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Groundwater Remediation and Alternate Energy at White Sands Test Facility

September 2008

Holger Fischer
Facility Operations

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Content

- WSTF Core Capabilities
- WSTF Groundwater Remediation Program
- Alternate Energy Programs
  - Wind Energy
  - Solar Testbed
    - Solar
    - Vehicle Plug-in
    - Energy Storage
  - Utility Size Peak Shaving Solar Generation Plant

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- WSTF Core Capabilities
  - Remote Hazardous Testing of Reactive, Explosive, and Toxic Materials and Fluids
  - Hypergolic Fluids Materials and Systems Testing
  - Oxygen Materials and System Testing
  - Hypervelocity Impact Testing
  - Flight Hardware Processing
  - Propulsion Testing

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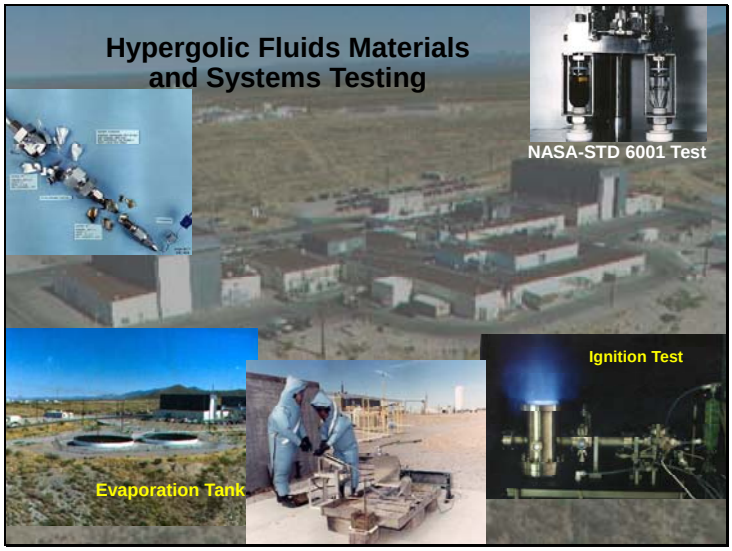

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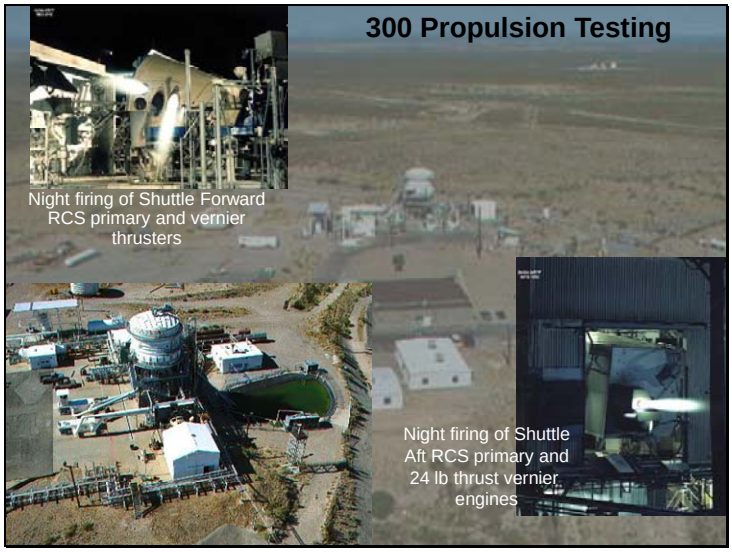

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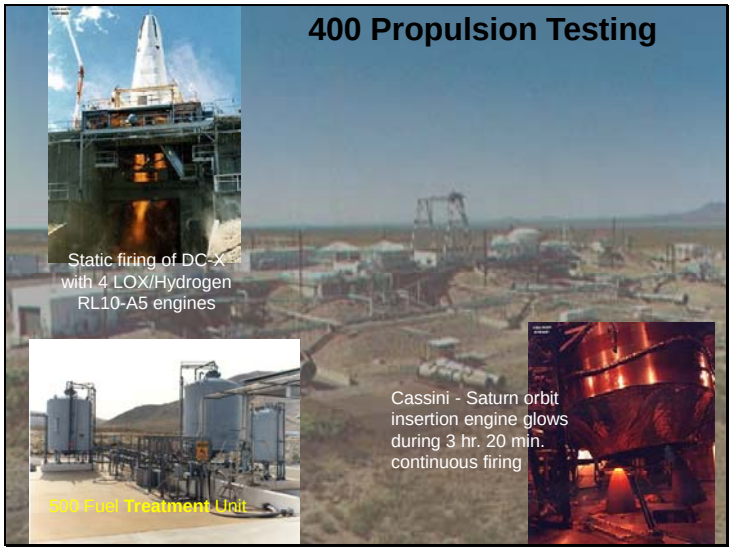

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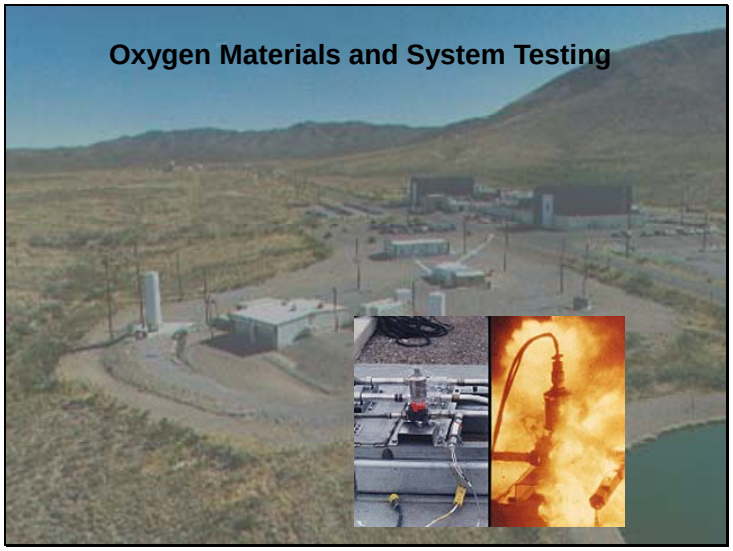

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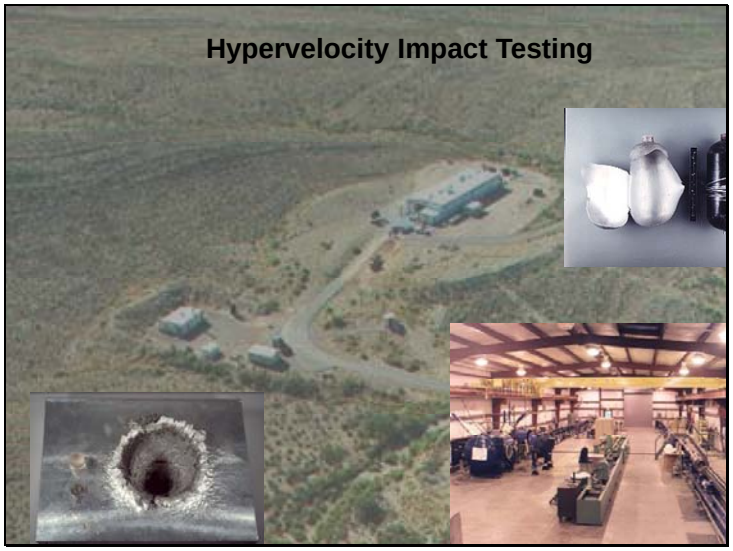

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Restoration Program

- Historic operations and practices beginning in the 1960's (through the early 1980's) resulted in contamination of WSTF's groundwater.
  - Propulsion system testing programs:
    - N-Nitrosodimethylamine (NDMA)
    - Dimethylnitramine (DMN)
  - Component Servicing and Cleaning Operations:
    - Trichloroethene (TCE)
    - Tetrachloroethene (PCE)
    - Freons: (11, 21, and 113)
- WSTF contaminated ground water is NASA HQ's greatest liability (estimated at $350M).

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Restoration Program

- Priority: Protect the public's health and the health of our workforce.
  - Containment
    - Stop the migration of contaminated groundwater
    - Greatest health-risk liability pursued initially
      - Plume Front
      - Mid Plume
      - Source Areas
  - Restoration
    - Clean-up the environment to preexisting conditions

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Public and Employee Assessment

- There is no impact to any drinking water well
  - Includes public wells and the NASA supply well.
- There is no public exposure
  - Groundwater is several hundred feet below ground.
  - No air or surface water exposure.
  - Plume is moving very slowly to the west.
    - Plume Front Treatment system will stop this westward movement.
- NASA performs on-going monitoring
  - More than 200 wells and zones are routinely sampled.
  - ~850 samples are obtained monthly and analyzed for over 300 different hazardous chemicals.

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Containment and Restoration

- A Staged Approach over ~60 years:
  - Attack the greatest risk to public health first
    - Stabilize the plume front (in progress)
  - Stop migration of contaminant into the plume front
    - Extraction and treatment at the Mid Plume Constriction Area (~2009)
    - 60% Review completed, 90% Review Oct 08
  - Stop migration into the Mid Plume Constriction Area
    - Clean up the source areas (~2012-2015)

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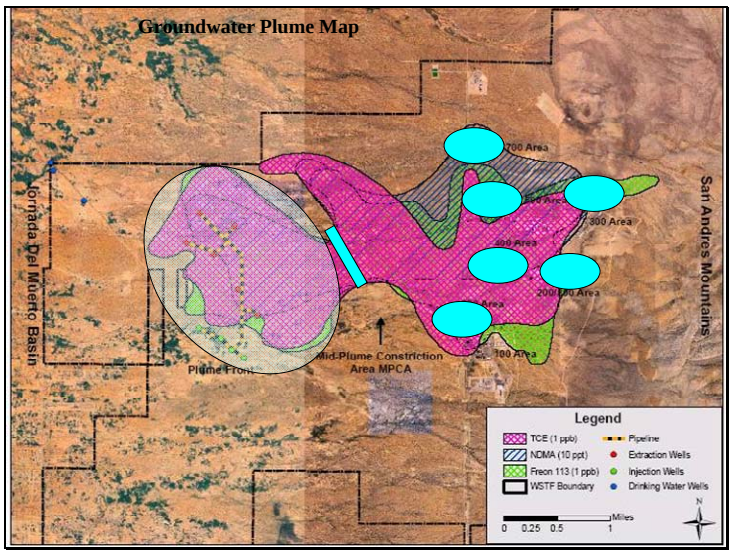

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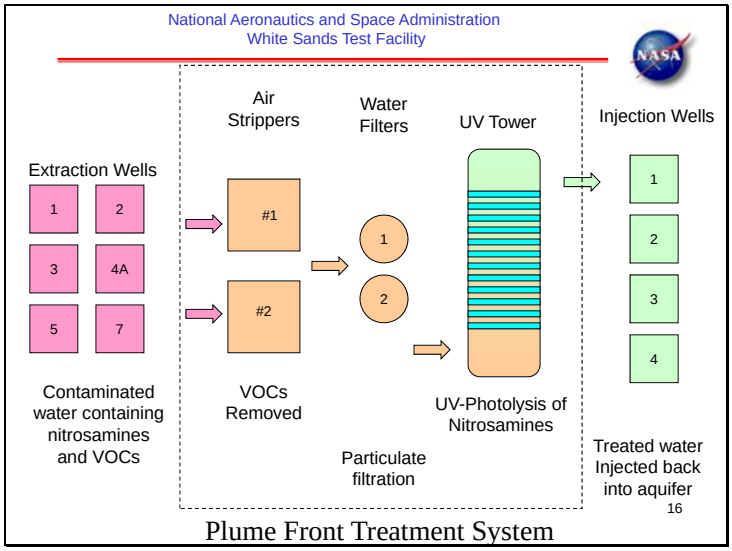

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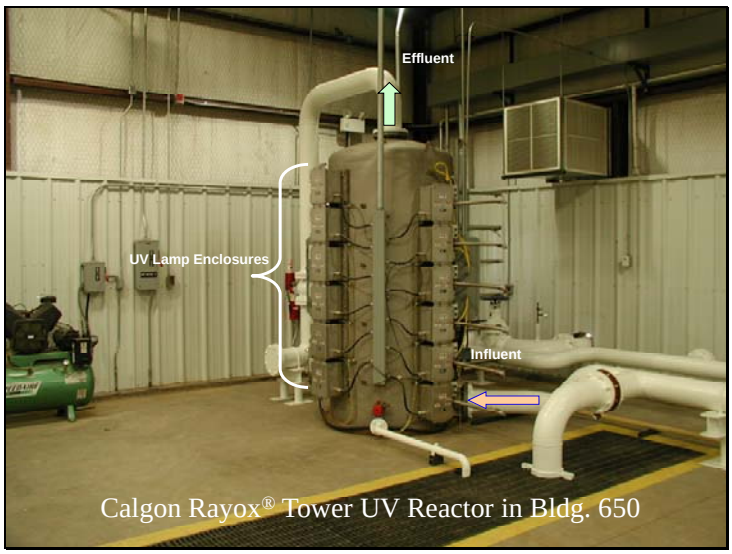

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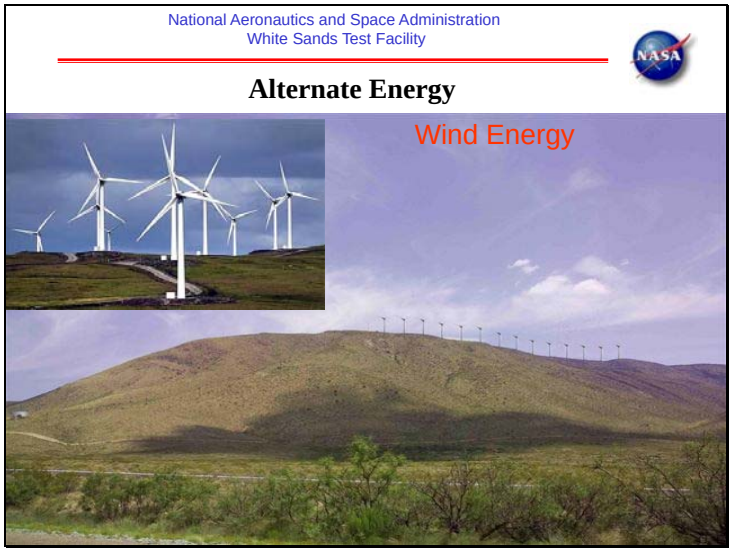

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Alternate Energy

- Wind Energy:
  - Monitored Quartzite Mountain Range since about 2005 – 4 to 5 class wind site
  - Initial EA performed by WSTF Environmental
    - Bat study (Fall 2007/Spring 2009)
    - Radar issues with WSMR (formed working group with WSMR test ops)
    - Cost for road to access planned wind farm area about $ 5 – 6 M
  - Developers interested in constructing wind and solar
  - EPEC interested in future wind project

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Alternate Energy

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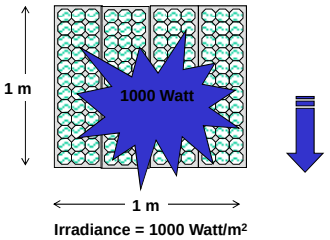
Photovoltaic System

- Task order has been issued
- PV will provide peak shaving during daylight hours
- Charge storage batteries
- Batteries will provide peak shaving
- System will provide shading for vehicles in parking lot.
- Provide Plug-in for POVs
- Could be used for PV test bed
  - Installation of separate modules (different technologies)

Efficiency of PV modules

- Commercial modules: 10-22%



Irradiance = 1000 Watt/m²

100 - 220 Watts
Electrical power

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PV/BATTERY HYBRID SYSTEM

• The test bed renewable system will charge batteries throughout the day during off peak load demand and discharge batteries during peak load demand.

-Will determine the benefits of utilizing the Zinc-bromine batteries for utility peak shaving application.

-Includes evaluating the economic benefits of the system and monitoring the operation and performance of the PV and Batteries.

- Data will be collected to evaluate the overall system performance overtime and to verify the storage system operates when necessary and provide the necessary power required by end user.

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Energy Storage Unit

50kWh Zinc Bromine
Battery module

Battery Bank

- Two 50kWh battery modules connected electrically in parallel.
- A control system (Power Conversion System (PCS,inverter)
- A pair of electrolyte storage tanks.
- Electrolyte circulation equipment.

Advantages

- Uses electrodes that do not take part in the reactions consequently there is no material deterioration that would cause long term loss performance.
- Rapid recharge (two to four hours).
- Deep discharge capability (100%).
- Built in thermal management system.
- Can be used for large scale application

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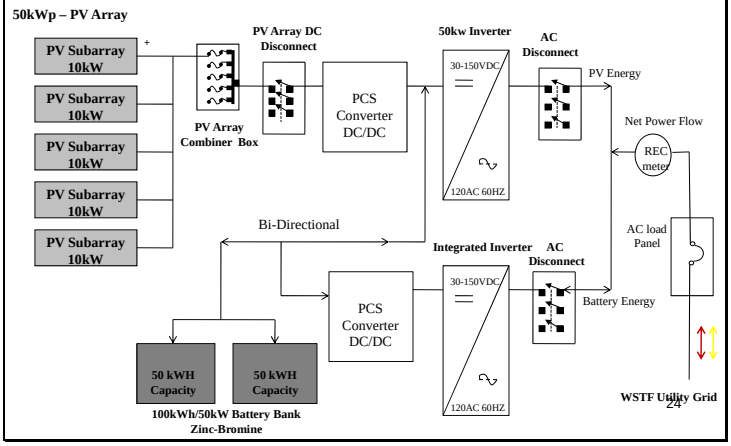
PV/Battery Hybrid System for Energy Storage Use



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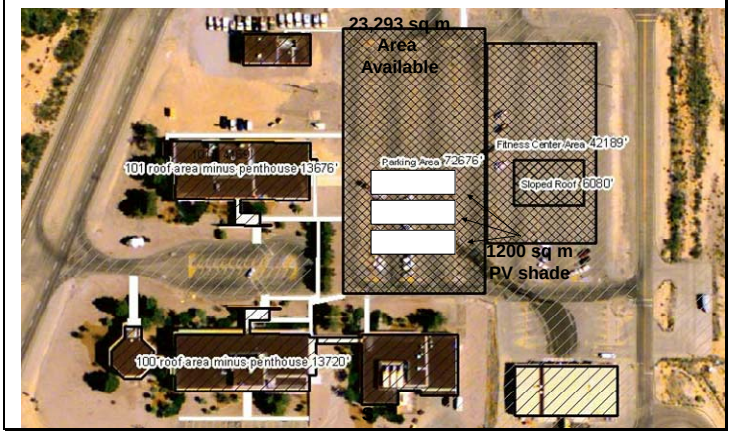
Shaded PV Structure Plan View



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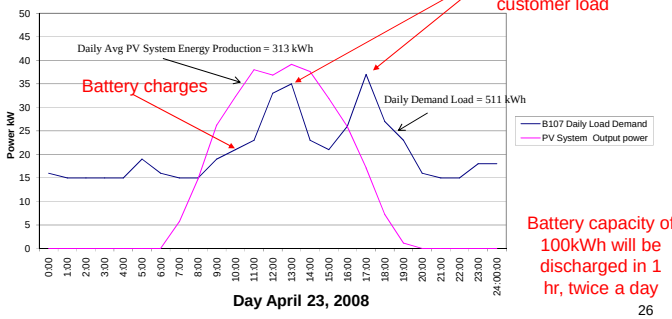
PV Power Coincides with Peak Demand Load

Building 107 Daily Peak Demand
Vs
Daily PV System Power Production
April 23, 2008

Battery discharges (100%) during customer peak usage, reducing the customer load



Day April 23, 2008

Battery capacity of 100kWh will be discharged in 1 hr, twice a day

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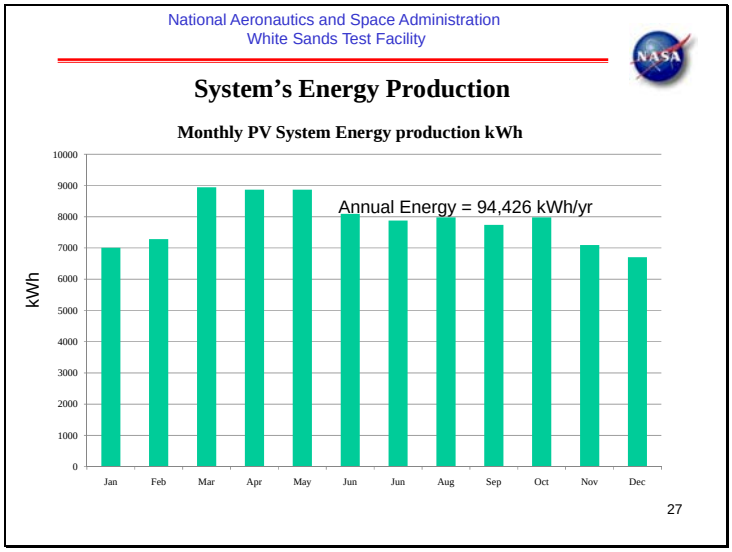

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Peak Shaving Solar Plant

- **NASA owns land at White Sands and could be available for a solar power generation plant**
  - **Approximately 400 acres**
  - **Existing injection and monitoring wells that NASA will need full access to (including drilling rigs)**
- **Plant will be built and operated by the developer.**
- **Developer is responsible for <u>ALL</u> financing of design, construction and operation.**

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Peak Shaving Solar Plant

- **Current Electrical Power to WSTF**
  - **69kV Transmission line to Apollo Substation from El Paso Electric Company**
  - **24kV distribution line down to NASA land area**
  - **Substation rated for 15MW**
- **NASA desires power to support site**
  - **Currently NASA has a ~5.5MW peak load**
  - **DOD Installation on-site is also interested in renewable energy**

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Peak Shaving Solar Plant

- **Preliminary Environmental Assessment (EA) has been completed, but a complete EA is required prior to construction start**
- **NASA facility-type support is available, but a cost will be associated with this support**

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Peak Shaving Solar Plant

- **RFI on GovBiz (14 responses)**
  - **Number:2008LUA**
  - **Posted Date: May 14, 2008**
  - **Response Date: May 27, 2008**
  - **14 responses recieved**
- **Industry day on Aug 12, 2008**
  - **MMA Renewable Ventures, LLC**
  - **Abencs/Abengoa**
  - **Acciona**
  - **International Power America**
  - **EverGuard Roofing, LLC**
  - **Greenlight Sunstream Holdings, LLC (dba Helios Energy)**
  - **Consolidated Solar Technologies**
  - **North Wind Inc**
  - **Juwi Solar**

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Peak Shaving Solar Plant

- **New website for vendors has been generated. We are in the process of posting project information and Q&A**
- **Working with NREL an NMSU on the RFP (late October)**
- **Options going forward:**
  - **Provide land to EPEC for 92 MW CSP plant (E-Solar)**
  - **Sell power to PNM or other NM utilities**
  - **Sell power out of state**
  - **Use power only behind the meter (NASA, WSMR, HAFB, Fort Bliss)**

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Backup Slides

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Component Description

- **PV Solar Modules:** 189 total, 265Wp each. Will provide shade for 1,200 m² (~13000 ft²).
- **Balance of Systems**
  - 2 Power Conditioning Unit for battery voltage control to manage power delivery bi-directional. Manage the charge and discharge rates of battery and ensure compliance with utility harmonics standards.
- **Inverter:** Utility Interactive 50kW rating
  - Zinc Bromine Battery package has integrated utility inverter built in.
- **Batteries (Zinc Bromine):** 2-50kW battery bank for Total of 100kWh storage capacity.
  - Batteries will be programmed to discharge during customer peak (weekday) usage, thereby reducing customer demand charges.
- **Data Acquisition System**
  - The DAS system will monitor real-time PV production, customer load, battery State of Charge, Charging and Discharging voltages and currents.
  - Campbell Scientific datalogger

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Energy Production Summary

PV Production		
Quantity	**Value**	**Units**
Rated Capacity	50	kW
Mean Output	294	kWh/day
Capacity Factor	24.5	%
Total Production	94426	kWh/year

Battery		
Quantity	**Value**	**Units**
Rated Capacity	50	kW
Usable Storage Capacity	100	kW
Discharging	4	Hr
Energy Out	154	kWh/day
Round Trip Efficiency	77	%
Battery losses	23	%

Environmental Benefits - Emissions		
Pollutant	**Value**	**Units**
Carbon Dioxide	36,557	Kg/yr
Carbon Monoxide	0	Kg/yr
Sulfur dioxide	158	Kg/yr
Nitrogen Oxide	77.5	Kg/yr

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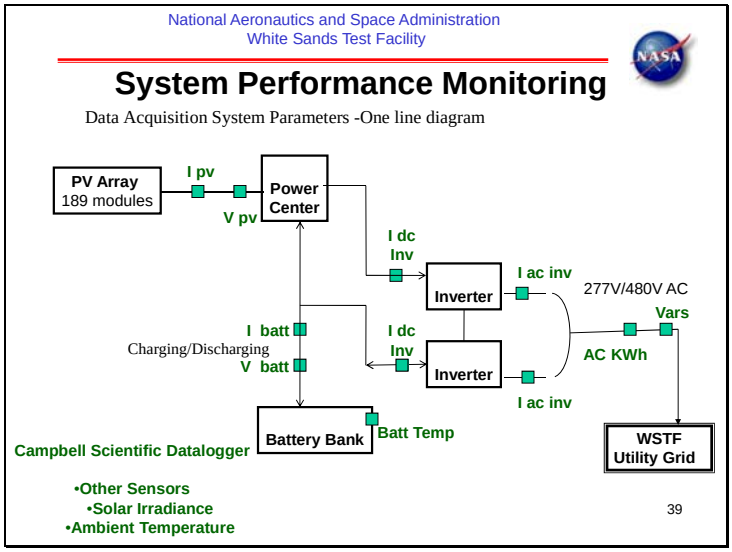

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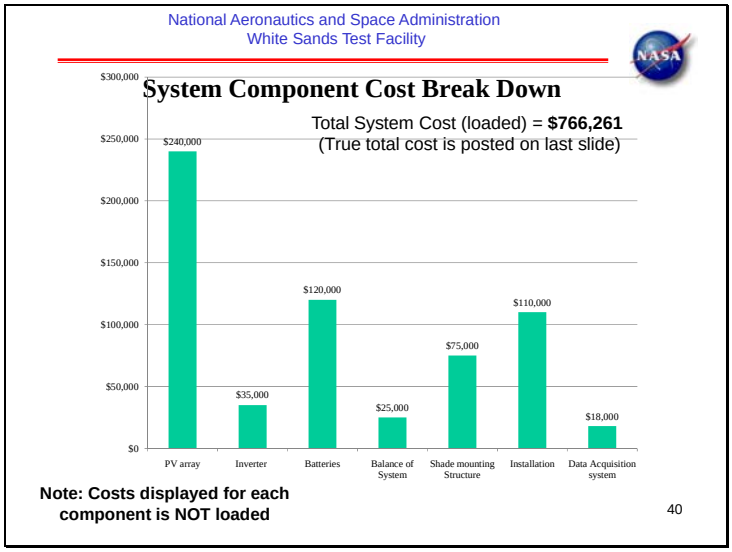

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Summary

System Architecture	
Total Area	1,200 m² (~13,000 ft²)
PV Array Rating	50 kW (approx. 189 PV modules of 265Wp)
Battery Bank	100 kWh Capacity (2 – 50kW modules)
Cost Break Down	
PV Array Modules	$240K
Inverter	$35K
Batteries Zinc Bromine	$120K
Balance of System	$25K (2 power conditioning unit)
Shade Parking Structure	$75K (~$20k to $30k per 18kW array)
Installation	$110K
Data Acquisition System	$18K (hardware only)
Cost Per Watt Installed	$12.46/Watt (PV/Battery application--$8/Watt PV only)
Total Loaded Cost of System	**$766,261**
Annual Energy Production	
AC Energy Production	94,426 kWH (output of PV/Battery System)
* Capacity Factor	24.0%
Levelized Cost of Energy	$0.25 kW/H (cost to produce energy kWh)

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New Technologies

- Implement Renewable Initiatives by combining the best technologies to arrive at most efficient system(s):
  - Solar power PV system
  - Geothermal heat pump systems
  - Wind generated power
  - Solar powered thermal system
  - Hydrogen
  - Fuel cells
  - Hybrid systems

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5 Year Long Term Goals

- Develop a Solar Powered PV farm for providing electrical power to WSTF and sell surplus power to utility companies.
- Develop 3MW of wind generated power with wind farm on top of Quartzite Mt.
- Utilize geothermal heat pump systems for WSTF facilities heating and cooling to greatly reduce utility costs.
- Provide renewable energy test beds for supporting future Orion energy requirements.

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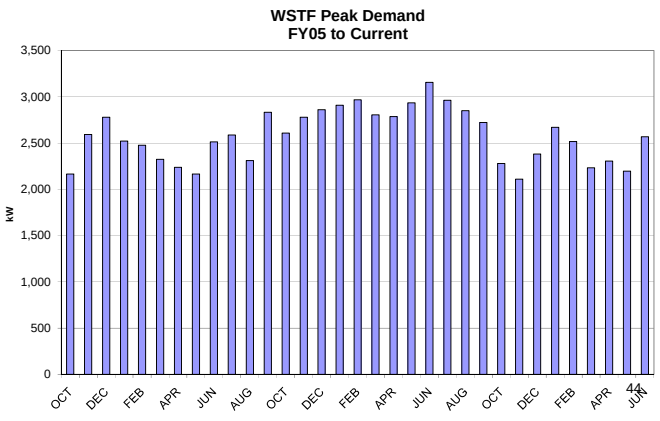
Facilities Peak Demand Load



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Facility's Peak Demand and PV System Production

Day - April 23, 2008
PV Power Vs WSTF Peak Demand Load