Renewable Energy Programs at Florida Gulf Coast University

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FGCU 2 MW installation

Photo Courtesy of Pinnacle Magazine - Winter 2010

Single-axis tracking, polysilicon modules from Mitsubishi 15 acres, 2 MW with 4 inverters. The field provides 60% electrical power to 3campus buildings.

We study power and energy performance under SW FL skies –

- **Annual Energy Production = 2,600 kWh AC per kW DC name-plate rating.**
- **Modeling single-axis-tracking flat plate PV**

DOE Multi-Model, Machine-Learning Solar Forecasting - Overview

IBM – NOAA – ANL – NREL – Northrop Grumman – UA/AzRISE/FGCU – NEU – TEP – Green Mountain - Petra – JUWI – Prime Solutions – 3-TIER - ISO NE – CAL ISO

- NOAA Surfrad/ISIS
- DOE ARM
- 1st Solar Plant (Smyrna, TN)

Integration:
- Website setup
- Forecast report generation using IBM Cognos linked to database
- Modeling PV installations (**FGCU**)
- PV Power Validation
- GMP Test Site Survey and Forecast
- **TEP Site visit survey and preparation for historical data and real-time data transfer (UA)**
- **Developing regional forecast strategies**

Close this Loop

- Introducing IBM MMT Tech for solar plant modeling
- Irradiance-Power modeling with forecasted irradiance / temperature (**UA/FGCU**)
- First PV Power forecast online

Optimal Solar Generation Forecast

Irradiance to Power Model

Optimal Irradiance Forecasts

Model/Information Blending

$w_m(\tau, x, s, E)$

ARM site-specific

$$I_{blend}(\tau,x,s,E) = \sum_m w_m^{ARM}(\tau,x,s,E)\, I_m(\tau,x,s) + \ldots + \sum_m w_m^{SITE}(\tau,x,s,E)\, I_m(\tau,x,s)$$

- Illustration of info blending
  - Site dependent blending
  - Use of blending for forecast
- Three Model Blending Substantial (>20%) improvement

Irradiance Forecasts

Radiative Transfer Model
Euler, Lagrange, Model

- Establish initial RT model
- RT model improvement
- Spectral dependent calculation

Atmospheric Profile Forecast

Big Data Bus

Eulerian | **Lagrange** | **Model** | **Domain**

- VM Setup
- DB (Informix) setup
- Daily RAP/HRRR input
- Daily NAM input
- Physical Infrastructure
- Automated data processing and feeding to database.

Machine Learning

Categori-zation

- **Model blending based on simplistic weather categorization.**
- **Weather categorization strategies**
- **Forecast based on persistence and climatology (ANL)**

Sensors
Local Weather Stations

Cloud Vector Fields
Sky Camera
Satellites
Regional Sensor Networks

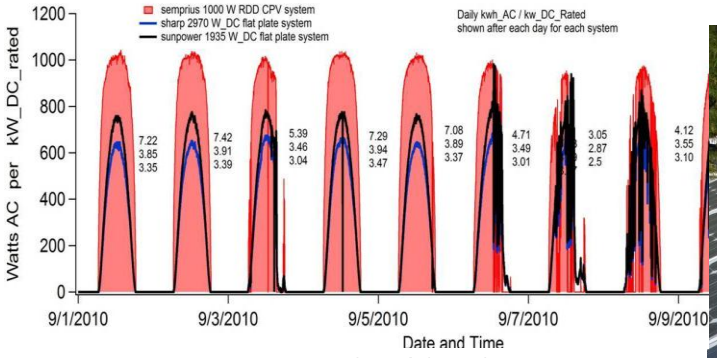
HRRR, WRF

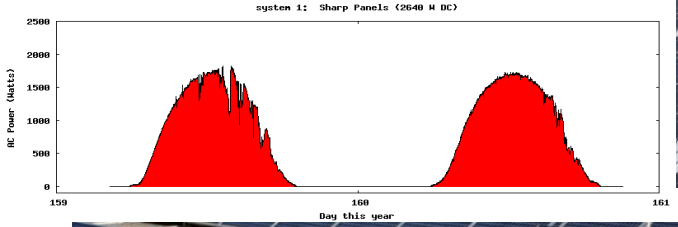
Technology
GIS
...

- Compact sky camera capable of direct sun imaging
- Climatology model
- GOES Cloud Analysis
- Advection based cloud field forecast
- RAP
- HRRR
- NAM
- SREF
- NASA MODIS

Florida Gulf Coast University Renewable Energy Institute

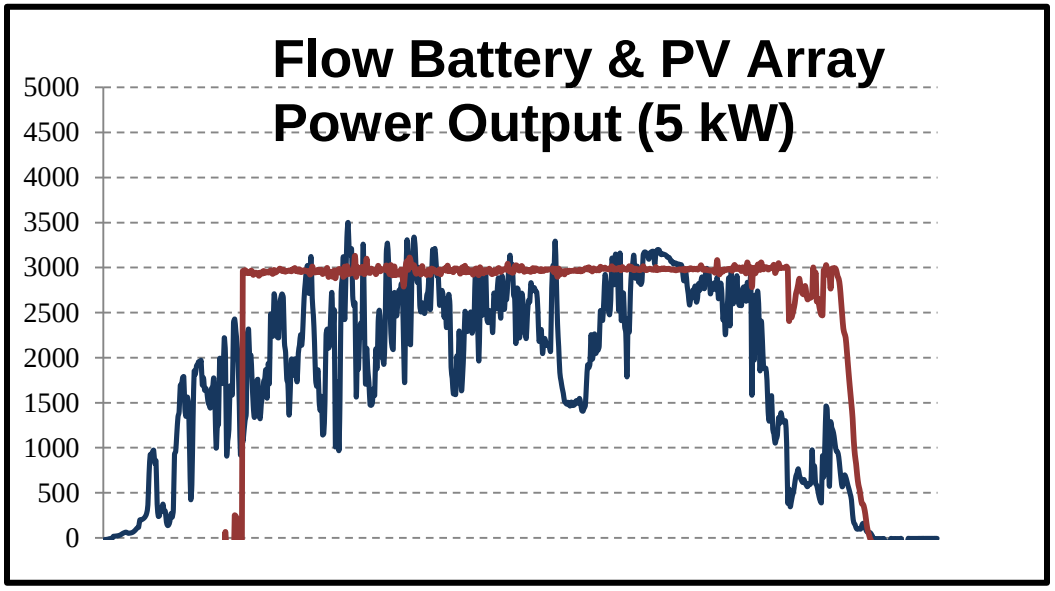
Existing AzRISE Solar Fields - TEP Solar Test Yard: flat plate and CPV technologies

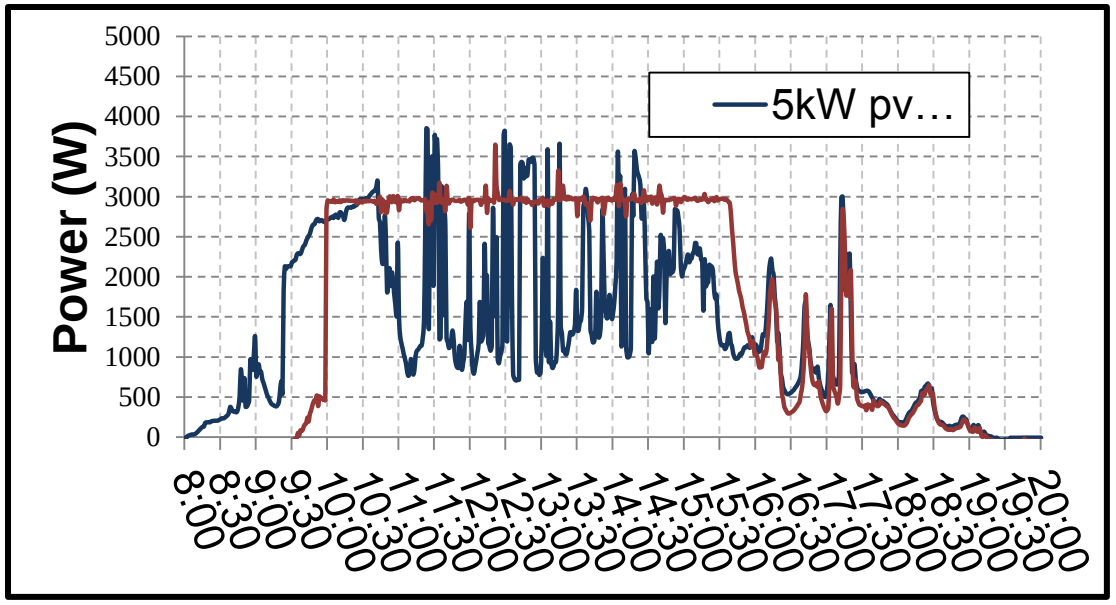




FGCU Solar Energy Park

Outdoor test facility:
PV testing – Solar Hot Water – Solar Desalination – Energy Storage – Solar Forecasting – Biofuels
Outreach – Education and hands-on training – Visitors Park – Demonstration and testing of new devices
Shared instrumentation and weather station
Solar-electric vehicle shuttle bus to campus



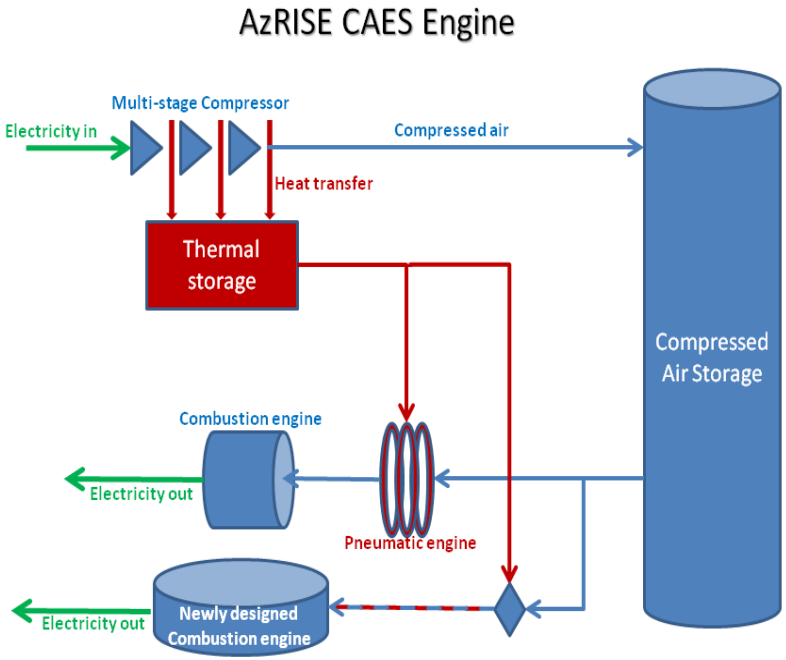


Energy Storage

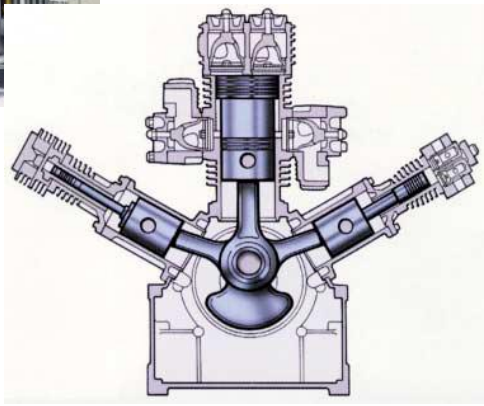
Measurements of power produced from a hybrid PV-battery system under various conditions of load and weather intermittencies show that the zinc-bromide flow battery can support the PV output to make solar electricity dispatchable and time shifted.

The operational ranges indicate a need to improve design and operational conditions. But the performance of the battery clearly supports its promise as a major component of future solar PV systems that require some measure of dispatchability.

Energy Storage



3-stage Bauer Compressor



- Thermodynamic analysis of efficiency with and without compression inter-cooling
- Build and test compressor operation with heat exchange system
- Build and test expansion turbine
- Evaluate reduction in NG consumption due to thermal management

Solar Economics!!! *Is Solar too expensive for the Sunshine State?*

- **The cost of a PV system today: (very approximate figures)**
  - **$0.85/watt for the modules**
  - **$0.25/watt for the inverter**
  - **$0.10/watt for other electrical components**
  - **$1.50/watt for installation**
  - **TOTAL = $2.70/watt installed (2012) Today - $2.00/watt (NO REBATES)**
  - **A good installer will produce 2,000kWh/kW (AZ) and 1,500kWh/kW (FL) annually. This translates to $1.35/kWh (AZ), $1.80/kWh (FL)**
  - **If amortized over 20 years, then the cost per year is well below the retail price of electricity ($0.12/kWh – grid price)**
    Solar AZ - $0.07/kWh and Solar FL - $0.09/kWh

Coal	Adv Coal	NG CC	NG CT	Nuke **	Wind	Solar PV	CSP	Geo	Bio
0.09	0.11	0.07	0.10	0.11	0.10	0.07*	0.31	0.10	0.11

Energy Information Agency 2011
except for Solar PV

Ongoing Projects

- FGCU 2MW Solar Field – Performance under SW Florida skies
- Solar power forecasting (DOE/IBM)
  - Modeling Single-Axis-Tracking flat-plate PV systems
- Energy Storage
  - Testing novel storage devices (flow batteries and supercapacitors)
  - Development of small-scale Compressed Air Energy Storage
- Solar economics – Critical to Florida
- Solar multistage desalination and water treatment (NFWF)
- Sandia multijunction solar cells
- Construction of I-Hub Research Park and FGCU Solar Park
- Collaboration with Algenol on algae-based ethanol production
- Development of Renewable Energy Engineering degree
- Outreach and regional economic development