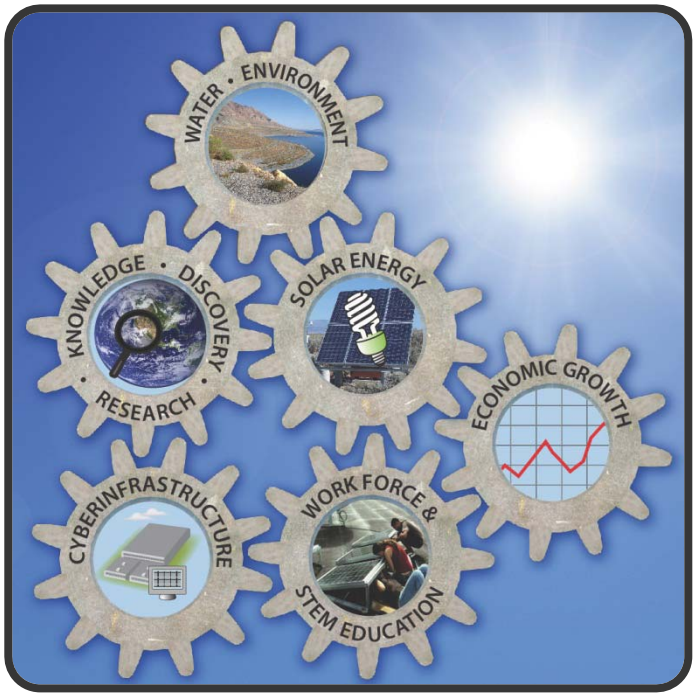
Project Summary

Development of renewable energy resources is a national priority, and Nevada is aligning its research and development activities in support of this important national goal. Three quarters of electricity production in the U.S. is from fossil fuels, which generate one third of total U.S. greenhouse gases and increase dependency on global markets. Harnessing renewable energy, such as solar, could supply all the energy the U.S. needs. The abundant solar flux in Nevada makes it one of the best sources for solar energy generation in the world, and development of this energy source has potential to significantly diversify the economy of the state. Yet, any substantial harvesting of solar energy must consider its collateral impact on Nevada's scarce water resources and sensitive desert environment. Understanding the nexus – or linkages – among solar energy development, limited water resources, and fragile environments is key to achieving benefits from solar energy in Nevada and the U.S. Nevada's proposed NSF Track-1 project will create a center of research excellence on solar energy conversion to electricity within the context of minimizing its negative impacts on water usage and the environment. The proposed center will bring together faculty and staff from a broad range of relevant backgrounds; create a new facility: the Nevada Environment, Water, and Solar Testing and Research Facility (NEW-STAR); support associated instrumentation and new faculty positions to bridge existing gaps in research capabilities; and attract talented graduate students to this area of research. The center will include enhanced cyberinfrastructure (CI) capabilities through the proposed Nevada Research Data Center (NRDC) for data management, communication, and processing that will serve the needs of the nexus, other interdisciplinary research, and education in Nevada as well as in more broadly dispersed regions. While there are other research centers in the U.S. focusing on solar energy technology, *NEW-STAR and NRDC will be unique in supporting coordinated research on the nexus of solar energy generation with impacts on water resources and the environment.*



The mission of Nevada's proposed Track-1 project is to advance knowledge and discovery through research on solar energy generation, its environmental impacts, and associated water issues and accelerate this research by developing new capabilities in cyber-infrastructure. Benefits include diversifying Nevada's economy, building its workforce, and developing innovative approaches to STEM education.
Figure credits: Blue marble image: NASA; Students w/ solar panel: research.gov; lake image: Duane Moser (DRI); Solar panel photo (NevCAN).

Intellectual merit: In order to achieve large-scale societal benefits from renewable solar energy projects in arid lands, it is essential to understand how to maximize use of limited water supplies and minimize impacts of energy development on sensitive environments. The proposed infrastructure improvements will enable an interdisciplinary team of engineers, hydrologists, biologists, ecologists, soil scientists, atmospheric scientists, and economists to meet this need through research in five interrelated areas: (1) improve and develop novel technologies to minimize water use at solar energy facilities; (2) determine desert ecosystem responses at multiple scales to perturbations associated with development of solar energy facilities; (3) develop advanced and sustainable water/wastewater approaches to support water needs for solar energy development; (4) improve the development and reliability of renewable and

solar energy supply with new interdisciplinary approaches; and (5) accelerate the nexus research with new and existing CI capabilities including advanced data services, real-time data streaming and visualization, data mining and analysis, image processing, data security, and cloud computing.

Creative, original and potentially transformative activities. Researchers propose to use nanotechnology to electro-actively remove dust particles from solar panels by fine-tuning the surface properties, which is a potentially transformative technology. Investigations into the physical, chemical, and spectral characteristics of dust can lead to improving the design of dust repellent solar panels and efficient dust removal mechanisms that will reduce the use of water at solar energy facilities. The application of new, potentially transformative low cost, high temperature devices and surfaces will lead to advanced dry cooling systems in solar plants that will result in substantial water savings. The environmental impacts research will result in science-based information that agencies can use for designing effective ways to manage and mitigate environmental issues. Additionally, it will advance understanding of landscape fragmentation in arid environments associated with solar energy development; use solar energy infrastructure to harvest rainwater and increase water availability for arid environments; increase the restoration effectiveness of land disturbed by renewable energy development; and open new potentially transformative opportunities to address population and community genomics on non-model organisms. Advances in water and wastewater treatment resulting from the research will result in more environmentally sustainable practices for solar plants by reducing discharge by-products into the environment and limiting chemical and material consumption for treatment, thereby minimizing energy for water treatment and transport as well as infrastructure footprints. Potentially transformative approaches used to improve development and reliability of renewable and solar energy supply will lead to higher reliability and quality of power; reduced uncertainty in sunlight availability for solar power generation; new uses of reuse and low quality groundwater for solar energy plants; and new economic feasibility methods that decision-makers can use in evaluating energy versus water tradeoff for solar energy investments. New CI capabilities will result in advances in obtaining and processing data and create a new archetype for CI research and development.

Broader impacts: The proposed capacity building on solar energy, water, and environmental research will have positive economic impacts in Nevada. A significant outcome resulting from the proposed research can be less expensive and thus more competitive, solar electricity. The center will attract solar companies that will take advantage of NEW-STAR's capabilities and expertise; train people in the skills needed to enhance the ability of Nevada to meet the qualified staffing needs of solar companies; demonstrate to solar companies that the state is eager to collaborate and facilitate work on technical issues; demonstrate to companies that performance improvements to solar plants are possible, with this message spreading through the industry; and assist governmental agencies in better understanding the implications of the solar plant approval process, resulting in a more company-friendly environment for locating operational plants in Nevada. The challenges to solar power development are not unique to the U.S; therefore, the proposed NEW-STAR facility will foster collaboration with researchers from other arid and sun-rich regions, including Southern Spain, Israel, Western China, North Africa, and Australia.

Through the proposed project, Nevada will develop innovative approaches to CI and STEM education, engage stakeholders, and build its workforce while diversifying its economy. Advanced CI capabilities will enable interdisciplinary research as well as education and outreach. Through a life-cycle approach, workforce and education development activities will build and sustain research capacity and Nevada's economic growth by (1) developing trained manpower at graduate, undergraduate, and community college levels that will supply needs of the solar power industry, environmental agencies, and the water industry; (2) developing and expanding a STEM teacher workforce; (3) enhancing education and public understanding of solar, water and energy that will lead to development of a sustainable STEM workforce; (4) establishing a sustainable social network for learning; (5) exposing and involving rural counties, K-12, and underrepresented communities to STEM topics and cutting-edge research; and (6) increasing participation in STEM education through peer-directed content and mentors. External engagement with stakeholders will enable Nevada scientists to collaborate locally and nationally while developing

relationships with industry and funding agencies to strengthen research that will support economic development in Nevada.

Supporting this Track-1 project are the following plans for diversity, workforce development, CI, external engagement, evaluation and assessment, sustainability, and management:

The goal of the **Diversity Plan** is to develop a comprehensive approach that leads to an increase in the number of underrepresented students graduating from STEM programs. The diversity team will work collaboratively with the research group to build a sustainable, integrated program through enhancing knowledge and participation while increasing aptitude, advancement, and diversification of STEM enterprises for individuals, institutions, and geographic regions.

The goal of the **Workforce Development Plan** is to develop a sustainable STEM workforce by creating a pipeline of STEM-trained students, educators, and workers while increasing public understanding of solar energy, water, and the environment. This integrated, multifaceted program will take a coordinated "life-cycle" approach involving pre-college, undergraduate, and graduate students; teacher professional development; as well as K-12 and public outreach. Plan activities will be aligned with the Nevada Governor's Plan for Excellence in Economic Development and will support industry sectors such as renewable energy and workforce diversification.

The goal of the **Cyberinfrastructure Plan** is to develop cutting-edge technologies to improve research and education in Nevada, from data generation through utilization and dissemination. The proposed project will enhance network, hardware, and software infrastructure, creating an end-to-end system that automates, manages, and curates data, driving long-term, interdisciplinary research.

The goal of the **External Engagement Plan** is to enable Nevada scientists to collaborate and develop relationships with industry, institutions, and the public to strengthen research supporting economic development of Nevada. Key activities that will promote this goal include rapid communication with project teams and stakeholders about project results and benefits; participation with stakeholders and institutional entities to increase knowledge sharing of the sciences; and activities that will enhance STEM education for students, particularly women and underrepresented groups, through strategic partnerships.

The goal of the **Evaluation and Assessment Plan** is to assess and evaluate demonstrable impacts and achievements of the proposed project. External evaluation will incorporate front-end evaluation to assess needs; ongoing formative evaluation to monitor the quality of project components and implementation while providing feedback to the leadership team; and summative evaluation to assess overall achievement of stated goals and broader impacts. An external advisory committee composed of national experts will review progress toward achieving project outcomes; make recommendations for improving and/or changing direction of the work underway; and advise the management team.

The goal of the **Sustainability Plan** is to create lasting operational support for the proposed infrastructure for an extended period of time despite changes in funding sources, program models, service providers, participating scientists, and stakeholders. Sustainability is built into the proposed project through targeted education and human resource development activities, and specified metrics for reaching extramural funding targets. Sustainability goals – with associated benchmarks, timelines, and metrics – for sustaining project achievements and impacts have been embedded in each of the project's goals.

The goal of the **Management Plan** is to implement the proposed research infrastructure improvement activities and manage all aspects of the proposed project. The plan draws on strengths of Nevada's NSF EPSCoR program structure, which includes a State Advisory Board, Management Team, Project Teams, as well as an Evaluation and Assessment team. Communication mechanisms to support project management include an annual state meeting, NSF EPSCoR project director and national meetings, and online video and/or teleconferences.

In summary, Nevada's proposed Track-1 project will enable development of an integrated program through investment in physical, cyber, and human infrastructure, building on Nevada's strengths in solar energy, water, and environmental research and expanding these capabilities to make the state more competitive in these fields while fostering expansion of the renewable energy industry.