

**Annual Meeting**  
Rutgers EcoComplex  
1200 Florence Columbus Rd.  
Bordentown, NJ 08505  
October 23-24

**Multistate Research Project**  
**Annual Station Publications Report**

PROJECT NUMBER: NECC-2001 (formerly NECC-1501)

TITLE: Sustainable Farm Energy Production and Use

PROJECT DURATION: 10/01/2020 - 09/30/2025

EXPERIMENT STATION: Connecticut

PARTICIPANTS: Xiusheng (Harrison) Yang

REPORTING PERIOD: October 1, 2022 – September 30, 2023

REPORT DATE: October 10, 2022

PUBLICATIONS:

**Dissertations, Theses (Published):**

Singh, A. K., 2022. GREENBOX Technology for Urban Crop Production: Technical Performance and Financial Feasibility. PhD Dissertation. University of Connecticut, Storrs, CT.

**Books (Published):**

None

**Book Chapters (Published):**

None

**Refereed Journal Articles (Published):**

Buss, G. P., P. A. Carroll, M. A. C. Griffith, X. Yang, J. L. Griffis, G. Papkov, S. Bauer, K. Jackson and A. K. Singh, 2023. The assessment of growth performance of Brassica rapa var. chinensis 'Li Ren Choi', Spinacia oleracea 'Auroch', Eruca sativa 'Astro', and Brassica rapa var. japonica using GREENBOX technology. *Agricultural Sciences* 14:1222-1237

Buss, G. P., P. A. Carroll, M. A. C. Griffith, X. Yang, J. L. Griffis, G. Papkov, S. Bauer, K. Jackson and A. K. Singh, 2023. The comparative performance of plug preparation using different fertilizer sources and concentrations. *Agricultural Sciences* 14:1193-1205

Mya A. C. Griffith, G. P. Buss, P. A. Carroll, M. A. C. Griffith, X. Yang, J. L. Griffis, G. Papkov, S. Bauer, K. Jackson and A. K. Singh, 2023. The comparative performance of nutrient-film technique and deep-water culture method of hydroponics for GREENBOX technology. *Agricultural Sciences* 14:1108-1120

Carroll, P. A., G. P. Buss, M. A. C. Griffith, X. Yang, J. L. Griffis, G. Papkov, S. Bauer, K. Jackson, and A. K. Singh, 2023. The comparative performance of soil-based systems with hydroponics. *Agricultural Sciences* 14:1087-1097

- Singh, A. K., McAvoy, R. J., Bravo-Ureta, B., & Yang, X., 2023. GREENBOX technology III: Financial feasibility for crop production in urban settings. *Journal of ASABE* 00:000-000 (Accepted 8/23/2023)
- Singh, A. K., McAvoy, R. J., Bravo-Ureta, B., & Yang, X., 2023. GREENBOX technology II: Comparison of environmental condition, productivity, and water assumption with greenhouse operation. *Journal of ASABE* 66:1089-1098
- Singh, A. K., McAvoy, R. J., Bravo-Ureta, B., & Yang, X., 2023. GREENBOX technology I. Technical feasibility and performance in warehouse environment. *Journal of ASABE* 66: 1077-1087

**Non-Refereed Conference Publications (Published):**

- Buss, G. P., M. A. C. Griffith, P. A. Carrol, **X. Yang**, J. Griffs, G. Papkov, S. Bauer and A. Singh, 2023. The comparative performance of plug preparation using different fertilizer concentrations and sources. ASABE paper No. 2300191. ASABE, St. Joseph, MI
- Griffith, M. A. C., G. P. Buss, P. A. Carroll, **X. Yang**, J. Griffs, G. Papkov, S. Bauer, K. Jackson and A. Singh, 2023. The comparative performance of nutrient film technique and deep-water culture hydroponics method using GREENBOX technology. ASABE Paper No. 2300258. ASABE, St. Joseph, MI
- Buss, G. P., M. A. C. Griffith, P. A. Carroll, **X. Yang**, J. L. Griffs, G. Papkov, S. Bauer, K. Jackson and A. K. Singh, 2023. The assessment of growth performance of different crops using controlled environment agriculture. ASABE paper No. 2300190. ASABE, St. Joseph, MI
- Carroll, P. A., M. A. C. Griffith, G. P. Buss, **X. Yang**, J. L. Griffs, G. Papkov, S. Bauer, K. Jackson and A. K. Singh, 2023. The comparative performance of soil-based systems with hydroponics. ASABE paper No. 2300276. ASABE, St. Joseph, MI

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NJ EcoComplex, Bordentown, NJ  
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**Multistate Research Project**  
**Annual Station Publications Report**

PROJECT NUMBER: NECC-2001 (formerly NECC-1501)

TITLE: Sustainable Farm Energy Production and Use

PROJECT DURATION: 10/01/2020 - 09/30/2025

EXPERIMENT STATION: New Jersey

PARTICIPANTS: David Specca, A.J. Both

REPORTING PERIOD: October 1, 2022 – September 30, 2023

REPORT DATE: October 15, 2023

PUBLICATIONS:

**Dissertations, Theses (Published):**

Lewus, D.C. 2023. Simulation of high tunnel ventilation using computational fluid dynamics. Ph.D. Dissertation. Rutgers University Libraries. 189 pp.

**Books (Published):**

None

**Book Chapters (Published):**

None

**Refereed Journal Articles (Published):**

Brumfield, R.G., D. Greenwood, M. Flahive DiNardo, A.J. Both, J.R. Heckman, R. Govindasamy, N. Polanin, A.A. Rouff, A. Rowe, R. VanVranken, and S. Arumugam. 2023. A risk management training program designed to empower urban women farmers. HortScience 58(11):1291-1296. <https://doi.org/10.21273/HORTSCII17305-23>

**Abstracts of papers presented at professional meetings (Published):**

None

**Refereed Symposium Proceedings Article (Published):**

Brumfield, R.G., M. Flahive Di Nardo, A.J. Both, J. Heckman, A. Rowe, R. VanVranken and M. Bravo. 2023. Online workshop empowers women farmers to manage business risk during the pandemic. Acta Horticulturae 1368:315-321.

**Popular (Trade Journal) Articles (Published):**

Shelford, T. and A.J. Both. 2023. Lighting: The design phase. *Consider six vital factors when designing sole-source or traditional greenhouse lighting*. Produce Grower, April issue.

**Other Creative Works:**

Both, A.J. 2023. High tunnel construction. In-person presentation with abstract in the Proceedings of the 68<sup>th</sup> New Jersey Agricultural Convention and Trade Show. February 7.

Both, A.J. 2023. High tunnel control with sensors. In-person presentation with abstract in the Proceedings of the 68<sup>th</sup> New Jersey Agricultural Convention and Trade Show. February 7.

Both, A.J. 2023. Humidity control. Webinar presentation for the GLASE Short Course on Climate Control. February 2.

Both, A.J. 2023. Overview of agrivoltaics. Webinar presentation as part of the series: Planning with Agrivoltaics in Mind. Hosted by Penn State University, Cornell Cooperative Extension, and the Farm Bureaus of PA and NY. January 19.

Both, A.J. 2023. Energy efficiency in greenhouse operations. Webinar presentation for the Greenhouse Grower School, Cornell Cooperative Extension of Orange County. January 18.

Both, A.J. 2023. How can you reduce your greenhouse energy bill? Long Island Greenhouse and Floriculture Conference. Riverhead, Long Island. January 17.

Both, A.J. 2022. Environmental sensors 101. Webinar presentation for the Indoor Ag Science Café (USDA-SCRI project OptimIA). Columbus, OH. November 15.

Both, A.J. 2022. Strategies to reduce greenhouse energy costs. In-person presentation for the GLASE Summit. Ithaca, NY. November 8.

**Workshop Sponsor:**

None

**Workshop Participant:**

None

**Refereed Journal Articles (Pending):**

Pejman Sereshkeh, S.R., B. Llumiquinga, S. Bapatla, M.J. Grzenda, D. Specca, A.J. Both, and J.P. Singer. 20xx. Staticaponics: Electrospray delivery of nutrients and water to the plant root zone. In review. Journal of Electrostatics.

**NECC-2001 Annual Meeting**  
Rutgers University  
Bordentown, NJ(also Online)  
23 October, 2023

**Multistate Research Project**  
**Annual Station Publications Report**

PROJECT NUMBER: NECC-2001

TITLE: Sustainable Farm Energy Production and Use

PROJECT DURATION: Oct 01 2020 – Sept 30- 2025

EXPERIMENT STATION: Pennsylvania

PARTICIPANTS: Daniel Ciolkosz, Siobhan Fathel, Gary Musgrave, Dana Ollendyke  
Daniel Brockett, Joseph Conklin, Matthew Svetz, Kaitlyn  
Spangler, Lauren McPhillips, Stephanie Buechler, Trevor  
Birkenholtz.

REPORTING PERIOD: Oct 01, 2022– Sept 30, 2023

REPORT DATE: 23 October, 2023

PUBLICATIONS:

**Dissertations, Theses (Published)**

Lopez, K (2023). A Techno-Economic Market Analysis of Pellet Production in Oaxaca Province. Master's Thesis. August, 2023. Pennsylvania State University. University Park, PA.

Tripathi, J. (2023). Glucose from Wheat Straw for Biofuel: a Characterization Study and a Techno-Economic Analysis of Torrefaction and Alkaline Pretreatment. Doctoral Dissertation. May 2023. Pennsylvania State University. University Park, PA.

**Books (Published)**

Ciolkosz, D. (ed.): Regional Perspectives on Farm Energy. Springer Nature Switzerland AG. ISBN 978-3-90830-0. pp. 1-14.

**Book Chapters (Published)**

N/A

### **Refereed Journal Articles (Published)**

- Tripathi, J., Causer, T., Ciolkosz, D., DeVallance, D. B., Białowiec, A., & Nunes, L. J. (2023). Non-energetic application of carbon-rich torrefied biomass in the bioeconomy: a review. *Biofuels*, 1-17.
- Chahal, A., Ciolkosz, D., Puri, V., Liu, J., & Jacobson, M. (2023). A Technoeconomic Model for Estimating Costs of Harvesting and Debarking Shrub Willow Highlights. *Applied Engineering in Agriculture*, 0.
- Khan, S. R., Zeeshan, M., Fatima, S., Ciolkosz, D., Dimitriou, I., & Jin, H. (2023). A comparative techno-economic analysis of combined oil and power production from pyrolysis and co-pyrolysis plants utilizing rice straw and scrap rubber tires. *Fuel*, 348, 128639.
- Valentin, M. T., Białowiec, A., Karayel, D., Jasinskas, A., Ciolkosz, D., & Lavarias, J. A. (2023). Investigation of the performance of a cylindrical hopper and metering device of a carrot seeder. *Scientific reports*, 13(1), 813.
- Tripathi, J., Ciolkosz, D., and Sykes, D. 2023. Torrefied paper as a packaging material and subsequently as a bioethanol substrate: Synergy of torrefaction and alkaline pretreatment for increased utility. *Resources, Conservation and Recycling*. 191(2023). 7pp.
- Nair, A., Rohith, A.N., Cibin, R., McPhillips, L. 2023. A framework to model the hydrology of solar farms using EPA SWMM. *Environmental Modeling and Assessment*. <https://link.springer.com/article/10.1007/s10666-023-09922-0>
- Yavari Bajehbaj, R., D. Zaliwciw, R. Cibin, L. McPhillips. 2022. Minimizing environmental impacts of solar farms: a review of current science on landscape hydrology and guidance on stormwater management. *Environmental Research: Infrastructure and Sustainability*. <https://iopscience.iop.org/article/10.1088/2634-4505/ac76dd>

### **Symposium Proceedings Articles (Published)**

#### **Popular Articles (Published)**

- Ciolkosz, D. 2022. Is it Time to Try a Different Type of Gas?. *Penn State Extension Renewable and Alternative Energy Newsletter* (online). <http://energy.extension.psu.edu> – published 24 October, 2022.
- Ciolkosz, D. 2022. Heating Fuel Prices Getting Hotter This Winter. *Penn State Extension Renewable and Alternative Energy Newsletter* (online). <http://energy.extension.psu.edu> – published 24 October, 2022.

Ciolkosz, D. 2022. New Rebates Available for Farm Energy Efficiency. Penn State Extension Renewable and Alternative Energy Newsletter (online). <http://energy.extension.psu.edu> – published 24 October, 2022.

### **Presentations (Papers)**

Ciolkosz, D., Smith, M., Tripathi, J., Savchick, P. (2023). Thermal Severity as a Key Parameter for Torrefaction System Optimization. Presented at 2023 Northeast Agricultural and Biological Engineers Conference. 01-03 August, 2023. Guelph, ON.

### **Other Creative Works**

#### **Workshop Sponsor**

Renewable Energy Academy Webinar Series (Penn State Extension)

- Solar Photovoltaics (08 June 2023)
- Renewable Biofuels (22 Sept 2023)
- Energy Policies and Programs (24 Aug 2023)

Biorenewables Symposium (Penn State Center for Biorenewables, 21 April 2023)

#### **Workshop Participant**

#### **Refereed Journal Articles (Pending)**

Spangler, K., Smithwick, E., Buechler, S., and Baka, J. “Just energy imaginaries? Examining realities of solar development on Pennsylvania’s farmland.” Under review at Energy Research and Social Science.

Asif, M., Farid, M., Nasir, A., Anjum, S., Ciolkosz, D. (2023). Prospects for biomass pelletization as an energy strategy in Pakistan: a techno-economic study. Biomass and Bioenergy.

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PROJECT NUMBER: NECC-2001 (formerly NECC-1501)

TITLE: Sustainable Farm Energy Production and Use

PROJECT DURATION: 10/01/2020 - 09/30/2025

EXPERIMENT STATION: Virginia Cooperative Extension/Virginia Tech

PARTICIPANTS: John Ignosh

REPORTING PERIOD: October 1, 2022 – September 30, 2023

REPORT DATE: October 10, 2022

PUBLICATIONS:

Cundiff, J. R. Grisso, J. Resop, and J. Ignosh. Load-out and Hauling Cost Increase with Increasing Feedstock Production Area. 2024. AgriEngineering. In Press.

Goerlich, G., P. Donovan, B. Herndon, and J. Ignosh. 2022. Virginia Land and Energy Navigator “VaLEN” Initial Report on the Development of a Map for Prime Farmland HB894 Workgroup (Chapter 488, 2022). Virginia Cooperative Extension. Published Online.

Pierce, T., Bovay, J., and J. Ignosh. 2022. On-Farm Energy Management and Renewable Energy AAEC-299NP. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Stephenson, S., S. Chase-Walsh, A. Lindrose, J. Worley, and J. Ignosh. 2022. Virginia Citizen's Guide to Environmental Credit Trading Programs: An Overview. Virginia Cooperative Extension Publication ANR-173P. Virginia Polytechnic Institute and State University, Blacksburg, VA.

PRESENTATIONS:

Best Management Practices to Minimize Impacts of Solar Farms on Landscape Hydrology and Water Quality, Two-Day Workshop and Utility-scale Solar Site Tour. State of the Science Workshop, Scientific and Technical Advisor Committee (STAC), Chesapeake Bay Program. L. McPhillips, A. Buda, Z. Easton, W. Daniels, S. Fathel, J. Ignosh, C. Raj, D. Sample. April 2023. Manassas, VA.

Carbon Markets and Climate Smart Ag Incentives. K. Stephenson, J. Gagnon, R. White, J. Ignosh. Virginia Cooperative Extension Winter Conference '23. February 2023. Blacksburg, VA.

Exploring Photovoltaic/Agrivoltaic Research and Generation, Needs and Opportunities, Virginia Tech and Catawba State Hospital Facilities. J. Ignosh, R. Hall. June 2023. Catawba, VA.

Information Session: Water, Sanitation, and Hygiene (WASH), Experiences from Guatemala and Appalachia. L. Krometis, M. Velasquez, J. Ignosh. February 2023. Blacksburg, VA.

Introduction to Solar Energy, Class 1. 5th Grade, Boones Mill Elementary. J. Ignosh, C. Martel. November 2022. Boones Mill, VA.

Introduction to Solar Energy, Class 2. 5th Grade, Boones Mill Elementary. J. Ignosh, C. Martel. November 2022. Boones Mill, VA.

Introduction to Solar Photovoltaics Workshop, J. Ignosh, J. Gilbert, B. Stieg. June 2023. Berryville, VA.

Introduction to Solar Photovoltaics Workshop, J. Ignosh, J. Gilbert, E. Torres, M. Reiter. May 2023. Painter, VA.

Introduction to Solar Photovoltaics Workshop, J. Ignosh, J. Gilbert, W. Stout. June 2023. Hampton, VA.

Multicriteria Decision Analysis (MCDA) Workshop - Stakeholder-engaged Methodology in Evaluating Utility-scale Solar Design Alternatives. J. Ignosh, T. Havranek, T. Taylor. October 2022. Blacksburg, VA.

Solar Energy Resources through the Virginia Cooperative Extension Service, Solar on the Farm Workshop, Piedmont Environmental Council. J. Ignosh. January 2023. Hybrid Virtual/Warrenton, VA.

Solar: Small, Medium, or Large? J. Ignosh, J. Fike. Virginia Cooperative Extension Winter Conference '23. February 2023. Blacksburg, VA.

Standalone Solar: Systems for Remote Locations. J. Ignosh, D. Ciolkosz. Ag Progress Days, Penn State College of Agricultural Sciences. Russell E. Larson Agricultural Research Center. August 2023. Rock Springs, PA.

The Virginia Land & Energy Navigator: A Decision Support Tool for Localities Balancing Natural Resource Conservation and Economic Development Interests, Southern Regional Extension Forestry. P. Donovan, D. Goerlich, B. Herndon, J. Ignosh. March 2023. Online.

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**Multistate Research Project**  
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**PROJECT NUMBER:** NECC-2001 (formerly NECC-1501)

**TITLE:** Sustainable Farm Energy Production and Use

**PROJECT DURATION:** 10/01/2020 - 09/30/2025

**EXPERIMENT STATION:** Michigan

**PARTICIPANTS:** Satish Joshi, Al Go, and Charles Gould

**REPORTING PERIOD:** October 1, 2022 – September 30, 2023

**REPORT DATE:**

**PUBLICATIONS:**

**Masters Theses (Published):**

Miller, H. A Decision Support System to Evaluate the Economic Feasibility of Solar Technology on Dairy Farms. Biosystems And Agricultural Engineering Department, MSU. Completed September 2023. [Al Go and Satish Joshi] <https://chipper-druid-38a6dd.netlify.app/>

**Book Chapters (Published):**

Ciolkosz, D. and A. Go. 2022. Energy Use on the Farm, Chapter 1. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 1-14.

Sanford, S. and Go, A. 2022. Energy Efficiency – Equipment Use and Installation, Chapter 3. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 19-26.

Sanford, S. and A. Go. 2022. Energy for Field Operations, Chapter 4. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 27-35.

Sanford, S. and A. Go. 2022. Energy for Dairy Farms, Chapter 5. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 37-44.

Sanford, S. and A. Go. 2022. Livestock Housing Energy, Chapter 6. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 45-55.

Sanford, S. and A. Go. 2022. Fruit and Vegetable Storage Energy, Chapter 7. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 57-61.

Sanford, S. and A. Go. 2022. Grain Drying Energy, Chapter 8. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 63-69.

Sanford, S. and A. Go. 2022. Irrigation Energy, Chapter 9. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 71-78.

Sanford, S. and A. Go. 2022. Maple Syrup Production Energy, Chapter 10. In *Regional Perspectives on Farm Energy* (D. Ciolkosz, Ed.). Springer, Switzerland. pp. 79-84.

**Other Creative Works:**

- Go, A. 2022. Retrofitting Solar-Powered Microinverter to Grid-Connected Irrigation Pump for Improving Water and Energy Use Efficiency. Presentation to the Michigan Agricultural Energy Council, MSU Campus, East Lansing, MI December 14.
- Go, A. 2022. Long-Day Dairy Lighting Systems. Presentation to the Michigan Agricultural Energy Council, MSU Campus, East Lansing, MI December 14.
- Go, A. 2022. Solar Hot Water Heating Project - MSU Dairy Farm. Presentation to the Michigan Agricultural Energy Council, MSU Campus, East Lansing, MI December 14.
- Go, A. 2022. Rural Electric Cooperative Carbon Capture, Storage and Resilience Projects. Presentation to the Michigan Agricultural Energy Council, MSU Campus, East Lansing, MI August 18.
- Gould, M.C. 2022. Potential benefits of investing in solar energy. Presentation to the Allegan County Commissioners, Allegan, MI November 10.
- Gould, M.C. 2023. Incorporating Solar Energy on a Vegetable Farm. Presentation at Southwest Michigan Horticultural Days, February 1.
- Gould, M.C. 2023. Potential economic and marketing strategies for adding renewable energy to your farm or retail tasting room operation. Presentation at Southwest Michigan Horticultural Days, February 2.
- Gould, M.C. 2023. Grazing Livestock in Solar Projects. Webinar presented on March 6 as part of the Michigan Ag Ideas to Grow With Conference.
- Gould, M.C. 2023. What Every Michigan Citizen Should Know about Solar Projects. Webinar presented on March 7 as part of the Michigan Ag Ideas to Grow With Conference.
- Gould, M.C. 2023. Pollinator Habitat in Solar Projects. Webinar presented on March 10 as part of the Michigan Ag Ideas to Grow With Conference.
- Gould, M.C. 2023. Dual-Use: Utilizing land for more than harvesting solar energy. Presentation at the Off-grid Solar Power Production on Farms Conference, Holland, MI March 23.
- Gould, M.C. 2023. Decisions, Decisions: Choosing the Right Solar Installer. Presentation at the Off-grid Solar Power Production on Farms Conference, Holland, MI March 23.
- LaPorte, J. 2023. Estimating the Cost of Solar For Your Farm. Presentation at the Off-grid Solar Power Production on Farms Conference, Holland, MI March 23.
- Gould, M.C. 2023. How solar energy projects can have a positive impact on our farmland and food production. Online presentation to the Michigan Association of Counties Environmental Committee, April 14.
- Gould, M.C. 2023. Dual Use Application in Solar Projects. Presentation at the Michigan Township Association Annual Meeting, April 19.
- Gould, M.C. 2023. Planning & Zoning for Solar Energy Systems. Presentation to the Ottawa County Department of Strategic Impact, May 4.
- Gould, M.C. 2023. Dual Use Practices for Solar Energy Systems. Presentation given at a specially called public meeting on solar development by the Delta County Commissioners, May 23.
- Gould, M.C. 2023. Dual Use Practices for Solar Energy Systems. Presentation given at the 77th Annual Midwestern Legislative Conference, July 11.
- Gould, M.C. 2023. Dual Use Practices for Solar Energy Systems. Presentation given to an advisory committee appointed by the Clinton County Planning Commission, July 20.

**Workshop Sponsor:**

- Gould, M.C. 2023. Off-grid Solar Power Production on Farms Conference, Holland, MI, March 23.

**Website Development:**

USDA-REAP Grant Assistance and Information (Energy Efficiency and Renewable Energy Projects) [AI Go]: <https://www.maec.msu.edu/educational-materials/reap-grant-application-information>

- [USDA-REAP Application Presentation](#)
- [USDA-REAP Fact Sheet](#)
- [USDA-REAP-Score Sheet](#)
- [Qualification Map](#)
- [Underserved Map](#)
- [SAM.gov | Home](#)
- [How to Register in SAMs](#)
- [Form 4280-3A \[Project cost < \\$80,000\]](#)
- [Form RD 4280-3B \[Project cost between \\$80,000 - \\$200,000\]](#)
- [Form RD 4280-3C \[Project cost > \\$200,000\]](#)

**Energy Audits Completed** [AI Go] – 14

**Renewable Energy Assessments Completed** [AI Go] – 6

**USDA-REAP Grant Application Completed** [AI Go] – 12 (100% Approved)