Solar Energy | Water | Environment

Nexus IN NEVADA

Innovative research to achieve water efficient and environmentally friendly solar power

SOLAR ENERGY-WATER-ENVIRONMENT NEXUS PROJECT

Are you interested in solar energy generation, associated water use, and the potential environmental impacts of large-scale solar energy generation?

The Nevada Solar Nexus project, funded by the National Science Foundation EPSCoR program, has developed state-of-the-art facilities that can catalyze research. We are seeking collaborators to perform research in these facilities.

180 Scientists, Engineers, and Educators

UNLV | University of Nevada, Reno | DRI Desert Research Institute

solarnexus.epscorspo.nevada.edu

Microgrid
Test new smart devices

Nevada Solar-Water Express
Water reuse and reclamation technologies in rural areas

Advanced Dry Cooling Test Facility
Improve dry cooling performance

Solar-Driven Supercritical CO2 Cycle Engine
Minimize water use for renewable/solar energy

Environmental Towers Network
Impact of solar plants on microclimates

NSF | EPSCoR NEVADA

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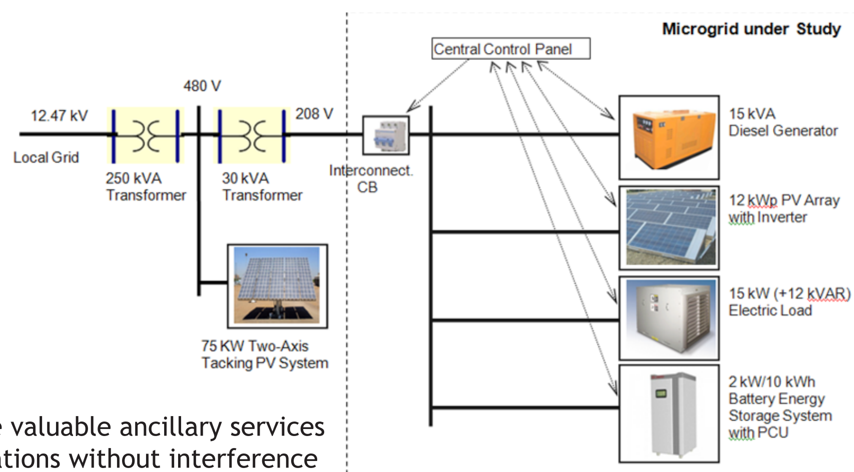
Microgrid - A Test Bed for Future Smart Grids with Distributed Energy Generation

A research microgrid has been built by Solar Nexus scientists at the University of Nevada, Las Vegas to test new "smart" devices that will be deployed in the future smart grid.

Microgrids, also called minigrids, are local power networks that use distributed energy resources and manage local energy supply and demand to increase reliability for the local load. Microgrids already exist in applications that require 100% power availability (e.g. hospitals, airports, data centers, military installations) and are among the major technical cornerstones in the U.S. Department of Energy's vision of the future "smart" electric power infrastructure.

CAPABILITIES OF THE UNLV MICROGRID

- Conduct field tests on new concepts in grid modernization.
- Increase solar photovoltaic penetration into the electric grid by minimizing its interference with grid operation.
- Improve ability of the power grid to adapt to short- and long-term changes.



RESEARCH RESULTS TO DATE

Results show that smart inverters can (a) provide valuable ancillary services to electric utilities, (b) still detect islanded situations without interference from advanced functions, and (c) generate harmonic currents well within the recommended limits specified in interconnection standards. The results have been presented in the following publications:

W. Peng, C. Hicks, O. Gonzalez, B. Blackstone and Y. Baghzouz, "Experimental Test on Some Autonomous Functions of Advanced PV Inverters", IEEE PES General Meeting, Boston, MA, July 17-21, 2016.

C. Hicks, W. Peng, and Y. Baghzouz, "Experimental Test on the Islanding of an Advanced PV Inverter", IEEE/SPEEDAM, Capri, Italy, June 22-24, 2016.

T. Taylor, O. Gonzalez and Y. Baghzouz, "Harmonic Analysis of a 'Smart' 3-Phase PV Inverter", IEEE/ICHQP, Belo Horizonte, Brazil, October 16-19, 2016.

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Nevada Solar-Water Express

The Nevada Solar-Water Express cargo trailer houses state-of-the-art and standard water/solar technologies to support research and educational activities on energy and water.

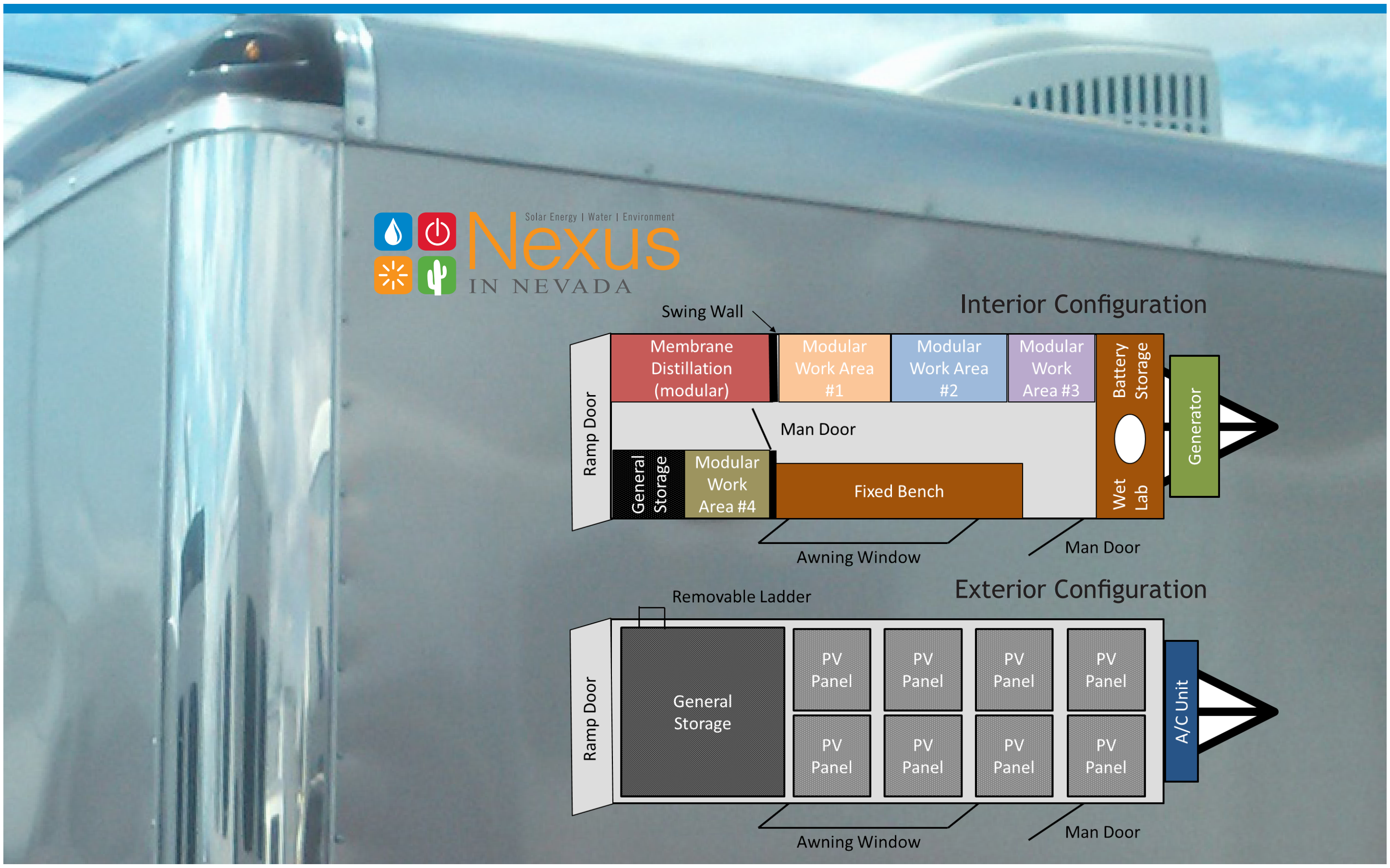
The Express can be located in remote sites for research and to demonstrate engineering and science applications statewide.

CAPABILITIES

- Mobile pilot-scale system for use on campus and at industry sites.
- Advanced water treatment technologies including ozonation, reverse osmosis, membrane distillation, and ion-exchange columns for use in treatment trains.
- Features include: window for demonstrations, extended tongue for generator, fixed bench-space, small wet-lab area, module areas for treatment technologies, and rooftop PV panels to demonstrate solar energy systems.
- Supports research on water reuse and reclamation and outreach activities in educational grants.

RESEARCH RESULTS TO DATE

Results show that membrane distillation operation with concentrations less than 0.05 wt% can be tolerated by the PTFE MD membranes without pore wetting. Membrane systems have been ordered and UV and ozone systems are being selected for purchase.



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Improvements to Dry Cooling Technology

A near full-scale, advanced dry cooling unit has been built by Solar Nexus scientists which includes forced convection ambient air flowing over finned copper tubes to condense vapor in steam power plants.

Improving dry cooling technology and developing more efficient thermodynamic cycles in solar plants can lead to less water use in thermal power plants. This saves considerable water in generating power but degrades plant efficiency. Since dry cooling can ideally result in only small deficits in performance compared to wet cooling while saving a great deal of water, performance improvements in current designs can be extremely valuable. Our advances in dry cooling will be nearly as efficient as wet cooling but with no loss of water.

CAPABILITIES

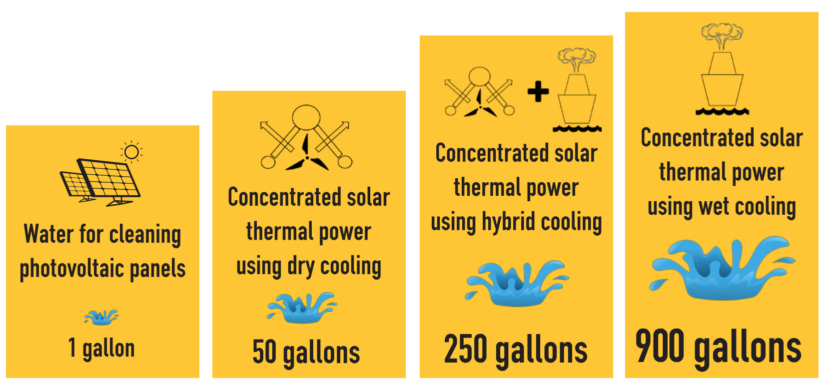
- Used to conduct experiments emulating an air-cooled cycle heat rejection device to understand and improve the performance of dry cooling systems.
- Good test facility to evaluate possible new potential improvements.
- The basic system design is a piece of equipment that can be used to evaluate advanced cooling approaches.

RESEARCH RESULTS TO DATE

New key computer analysis codes increases our understanding of the steam condensing phenomena both for power cycles as well as other related processes. Modifications to the experimental air-cooled heat exchanger system resulted in an improvement in accumulated condensate in the lower manifold. Complete condensation could be accomplished using a fraction of the original fan power. Mass flow rate measurements demonstrated that heat transfer coefficients were consistent (<2% variation) across multiple tests for identical system parameters.

WATER USE OF SOLAR ENERGY PRODUCTION

(Water consumed to produce one megawatt-hour of electricty, which is enough to power 1,000 homes for an hour.)



Data based on median values, rounded, from Macknick J, R Newmark, G Heath, and KC Hallett. 2012. Operational water consumption and withdrawal factors for electricity generating technologies: a review of existing literature. Environ. Res. Lett. (2012) 045802. Icons by freepik.com.

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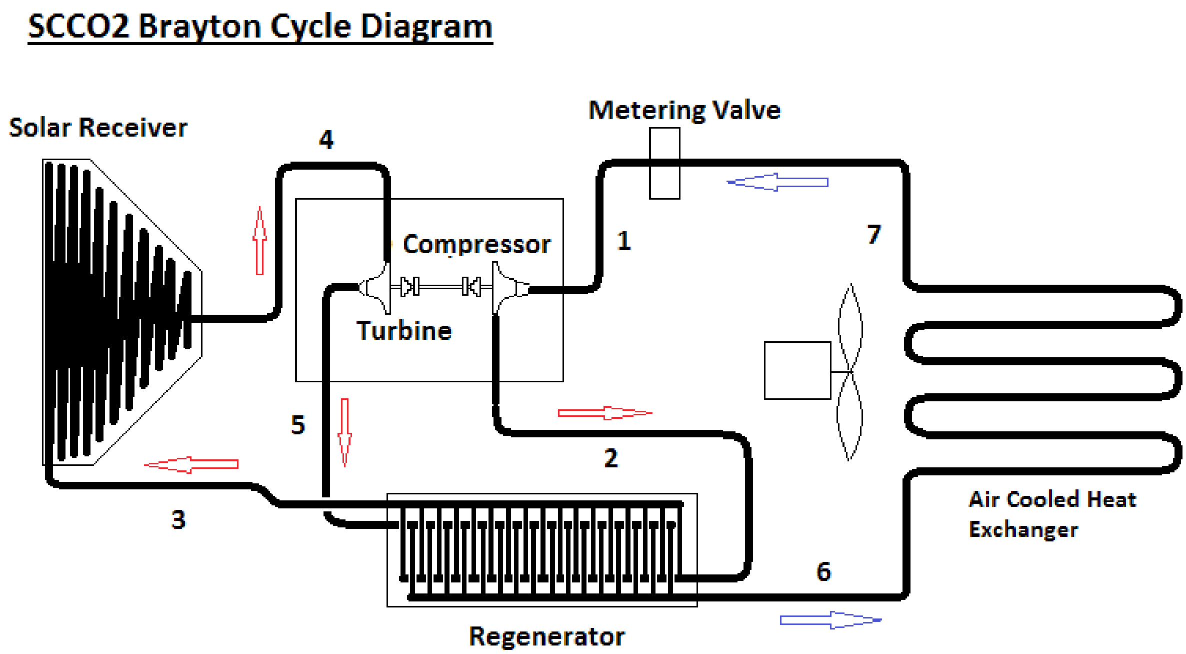
Solar Powered Supercritical CO_2 Engine



The Solar Nexus project has built the first solar-driven supercritical CO2 cycle engine for conducting research on advanced high efficiency power cycles.

Motivations include using higher operating temperatures and to achieve greater thermal conversion efficiencies, advanced equipment concepts including heat exchangers, receivers, turbines and compressors, and combining these to yield high efficiency thermal performance. New designs include heat exchangers and advanced turbine/compressor units with major improvements in system integration.

CAPABILITIES

- Uses a more efficient power generation cycle with a solar concentrator, while vastly reducing water consumption by using carbon dioxide as the working fluid.
- Supercritical Brayton power cycles will provide experimental data and analyses which connect published system modeling results with experimental efficiency, economic trade-offs, and reliability of data collected.
- Could minimize water use at solar energy facilities and improve reliability, economic modeling, and sunlight forecasting for renewable/solar energy supply.

RESEARCH RESULTS TO DATE

A solar dish concentration system furnishes energy to the receiver portion of the new engine and achieves a solar concentration up to about 500X. A new control system uses common control devices. Systems committed to hardware are time consuming and expensive to apply major changes. Therefore, a simulation computer code was developed to describe the system operation, which enables the evaluation of a system variations for improving performance in future designs.

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Environmental Research Towers at Full-Scale Solar Plant in Eldorado Valley, Nevada

Do large scale solar facilities alter the microclimate and surface hydrology of desert ecosystems?

To answer this question Solar Nexus scientists set up a network of environmental towers next to a solar plant (photovoltaic panels) in Eldorado Valley in Southern Nevada that generates enough energy to power about 50,000 homes.

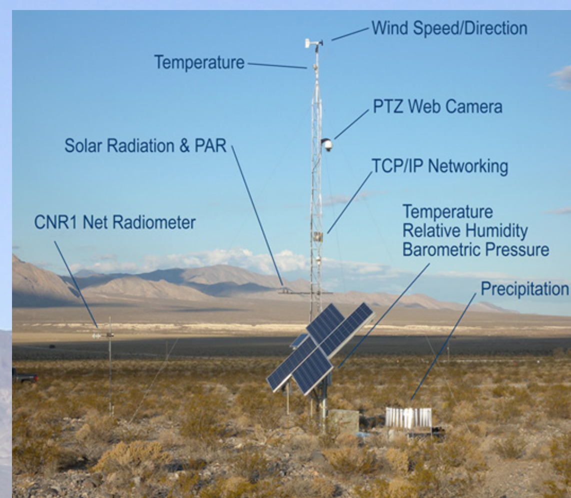
CAPABILITIES

Three 10-meter high environmental towers are installed:

- one just within the southern boundaries of the facility,
- a second 100 meters outside the facility on the north side,
- a third, 2.3 kilometers north again.

Each tower records atmospheric conditions including temperature, relative humidity, wind speed, solar radiation as well as soil conditions such as soil moisture and temperature. There is potential for other sensors to be added.

A grid network of mini towers are also installed, which house air temperature sensors located at heights of 10 centimeters, 1 meter, 2 meters and 3 meters above ground level.



RESEARCH RESULTS TO DATE

The large scale solar facility impacts desert plant microclimate and hydrology by:

- Altering turbulence which creates greater mixing and movement of air and vapor in the adjacent plant community.
- Altering thermal patterns in the adjacent plant community.
- Altering surface hydrology impacting water balances of plant communities.
- Altering plant water status, with plants growing within 500 m down gradient of the facility under significantly greater levels of water stress.

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