measurement and Verification Protocols (IPMVP) were developed by an international coalition led by the U.S. Department of Energy (DOE). These protocols set standards and best practices for evaluating energy efficient technologies, including combined heat and power systems and renewable energy projects, both of which are covered as part of this bill. For combined heat and power systems, measurement and verification determines demand reduction (kW) and energy savings, either in the specific energy process (electric or natural gas) that the CHP system is displacing, in terms of kWh or therms, or in the actual amount of source fuel (MMBtu) that the system is now using less of during generation.¹⁴

Greenhouse Gas Emissions Avoidance

The percentage decrease of greenhouse gas emissions is another factor that will determine the success of the program and its proposed technology solutions. The EPA Emissions Calculator for combined heat and power plants is an Excel spreadsheet provided by the USEPA. This approach utilizes the fuel input (in MMBtus),

¹⁴ NYSERDA Distributed Generation-Combined Heat and Power, *DRAFT Evaluation, Measurement and Verification Plan*. October 2010. Web.
[https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/766a83dce56eca35852576da006d79a7/\\$FILE/NYSERDA_DG-CHP.EvalPlan_10.7.10.pdf](https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/766a83dce56eca35852576da006d79a7/$FILE/NYSERDA_DG-CHP.EvalPlan_10.7.10.pdf)

operating hours, and other factors, and calculates the emissions from the CHP system, the displaced emissions, and measures that total against the displaced grid emissions. The calculator compares the anticipated carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), carbon dioxide equivalent (CO₂e), sulfur dioxide (SO₂), and nitrogen oxide (NO) from a CHP system to those of a separate heat and power system. It also provides an estimation of equivalent cars and homes removed.¹⁵

Energy Resiliency and Reliability

A third important measurement indicator that pertains to this legislation typically applies to the smartgrid application, for which there is not an established set of evaluation protocols. Energy reliability and resiliency hinges upon the reliability and resiliency of the electrical grid. There are many markers that may be used for this. For grid reliability, the System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) measure the frequency and duration of outages, indicating the strength of the power sources. For energy resiliency, the number of energy sources and the percent of demand generated by the different sources must be observed. These factors will give us an indication of how well the grid can adapt between sources in order to avoid outages.¹⁶

¹⁵ CHP Emissions Calculator. United States Environmental Protection Agency (US EPA). Web.
<http://www.epa.gov/chp/basic/calculator.html>

¹⁶ Mansoor, Arshad. Electric Power Research Institute (EPRI). *Framework for the Evaluation of State Smart Grid Pilot Projects*. FERC /NARUC Smart Grid Collaborative Workshop. Presentation. July 2008.
<http://www.narucmeetings.org/Presentations/Framework%20for%20the%20Evaluation.pdf>

Challenges in Measuring Success

The preceding sections outline common measurements and indicators for the outcomes this bill is trying to stimulate. However, it is important to note that these are approximations, and each technology comes with its own set of uncertainties. Moreover, when these technologies are as interconnected as combined heat and power and smartgrids, it is difficult to isolate them for the purpose of measuring effectiveness and efficiency. Lastly, while combined heat and power is already an established technology with widely accepted standards and protocols, smartgrid is still relatively new and untested. Evaluations rely solely on computer modeling and simulations and thus possess a degree of uncertainty.

VIII. Conclusion

The growing demand for energy in today's world is met with an increasing awareness of the environmental harm that it causes. Events such as Hurricane Sandy have revealed the need for greater resiliency of current infrastructure. The rising costs of wasted energy and transmission losses should no longer be ignored, especially when innovative solutions are readily available. The Local Energy Supply and Resiliency Act of 2013 presents an opportunity to shift away from the traditional energy supply model.

There is strong scientific evidence to support how combined heat and power and smartgrid technologies can provide energy needs to buildings, industries and communities. The Act proposes an important step by providing local level assistance for more efficient energy systems. Policy action is needed in order to achieve these goals and to make the smart investment for the future.

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