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A River of Energy Solutions

Air Force Academy

Mr. Russell Hume



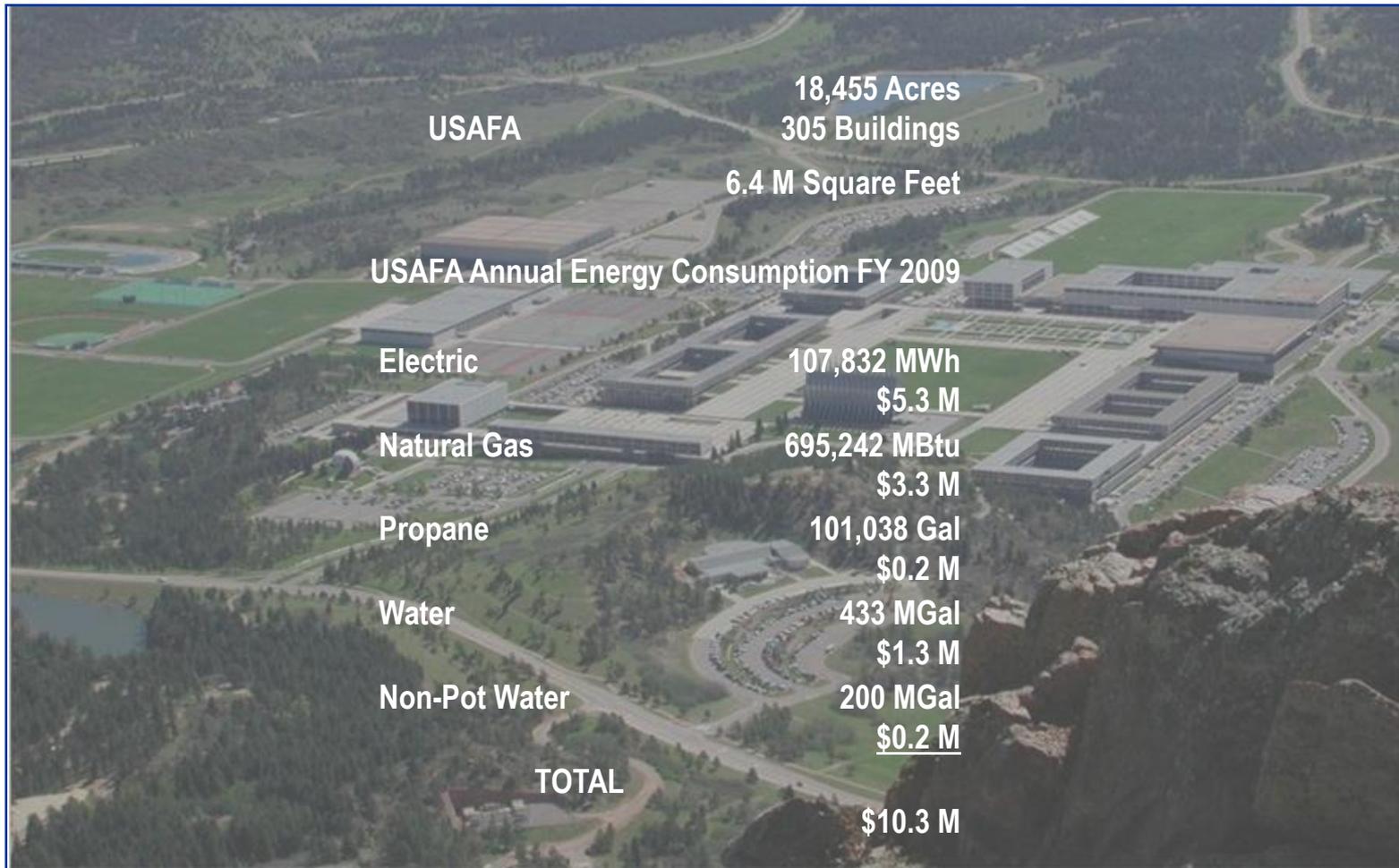
Overview



- Air Force Academy and Net-Zero
- Energy Initiatives
- USAFA's Solar Project
- Building-Integrated Photovoltaic Roofing
- Research and Deployable Emerging Technologies



United States Air Force Academy

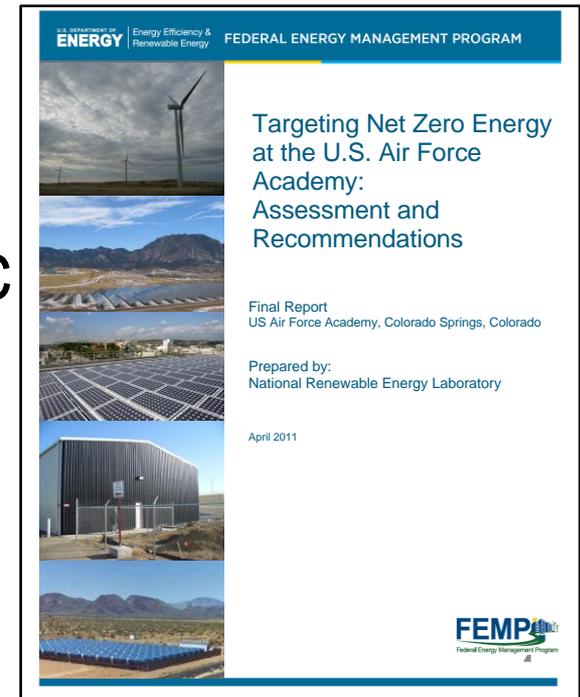




Net Zero



- The Air Force Academy was chosen by the Air Force as representative in the Department of Defense/Department of Energy Net Zero Energy Installations (NZEI) initiative.
- Draft report delivered on 22 Apr 11
- USAFA to develop revised strategic plan based on report suggestions

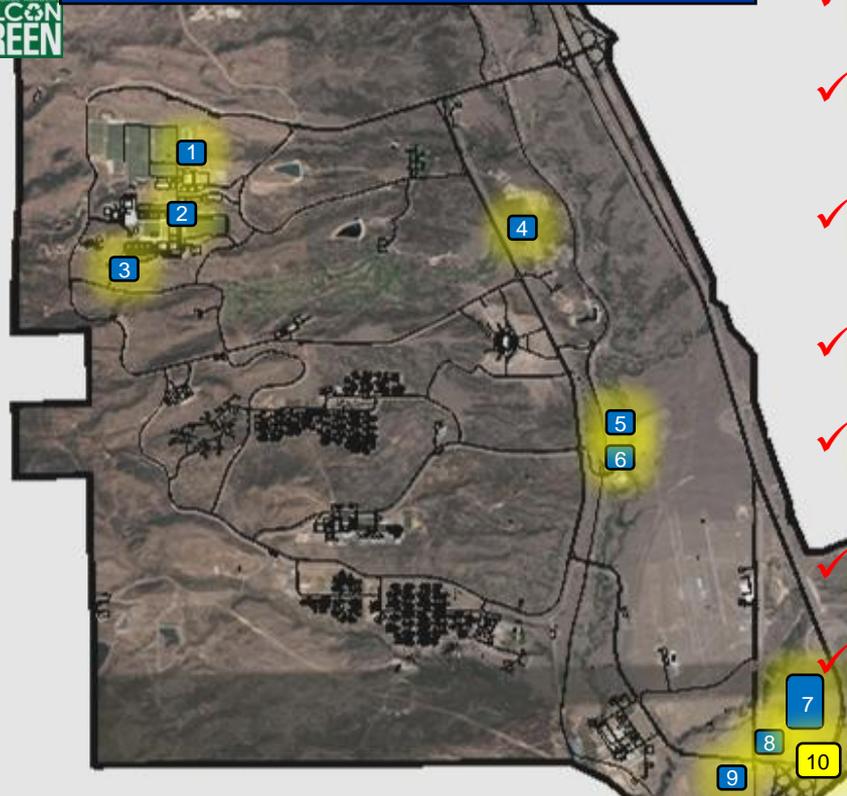


USAFA Energy Initiatives



Conservation, Innovation, Education

The Air Force Net Zero Installation



✓ - Complete

Demonstration Projects

10 16 kW Concentrated PV

USAFA Energy Initiatives

- ✓ 1 Ground Source Heat Pumps at Batting Cages
 - Installed 2006
- ✓ 2 Photovoltaic Roofing Vandenberg Hall
 - 177 kW – Installed
 - 300 kW – Under Contract
- ✓ 3 Ground Source Heat Pumps at Entry Control Points C-1 and C-2
 - Installed 2004
- ✓ 4 Maxicon Irrigation Control System
 - Installed 2010
- ✓ 5 Methane Recovery Sludge Reheat at Waste Water Treatment Plant
 - Installed 1998
- 6 30 kW Microturbine Burning Digester Gas
 - Installed 2004
- 7 6MW Solar Array Funded with ARRA funds
 - Fully operational June 2011
- 8 Ground Source Heat Pumps at Visitor Pass and Identification
 - Installed in 2003
- ✓ 9 Ground Source Heat Pumps at South Gate
 - Installed in 2003

USAFA's Solar Project



- The Air Force Academy's Energy Strategic plan devised in late 2008 specified two solar arrays to be sited on USAFA
- American Recovery and Reinvestment Act of 2009 provided an opportunity to acquire the funding necessary for one of the arrays
- The initial concept was a 2 MW ground-mounted array



Project Concept Development



- USAFA's "portion" of the stimulus was increased slightly to match the estimate of \$18.3M that it would cost to construct a 2 MW array
- How could we improve Return on Investment?
 - Business Case Analysis – USAFA ownership not best
- USAFA is interested in power, not necessarily in ownership of an array – especially since electric distribution system partially owned by local utility

Project Concept Development (cont.)



- As an arrangement for power, vice a construction project what are factors to consider:
 - 40 USC 591 – go to current provider first for provision of electric service
 - How is current provider's contract written – do you need a new contract or can you use existing?
 - Siting, environmental considerations and real estate provisions
 - Type of money and expensing money properly

The USAFA Solar Project Concept



- Award delivery order to current utility provider, Colorado Springs Utilities (CSU) under existing General Services Administration (GSA) area-wide contract
- Use \$18.3M as connection charge under guidance from Air Force Instruction (AFI) 32-1061 & Federal Acquisition Regulations (FAR) parts 41 and 32
- USAFA receives solar power at \$0.00 per kWh for life of the array

Benefits of the Project Concept



- USAFA gets power - guaranteed minimums, operations and maintenance, capital upgrades to components
- CSU creates structure to take advantage of incentives
 - 30% tax grant on solar afforded by ARRA
 - Accelerated depreciation
 - Sells Renewable Energy Certificates (RECs); benefit goes to USAFA

Details of the Deal



- Delivery Order under GSA contract awarded in Aug 09
- CSU writes Request for Qualifications (RFQ) to determine qualifications of offerors and interest in the project – Jan 10
 - 20+ respond to RFQ
- CSU, with USAFA on the selection team, determine 6 most highly qualified offerors to bid on project

Details of the Deal (cont.)



- Request for Proposal (RFP) developed and distributed to 6 most highly offerors in Apr 10
- Once bids received, evaluation began
- In summer of 2010 intent to award the project was released
- CSU awarded subcontract in fall; construction started in fall
- Commercial operation in Jun 11





Summary of the Project



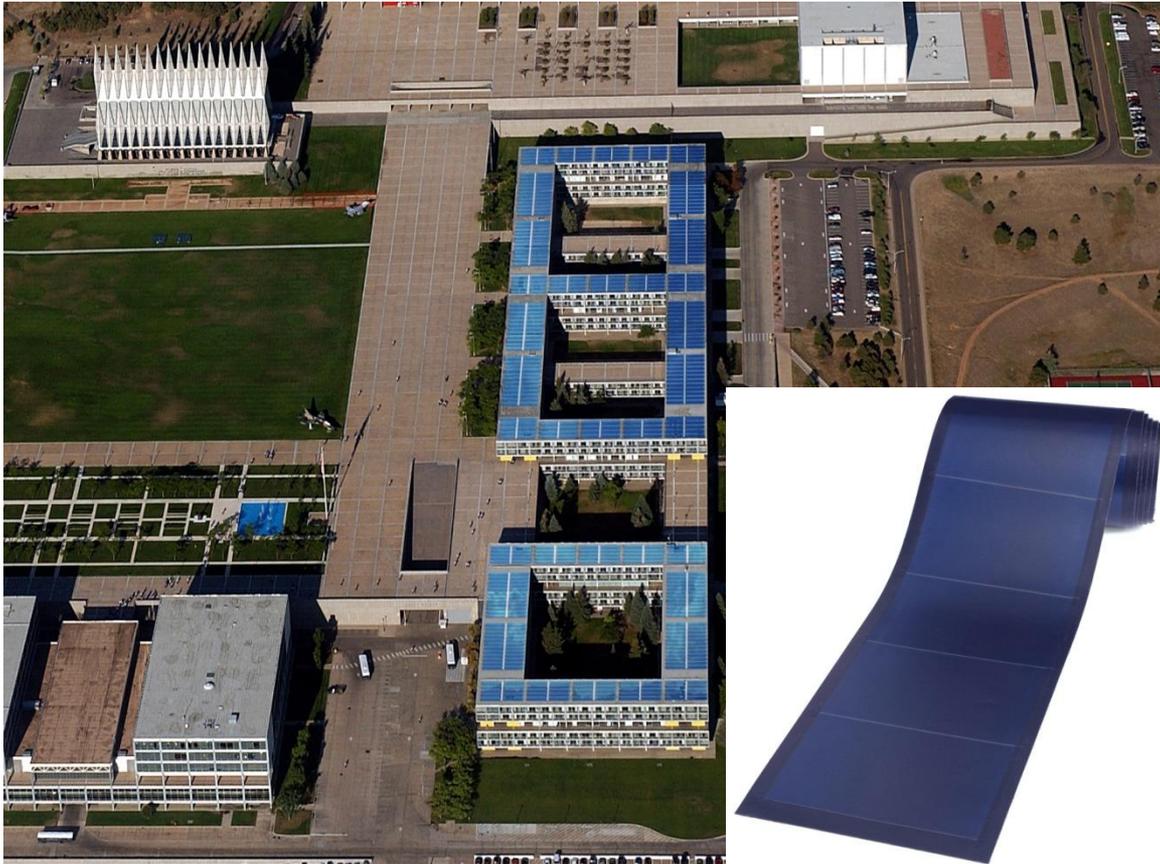
- \$18.3M investment
- 6 MWp (5.2 Mwac) - \$3.0M per MW!
 - Sun Power T0 Tracker
 - ~19,000 panels
 - ~4,800 piers
 - 32.4 acres of panels
 - 40.5 acres in total
- 11% of USAFA's current electrical need
- Saves an estimated \$1M+ annually



The Finished Product



Building Integrated Renewables



Vandenberg Hall PV

- “Fix USAFA” Renovation
- Roof Area ~150,000 SF
- Solar PV Area ~112,000 SF
- Savings of \$95K per year
- East tower PV output 173 kW
- West tower under contract - 300 kW

Total roof production constitutes 1% of USAFA’s projected 2015 consumption



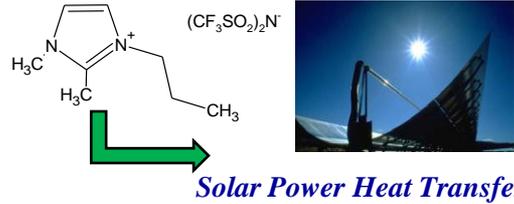
USAFA Energy Research



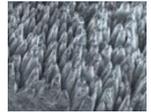
Creating a Sustainable Future

Chemistry Research Center

- Ionic liquids for heat transfer
- Hydrogen generation/storage



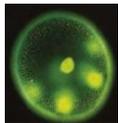
Laser & Optics Research Center



- “Black silicon” for more efficient solar cells

Life Sciences Research Center

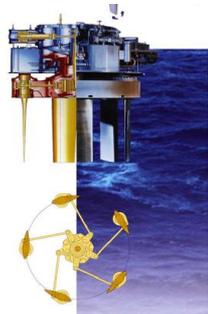
- Algae cultivation for biofuels
- Biofuel extraction & use in aviation



Algae



Biofuel

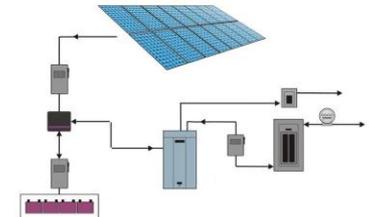


Aeronautical Engr

- Wave power from the ocean

Electrical & Computer Engr

- 7KW solar Green Energy lab
- Power generation, storage, and conversion

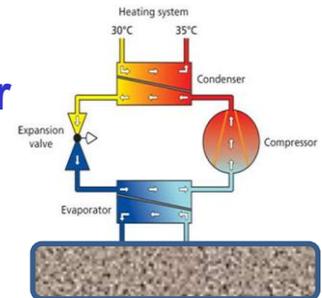


Engineering Mechanics

- Wind energy to power sensors and transmitters on bridges & remote sites

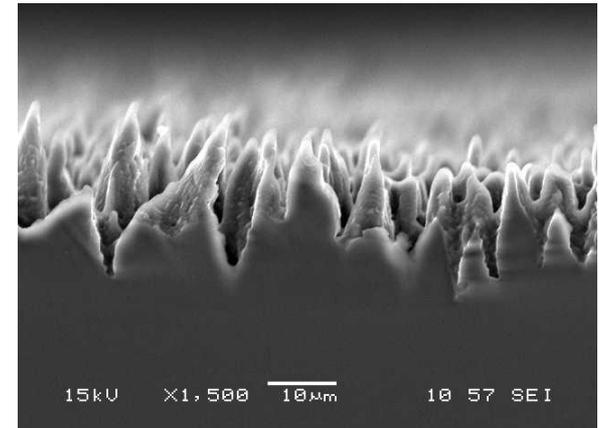
Civil & Environmental Engr

- Energy foundations
- Geothermal heat pumps



Black Silicon

- Surface modification of ordinary silicon to enhance light absorption
 - Originally created via laser etching in sulfur-rich atmosphere
 - Visible enhancement attributed to morphological changes
 - Infrared enhancement attributed to chemical effects
 - Applications
 - Silicon based night vision
 - More efficient solar cells
- State of the art prototypes
 - National Renewable Energy Laboratory
 - Chemical wet-etching technique (only changes morphology)
 - Significant solar cell efficiency enhancement



USAFA Research

- Focusing on understanding underlying physics
 - Separate morphological vs. chemical effects
 - Investigating ways to enhance IR absorption
- Understanding the science will enable process optimization, further enhancing solar cell efficiency

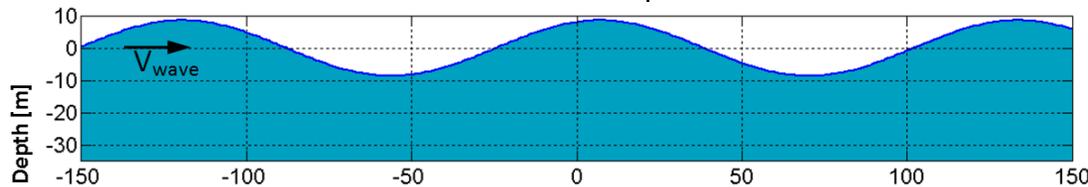
Cycloidal Wave Energy Conversion



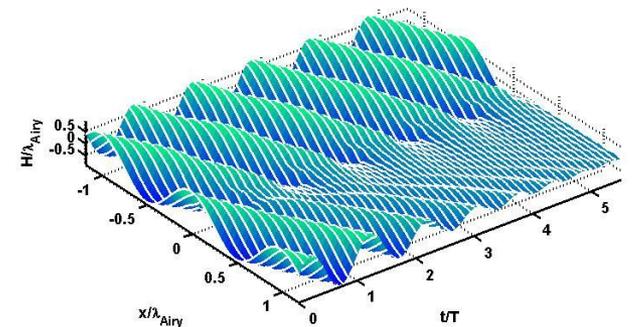
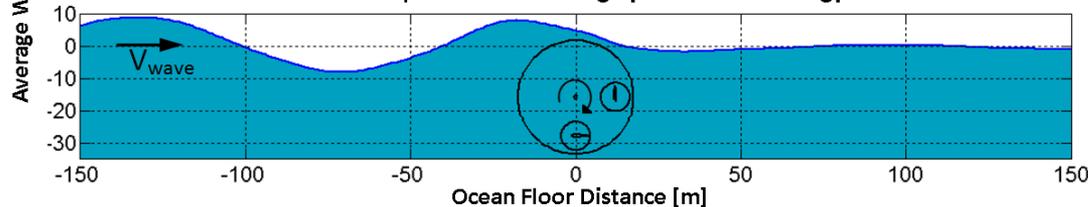
- **Cycloidal Wave Energy Conversion**
 - **Harness the Energy of Ocean Waves**
 - **New approach using a Cycloidal Turbine**
 - **Wave cancellation with >99% efficiency**
 - **Can survive storms by feathering**
 - **Funded by the National Science Foundation**



Standard North Atlantic Deep Ocean Wave



Cancellation of Deep Ocean Wave Using Cycloidal Wave Energy Converter



*Patent # 7,686,583 Cyclical
Wave Energy Converter*

Cycloidal Wave Energy Conversion



- **Outcomes & Breakthroughs:**
 - Investigated cycloidal wave energy conversion in 1:300 scale experiment and simulation
 - Achieved 99% efficient wave cancellation in simulation and 95% in experiment
 - Successful feedback control
 - Efficient cancellation of harmonic and irregular waves
- **Impact:**
 - Utility scale wave power to electricity conversion, multiple MW from a single unit, low cost of energy
 - Ability to survive storms due to fully submerged operation and blade feathering
- **Outlook:**
 - Spinoff company Atargis Energy Corporation, founded in 2010
 - 1:10 scale tests in Aug 2011 will measure electric power output, funded by Dept. of Energy, to advance TRL from 3 to 4 by 2012
 - More information: <http://www.atargis.com>

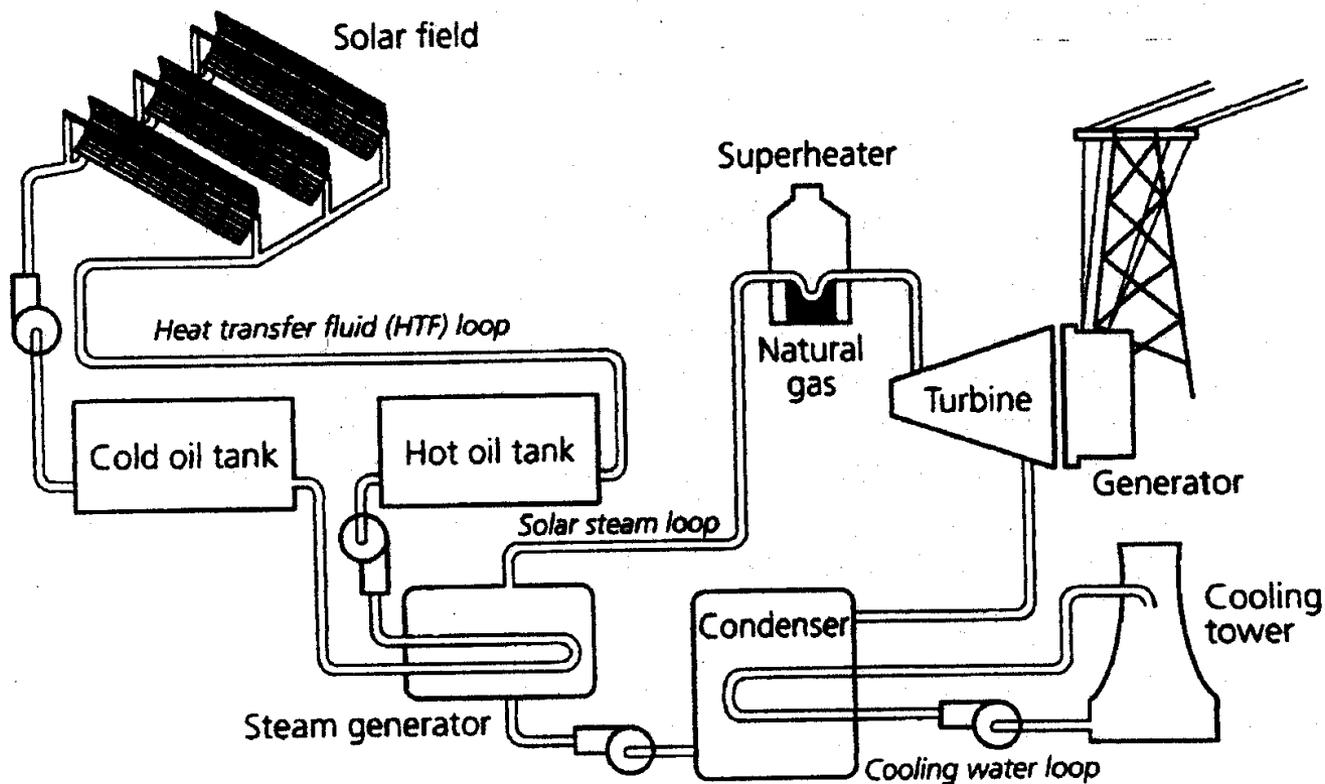


Ionic Liquids

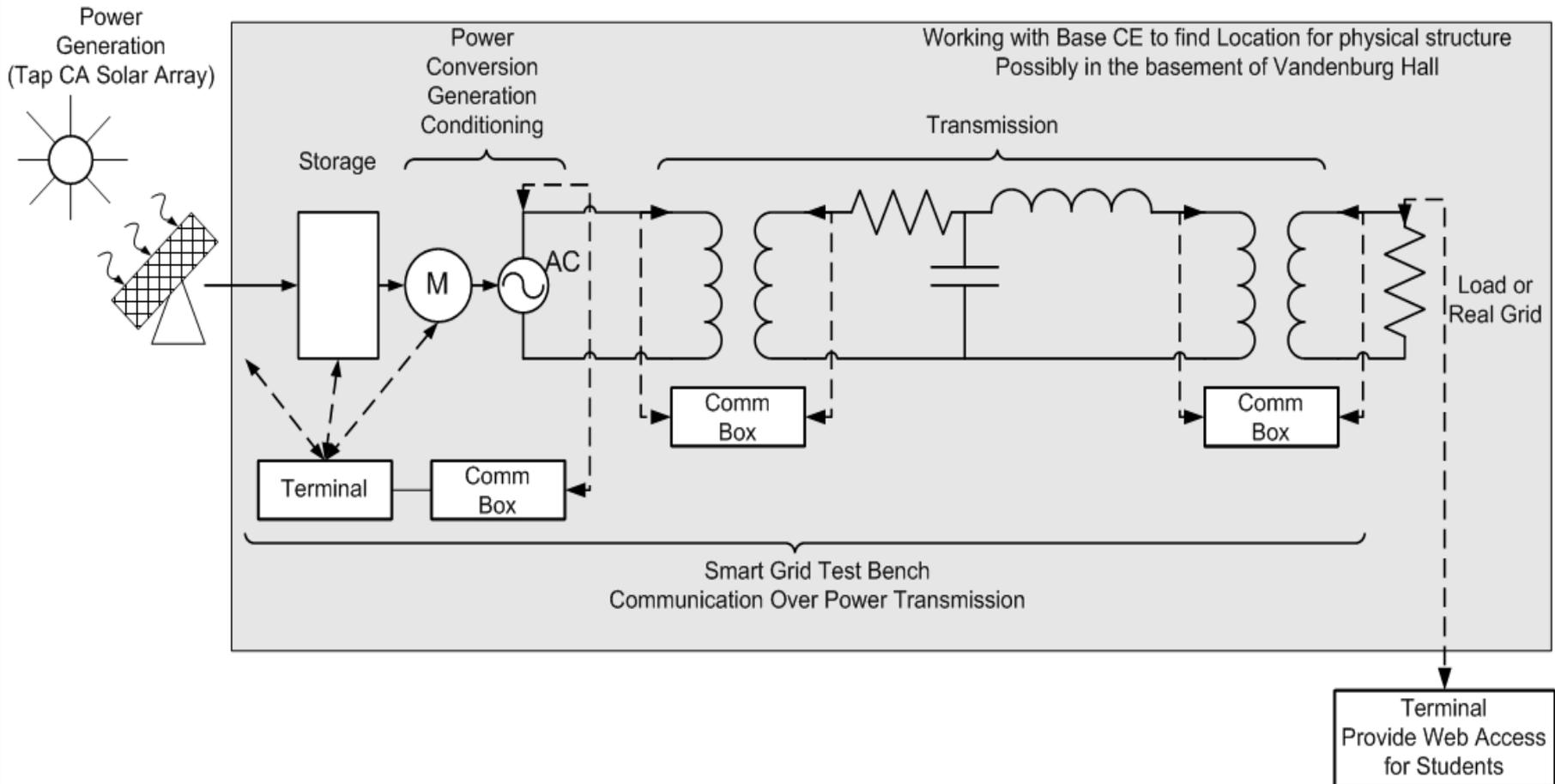
Definition

- A salt with a freezing point below the boiling point of water. Usually liquid at room temperature.
- Synonyms:
 - Room temperature molten salt
 - Low temperature molten salt
 - Ambient temperature molten salt
 - Liquid organic salt

Parabolic Trough Solar Power Plant



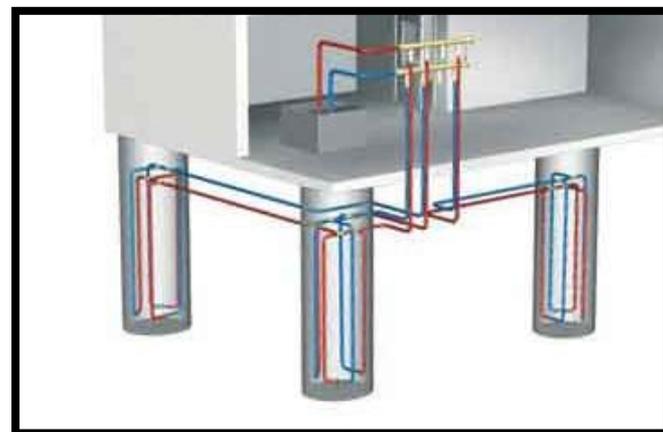
Micro grid/Energy Storage Mini Lab



Energy Foundations



- Energy foundation demonstration project
 - Geotechnical investigation
 - Shallow foundation design
- Research objective
 - Compare fuel & emissions savings between conventional and energy foundation heating systems



GreenVolts Concentrated PV



- 16 kW unit
- Tie into Pass & ID building
- Will make Pass & ID net zero during daytime
- Execution in Calendar Year 11

Questions?

