ELK CREEK SOLAR, LLC

MINNESOTA PUBLIC UTILITIES COMMISSION

COMMISSION DOCKET NOS. IP-7009/GS-19-495 and IP-7009/CN-19-351

DIRECT TESTIMONY OF MICHAEL MORRIS

JULY 17, 2020

I. INTRODUCTION AND QUALIFICATIONS

Q. Please state your name and business address.

A. My name is Michael Morris, and my place of business is 8400 Normandale Lake Boulevard, Suite 1200, Bloomington, Minnesota.

Q. With whom are you employed and what is your position?

A. I am employed by Geronimo Energy, LLC (Geronimo"), as a Senior Director, Energy Assessment and Project Planning.

Q. Please briefly describe your educational background and experience.

I have a bachelor's degree (2006) in Meteorology and a master's degree (2008) in Meteorology from the University of Oklahoma. I am a member of the American Meteorological Society and have been working in the renewable energy industry since 2008. I have been responsible for siting, design, and resource assessment activities for over 10,000 megawatts of projects in 14 states. My areas of expertise include atmospheric remote sensing, numerical modeling and statistical analysis of weather data. My resume is attached as Exhibit A.

Q. What is your role with respect to the Elk Creek Solar Project (Project)?

A. I am responsible for solar resource assessment of the Project site, Project design, and negotiating equipment supply contracts.

II. OVERVIEW

Q. What is the purpose of your Direct Testimony?

A. The purpose of my Direct Testimony is to respond to public comments about the electrical output of the Project, and the durability and recyclability of photovoltaic (PV) solar panels that will be used for the Project.

Q. What schedules are attached to your Direct Testimony?

A. The following exhibits are attached to my Direct Testimony:

- Exhibit A: Statement of Qualifications
- Exhibit B: End-of-Life Management for Solar Photovoltaics: Recycling

Q. Are you sponsoring any portion of the Elk Creek public hearing presentation (attached to the Testimony of Melissa Schmit as Exhibit B)?

A. Yes. I am sponsoring slide numbers 12 and 13 of that presentation.

III. RESPONSE TO PUBLIC COMMENTS

Q. Public comments raised questions about the actual electrical output of the Project. Can you describe how the 80 megawatts (MW) alternating current (AC) nameplate capacity of the Project compares to the actual electrical output of the Project?

A. The Project will have enough panels installed to generate 80 MW of AC electrical power. The Project is anticipated to be available at least 98 percent of the time with a net capacity factor of between approximately 22.2 and 24.0 percent. That would mean the Project is projected to have an average annual output of between approximately 156,000 and 168,000 MW hours. By way of example, that is enough energy to provide electricity for approximately 19,000 homes annually and avoid the emissions of approximately 119,000 metric tons of carbon annually.

Q. A member of the public asked about the degradation rate for PV solar panels used for the Project. Do you have a response?

A. Yes. Like other forms of electricity generation, PV solar panel performance degrades over time with exposure to the elements. The degradation rate represents a reduction in the peak output of the PV solar panel over time. Most modern PV solar panels come with a warranty guaranteeing a degradation rate of no greater than 0.5 percent per year for 25-30 years, though newer manufacturing processes are anticipated to reduce that degradation rate to 0.3 percent or lower

per year. By way of example, a PV solar panel rated at 450 watts at the time of installation that is subject to a degradation rate of 0.5 percent per year would be capable of no less than 389.1 watts after 30 years.

Q. Public comments raised questions about the durability of PV panels and the potential for PV solar panels to shatter due to hail. Do you have a response?

A. Yes. PV solar panels are designed to withstand the impact of weather systems, including hail, and the probability of a PV solar panel shattering due to hail is extremely low. Applicable International Electrotechnical Commission design requirements (i.e., IEC 61215) requires PV solar panels to withstand hail up to one inch in diameter,[1] though some manufacturers test and obtain certification to greater levels. A review of historical hail report data[2] dating back to 1955 indicates 57 hail events, with hail greater than one inch in diameter, within 50 kilometers of the Project. The National Renewable Energy Laboratory conducted a detailed study of 50,000 PV systems totaling 1.7 gigawatts of installed capacity in the United States (U.S.) from 2009 to 2012, and found that the probability of PV system damage due to hail is below 0.05 percent.[3] Therefore, the potential for PV solar panels installed at the Project to be damaged by hail or other common weather events in Minnesota is minimal. Any PV solar panels damaged during construction or during operation of the Project will be removed, properly disposed of and replaced.

Q. Public comments raised questions about the potential for PV panels to release hazardous materials. Do you have a response?

[1] International Electrotechnical Commission. Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules (2016), available at https://www.iecee.org/dyn/www/f?p=106:49:0::::FSP_STD_ID:24313 (Accessed July 12, 2020).

[2] National Climatic Data Center. Storm Events Database (2020). Available at https://www.ncdc.noaa.gov/stormevents/ (Accessed July 12, 2020)

[3] NREL. Reliability and Geographic Trends of 50,000 Photovoltaic Systems in the U.S. (2014) available at https://www.nrel.gov/docs/fy14osti/62801.pdf (Accessed July 1, 2020).

A. Yes. PV solar panels are nearly entirely encapsulated in glass and aluminum, which are not hazardous materials. The PV solar panels do, however, contain small amounts of metals that are, by themselves, characterized as hazardous materials by the United States Environmental Protection Agency (EPA). When panels are disposed of at recycling facilities or landfills, the characteristics of those elements and the likelihood that they will leach from the PV solar panels into the environment must be determined and reported. Many manufacturers of PV solar panels are taking proactive actions to determine the potential for the metals contained in PV solar panels to leach from the panels during operation of the panel or if it is broken into pieces. The EPA-approved method for determining whether a hazardous substance is likely to leach into the ground and ground water is the Toxicity Characteristic Leaching Procedure (TCLP). Each of the manufacturers being considered by Elk Creek to provide PV solar panels completes TCLP testing as part of the product development process and has determined that all existing products passed TCLP testing. In other words, no hazardous materials (including arsenic, barium, cadmium, chromium, lead, mercury, selenium or silver) leached from the tested products resulting in leachate concentrations above the EPA's regulatory thresholds. In light of the panels being fully encapsulated, unlikely to shatter and not expected to leach hazardous materials into the environment, the risk to the environment from the contents of the PV solar panels will be minimal. If a PV solar panel is broken at the Project, the broken pieces and the remainder of the panel will be recycled or disposed of and replaced, thereby further reducing the risk for hazardous materials contained in the PV solar panels to leach into the environment.

Q. Public comments raised questions about whether PV solar panels can be recycled. Do you have a response?

A. Yes. PV solar panels are durable and can last for decades. Nonetheless, PV solar panels and other equipment utilized by the Project will, at some time, need to be managed as waste products. Therefore, certain manufacturers, PVCycle (an international program that some silicon manufacturers participate in), waste

management companies, or other entities such as the Solar Energy Industries Association (SEIA), of which Geronimo is a member, have been actively seeking and developing PV solar panel and associated equipment recycling partners across the U.S. SEIA has produced a fact sheet on PV solar panel recycling that provides useful summaries of current recycling capabilities in the U.S. and efforts to expand such capabilities in the future (*see* Exhibit B). For example, as of January 2020, SEIA's recycling partners have processed more than four million pounds of PV solar panels and related equipment since SEIA's recycling program was initiated in 2016. The heaviest components of PV solar panels, glass and aluminum are common and easily recyclable. Other PV solar panel components that can be successfully recovered are copper, silver and semiconductor materials. More than 90 percent of semiconductor material and glass can be reused in new modules and products. Future research and development of recycling equipment should further optimize the recoverability of additional PV solar panel materials and the purity of any reclaimed materials. I anticipate that, by the end of the useful life of the PV solar panels used for the Project, PV solar panel recycling will be sufficiently established in Minnesota or surrounding states to recycle the PV solar panels and associated equipment used for the Project.

IV. CONCLUSION

Q. Does this conclude your Direct Testimony?

A. Yes.

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GERONIMO ENERGY
a nationalgrid company

Michael Morris, *Senior Director, Energy Assessment and Project Planning*

PROFESSIONAL EXPERIENCE

2018 – Present	Senior Director, Energy Assessment and Project Planning, Geronimo Energy, Edina, MN
2015 – 2018	Director of Resource Analysis, Geronimo Energy, Edina, MN
2010 – 2015	Meteorologist, Geronimo Energy, Edina, MN
2009 – 2010	Wind Resource Analyst, First Wind, Boston, MA
2008 – 2009	Data Analyst, Noble Environmental Power, Essex, CT

SPECIALTY AREAS/ EXPERTISE

Meteorologist – Michael Morris has led resource assessment and project design campaigns for over 7,000 megawatts of wind energy and over 1,000 megawatts of solar energy across the United States. Mr. Morris has also performed operational assessments on over 1000 megawatts of existing wind projects. His areas of expertise include atmospheric remote sensing, numerical modeling and statistical analysis of weather data.

AWARDS, PUBLICATIONS AND RECOGNITIONS

Microphysical Retrievals from Simultaneous Polarimetric and Profiling Radar Observations, 2009 (Primary Author)

An Inter-Comparison of Raindrop Size Distributions Retrieved from Polarimetric Radar Parameters, 2008 (Primary Author, Presenter)

A Field Experiment to Study Rain Microphysics Using Video Disdrometers, a Profiler, and Polarimetric S and X-Band Radars, 2008 (Supporting Author)

Retrospective Forcing of the NCEP Noah Land Surface Model with Observations from the OASIS Network, 2008 (Primary Author, Presenter)

EDUCATION

B.S.
University of Oklahoma
Norman, OK
2006
Meteorology

M.S.
University of Oklahoma
Norman, OK
2008
Meteorology

SCIENTIFIC ORGANIZATION MEMBERSHIPS

American Meteorological Society

AWEA Wind Resource Assessment Working Group

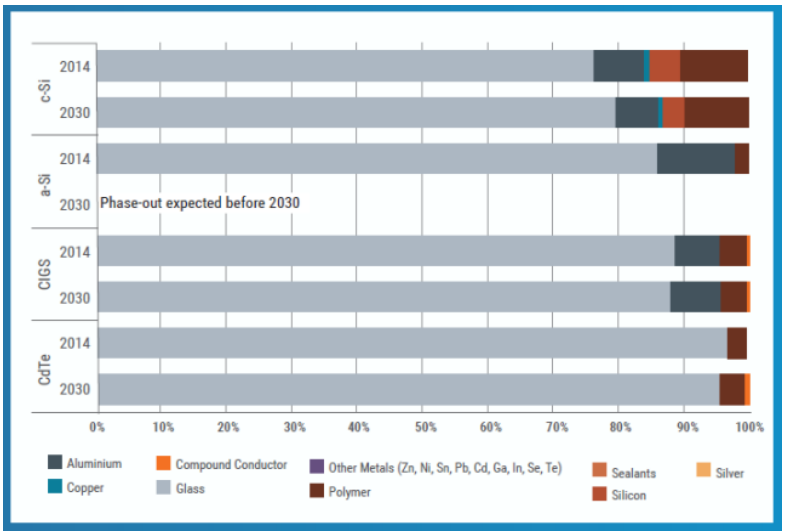
End-of-Life Management for Solar Photovoltaics: Recycling

SEIA Solar Energy Industries Association®

SEIA PV Recycling Partner Network

SEIA's PV Recycling Working Group has been actively seeking and developing recycling partners across the U.S since 2016. Over 95% of PV modules deployed in the U.S have been installed since 2012, and such modules will stay in service for more than 25+ years. Nonetheless some waste is generated when panels are damaged during production, shipment or installation, determined to be defective, by weather events, and for warranty-related claims.

SEIA's National Recycling Program is preparing now for larger volumes of waste to come in future years. Already SEIA's recycling partners have processed >4M pounds of PV modules and related equipment since the program launched.

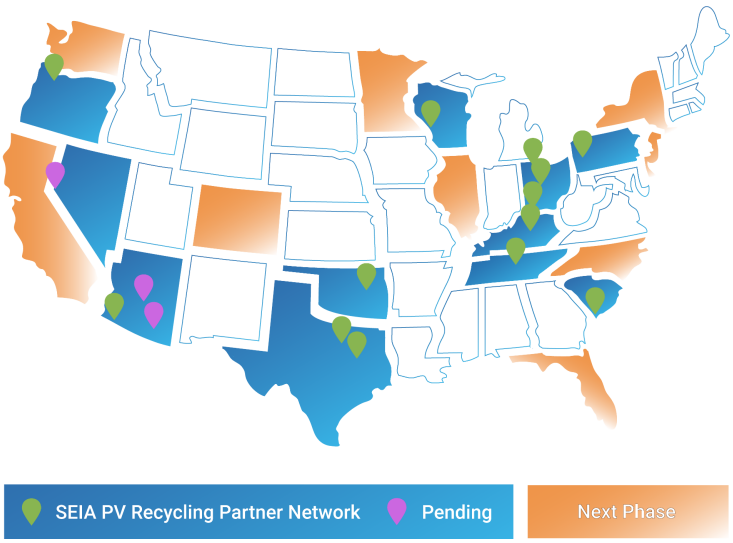


Source: IRENA and IEA-PVPS (2016), "End-of-Life Management: Solar Photovoltaic Panels," International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems.

While they offer specific benefits to SEIA members, the recyclers provide their services to interested installers, project and system owners, developers, distributors and other parties.

SEIA's current partners have prior expertise in recycling glass, polymerics, aluminum, scrap metal, and electronics; all of which provide a good foundation for recycling PV modules, inverters, racking systems and other components of a PV system. Our current network partners offer and provide services to SEIA members and industry throughout the U.S. SEIA is continually working to find new partners in more geographies to make recycling more accessible in areas where solar is installed.

The graphic below shows where SEIA's current partners are located and where we are in process of adding new partners. As we expand our network to more areas, we help partner companies to develop their processes and equipment for our technology. Overall, we aim to add 2-4 new partners yearly and for both new and existing partners to expand their collection and processing locations.



CEM Cascade Eco Minerals
CLEANLITES RECYCLING
DYNAMIC LIFECYCLE INNOVATIONS
Echo Environmental
First Solar
GREEN CENTURY RECYLLING

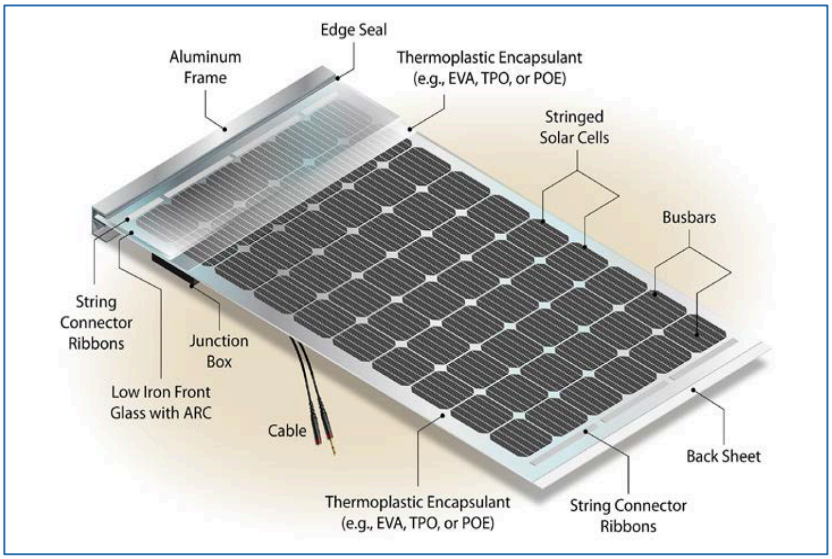
End-of-Life Management for Solar Photovoltaics: Recycling

SEIA Solar Energy Industries Association®

Photovoltaic equipment and options for first end-of-life stages

Like many other durable products and construction materials, solar equipment can last for decades, particularly with proper maintenance. In some cases, PV modules can be reused or refurbished to have a 'second life' generating electricity. The other components of solar systems can also be handled responsibly. Inverters can be recycled as e-Waste and racking equipment can be re-utilized with newer technology or recycled like other metals.

SEIA advises manufacturers, system and project owners to consider reuse, refurbishment and / or recycling of first end-of-life PV modules, inverters, racking equipment and associated components when possible.



Source: NREL, Crystalline Silicon Photovoltaic Module Manufacturing Costs and Sustainable Pricing, 2019

Recycling

While most PV panels produced today will have a useful life for decades, there is inevitable waste created during production, when panels are damaged during shipment or installation, determined to be defective, become obsolete or reach their end-of-life. High-value recycling can help minimize lifecycle impacts and recover valuable and energy-intensive materials, thereby increasing sustainability within the PV industry.

PV panels typically consist of glass, aluminum, copper, silver and semiconductor materials that can be successfully recovered and reused. By weight, more than 80 percent of a typical PV panel is glass and aluminum – both common and easy-to-recycle materials. Recycling of solar equipment is increasingly possible as more recyclers accept modules.

Cooperation throughout the value chain

Research and development of PV-specific recycling equipment can optimize the recoverability and purity of reclaimed materials. The start-up and support of new organizations will help the industry extend the useful life of existing products while maintaining the quality and safety of the equipment. Working together with stakeholders from all these areas will help inform and develop policy appropriately so that end-of-life management solutions complement the deployment of solar.

SEIA and its members participate in research studies and projects, white papers, collaborative programs and present information, findings and research at stakeholder meetings, conferences and events to keep industry and others updated on our progress in developing end-of-life solutions.

R&D Organizations, Producers, Academia	Repair/Re-use/ Refurbishment Services	Recycling and Waste Management
• Public institutions • Private organizations • OEM Manufacturers • Component Manufacturers	• Manufacturers • Service providers • Contractors • Installers and EPCs • Operations & Maintenance companies • Waste management companies • Pre-treatment companies	• Public waste agencies • Regulators • Waste management companies • Pre-treatment companies • Manufacturers