Chapter 10
Research and Development Needs for a Low-Carbon Future

Introduction

The New York State goal to reduce greenhouse gas (GHG) emissions to 80 percent below 1990 levels by 2050 (80 by 50) may not be achievable in a politically and socially acceptable manner with the suite of energy technologies commercially available today. New York's Climate Action Plan must include a commitment to support research, development, and demonstration (RD&D) in partnership with the federal government and the private sector, to ensure that cost-effective technologies and practices are developed to mitigate climate change impacts and promote the economic strength of local businesses. Statewide RD&D investments, across all economic sectors, must be targeted to provide direct benefits for New York companies.

A long-term RD&D investment strategy is needed to begin the process of improving the local economy and reduce New York's GHG emissions. The two issues are linked and complementary. The subsequent development of this investment strategy represents a critical follow-on task that will build upon the high-level recommendations presented in this chapter and include broad stakeholder input across all economic sectors in New York State. The investment strategy will further define New York's technological strengths, establish multi-disciplinary collaborative teams between universities and industry, and identify all opportunities to further leverage limited in-state resources with federal and private sector funds.

A recent quote from Jeffrey Sachs, director of the Earth Institute at Columbia University, emphasizes the importance of innovation in the energy sector and the need for additional RD&D investment:

> "If we try to restrain greenhouse gas emissions without a fundamentally new set of technologies, we will end up stifling economic growth. We need to develop radically advanced low carbon technologies, which can only come about with greatly increased spending by determined governments on what has so far been an anemic commitment to RD&D."[1]

This Interim Report provides a high-level overview of the RD&D needs within the mitigation sectors, identifies technology areas where New York can best leverage its investments and capabilities to benefit local businesses, and presents "order-of-magnitude" funding estimates necessary to support the innovation ecosystem to advance low-carbon technologies. It is expected that any future state-funded RD&D program established to support the implementation of New York's 80 by 50 goal would be managed by a broad array of public stakeholders throughout the State—with active private sector involvement.

It is important to note that New York State cannot support the entire technology development process (basic research, technology development, large-scale demonstration, commercial adoption) on its own. A clear role must be established for the federal government and the private

[1] New York Times. April 6, 2008

sector that efficiently optimizes limited resources, appropriately assigns technical and business risk, and ensures a consistent and stable flow of investment capital to finance advanced energy technologies. Any State-level investment strategy must function as an advocacy tool to drive national RD&D energy policy and leverage private-sector RD&D investments.

Overarching Principles

Developing a comprehensive RD&D strategy that cost-effectively reduces GHG emissions across all sectors of the economy is a complex task that requires a coordinated effort among all stakeholders. It is essential to recognize that a technology solution implemented in one sector may impact another. For example, if plug-in hybrid electric vehicles (TLU sector) outfitted with vehicle-to-grid capability achieve widespread market penetration, then these mobile electric energy storage systems may obviate the need for larger stationary storage systems (PSD sector) such as flow batteries and flywheels. A systems approach will be necessary that includes technical/business experts across all disciplines and sectors in order to ensure that RD&D investments yield optimized results. A set of seven overarching principles will be used to guide the RD&D program to maximize effectiveness[2]:

- There must be ample and sustained support for early-stage research and exploratory development.
- The research program must be managed to ensure that it encompasses the full range of energy challenges from supply to production to distribution to end-use.
- The research program must span the spectrum from early-stage research to later-stage demonstration, and therefore, there should be an intimate relationship between setting policy and designing programs to stimulate innovation.
- The decision-making process must be integrated so that factors of cost, technical performance, and environmental impact are factored in at every stage of development.
- A multi-year plan must establish a role for governments, industry, universities, and laboratories.
- All later-stage demonstration projects must be carried out on as close to commercial terms as possible in order to provide the private sector with the information it needs to make large investments in new energy technologies.
- There is an opportunity for substantial international participation in selected energy R&D projects, and all energy initiatives must develop technologies that are attractive not only to U.S. companies but to foreign countries and investors as well.

State-level RD&D investments will help New York businesses institute technology development processes consistent with these principles in order to increase the pace of innovation and improve the success rate of commercially viable low-carbon products and services.

[2] The Center for American Progress. *A New Strategy to Spur Energy Innovation*. January 2008. Peter Ogden, John Podesta, and John Duetch.

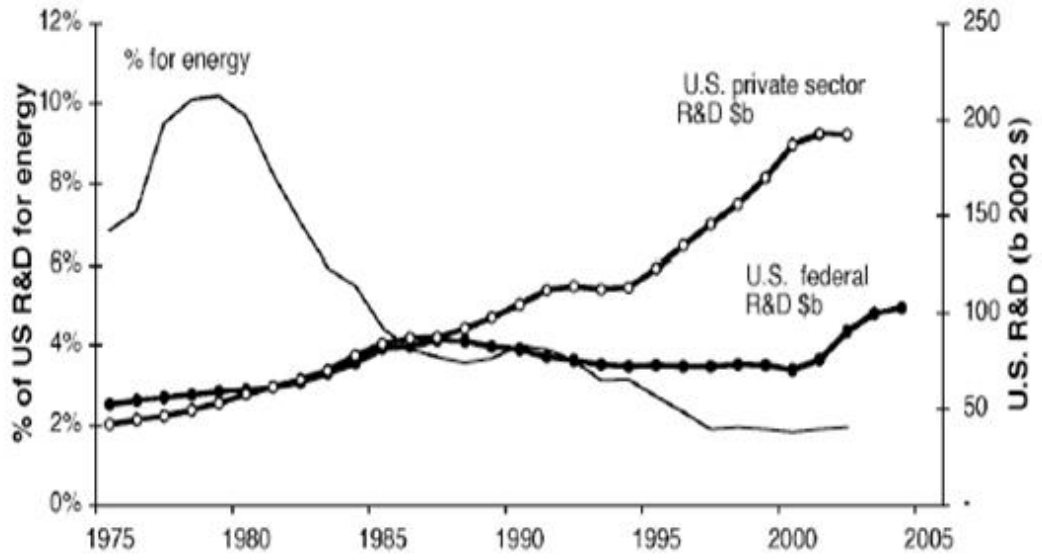
National Energy RD&D Perspective

Past

Energy RD&D funding peaked in 1980 at 10 percent of total U.S. RD&D spending (both private and public) across all sectors of the economy (Figure 10-1). The precipitous reduction in energy RD&D spending after 1980 correlates with the decline in global oil prices following the Iran/Iraq War. Energy RD&D spending leveled off in 1985 to approximately 4 percent of total U.S. RD&D expenditures until the electric power industry was de-regulated in many parts of the country in the mid/late 1990s and oil prices plummeted further to new historic lows. Energy RD&D funding has remained fairly level over the past decade and currently represents less than 2 percent of all U.S. RD&D funding.

It is worth noting that since the establishment of the U.S. Department of Energy (DOE) in 1977, private sector energy RD&D (including large corporations and venture capital) investment has never exceeded public funding levels. This is symptomatic of a fundamental problem and reinforces the notion that 1) existing markets do not provide a sufficient return on investment to warrant adequate private investment in energy RD&D, and 2) substantial benefits accrue to society in general rather than to any specific industry segment or individual corporation.

Figure 10-1. Historical U.S. RD&D Expenditures[3]



Present

Current (fiscal year 2010) annual federal energy RD&D spending is approximately $5 billion, excluding recent one-shot initiatives funded under the American Recovery and Reinvestment Act (ARRA). Corresponding private sector investment in the U.S. is $3 billion annually. This ratio (0.6:1) of private to public energy RD&D expenditures is significantly lower than other

[3] Elsevier: Energy Policy. *U.S. Energy R&D: Declining Investment, Increasing Need, and the Feasibility of Expansion*. February 2006. Greg Nemet and Daniel Kammen

sectors—specifically in comparison to the healthcare and defense industries, which maintain an equivalent ratio of 2:1 and account for the vast majority of public RD&D funding. A comprehensive national energy policy must be established that adequately encourages greater private sector participation. A tangible metric for gauging the success of any given federal policy may be to measure over time whether the private-to-public energy RD&D investment ratio steadily climbs from 0.6:1 to 2:1. Although not a sole diagnostic, monitoring this ratio may yield valuable insights.

U.S. energy companies, on average, spend 0.23% of total revenues on RD&D. This is in stark contrast to other industries that invest on average 2.6% of revenues back into RD&D.[4] Some more innovative industries such as IT and pharmaceutical companies invest closer to 15 percent of their revenues in RD&D. Over the long-term this lack of revenue re-investment undermines the competitive position and innovative rigor of the U.S. energy industry.

What is the appropriate level of federal energy RD&D investment to effectively address climate change? Many research studies have focused on this question over the past decade. A report by Robert Schock[5] presents a unique methodology for determining appropriate energy RD&D levels by calculating its insurance value to mitigate four significant risk factors—oil price shocks, electricity supply disruptions, local air quality, and climate change. Each issue is independently analyzed to reveal separate price points or premiums for the four risk factors. The results suggest that a three to seven-fold increase in federal energy RD&D spending is warranted to insure against the potential impacts of climate change alone. Taking the average (five-fold increase in RD&D funding) of this range translates to an annual federal energy RD&D budget of $25 billion (5 X $5 billion). This level of funding is commensurate with commitments to other grand challenges that the U.S has supported over the years (Apollo Mission, Manhattan Project). New York's portion of these federal funds could be as high as $1.5 to $2.0 billion annually (New York represents 6.5% of U.S. total population).

Federal energy RD&D funds should be directed toward low-carbon initiatives that cannot be adequately addressed by state governments and the private sector. These include high-risk/high-cost areas focused on the development and deployment of nuclear energy systems and carbon capture and sequestration technologies as two primary examples. Additionally, the federal government must continue to support basic scientific research and first-of-a-kind large-scale commercial demonstration projects, which require significant capital investment.

State Energy RD&D Perspective

New York State's annual energy RD&D expenditure is approximately $50 million and this supports a broad array of initiatives across all sectors. These energy RD&D funds are managed by a number of state entities including the investor-owned utilities and have traditionally leveraged an additional $150 million in cost sharing. By comparison, California invests roughly $100 million annually in energy RD&D, also with substantial leveraging.

[4] Institute of Electrical and Electronics Engineers (IEEE). IEEE Spectrum Top 100 R&D Spenders. S&P Data2006.

[5] Annual Review: Energy and Environment. *How Much is Energy R&D Worth as Insurance*? Robert Schock 1999.

New York State recognizes the need to continue support for long-term energy RD&D to create our clean energy economy. The first step in formalizing this commitment occurred when New York established the Regional Greenhouse Gas Initiative (RGGI) and successfully encouraged neighboring states in the northeast to adopt GHG emissions targets for large-scale electric power plants. New York further developed an Operating Plan, which detailed how auction proceeds resulting from the RGGI cap and trade program were to be used to reduce carbon emissions across all economic sectors.

The Operating Plan included a total annual budget of $100 million. Funds were allocated to support both short-term mitigative initiatives and longer-term R,D&D initiatives that reduce carbon dioxide emissions. Total annual long-term RD&D investments amount to $28.5 million and reinforce the fact that a significant portion of the funds must support the continued development of advanced technologies. The RGGI RD&D program targeted the four mitigation sectors (RCI, PSD, TLU, and AFW) plus cross-cutting research.

The targets established under the RGGI program require the electric power sector (PSD) to reduce aggregate GHG emissions by 10 percent by 2018. This pales in comparison to challenges associated with attaining the economy-wide 80 by 50 goal. An order-of-magnitude increase in RD&D funding, beyond that outlined in the RGGI Operating Plan; i.e., closer to $250 million per year, may be necessary in order to achieve New York's more stringent 2050 GHG reduction goal. This level is consistent with preliminary estimates of specific research needs in New York within the four sectors identified below. This estimate will be developed further in the Final Climate Action Plan.

New York RD&D funds would be specifically targeted towards helping local businesses develop low carbon technologies. This level of State funding must be integrated with a comprehensive long-term economic development strategy to diversify New York's economy. Total current annual energy expenditures (across all sectors and all fuels) in New York sum to approximately $80 billion. A $250 million energy RD&D cost therefore represents 0.3% of total statewide energy expenditures. Relevant State agencies and the electric utilities would be responsible for administering these funds in a coordinated manner that specifically builds on the technical capabilities of New York businesses and optimizes all local economic development opportunities.

It is assumed that continued environmental research (including climate change adaptation planning) and business develop initiatives (technology incubators, proof of concept centers, etc.) would be an integral component of each sector's overall RD&D implementation plan. Specific and tangible benchmarks for technological, business, and environmental performance must be considered throughout the entire innovation process—from basic research through commercial adoption.

RD&D Program Implementation

The formation of a statewide RD&D Advisory Council (Council) will be necessary in order to effectively manage expenditures across all sectors in a manner that optimizes collective value. Representatives from each mitigation sector (RCI, TLU, PSD, and AFW) will serve on the Council. The first task will be to define a technology development framework consistent with New York's carbon mitigation abatement curve (the development of this abatement curve is

currently underway). Specific RD&D initiatives will be prioritized and sequenced in an effort to systematically build on previous investments and carbon reductions in the most cost-effective manner.

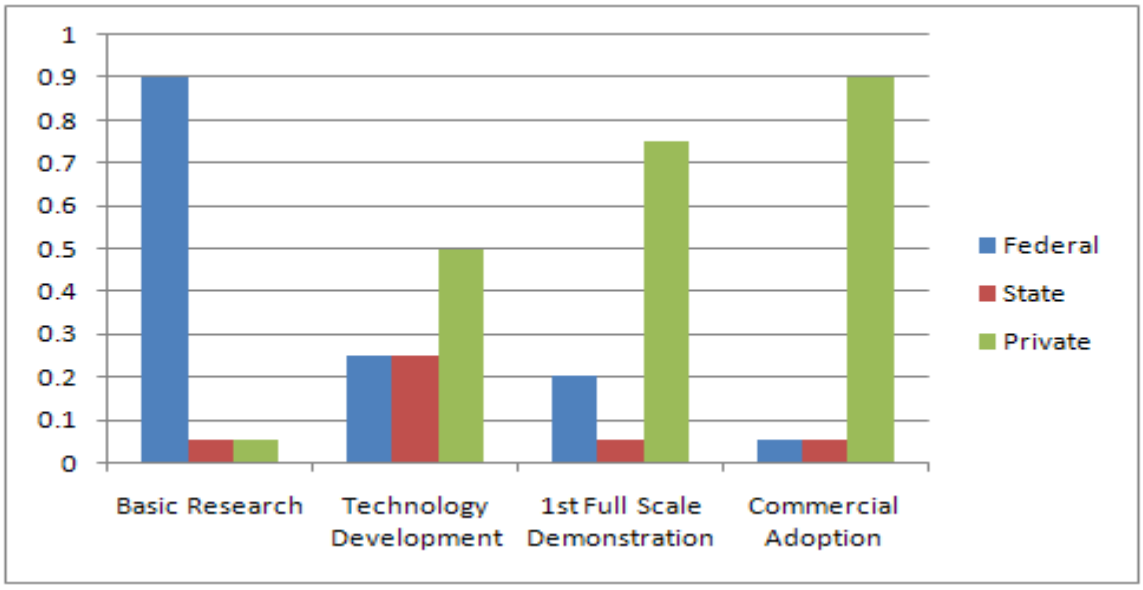
Although the Council will map out a high-level coordinated statewide strategy, the individual sectors will be responsible for establishing multidisciplinary teams (including representatives from industry, academia, government and the investment community) to execute specific carbon reduction projects. Technology, environmental, and business milestones will be established before a project is started in order to provide tangible benchmarks for gauging performance along the way. Projects failing to meet pre-determined targets will be quickly abandoned and RD&D funds will be allocated to other more promising areas within the sector. Federal and private sector financial commitments to support a project throughout the entire innovation process—assuming successful completion of all milestones—will be required before State funds are assigned to the project.

The specific roles of the federal/State governments and the private sector may vary depending on the type of project pursued. However, Figure 10-2 illustrates a reasonable template as to the level of commitment necessary from all three parties (federal, State, and private sector) for the vast majority of initiatives. The technology innovation process is broken down into four steps: basic research, technology development, technology demonstration at scale, and commercial adoption. A more granular breakdown is certainly possible, but these categories are used to simply illustrate a common pattern.

The chart clearly illustrates a waning level of federal funds coupled with a concurrent waxing of private sector investment as the technology moves closer towards commercial adoption. This result is to be expected and is governed by the reduced level of technical and business risk as a given technology matures.

What is less clear from Figure 10-2 is the underlying nature of the State's role within this continuum. This deserves more detailed scrutiny because the role varies substantially from one step to the next. The main objective, however, is to spend the minimum amount necessary in order exploit any/all opportunities for New York businesses that reveal themselves along the way.

Figure 10-2. Apportionment of Funding Levels throughout the Innovation Chain



A brief description of New York State's role in each step follows.

Step 1—Basic Research

State funds are predominantly used to increase the competitive performance of proposals submitted by New York universities and companies to federal agencies seeking very high leveraging, typically more than 10:1. State support can provide significant value and has recently demonstrated successful results yielding five Energy Frontier Research Centers (EFRCs) and a variety of Advanced Research Projects Administration—Energy (ARPA-E) grants in New York through DOE.

Step 2—Technology Development

States can play a critical and potentially game changing role at this point in the innovation process where the so called Valley of Death often presents a virtually insurmountable obstacle. This area requires significant State investment to assist New York companies with a wide array of risk-sharing and technology and business development support. This can then position the company for subsequent private sector investment.

Step 3—Technology Demonstration (Full Scale)

This is a very expensive step (often referred to as the Mountain of Death) and limited State resources cannot be expected to carry the high capital costs associated with large-scale technology demonstrations. The State should participate at a minimum level to gain access to important technical information that may be useful for New York businesses in a strategic position to supply value-added parts/components/services associated with the technology. The State should also begin the development of innovative policies that reinforce, streamline, and accelerate ultimate commercial adoption.

Step 4—Commercial Adoption

The commercial adoption step provides an opportunity for states to exploit potential work force development and training opportunities resulting from widespread technology market penetration. This may at first blush seem outside the realm of RD&D activities, but the initial mobilization of qualified engineers, scientists, technicians, and service personnel can require innovative training methods and catered instruction techniques developed in partnership with a variety of New York academic institutions.

The RD&D program needed to achieve the 80 by 50 GHG reduction goal only works when federal, State, and private-sector organizations collaborate. Risk profiles need to be fully understood and costs equitably allocated to promote innovation. In the long-term, a private to public energy RD&D funding ratio exceeding 2:1 will be necessary to ensure continued development and market introductions of innovative low-carbon technologies. This will take some time to achieve. The adoption of a national climate and energy policy is critical to promoting long-term and sustainable levels of private sector RD&D investment within the energy sector.

Descriptions of the RD&D strategy for each of the four mitigation sectors are provided in the following sections. Adaptation related RD&D needs are presented in Chapter 11.

Residential, Commercial/Institutional, and Industrial (RCI) Sector RD&D Needs

Overview

Buildings account for 40 percent of the state's energy use and a similar percentage of GHG emissions. Emissions associated with buildings and appliances are projected to grow significantly yet according to the Brookhaven National Laboratory[6] net carbon emission from this sector needs to approach zero by mid-century to achieve New York's 80 by 50 target. The industrial sector is a heavy consumer of fossil fuels for process heating in manufacturing, and while this sector can improve its efficiency substantially, this sector will likely account for a sizable portion of the total economy-wide GHG emissions in New York under 80 by 50.

RD&D funds are needed to advance low- and zero-carbon energy technologies in buildings and industry. Research for all building types should focus on more energy-efficient designs for new construction and retrofit technologies for existing facilities, elimination of fossil fuel use, increased use of on-site renewable energy, and human factors that influence operating modes. For the industrial manufacturing sectors, RD&D should focus on new products and processes that reduce the carbon intensity of the industrial sector.

Cost effective and easily implementable advances in energy technologies are needed to raise building performance levels far beyond today's best practices and available technologies. Present best practices and commercially available technologies for residential and non-residential new

[6] BNL; *Envisioning a Low-Carbon 2050 for New York State*; A White Paper submitted to the Climate Action Council. Stokes and Looney. March 2010.

construction energy efficiency programs typically only attempt to achieve 20—30 percent energy savings. Nearly all buildings are subject to financial decisions that favor property market values over reductions in energy costs therefore technologies need to be exceptionally robust in terms of return on investment. Building design, production, and warranty are performed by different entities, as compared to other mass-produced goods, and require substantial external impetus and coordination of RD&D activities to cost effectively achieve the performance necessary for a low carbon economy.

Equally challenging are the efforts to reduce energy use by improving the fabrication methods used by New York manufacturers. Typically manufacturers are reluctant to change their established fabrication methods without clear and significant financial benefits, or without government regulations. It is true that manufacturers are often very interested in reducing the energy content of their product, which will reduce GHG emissions. However, as manufacturers' financial resources are currently stretched so thin that they struggle to remain viable, few manufacturers have the capital to invest in the engineering and equipment resources to research, adopt, and implement emerging processes and products that would reduce GHG emissions.

Additionally, energy-efficiency technology developed in a laboratory may require innovative fabrication methods for its mass production. Such new fabrication methods can require significant financial capital to develop. Without sufficient financial capital, a proven technology's entry into the market may be delayed or prevented because it cannot be produced.

Program Design

The State should support RD&D activities that result in the advancement and commercialization of clean energy and energy efficient products, services, and production methods for buildings and industry. The State should strategically bridge gaps between federally supported basic research and market-driven private interests, avoiding redundancy and inadequacies. The RD&D strategy must be inclusive of near, middle, and long term elements and recognize those aspects of RD&D that are best accomplished at the national, regional, or State level. State RD&D investments in RCI should seek to achieve the following objectives:

- Develop technologies that have the potential to increase energy efficiency and/or reduce GHG emissions of the magnitudes necessary for accomplishment of 80 by 50 goals;
- Prioritize technology goals to increase efficiency, eliminate use of fossil fuels, and promote use of on-site renewable energy sources;
- Prioritize technology development that is relevant to new and existing building stock and industrial capacity in New York State;
- Prioritize high-performance incremental and new technology in the context of near, medium and long term implementation;
- Prioritize technology development according to market-based value propositions;
- Establish concurrent requirements to enable path-to-market; provide support for manufacturing capacity development; increase consumer acceptance and education; and coordinate government policy (codes, standards, regulation, deployment);
- Utilize public, university; and private partnerships where appropriate.

Federal Role

The primary research role of the federal government in RCI is to support basic energy research to advance net zero-energy-use buildings, including development of new materials, new heating and cooling processes, and low-density energy scavenging devices. For the industrial sector, necessary federal efforts should include research for advanced materials, materials processing, and electro-technologies that replace traditional thermal processes. The federal government should also continue to co-fund some near-term research activities (e.g., demonstrations) and medium-term activities located at regional building science and industry application centers.

State Role

Demonstrating advanced building and industry technologies at New York locations to accelerate local adoption and help New York companies gain a strategic advantage is an important role for State government. This research can best be accomplished at a regional level to address the unique building stock, climate conditions, construction practices, and industrial activities at the local level. Demonstration and evaluation of whole building systems will be critical to advancing net zero-energy buildings. As we attempt to ramp up building performance, understanding the human interface will also be critical. The State should also continue to support various building science and industry application consortia in New York and facilitate university and industry collaborations. Examples of successful research collaborations include lighting technologies with the Lighting Research Center at Rensselaer Polytechnic Institute, Building and Energy Systems at Syracuse University, and materials work with the Center for Advanced Material Processing at Clarkson University. Funding research in precision measurement and controls, robotics, and sensors could help New York's industrial sector to reduce its energy footprint.

Private Role

Many smaller and mid-sized corporations will need to participate as partners in demonstration projects for innovative building and industrial technologies to advance. Large corporations, which have the resources and talent pool to make major advances in technology, will need to continue to make substantial investments in energy research (e.g., GE Global Research, IBM, Corning, and Kodak). Utilities will likely need to be more involved in demonstrations of advanced buildings systems, which will increasingly need to have two-way communications and smart-grid interfaces.

Target Areas

The development period to commercialize a new technology and apply an existing one can be long. This delay is often the result of start-up companies lacking the business skills to advance a technology from the R&D phase to the commercialization phase, or of mature companies unaware of potential partnering opportunities. Mechanisms need to be developed to provide start-up companies with executive level mentoring and management advice to help them make the jump between these stages. For buildings, RD&D target areas could include improved building envelopes to reduce heating and cooling loads, down sized mechanical systems that are more efficient, advanced controls for building optimization, and increased plug load efficiency. Projects might also include the use of dual function elements, which provide either power generation or increased energy efficiency in additional to a conventional purpose. Examples include windows with embedded photovoltaic (PV) elements or thin films that generate electricity when sunlight strikes them, or membrane roofing materials with PV films

incorporated in the layers. In both of these cases the PV systems replace conventional building products, reducing the additional overall cost to the developer or owner. Additionally, projects can include innovative design and construction processes that contribute to a carbon-neutral or negative building.

Additional examples of possibly supported building technologies and systems include the following:

- Innovative energy storage systems,
- Building-scale renewables,
- MicroCHP,
- Active power management,
- Smart grid,
- Energy-efficient building envelope technologies,
- Breakthrough light emitting diode lighting products,
- Consumer behavior modification,
- Whole building system design.

Industrial sector RD&D investments could include advanced heating processes, methods that reduce fossil fuel usage for thermal destruction of byproducts, new heat recovery approaches, and novel cost-effective applications of combined heat and power technologies. Additional examples of possibly supported industrial technologies include the following as examples:

- Microwave sintering of ceramics,
- UV curing that eliminates the need for VOCs and energy intensive thermal oxidizers used to destroy them,
- Electron-beam curing of coatings,
- RF and induction heating.

For industry, examples of product improvement projects include:

- Lower energy content of products,
- Reduced scrap and emissions,
- Use of green and organic materials ,
- Increase use of life-cycle assessment based concepts in product designs.

Other Considerations

The time frame to develop a new technology from an initial concept to its final design is frequently five to ten years. Compounding this factor is that the construction industry is very risk adverse, and therefore slow to adopt new technologies. An additional 5 to 10 years frequently passes from when a new technology enters the market to it becoming standard practice in this industry. Similarly, consulting engineering practices that offer process design services to

industrial clients are very risk averse, and therefore slow to recommend new fabrication methods. To have new technology ready to assist in achieving 80 by 50 goals during the 2020 to 2030 timeframe, their development must start now.

The RD&D activities required to achieve the climate change goals need to start as soon as possible so that their benefits can be accrued quickly and avoid unnecessary GHG emissions in the mid- and long-term horizons.

Transportation and Land Use (TLU) Sector RD&D Needs

Overview

Twenty years ago the transportation options such as lithium–ion batteries and fuel cells, which we now believe will play a key role in our ability to meeting our GHG reduction targets, did not exist. These technologies supported by public RD&D investment are just now showing the potential performance needed to achieve the performance and cost targets necessary meet 2030 goals. RD&D in yet additional transportation options over the next several decades will be needed to achieve our 2050 goals. Public policy must provide increased support for research, development and demonstration of technologies, products, and business models that create these new options and accelerate their adoption. RD&D investments within the State and region provide both immediate and long term economic benefits enabling the level of prosperity necessary to fund continued improvements. Public RD&D investment will be needed in: vehicle technology, low carbon fuels and infrastructure, public transit, transportation systems, and demand management technologies and innovations.

It took 15 years from the time of initial development and demonstration for hybrid–electric vehicles to achieve a 4 percent market penetration rate. The products and technologies we have in the market today are not capable of delivering the level of efficiency improvements needed to achieve our GHG reduction goals. Technology development, demonstration, and validation cycles must be accelerated to deliver market introduction of new options that will play pivotal roles in achieving GHG reduction goals.

Creating the clean energy economy will require a multi-faceted approach, including increased use of alternative fuels, significant improvements in the energy efficiency of the vehicle fleet, improving the performance and efficiency of public transit, and reducing trips and vehicle miles traveled (VMT) through changes in travel habits and land management. RD&D investments that support accelerated, validation, and utilization of GHG reduction technologies and approaches are called for in all of these areas.

Program Design

The goal of public investment in transportation RD&D is to develop, demonstrate, and validate new innovative transportation options, stocking the shelves with better products accelerating progress towards meeting GHG reduction targets at lower overall cost. The investment must promote new discoveries that will allow us to achieve our long term goals, demonstration of emerging technologies to validate practicality and benefits, and pilot programs that seed the market and accelerate the introduction of new options. Advancements are needed in all areas, from basic research into new battery chemistries, innovations in public transit technology and performance, new products, and business models that enable electric vehicle charging or on-

demand public transit. As noted above, the RD&D investment strategy must be inclusive of near, mid, and long term elements and recognize those aspects of RD&D that are best accomplished at a national, regional, or State level.

Federal Role

Light-duty vehicles (LDV) are produced on a global scale and it is primarily through influencing vehicle standards that states influence LDV research efforts. In the United States, only the federal government and California are allowed to set vehicle emission standards. New York has elected to adopt California standards. State-funded research can support vehicle components manufactured locally and result in a significant positive contribution to state gross domestic product.

Similarly, Federal support of long-term and high-risk basic research such as fuel cell and new battery chemistries is critical to the technology advancements and cost reduction necessary to achieve 2050 goals. This Federally funded research will generally be done at competitively selected research, academic, and industrial centers. States have an opportunity to influence the choices through their own research investments and support of clusters of organizational expertise in these clean tech growth areas.

The U.S. Department of Transportation (DOT), U.S. Environmental Protection agency (EPA), and DOE all support transportation research through the Transportation Research Board (TRB), as well as programs run through Federal Highway Administration, Federal Transit Administration, Federal Rail Administration, Federal Maritime Administration, and the Federal Aviation Administration. In general the federal programs address issues based on national priorities. New York's transportation system components are unlike the rest of the country. No other state approaches our commuter rail and subway system in terms of passenger trips or physical size, or New York's public transit bus operations, taxi fleets, or commercial delivery truck fleets. Federal research programs often do not fund the research needed to improve components these transportation system components.

Federal parties include: DOE, DOT, National Institute of Standards and Technology (NIST), National Labs, ARPA-E, and TRB.

State, Regional, and Local Roles

State, regional, and locally supported research plays a key role in addressing specific needs not adequately addressed by federal programs. Examples of high-impact State-supported RD&D include the development of heavy-duty hybrid–electric drives for transit busses, and energy storage products designed to capture train braking energy in electrified rail and subway applications. Stat- supported RD&D in these areas has and is developing products that are providing huge energy efficiency benefits to New York and creating jobs for New Yorker's manufacturing products that are being sold to the rest of the country.

State, regional, and local RD&D is also validating the benefits of new technologies and approaches prior to transportation agencies making major commitments. Newly emerged and unproven products and approaches involve risk both technical and financial. Few transportation operations can allocate resources to unproven endeavors. State and local RD&D funding helps minimize the risk associated with testing, demonstrating, and validating new products and ideas

and in disseminating information on the cost and performance of the demonstration to other potential beneficiaries.

Examples of State, regional, and local RD&D efforts that have helped inform public policy decisions include: anti-diesel idling technologies such as fuel fired heaters and hybrid refrigeration systems, traffic light signal controls, high speed commercial vehicle inspection technology, car sharing, and van pool pilot program demonstration. Current projects in short sea shipping, aviation departure optimization, off-peak utilization of subway assets, and commercial goods movement show potential for significant GHG reductions. To achieve our clean economy goals, the rate at which new options such are developed and validated must be accelerated through RD&D programs that select sponsored efforts based on merit, mitigate risk, provide creditable third party evaluation of performance, and disseminate the results via technology transfer programs.

State, regional, local parties include: state DOTs, Metropolitan Transportation Authority, Port Authority of New York and New Jersey (PANYNJ), New York State Energy Research and Development Authority (NYSERDA), regional transit properties, metropolitan planning organizations, New York City Department of Transportation (NYCDOT), municipal governments, academic institutions, private-sector service and product suppliers.

Private Sector Role

State RD&D should promote clusters of technical expertise that develop innovative products and services, create jobs, and produce innovative solutions to New York problems. Helping private firms minimize the technical and financial risk inherent to research activities provides public benefits. Once technical risk or profitability risk is reduced, it is the role of the private sector to complete development and commercialize the advancement.

Public funding alone is not always adequate to entice private investment and sometimes public and private funding must be combined to reduce risk and accelerate development. Examples of such cooperative successes in New York include: support of applied research in fuel cell technology, batteries, and materials research with programs, such as the New York Battery and Energy Storage Consortium (NY-BEST), which has catalyzed a cluster of expertise and attracted outside investment developing next generation energy storage technology; programs supporting developing products for heavy duty vehicle original equipment manufacturers, as well as aftermarket and repower suppliers; improving the efficiency of electrified rail and subway systems; support of intelligent transportation systems, transportation system management, and transportation demand management technology development; and the creation of service providers offering hardware, software, and operation that enable VMT reduction and system level efficiency improvements.

Demonstration and assessment of newly emerged products, services, and approaches is an important role for State and local RD&D and frequently the final step in verifying to the private sector that their continued investment is warranted. In well designed research programs, cost to benefit ratios, and best practices can be determined even in areas where cause and effect can be difficult to assess and benefits difficult to quantify such as eco-driving education programs, some DSM measures and ITS technology. This is what differentiates a research program from financial assistance and deployment incentives.

Implementation

A robustly funded RD&D program would be most effective if it is consistent with a State Transportation Research Master Plan. The RD&D investment strategy should define individual research programs, each focused on a specific segment of the Transportation and Land Use sector. Each program area should be staffed and administered by representatives from governmental units having responsibly in that segment and advised by representatives from universities, industry, government, and private sector stakeholders.

To address New York's pressing transportation challenges, a multi-dimensional program involving NYSERDA, State agencies (New York State Department of Transportation, NYC DOT, and New York State Department of Environmental Conservation), universities, and the private sector is necessary. The program should not supplant the responsibilities of State agencies, but should provide coordination of energy efficiency-sustainability measures, sponsor research and pilot projects that validate benefits, and accelerate the utilization of products, processes and alternative measures. In addition, funds should be utilized to educate, subsidize, and accelerate the early adoption of solutions in both the public and private sectors. Extensive use of the private sector will foster in-state economic and intellectual property development.

As indicated in Table 10-1, the program should support four types of activities in seven focus areas. All program areas would involve analysis/policy studies and education/outreach activities. Several of the program areas would additionally address needed RD&D, transitional strategies, or deployment mechanisms aimed at developing, demonstrating and implementing innovative solutions for the transportation sector.

Table 10-1. TLU RD&D Program Activities

Program Area	Program Activity			
	Policy Studies/ Analysis	Technology Development	Demonstration Verification	Education Outreach
Government Agency Practices	X			X
Public Transit	X	X	X	X
Freight/Commercial	X	X	X	X
Vehicle Efficiency		X	X	X
Transportation Infrastructure	X	X	X	X
Alternative Fuels	X			X
Smart Growth	X		X	X

X= areas of proposed funded activities.

Other Considerations

Each of the Transportation and Land Use policy working groups has established target reductions goals for 2030. These goals will universally require the wide-scale utilization of options that are today unproven or not currently cost effective. Most of these goals such as: 30 percent of vehicle-miles-traveled by zero-carbon vehicles, or 50 percent of all up-state (80 percent downstate) travel by public or shared ride leave open the pathway used to achieve the goal. However, achieving the goal will require a major pathway decision in the near term

(electric vehicle charging infrastructure or fuel cell hydrogen) and significant public investments in infrastructure if these targets are to be achieved. The first goal of public transportation RD&D policy is to invest in research activities in the near term that allow accelerated exploration of emerging options together with field test, demonstrations, and pilot programs for a wide variety of the most promising options thereby allowing the best possible and most timely public policy and investment decisions.

These public RD&D investment decisions should be driven by assessments of risk and benefit. Benefits should consider economic development, mobility, environmental justice, and cost effectiveness as well as potential to meet carbon reduction targets.

In a period of constrained resources it is important that RD&D investments are prioritized and made in the most effective way. Modest investments must be made in long-term higher-risk research into options that will be needed to achieve long term 2050 goals. Accelerated investments must be made in optimizing and evaluating approaches that could meet mid-term goals. Options showing the greatest potential must be demonstrated, piloted, and validated prior to making major investments in approaches that prove to be dead ends or non-competitive.

It generally takes 10 to 15 years after initial introduction for a new technology (microwave oven, cell phone, hybrid vehicle) to have significant market penetration. If we are to achieve 2030 goals the technologies and approaches that will get us there must at a minimum be at a point of initial introduction with public policy commitment by 2015.

Power Supply and Delivery (PSD) Sector RD&D Needs

Overview

Substantial RD&D investments are needed to develop new sources of renewable generation, improve the efficiency/performance of existing renewable and traditional generating options, and develop technology that will enable the efficient and cost-effective delivery of electric energy.

Meeting electric demand in a manner that satisfies climate protection goals will require continued advances in the performance of current renewable and traditional generating resource technologies, the development of new sources of renewable generation including generation utilizing fuels derived from sustainable chemical conversions and the fuels they will require, new technologies associated with the efficient management (storage and regulation) of increased intermittent renewable energy upstream from customers (e.g., large wind) and downstream, at the end use level (e.g., distributed solar), the development of technologies and operating practices for the transmission and distribution system (delivery system) that enable the penetration of these new renewable resources while maintaining system reliability and increasing the efficiency of the delivery system. Finally, electric supply and delivery systems must evolve to accommodate the expectation for electrification of transportation and the resulting impacts on electric use and peak demand.

New York is fortunate to have RD&D assets already in place that can be leveraged with federal and non-New York interests to build an economy upon climate and environmental preservation. These assets are listed below in the section: State Role.

Program Design

This policy would support RD&D and early deployment activities that result in a material increase in the proportion of electric energy used in New York generated by renewable, non-carbon emitting resources and increased capacity of the delivery system to enable their integration and be more efficient at doing so. Such activities include:

- Development of short, medium, and long term technologies;
- Use of private-public partnerships where appropriate;
- Supporting the development and deployment of technologies by facilitating end-use customer engagement in the RD&D and early deployment process and encouragement of early adopters, to mitigate the risk of high cost technology development;
- Supporting the development, testing and verification of control and communication technologies that increase efficiency of the delivery system and enable the integration of renewable, intermittent resources;
- Supporting a continuum of activities from early-stage, scientific assessment through technology demonstration and business development in support of new renewable energy resources;
- Supporting significant improvements in the environmental and efficiency of existing electric generating technologies.

State and federal commitments to early-stage research, technology validation, and demonstration will be critical to enticing increased infusion of private sector capital that will become necessary over the longer-term to take new products to market and to finance the scale of renewable generating projects that are expected to be necessary to achieve ambitious climate preservation goals. Such a commitment will validate the significance and vitality of climate change policies and reduce risks to levels where private capital will become vested in amounts sufficient to meet policy goals. To be effective over the long term, RD&D and early deployment programs must include consideration of the business and environmental case that must be made for adoption and development of technologies, projects, and implementing mechanisms and provide complimentary programs to ensure that businesses that will develop, manufacture, and deploy preferred technologies can be created and operated profitably. Concerns about the impacts of RD&D efforts that rely on expanding existing infrastructure or that involve the deployment of new technologies with uncertain or unknown impacts on public health should also be accounted for.

Federal Role

Marine-based Resources

Offshore marine hydrokinetic energy technology comprises only a few prototype systems today. If New York is to exploit its vast offshore marine-based resources, and wave and ocean current technologies are considered necessary, their development would require a research and development program similar in scale to that enjoyed by onshore wind technology over the last 20 years, and involvement of the DOE and its national laboratories, industry, federal, and State authorities, and academia. The research agenda for such early-stage resource development would include proof-of-concept assessments for conversion devices; lab scale modeling/design;

development of enabling technologies (e.g., moorings, materials); met/ocean characterization and modeling; and full scale in-ocean testing. This would be long-term and involve high risk research so a strong federal commitment would be necessary. The use of such resources for the period of interest (2025–2050) will also require the building of new supplier chains and infrastructure (port facilities/service capabilities) and this must be considered when developing a research agenda. If an ambitious research agenda supported at the federal level for wave and current technology commenced immediately, New York would not likely benefit from this resource until 2030–2035.

Energy production from offshore wind turbines could occur more rapidly (2015-2020) than that from other marine technologies. The American Wind Energy Association Offshore Wind RD&D working group set forth a RD&D agenda that should provide a basis for developing a long-term offshore wind development program for the US and guide decisions on focus and funding that would be of interest in New York. Current industry estimates place the cost for this research agenda at about $600 million over the next 5–7 years. Pending federal legislation would authorize the appropriation of $200 million a year over the 2010–2014 period for research, development, and demonstration activities related to wind energy systems and would direct DOE to establish a research and development program to improve the efficiency of wind turbines, reduce the cost of wind energy systems, and conduct a demonstration program to measure the performance of wind energy systems at locations across the United States. It is assumed that this funding, if authorized, would be administered by DOE and allocated across land and offshore based wind technology and require cost sharing between federal and state governments and the private sector.

Nuclear Energy

The State will have limited influence on research into advancements in nuclear energy generation. The federal government and selected, highly capitalized industries will dominate in terms of any research agenda and investment. The federal government will be responsible for managing the matter of long-term storage, reprocessing, and neutralization of spent fuel.

Fossil Generation

Compared to many other states, fossil generating resources in New York represent a smaller fraction of the electric generation mix. New York should continue supporting a research agenda that focuses on technologies that can be demonstrated to increase efficiency and environmental performance of power plants. New York can partner with the federal government to support the development of carbon capture and sequestration demonstration projects in New York. Investment in this research can be funded through an appropriate mix of State, federal, and other funding sources, while avoiding duplication of effort.

Power Supply Transmission and Distribution Systems

The federal government should be tasked with coordinating the development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems including advanced networking and cyber-security.

Participation on DOE ARPA-E and other research, development, and demonstration initiatives should continue to be evaluated and pursued if such activities can be shown to present

opportunities for learning, customer savings, and business growth that are unique to New York and unlikely to occur through the actions of others.

Examples of federal organizations that would be key stakeholders with the states in any research and development agenda include, but are not limited to DOE (including ARPA-E) and affiliated laboratories, NIST, and the Electric Power Research Institute.

State Role

Marine-Based Resources

The coastal states and federal authorities have initiated processes to collaborate on various aspects of offshore wind project development and to a limited degree, technology development. Affected organizations include the US Offshore Wind Collaborative, Atlantic Offshore Wind Energy Consortium lead by the U.S. Department of the Interior, the Mid-Atlantic Regional Council on the Ocean; and specific to New York, New York State Department of State, NYSERDA, Con Edison Company, Long Island Power Authority, and the New York Power Authority. These organized efforts to address pressing technology and project development is expected to drive the agenda for applied research and development activities for the ocean and off shore environment. New York's share could represent an investment of upwards of $60 million should the costs be shared by coastal states. The research agenda encompasses the following areas: scale up of turbine size and evolution of gearbox and blade designs and materials, development of alternative/deep water/floating foundations, development of facilities for component testing/validation, comprehensive resource characterization/measurement campaigns, aerodynamic flow modeling, codes and standards, deployment and servicing strategy formulation and infrastructure development, avian and marine ecological evaluation, and grid integration.

These same entities could play a role in field testing/demonstration of other marine-based energy production technologies (wave, current, hydrokinetic) that emerge from federally supported efforts. New York's contribution to the evolution of technology, resource characterization, and demonstration/validation could be measured in the tens of millions of dollars—staged over 20 years.

Land-Based Wind

State-funded research with respect to on-shore wind technology should be limited to advanced wind resource forecasting/mapping and turbine condition monitoring and diagnostics, and such efforts in these areas should continue in support of State policy objectives. Increased performance of the existing fleet of turbines should be expected to occur during the next decade (2010–2020) and improvements on the order of 1–2 percent in terms of energy capture are realistic. Such an effort would require a modest investment of several million dollars over the next five years.

Carbon Sequestration

New York may have the geology appropriate for sequestration of carbon, and characterizing and testing this potential for the purposes of sequestering carbon from fossil-fired power plants is an avenue of research that New York can undertake at reasonable cost. New York can partner with the federal government to support the development of carbon capture and sequestration

demonstration projects in New York. A template for a state-specific research initiative would be activities outlined in NYSERDA's initial operating plan under the RGGI program[7].

Solar

Additional research is needed to prepare utilities and other stakeholders for the eventual integration of larger amounts of PV at the distribution voltage level. Analytical tools and models must be developed that establish the value proposition for PV at this voltage level including estimation of the benefits and costs to grid operations associated with deeper penetrations of this technology coupled perhaps with local storage devices. Any research agenda should also include the development of assessment tools and guidance for the integration of PV systems with building energy management systems and infrastructure. In addition, since the large scale deployment of solar has largely been a southwest exercise, the New York/Northeast performance expectations and optimizations will require investigation. Investment for this research could approach several million dollars over the next five years.

Biomass and Sustainable Fuels

Advances in biomass conversion processes (e.g., gasification, direct combustion, pyrolysis) as well as advances in sustainable fuel generation (e.g. water splitting, carbon dioxide reduction, fuel generation catalysis) should continue to be pursued. Equally important are the application of life-cycle assessments of project attributes and fuel/feed stock (e.g., minimization of environmental impact, i.e., carbon neutrality) and feed stock depletion. The question of what will constitute low carbon or carbon neutral application of biomass and other sustainable chemical conversions to create fuels is critical in terms of determining the contribution that biomass and sustainable chemical conversions may make to long-term renewable energy production goals. For biomass to be a material contributor to renewable energy goals, the definition of sustainability with specific regard to carbon must be answered. The question of feed stock availability for power generation (bio-power) was the subject of extensive review/analysis.[8] Any research agenda for biomass should take into consideration the findings contained therein. Investment in this research agenda could approach several million dollars over the next five years.

Power Supply Transmission and Distribution Systems

With respect to improvements in the delivery system to increase its efficiency, enable greater penetration, delivery, and value of renewable energy, New York stakeholders will have a more influential role in research, development, and demonstration. The New York Independent System Operator and utilities (transmission owners) will need to consider how best to deliver energy associated with increasing penetration of intermittent, wind generation (land-based in the coming years; off-shore by the last years of this decade) at both ends of the system. They will do this as they consider making the delivery system more efficient and reliable and as they consider

[7] *Operating Plan for Investments in New York under the CO_2 Budget Trading Program and the CO_2 Allowance Auction Program*, April 16, 2009, pages 41 – 42, http://www.nyserda.org/RGGI/Files/Final%202009-2011%20RGGI%20Operating%20Plan.pdf.

[8] Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply for New York. NYSERDA Report 10-05. April, 2010.

transforming the grid from an electromechanical to digitally controlled system and making the delivery system more intelligent (smart grid). Energy storage will play a key role in enabling smart grid functionality. NY-BEST will serve as a key stakeholder in the development and demonstration of a wide variety of energy storage technologies for stationary power applications.

The New York Public Service Commission (PSC) has instituted a proceeding aimed at establishing a strategic vision and plan for investing in smart grid technology for New York that will guide future research, development, demonstration, and deployment (RDD&D) in New York in support of the policy objectives stated herein. Some potential avenues of RDD&D for consideration are described below.

Research should continue the development of technologies, practices, and programs that promise to improve the efficiency and operation of transmission and distribution systems. Such activities could include the automation of communication and control processes (e.g., deployment and testing of advanced sensors and communication devices) to reduce energy losses and extend equipment life, and would involve demonstrations, testing, and validation to aid in making determinations as to the scale, phasing, and the expected costs of implementation. As the power supply system in New York grows less-carbon intensive over time, the value of electric system efficiency improvements will decline and the research focus shift toward evolving end-use technologies such as electric-vehicle charging and distributed storage that offer the potential for improved grid load shape, asset utilization, and reliability. Research of electric vehicles and batteries, consumer and vehicle load profiling, smart charging and storage technologies at the distribution voltage level, and related consumer metering and billing are expected to be a key components of the RDD&D program over the next 10 years.

State investment in research in support of the Power Supply Transmission and Distribution Systems RDD&D agenda could approach $75 million over the next 5–10 years, excluding investment by electric utilities.

Investor-owned utility systems in New York will become a laboratory for testing/demonstrating various smart grid technologies including distributed resources, grid power vehicles, smart appliances, and storage. Utilities could also invest in research and demonstration of advanced power conditioning and cabling related to the interconnection of off-shore renewable resources. Such RDD&D investment could easily approach $250 million over the next 10 years

Examples of State organizations that would be stakeholders in any research and development agenda include, but are not limited to, Smart Grid Consortium members,[9] the PSC, NYSERDA, New York State Foundation for Science, Technology and Innovation (NYSTAR) Centers of Excellence and Centers of Advanced Technology, New York Academy of Sciences, PANYNJ, State University of New York (SUNY) colleges and universities, and Pace Energy and Climate Center.

[9] Advanced Energy Research and Technology Center, Brookhaven National Laboratory, Central Hudson G&E, City of New York, Clarkson University, Computer Associates, Consolidated Edison (Con Ed), General Electric, IBM, Long Island Power Authority, National Grid, New York Department of Public Service, New York Independent System Operator, New York Power Authority, New York State Business Council, New York State Electric & Gas, New York State Energy Research and Development Authority, New York State Foundation for Science, Technology and Innovation (NYSTAR).

Private-Sector Role

While government is expected to set the agenda for long term societal imperatives, private sector organizations/companies with the involvement of institutions of higher learning, are expected to yield the ideas and innovation that government will look to enable with its funding. Companies will provide valuable engineering and equipment/facilities to test and validate concepts that they and academia collaborate on. State and federal government will partner with these types of entities to buy down or cover risks that these and other private sector participants (e.g., venture capital and infrastructure capital investors) are unable or unwilling to fund. As the menu of options necessary to meet ambitious climate protection goals expands, existing institutions for business incubation will grow in significance and number. Such institutions will continue to provide essential support for business planning and product commercialization.

Private sector organizations located in New York State that would be stakeholders include Smart Grid Consortium members, private universities and colleges, General Electric (e.g., solar, wind, bio-fuels, batteries), IBM (e.g., thin film PV devices, consumer smart appliance controls), AWSTruepower (e.g., meteorological modeling, wind/PV energy modeling and engineering), technology incubators (e.g., Syracuse, SUNY Buffalo and Stony Brook, Rochester Institute of Technology, Polytechnic Institute of New York University), and investors (e.g., Hudson Clean Energy Partners, Environmental Capital Partners, GE Finance).

Agriculture, Forestry, and Waste Management (AFW) Sector RD&D Needs Overview

The agriculture, forestry, and waste management sectors are critical drivers in the economy of New York State. With a long-term investment in research, development, and demonstration, these sectors can also serve as a primary sustainable resource for the production of fuels, chemicals, and products. An integrated portfolio of strategies can be implemented to achieve key carbon reduction initiatives and prepare the state to adapt to changing climates. It is important to acknowledge from the outset that many of the approaches and goals in these sectors are related to each other. Progress in any one area requires concomitant commitments in the other areas.

The research agenda can be categorized into the following broad areas: Reduce the carbon intensity of agricultural and forest management activities and optimize the ability of agriculture and forestry lands to sequester carbon. Develop, demonstrate, and commercialize technologies and processes to convert sustainable resources into fuels, chemicals, and products that will result in an overall reduction in carbon. Support and optimize market participants along the relevant supply chains to ensure that products can efficiently reach the customer. Invest in research activities to continuously develop new crops and cultivation techniques that will supply the conventional customer base and the renewable feedstock customer base as efficiently as possible. Develop and implement adaptation strategies to allow for the continuation of resource supply as environmental conditions change. Maximize urban green space, avoid forest land conversion, and improve the long-term storage of carbon in New York's rural forests. Maximize waste prevention and recovery and utilization of recyclable materials.

Achieving the carbon goals outlined for this sector will require coordination at all levels of government and an alliance among public and private stakeholders, including landowners and research universities to identify strategic research needs, develop partnerships to move the

research forward, and financial mechanisms to provide long-term funding for the research to achieve the state's carbon reduction goals. The federal and State governments have a long history in the agriculture and forestry areas. Academic research institutions (land-grant universities) serve as the foundation of research and training for these sectors. Private landowners will need to make commitments to the goals of the program and commercial businesses will have the primary responsibility to convert sustainable feedstock into fuels, chemicals, and products and establish the supply chain.

Program Design

The recommended program involves the long-term commitment and investment of financial support on the part of all participants. Early in the program, supported activities provide a baseline of information and tools to define, for example, sustainable and best management practices, and appropriate methods to verify performance, for agriculture and forestry; provide insight into biomass resource competition to develop a sustainable feedstock/materials management strategy that first aims to reduce or eliminate waste and divert materials for re-use, recycling and composting; and analyze the waste stream to determine the amount, availability and characteristics of waste biomass and trends in industrial and municipal solid waste generation among rural, suburban, and urban areas. These are core activities that can bring research and market participants up to a common level of knowledge. As outlined below, there are some activities that with both federal and state roles. Also identified below is an activity that is likely to be primarily a state effort.

Federal Role

Federal support is important to finance and facilitate the research programs that address key problems of national, regional, and multi-state importance and to provide the financial support and risk management for large-scale investments prior to private sector commercialization. Research and development topics warranting federal support include:

Sustainable Feedstock Supply

- Research focused on crop breeding and optimization of new and existing bioenergy feedstocks to increase yields and improve the economic viability of these systems;
- Development and improvement the crop management for perennial energy crops;
- Research on the long-term system-wide sustainability of specific existing and emerging bio-energy pathways.;
- Developing models to predict responses of soil and biomass productivity to climate change;
- Examining the balance between carbon sequestration, adaptation, and other ecosystem services such as carbon sequestration, wildlife habitat conservation, or water quality protection.

GHG Management

- Improving quantitative models of carbon, nitrogen, and water cycles in bioenergy feedstock production systems to predict productivity and environmental outcomes from field to landscape scales;

- Investigating landscape ecology at regional scales to understand the relationships among diverse processes;
- Determining approaches that will cost-effectively allow private landowners with relatively small parcels of forest land to harvest biomass in a way that is conducive to carbon sequestration and the long-term productivity and health of their woodlots;
- Continued research focused on improving cradle to grave efficiencies (increasing yields, improving conversion technologies, understanding and improving sustainability criteria) will impact the rate at which biomass production occurs.

Feedstock Conversion and Business Risk Management

- A long-term commitment of public (primarily federal) sector funding will be necessary to partner with industrial funding to support the development of new technologies and the realization of the lessons learned from market experience. Research will be conducted in both academic and private laboratories. The importance of a long-term commitment to research cannot be overemphasized. After the initial research stage, new products will need to move through a demonstration and market assessment stage of development. The relative level of investment to move a new product or process towards commercialization will tend to increase at this stage.
- When the technology is ready to be developed at a commercial-scale, public support could be in the form of low-cost financing or other innovative mechanisms to reduce the technical uncertainty of the new technology to the private investment community. Building commercial-scale manufacturing/conversion process systems for new technologies is a risky venture. Innovative risk-sharing programs can be implemented to share the technical and market uncertainty and promote private-sector investment.

State Role

States will take the lead in areas where the benefits are easier to define at the state or local level and the majority of the program participants are in the state. For projects along the research – commercialization continuum, State support will primarily focus on supply chain and market transformation issues. The State should also lead the effort to design and implement tools to manage integrated programs, evaluate, and assess progress towards goals and to provide overall program integration and coordination.

Baseline Date/Resource Inventory and Tools

- Ongoing assessment of measurements of state-wide, sustainable resource availability;
- Support the development of a comprehensive inter-agency database to store baseline and monitoring data on land and forest management and the condition of the state's agricultural and forest land resources.;
- Develop and implement a system for identifying recently unmanaged or neglected/degraded forest stands that are under stocked by 2015. By 2025, identify and treat, using necessary and appropriate methods, 25 percent of all appropriate (i.e., poletimber and sawtimber size classes) timberland acres.

- Develop and implement critical survey, monitoring, and mitigation methods for potential and existing forest pests;
- Develop and implement programs that alter traditional cultural and commercial conventions that have proved to spread destructive pests;
- Develop and implement a system for identifying owners of vacant idle land that is unsuitable for agriculture but suitable for reforestation by 2015. By 2025, identify and reforest 50 percent of all suitable vacant idle land.
- Currently New York-specific data quantifying Food Miles Traveled and the resulting benefits has not been thoroughly studied. Additionally, it needs to be recognized that food mile reductions must be assessed on a product-by-product basis that includes life-cycle analyses of the numerous crop specific inputs and concomitant production methods.
- Establish benchmark sites, suitable for measurement of soil carbon and other parameters; integration of remote sensing data and application of new technologies for more rapid less expensive measurement of carbon stocks and GHG fluxes; and improvements in forecasting future agricultural GHG emissions and sinks;
- State-level monitoring to document trends and predict forest composition changes; research to focus on identifying tree species that will be suitable for the anticipated changes in climate.

Business Risk Management

- Develop targeted programs to share the risk of new business development. This includes business models for biomass feedstock production, infrastructure requirements, employment options, and possible public awareness concerns in order to overcome misperceptions and barriers to the use of biomass.
- Conduct research on strategies to connect consumers with farmers who direct market their products (i.e. farmers' markets) that will work in rural, suburban, and urban communities and with a broad base of consumers within each community. Such strategies may include various means of transportation, outreach, and incentive programs.
- Support initiatives that add both economic and nutritional value to New York State agricultural products through the development of new products (such as sauces, jams, juices, etc.). This includes processing and packaging initiatives that help make fresh foods more accessible and convenient. Recognize that minimally processed products often preserve optimal nutritional benefit.

Stakeholder Coordination

- Support the development of a system for State agencies and State-owned facilities that purchase food and food products to identify the percentage of locally produced agricultural products purchased throughout the fiscal year; and track and report locally produced agricultural products purchased on an annual basis.

Sustainable Feedstock Supply

- Support sustainable production strategies and research that help farmers remain competitive and viable such as organic, integrated pest management; season extension technologies, and nutrient management programs. Sustainable production strategies are consistent with adaptation strategies.
- Develop and support prevention, early detection, and rapid response programs that seek to prevent the introduction of exotic and invasive forest pests and mitigate/eradicate the impacts of current or future introductions. In addition, develop and support programs that reduce the potential for and severity of wildfire.
- Develop forest management plans, methods, and technologies that increase overall forest productivity and benefits on all forests identified as timberland, and that increase the rate of carbon sequestration in forest biomass and soils and in harvested wood products.
- Data on key management practices (e.g., tillage, fertilization, and grazing) could assist in the design of policies to maximize the role of agricultural in mitigating climate change.

Private-Sector Role

As a land-based policy, the private landowner community is an integral partner in the success of strategies in the agriculture, forestry, and waste management sectors. Landowners will need to be involved in every component of the program. In the case of product development, beyond the point of commercial-scale manufacturing, private-sector support will be the primary mechanism to build and operate conversion facilities and to move products along the supply chain. Public (both federal and State) support will be necessary to reduce risk and uncertainty to a level that private-sector investment can take over.

Other Considerations

Achieving the research, development, and commercialization goals outlined in the section will require the commitment of a diverse set of stakeholders and the application of a portfolio of financial strategies. It will be incumbent upon the State sector to facility the coordination of the stakeholders.