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August 13, 2015
CEF Case No. 14-M-0094

Public Service Commission
New York Energy Research and Development Authority
Comments on the Clean Energy Fund Supplemental Filing
Submitted by the College of Agriculture and Life Sciences, Cornell University

To whom it may concern;

Thank you for providing the opportunity for interested stakeholders to comment on the supplemental filing of the Clean Energy Fund proposal, which will serve to implement the "Reforming the Energy Vision" in New York State.

The College of Agriculture and Life Sciences (CALS) is part of New York's Land Grant Cornell University, recently ranked by U.S. News and World Report as the #1 University in the world for the study of plant and animal sciences. CALS, together with the College of Human Ecology, also serves as the statewide administrator of the Cornell Cooperative Extension (CCE) system, with a responsibility of extending research based knowledge within the county communities in which the local offices are based. CALS is most broadly known in New York for our faculty and extension excellence in farm and food systems, however, the College is also home to a robust life sciences faculty with expertise in everything from anaerobic digesters (farm, commercial, and municipal), biomass and biofuel, and renewable energy technology.

These comments are meant to be helpful to NYSERDA and the PSC and reflect the range of policy expertise contained within the College, based on our faculty and extension experts' fields of knowledge.

General comments

Faculty and extension staff have long expressed both appreciation to NYSERDA for funding significant research and extension work within the farm and energy sector as well as frustration with the rather limited constraints of tailoring a desired research area strictly to an inflexible NYSERDA PON. While not certain of the envisioned RFP process in the future, CALS welcomes the greater flexibility given to NYSERDA in helping the research and extension community address evolving challenges. Such flexibility will allow

researchers and extension educators to use their ingenuity which, overall, has a proven track record of success as evidenced by the impacts to society that CALS has achieved.

CALS appreciates the commitment within the CEF to real time energy monitoring systems. Cornell University has recently built a dashboard which provides real time energy monitoring and usage (http://buildingdashboard.net/cornell/#/cornell) which we expect to grow in usage and help our broader campus community understand the real world impact of conserving electricity usage.

While CALS agrees with NYSERDA's overall focus on commercial buildings and real estate as great opportunities for energy efficiency improvements, CALS respectfully suggests that NYSERDA give greater thought (or clarify) whether or not institutions such as colleges and universities, hospitals and schools, are included within the commercial category for available incentives. Institutions face particular challenges with largely transient populations and unique peak energy demands. Certainly, with NYSERDA and the PSC close to implementing the REV campus challenge, there is recognition of the value of colleges and universities as role models in educating the next generation about appropriate sustainability measures. CALS would respectfully suggest some clarification or consideration be given to ensure that "commercial" programs are also developed to assist institutions in meeting REV goals.

As an institution of higher education, CALS appreciates NYSERDA's continued recognition on the value of workforce training. CALS conducts workforce training in a variety of ways, from our students in bachelor's and graduate programs (graduate students as the next energy innovation researchers should also be considered in the rubric of workforce training) to our partnerships with industry and community colleges for short courses and other programs. Creating a clean energy workforce through re-training existing workers and ensuring a robust pool of qualified employees will be critical to the future transition of a market driven clean energy economy.

Agriculture

CALS is quite pleased with the specific iteration in the CEF of a policy directed towards assisting the agriculture sector in reducing GHG emissions and greater adoption of energy efficient practices. CALS works with the farm community in various capacities, and appreciates the inclusion of faculty and extension expertise in the emerging work on the Clean Energy Fund for Agriculture Task Force. Additionally, CALS faculty and extension staff see the same barriers identified by NYSERDA as impediments to greater on-farm adoption of best management practices and energy generation and efficiency technologies.

CALS agrees that an on-line platform or tool kit would greatly assist the farm community in assessing opportunities within GHG mitigation and reduction and energy efficiency. Many CALS programs for growers are moving in the direction of on-line, web based service delivery platforms (see http://newa.cornell.edu/) and pest and pathogen web based forecasting models are utilized heavily by the grower community. Cornell's Institute for Climate Change in Agriculture is developing an on-line platform,

climatesmartfarming.org that will contain web-based tools for farmers to have the latest adaptation information at their fingertips. The first tools will shortly be on-line, and CALS plans are to continue to expand the site with the development of more robust and sophisticated tools for farmers.

CALS would submit that such tools are best developed utilizing the latest scientific and research based information, coupled with a strong extension effort. CALS sees no reason why the development of farm best management practices towards energy efficiency and greenhouse gas emissions reduction would not be successful in the broader agricultural community and agrees with NYSERDA's CEF plans in this arena.

Controlled Environment Agriculture is an area of great potential in New York State. CALS notes the inclusion of controlled environment agriculture as a specific area of focus, but is concerned that the appendix to the CEF details a timeline for work commencement in this area in the year 2018. CALS would strongly suggest that the timeline for work commence with the inception of the CEF in 2016.

It is clear to CALS that the opportunity for New York to be a leader in energy efficiency technology in greenhouses exists now. New York has the required water resources, agricultural land, and proximity to urban populations needed to capitalize on the market opportunity for fresh year-round, local produce. All of the leading climate change predictions by both Cornell University faculty and other nationally recognized academics show that New York will continue to have ample supplies of clean, fresh water, which is not the case in locations such as the California's San Joaquin Valley which is currently the single largest geographic producer of agricultural products in the United States. Given scarce water resources in the largest agricultural region, there is an anticipated shift in where food will be grown in the United States. This creates a market opportunity for New York and one that, in the interests of broader food security needs, the associated agricultural and research community should be preparing for energy efficient growth immediately.

CALS already houses many of the resources to pull together an effective and efficient controlled environment agriculture initiative in New York, from our faculty researchers to our extension staff who work in this area already. Extension expertise and business planning expertise already exist within Cornell [1] in the areas of business planning, high tunnel and controlled environment agriculture extension and efficiency research programs. However, the missing gap is a synergistic approach to research needed to both reduce energy costs of LED lighting in greenhouses with an eye towards fully utilizing the available light spectrums to boost plant yield and growth. Research breakthroughs that will help farmers grow consistent annual crops, increase the competitive advantage of a CEA system, and reduce the overall carbon footprint would fundamentally change the profitability and sustainability dynamic for farms of all scales in New York (see attachment A).

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[1] http://cvp.cce.cornell.edu/greenhouse_tunnels.php; http://www.cornellcea.com/; http://www.nyfarmnet.org/; http://smallfarms.cornell.edu/

CALS is intrigued with the concept of Technology Advancement Pilots. If CALS is correct, these types of pilots could be designed to synergize multiple energy efficient technologies (i.e. co-location of a farm AD system and a controlled environment agriculture operation to optimize efficiencies, a topic of recent study by the Cornell PRO-DAIRY program). CALS would suggest that utilizing the CALS, CCE and SUNY system research and teaching farms might be ideal locations to pilot various projects, as the risk to the farmer will not be undertaken in the adoption of a new system. While CALS conducts field research trials both at privately owned farms and within our own research farm environment, it is clear that for truly innovative and risky projects utilizing a college or University farm avoids undo financial risks for the farmer.

CALS understands the competing need to ensure adequate time for transition to a more market based approach by NYSERDA in funding incentives, as well as the greater need to refine incentive programs that may not have been as successful in securing market based adoption in agriculture. CALS agrees that it is wise to continue successful programs like the popular farm energy audits for the farm community until more robust and deployable web-based tools are developed. However, CALS also suggests that the ability to transition will be limited by the phased in approach designed by NYSERDA. As the transition period is observed (for instance, in farm AD incentive programs until 2017, as identified in CEF 6.9.2) without a simultaneous effort to conduct the type of needed work in the farm AD system (see attachment B) once the transition period is complete the market based adoption which is the end goal will not occur. CALS is not certain what NYSERDA would view as a work-around solution to this dilemma, but does note that the transition time will not come without a costly delay in finding creative market-based approaches to clean energy adoption in agriculture without greater flexibility in timing deadlines than appears to exist now within the phased in approach.

Following the currently inflexible PON incentive based process for a two year transition period will, respectfully, not yield the type of practical, research based and repeatable or standardized systems that could then be utilized in 2017 and 2018 by the farm community.

As the Department of Environmental Conservation discusses the policy implications of potentially establishing a ban on the disposal of organic matter within landfills for greater GHG emissions reductions, the timing would appear to be right for a major investment in the farm community in AD technology to assist in meeting a market driven need for food manufacturers, retailers, etc., to find a more environmentally sustainable and economic approach for organic waste. Without a more accelerated approach to finally determining the barriers to farm AD systems, information will not be greatly available to the farm community when and if such a demand occurs, making a research investment in several pilot projects now a more feasible approach than simply waiting until after 2017.

Cornell Cooperative Extension

CALS is pleased with NYSERDA's recognition of the great value of the land grant mission, extended to the local communities through our Cornell Cooperative Extension partners. While CCE does excellent work in agriculture, it should be noted that CCE plays a substantial role in working directly with the Low to Moderate Income (LMI)

community. In fact, in many areas of the state CCE is the contracted entity with the state and federal governments to provide nutrition education and assistance to SNAP recipients, as well as general outreach and education efforts to the LMI community. CCE has also appreciated the opportunity to work extensively with NYSERDA in conducting community based energy efficiency workshops. CALS seeks clarification to ensure that CCE is considered within that rubric of community organization as a potential eligible applicant. Conducting community forums and educational and training events is a specialty of CCE, as staff are embedded within the community in which they live, as well as responsive to other local organizations and governments making CCE staff uniquely qualified for community engagement.

Innovation and Research

CALS acknowledges the great importance of energy-related environmental research, and looks forward to partnering with NYSERDA in a variety of ways with faculty engaged in climate change research with a particular focus on agriculture, and extension as well as other sustainable energy research.

CALS seeks further clarification in how NYSERDA will propose to handle RFP's (former PON's) and basic energy research. It is clear to our faculty that in order to stay on the leading edge of innovation of clean tech in New York the flexibility envisioned by NYSERDA in a newly revamped investment approach will be helpful. On the other hand, it is not clear to CALS what NYSERDA's vision is for the future role of research universities within this critical portion of the CEF. NYSERDA specifically recognizes within the Innovation Capacity and Business Development sector the fact that New York is third in the nation in university research expenditures in this sector, and CALS along with many other faculty at Cornell University have been helpful in achieving the state's high ranking of successful competitions for federal research dollars. However, with overall federal investment in all areas of research declining over the past decade, it's clear to CALS that the importance of NYSERDA funding for energy related research and innovation is paramount.

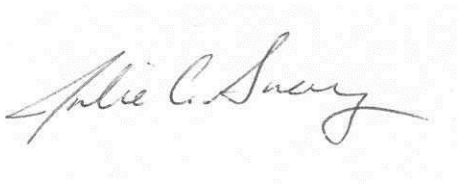
NYSERDA justifiably gives great weight to research into product innovation in the clean tech sector, but it is not clear to CALS what emphasis NYSERDA will continue to place on needed funding for research universities in order to drive the type of overall energy innovation that will continue to keep New York a leader in this field. In order for NYSERDA to help New York meet the ambitious and laudable goals for GHG emissions reduction, it is absolutely critical that NYSERDA continue to be a key partner with Cornell and other leading research university's in New York for research and development so that together, these goals can be achieved.

CALS believes strongly in the value of research conducted by universities, sometimes in partnership with the private sector, as such research is generally replicable, validated, and peer reviewed. Research university conducted results are also available in the public domain for further usage and adoption. Clarification as to NYSERDA's views on the role of research institutions in continued competitive responses for energy innovation research would be greatly appreciated. While CALS is engaged in many public-private

partnerships, matching requirements for research funding can be challenging to secure for the type of ground-breaking work done by many of our most innovative faculty members.

In conclusion, CALS appreciates the tremendous work and thought by NYSERDA and the PSC in both envisioning a truly transformative approach and ambitious goal for New York to undertake over the next few decades as embodied in the REV proceedings, and looks forward to continuing to partner with the state of New York as the Land Grant University in the years to come under a successful CEF process.

Sincerely,



Julie C. Suarez, Assistant Dean
College of Agriculture and Life Sciences

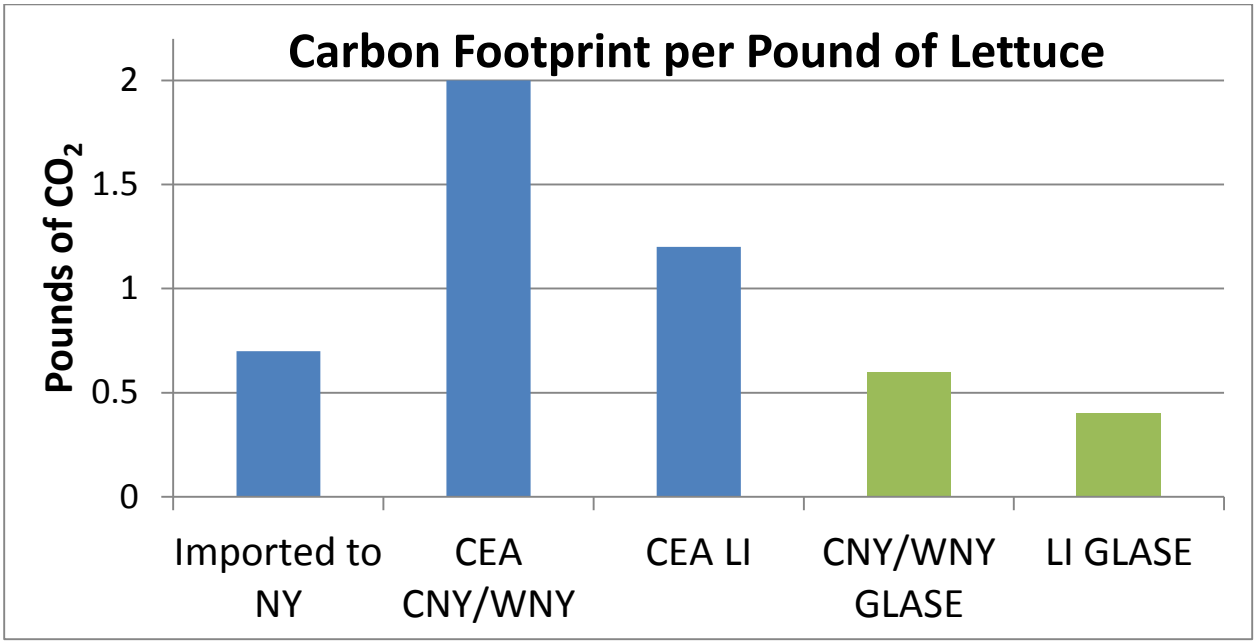
Attachment A – prepared by Dr. Neil Matteson, Cornell University
Market for Year-Round Locally Grown Produce in New York State

- Greater than 95% of the lettuce, tomatoes, and spinach we consume comes from out of state. For strawberries, 93% of our consumption comes from out of state.
- CEA production is the only viable method to produce these crops out-of season in a consistent, high-quality way.
- National market demand for "local food" has expanded from $1 billion to $7 billion in the last 9 years.
- Patterns of drought in the west will push more produce to be NY grown
    - CEA greenhouse production uses 20 times less water per pound produced than CA field-grown

Carbon Footprint of Imported Produce vs. CEA grown

- NY grown field or high-tunnel grown produce has the lowest carbon footprint, but if consumers want year-round produce it must be imported (CA, FL, AZ, etc.) or produced locally using CEA technology.
- CEA greenhouses use intensive amounts of energy (83% for plant lighting, 17% for heat)
    - 1 acre of greenhouse produces
        - 800 metric tons of CO_2 at power plants per year for electricity for lighting
        - 165 metric tons of CO_2 per year from furnace/boiler exhaust to heat with natural gas
    - We estimate adopting GLASE (Greenhouse Lighting and Systems Engineering) technologies reduces 1 acre CO_2 production to
        - 200 metric tons CO_2 per year for lighting (75% reduction)
        - 87.5 metric tons CO_2 per year for heat (50% reduction)
        - Total: 70% reduction in CO_2 emissions for greenhouses adopting GLASE technology

- Carbon footprint for lettuce using current technology
    - Imported to NY (transportation footprint, avg. 2,963 food miles) 0.7 lbs. CO_2 per lb. lettuce
    - CEA grown in central/western NY (light/heat, low winter light) 2.0 lbs. CO_2 per lb. lettuce
    - CEA grown Long Island (light/heat, more winter light) 1.2 lbs. CO_2 per lb. lettuce
    - Plant Factory (only artificial light) 5.5 lbs. CO_2 per lb. lettuce
    - CEA with GLASE (CNY/WNY) 0.6 lbs. CO_2 per lb. lettuce
    - CEA with GLASE (Long Island) 0.4 lbs. CO_2 per lb. lettuce



→ **Implementing GLASE makes locally grown produce more sustainable than imported.**

Cornell University
College of Agriculture and Life Sciences

Comments prepared for NYSERDA, June 2 2015
Benefits and Potential Growth in the Farm Anaerobic Digester Sector
Submitted by Curt Gooch, Cornell University PRO-DAIRY and Julie Suarez, College of
Agriculture and Life Sciences

Cornell University's College of Agriculture and Life Sciences (CALS) and the Cornell PRODAIRY program, as part of the Land Grant University in New York, are pleased to have the opportunity to offer comments as part of the emerging Clean Energy for Agriculture Task Force, announced by Governor Cuomo at the 2014 Dairy and Yogurt Summit. At NYSERDA's request, these comments seek to present a broader context behind New York's dairy farm community, outline private market forces influencing opportunities for economic growth, and explain the benefits of utilizing a farm AD (anaerobic digester) for greenhouse gas emissions reduction, renewable energy production, odor control and environmental sustainability. Specifically, this document is designed to help NYSERDA identify and address key barriers to the developing farm anaerobic digester (AD) industry. Agriculture has great potential to assist in meeting New York's ambitious goal of 60% of our energy in the future being derived from renewable sources.

Cornell University's PRO-DAIRY Environmental Systems and Management Program has a vision for the dairy industry in the future as a well-developed and sustainable dairy community that includes optimal recycling of dairy manure and other dairy farming co-products along with pre-and post-consumer food wastes and other organic materials. These co-products contain nutrients that are critical for optimum forage crop growth, and when properly utilized and managed can meet both soil and crop health goals while minimizing the environmental footprint of the dairy community.

CALS and PRO-DAIRY, along with other stakeholders, hopes to continue to partner with NYSERDA and convey a broader vision for the state's agricultural community to achieve economic and environmental sustainability through growth and innovation with an emphasis on renewable energy systems. This document, however, addresses NYSERDA's specific desire for comments outlining ongoing barriers to farm AD adoption despite increasing financial incentives offered by NYSERDA PON's. CALS and PRO-DAIRY, with assistance from strategic partners

would like to suggest a pathway for NYSERDA future actions via the Clean Energy Fund to truly transition the farm AD sector to a market based one over a multi-year transition period.

CALS believes firmly in the value of industry and partner input, and suggests respectfully that further consultation and consideration would be of great value within the construct of the Governor's emerging Clean Energy for Agriculture Task Force. This document was prepared for NYSERDA with direct industry involvement and consultation, but is in no way meant to provide a full scope of the various policy actions surrounding the Renewable Energy Vision (REV) process and renewable energy production as it relates to farm AD and other renewables. The Clean Energy for Agriculture Task Force will be an excellent vehicle, because of its higher education, stakeholder, and state agency representation, to help NYSERDA sort through various policy suggestions concerning the REV process to convey to the PSC as it relates to agriculturally based renewable energy production.

Dairy in New York

New York dairy farms contribute $14.8 billion to the state's economy, according to a Cornell University May 2014 economic analysis. Direct dairy receipts (i.e. the prices paid to farmers) demonstrate that dairy represents just over half of the state's total farm sector. From a Northeast consumer's perspective, New York dairy farms are vitally important to the fluid and dairy product supply chain. New York dairies in 2013 supplied just under ***half*** of the milk pooled within the Northeast Milk Marketing Order, supplying a vast number of metro NY and beyond customers with local, high quality milk, ice cream, cheese and other tasty dairy products.

It is important for NYSERDA to have a more comprehensive knowledge of the structure of New York's almost 5,000 dairy farms. Figures from the 2012 Census of Agriculture, prepared by the USDA's National Agricultural Statistical Services, shows that the average herd size in New York is still relatively small, at 121 cows. This size of a farm is generally not a great target for farm AD, but can and will become a great utilizer of other renewable energy production strategies such as solar and small wind. However, 5% of New York's dairies have 500 or more cows, and produce slightly over 50% of New York's entire milk supply. An additional 5% of New York dairies have between 200 to 500 cows, and produce 14% of New York's milk supply. These medium to large size farms are a direct target for farm AD technology, and are critically important not just for their economic impact, their potential to reduce greenhouse gas emissions, but also because of their substantial role in supplying milk products to Northeast consumers. These farms are also prime candidate locations for receiving biomass diverted from landfills, which would further reduce anthropogenic greenhouse gas emissions creating an additional societal environmental benefit.

Energy costs are an important part of a dairy farm operation, and it is vital to understand that as farmers continually seek to control costs, a market based incentive does exist for farmers to install farm AD systems. Should NYSERDA be able to provide better assistance in breaking down current barriers towards the farm AD industry, this action can help to drive revenue to the farm from the production of renewable energy as well as offset costs at a time when financial sustainable is paramount. However, avoided electricity costs alone are not the sole determiner of the financial equation of installation of a farm AD system. Frequently, other financial incentives and revenue metrics (adding value to the digestate in the form of bedding, compost, or other future products, carbon credits and/or tipping fees from food and organic wastes, etc.) are necessary to finalize a farm AD project. Data from the 2013 Dairy Farm Business Summary, a program of PRO-DAIRY's business management team, shows the following cost (in dollars) for fuel, and oil, and utilities. The cost represents the average of the farms utilizing the program to analyze their costs and benchmark the farm operation against similar businesses. The utilities category includes electric, heating oil/propane, and telephone services.

Herd Size, cows	Fuel & Oil	Utilities	# of Farms
47	$8,808	$6,199	14
77	14,352	11,652	13
143	33,044	15,268	24
298	66,845	34,376	22
491	100,284	48,157	20
729	155,567	68,538	28
1,387	299,006	143,333	50

Specifically, there are approximately 530 permitted CAFO (Concentrated Animal Feeding Operations) dairy farms in New York. There are currently 24 operating dairy farm AD systems installed. In terms of growth potential, there are at least 500 farms that are prime targets for farm AD systems, with the associated benefits of renewable energy production and greenhouse gas emissions reductions. If we assume the 500 farms have on average, 500 cows, than the annual electrical energy production with cow manure only could be 416 megawatts annually with a capacity factor of 0.95. If on average a low/medium quality food waste is added the production is 2.5 fold. If a higher end food waste is utilized, the production can be 5 times or over 2,000 megawatts per year. Associated greenhouse gas emissions

reductions can be the equivalent of 125,000 US cars worth of emissions annually for the manure only case. In the long-term, additional thought needs to be given to meeting small-scale dairy farms need for farm AD systems as technology evolves.

National and International dairy market forces

Nationally, New York ranks third in the nation in terms of milk production, with California as the top ranked dairy state. In contrast to California, New York's climate is cow friendly – mild summers and long cool and cold winters are appreciated by dairy cows and thus provide good conditions for making high volumes of quality milk. In normal years, New York has the distinct advantage over many direct competitors in other states as ample supplies of quality water are available for dairy cows. Generally abundant rainfall in New York creates high quality forage crops for livestock feed, an important factor in New York dairy farm's profitability. While western states average milk production has decreased over the past year, New York dairy farmers have increased milk production to meet market demands. While the cyclical nature of world market forces and dairy prices means our milk supply is a little overabundant at the moment, the essential point is that New York's dairy community is poised for growth at a time when long term, structural and climactic forces will provide market signals and return on investment for dairy expansions.

With California in the middle of a four year drought, the agricultural news magazine, Growing Produce, just reported ground breaking and potentially a food price altering agreement between California's delta growers and the Water Resources Board to agree to a 25% reduction in water usage for agriculture. This action comes after other voluntary, and mandatory, restrictions for agricultural water usage in California, with additional water conservation measures expected. This does open a door to an opportunity for New York dairies and food manufacturers in the long term. With average precipitation forecasts in the future, along with food price increases projected as a result of California by necessity exiting the volumes of water intensive specialty crops (see Appendix B) climate change brings both challenges and opportunities to increase production. New York's water resources will be a long term factor in the future growth of dairy.

Internationally, world food demand projections are staggering, with the Food and Agriculture Organization reporting that collectively the world needs to double its current food production by 2050. Additionally, with consumers in Asia and Africa growing economically and increasing dietary protein demand, dairy is poised for greater opportunities to compete in the international marketplace. This broad environmental and global market place context is important for NYSERDA to understand that developing a farm AD industry now will have a significant impact on future economic opportunities. By breaking down the barriers against adoption

in the current moment, the state of New York will be poised to help future generations of dairy farmers grow responsibly, effectively, and with an emphasis on renewable energy production and greenhouse gas emission avoidance.

Why emphasize farm AD technology?

CALS recognizes that NYSERDA has been active in the farm AD arena for many years, offering various incentive programs to support farmers and digester installers. Cornell's PRO-DAIRY program is pleased to partner with NYSERDA in a host of different digester research and extension projects, and is conducting informal case studies of various digester systems to better facilitate technology transfer and producer education. With that said, it is fair to state that all involved have come to recognize that there are additional opportunities to adjust the NYSERDA program offerings available through the upcoming vehicle of the Clean Energy Fund to be more effective, have higher impact, and result in the eventual development of a market-based, private sector supported farm anaerobic digestion industry.

Farm AD's are important for many reasons (see Appendix A). With respect to the Clean Energy Fund goals, it is important to note that anaerobic digesters alone reduce on-farm greenhouse gas emissions by approximately 2.5 to 3 metric tons per cow per year (Pronto and Gooch, 2010) and even more when coupled with an engine-generator set producing renewable electricity by way of displacing fossil fuel-based emissions. From a renewable energy production perspective, farm AD systems provide baseline, not intermittent power. As compared to solar or wind, repeatable farm AD systems will have a capacity factor that is 3 times that of wind and 4 times greater than solar in New York, a significant fact as NYSERDA considers electric grid capacity and demand issues

Anaerobic digestion of dairy manure greatly reduces the greenhouse gas emissions associated with storing untreated manure long-term. Farmers need to store manure long-term because it is a water quality best management practice utilized by most CAFO farms as a consequence of the Comprehensive Nutrient Management Plan. Biogas produced by anaerobic digestion of dairy manure (and other biomass sources) is generally used as a fuel source for engine-generator sets, thus lessening the need to use fossil fuels to generate electricity.

For every two dairy cows' worth of manure digested annually the greenhouse gas emissions associated with one car is mitigated, a significant benefit and a positive linkage to NYSERDA's overall change in direction towards emphasizing greenhouse gas emissions reductions in addition to greater energy efficiency via the upcoming Clean Energy Fund process. Additionally, with a combined heat and power system (CHP), heat of combustion harvested from the engine generator sets can also be used in a beneficial way, thus creating further reductions in greenhouse gas emissions.

Cornell's PRO-DAIRY program currently has a federal Hatch Act funded proposal to undertake basic study of the technical and environmental feasibility of coupling a digester system with a greenhouse system. This is both for the benefit of heat recycling and establishing a new market opportunity in plant production – a possibility made more realistic by overall climatic trends in California and national market forces in specialty crops production.

A significant benefit to NYSERDA taking a stronger look at the utility of solving the barriers towards greater farm AD adoption includes the policy discussions surrounding the disposal of food and organics wastes. Certainly, the greater the number of farm and non-farm AD's in New York, the easier it will be to establish long term, mutually beneficial contracts for AD systems to appropriately co-digest food and organic wastes. Farm AD systems, however, are preferred places to receive organics for recycling of nutrients and carbon, as the nutrients are of great value in accomplishing other farm and environmental goals including soil health, fertility, and high quality forage crop growth. This is important in the greater policy context surrounding these issues as the current practice is simply to landfill food and organic wastes, leaving a missed opportunity to realize additional greenhouse gas emission reduction through landfill avoidance and to obtain beneficial use of the waste stream by recycling carbon and nutrients on cropland.

Addressing the barriers

Despite the potential for greater adoption in New York's dairy economy, farm AD installations while increasing over the past five years - have significant untapped potential. Farmers can see the environmental and energy benefits, but frequently cite the other benefit, that of avoiding neighbor conflicts as digesters greatly improve odor control, when taking the leap of faith, paperwork and aggravation often associated with installing a farm AD system. Currently farms are only paid the utility's avoided cost (3 to 5 cents/kWh in New York State) for electricity sold to the grid, making it a better option financially to use the energy on-farm since the purchase price is two to three times higher than the price obtained by the utility. However, many farms find that if they digest all their manure, they can produce electricity in excess of that required for their needs, especially if they have several meters across the operation. This additional electricity, if not valuable to be sold back to the grid, coupled with excess heat leads one to concur that facilitating additional value-added technology/business partnerships (such as PRODAIRY's commercial greenhouse study) will be critical to transitioning to a private marketplace. If initial investigations into value-added partnerships prove positive, demonstration projects supported by NYSERDA would be wise to establish feasibility and technology transfer.

One of the major barriers to greater farm AD adoption cited by farmers are the unknowns of basic operations and maintenance, and the lack of a skilled workforce that can provide for contract operational support. Dairy farmers, particularly those in the medium to large scale which would yield the largest greenhouse gas emissions reduction and stable renewable energy generation, are successful at managing cows, field crops, machinery, business agreements and people. Adding a complex AD system into the equation that necessitates adding skills or personnel with skills to handle organic waste contracting and billing arrangements, operational and maintenance requirements, and oversight of initial system installation is a major deviation from the day-to-day activities and expertise associated with operating a dairy farm. This unknown workload along with day-to-day AD system operation and management can become a significant barrier to many dairy farmers who are focused on excellence in milk production.

Barriers most frequently cited by farmers towards adopting farm AD technology include the very real need for financial incentives (digesters do not currently add enough to the bottom line of New York's medium sized farms to cash-flow the investment, particularly in a time of price volatility), a lack of sufficient and affordable construction technology and knowledge of repeatable, long term data of existing systems, the lack of a significantly valuable secondary market (either for electricity sales, added value to the digester effluent stream, or other market based farm opportunities) and the lack of time and trained personnel to operate, maintain, and aggregate food and organic waste stream long-term contracts.

CALS, the PRO-DAIRY program, with stakeholder input, have identified several barriers and suggestions for solution. These can be categorized in three general areas: Cost, Policy & Technology Transfer; Research Innovation; and Workforce Development. Appendix C outlines several of these recommendations in a way that is designed to establish a logical pathway for NYSERDA to utilize as CALS and PRO-DAIRY's recommendations to address barriers to farm AD systems in New York.

Cost, Policy & Technology Transfer

While NYSERDA and the PSC have in the initial Clean Energy Fund proposal expressed a long term vision and a goal of avoiding the former practice of "one-off" PON's, for agriculture, a typically underserved and undercapitalized industry, incentive programs have been welcomed and have promoted renewable energy technologies, reduced energy usage, and created greenhouse gas emission reductions. NYSERDA's extremely popular farm energy audits were greatly welcomed by the farm community, and created a great deal of economic and environmental benefit to farmers and everyone who enjoys eating local products. "One-off's", such as NYSERDA has articulated in the Clean Energy Fund as an

incentive for a single renewable energy project, in the farm community have provided the entire state with great benefits of renewable energy production in the form of installed solar panels on New York vegetable farms, farm AD projects, as well as energy efficiency incentives such as the installation of variable speed vacuum pumps on dairy farms.

The agricultural community in New York, particularly the dairy sector, has incredible opportunities in the future but does need some transition time to develop a truly market based private sector anaerobic digester industry. NYSERDA should continue to be actively involved in incenting anaerobic digester technology adoption to farmers, and fostering sound research into solving technical, workforce development, and profitability challenges to create a truly innovative and market based farm AD industry.

The ability of dairy farms to adopt farm AD technology over the next transition time will depend greatly on available incentives. Certainly, CALS own recent experience in issuing an RFP, or several RFP's, for the installation of a farm AD on the Cornell Dairy Ruminant Center has provided first hand, as well as academic, experience in the financial stress over the prohibitive cost of construction and installation. An added complication for Cornell's own research farm and many dairy farmers in New York is the general preference for sand bedding to improve cow comfort and udder health, as prescribed by the Cornell Department of Veterinary Medicine. A long desired research opportunity for Cornell is to develop a digester that will handle raw sand laden dairy manure, without requiring a sand separation process that must be meticulously maintained prior to entering the digester.

A further complication is that many dairy farmers (including Cornell's dairy farm operation) simply do not want to own, operate and maintain an AD system, along with fostering the connections needed to source food and organic wastes. A consideration for NYSERDA is whether in addition to the continuation in a transition period of financial incentives from the PON process to the Clean Energy Fund, a pilot project(s) encouraging the development of farm AD systems that are from start to finish installed, operated, and maintained over the long term by a private sector management company would be highly attractive. It is clear that for a medium scale farm, the hassle factor of operating an AD system, maintaining, and perhaps just as importantly, sourcing organic wastes and developing agreements, is a vital next step in the development of a truly marketplace supported farm AD industry. While there are multiple AD companies operating now in New York, few if any of the existing companies offers a consultative and ongoing service on a contract basis to actually operate the farm AD from start to finish (including contracted food waste and technical expertise for agronomic land disposal practices). Economies of scale would start to make this a viable business opportunity for a private sector partner, should the pilot projects prove successful.

As mentioned prior, further coupling a pilot project to explore a business model that establishes a new on-farm market opportunity, such as in the controlled environment agriculture (greenhouse) arena, could be additionally attractive to develop new environmentally sustainable business opportunities for New York's dairy farmers.

In terms of economics, CALS recognizes that significant policy barriers exist for the adoption of farm AD systems because of the utility market structure currently in place in New York. Cornell respectfully suggests that NYSERDA and the PSC consider whether, within the context of REV, allowing consumers a greater option to purchase "cow power" at attractive rates would help to provide the final boost of private sector support and market demand needed to considerably expand the farm AD sector. Clearly "green bank" financing is another attractive option for dairy farmers should the revenue equation and financial profitability of farm AD be improved. It is currently difficult for traditional financing institutions to underwrite farm AD systems when the financial margins have not been shown as of yet to have long term financial, as opposed to environmental, return on investment. Utility interconnection issues remain a major barrier for New York's dairy farmers in installing farm AD systems, and should be thoughtfully addressed by NYSERDA in partnership with the PSC and New York's utilities in order to facilitate adoption.

While the REV process is outside the scope of CALS expertise, from PRO-DAIRY's long term work with dairy farms installing farm AD systems, it is clear that farm energy net metering has provided financial incentives to farmers that positively impact the farm AD feasibility. It is clear that as REV goes forward, some means of ensuring favorable treatment of farm AD, and other types of farm based renewable energy, would do much towards ensuring both the production of renewable energy as well as the environmental sustainability of New York's food production for New York consumers.

Technology transfer will continue to be an ongoing issue for New York's farms seeking to install farm AD systems. Cornell's PRO-DAIRY program looks forward to continuing to be an ongoing partner with NYSERDA and the dairy farm community as research is conducted, to ensure extension of knowledge and adoption in the private sector. As an example of partnerships, Cornell's PRO-DAIRY program worked extensively with the New York Power Authority's contracted "ombudsman" service to facilitate farm and utility communications surrounding the utility interconnect issue. This specific service, along with project conception to grant paperwork preparation to system performance troubleshooting all conducted under the same umbrella successfully brought several farm AD projects to fruition subsequent to the Governor's first Yogurt and Dairy Summit.

Cornell's PRO-DAIRY program, along with its industry partner, have been selected by NYSERDA to continue this effort as a result of a competitive proposal submitted

in September 2104. It is important to continue the ombudsman effort during the transition time to a market based sector so this assistance can be available for the strategically located repeatable demonstration projects recommended within this document.

Research Innovation

Positioning New York as a leading innovator
Basic, applied and field research work is needed to advance knowledge and ultimately financial feasibility in the area of manure-based anaerobic digestion. Basic research should focus on new discoveries and technologies that would facilitate additional product innovation. For example, research conducted within the College of Agriculture and Life Sciences Biological and Engineering Department is showing promise in meeting the industry demand for renewable chemicals. Organic wastes, funneled through an anaerobic digestion process, produce a large quantity of methane but that gas is currently a relatively lower value chemical. The basic research question to drive further innovation is to determine whether or not utilizing anaerobic digestion and biotechnology with reactor microbiomes can yield a high value, renewable chemical. Adding value to the waste stream of the anaerobic digester is truly the next step in financial profitability of anaerobic digester technology on dairy farms, as well as a potential new market. This type of basic research into further innovative added value possibilities for the creation of a higher secondary market is needed to drive adaptation and greater acceptance in the private sector of anaerobic digestion in multiple industry AD sectors, but particularly within the farm AD industry.

Applied research, or field research, is also needed to foster greater profitability and adaption of AD technology in New York. For example, one key challenge faced by farmers is the capital cost of systems (even with available NYSERDA incentives) and their minimal correlation to farm profitability. Private capital providers find it difficult to offer financing for a significant capital project that has minimal dollar return, but provides environmental, energy, and odor control benefits. Field research should focus on the long-term testing and evaluation of promising anaerobic digestion system components in order to document and demonstrate their technical and economic performance. The industry needs to utilize repeatable systems, with documented criteria, that financiers and farmers can utilize to judge project efficacy, profitability potential, and long term success.

While PRO-DAIRY's extension publication of farm AD system case studies and specific farm monitoring reports have been helpful to provide system overviews and detailed information, it is clear that a systemic analysis is needed using repeatable systems. This knowledge would greatly impact the comfort level of farmers in installing a farm AD system. NYSERDA has done excellent work with the digesters

that are currently on New York State farms, however, an analysis that includes technical, economic, and performance data has not been done comprehensively or in a long-term fashion for repeatable systems. Specifically, financial incentives to the farmer to install repeatable systems on multiple farms would break down barriers towards farm AD technology as knowledge would be expanded and recommendations more able to be developed by Cornell's PRO-DAIRY program. Additionally, understanding performance of repeatable systems and financial performance data will be a key to attracting private sector debt capital into the New York farm AD industry.

Additional technological research could significantly help address one of the other major barriers to AD adoption – the capital costs. One of the major costs of construction is the anaerobic digestion vessel. Currently, rather large vessels are needed to hold and heat manure and codigestion products for many (20 to 30) days. If, through applied research, an improved way to accelerate the breakdown of the in-vessel organic matter can be found, the size of the vessel could possibly be reduced, which in turn lowers the capital cost for the system. Initial work performed by the Cornell PRO-DAIRY program has shown that significant reductions in retention time are likely possible when digester influent is seeded with a proprietary product that is readily available, and further research would be well received in this arena.

Other options that may make longer term economic sense for meeting the desire for additional greenhouse gas emissions and renewable energy production for the majority of New York's smaller sized dairy farms include additional work on constructing regional, centralized anaerobic digester systems such as currently found in Denmark. The cost of hauling manure is a significant barrier, and it is questionable within this decade as to whether this strategy will be feasible. However, as the Clean Energy Fund process is designed to be renewed every ten years, Cornell respectfully suggests that NYSERDA continue monitoring private market forces within the dairy community, food and organic waste policy trends, and renewable energy production needs with an eye towards researching regional systems again for smaller scale farms when it becomes more feasible.
Perhaps the highest priority within this section is conducting the basic economic and policy analysis that is needed to answer the questions pertaining to the correct mix of revenue programs that will allow the farm AD industry to transition to a market supported industry. Cost-benefit analysis/research is needed relative to third party design, build and/or ownership of on-farm anaerobic digesters in order to clarify the appropriate sharing of rights and responsibilities of parties in such relationships. Further investment in research is needed to identify/define the best technology(s) and operational model(s) that will attract additional capital into the industry.

Workforce Development

Adult education

For the New York AD industry (both farm and non-farm) to increase throughout New York, workforce development is needed to ensure trained and qualified technicians working in the private sector to operate, maintain, repair, and manage these complex renewable energy systems.

Cornell's PRO-DAIRY program was engaged in a project with NYSERDA entitled the Anaerobic Digestion Work Force Development Project, which aimed to train a workforce of supporting engineers, technicians, operators and service personnel. 5 short courses were developed in 2014, with 4 courses delivered to 26 farms directly with a total of 173 farms and employees trained, demonstrating the ongoing need for support for training materials. Key areas suitable for the on-going development of training materials include: technical and economic feasibility updated materials for farm AD systems, technician's start up and operation short courses, and biogas utilization systems selection, operation, and maintenance.

As an example of why this ongoing education is still necessary, a 2014 PRO-DAIRY case study of Lawnhurst Farms found that the principle operator of the digester spent four months in Europe gaining education needed to operate and maintain the digester system – a commitment which is unaffordable on most of New York's dairies. Training materials and short courses need to continue to be developed for farmers, farm owners, and key management personnel to address this existing gap and obviate the need for New Yorker's to travel to Europe for farm AD education.

Post-secondary education

Similarly, institutions of higher education with working dairy farms have varying levels of educational programming occurring with minimal collaboration. For example, SUNY Morrisville has an on-farm digester (an older model that is currently under bid for replacement with SUCF dollars) and a Renewable Energy Training Center for entry level technical workers. CALS has several faculty engaged in AD research, and is training graduate level students in related research fields concerning anaerobic digestate. SUNY Cobleskill has recently completed construction of a farm AD, but does not to CALS knowledge teach students on digester operations and maintenance. This lack of a formalized, consistent and comprehensive training program for workforce development of technicians and upper level management, as well as the graduate students, who will become the technological innovators in the future, results in a barrier to AD deployment throughout New York in all sectors of the economy.

Consideration should be given to establish a partnership between the Land Grant University at Cornell, and the SUNY system schools with farm AD's to develop a

collaborative approach and curriculum that will foster workforce development in this area, whether through Associates' degrees or, as CALS and PRO-DAIRY have long standing expertise in establishing, pertinent and repeatable short courses or certificate programs. Collaboration between schools with farm AD systems and active animal science departments will ensure that relevant course work familiarizes students with farm AD system technology, as these students will be the next generation of farmers and farm employees. Because farm AD's do not currently add to a farmer's profitability, it is critically important to reach the next generation of farmers to encourage broad adoption of AD technology.

Conclusion

Farm AD systems show great progress in reducing greenhouse gas emissions on dairy farms, producing on-farm renewable energy, and in assisting New York's dairy community in meeting future growth potential given the broader national and international market forces. CALS, along with the Cornell PRO-DAIRY program, believes strongly that farm AD technology has a vibrant role in the future if NYSERDA is able to continue its partnership through the Clean Energy Fund and provide appropriate support to take the next step in breaking down the current barriers towards installation and adoption of farm AD systems.

While these comments were prepared by CALS and the Cornell PRO-DAIRY program, the thoughts were influenced by many of our private sector partners within the dairy and agribusiness community. These comments are also not meant to exclude other sectors of agriculture, particularly in the plant based arena, which have needs for a strong and smart renewable energy and energy efficiency strategy. The following organizations were willing to provide their endorsement of these comments, (while not precluding forwarding further comments by the undersigned entities) which will hopefully help NYSERDA to realize the potential and need for continued involvement within the farm AD sector of renewable energy production.

Organizations alphabetically:

AgriMark/Cabot Cooperative
Dairy Farmers of America (DFA)
Dairy One
Farm Credit East
New York Cow Power
New York Farm Bureau
Northeast Dairy Producers Association
Upstate Niagara Milk Cooperative

Sources and references for further reading:

http://dyson.cornell.edu/outreach/extensionpdf/2014/Cornell-Dyson-eb1404.pdf

http://www.manuremanagement.cornell.edu/Pages/Topics/Anaerobic_Digestion.html

http://www.epa.gov/agstar/documents/conf10/Pronto.pdf

http://prodairy.cals.cornell.edu/sites/prodairy.cals.cornell.edu/files/shared/documents/DigesterGr eenhouseProject.pdf

http://www.ansci.cornell.edu/pdfs/pd2012Novp24.25.pdf

http://www.growingproduce.com/vegetables/californias-delta-growers-to-cut-water-use-by-25/

http://prodairy.cals.cornell.edu/sites/prodairy.cals.cornell.edu/files/shared/documents/2014Annua lReport.pdf

http://www.fao.org/publications/sofi/2014/en/

https://ahdc.vet.cornell.edu/Sects/NYSCHAP/docs/BeddingMaterialsUdderHealth.pdf

http://angenent.bee.cornell.edu/research.html

https://www.asabe.org/media/163589/kristen_perano_-_cornell_u._-_paper.pdf

http://www.progressivedairy.com/dairy-basics/cow-comfort/11984-multi-faceted-study-capturesheat-cools-cows

APPENDIX A

Benefits of Anaerobic Digestion of Dairy Manure

There are many benefits of farm-based anaerobic digestion systems that benefit farmers and nonfarmers alike, thus providing substantial reason for pursuing farm-based anaerobic digestion systems. The major benefits include:

- **Reduction of Greenhouse Gas Emissions** – Cornell applied research has shown that on average for every two cows' worth of manure digested annually, one US car's worth of GHG emissions are removed. This is good for the environment and further shows consumers that farmers strive to be good environmental stewards.

- **Odor Reduction** – Manure is commonly stored long-term (6 months or more) to reduce the chance of pollution to water bodies. Long-term storage of raw (untreated) manure releases offensive odor emissions, especially when the storage is agitated prior to empting and when applied to a farm's cropland. However, digested manure can be stored and recycled to the farm's land base with far less odorous emissions; less odor allows a farmer to be more flexible in dealing with how manure is stored and recycled to the land base.

- **Conservation of Crop Nutrients** – The anaerobic digestion process does not consume the manure nutrients nitrogen (N), phosphorus (P), or potassium (K) all of which are important for crop production. The ration of N, P, and K to meet crop nutrient demand will be likely different than as is in digester effluent, thus providing for the opportunity to further process manure for use by plants.

- **Improvement in Crop Utilization of Manure Nutrients** – Effluent from digesters can be stored long-term without significant odor problems allowing farmers to apply nutrients to even sensitive field crops in an agronomic, timely fashion, thus reducing the potential for surface water and/or groundwater contamination. Additionally, the specific forms of the crop nutrients N and P are more available for use by planted crops than raw manure, increasing potential nutrient recapture when managed properly.

- **Improvement of Water Quality** – Summer application of AD treated manure can be readily made on hay fields in compliance with CAFO permit requirements and without causing neighbor relations issues. The hay crop is perfectly suited to utilize the additional nutrients, while water quality is protected as the risk of water run-off and leaching is low.

- **Generation of Renewable Fuel/Energy** – Biogas can be used to generate electricity and hot water and/or dry materials such as corn and cow bedding, or used in a number of other potential alternative uses that can be used on- or off-farm, including liquid fossil fuel replacement.

- **Revenue Potential** – Besides reducing on-farm purchased energy costs for electricity and/or heat, the digester may facilitate other enterprises such as digested manure solids sale as compost or bedding, excess electricity sales, or co-digestion of food waste for a tipping fee.

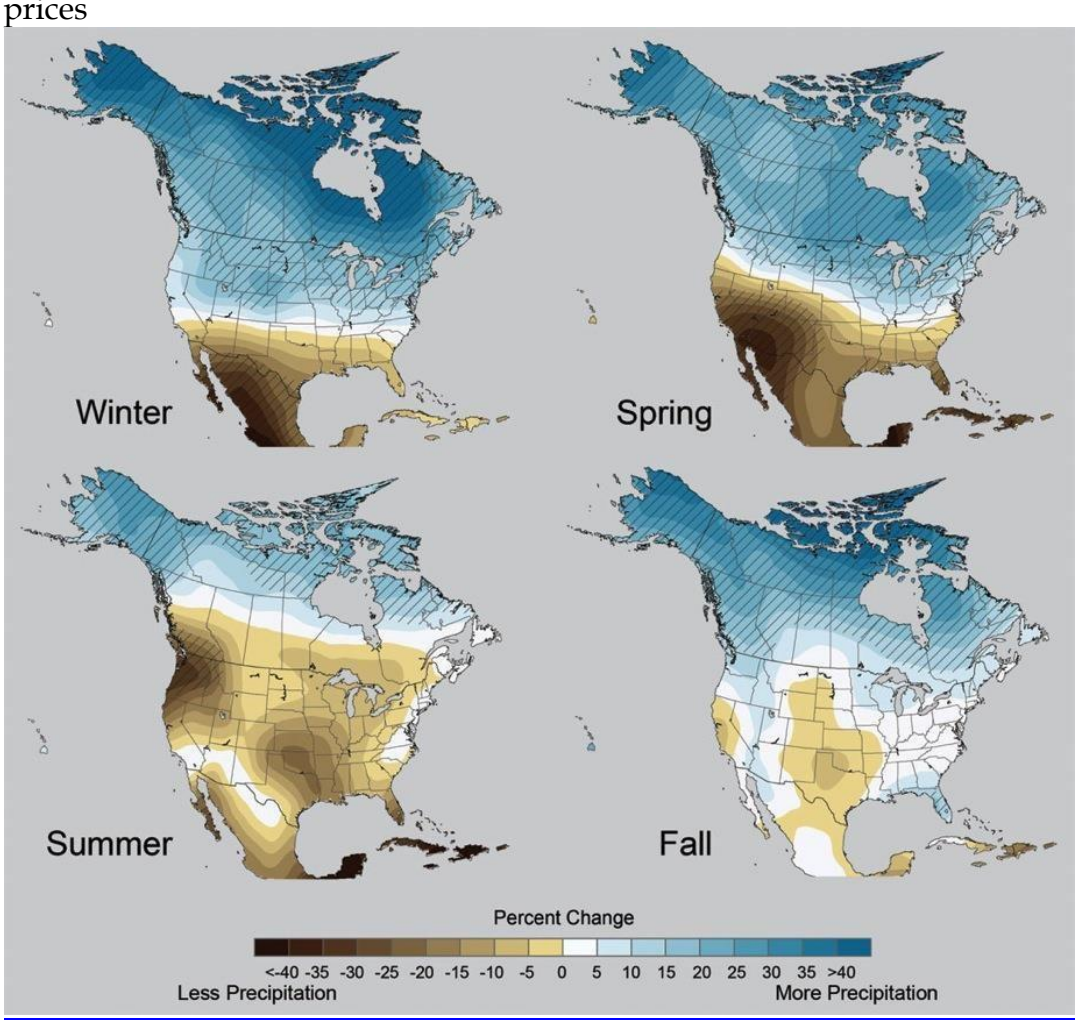
- **Pathogen Reduction** – Cornell research has shown a 99.9 percent reduction of indicator organisms (those that are commonly used to evaluate the success of a system's performance relative to killing pathogens).

- **Pre-treatment** – Anaerobic digestion produces a consistent effluent material (same temperature and pH) that is in good form for further treatment including ammonia nitrogen and phosphorus separation into discrete, usable forms for sale or on-farm use.

- **Co-digestion** – The performance of farm-based digesters is enhanced by adding off-farm substrates. Many of these substrates are costly to dispose of by other means and are not fully utilized for their energy and nutrient values.

APPENDIX B

Climate Change Projections for Precipitation and Impact of CA drought on food prices



Graph depicts the projected change in precipitation in the years 2081-2099, relative to data from 1960-1990. Source: NOA.

APPENDIX C

Appendix C is designed to excerpt from the narrative key areas of focus suggested to NYSERDA to better facilitate discussion for future Clean Energy Fund strategies. CALS and PRO-DAIRY have ordered the recommendations to provide a pathway to addressing specific barriers which Cornell believes would significantly assist in accomplishing farm AD adoption.

No. 1: Farm-Based Comprehensive AD Economic Model Development and Utilization - program effort to develop a comprehensive farm AD economic model and use that model to run several "what if" scenarios in order to determine what combination of revenue items and values for those items are needed to make viable AD project business model(s) that when implemented lead to a market place driven farm AD industry.

No. 2: Repeatable AD Systems – program effort to develop a farm AD system evaluation criteria for use in selecting repeatable systems for installation and implement chosen criteria.

No. 3: **Develop and Implement Repeatable AD System Demonstration Projects** Perform analyses to strategically select multiple sites and scales of dairy farms where a repeatable design model can be best implemented, demonstrated, and monitored.

Utilizing the repeatable design criteria and results of Item No. 1, develop and implement an RFP for construction and operation of the repeatable model projects (focus will include the development of sufficient core system mass to allow digester developers adequate infrastructure, skilled personnel, and economies of scale.

Commission a third party to monitor and report on the technical, economic and practical performance of the systems by conducting an independent analysis and extend that knowledge to the farm AD industry to facilitate installation implementations via a completely transparent process outlining business models, finances, economic, and management.

No. 4: Work Force Development – Expand upon training certification and short courses for existing farmers and key personnel, and explore other possibilities for further curriculum development to develop a core mass of skilled employees at all levels of the farm AD industry.

No. 5: Transition - Continue Current RPS Program or structure a transition period into the Clean Energy Fund for agriculture until a market based farm AD sector is developed.

No. 6: Research Initiatives - Encourage Innovative Advancements in AD Technology and Biogas and Digester Effluent Utilization to ensure scientific discoveries can impact the financial profitability of farm AD and transition to a market based industry.

No. 7: Business and Operational Model Development –Ensure program efforts include developing business models based on new information learned from efforts made in the advancement of relevant science, lessons learned from the demonstration of repeatable system projects, and governmental policy changes.