



# MICROGRIDS



## U.S. Activities

By

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Office of Electricity Delivery and Energy Reliability

*(U.S. DOE Smart Grids: Merrill Smith, Eric Lightner, & Dan Ton,  
CERTS: Joe Eto, Bob Lasseter, & Juan Torres)*

presentation at

**Microgrids: Novel Architectures for Future Power Systems**  
**Paris, 29 Jan 2010**



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# Outline



## CERTS MICROGRID

- history of pioneering microgrid technology
- detail on SMUD demonstration (& Santa Rita Jail below)

## ONGOING MICROGRID DEMONSTRATIONS

- 9 ongoing demonstrations funded by RDSI/SG Program

## STIMULUS MICROGRID & SMART-GRID SPENDING

- overview of stimulus legislation
- Investment Grants & Demonstration/Storage projects



# CERTS Microgrid



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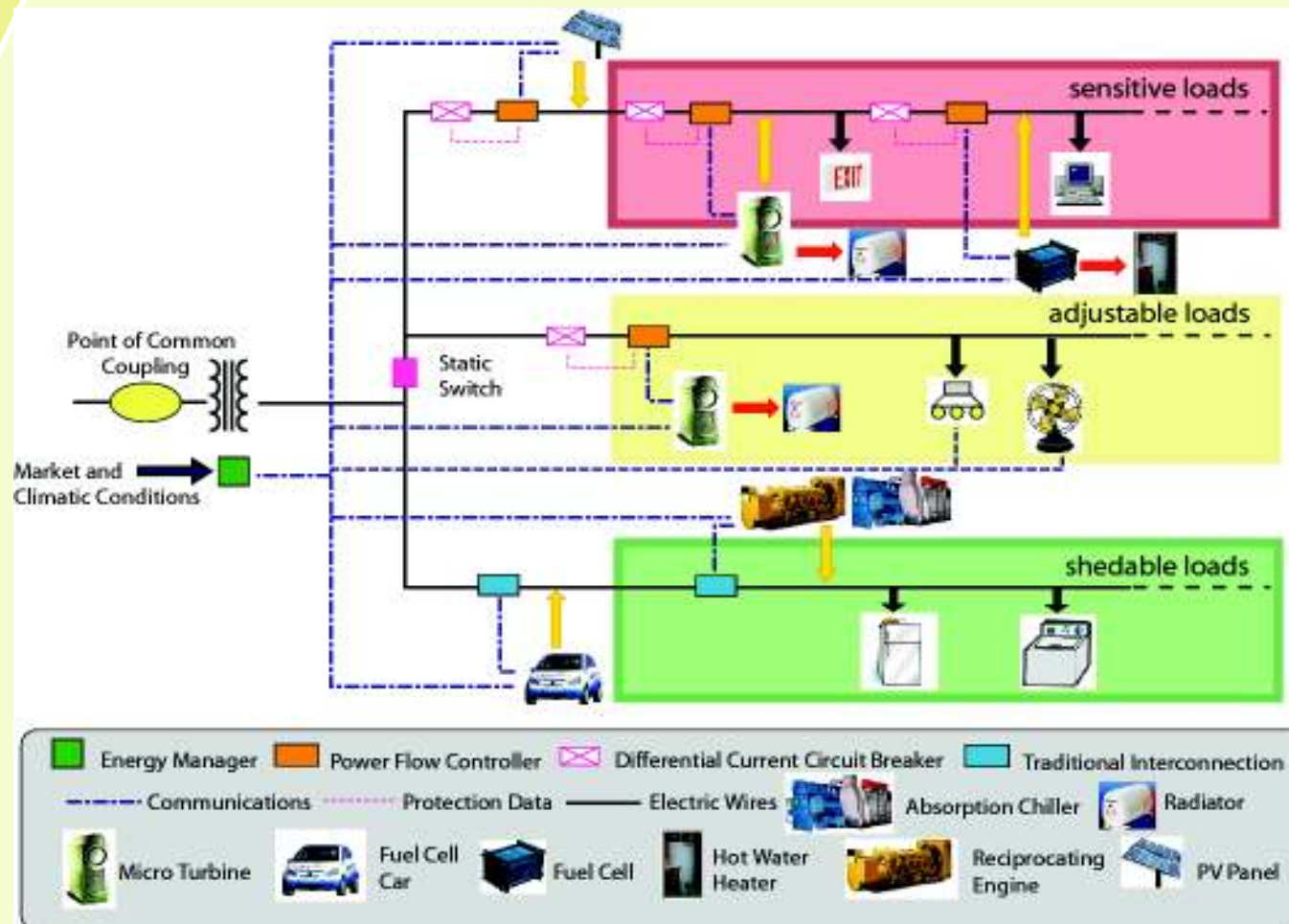
# CERTS Microgrid Program



- Consortium for Electric Reliability Technology Solutions (CERTS formed 1999, centered at Berkeley Lab, U. of WI-Madison, Sandia Lab, ..., DOE funds)
- CERTS Microgrid (CM) devised and presented 2002
- bench testing at U. of WI 2001-2006 (DOE)
- testing AEP Dolan TC, Columbus OH (2007-present, CEC)
- principle proven with 3-unit inverter based CM
- recent work at U. of WI on mixed systems (2006-2009) (synchronous generators, storage, etc.)
- field demonstrations: SMUD from 2010 (CEC), Santa Rita Jail 2009 (DOE), 3 military bases (DOD)
- DER-CAM &  $\mu$ GRD also developed under this program
- TECOGEN commercialized a version (CM-100, 2007)



# Example CERTS Microgrid







# Dolan Tech Center 1



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# Dolan Tech Center 2



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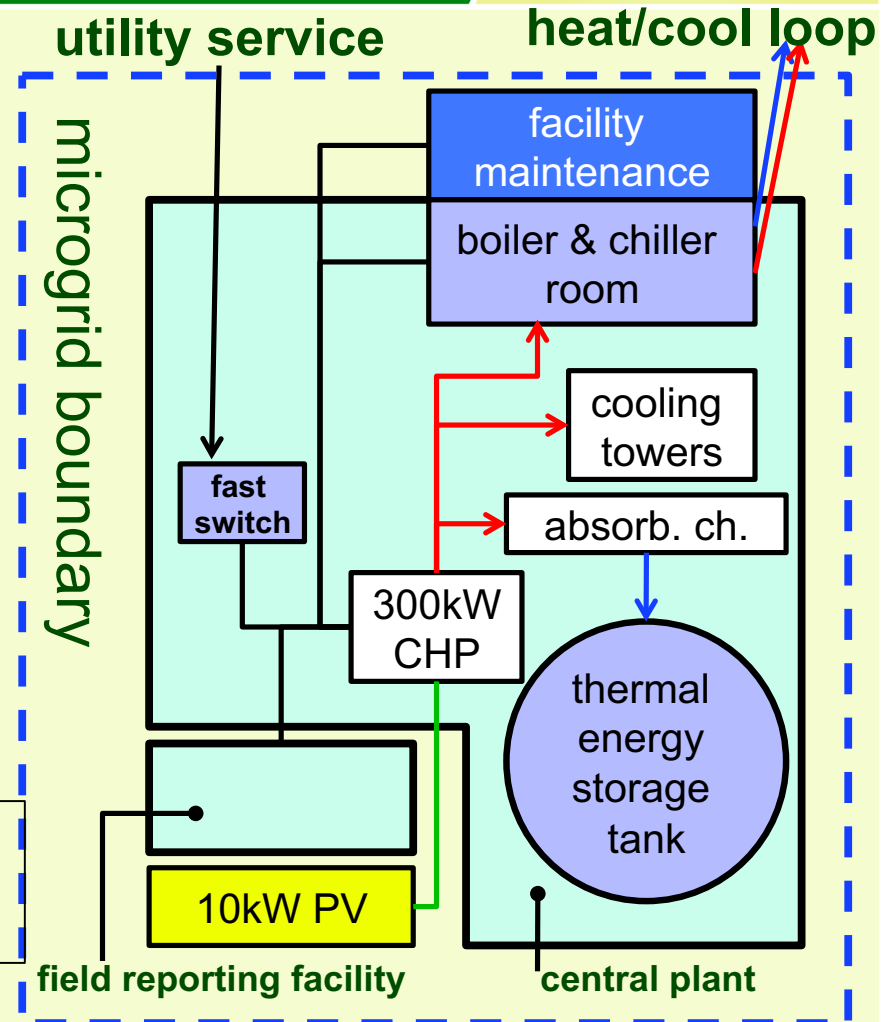
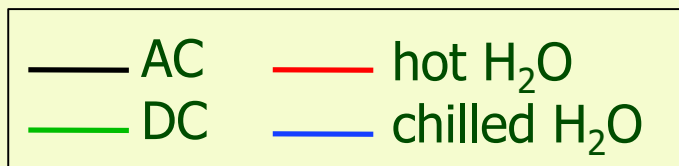




# SMUD CERTS Microgrid



- 3-100 kW CM-100 engines & 10 kW PV
- CM capability
- island of central plant and field reporting center
- CHP waste heat CHP for hot & chilled H<sub>2</sub>O loop
- economic value to customers & SMUD
- operational in 2011



source: SMART GRID ACTIVITIES AT THE SACRAMENTO MUNICIPAL UTILITY DISTRICT (SMUD) ppt



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# Overview of Ongoing Microgrid Projects





# Ongoing DOE Microgrids



\$55M over 5 yrs. for projects that advance microgrid technologies from 2008

## **Santa Rita Jail CERTS microgrid**

- large-scale battery storage
- PV
- fuel cell
- wind turbine

## **Fort Collins in Colorado State, ~4 MW**

- PV
- CHP
- thermal storage
- fuel cell
- microturbines
- PHEV
- DR

## **Consolidated Edison (utility in NY state)**

- DR
- PHEV
- fuel cell
- islanding
- dynamic configuring
- fault isolation

## **Univ of Hawaii – transmission congestion relief**

- intermittency mgmt system
- DR
- wind turbines
- dynamic simulations modeling

## **Defense company in Utah, ~2.6 MW**

- hydro and wind turbine
- solar thermal
- waste heat recovery

## **Illinois Institute of Tech., Chicago**

- advanced meters
- intel. perfect power sys. control.
- DR controller
- UPS
- energy storage

## **San Diego “Beach Cities Microgrid”**

- DER
- energy storage
- advanced metering
- outage mgmt system

## **Univ of Nevada, Las Vegas– “hybrid” homes**

- PV
- in-home dashboard
- automated DR
- energy storage

## **Allegheny Power, ~2.1 MW**

- biodiesel engine
- microturbine
- PV
- energy storage
- adv. wireless comm.
- dynamic feeder reconfig.

source: “Renewable and Distributed Systems Integration Demonstration Projects” pdf  
EPRI Smart Grid Demostration Advisory Meeting Oct 12-14 2009 Albuquerque, NM



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# Santa Rita Jail Overview



- 5<sup>th</sup> largest jail in the US (4100 short-term inmates)
- biggest energy consumer of all the Alameda County buildings
- PV system completed in 2002 (then largest rooftop install. in the US)  
rated at 1.18 MW but never produced > 800 kW
- 1.0 MW fuel cell with CHP for water heating 2006
- addition of 2.0 MW, 14 MWh NAS batteries



source:

<http://www.energy.ca.gov/distgen/installations/santarita.html> ; [http://www.chevronenergy.com/case\\_studies/alameda\\_county.asp](http://www.chevronenergy.com/case_studies/alameda_county.asp) ; photos jlai



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# American Recovery and Reinvestment Act 2009 (ARRA or “stimulus”)



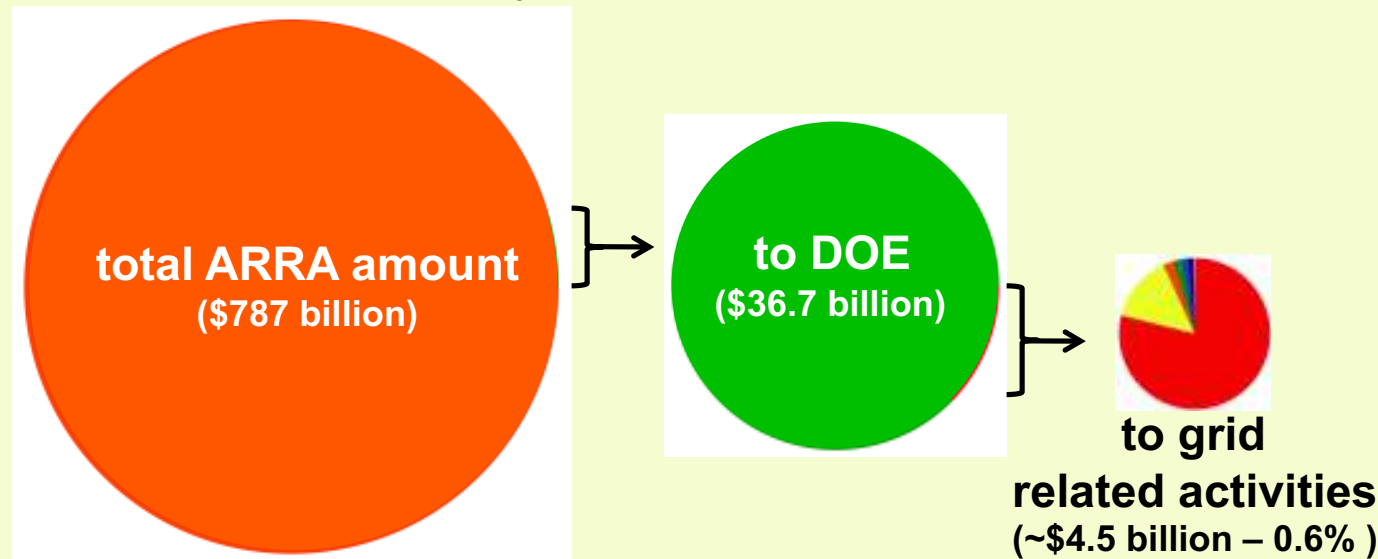




# ARRA background

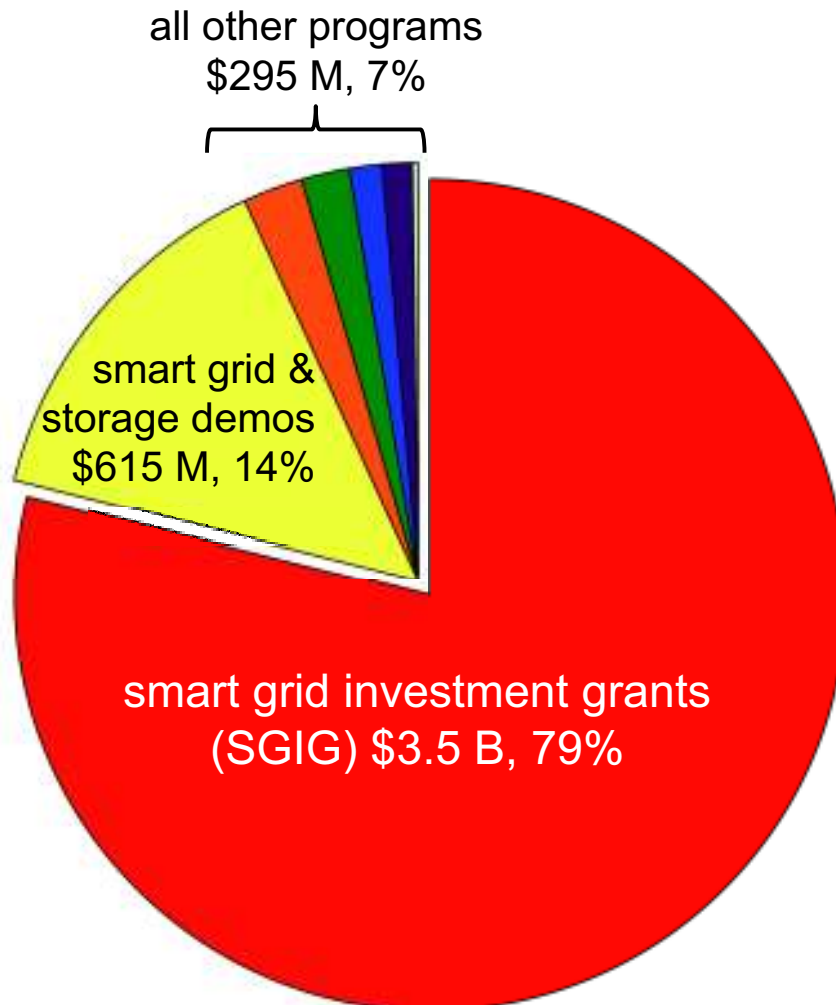


- signed by President Obama on 17<sup>th</sup> Feb. 2009
- \$787 billion distributed via contracts/jobs, grants, loans, and tax relief
- tax relief accounts for the largest share (~36%) of ARRA
- 36.7 billion (~5%) available to Department of Energy programs
- Energy Independence and Security Act 2007 (EISA) defined Smart Grid
- ARRA funds rapid deployment





# ARRA Provisions



- \$4.5 B to fund **grid** related projects most going towards smart grids.
  - 100 SGIG awarded (only 8 propose *microgrid* capability)
  - 16 SG demonstrations & 16 energy storage projects (6 demonstrations and 4 storage projects propose *microgrid* capability)
- **other than grid** related research, ARRA supports related DOE programs:
  - energy efficiency, renewables & transportation
  - clean up of nuclear sites
  - loan guarantees for renewable energy
  - carbon capture and storage
  - scientific research
  - ARPA-E



# SG Investment Grants

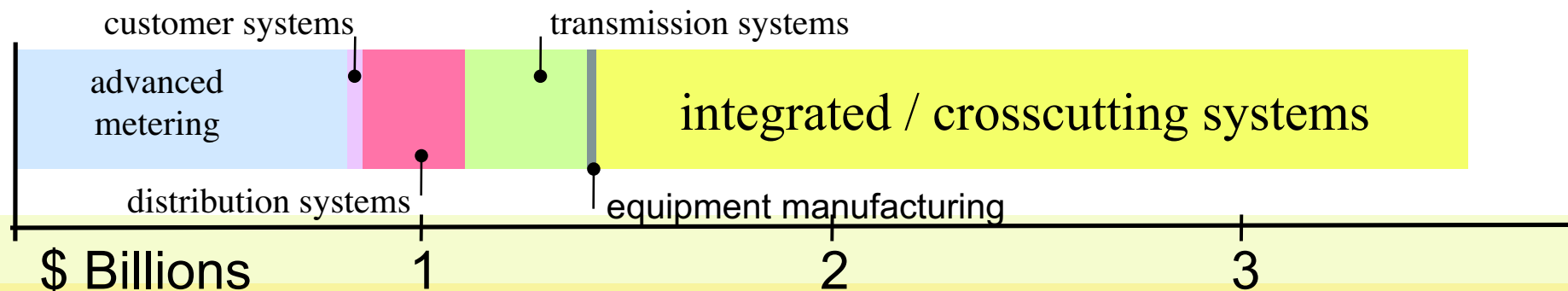


## Purposes:

- economic recovery and job creation
- modernize electricity delivery
- verify the value benefits of SG
- expand SG "best practices" throughout

## Amounts:

- SG Investment Grants require *cost shares*
- Total ARRA grant amount is ~\$3.5 B.
- If cost shares are included, total investment into smart grid research = **~\$8.1 B**



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source: <http://www.oe.energy.gov/recovery/1249.htm>

[http://www.oe.energy.gov/DocumentsandMedia/SmartGrid\\_Grant\\_Locations3.pdf](http://www.oe.energy.gov/DocumentsandMedia/SmartGrid_Grant_Locations3.pdf)



# SG Demonstration & Storage Projects



- \$430.2 million for 16 smart grid demonstrations
  - with *cost share*, total of \$877.2 million for the demonstrations
  - 6 demonstrations propose *microgrid* capability
- \$184.8 million for 16 energy storage projects
  - with cost share, total of \$770.4 million for storage projects
  - 4 demonstrations propose *microgrid* capability
  - sizes range from smallest experimental battery (25kWh) to utility-scale project (300MW)
  - technologies explored:
    - CAES
    - CES (Community Energy Storage)
    - flywheel
    - flow batteries (zinc-bromine, VRB, TransFlow 2000)
    - solid state, lithium ion, lead-carbon





# Sacramento Municipal Utility District (SMUD)



Sacramento  
San Francisco

- service area population: 1.4 million
- service area: 2331 km<sup>2</sup>
- customers: 590 000 (523k res., 67k com.)
- employees: 2000
- transmission lines: 761 km
- distribution lines: 15746 km
- peak demand: 3299 MW (2006-Jul-24)



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# SMUD SG Project



- DOE awarded \$127.5 million (plus \$180.2 million *cost share*)
- tasks include:
  - build 400 MW pumped storage facility; install 600k smart meters, 100 EV charging stations, 50k DR controls (programmable smart thermostats), and home EMS
  - install PV on rooftops, parking lots and other open spaces
  - consider other DG technologies such as waste to energy plants from waste collected in neighborhoods
  - identify cost-effective CHP projects
  - develop infrastructure standards for PHEV that charge off-peak and generate during peak periods
  - test the effectiveness of battery storage and power management products
  - enable time differentiated rates and critical peak pricing
  - enables communication with appliances and equipment for DR



# Thank you!

<http://www.youtube.com/watch?v=3XuCJBvq6Sk>

<http://der.lbl.gov>

28 & 29 April 2010 – CADER Conference at U.C. San Diego



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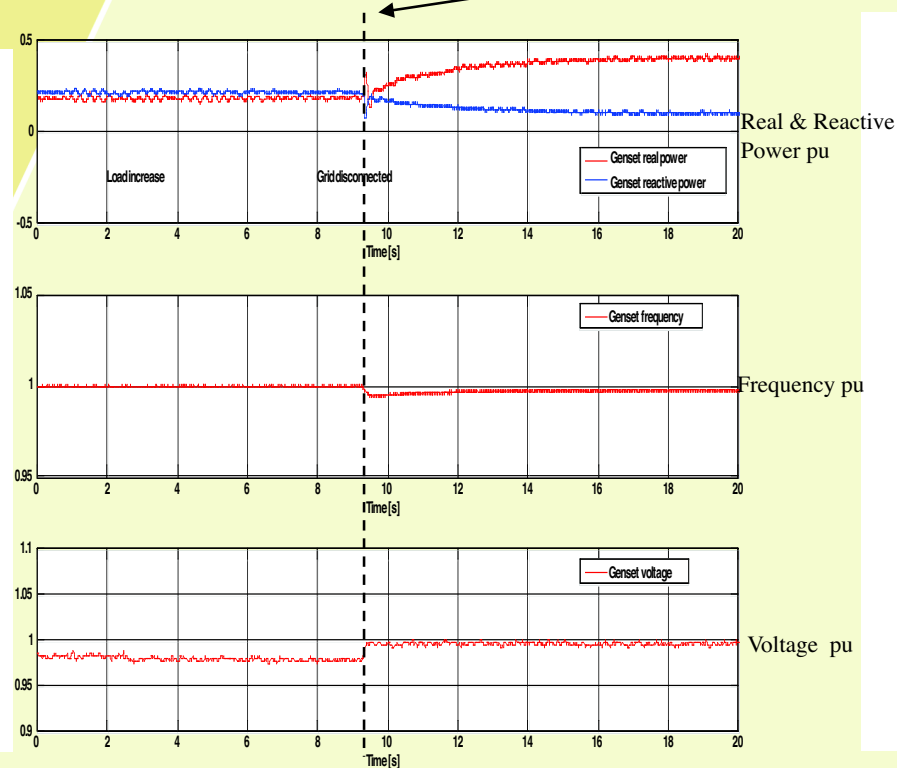
# Both Synchronous & Inverter Sources



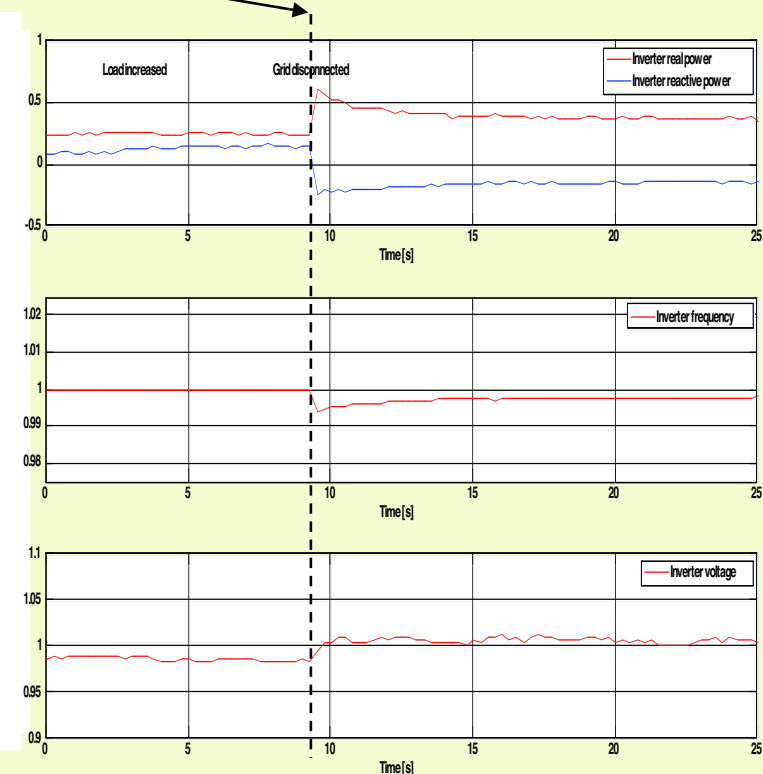
## Islanding of two Sources on UW Microgrid

draft report

SS opens



Kohler Genset



Inverter based source





# Hawaii Renewable Project



## ■ Hawaii Clean Energy Initiative

- grid stability solutions for variable renewables on Kauai
- Optimizing energy efficiency & renewables for military housing on Oahu
- Lanai High Penetration Renewable Energy Grid
- regulatory and policy support

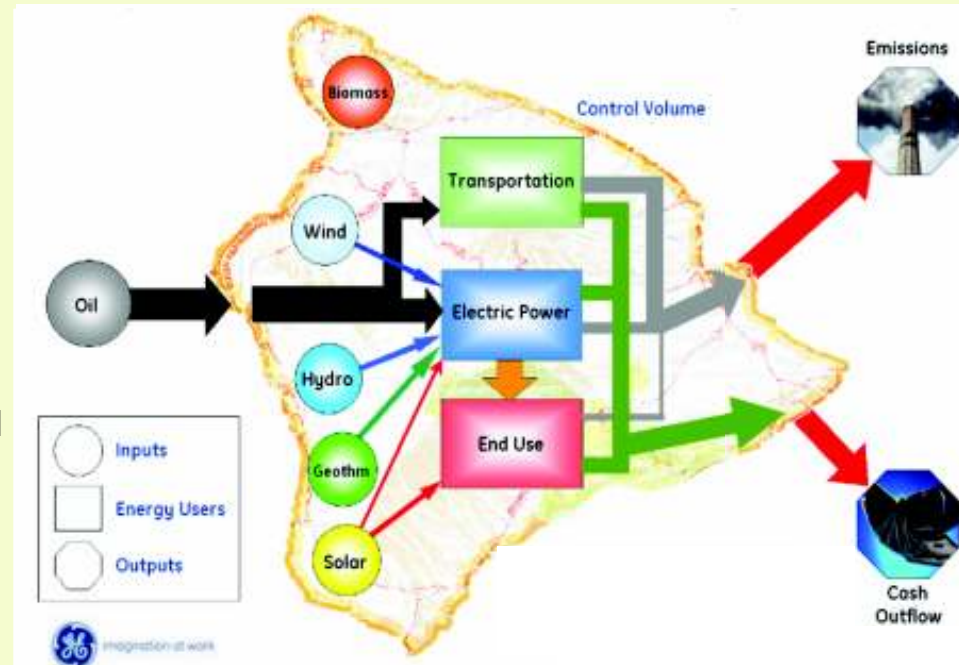
## ■ Use distributed resources to reduce peak power (min 15% reduction) on distribution feeder or substation) – Distribution Management System for peak load reduction

- Develop & demonstrate a distribution automation solution that aggregates DG, energy storage, and DR technologies in a distribution system to achieve both T&D level benefits at the Maui Lani Substation

## ■ Hawaii DER for Energy Security

- HNEI, GE, and local utilities, are developing detailed models of the energy infrastructure for each of the major Hawaiian Islands using GE's proprietary software. To date, models have been validated for the Big Island & Maui; under development for Oahu & Kauai

Today —————> 2030



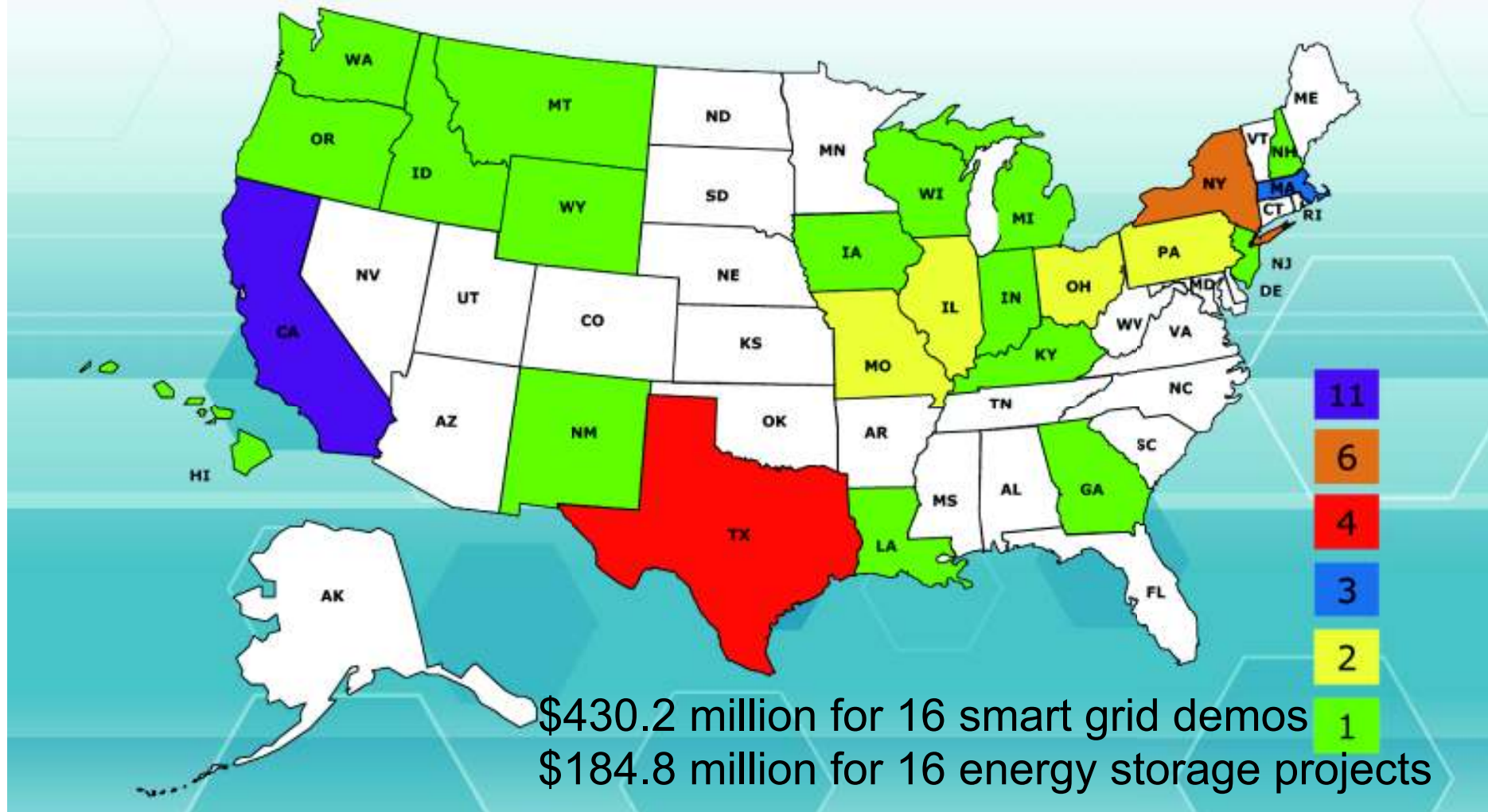
Goal: Hawaii will supply 70% of its energy needs with clean energy by 2030



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# Demonstration & Storage

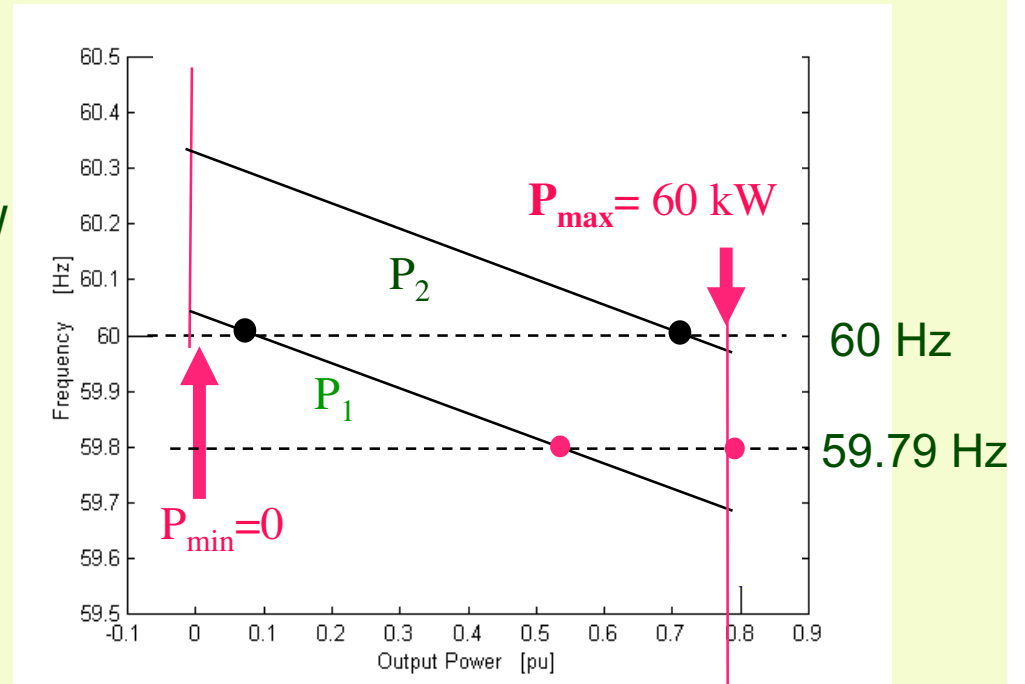
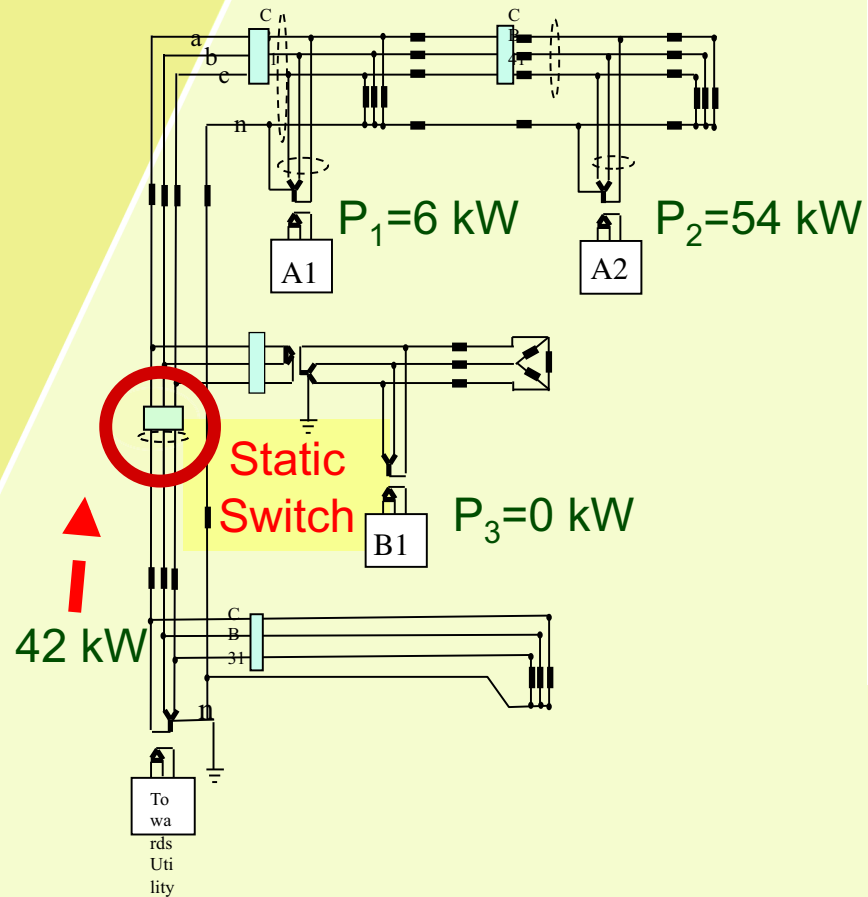




# Islanding Microgrid



load 102 kW



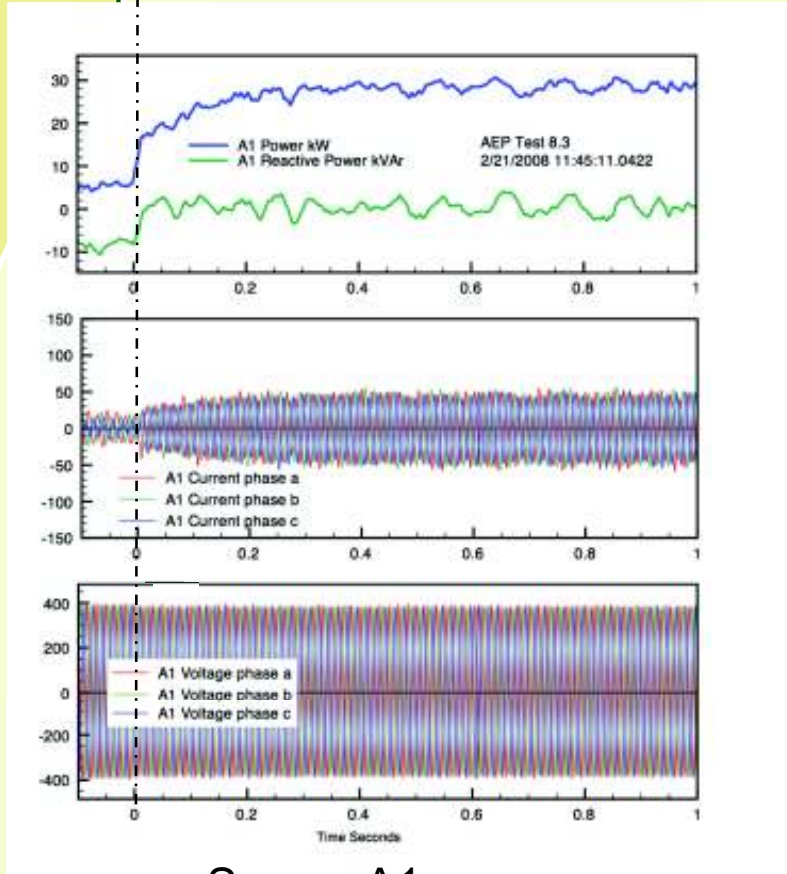




# Power Limit Test

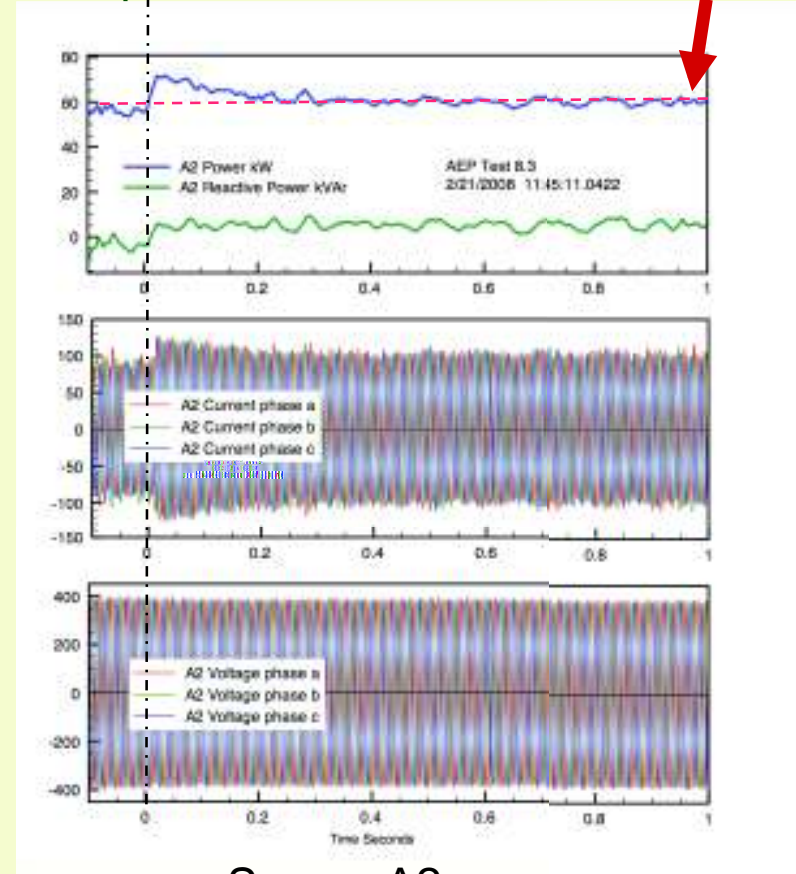


SS opens



Source A1

SS opens



Source A2



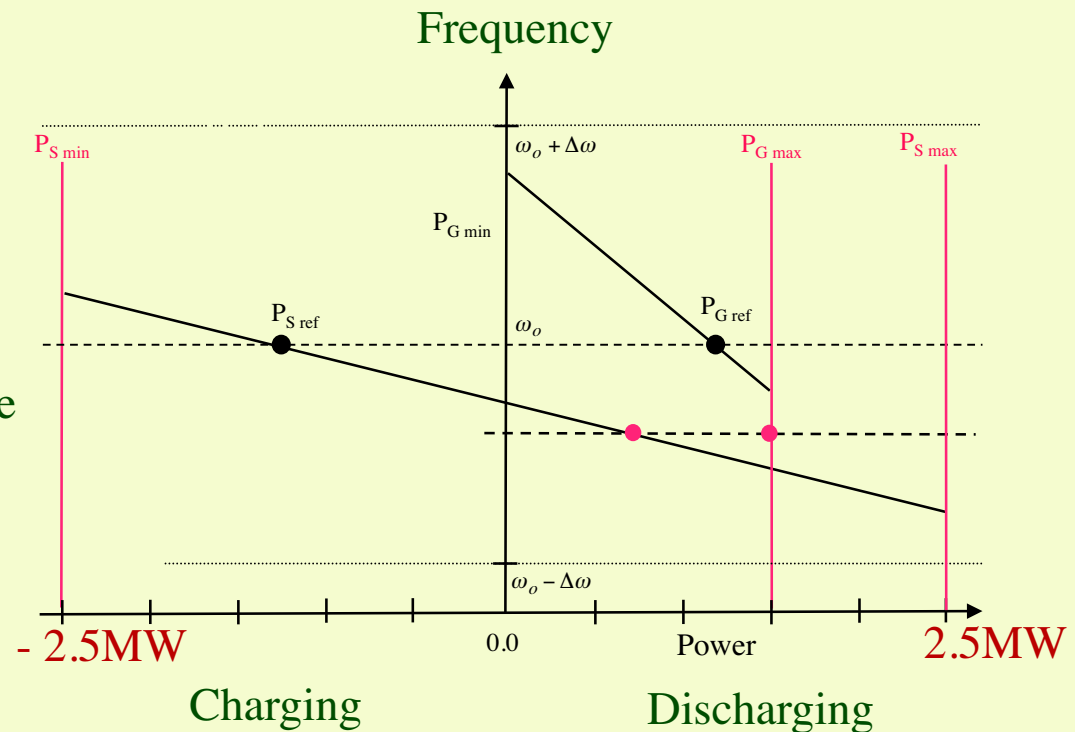


# Storage and Generation Droop



## Genset and Storage

1.  $P_{S \text{ ref}}$  &  $P_{G \text{ ref}}$  are dispatched powers while grid connected
2. Red circles indicate the new operating points after islanding if there is loss of power from the grid.
3. Note different slopes.





# OE Funds From ARRA



Office of Electricity Delivery and Energy Reliability	\$ Millions
<b>Smart Grid Investment Grant Program; ≤3 years</b>	<b>\$3,400</b>
Smaller projects, \$300K-\$20M; 40% of funding	
Larger projects, \$20M-\$200M; 60% of funding	
<b>Smart Grid Demonstrations; 3-5 years</b>	<b>\$615</b>
Regional Demonstrations, up to \$100M per project	
Grid-scale Energy Storage Demonstrations	
<b>Interoperability Framework Development by NIST</b>	<b>\$10</b>
<b>Resource Assessment and Interconnection-Level Transmission Analysis and Planning</b>	<b>\$80</b>
<b>State Electricity Regulators Assistance</b>	<b>\$50</b>
<b>Enhancing State Government Energy Assurance Capabilities and Planning for Smart Grid Resiliency</b>	<b>\$55</b>
<b>Workforce Development</b>	<b>\$100</b>

source:  
Ton\_UCLA1119\_rv.ppt



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