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Memorandum

ORIGINAL

From the office of
Commissioner Bob Burns
Arizona Corporation Commission
1200 W. WASHINGTON
PHOENIX, ARIZONA
(602) 542-3682

Arizona Corporation Commission
DOCKETED
APR 30 2014
DOCKETED BY

TO: Docket Control

DATE: April 30, 2014

FROM: Commissioner Bob Burns

SUBJECT: Emerging Technologies in Energy, Docket No. E-00000J-13-0375

The agenda and presentations from the April 25, 2014 Emerging Technologies Response Workshop have been docketed. If for some reason you cannot access eDocket, please contact my Executive Aide, Jessica Perry, to receive copies of the presentations.

Original and thirteen (13) copies of
the agenda and presentations filed this 30th day of
April, 2014, with:

Docket Control
Arizona Corporation Commission
1200 West Washington Street
Phoenix, Arizona 85007

RECEIVED
2014 APR 30 A 10 12
AZ CORP COMMISSION
DOCKET CONTROL

Copies of the memo mailed
this 30th day of April, 2014, to:

Service List

REVISED N O T I C E
SPECIAL OPEN MEETING
OF THE ARIZONA CORPORATION COMMISSION

Commission Workshop on Emerging Technologies
Docket No. E-00000J-13-0375

DATE: Friday, April 25, 2014 **START TIME: 9:00 a.m.**

Arizona Corporation Commission
Hearing Room One
1200 W. Washington Street
Phoenix, Arizona 85007

This shall serve as notice of a special open meeting of the Arizona Corporation Commission at the above location for consideration, discussion, and possible vote of the items on the following agenda and other matters related thereto. Please be advised that the Commissioners may use this open meeting to ask questions about the matters on the agenda; therefore, the parties to the matters to be discussed or their legal representatives are requested, though not required, to attend. The Commissioners may move to executive session, which will not be open to the public, for the purpose of legal advice pursuant to A.R.S. §§ 38-431.03.A.2, 3 and/or 4 on the matters noticed herein. The Commissioners may also move to executive session, which will not be open to the public, for other purposes specified in A.R.S. §§ 38-431.03, including discussions, consultations or considerations of Commission personnel and salary matters, on matters noticed herein.

The Arizona Corporation Commission does not discriminate on the basis of disability in admission to its public meetings. Persons with a disability may request a reasonable accommodation, such as a sign language interpreter, as well as request this document in an alternative format, by contacting Shaylin A. Bernal, phone number (602) 542-3931, E-mail sabernal@azcc.gov. Requests should be made as early as possible to allow time to arrange the accommodations.

Jodi Jerich
Executive Director

Response Workshop Agenda

Presentations and discussions concerning the potential impact on emerging technologies on the current energy model, including distributed supply and storage and utility-scale storage.

Morning Session: 9:00 a.m.

Welcome and Opening Remarks

Questions and Answers from the March 20, 2014 Workshop

Tom Harris, Solar Developer and Financial Broker, PV Advanced Concepts
"Combined Heat and Power (CHP): A Strong Distributed Energy Partner"

Mike McClure, Account Executive, Energy Systems Groups
"Waste to Energy (WtE) Technologies: Deriving Renewable Energy From Landfills, Treatment Plants and Agricultural Waste"

Jerry Smith, Owner, P&R Consulting
"System Adequacy in a Depleted Inertia Future"

Lunch Break

Afternoon Session: 1:30 p.m.

Ted Burhans, Senior Program Manager of Renewables, Tucson Electric Power
Justin Orkney, Technical Specialist of Renewables, Tucson Electric Power
William Holmgren, Post-Doctorate of Physics, University of Arizona
Daniel Cormode, Energy Storage Specialist, SOLON
Bill Richardson, General Manager, SOLON
"Battery Storage and Forecasting for Improved Grid Integration"

Jeff Schlegel, Arizona Representative, Southwest Energy Efficiency Project
Ellen Zuckerman, Arizona Program Associate, Southwest Energy Effieciency Project
"Changing Customer Energy Use Patterns: An Arizona Focus"

Questions and Comments from the Public

Wrap-up and Closing Remarks

NOTE: NO VOTES ON ANY MATTER WILL BE TAKEN BY THE COMMISSION AT THIS MEETING.

Distributed Energy Workshop
Combined Heat and Power (CHP):
A strong distributed energy partner

Tom Harris | PV Advanced Concepts
Tom.Harris@PVAdvancedConcepts.com | (602) 317-0015

5215 E Orchid Ln Paradise Valley, AZ 85253

PV Advanced Concepts

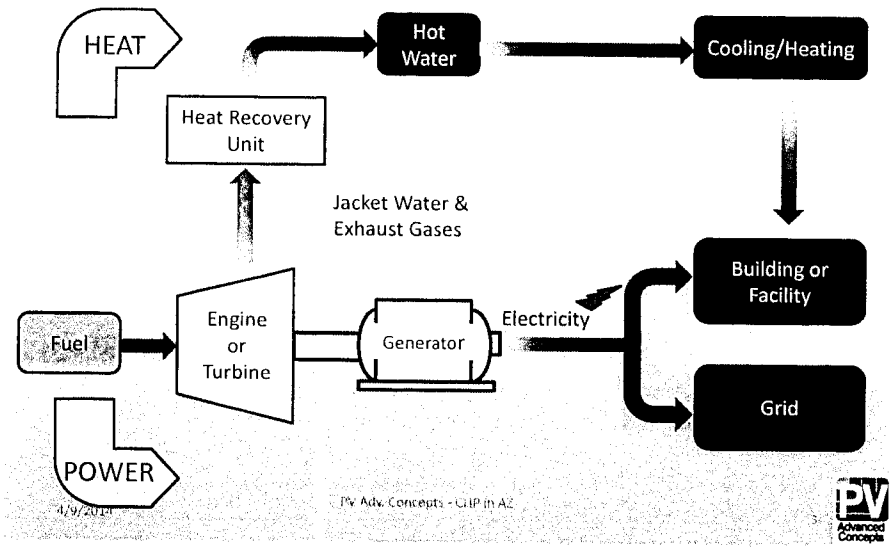
PV Advanced Concepts - Intro

- Clean energy for small/medium commercial & non-profits.
- Initially solar PV. Now CHP plus related DE technologies.
- Completed over 5 MW of Solar PV (APS-Schoolsmostly non profits)
- Staff: 3 Full Time Equivalent plus extensive network

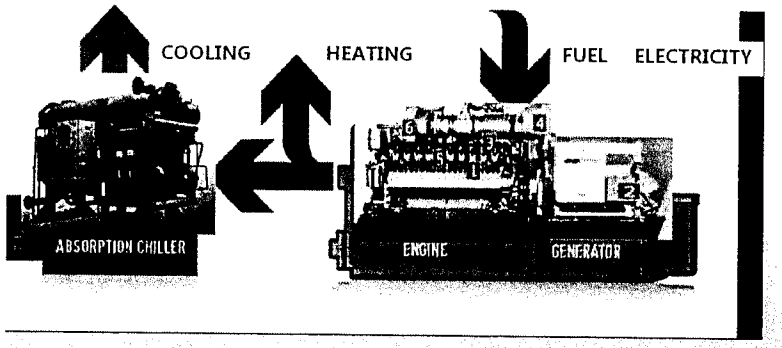
PV Advanced Concepts

Combined Heat and Power (CHP) Concept

on-site generation of electricity and use of the engine heat



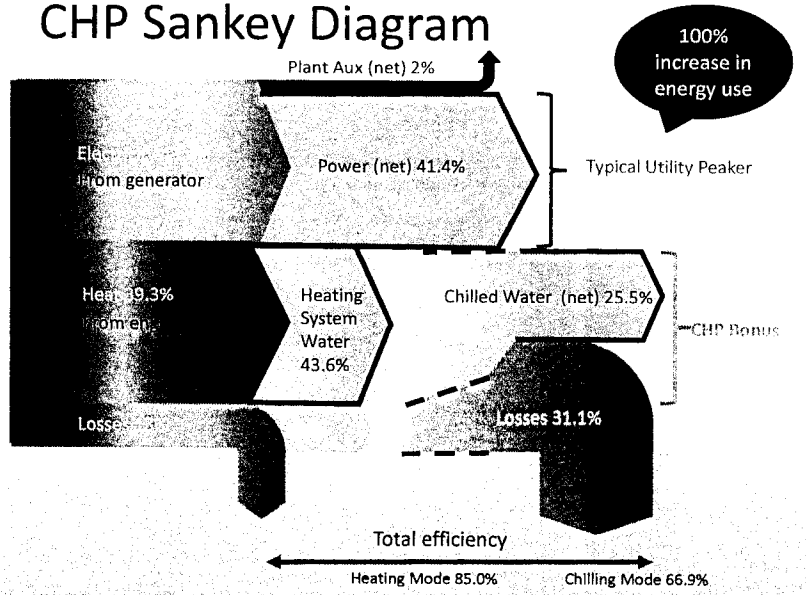
CHP: Gas Generator with Absorption Chiller



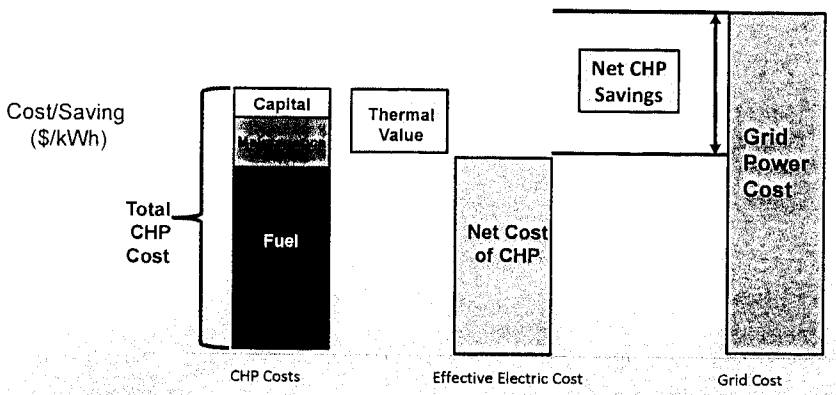
The 5 Prime Movers

1) Steam Turbines
2) Micro Turbines
3) Fuel Cells
4) Reciprocating Engines
5) Gas Turbines

CHP Sankey Diagram



CHP Costs and Savings Structure



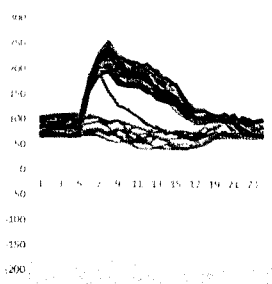
Impact of Dispatchable DE Source

- Ramps from 0% to 100% in minutes
- Efficient from 50%-100%
- Multiple small units increase flexibility
- Programmed and/or "real-time"

CHP: Partner to Solar: Feb. Demand Mitigation

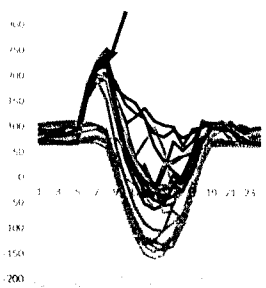
APS Feb G32M Tariff ($/kWh)		
Hour (24h)	M-F	S&S
2000-0500 & 1100-1400	0.04342	0.04342
0500-1100	0.11607	0.04342
1500-2000	0.08599	0.04342

Original Utility



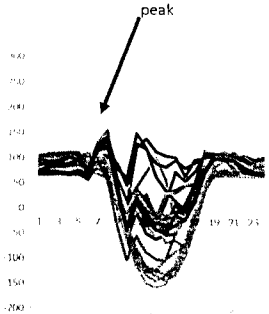
Utility + Solar

Solar Misses Winter early morning peak (Battery Also)



Utility + Solar+ CHP

CHP minimizes morning peak

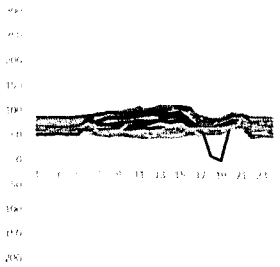


Actual AZ School 15 min. Interval Data
Solar: 220 kW
CHP: 100 kW; Runs 5d/week from 0600 to 1000

CHP: Partner to Solar: Baseline Driver

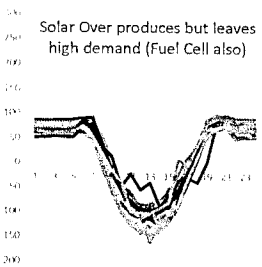
APS Feb G32M Tariff ($/kWh)		
Hour (24h)	M-F	S&S
2000-1100	0.06487	0.06487
1500-2000	.173430	0.06487
1100-1500	0.128470	0.06487

Original Utility



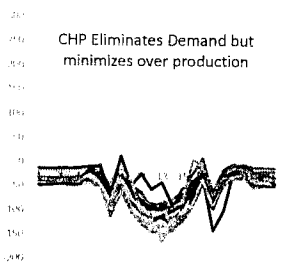
Utility + Solar

Solar Over produces but leaves high demand (Fuel Cell also)



Utility + Solar+ CHP

CHP Eliminates Demand but minimizes over production

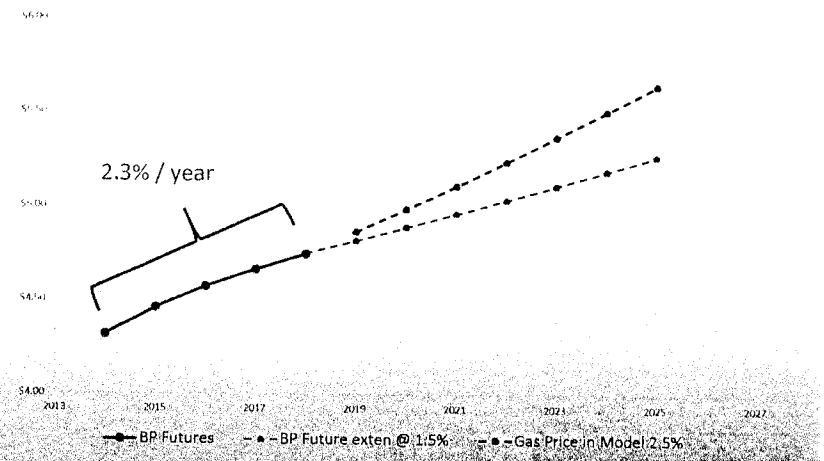


Solar: 220 kW
CHP: 100 kW; Runs 7d/week from 1700 to 0800

Drivers & Barriers

- Barriers:
  - Costs
    - Equipment
    - Utility interconnection fees
    - Natural Gas
  - Utility infrastructure
  - Market uncertainty
- Drivers
  - Energy reliability
  - Energy efficiency
  - Economic benefits
  - Environmental benefits
  - Future Growth
  - Public Relations

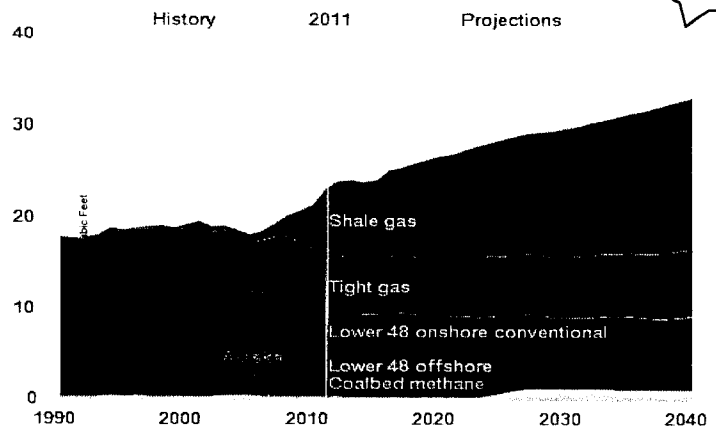
Natural Gas Futures*and extrapolated prices



* Natural gas delivered to SWG Citygate in Phoenix; based on market quote from reliable supplier

Projected Natural Gas Production

(Almost) Doubles in next 30 years



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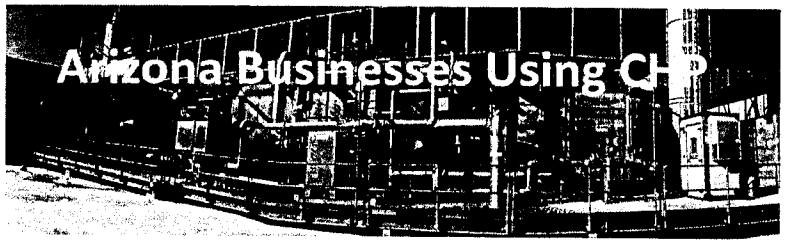
PV Advanced Concepts

Arizona Businesses Using CHP

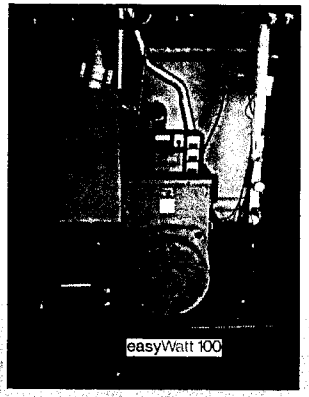


City	Facility Name	Application	Oper Year	Prime Mover	Capacity (kw)	Fuel Type
Green Valley	La Posada Retire	Nursing Homes	2012	Other	36	OTR
Phoenix	Clarion Hotel	Hotels	2012	Recip Engine	100	NG
Tucson	El Dorado Hospital	Hospital	2012	Recip Engine	900	NG
Tucson	NRG Phx-Tucson	District Energy	2009	Recip Engine	1,600	NG
Flagstaff	Wildcat Hill	Wastewater	2008	Recip Engine	292	Biomass
Tempe	ASU	Colleges/Univ.	2005	Turbine	16,000	NG
Tucson	Tucson District Heat	District Energy	2003	Recip Engine	1,800	NG
Tucson	University of AZ	Colleges/Univ.	2001	Turbine	14,000	NG
Yuma	America West Ind.	Textiles	1994	Combine Cycle	51,000	NG
Tucson	Tucson Medical	Hospitals	1989	Turbine	750	NG

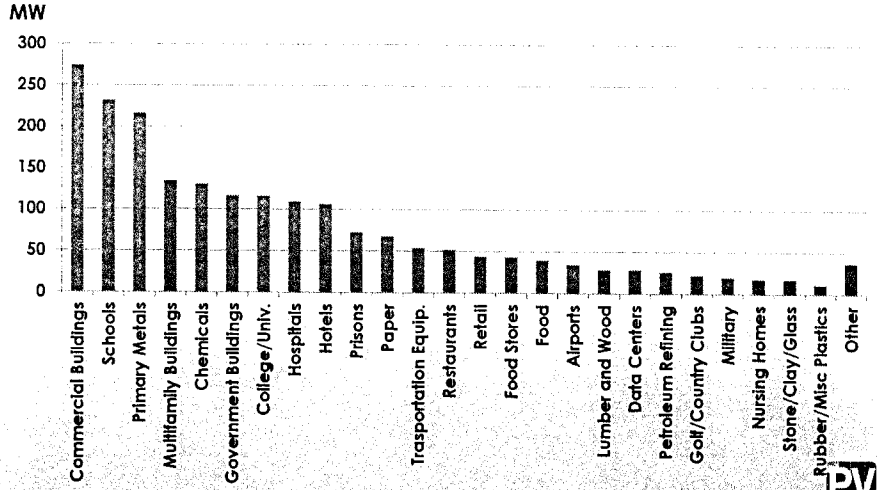
PV Advanced Concepts

Clarion Hotel Phoenix – 100 kW

- Installed June 2012
- No Interconnect (Cost)
- Reduces on peak
  - Hotel less cost
  - Utility lower demand spike
- Lowers Utility bill $30,000/yr
- Used SW Gas Incentive



2051 MW of Technical Potential in AZ in Many Sectors

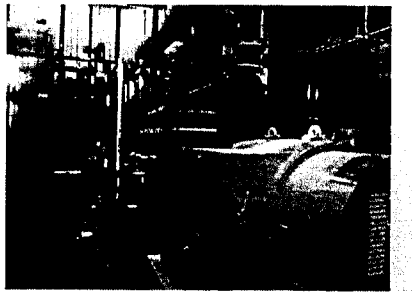


Onsite potential only, not counting exp
Source: ICF International, 2013

Informal Survey of Selected Energy Sources

	Coal Plant	Solar	Natural Gas
Available 24 hr/day			
Inexpensive Fuel			
High Efficiency			
Low Emissions			
Load Following			
Proven Technology			
Easy to Maintain			
High Energy Density			
Scalable			
Use when Grid Down			
Transmission Losses			
Utility Incentives Required			

Policy Opportunities to Further CHP Growth



...and these barriers are fixable

CHP Policy Issues

1. Clear/ published req's for Interconnection
2. Clarification of rules for third party PPA's
3. Impact of Standby Charges
4. Impact of Tariffs on Distributed Energy adoption
5. Support SW Gas Energy Efficiency incentive

#1:Interconnection Standards:

(and following such)

- Allow businesses that invest in CHP to safely connect with the utility grid
- Provide clear and uniform processes and technical requirements that meet the needs of both the utility and the consumer
- Reduce regulatory red tape and streamline the process of connecting

#2: Clarify rules on CHP third-party ownership

- Clarification on use 3rd Party Power purchase Agreements (PPAs)
- Should follow the same rules as solar PPAs (Solar City decision)

#3 Impact of Standby Charges

- CHP systems greater than 100 kW are not treated as renewable sources and are subject to the E-56 Partial Services rider
- Systems less than 100 kW are covered by the E-56R (R for renewable tariff)

#4 Impact of Tariffs

- With quick response dispatchable distributed energy solutions it is critical Tariffs send the market correct pricing signals.

#5 Southwest Gas CHP Rebate Program

Catalyst for CHP Adoption

- Commercial/industrial now
- CHP units must achieve a total efficiency of 60% or higher.
- Only steam turbines, combustion engines and reciprocating engines are approved on the 2013/2014 filing.
- Incentives up to $500 / kW are significant in reducing adaption barriers
- Rebates as high as $50,000 can be given to customers using CHP
- Only $300,000 available in current FY3/FY4 program
  - FY2 program was oversubscribed
- Requested improvements:
  - Include all 5 prime movers
  - Increase funding of SWG EE program to reduce over-subscription

Key Message

Combined Heat and Power (CHP) is a powerful, highly efficient distributed technology with significant opportunities for deployment in Arizona.

If interested in CHP in Arizona please contact me.
Tom Harris (602.317.0015) or Tom.Harris@PVAdvancedConcepts.com

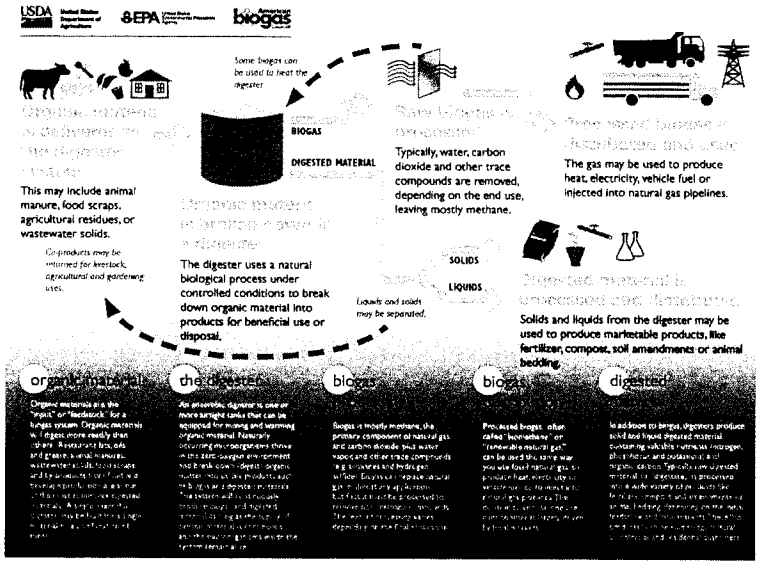
Waste to Energy (WtE)

Deriving renewable energy from landfills, treatment plants and agricultural waste

American biogas Council MEMBER

April 25, 2014
Mike McClure
Energy Systems Group, LLC
mmcclure@energysystemsgroup.com
P: 602-938-4073

Handout



http://www.americanbiogascouncil.org/biogas_howSystemsWork.asp

Inputs

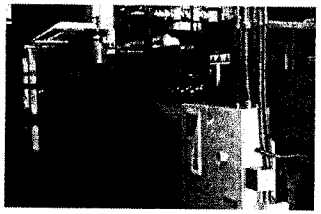
Waste Stream Sources

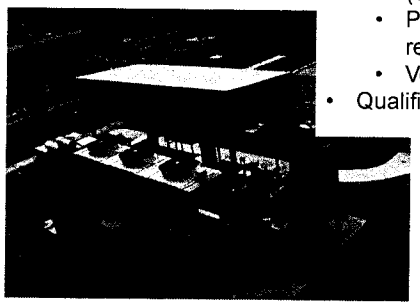
- Landfill
- Waste Water Treatment Plants
  - Gas
  - Organics
- Farms & Ranches
  - Cattle waste
  - Chicken waste
  - Organics
- Others:
  - Food industry
  - Restaurants

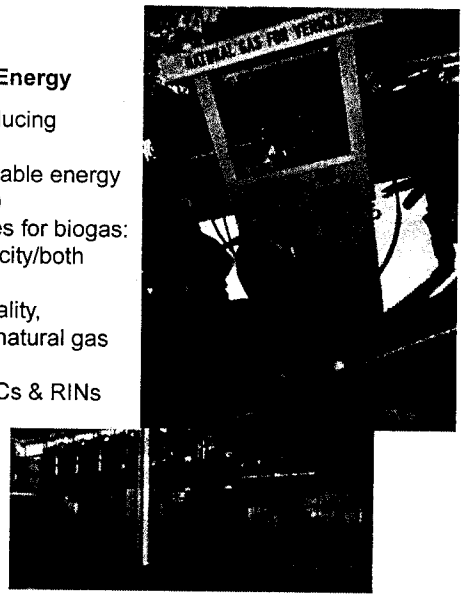
Outputs

Renewable Energy

- Net-energy producing
- Very reliable
- Baseload renewable energy (not intermittent)
- Multiple end-uses for biogas:
  - Heat/electricity/both (CHP)
  - Pipeline quality, renewable natural gas
  - Vehicle fuel
- Qualifies for RECs & RINs

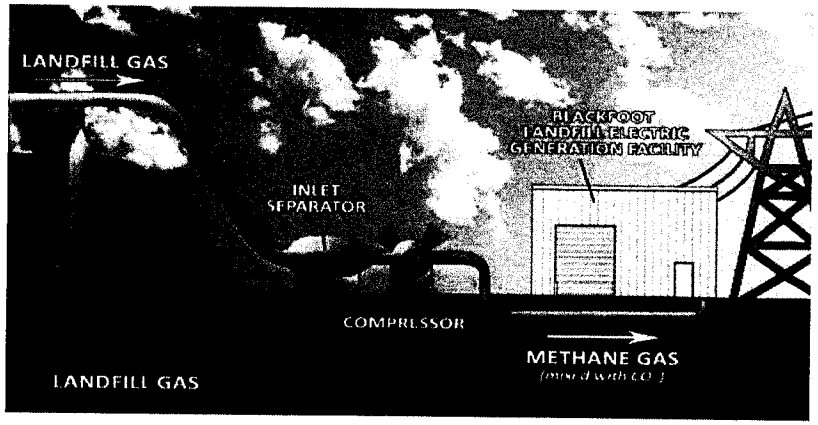






Waste Gas to Electricity

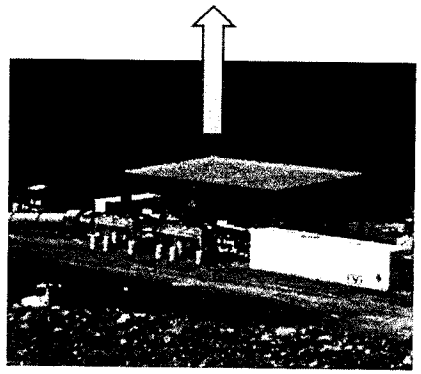
Currently happening at the Glendale LF

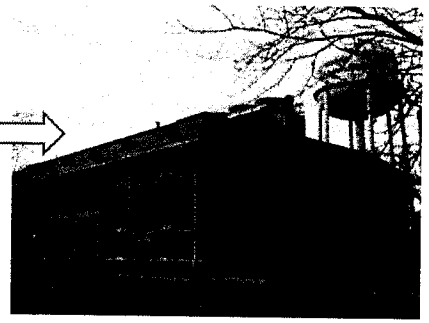


Landfill Gas Powering VA Medical Facility

Iris Glen Landfill, Johnson City, TN
Mountain Home VA Medical Center

Landfill gas is captured and piped 4 miles to a VA Medical Center, where it helps power an Energy Center





Complete Service Energy Center with

- 5.7 MW of electric generation
- 5,000 tons of chilled water systems
- 700,000 gallons of chilled water storage
- 100,000 pounds capacity per hour of steam production for VA

What's Left Over?

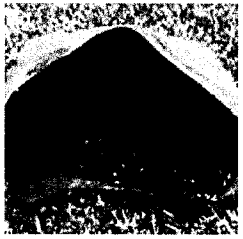
http://www.clearhorizonsllc.com/html/products/indexEP.htm

http://www.dailysunnews.com/news/2009/jun/19/local-dairy-going-green-with-enviromoss-product/

http://www.magic-dirt.com/

Remaining byproducts

- Fertilizer
  - Secondary market opportunity
- Ash
  - < 10% of waste stream goes to landfill
  - Extending the life of the landfill
  - BioChar



http://www.phoenixenergy.net

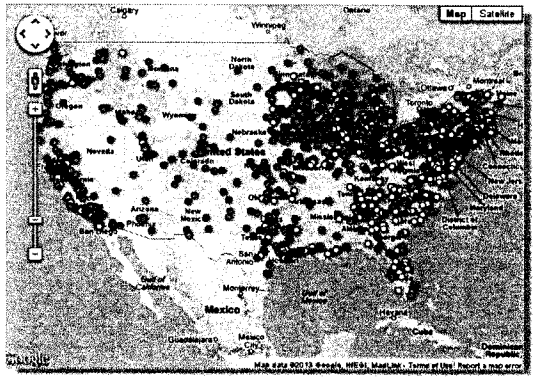
U.S. Biogas Market – Current and Potential

2,000+
Operational
Biogas Systems

594 at Landfills

192 on Farm
(Dairy AND Swine)

1,238 Wastewater



12,000+
Potential
Biogas Systems

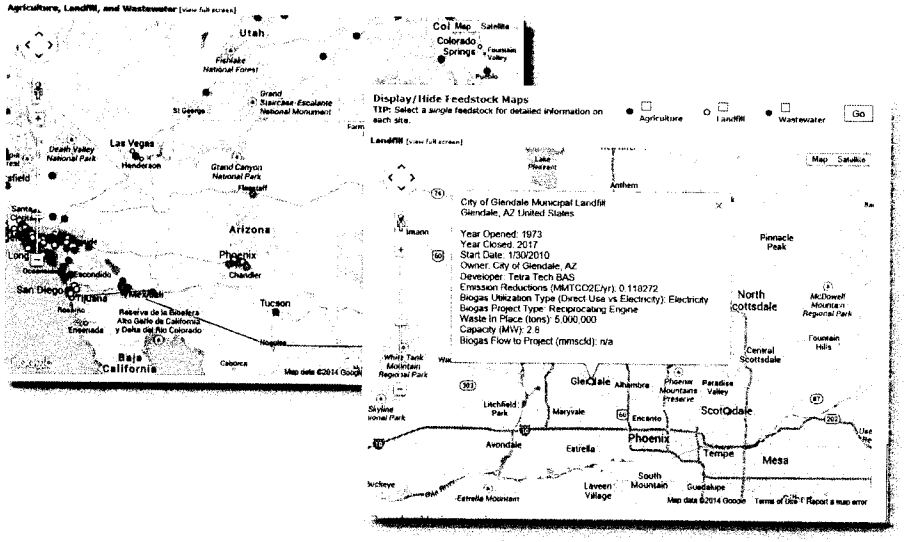
540 at Landfills

8,200 on Farm
(Dairy AND Swine)

4,200 Wastewater

https://www.americanbiogascouncil.org/biogas_maps.asp

U.S. Biogas Market – Interactive Map



https://www.americanbiogascouncil.org/biogas_maps.asp

Overview of Market and Customers

- Customer classes:
  - Municipalities
  - Large military facilities
  - Large agricultural operations
- Off-takers could include schools, commercial and other non-municipal or DoD entities
  - Public CNG refueling stations

Cost & Benefits

- WtE Electricity generation could be on par with grid-supplied electric
- Green gas currently carries a premium over brown (pipeline-supplied) gas
  - Premium price could be offset with RECs and RINs

- Eliminates major air and ground pollutant from landfill and agricultural operations
- Eliminates waste gas flaring
- Could eliminate up to 70% of landfill waste
  - Extends life of landfills
  - Secondary market products

Impacts

- Uses:
  - Core applications:
    - Renewable electric generation
    - Renewable pipeline-quality gas
    - Renewable CNG refueling
    - Waste pelletizing
      - Refuse-Derived Fuel (RDF)
- Customer support requirements:
  - Similar support for central plant operations
  - 3rd party ownership eliminates many support requirements

Impacts (cont.)

- Safety:
  - Similar to:
    - Waste recycling facility
    - 'Mini' refinery
    - Central CHP Plant
- Reliability:
  - Proven technology that has been around for decades
- Power Quality:
  - Could be utilized as 'base load' power
- Physical & Cyber Security:
  - Self-contained solution means more secure
  - Key component to the DoD's energy security initiative
    - Ex: 2013 Army Biogas MATOC Initiative

Business and regulatory impacts

- Business:
  - Can work in a smart grid infrastructure
    - Great for load balancing requirements
  - Can be used as part of a demand shedding plan for large electric customers
- Regulatory:
  - Will need clarification from the ACC about the legality of 3rd party ownerships of these plants

Impact on other regulated industries

- Gas:
  - Complements gas industry
  - Pipeline-quality green gas can augment brown gas
- Electric:
  - Similar impact as solar with the following exceptions:
    - 7 x 24 utilization
    - No 'cloud' factor:
      - Can plan for shut downs
      - Eliminates the need for 'stand-by' charges

To Learn More…

Federal Agencies

- Agriculture (USDA)—Rural Development, Conservation
- Environmental Protection EPA:
  - AgStar
  - Landfill Methane Outreach Program
- Energy (DOE)
- Defense (DOD) –shore power, base energy needs
- Federal Energy Regulatory Commission (DOE)—interstate pipelines

Thank You!

Mike McClure
Energy Systems Group, LLC
mmcclure@energysystemsgroup.com
P: 602-938-4073

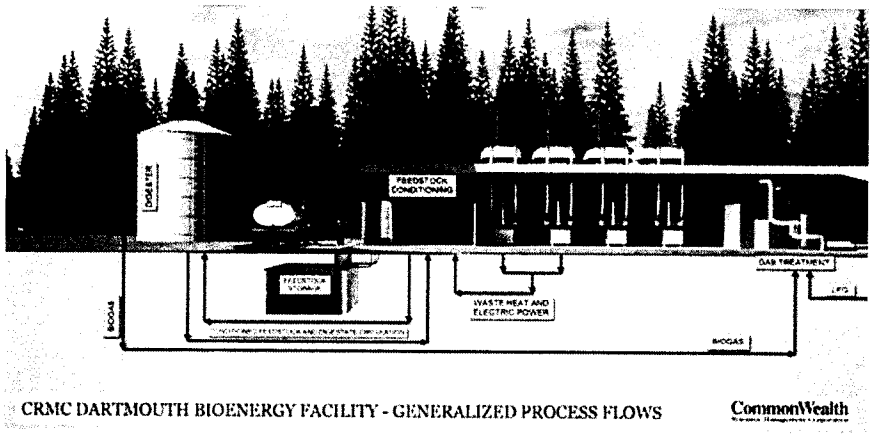
www.AmericanBiogasCouncil.org

Appendix

Examples of Other Biomass Projects Around the Country

Anaerobic Digester (MA)

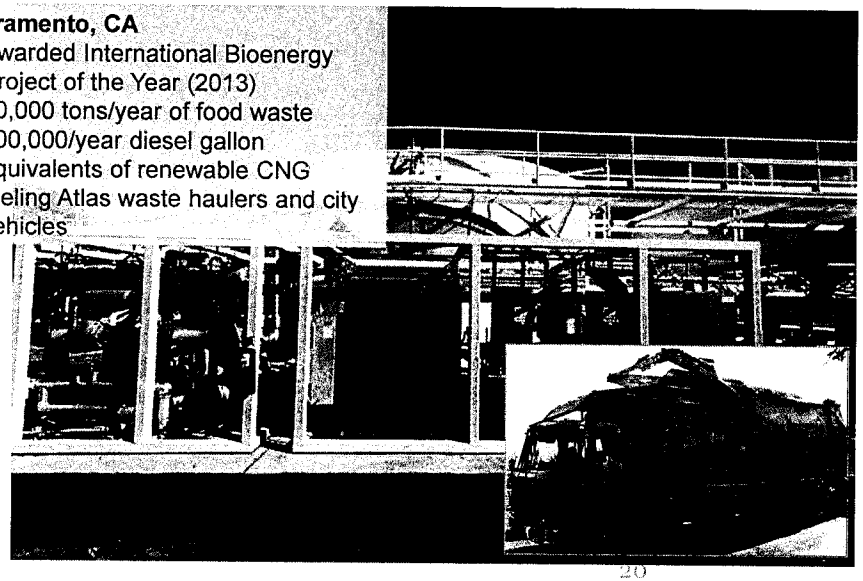
- AD facility at Crapo Hill Landfill, in Dartmouth, MA
- Biogas added to existing 3.9 MW landfill gas gen-sets
- Phase 1: 3,000 gallons per day
- Phase 2: 30,000 gallons per day



Food Waste (CA)

Sacramento, CA

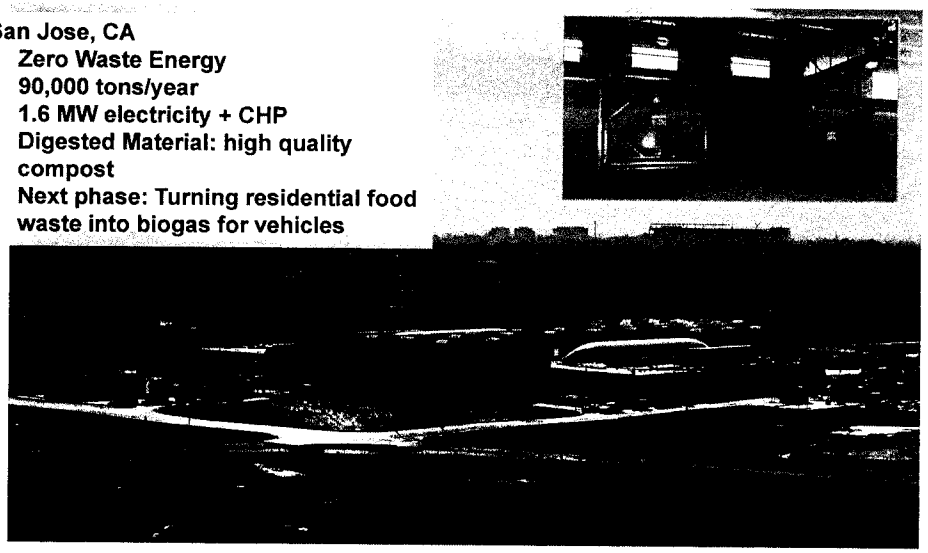
- Awarded International Bioenergy Project of the Year (2013)
- 40,000 tons/year of food waste
- 700,000/year diesel gallon equivalents of renewable CNG fueling Atlas waste haulers and city vehicles



Food + Yard Waste (CA)

San Jose, CA

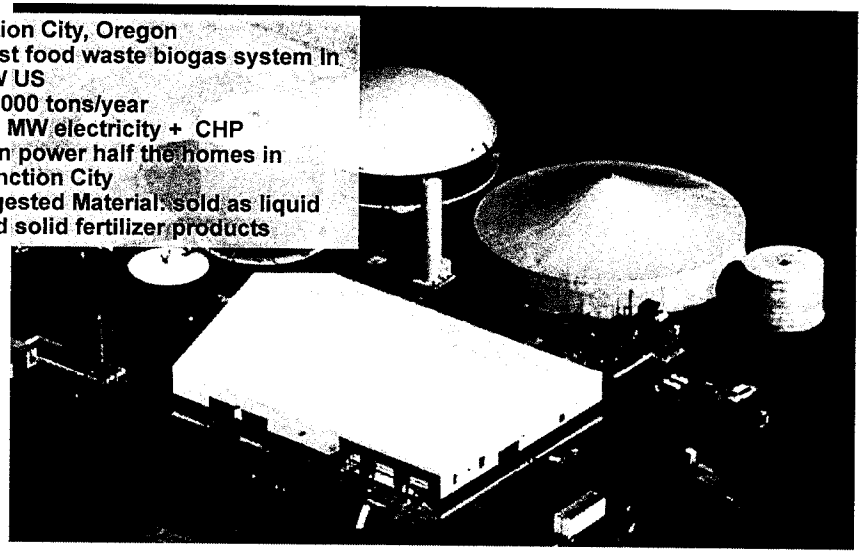
- Zero Waste Energy
- 90,000 tons/year
- 1.6 MW electricity + CHP
- Digested Material: high quality compost
- Next phase: Turning residential food waste into biogas for vehicles



Food Waste (OR)

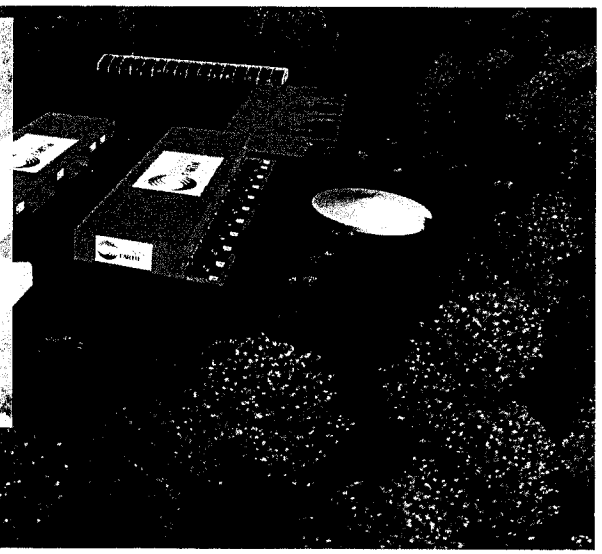
Junction City, Oregon

- First food waste biogas system in NW US
- 25,000 tons/year
- 1.6 MW electricity + CHP
- Can power half the homes in Junction City
- Digested Material: sold as liquid and solid fertilizer products



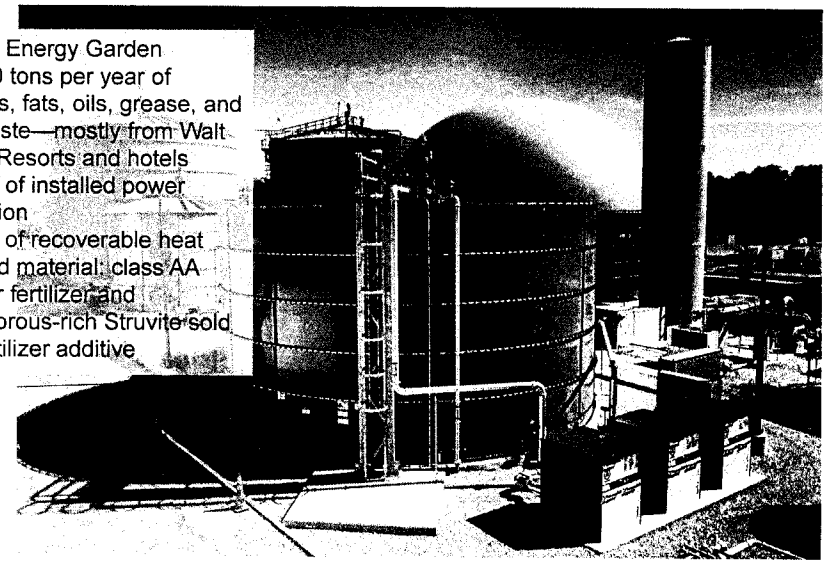
Food + Yard Waste (CT)

- Central Connecticut Organics Recycling Facility (Hartford, CT)
- 75,000 tons/year of municipal and commercial organics (Food, yard and woody waste)
- 16 municipalities contributing
- 1.4 MW + CHP
- Digested Material: high quality compost and engineered soil products
- Construction: late 2014
- Commissioning: late 2015



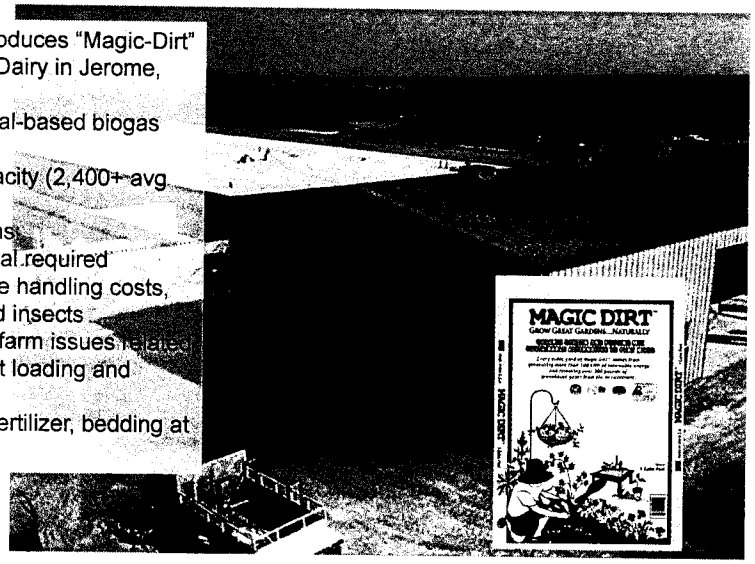
Food Waste + Biosolids (FL)

- Harvest Energy Garden
- 130,000 tons per year of biosolids, fats, oils, grease, and food waste—mostly from Walt Disney Resorts and hotels
- 3.2 MW of installed power generation
- 2.2 MW of recoverable heat
- Digested material: class AA granular fertilizer and phosphorous-rich Struvite sold as a fertilizer additive



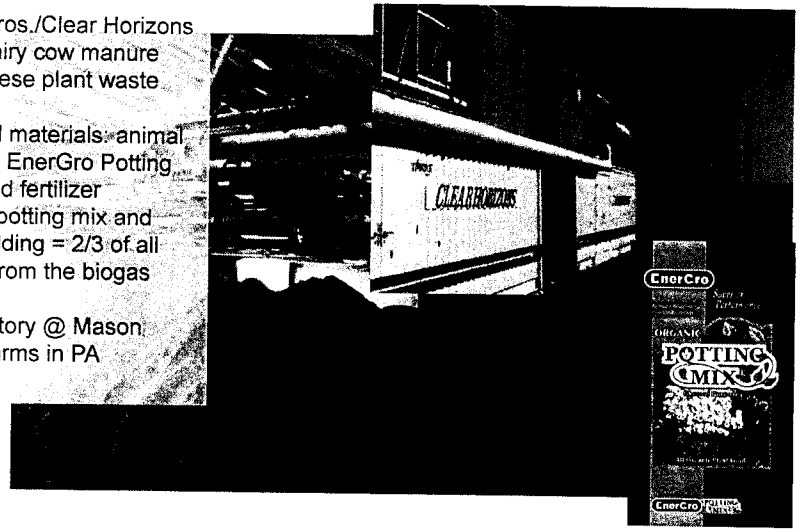
Dairy + Co-Products (ID)

- AgPower: Produces "Magic-Dirt"
- 15,000 Cow Dairy in Jerome, Idaho
- Largest animal-based biogas project in US
- 4.5 MW Capacity (2,400+ avg U.S. homes)
- Offers to farms
- No farm capital required
- Lower manure handling costs, less odor, and insects
- Reduction of farm issues related to soil nutrient loading and methane
- Waste heat, fertilizer, bedding at no cost



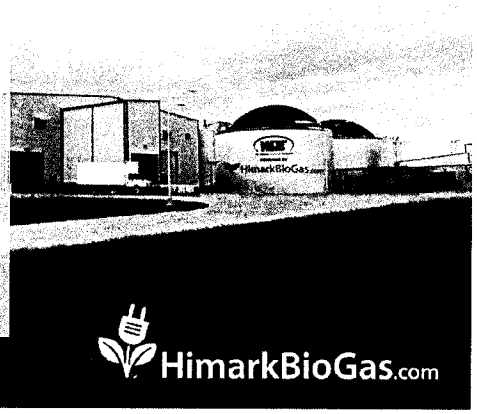
Dairy + Co-Products (WI)

- Crave Bros./Clear Horizons
- 1,900 dairy cow manure plus cheese plant waste
- 633kW
- Digested materials: animal bedding, EnerGro Potting Mix, liquid fertilizer
- $$ from potting mix and farm bedding = 2/3 of all income from the biogas system
- Similar story @ Mason Dixon Farms in PA



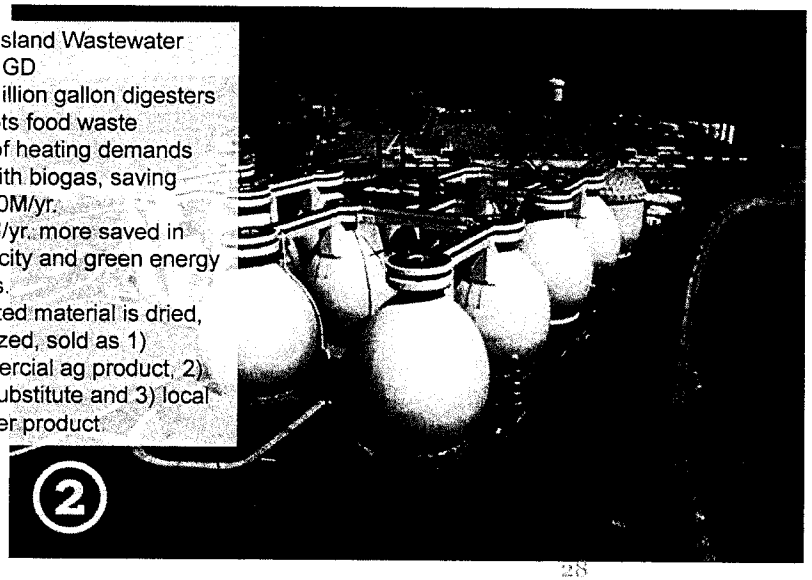
Biogas + Ethanol (KS)

- Himark BioGas/Western Plains Energy
- Biogas and ethanol (50M gal/yr) production
- Biogas Inputs: cattle feedlot manure, ethanol plant waste, slaughter-house waste and municipal organics, rich in sand, dirt, rocks, plastic, and cellulose.
- Biogas offsets fossil natural gas in ethanol plant (13MW equiv.)
- Digested materials fertilize largest plot of sweet sorghum in US



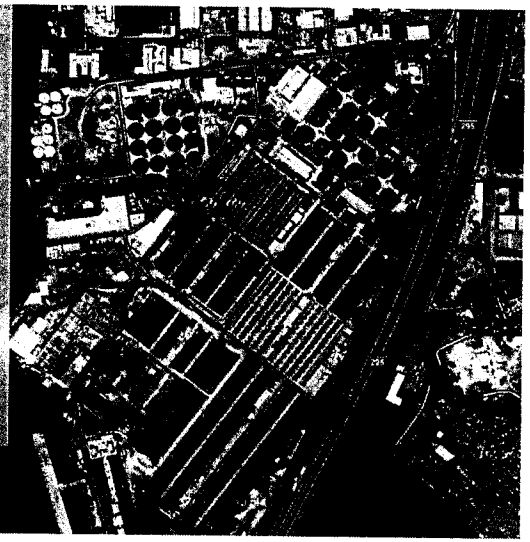
Municipal Wastewater (MA)

- Deer Island Wastewater
- 360 MGD
- 12 3million gallon digesters
- Accepts food waste
- 98% of heating demands met with biogas, saving $15-20M/yr.
- $2-3M/yr. more saved in electricity and green energy credits.
- Digested material is dried, pelletized, sold as 1) commercial ag product, 2) coal substitute and 3) local fertilizer product



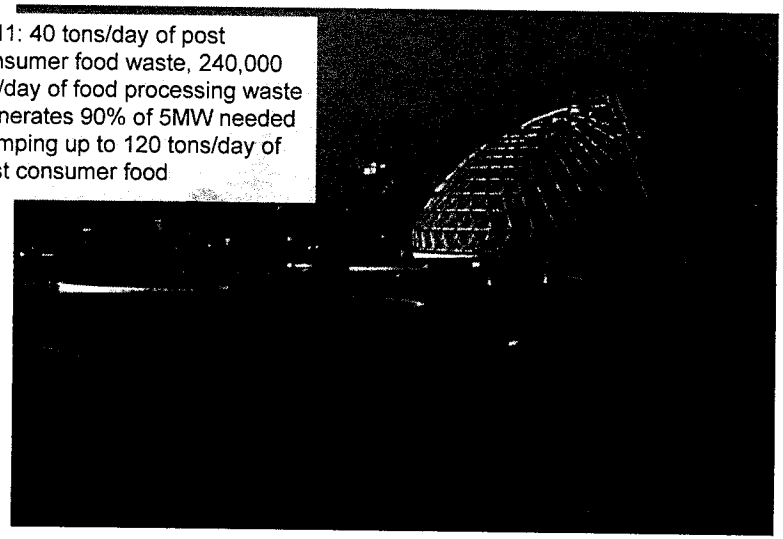
Municipal Wastewater

- DC Water
- Largest advanced wastewater facility in world
- 370 MGD wastewater
- $400 million project
- 13 MW generated uses 26 MW
- Saves $10M/year in electricity costs + $15M/year in other costs (30 fewer truck trips to the landfill/day)
- Wants to sell digested material products to Home Depot
- 100% emergency power if major failure
- Operational 2015



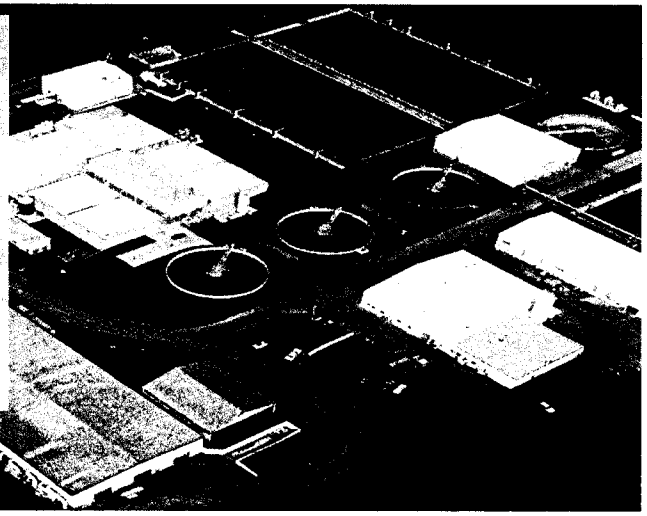
East Bay MUD

- 2011: 40 tons/day of post consumer food waste, 240,000 gal/day of food processing waste
- Generates 90% of 5MW needed
- Ramping up to 120 tons/day of post consumer food



Anheuser Busch Brewery

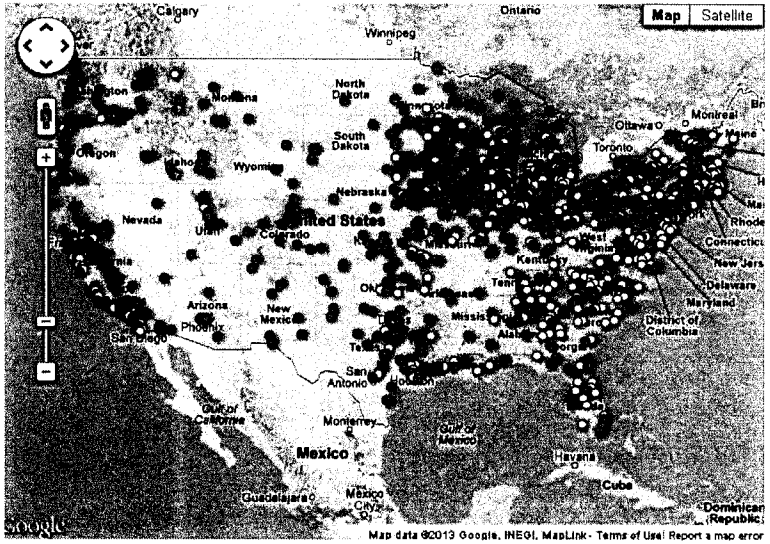
- First 4 digesters installed in 1991in Baldwinsville, NY
- 1.5 million gal/day of wastewater
- Biogas recovered replaces 15% of brewery's fuel needs and 60% of electricity
- Electric power reduction from digester use = 9 million kWh/year



American biogas Council

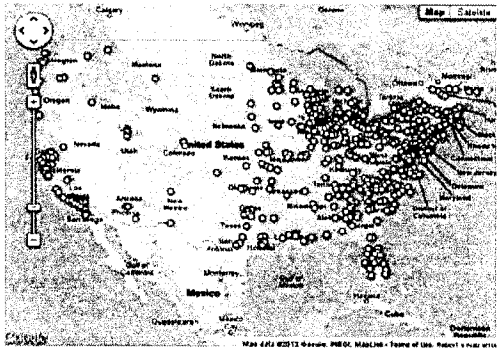
Current and Potential Biogas Production

Biogas is produced from organic waste using a natural process called anaerobic digestion (AD). Biogas can be used to make renewable electricity and is a renewable substitute for traditional natural gas. What counts as organic waste? Manure from dairies, sludge filtered from wastewater, municipal solid waste, food waste, yard clippings and more. Biogas can fuel vehicles and power plants, making electricity for homes and businesses. Bonus: making biogas creates these useful byproducts: pathogen-free fertilizer, animal bedding and compost.



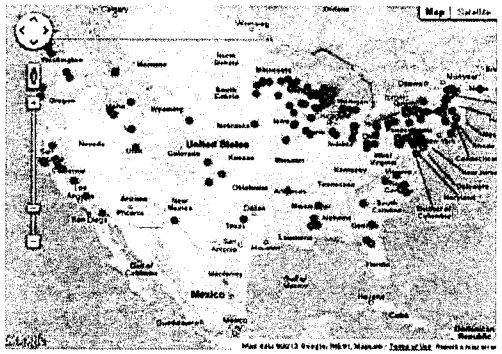
US Operational Biogas Systems

The U.S. has about 2,000 sites producing biogas: 192[1] anaerobic digesters on farms, 1,238[2] wastewater treatment plants using an anaerobic digester (~860 currently use the biogas they produce) and 594[3] landfill gas projects. The potential for U.S growth is huge. We count almost 12,000 sites ripe for development: 8,200 dairy and swine farms, 4,000 wastewater treatment plants (including ~378 who are making biogas, but 150 not using it) and 540 landfill gas projects which could support a digester today. For comparison, Europe has over 10,000 operating digesters; some communities are essentially fossil fuel free because of them.



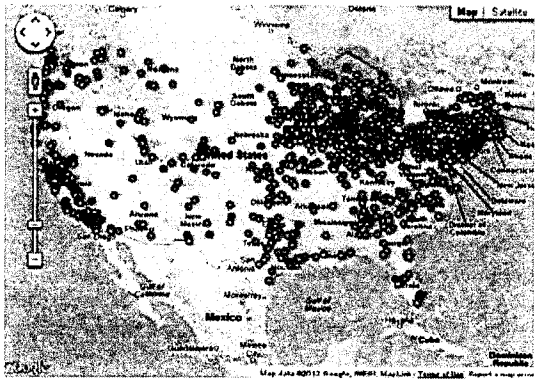
Potential Methane Production from Landfills

536 billion scf-enough for 5.5 million homes or to make 54 billion kWh of electricity (NREL)



Potential Methane Production from Manure Management

88 billion scf-enough for 894,000 homes or to make 8.8 billion kWh of electricity (NREL)
8,241 farms, 1,667 MW of power, 13.1 million MWh/year of electricity (AgSTAR)



Potential Methane Production from Wastewater

20 billion scf - enough for 200,000 homes or to make 2 billion kWh of electricity (NREL)

www.americanbiogascouncil.org 202/640-6595

[1] http://www.epa.gov/agstar/projects/index.html
[2] www.biogasdata.org
[3] http://www.epa.gov/lmop/projects-candidates/index.html

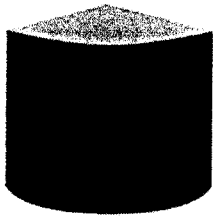
USDA United States Department of Agriculture | EPA United States Environmental Protection Agency | American biogas Council

Organic material is delivered to the digester system

This may include animal manure, food scraps, agricultural residues, or wastewater solids.

Digested material may be returned for livestock, agricultural and gardening uses.

Some biogas can be used to heat the digester.

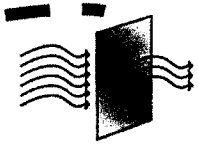


BIOGAS

DIGESTED MATERIAL

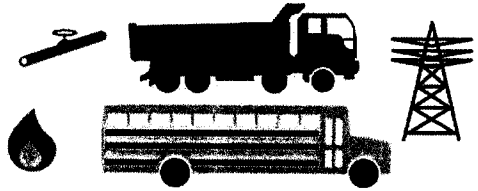
Organic material is broken down in a digester

The digester uses a natural biological process under controlled conditions to break down organic material into products for beneficial use or disposal.



Raw biogas is processed

Typically, water, carbon dioxide and other trace compounds are removed, depending on the end use, leaving mostly methane.



Processed biogas is distributed and used

The gas may be used to produce heat, electricity, vehicle fuel or injected into natural gas pipelines.

Liquids and solids may be separated.

SOLIDS

LIQUIDS

Digested material is processed and distributed

Solids and liquids from the digester may be used to produce marketable products, like fertilizer, compost, soil amendments or animal bedding.

organic material

Organic materials are the "input" or "feedstock" for a biogas system. Some organic materials will digest more readily than others. Restaurant fats, oils and grease; animal manures; wastewater solids; food scraps; and by-products from food and beverage production are some of the most commonly-digested materials. A single anaerobic digester may be built for a single material or a combination of them.

the digester

An anaerobic digester is one or more airtight tanks that can be equipped for mixing and warming organic material. Naturally occurring microorganisms thrive in the zero-oxygen environment and break down (digest) organic matter into usable products such as biogas and digested materials. The system will continuously produce biogas and digested material as long as the supply of organic material is continuous, and the microorganisms inside the system remain alive.

biogas processing

Biogas is mostly methane, the primary component of natural gas, and carbon dioxide, plus water vapor, and other trace compounds (e.g. siloxanes and hydrogen sulfide). Biogas can replace natural gas in almost any application, but first it must be processed to remove non-methane compounds. The level of processing varies depending on the final application.

biogas distribution

Processed biogas, often called "biomethane" or "renewable natural gas," can be used the same way you use fossil natural gas: to produce heat, electricity, or vehicle fuel, or to inject into natural gas pipelines. The decision to choose one use over another is largely driven by local markets.

digested material

In addition to biogas, digesters produce solid and liquid digested material, containing valuable nutrients (nitrogen, phosphorus and potassium) and organic carbon. Typically, raw digested material, or "digestate," is processed into a wide variety of products like fertilizer, compost, soil amendments, or animal bedding, depending on the initial feedstock and local markets. These "co-products" can be sold to agricultural, commercial and residential customers.

Arizona Corporation Commission

Technology vs Regulatory Model Workshop
Docket No. E-00000J-13-0375

System Adequacy in an Inertia Depleted Future

by

Jerry D. Smith
P&R Consulting LP

April 25, 2014

Foundation for Remarks

This presentation represents my personal views and opinions based upon 46 years of experience in the electric utility industry. Such experience includes:

- 29 years as a SRP engineer and manager
- 8 years as an ACC staff member
- 8 years as an engineering consultant

The contents of my remarks should not be viewed as representative of the views and opinions of my past or active clients.

Topics Covered

- A historical system view
- Where our policies are leading us
- Operational challenges
- System risks / concerns
- Technology needed
- Regulatory Framework Voids

Western Interconnection

- Unique System Characteristics
  - 13 western states, 2 Canadian provinces and northern Baja California
  - dispersed large load centers
  - served by large remote joint participation power plants
  - via a sparse network of series compensated EHV transmission lines
- "Largest man made machine"–Jack Davis

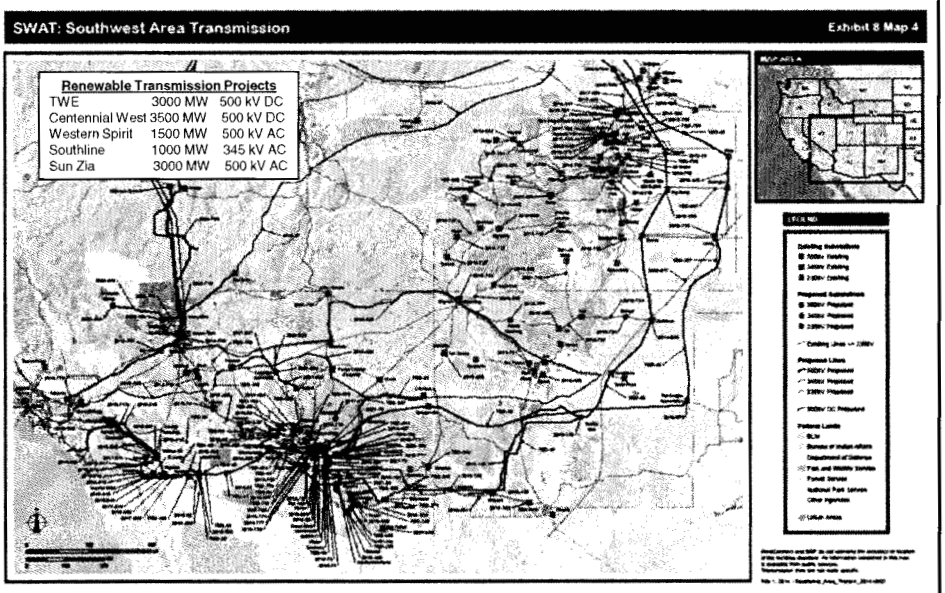
Our Future Is Changing

- Large joint central power plants are being replaced by dispersed intermittent renewable wind and solar resources
- Regulatory policy has set renewable resource targets and GHG targets are looming on the horizon
- "How much renewables can we deploy without system reliability and operational concerns?" - 2001 ACC RPS proceedings
- Regulatory policy is driving unit retirements

Nature of Future System

- More complex operational paradigm:
  - Intermittent renewable resources
  - Additional layers of protection and control will be required for frequency / voltage control
  - Customer's self-supply not under control of utility
- Increasing system risks:
  - Renewable resources are non-firm and non-dispatchable
  - Exposed to significant weather related outages
  - Outage of large renewable transmission lines and associated resources

ref: 2014 WestConnect Annual 10-Year Transmission Plan



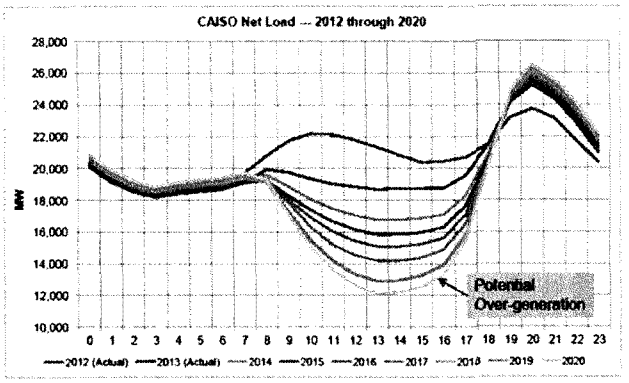
System Adequacy Concerns

- Generation operational paradigm changing due to non-dispatchable renewables
- Increasing renewable integration levels yields additional operational complexities and disturbance risks
- Retirement of coal, nuclear, and once thru cooling units reduces inertia needed for:
  - Frequency / voltage control
  - Ability to manage system disturbances

CAISO Ramp

ref: CAISO Presentation at CA Energy Summit Dec 2013

Non-summer months --- Net load pattern changes significantly starting in 2014



California ISO CL – 6/2013 Slide 7

CAISO's Future Integration Challenge

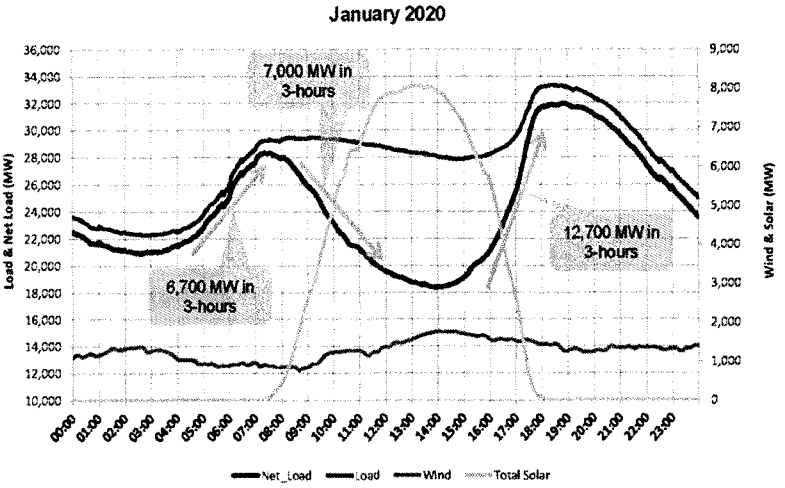
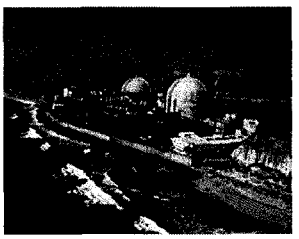


Figure 6: Load, Wind, and Solar Profiles – Base Scenario

Unit Retirements (Major Sources of Inertia)

Arizona /New Mexico/Nevada		
Location	Type	MW
Navajo	Coal	750
Four Corners 1,2,3	Coal	560
San Juan 2,3	Coal	924
Reid Gardner	Coal	557
	Total	2,791

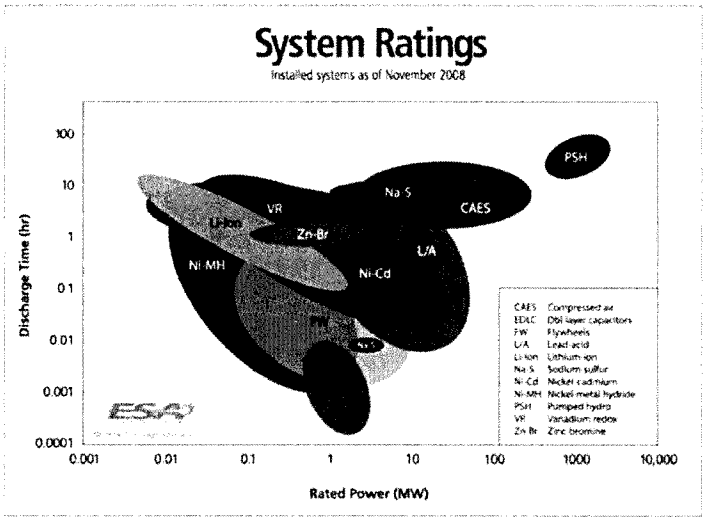
California		
Location	Type	MW
SONGS	Nuclear	2,000
Once Thru Cooling	Gas-Fired	8,000
	Total	10,000



Depleted Inertia Concerns

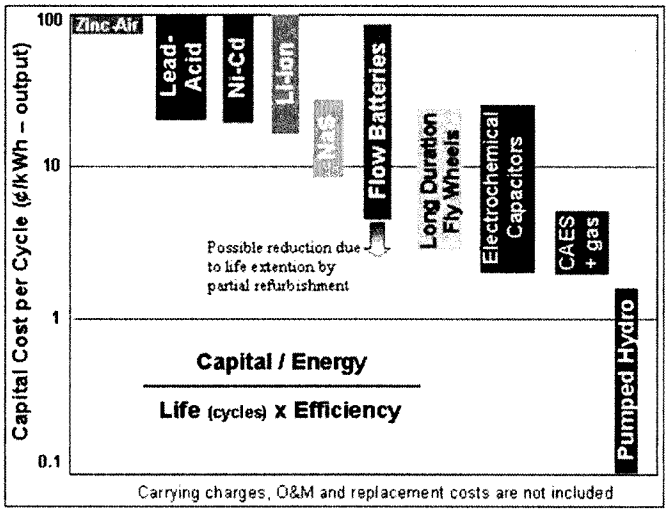
- Impact of retiring ~ 20 % of CA and Desert Southwest generation fleet is still being investigated and studied
- Inertia of these large base loaded units has been critical to
  - Managing system disturbances
  - Achieving higher transmission path ratings which are often transient stability limited
  - Coastal units provided reliability for local transmission constrained zones

Storage Technology



Storage Cost Comparison[1]

[1] Energy Storage Association



Best Available Technology: Pumped Storage Hydro (PSH)

- Provides significant sources of inertia
- PSH units provide storage and firming for non-dispatchable renewable resources
- PSH units are dispatchable and provide assorted ancillary services
- Variable spread PSH units provide fast response for voltage and frequency regulation in both generate/pump mode

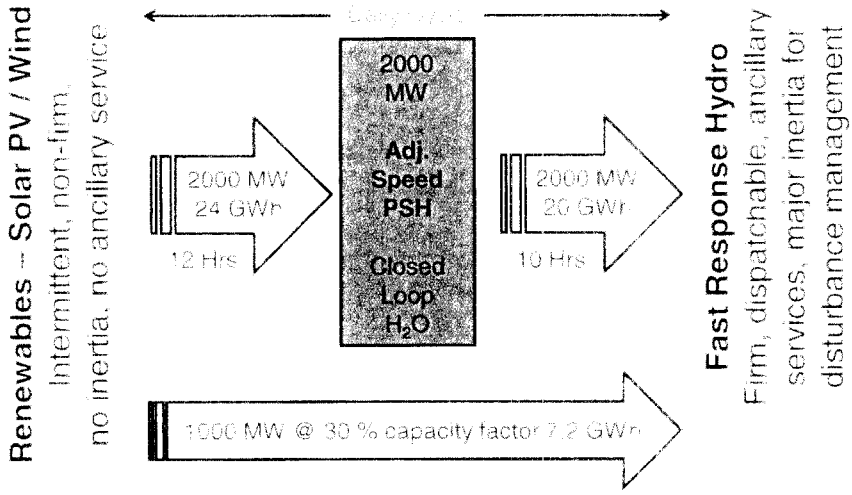
Longview Water Use vs. Other AZ Plants

Category	Navajo Power Plant	Redhawk[2] Combined Cycle	Longview Energy Exchange
Technology	Coal	Natural Gas	Hydroelectric
No. of Units	3 – 750 MW	4 – 550 MW	8 – 250 MW
Total Capacity	2250 MW	2120 MW	2000 MW
Water Use / Yr	26,274 AF[1]	13,300 AF	1,200 AF

[1] Western Resource Advocates, http://www.westernresourceadvocates.org/water/waterenergy.php

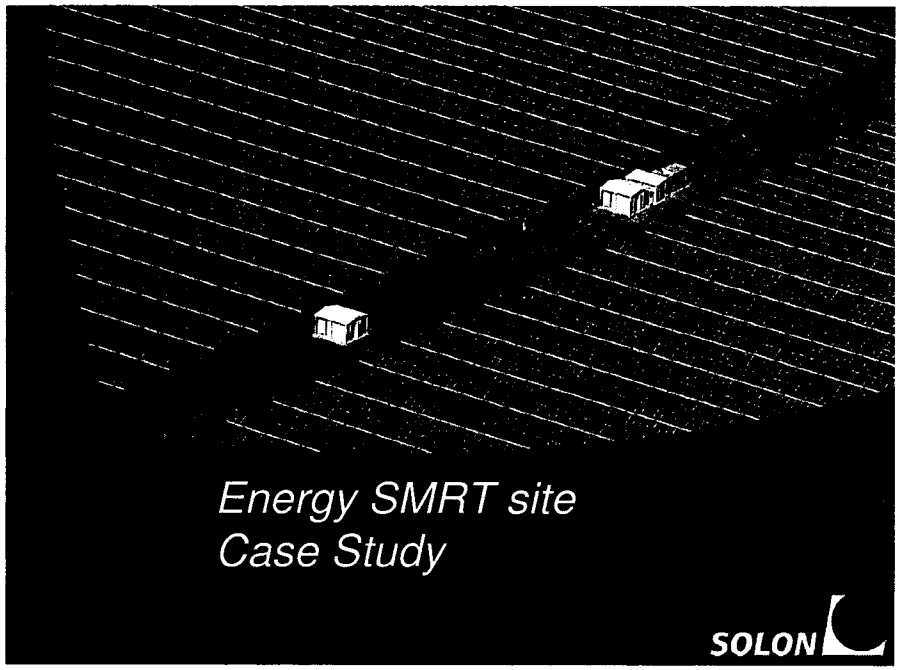
[2] Arizona Corporation Commission, CEC application, only 2 units constructed, Docket No. L-00000J-99-0095.

PSH As Requisite Renewable Complement



Regulatory Insights

- Net metering disguises impact of major weather events and generation ramp up and ramp down needs of balancing authority
- Firming for renewables needs to be on receiving end of renewable transmission projects
- Adjustable speed PSH is
  - the best available technology to replace inertia of large retired units
  - Needed as a requisite compliment for renewables
- No ACC siting requirements for renewables



Energy SMRT site – *What is it?*

Site Overview

Smoothing of PV Intermittency

Frequency Response

Conclusion

SOLON

Energy SMRT site – Who is involved?

SOLON – Project manager, overall system and control design

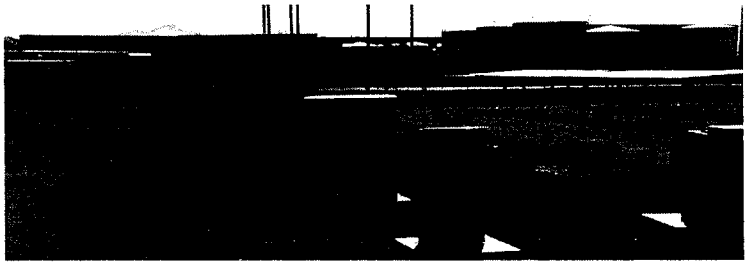
Tucson Electric Power – PV plant owner, design participation, technology selection

SMA – Inverter design/supply , data interpretation

– Data interpretation, report preparation

SOLON

Energy SMRT site – *What is it?*

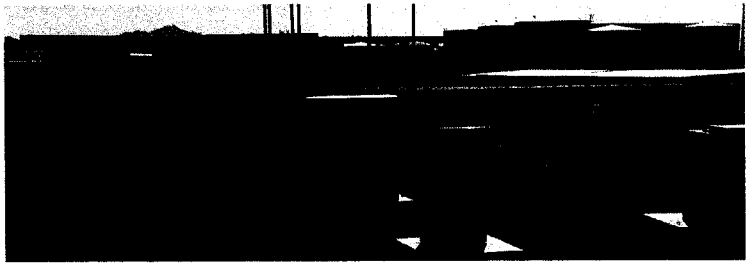


MW scale battery storage and PV integration

Storage Management Research and Testing

SOLON

Energy SMRT site – *What is it?*



Installed at Science and Tech Park

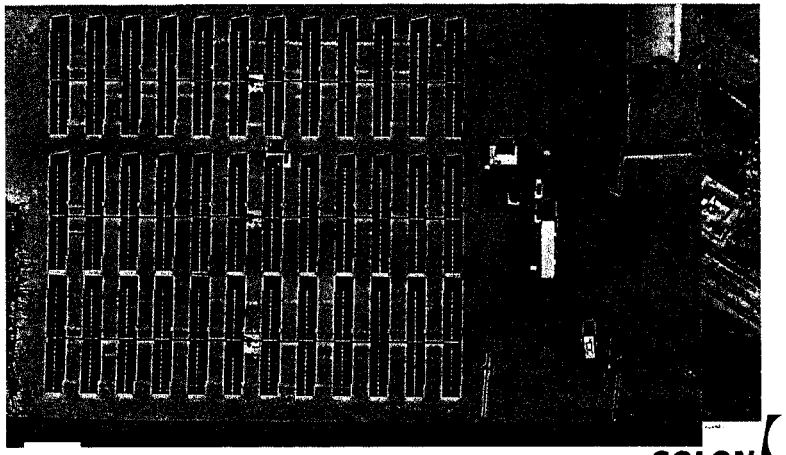
First operation in Oct 2012

Continuous Testing and Development

SOLON

Energy SMRT site – Where is it?

"The Solar Zone" - The largest multi-technology utility-scale research and demonstration center in the nation.



SOLON

Energy SMRT site– What is it?

SOLON 1.6 MW PV plant

500 kW Inverter and Battery

SOLON control system

SOLON

Energy SMRT site– What is it?

Li-ion battery

High Power – Low Energy

Small footprint

Wide temperature range

SOLON

Energy SMRT site – Why did we build it?

To quantify value of energy storage.

To learn what is involved in designing and executing energy storage projects?

To learn how to evaluate systems.

Summary: Build Expertise.

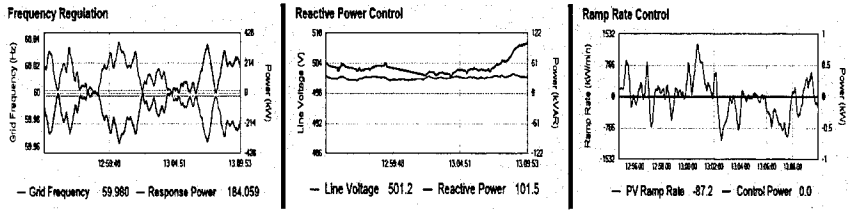
SOLON

Energy SMRT – What do we DO with it?

Smooth Intermittency

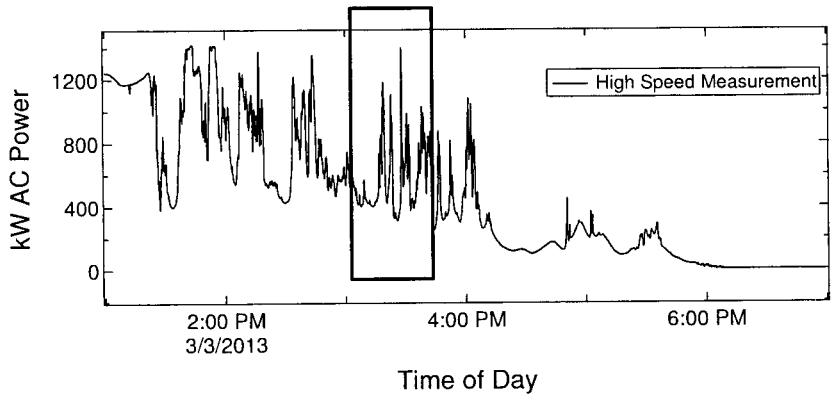
Frequency Regulation

Voltage Support



SOLON

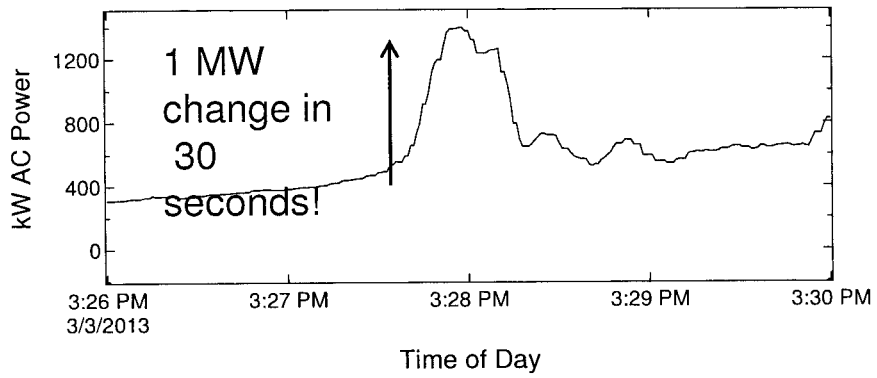
Smooth Intermittency



Sudden swings in production

SOLON

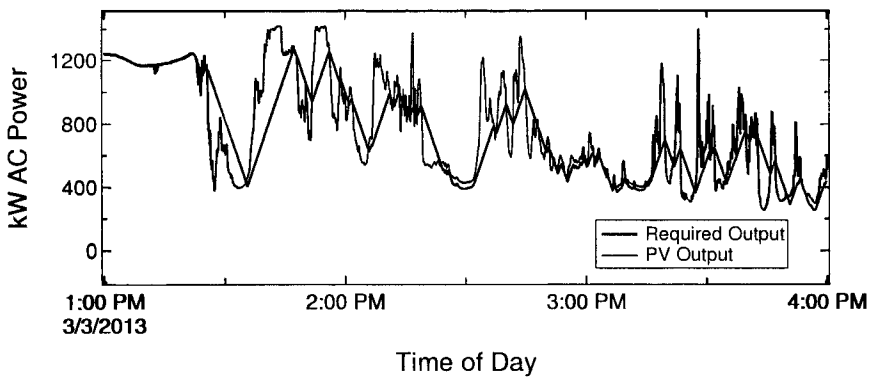
Smooth Intermittency



Sudden sharp peak. Output doubles to 1MW in 30 sec, then reverses in next 30 seconds

SOLON

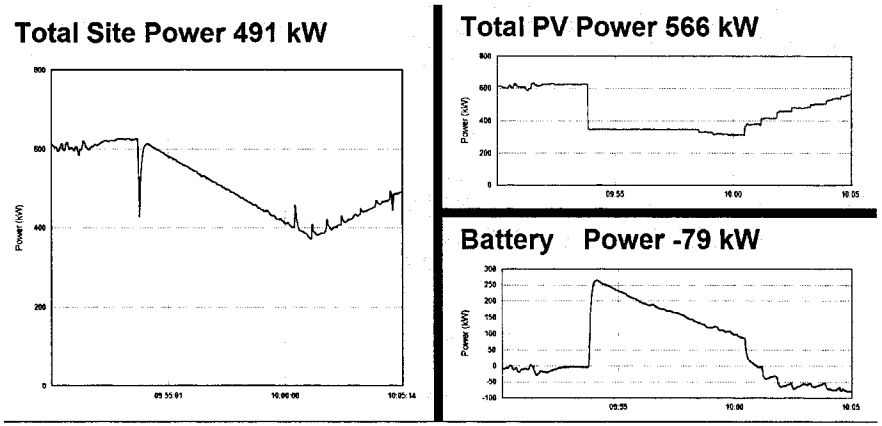
Smooth Intermittency



Puerto Rican Utility requires PV output never change by more than 10% per minute.

SOLON

Smooth Intermittency - Results



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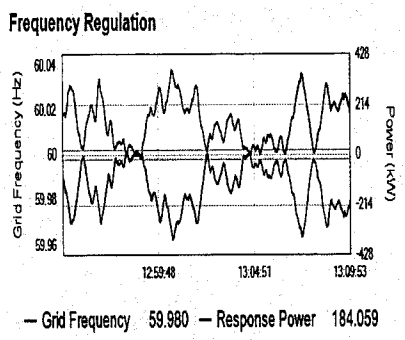
Frequency Response

Imbalance between Load and Generation causes grid frequency to change.

Frequency response scales

Disruption (tripped generator)
- Halt frequency drop
- Brief, very high power

Normal operations
- Frequency stabilization
- Continuous, lower power



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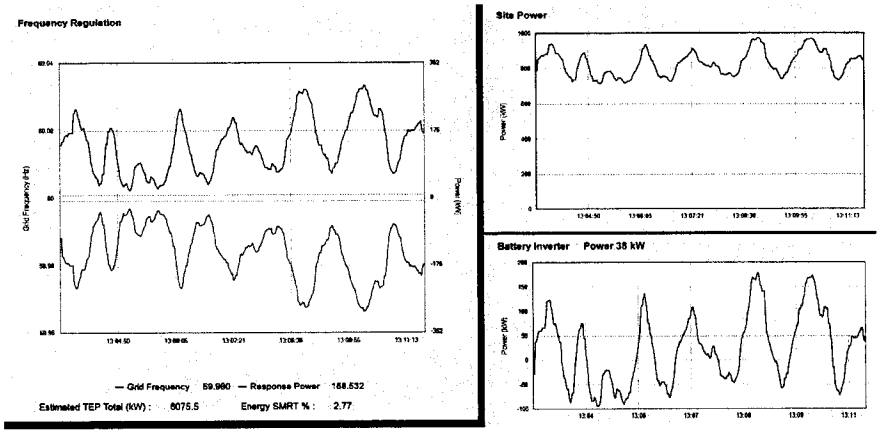
Frequency Response - Results



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Frequency Response

Energy SMRT site provides:

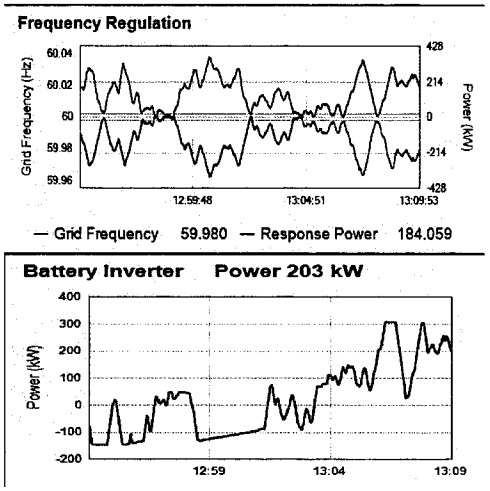
Support during normal operation periods.

Real-time automatic proportional response to grid frequency deviations.

Full power response in about one second

Virtual "high heat rate reserve"

Can supply approximately 1-2% of TEP's ACE requirement.



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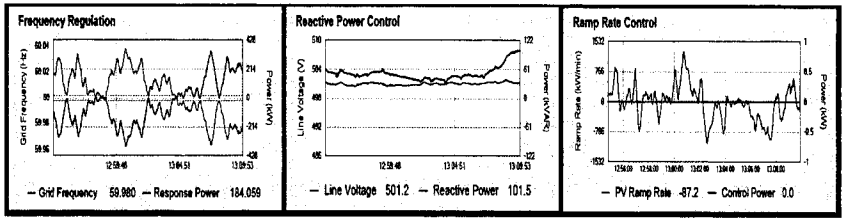
Energy SMRT site – Live Control



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Energy SMRT site - Conclusion

- Increases the value of power from installed PV system
- Smoothing of intermittency control reduces variability
- Relatively small system has impact
  - Provides frequency response for ~50 MW of PV power plants
- Demonstration of remote control

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Energy SMRT site

Thank You

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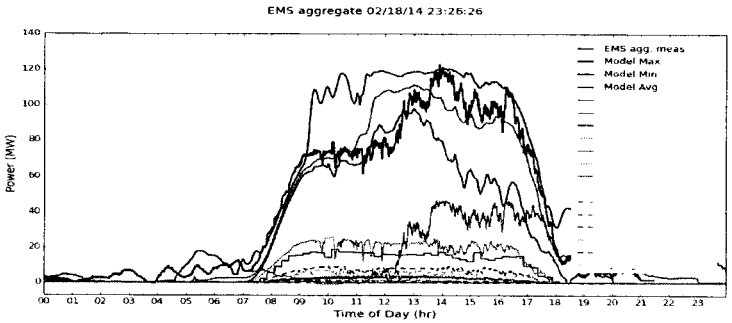
Real-Time Renewable Power Forecasting



Will Holmgren
Postdoctoral Research Assistant
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University of Arizona

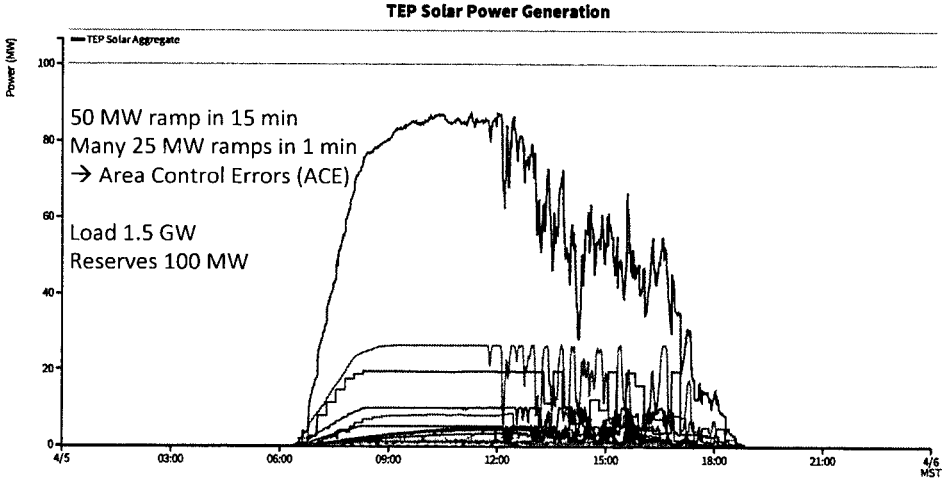
ARIZONA

Alex Cronin, Associate Professor, Physics
Antonio Lorenzo, Grad Student, Opt. Sci.

Eric Betterton, Dept. Head, Atmo. Sci.
Mike Leuthold, Meteorologist, Atmo. Sci.
Chang Ki Kim, Post doc, Atmo. Sci.

Ardeth Barnhart, Director, UA-REN
Rey Granillo, Developer, UA-REN

The Problem: TEP's Solar Power Variability



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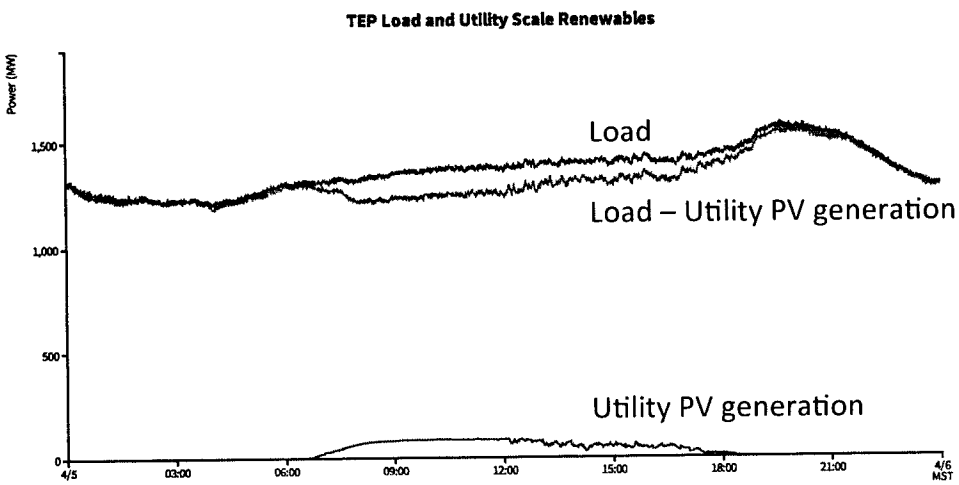

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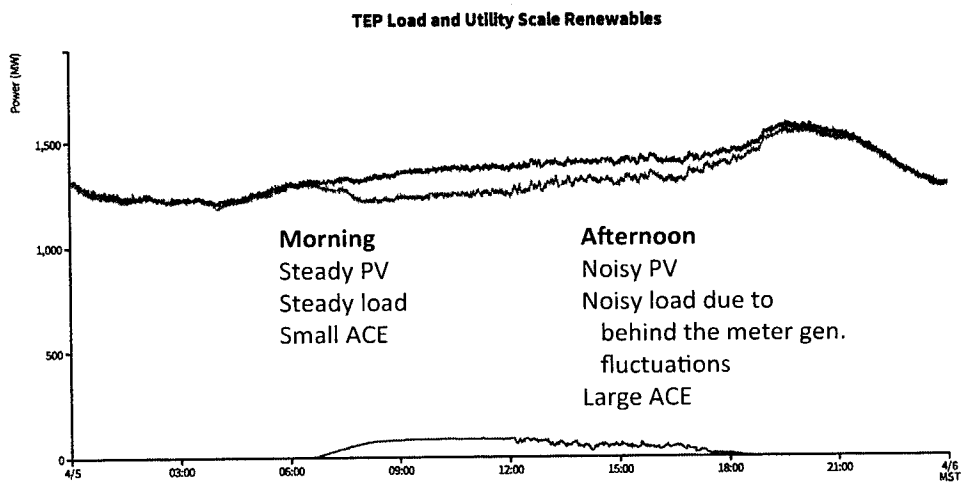

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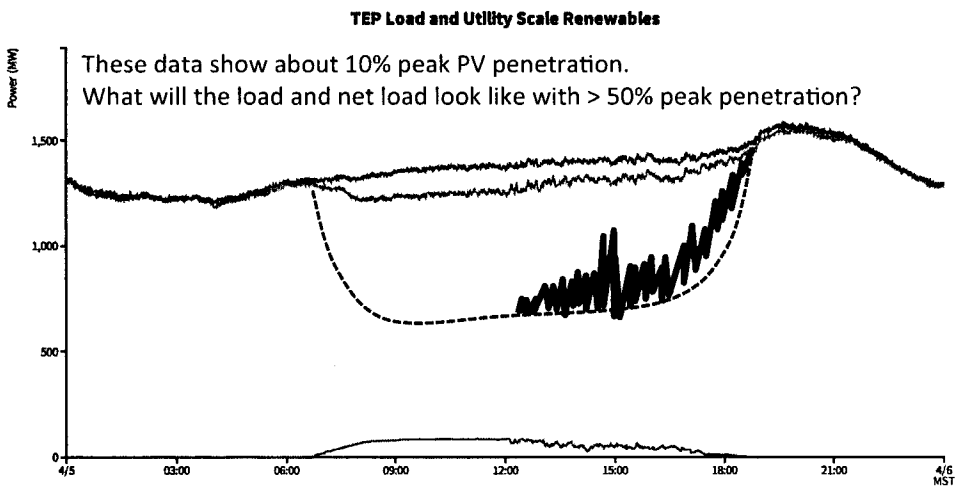


These data show about 10% peak PV penetration.
What will the load and net load look like with > 50% peak penetration?

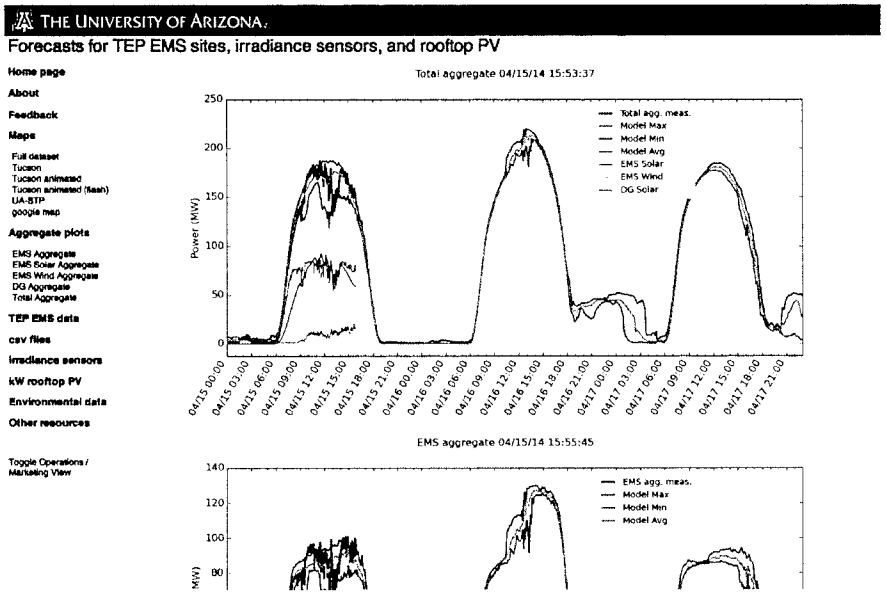
The Solution:
UA + TEP developing renewables forecasts

How can forecasts help utilities keep energy costs low and maintain grid reliability?

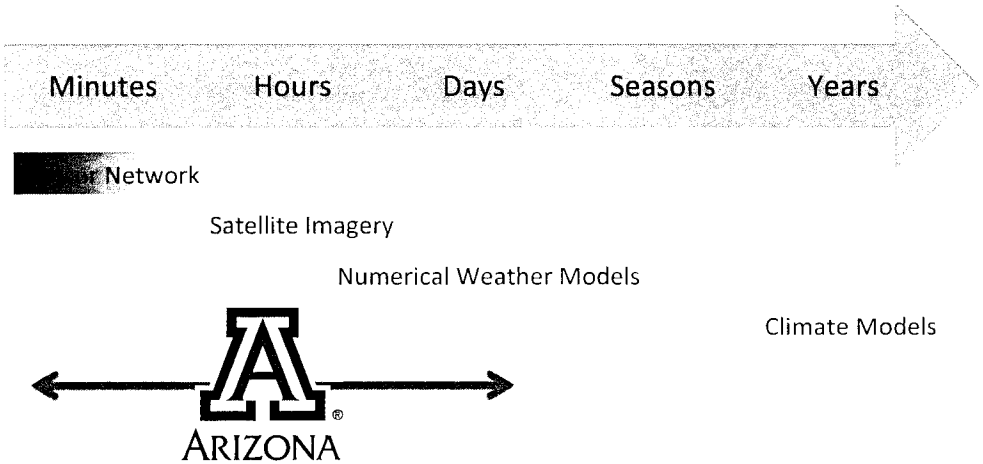
- Better predictions of generation and load requirements
- Improve energy market trading strategies
- Schedule more efficient generators (e.g. combined cycle vs. combustion turbine)
- Reduce costs associated with generator starts
- Defer maintenance associated with excessive generator set point seeking
- Optimize the use of battery storage

UA is providing TEP with forecasts as we speak!

Forecasting Website for TEP

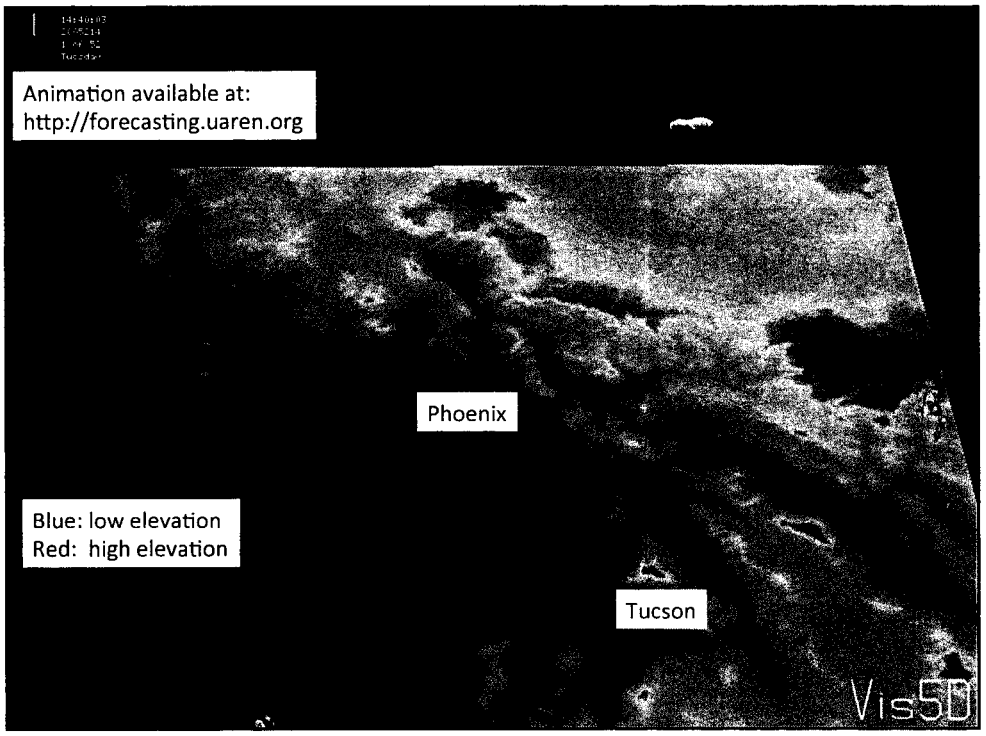


Different forecasting methods work better at different time scales.

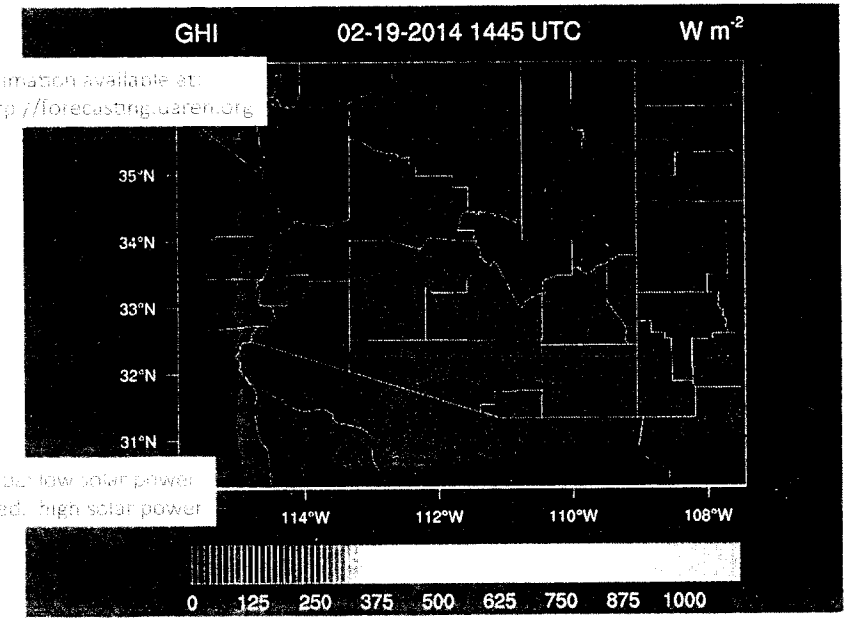


Numerical Weather Prediction at UA

- Local/regional knowledge of weather is extremely important
- State of the art model modified to better represent the unique characteristics of southwestern U.S. weather
  - Mountains + moisture + heating = monsoon storms
  - Unreliable initialization data from Mexico
  - Extreme planetary boundary layer heights
  - Rapidly changing land/surface characteristics
- Five model runs per day, out to 72 hours in advance
- 1.8 km resolution, 3 minute outputs of:
  - GHI, DNI, 10 m wind, 80 m wind, temp



Satellite Derived Solar Irradiance



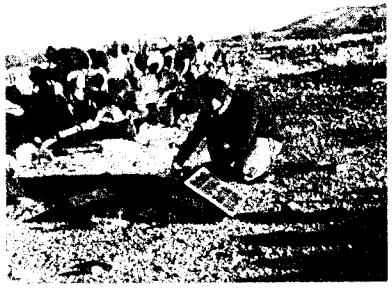
Animation available at:
http://forecasting.uaren.org

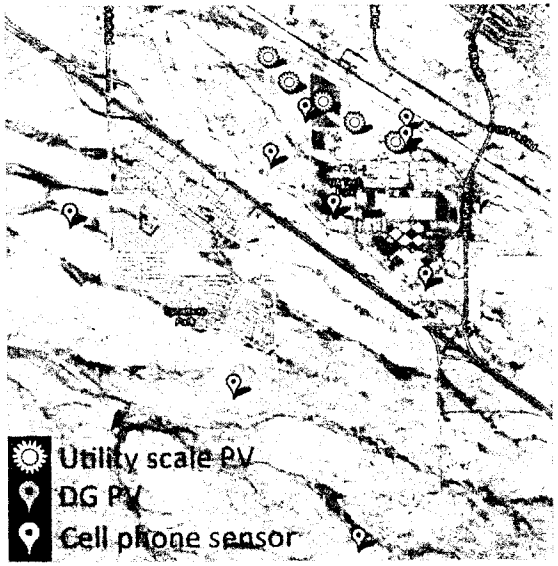
blue: low solar power
red: high solar power

PV Cloud Detection Network

UA Science and Technology Park
20 MW of Solar PV

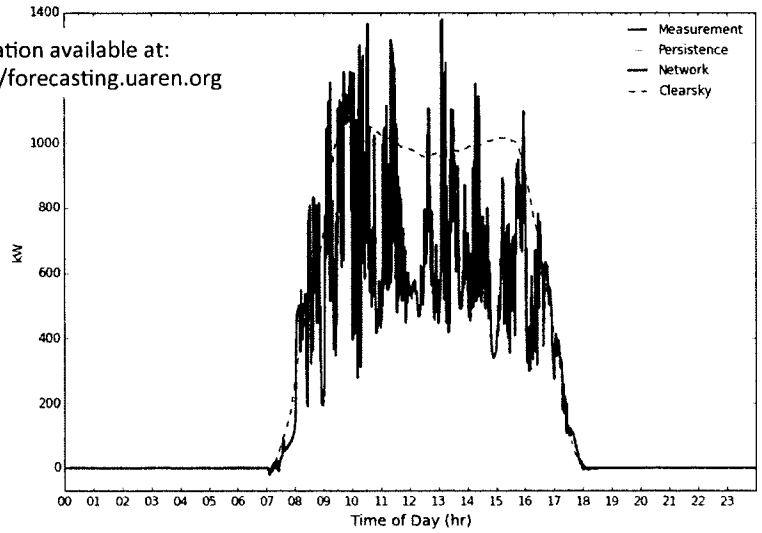
Network of irradiance sensors provides 15-30 minute ahead warnings of clouds



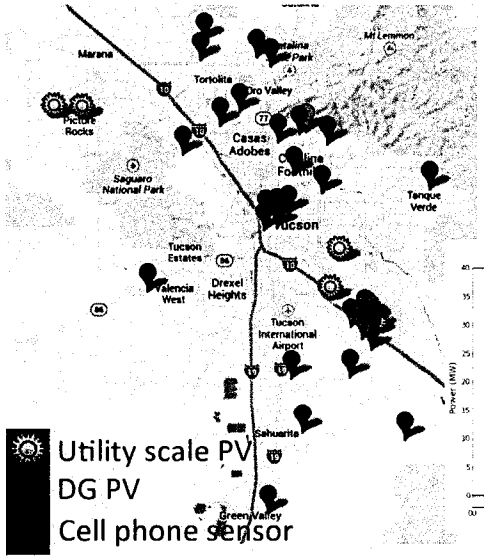


Network Forecast

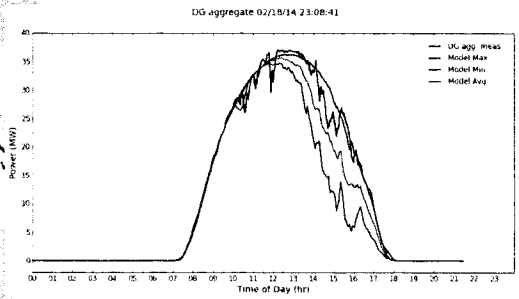
Animation available at:
http://forecasting.uaren.org



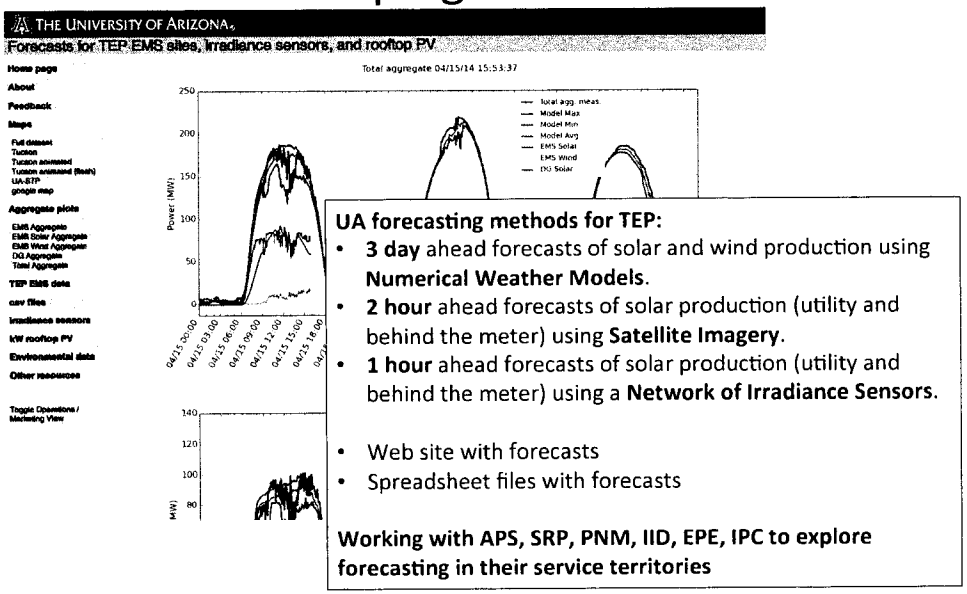
Behind the Meter Visibility and Forecasting



Partnered with Technicians for Sustainability to obtain access to real-time data feeds of residential PV systems



The Solution:
UA + TEP developing renewables forecasts



UA forecasting methods for TEP:

- **3 day** ahead forecasts of solar and wind production using **Numerical Weather Models**.
- **2 hour** ahead forecasts of solar production (utility and behind the meter) using **Satellite Imagery**.
- **1 hour** ahead forecasts of solar production (utility and behind the meter) using a **Network of Irradiance Sensors**.

- Web site with forecasts
- Spreadsheet files with forecasts

Working with APS, SRP, PNM, IID, EPE, IPC to explore forecasting in their service territories

The Solution:
UA + TEP developing renewables forecasts

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UA is providing TEP with forecasts as we speak!

Changing Customer Energy Use Patterns: An Arizona Focus

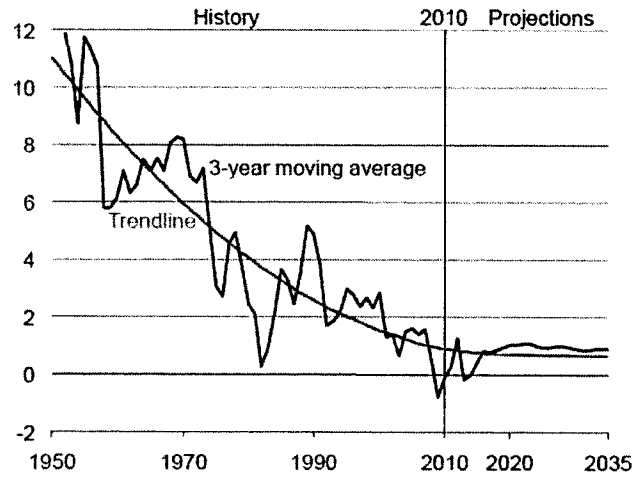
SWEEP

Jeff Schlegel & Ellen Zuckerman
Southwest Energy Efficiency Project (SWEEP)

ACC Emerging Technology Workshop, Response to #1 – April 25, 2014

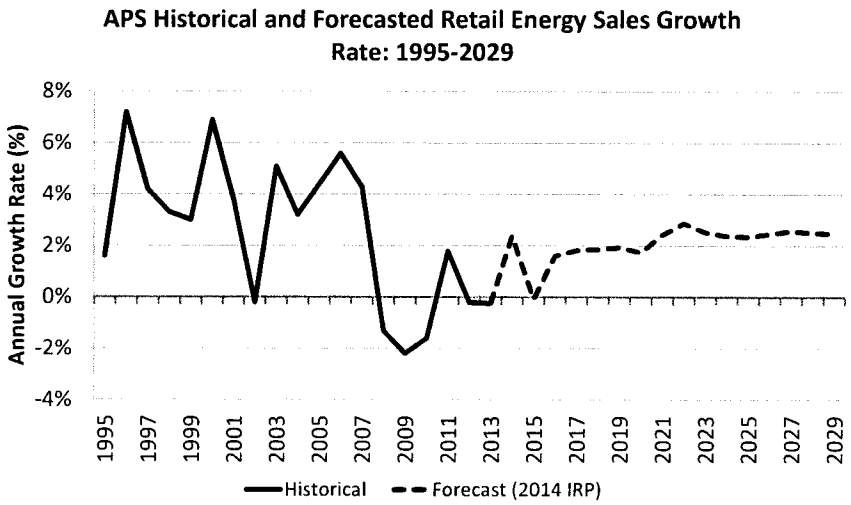
In March, Dr. Faruqui highlighted the lower growth rates for electricity sales in the U.S.

U.S. Electricity Demand Growth, 1950-2035 (percent, 3-year moving average)



Source: EIA, 2012 Annual Energy Outlook

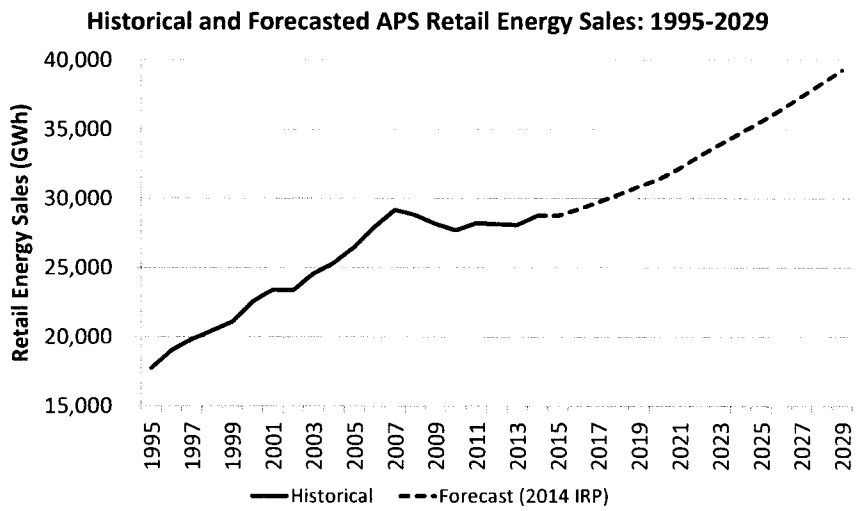
Arizona has experienced similar patterns; APS is forecasting moderate growth ahead



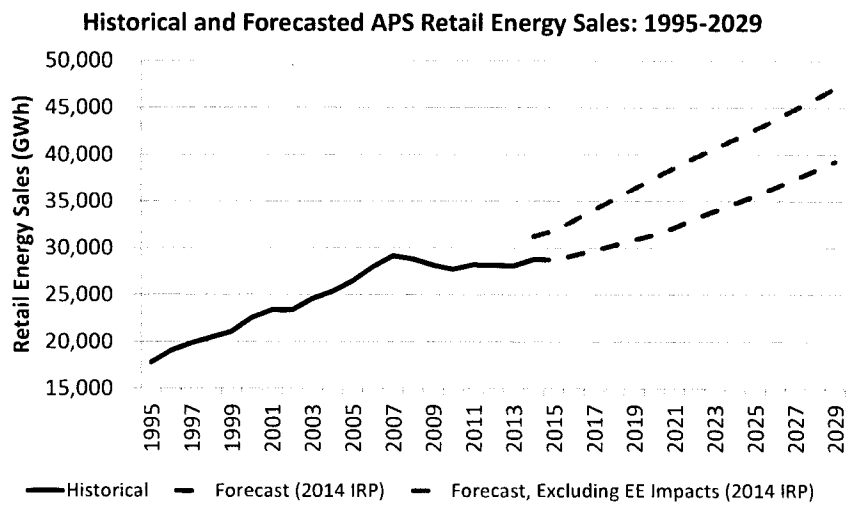
Lower growth rates may be a concern for industry, but they are good for customers

- SWEEP understands that higher growth rates are perceived as good for utility revenues and profits
- But lower growth rates can be good for customers
  - Less upwards cost pressure due to new resources
  - Less exposure to risks
  - Customers are choosing to have lower energy bills
  - Increased energy efficiency helps to lower customer bills
- Lower growth rates also help the utility manage the utility system to meet customer needs
  - Easier to manage some risks the utility faces

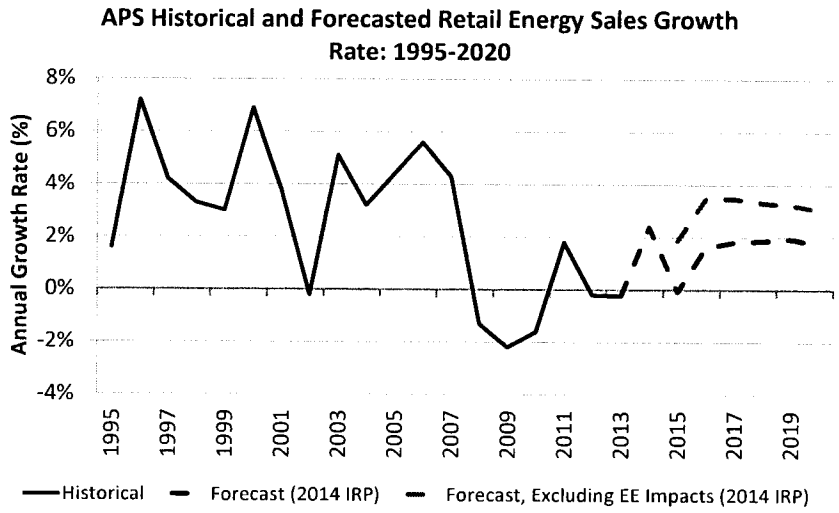
APS is forecasting moderate growth in sales even with the impacts of EE and DG



Electricity sales (and customer bills) would be much higher without the EE programs



APS electricity growth rates would also be higher without the EE programs



Thank you!

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  602-466-1513