CALIFORNIA ENERGY COMMISSION

Advanced Distributed Generation Research Workshop

Current Status and Future Recommendations

California Energy Commission

Charles Imbrecht Hearing Room

November 18, 2015

Kevin Uy, Rizaldo Aldas

Energy Generation Research Office

Energy Research and Development Division

Housekeeping

- In case of emergency
- Facilities
- Sign-In Sheet

Implementing Diverse and Inclusive Energy Innovation in California

- The Energy Commission is committed to ensuring that a diverse range of applicants has the opportunity to participate in research projects, including small businesses, women, minorities, LGBT, and disabled veterans
- Under the research program, the Energy Commission also seeks to include the participation of businesses from a range of geographic regions

Agenda

Part I: Staff Presentation

9:00 – 9:05	Welcome and Introductions
9:15 – 10:05	Advanced Distributed Generation Research Roadmap Summary and Findings Kevin Uy and Rizaldo Aldas, California Energy Commission
10:05 – 10:20	General Q&A
10:20 – 10:30	Break

Agenda

Part II: Panel Discussion

10:30 – 12:00 Panelist Introduction and Panel Discussion

Moderator: Rizaldo Aldas, California Energy Commission

Panelists: Al Baez, South Coast Air Quality Management District

Dave Mehl, California Air Resources Board

Neeharika Naik-Dhungel, EPA CHP Partnership

Jason Harville, California Energy Commission

George Simons, Itron Inc.

Jim Zoellick, HSU Schatz Energy Research Center

Cherif Youssef, Southern California Gas Company

12:00 – 1:00 Panel Q&A and Public Comment

Part I: Staff Presentation

Kevin Uy
Energy Generation Research Office
Energy Research and Development Division

State Energy Policy Drivers

	2008	2010	2013	2015	2016	2020	2025	2030	2050
Energy Efficiency	40,000 GWh/year			63,000 GWh/year	Zero Net Energy Residential Buildings Goal	Zero Net Energy Commercial Buildings Goal Double Energy Savings in Existing Buildings Goal			
Demand Response	Economic DR at 5% of peak Goal		Achieve 100% of Economic Potential Goal						
Renewable Energy	11% RPS Goal		20% RPS Goal			33% RPS Goal 12 GW DG Goal 8 GW Utility-Scale Goal		50% RPS Goal	
Transportation Energy			10% Light-Duty State Vehicles be ZEV			25% of Light-Duty State Vehicles be ZEV	Over 1.5 million ZEVs on California Roadways Goal		
Greenhouse Gas Reductions					Reduce GHG Emissions to 1990 Level (AB 32) – Represents 30% Reduction from Projected GHG Emissions			Reduce GHG Emissions by? (TBD - Interim Goal)	Reduce GHG Emissions 80% Below 1990 Levels (Exec. Order)

Investments Will Fill Key Funding Gaps Within the Innovation Pipeline

Energy Innovation Pipeline

Research Funding Programs

Electric Program Investment Charge ~$115 M/yr	Natural Gas RD&D ~$24 M/yr

- Significantly Reduce Energy Use in Buildings, Agriculture & Industries
- Encourage Clean, Local Renewable Energy & Advanced Generation
- Dramatically Reduce Environmental Impacts of Energy Technologies
- Improve Transmission & Distribution for Safe, Smarter Power
- Improve Electric and Natural Gas Infrastructure
- Sustainably Integrate Transportation Systems into Energy Infrastructure

Rate Payer Benefits

Program Background

- The Natural Gas Research, Development and Demonstration Program is funded by a natural gas ratepayer surcharge established by the California Public Utilities Commission (CPUC) in 2000
- The purpose of the Natural Gas RD&D Program is to benefit the ratepayers of natural gas investor-owned utilities*
- The Natural Gas RD&D Program funds clean energy technology projects that promote greater natural gas reliability, lower costs, and increased safety
- Annual program funds total $24 million

* Pacific Gas and Electric Co., San Diego Gas and Electric Co., and Southern California Gas Company

Renewable and Advanced Generation Research

Promoting Renewable-Based Communities

Integrating Renewables and Improving Grid Reliability at Camp Pendleton

Renewable Forecasting & Modeling

Advancing Combined Heat and Power Technologies

Converting waste to energy

Thermal Energy Storage for Concentrated Solar

Benefits of Distributed Generation

- Distributed generation systems have a number of benefits when compared to conventional centralized generation including:
  - Consumer cost savings
  - Increased local reliability, flexibility, and power quality
  - Reduced transmission and distribution losses
  - Reduced transmission congestion
  - Overall lower greenhouse gas emissions
  - Overall higher system efficiency

Advanced Distributed Generation Research Roadmap

- Purpose and Scope
- Overview of Technologies
  - Internal Combustion Engines
  - Microturbines
  - Fuel Cells
  - Organic Rankine Cycle (ORC)
  - Others
- Findings and Recommendations
  - Current status of technology
  - Current Installations
  - Current Research
  - Possible Future R&D Initiatives

Purpose and Scope

- The purpose of this roadmap document is to
  - Identify technical barriers and challenges
  - Recommend possible future research initiatives

- The scope is limited to
  - Small (<5 MW) DG systems, with emphasis on very small or micro-scale DG system (250 kW or smaller)
  - Thermochemical conversion systems fueled by natural gas, biogas, or other renewable fuels
  - Solar PV, solar thermal, wind, small hydro, and geothermal systems are not considered

Overview of Technologies

- Internal Combustion Engines
- Microturbines
- Fuel Cells
- Organic Rankine Cycle (ORC)
- Absorption Chillers
- Others

Overview of Technologies

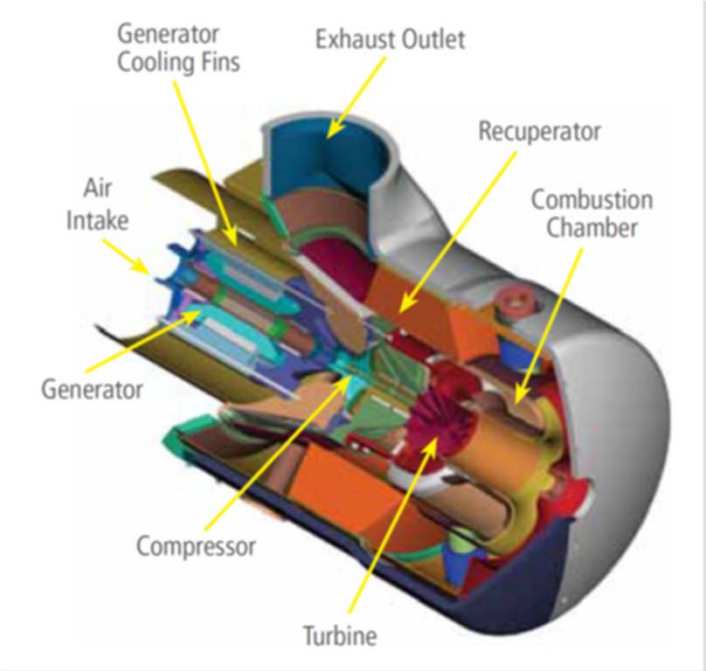
Internal Combustion Engines

- Very common – high familiarity and acceptance
- Can use natural gas, gasoline, diesel, propane, or biogas
- Natural Gas is the fuel of choice
- Requires emissions controls
- Electrical efficiency: 25-45%
- Power output range: 1-400 kW+

Overview of Technologies

Microturbines

- Uses Brayton thermodynamic gas cycle
- Can use natural gas, biogas, sour gas, kerosene, or fuel oil
- Has naturally low emissions when using natural gas
- Expensive
- Electrical efficiency: 12-35%
- Power output range: 25-1000 kW



Single Shaft Recuperated microturbine. Credit: Capstone Turbine Corp.

Overview of Technologies

Fuel Cells

- Electrochemical device that converts chemical energy to electricity
- Three subsystems: reformer, stack and inverter
  - Reformer: supplies the stack with hydrogen stripped from primary fuel
  - Stack: combines hydrogen with atmospheric oxygen to produce DC current
  - Inverter: converts DC to AC power
- Types: solid oxide, molten carbonate, PEM, phosphoric acid
- Can use natural gas, sour gas, biogas, or LPG
- Extremely low emissions
- Sensitive to fuel impurities
- Expensive
- Electrical efficiency: 30-60%
- Power output range: 0.3-5000 kW

Overview of Technologies

Organic Rankine Cycle

- Similar to steam turbines but uses organic fluid instead of steam
- Lower boiling point means it can utilize lower temperature sources
- Used as bottoming cycle to recover waste heat from other processes
- Also used for geothermal and solar thermal power generation
- Can use R-134, R-245, isobutene, propane, pentane, and many others
- No emissions
- Less expensive & less complicated than steam turbines
- Toxic or flammable working fluid
- Electrical efficiency: 5-14%
- Power output range: 100-2000 kW

Overview of Technologies

Stirling Engines

- External combustion engine
- Contains a closed system
- Electrical efficiency: 11-36%
- Power output range: 1-1000 kW

Thermoelectric

- Generates electricity directly from a temperature differential
- Electrical efficiency: 4-10%
- Power output range: 1-1000 W

Overview of Technologies

Absorption Chillers

- Uses solubility of a low-boiling point gas in aqueous solutions
- External heat source boils off working fluid, starts series of reactions
- Results in low temperature heat transfer in evaporator
- Typical refrigerants: ammonia and water, lithium bromide solution
- Needs a cooling tower to remove heat from system

Desiccant Dehumidification Systems

- Conventional chiller systems lower humidity through condensation
- When cooling is not needed, chillers can only remove humidity by overcooling and reheating the air
- Chillers use less energy to cool dehumidified air
- Desiccants can be used with chillers or independently to save energy

Findings and Recommendations

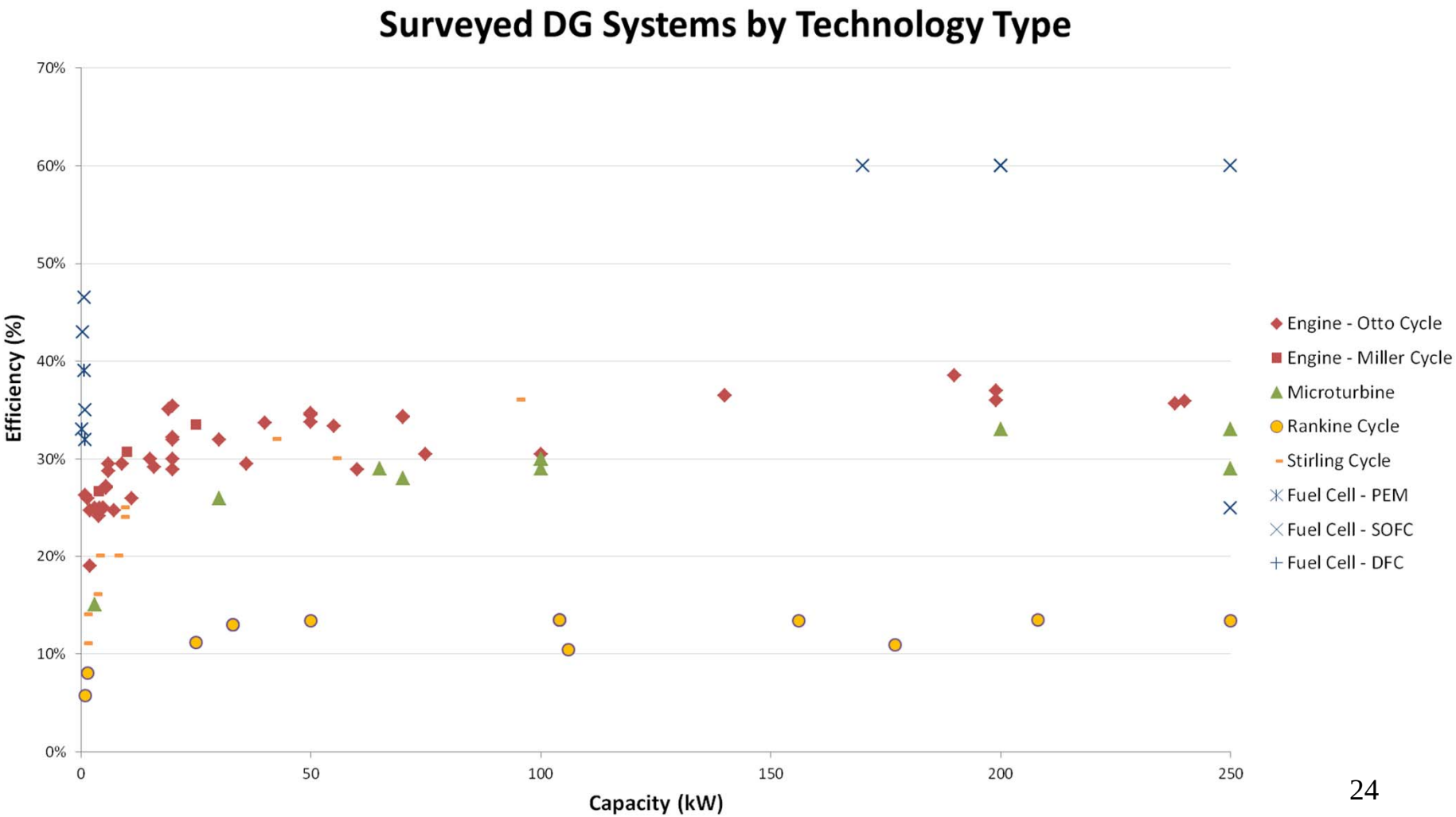
- Current status of technology
- Current Installations
- Current Research
- Possible Future Funding Initiatives

Findings and Recommendations

Current Status of Technology

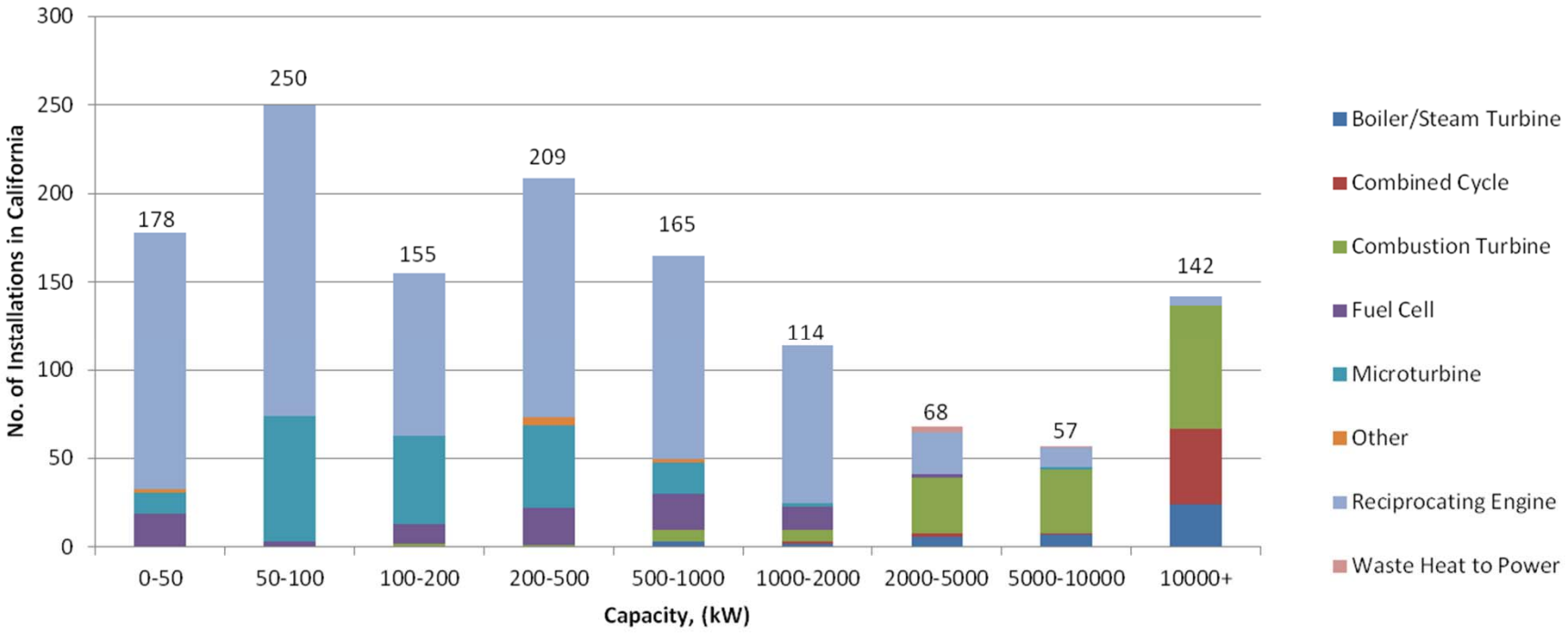
- Staff surveyed a wide variety of commercially available DG technologies in the up to 250 kW range

Findings and Recommendations



Findings and Recommendations

Current CHP Installations by Technology in California



Source: Combined Heat and Power Installation Database. ICF International for U.S. DOE. 2015.

Findings and Recommendations

Current Research

- There is a large variety of recently completed and currently active DG research projects funded by the Commission
- Some are highlighted in detail here with a complete listing provided in the roadmap document

Projects which integrate combined heat and power with thermal energy storage

Goal: Demonstrate economical operation of CHP with thermal energy storage at a modern greenhouse facility

Technology Summary:

- 4.3 MW reciprocating natural gas engine generator sized and operated to meet the thermal load with excess electricity sold back to the grid
- 1 million gallon hot water thermal energy storage
- Grid interconnection agreement with SCE, consistent with Rule 21, for sellback of excess power
- Power Purchase Agreement (PPA) with SCE through the new feed-in-tariff implemented by the CPUC

Features and Benefits:

- Measured electrical efficiency of 36-39%, overall efficiency of 85-90%
- Robust after-treatment system resulted in 2-3.3 ppm NOx and <1 ppm CO
- Simple payback period of approximately 3.7 years

Contractor: Southern California Gas Company
Location: Camarillo, CA
Term: 6/29/2012 – 3/31/2015

Projects which integrate combined heat and power with thermal energy storage

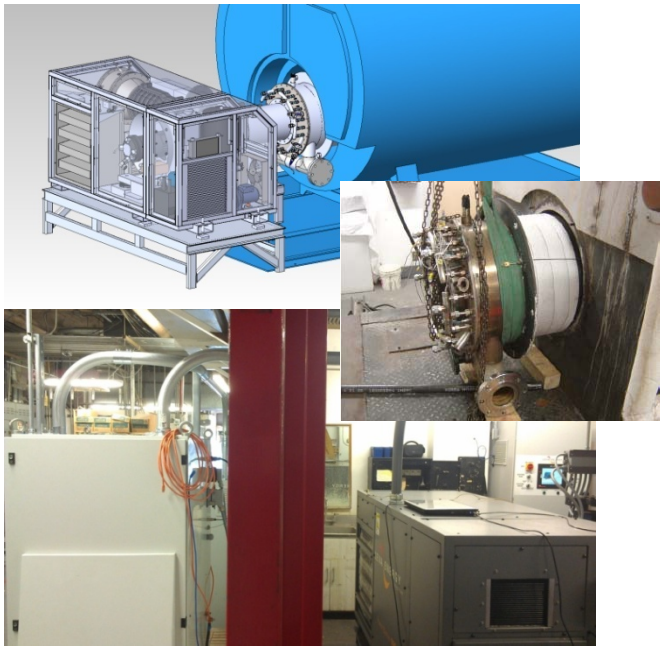
Goal: Microturbine-based Power & Heat at Lowest Possible Cost.

Technology Summary:

- Engineered and integrated SCGT with an innovative boiler burner
- Tested in a firetube boiler of 10 million Btu/hr scale
- Providing heat and power since 2012
- UL Listed as "Field Evaluated Product" at City's request
- Meets modified AQMD Emissions Requirements
- Performance and economics of completed met initial goals

Features and Benefits:

- 100 kWe Simple Cycle Microturbine
- Meets thermal need and produces power at $.065/kWh
- Reduces GHG by up to 30% versus grid
- Has improved reliability versus alternative CHP
- Two year payback
- Meet emissions limits for all CA regions

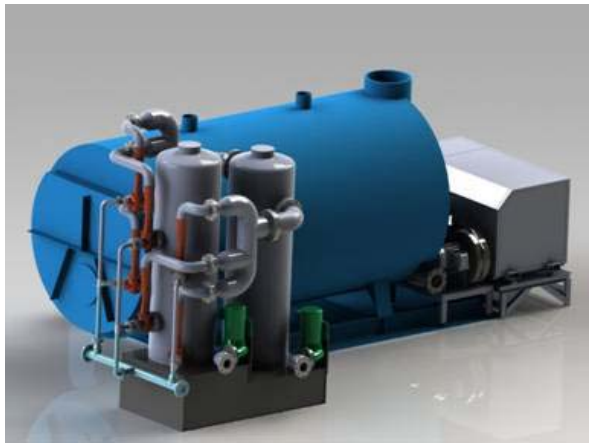


BBEST installation at Westin Hotel in Costa Mesa, CA

Contractor: Altex Technologies Corporation
Location: Costa Mesa, CA
Term: 6/21/2010 – 3/30/2013

Projects which integrate combined heat and power with absorption chiller technology

Goal: Development of a simple, low-cost steam jet refrigeration system that that utilizes waste heat recovery for cooling.



Technology Summary:

- All water refrigeration (no CFC's or HFC's) resulting in diminished environmental impact
- Development of a compact, advanced Altex High Efficiency Condenser (AHEC) heat exchanger
- Combined with Altex's Boiler Burner Energy Systems Technology (BBEST), the system produces 100 kWe electricity while flexibly providing up to 10 MMBtu/hr of steam or 5.9 cooling tons of chilled water (depending on facility demands)

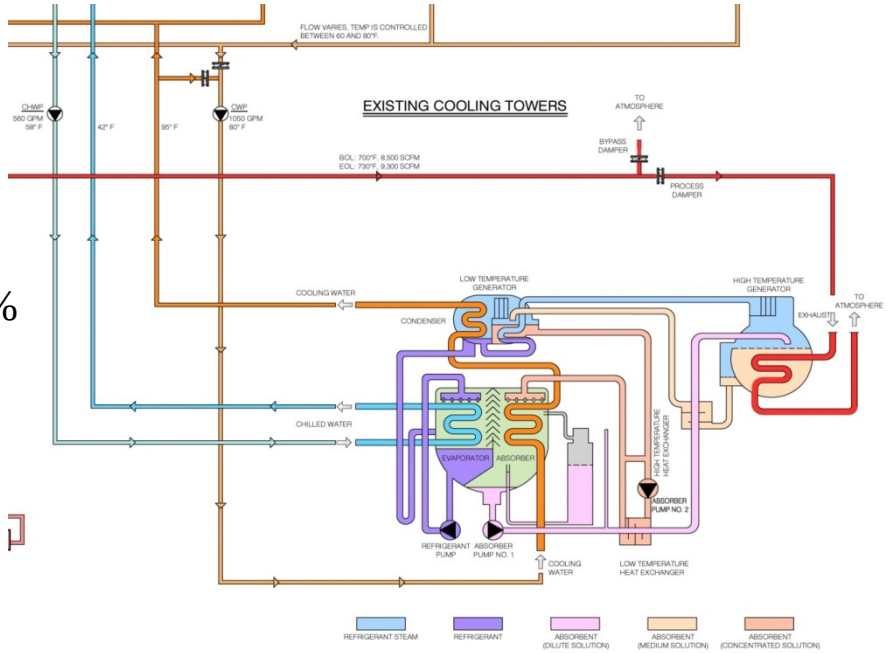
Features and Benefits:

- Peak electric coefficient of performance, COPe, of 5.3
- Scale-up to 150-tons of cooling is planned

Contractor: Altex Technologies Corporation
Location: Sunnyvale, CA
Term: 6/29/2012 – 1/25/2015

Projects which integrate combined heat and power with absorption chiller technology

Goal: Instrument, collect operational data, and analyze the performance of a 330 ton heat recovery absorption chiller to be integrated with a commercialized 2.8 Megawatt (MW) molten carbonate fuel cell that utilizes directed biogas fuel.



Technology Summary:

- "Ultraclean" 47% efficient molten carbonate fuel cell integrated with Exhaust-Fired Absorption Chiller
- Expected to raise the system's efficiency from 47% to 68+%
- Exhaust temperature of 700 °F able to support a two-stage absorption chiller with Coefficient-Of-Performance (COP) of approximately 1.2

Features and Benefits:

- Will displace a 224 kW electric chiller load
- Will collect ample performance data
- Project represents global and national firsts for CHP Fuel Cells

Contractor: University of California, San Diego
Location: San Diego, CA
Term: 6/30/2014 – 3/31/2017

Projects which demonstrate emissions compliance via novel pre- and post-combustion treatment

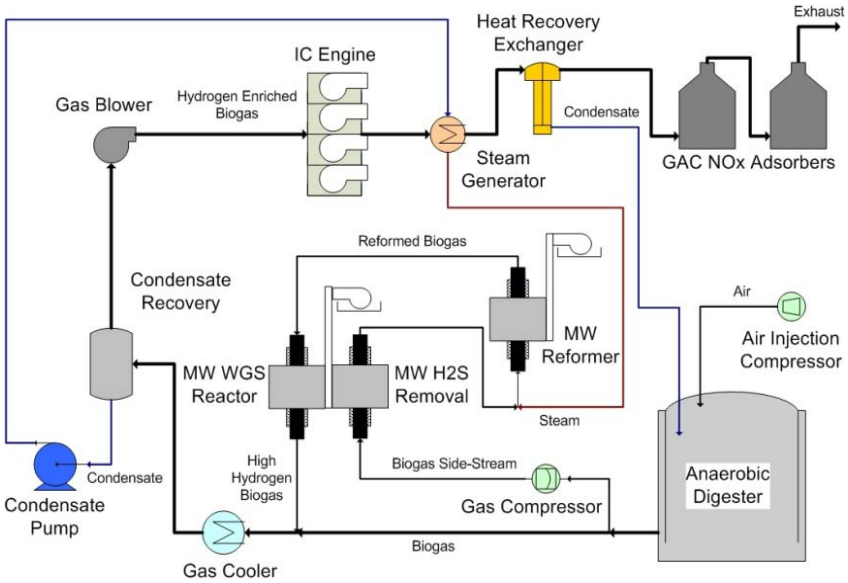
Goal: Demonstrate integrated microwave technology for pre-and post-combustion NOx control of bio-gas powered engines. Show that the H_2S in the microwave treated biogas is <0.5 ppm and that this technology will reduce NOx to <5 ppm and remove >90% of SO_2 and VOCs in exhaust.

Technology Summary:

- Hydrogen Assisted Lean Operation (HALO) allows stable engine operations at ultra-lean conditions
- Pre-combustion system consists of microwave H_2S removal unit and microwave steam reformer to produce H_2 to implement HALO
- Post-combustion system consists of an exhaust cooler and two activated carbon adsorbers in series to remove NOx, SO_2 and VOC

Features and Benefits:

- Reduce warm-up time and emissions of emission control equipment
- Reduce complexity of emissions control systems, improve overall performance and energy efficiency
- More economical NOx removal using the microwave technology than the conventional ways



Contractor: CHA Corporation
Location: Sacramento, CA
Term: 6/30/2014 – 3/31/2017

Projects which demonstrate fuel-flexible operation with minimal pre- and post-processing

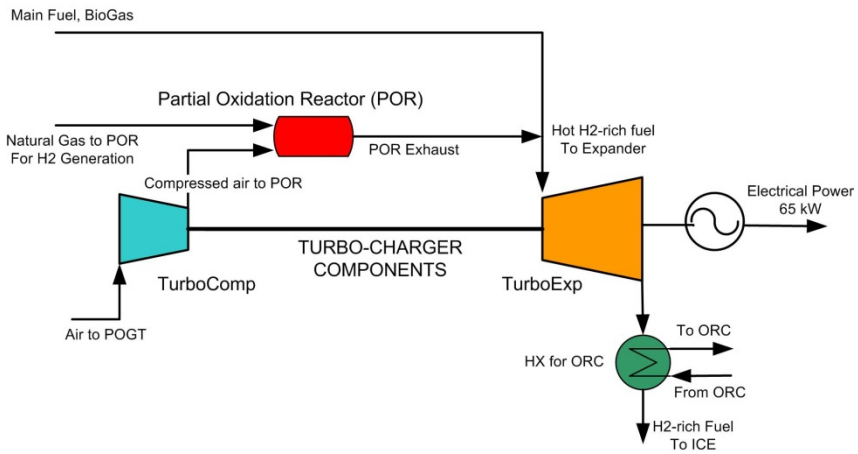
Goal: Develop and demonstrate a Partial Oxidation Gas Turbine system integrated with an IC Engine to reduce emissions to new, lower levels for half the capital than with SCR.

Technology Summary:

- Can use biogas or natural gas for hydrogen production
- Does not require any catalysts
- Unlike SCR, the system will increase power output, potentially improve the engine efficiency and increase overall CHP efficiency

Features and Benefits:

- Produces additional electrical energy and heat that can be used onsite
- Does not introduce new requirements for biogas or natural gas clean-up



Simplified Flow Diagram – POGT (Source: GTI)

Contractor: Gas Technology Institute
Location: San Bernardino, CA
Term: 6/29/2012 – 3/31/2016

Projects which demonstrate fuel-flexible operation with minimal pre- and post-processing

Goal: Demonstrate a novel, fuel flexible oxidizer and gas turbine system which produces electricity from low-quality landfill gas that would otherwise be flared

Technology Summary:

- 250 kW gas turbine combined with power oxidizer is capable of converting low-quality fuels (350 - 2,600 Btu/scf) to electricity
- Will utilize low-quality landfill gas from a closed landfill whose methane content is too low for conventional generators and would otherwise be flared
- Minimal pre-treatment required when compared to combustion generation systems

Features and Benefits:

- System capable of achieving ultra low emissions (<1 ppm NOx and CO) without after-treatment
- If successful, system could be deployed at any closed landfill

Contractor: University of California, Irvine
Location: Silverado, CA
Term: 6/1/2015 – 3/31/2019

Projects which demonstrate secure, reliable generation by converting local biomass resources to renewable heat and power

Goal: Demonstrate a woody biomass gasification to hydrogen fuel cell CHP system capable of meeting ~35% of the Blue Lake Rancheria's electricity needs

Technology Summary:

- Redwood sawdust is converted to syngas via gasification, purified into hydrogen via gas cleanup and conditioning, and converted into electricity via a fuel cell generator.
- Key system components include: biomass storage and feed system, gasifier feed system, gasifier, gas conditioning, pressurization, gas cleanup, flare, biochar discharge, and hydrogen fuel cell generator

Features and Benefits:

- First-of-it's-kind technology demonstration project which combines several pre-commercial technologies
- Utilizes locally available biomass resource to provide renewable heat and power for on-site use

Contractor: Redwood Coast Energy Authority
Location: Blue Lake, CA
Term: 6/19/2013 – 3/31/2015

Projects which demonstrate secure, reliable generation by converting local biomass resources to renewable heat and power

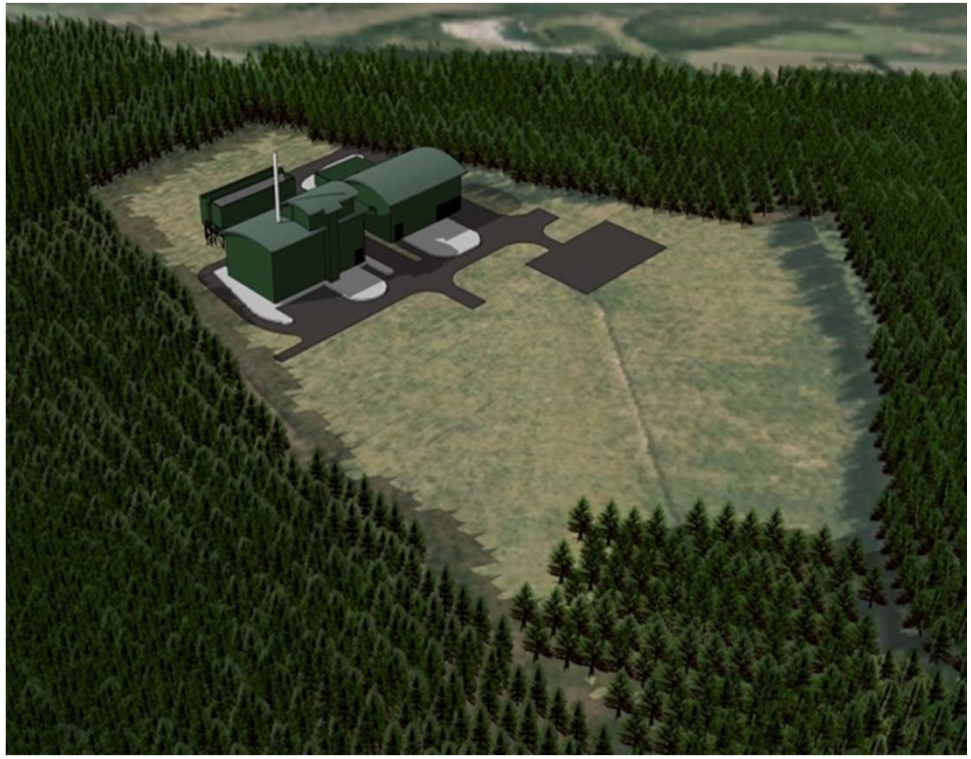
Goal: Develop a biomass-fired CHP system at Plumas County's Health and Human Services facility and Feather River College dormitories.

Technology Summary:

- Local forest biomass fuels the CHP facility to produce heat and power on-site
- Organic Rankine Cycle unit produces electricity
- Thermal output will provide heating to six separate buildings

Features and Benefits:

- 71% decrease in the daily average energy demand during peak times
- Reduction in peak electrical demand by approximately 300 kW and reduce propane consumption by 17,000 gallons each year
- Buildings served by the CHP district energy system will not require their own boilers or air conditioners



Contractor: Sierra Institute for Community and Environment
Agreement No: Quincy, CA
Term: 6/29/2015 – 7/31/2018

Projects which demonstrate industrial waste heat to power generation

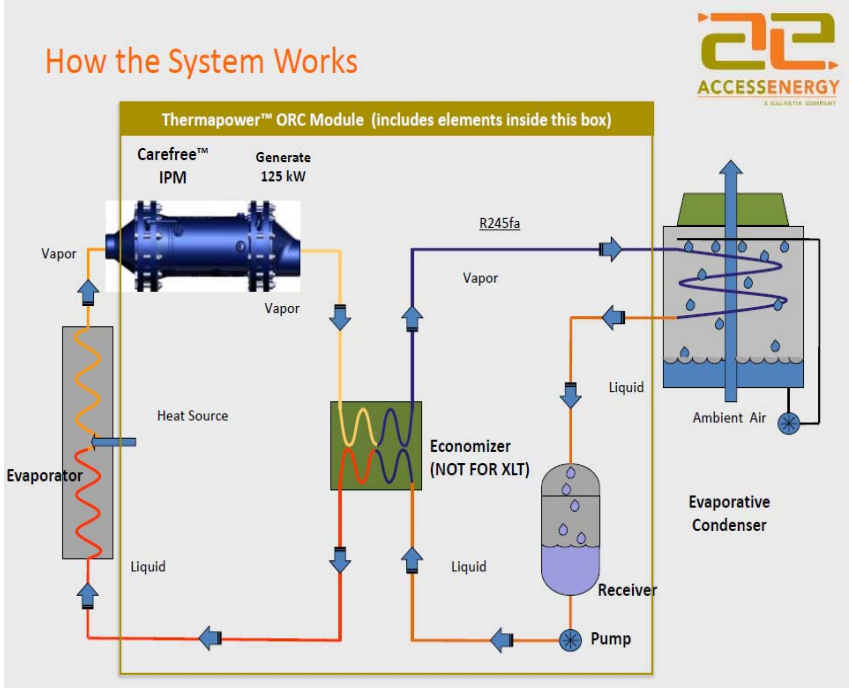
Goal: Evaluate the application of ORC technology to cost-effectively generate electricity by recovering waste heat from industrial processes.

Technology Summary:

- The ORC is similar to other generation cycles, except that the organic working fluid enables flexibility in evaporator temperature.
- A fluid with a lower boiling point enables power extract from lower temperature heat sources.

Features and Benefits:

- A packaged solution that includes turbine, pump, refrigerant management system, and economizer
- Frictionless magnetic bearings improve efficiencies
- Refrigerant charge management system (charge flexibility needed as operating temperatures vary)
- Flexibility in choice of heat exchangers both for evaporator and condenser
- No emissions (uses waste heat instead of fuel)



Contractor: Electric Power Research Institute
Location: Hawthorne, CA
Term: 6/29/2015 – 7/31/2018

Findings and Recommendations

Possible Future R&D Initiatives

- Research recommendations created by surveying DG stakeholders and staff background studies
- DG stakeholders were from a variety of sectors including academia, industry, utilities, research institutions, and local and state agencies
- Research recommendations will serve as a guide for future budget planning, solicitations, and individual projects

Findings and Recommendations

Possible Future R&D Initiatives

Emissions control strategies to enable deployment of existing DG systems

- Compliance with strict local air district standards are a barrier
- Current after-treatment systems are complex and expensive
- There is a need for low cost after-treatment systems or DG systems which are emissions compliant “out-of-the-box”

Findings and Recommendations

Possible Future R&D Initiatives

Development of flexible DG systems to complement intermittent renewables

- Renewable sources are both intermittent and highly variable
- DG flexibility in peak shaving or load following configurations
- Need very low capital cost, very high efficiency, or both

Findings and Recommendations

Possible Future R&D Initiatives

Demonstration of district scale CCHP systems at universities, large commercial campuses, or business parks

- CHP/CCHP systems providing heating and cooling to several buildings at once can be far more economical compared to single building applications
- High potential for reproducibility state wide

Findings and Recommendations

Possible Future R&D Initiatives

Demonstration of bottoming cycle systems for electric generation from industrial waste heat

- 402 MW of potential generation at 53% market penetration
- ORC technology is fairly mature
- The average payback based on industrial electric rates is 2 years
- Economical demonstrations of ORC systems can build consumer confidence

Source: ***Waste Heat to Power Market Assessment***. ICF International for the US DOE. 2015.

Findings and Recommendations

Possible Future R&D Initiatives

Advancement of small absorption chiller technology to increase efficiency and cost effectiveness

- Studies have noted high market potential for CHP systems that use cooling
- CCHP systems are sometimes more economical than CHP
- There is a need for efficient, small absorption chillers

Source: ***Combined Heat and Power: Policy Analysis and 2011-2030 Market Assessment***. ICF International for the CEC. 2012.

Findings and Recommendations

Possible Future R&D Initiatives

Demonstration of CCHP systems with thermal storage to enable flexible operation and maximize operating time

- Reducing the operating hours of a CHP system can make the system uneconomical
- Using thermal energy storage can substantially increase the flexibility of a CHP system
- Allows CHP systems to be operated when electrical demand is high but thermal demand is low, storing produced thermal energy for later use

Findings and Recommendations

Possible Future R&D Initiatives

Cascaded DG systems where heat from one generator drives another

- Examples include ORC or thermoelectric systems combined with conventional generators
- Could be cost-effective if modest increases to overall efficiency are achieved

Findings and Recommendations

Possible Future R&D Initiatives

Development of breakthrough technologies for CHP applications

- Potential technologies may fall outside the internal combustion engine/ microturbine/ fuel cell paradigm
- Potential technologies could be extremely fuel flexible, able to operate on a wide variety of off-spec gasses with minimal preconditioning

EPIC Innovation Symposium
Save the Date: December 3, 2015

Beginning at 9:00 a.m.

Lake Natoma Inn, 702 Gold Lake Drive, Folsom, CA

- Showcase of more than 30 EPIC projects
- Post-symposium workshop: "How to Apply to EPIC"
- Select preferred breakout session topics: https://www.surveymonkey.com/r/SZLCW5L
- Additional information: http://www.energy.ca.gov/research/epic/documents/.

Q&A

- Please state your name and affiliation
- Please limit your questions or comments to 3 minutes

Questions and comments can also be submitted via email to:
kevin.uy@energy.ca.gov
using the email subject heading "Advanced Distributed Generation Research"

Deadline for comments is Friday, December 4, 2015 at 5 pm PST

Break

- 10 minute break

Part II: Panel Discussion

Rizaldo Aldas
Energy Generation Research Office
Energy Research and Development Division

Expert Panelists Introduction

- Al Baez, South Coast Air Quality Management District
- Dave Mehl, California Air Resource Board
- Jason Harville, California Energy Commission
- Neeharika Naik-Dhungel, EPA CHP Partnership
- George Simons, Itron Inc.
- Jim Zoellick, HSU Schatz Energy Research Center
- Cherif Youssef, Southern California Gas Company

Al Baez

- Program Supervisor, Best Available Control Technology
- South Coast Air Quality Management District
  - 27 years at SCAQMD, Mechanical Engineer
  - Engineering Permitting, Rule Development, Public Affairs Small Business Assistance, currently in Science and Technology Advancement Office
  - abaez@aqmd.gov
- Relevant DG Work:
  - Demonstration Projects
    - Solar
    - Fuel Cell & I.C. Engines (nat gas & Biogas)
    - Energy Storage (Battery, Flywheel, V2G)
  - Rule 1110.2 – Stationary Engines (nat gas & biogas)
  - Microturbine deployment (110+ units)

Dave Mehl

- Manager of Energy Section at Air Resources Board
  - Renewable Electricity Standard, 1st Update to Scoping Plan, and Short-Lived Climate Pollutant Strategy
  - Implement Distributed Generation Certification Program
  - Lead on distributed generation (including combined heat and power), water, and dairies
  - Engaged in natural gas, biogas, and biomass
  - 25 years in air quality at ARB and local air districts
  - dmehl@arb.ca.gov

Jason Harville

- Electric Generation System Specialist
- California Energy Commission
  - Energy Assessments Division, Supply Analysis Office
  - Provides analysis and technical expertise on issues associated with integrating distributed energy resources into California's electric grid at both the transmission and distribution levels
  - jason.harville@energy.ca.gov
  - (916) 654-3842
- Relevant DG Work:
  - Certification of CHP projects under the AB 1613 Feed-in Tariff.
  - Policy analysis for CHP- and DER-related issues.

Neeharika Naik-Dhungel

- Program Manager
- Environmental Protection Agency CHP Partnership
  - A **voluntary program** that seeks to reduce the environmental impact of power generation by promoting the use of **highly efficient CHP.**
  - Through 2013, **the CHPP and its Partners** put into operation around 910 CHP projects with 6,200 MW of capacity.
  - The CHPP offers services and tools for Partners to assist with CHP project development, overcoming regulatory barriers, transform markets ripe for CHP, and public recognition.

Neeharika Naik-Dhungel

- Relevant DG Work:
  - Catalog of Technologies
  - Superiorly performing systems: ENERGY STAR CHP Awards, Work in CHP and LEED and ENERGY STAR Portfolio Manager
  - DG benefits in air regulations, energy-water nexus

Partnership Website: www.epa.gov/chp

Email: Naik-Dhungel.Neeharika@epa.gov

George Simons

- Itron, Inc. (2005 to present)
  - Director in charge of supply side services
  - Responsible for evaluation of distributed energy resources and connecting DERs to smart grid solutions
- California Energy Commission
  - PIER Renewables Program Manager from 1998-2005
  - ETAP Program Manager from 1986-1998
  - Responsible for establishing R&D pathways for increased market adoption of renewables and DERs through improved costs and performance
- Relevant DG Work:
  - Led evaluations of the $3 billion CSI and $1 billion SGIP program; and acted as the Program Manager for the CSI Solar RD&D program
  - Conducted performance evaluations on hundreds of CHP and DG systems in California, Massachusetts and New York
  - Established and have led numerous market analyses and cost effectiveness evaluations on DG and CHP
  - Currently developing national CHP protocol for NREL

Growing a Sustainable DG Market in California

- Market transformation of DG and CHP in California
  - Primary purpose: determine the extent to which DG and energy storage markets are being transformed
  - Surveyed host customers, equipment manufacturers, project developers, Program Administrators (inside and outside of CA), and other key stakeholders
  - Developed technical, economic and market potential estimates for CHP, wind, biogas, AES
  - Developed program theory and logic model identifying short, medium and long term outcomes
  - Conducted statistical analyses comparing the growth of DG, wind and biogas in California to other states to see the impact of SGIP on market growth
  - Developed lessons learned and recommendations
- Report is pending approval

The Potential of CA's DG Market

Technology/resource	Estimated Potential (MW)		
	Technical	Economic	Market
CHP: natural gas	24,236	15,500	4,500
AES	14,940	5,303	1,856
Wind	16,166	9,759	1,200
Biogas	724	665	234

- Technical estimates developed from bottom up analyses
- Economic estimates based on Total Resource Cost tests conducted using SGIPce model
- Market estimates based on historical data, logistic modeling and Delphi approach on generated annual growth rates

Lessons Learned for Transforming CA's DG Market

- SGIP has had a significant impact on growth of technologies
  - Statistically demonstrated for CHP
  - Strong indications for biogas, wind and AES
- Market transformation is about changing market behaviors
  - Most barriers are not cost effectiveness barriers but perceptions of risk; and policy and institutional barriers
  - Program objectives should address these larger market barriers
- Balanced portfolios and meeting customer needs are essential
  - California is rich in resources and technology solutions
  - Essential to fit technology programs to customer and utility needs
- Create utility-project developer partnerships
  - New business models are necessary to enable developers and utilities to both succeed in an evolving energy landscape
- The importance of uniform and sustained policies
  - Sustainable market require investors confident of the future

Questions?

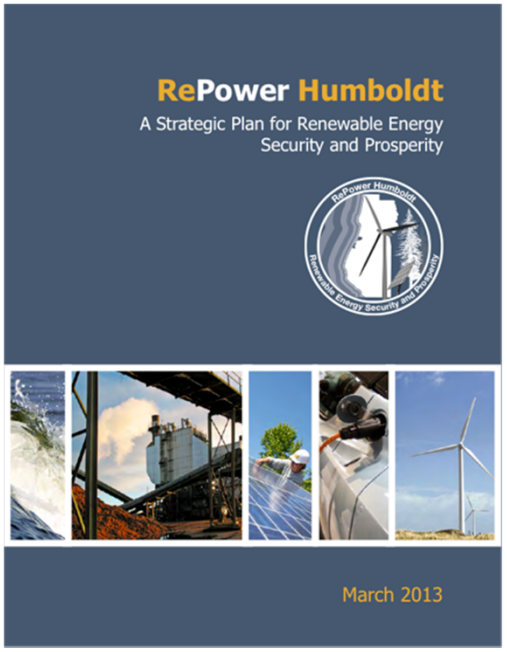
George Simons
George.Simons@itron.com
(509)891-3180

Jim Zoellick

- Senior Research Engineer
- Schatz Energy Research Center
  - Located at Humboldt State University
  - Founded in 1989
  - Promoting the use of clean and renewable energy
  - James.Zoellick@humboldt.edu
- Relevant DG Work:
  - RePower Humboldt Strategic Plan
  - Design/installation of integrated biomass gasification fuel cell generator
  - Currently installing microgrid system with PV, battery, fuel cell, controllable loads, & microgrid controller

RePower Humboldt Strategic Plan

- Funded by CEC PIER Program
- Key partners included Redwood Coast Energy Authority (RCEA) and PG&E
- Developed plan for RE development that could meet majority of electricity needs and large portion of heating and transportation needs
- Identified distributed generation as an important tool for developing community-scale projects



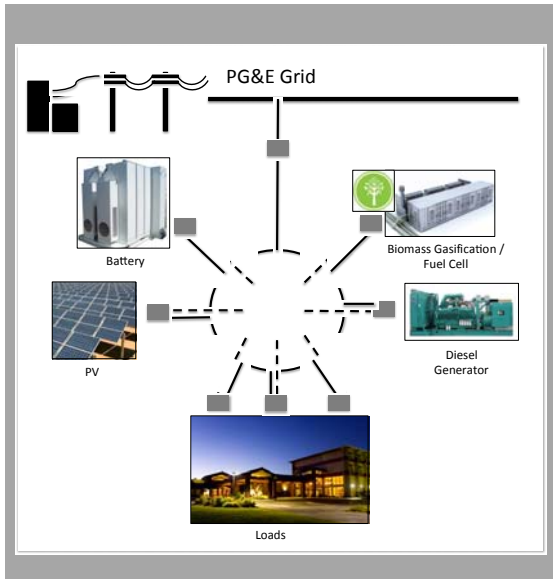
RePowering Humboldt Implementation Project

- Funded by CEC PIER Program
- Key partners included: RCEA and the Blue Lake Rancheria
- Demonstrate woody biomass gasification to hydrogen fuel cell power system
- Converts redwood sawdust to syngas, H_2 is purified, 175-kW_e PEM fuel cell converts H_2 to electricity
- First-of-it's kind technology demonstration, uses local biomass resource, will provide ~35% of site electricity needs, still in commissioning phase

Microgrid Project

- Funded by CEC EPIC Program
- Key partners include:
  - Schatz Energy Research Center
  - Blue Lake Rancheria
  - Siemens, Tesla, REC Solar
  - Pacific Gas and Electric
  - Idaho National Laboratory
- Project Goals:
  - Install 420-kW AC PV Array & 1-MWh of battery storage along with a microgrid controller, integrate with existing biomass gasification fuel cell system & diesel gensets
  - Operate system for economic benefit
  - Operate in island mode during local grid outages, provide power for critical emergency services to a Red Cross evacuation site
  - Maximize use of onsite renewable generation
  - Installation to occur summer 2016

Credit: Dennis Schroeder/ NREL



Source: By permission, adapted from Siemens

Cherif Youssef

- Technology Development Manager
- Southern California Gas Company
  - Largest natural gas distribution utility nation-wide
  - Extensive technology research and development program
  - cyoussef@semprautilities.com
  - 213-244-5325
- Relevant DG Work:
  - CHP Demo at Houweling Tomato - Oxnard
  - CHP Demo at Inland Empire Food - Ontario
  - CHP Demo at SCG Data Center - Monterey Park
  - Zero Net Energy Demo - Playa Vista
  - MicroCHP Development

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Advanced Distributed Generation Research Workshop

Current Status & Future Recommendations
California Energy Commission

Cherif Youssef
Technology Development Manager

November 18, 2015

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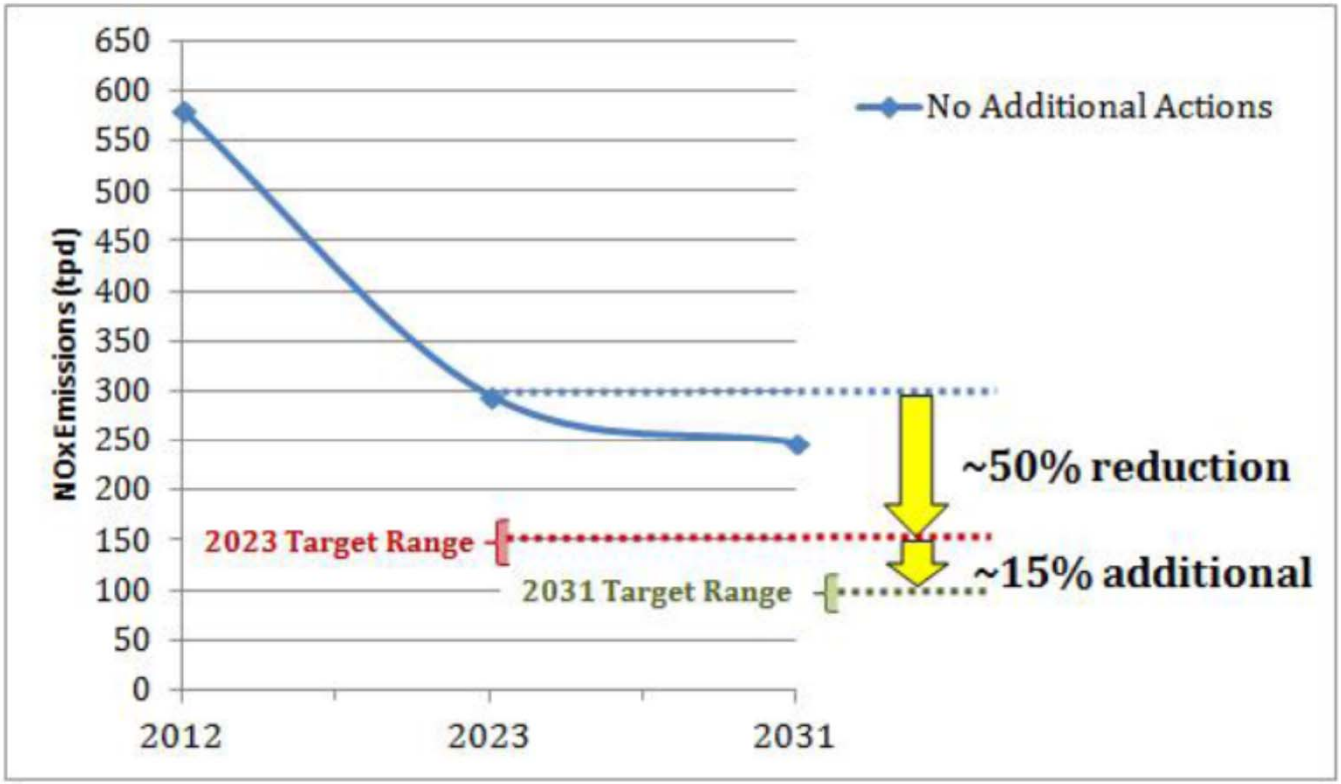
List of Current RD&D Successes

- Low Emissions IC Engine
  - Tecogen
    - Community Pool - Northridge
    - ZNE Community Center - Playa Vista
  - Continental Controls
    - SCG Honor Ranch Compressor
  - Jenbacher
    - Greenhouse - Thermal Storage – Houwelling Tomato
- Microturbines
  - Capstone
    - Inland Empire Foods - Ontario
    - SCG Data Center - Monterey Park
- Fuel Cell
  - Fuel Cell Energy
    - OC Sanitation District
    - UCI Medical Center

Significant Barriers

- Emissions
  - NOx Emissions
    - SCAQMD and SJV-APCD DG Emissions
      - NOx < 0.07 lb/MW-hr
    - CARB DG Certification
  - GHG Emissions
- Proposed SGIP GHG Eligibility Targets
- RPS 50% by 2030
- ZNE for Residential by 2020 and Commercial by 2030
- Improve product performance and reduce cost (Fuel Cell)
- Barriers that continue to slow market progress of CHP
  - Energy Rate – DLC, Demand and Standby Charges
  - Interconnection
  - Permitting Costs & Time
  - Technical complexity

NOx Reductions Needed in SCAQMD



*Based on Preliminary 2016 AQMP analysis; subject to change

Source: SCAQMD

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Policies or Incentives

» *SGIP Proposed GHG Eligibility Emissions Factors*

- Current GHG 379 kg CO_2/MWhr
- Proposed GHG 350 kg CO2/MWhr
- Assumptions:
  - 10 year life expectancy
  - 1% electric efficiency degradation per year*
  - 80% boiler efficiency
  - T&D loss 8.4%

Program Year	2016	2017	2018	2019	2020
10-Year Average	350	347	344	340	337
First-Year Average	334	332	329	325	321

» SGIP Inequities for CHP vs. fuel cells and battery storage

» SGIP offer insignificant value for MicroCHP (<50KW)

» Uncertainty of future ITC

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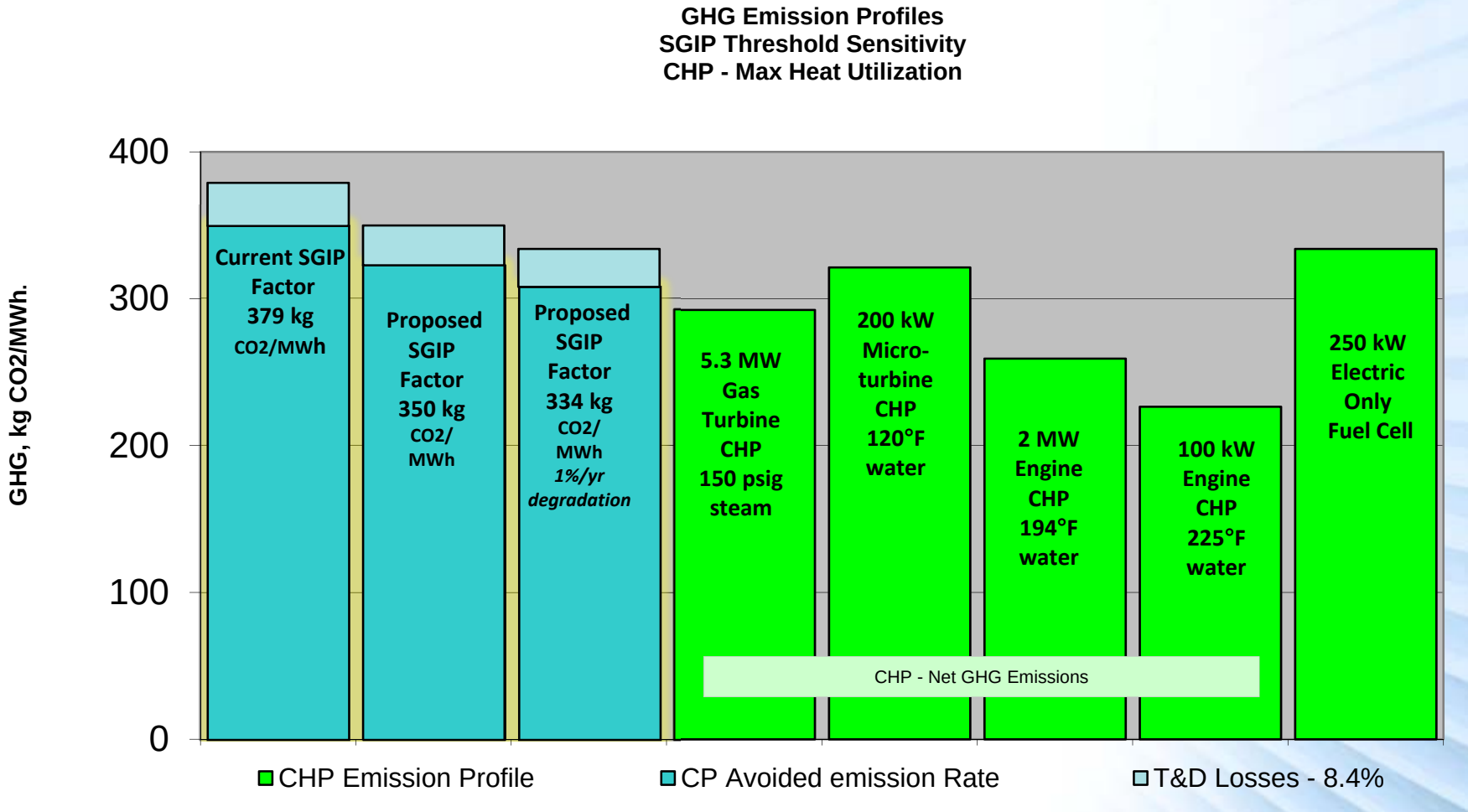
GHG Performance of Various DG/CHP



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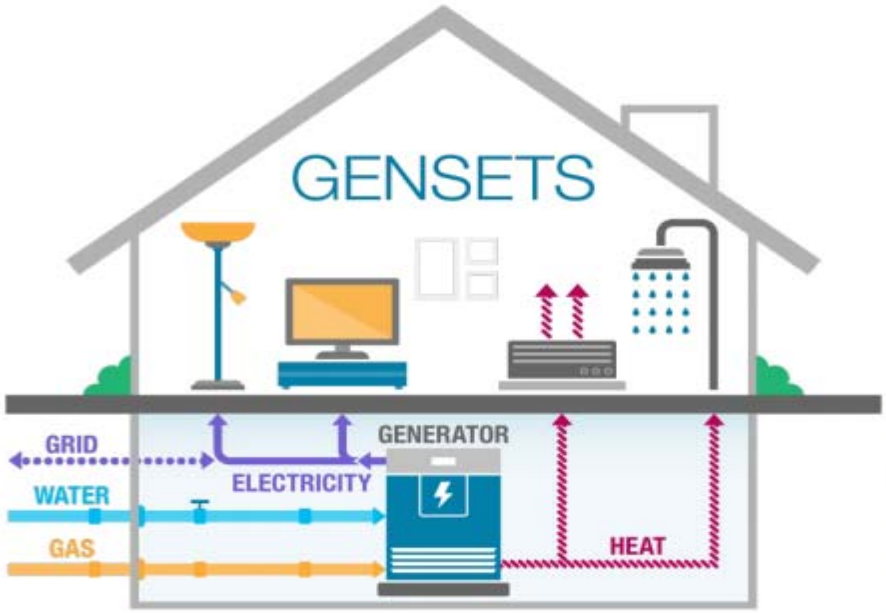
Specific DG-CHP Technologies

- Integrate MicroCHP with PV to meet ZNE (Res/Com)
- PV Based Solar-Water Heating for Space Cooling (100 °C-220 °F)
  - Thermal Storage
- Solar-Thermal Cooling
  - Absorption Cooling
- CHP System for Supermarkets
- Stirling Engine
- Thermoelectric
- Waste Heat Recovery - Organic Rankine Cycle
- Water-Energy benefits

MicroCHP Challenges

- Load match, high utilization, and system integration are critical to economic performance.
- Thermal CHP best suited as boiler enhancement in colder climates
- Electric CHP is residential option for warmer climates < 2 kW
- Many products are not commercially available in the US
- Existing product are too costly >$2,500/KW
- Ultra low NOx emissions compliance in CA
- 1 – 2 kW best size for medium/large home market
- > 5 kW, market for XL homes, multi-family & light commercial, more economical use of waste heat

GENSETS: GENerators for Small Electrical and Thermal Systems



- 1 kW electricity system
- 40% electrical efficiency
- 10 year durability/life
- $3,000 system cost

Technologies to enable widespread deployment of CHP systems for residential & commercial sectors

- Save energy (~ 2.5 quads)
- Save $ (~ 4-5 year payback)
- Reduce CO_2 by 200 million tons
- Reduce fresh water withdrawal (~4% of US total)
- Increase power reliability
- $200 billion business opportunity

arpa·e CHANGING WHAT'S POSSIBLE

Improve Efficiency ✓ **> +25% ↑**

Reduce Emissions ✓ **– 200 million tons ↓**

Reduce Imports ☐

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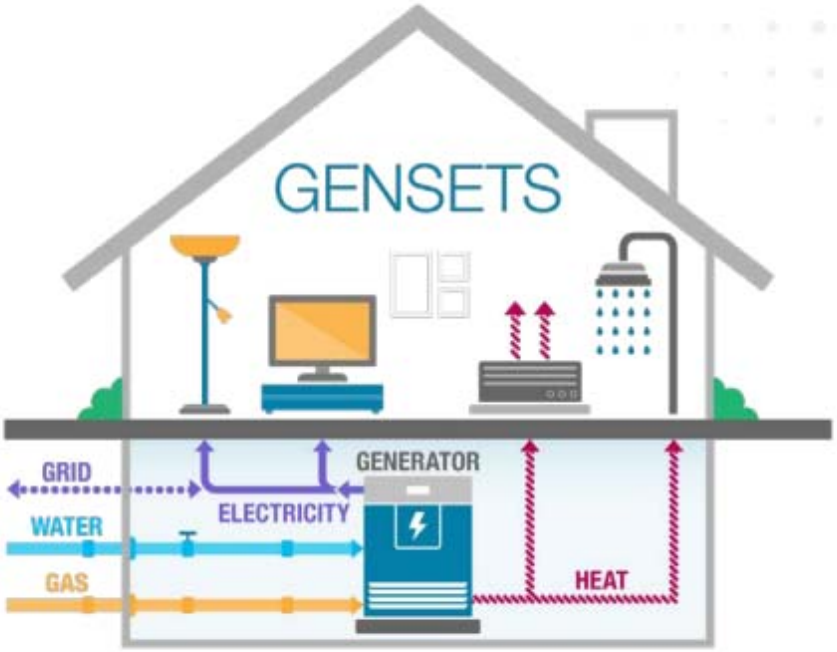
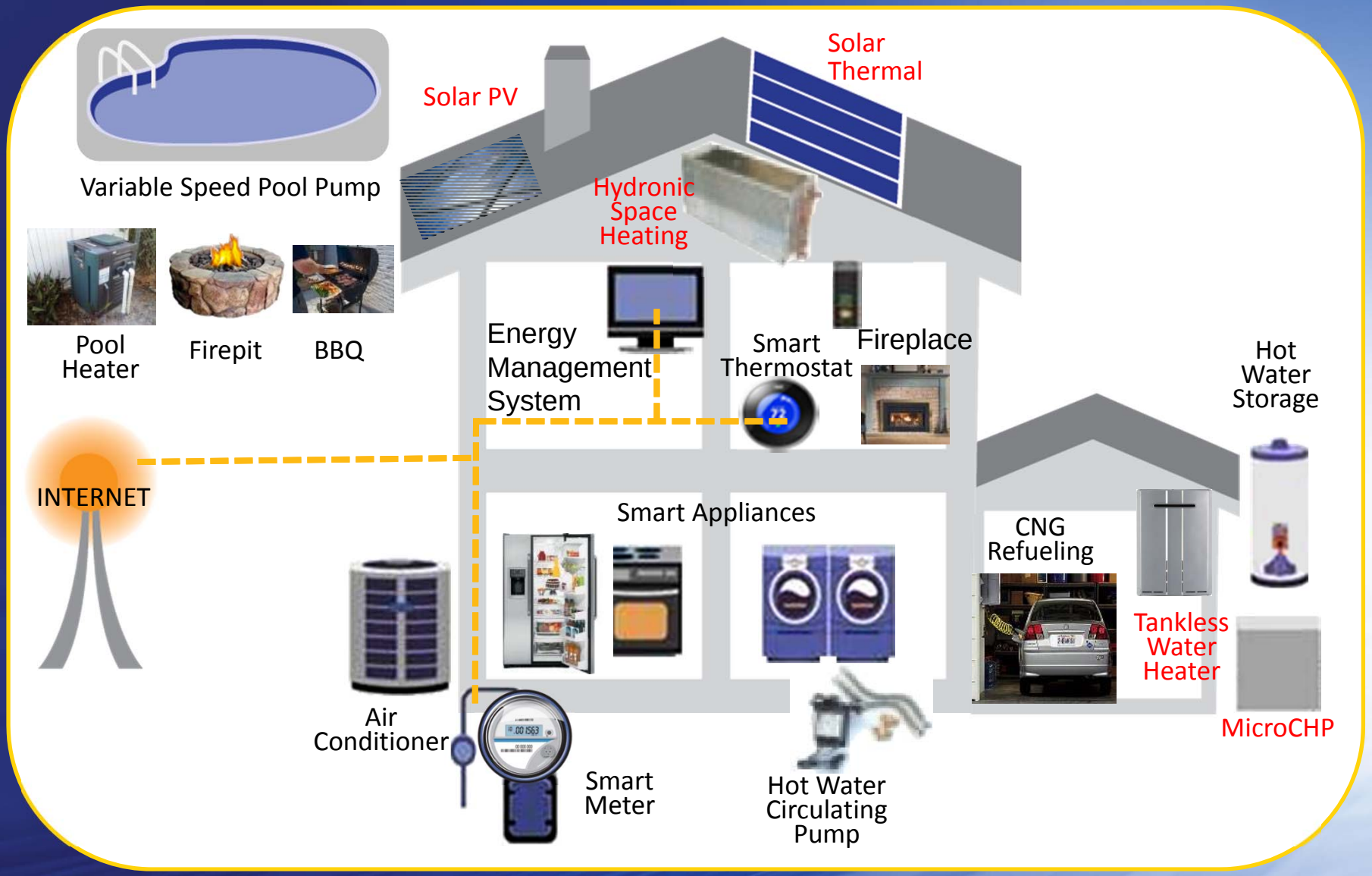
http://arpa-e.energy.gov/?q=site-page/gensets-kickoff-meeting

Effective integration with hot water tanks & HVAC

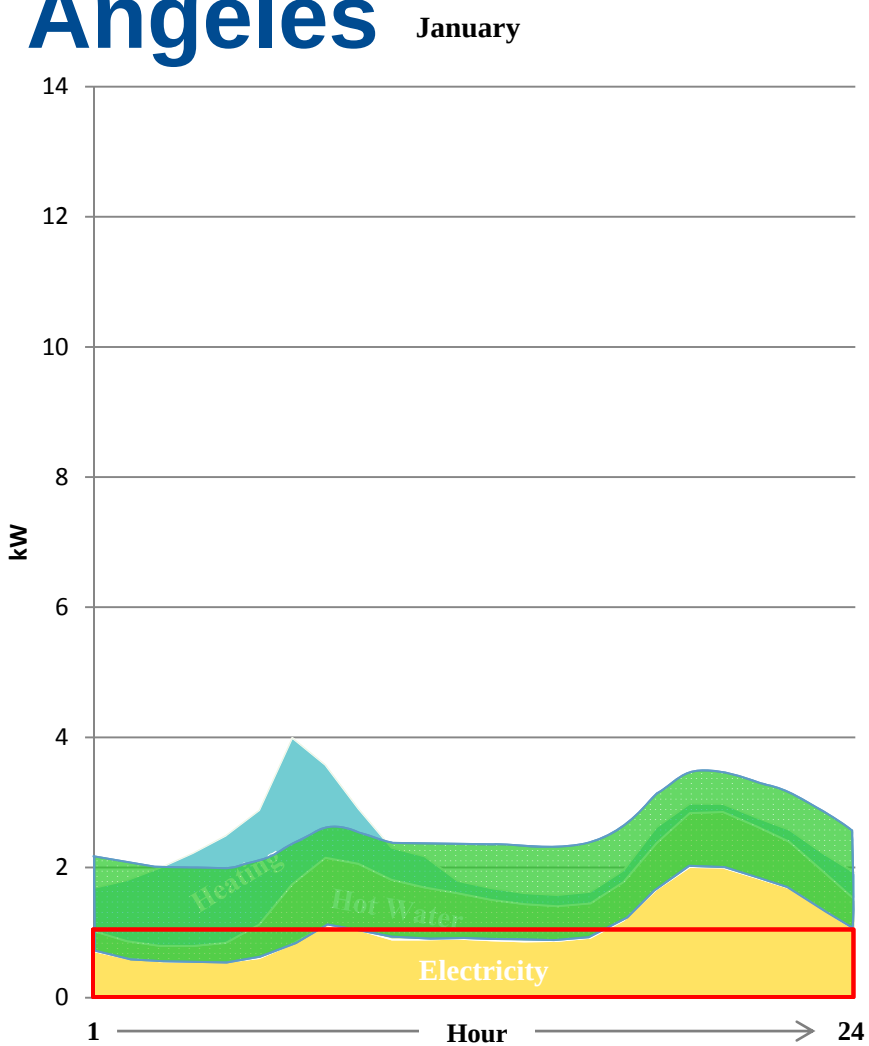
- 2.5 to 5 kW_{th} system
- High efficiency
- Low cost: < \$100 / kW_{th}
- 10 year lifetime
- Easy integration with hot water tanks and HVAC's
- Efficient heat to cooling technology
- Low manufacturing / development cost

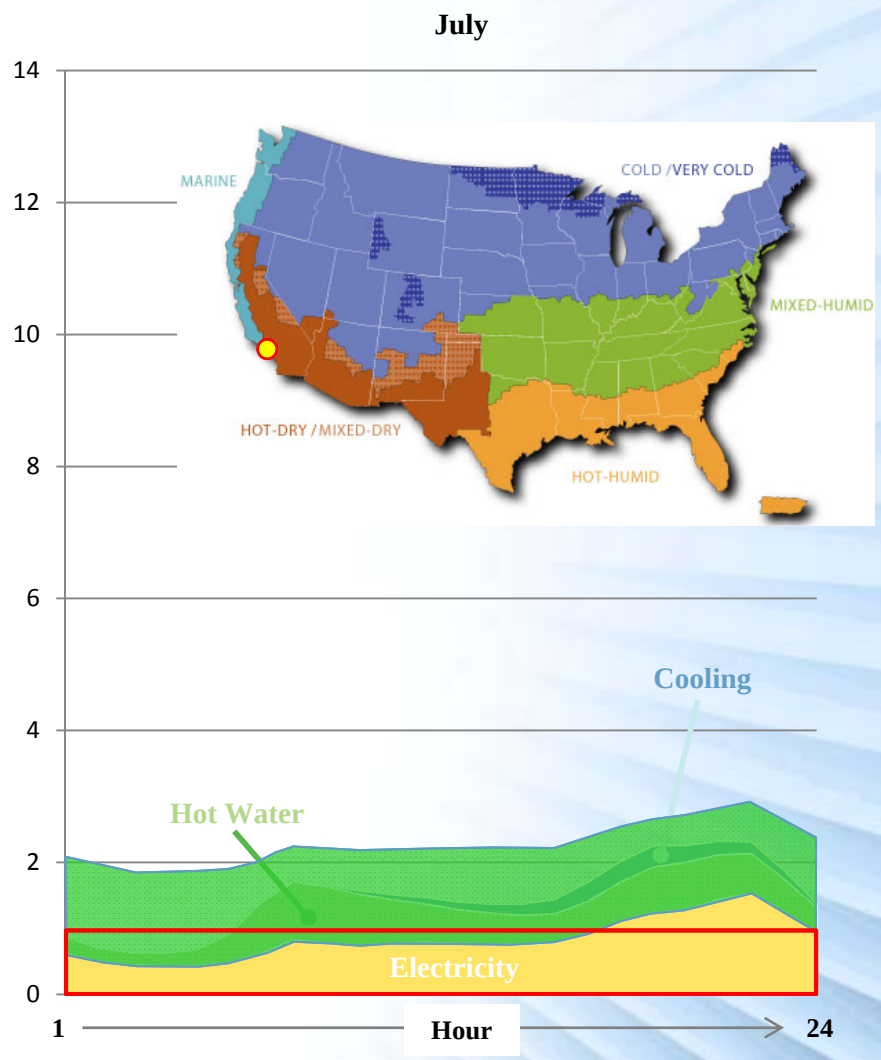


Smart ZNE Home



Hourly residential load profile: Los Angeles





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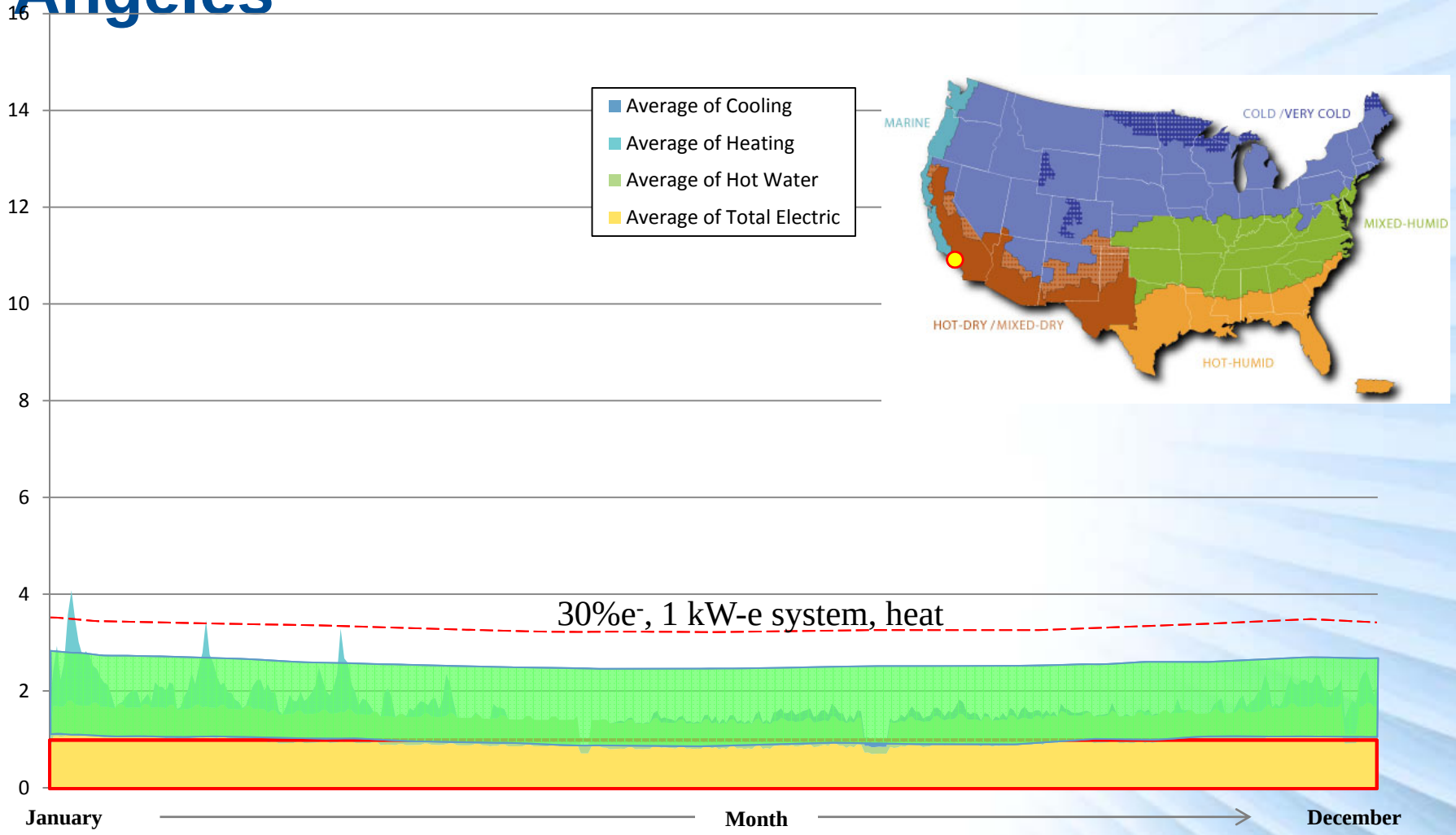
Source: NREL BEopt

Annual residential load profile: Los Angeles



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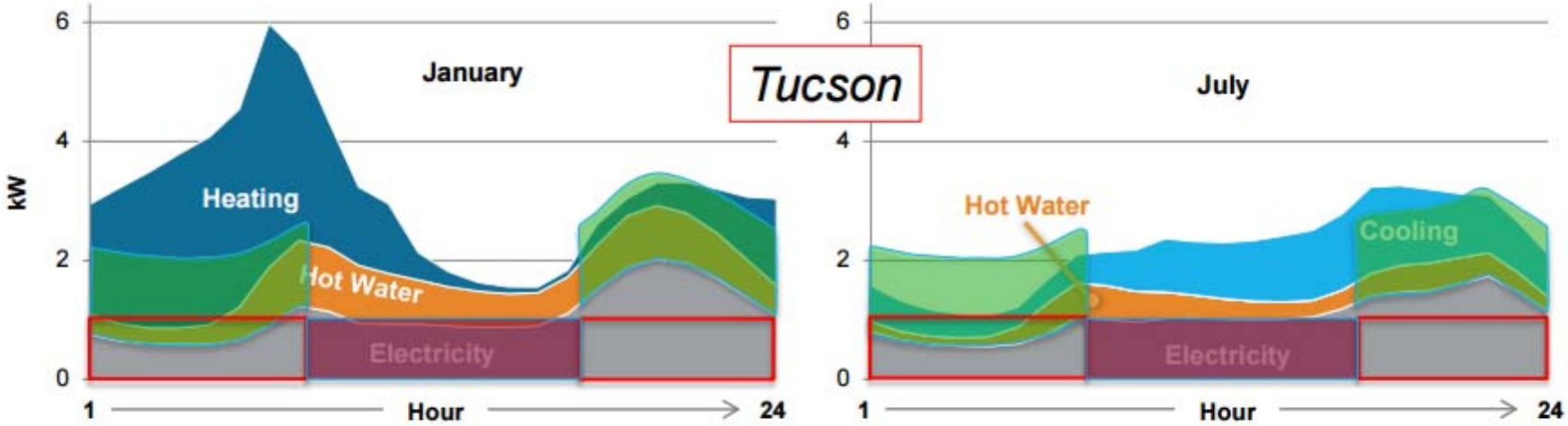
Source: NREL BEopt

Other modes of operation…

Integration with solar … load-leveling … load-peaking



Source: NREL BEopt

Various MicroCHP Products

IC Engines	Stirling Engines	Fuel Cells	ORC
EC Power (10 – 25 KW)	Pyro E (1.5 KW)	Panasonic-Toshiba (700 W)	Electratherm (35 - 110 KW)
Mazda Rotary (35 KW)	Disenco (Inspirit) (0.5-3 KWe – 12 KWt)	SolidPower (CFC) (2 KWe – 3 KWt)	Energetix (Flow) (1 KWe)
EcoPower - Marathon (4.5 KWe – 12KWt)	Dverga (2 KW)	Ceres Power (1 KW)	Probe - Calnetix (125 KW)
Yanmar (5 - 35 KW)	Qnergy (3.5 – 7 KW)	Bloom (30 - 200 KW)	NanoConvrsion – Electromechanical (200 W)
AO Smith (Bridge Stratten) (21 KW)	Navien Microgen Engine (1 KW)	Plug Power (5 KWe – 8 KWt)	
Mtrigen - PowerAire (25 KW)	Whisper Tech (1 KWe – 7 KWt)	Kyocera (700 W – 3 KW)	
Etagen (100 KW)			
Tecogen (75-100 KW)			

Potential for DG-CHP Deployment

Residential

- Single family homes (1 to 3 kW)
- Multi-family
- Single Family Community - MicroGrid

Commercial/Institutional

- Colleges/Universities
- Hospitals
- Government Buildings
- Hotels
- Schools
- Nursing Homes
- Supermarket
- Health Clubs

Industrial

- Food Processing
- Paper
- Chemicals
- Petro Refining

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Tools & Resources

- Design standardization and factory packaging to reduce cost and improve reliability. See NYSERDA program at: http://www.nyserda.ny.gov/Cleantech-and-Innovation/Power-Generation
  - Lower engineering, permitting and installation costs
- Simple application modelling tools that include thermal and electric diurnal and seasonal load shapes for a variety of applications and California climates
- CHP design guidelines that address proper sizing and operating strategies, including the integration of storage (thermal hot and cold, and electric), renewables (PV, wind and biogas), and microgrids

Summary

- CHP can get the most out of a fuel source enabling
  - High overall utilization efficiencies
  - Reduced environmental footprint
  - Reduced operating costs
- Significant potential for new CHP remains in CA
- Need proven technologies that are commercially available that cover full range of sizes and applications
- High heat utilization key to good economics and minimal carbon footprint
  - Size to thermal load
  - Operate to follow thermal load
  - Thermal Storage (hot or cold) to even out diurnal variations

Panel Discussion

Question 1

- How significant of a barrier is emissions compliance to deployment of small DG systems in California? In addition to emissions, what other key technological barriers exist and what research and development activities should be conducted to address these barriers?

Panel Discussion

Question 2

- What policies or incentives, new or existing (i.e. expanded SGIP or ITC), would promote deployment of small DG systems in California? How can the state further support the development of an active DG market in California?

Panel Discussion

Question 3

- What specific distributed generation technologies or enabling technologies have significant potential to succeed in the California market and why? What further research and development are needed, if any, to accelerate the market adoption of these technologies or strategies?

Panel Discussion

Question 4

- What specific sectors, if any, have significant potential for DG deployment in California and why? Are there relatively untapped markets or new opportunities?

Panel Discussion

Question 5

- What tools and resources are needed to increase private investment in the DG market (i.e. technical assistance, networking hubs to connect service providers and customers, etc.) and how could research funding help advance the needed tools and resources? Are you aware of resources that exist today that the public should be aware of?

Panel Q&A and Public Comment

- Please state your name and affiliation
- Please limit your questions or comments to 3 minutes

Questions and comments can also be submitted via email to:
kevin.uy@energy.ca.gov
using the email subject heading "Advanced Distributed Generation Research"

Deadline for comments is Friday, December 4, 2015 at 5 pm PST

EPIC Innovation Symposium
Save the Date: December 3, 2015

Beginning at 9:00 a.m.

Lake Natoma Inn, 702 Gold Lake Drive, Folsom, CA

- Showcase of more than 30 EPIC projects
- Post-symposium workshop: "How to Apply to EPIC"
- Select preferred breakout session topics: https://www.surveymonkey.com/r/SZLCW5L
- Additional information: http://www.energy.ca.gov/research/epic/documents/.

Connect with the Energy Commission!

…and the Energy Commission's listserves
www.energy.ca.gov/listservers

Links to Other DG Reports and Resources

Reports:

Barriers to Industrial Energy Efficiency: Report to Congress. (***Accompanying Study***). US DOE. 2015.

Waste Heat to Power Market Assessment. ICF International for the US DOE. 2015.

2013 SGIP Impact Evaluation. Itron for PG&E and the SGIP Working Group. 2015.

Catalog of CHP Technologies. US EPA CHP Partnership. 2015.

A New Generation of Combined Heat and Power: Policy Planning for 2030. CEC. 2012.

Combined Heat and Power: A Clean Energy Solution. US DOE and US EPA. 2012

Combined Heat and Power: Policy Analysis and 2011-2030 Market Assessment. ICF International for the CEC. 2012

Public Interest Energy Research Advanced Generation Roadmap. (***Background Paper***). Navigant Consulting for the CEC. 2009

Links to Other DG Reports and Resources

Resources:

US EPA CHP Partnership

US DOE CHP Technical Assistance Partnerships (CHP TAPs)

US DOE Pacific CHP TAP

Workshops:

Combined Heat and Power to Support California's Energy and Environmental Goals. (Workshop recording and presentations). California Energy Commission. July 10, 2014.

Efficient Small Engines for Combined Heat and Power. (Workshop presentations). US DOE Advanced Research Projects Agency-Energy (APRA-E). May 28, 2014

Thank You!

Please email comments to

Kevin Uy at

kevin.uy@energy.ca.gov

Using the email subject heading:

"Advanced Distributed Generation Research"

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