Potential Benefits from Combined Heat and Power Applications at Tribal Facilities

USDOE Office of Indian Energy Policy and Programs

August 3rd, 2022

Gilbert A. McCoy, P.E.
Senior Energy Systems Engineer
Deputy Director, U.S. DOE Northwest CHP TAP
Washington State University Energy Program

CHP Technical Assistance Partnerships
NORTHWEST

Topics and Some Questions We'll Answer

- What is Combined Heat and Power (CHP)?
- Brief CHP general description
- Applications where CHP makes sense
- Exciting recent developments and innovations
- How can the DOE CHP Technical Assistance Partnership program help you to capture your CHP potential ?

Overview: What is Combined Heat and Power (CHP)?

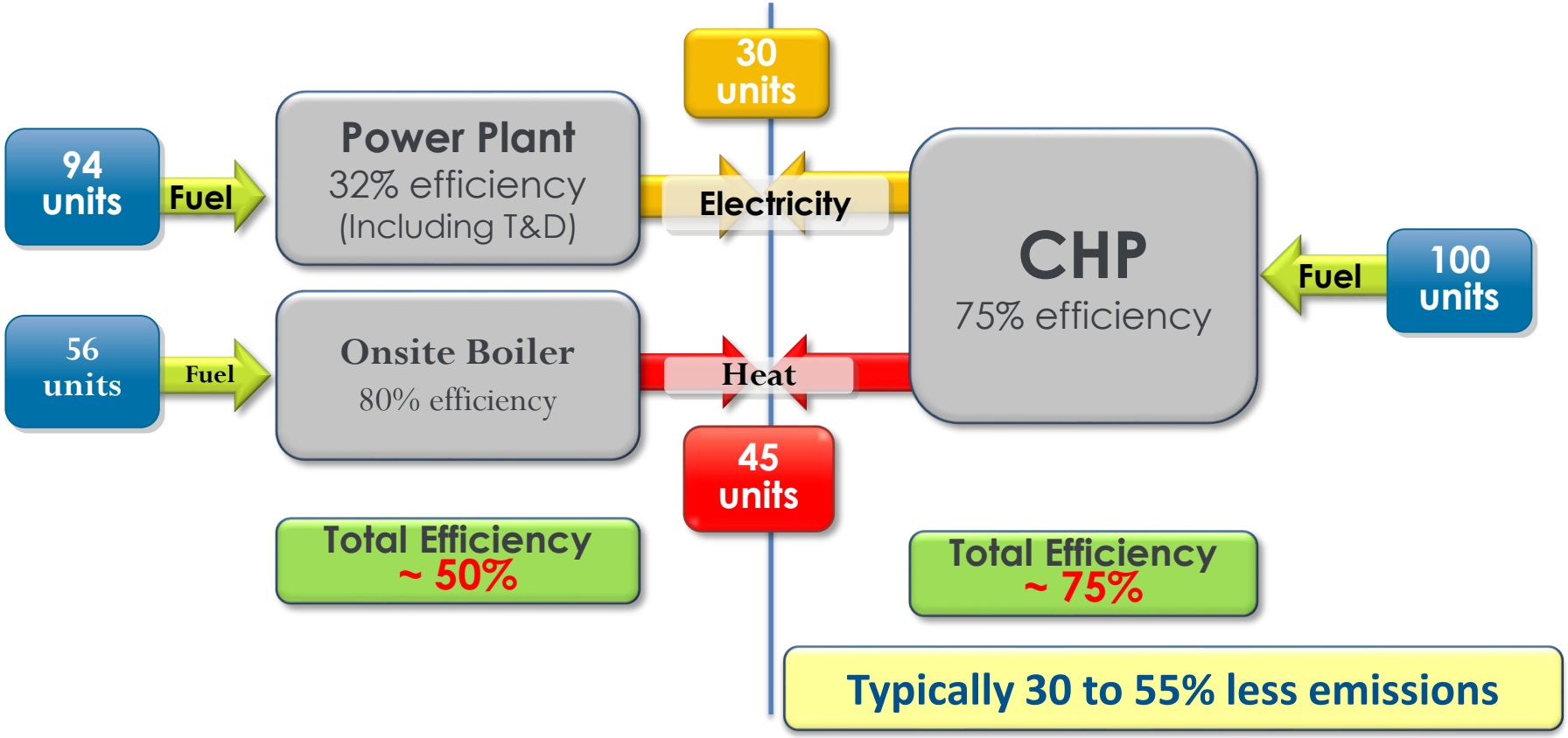
Tried and True: CHP is an established *efficient technology application strategy* that is located at or near a building/facility. CHP:

- Greatly increases the net energy efficiency of electric power generation supply compared to other thermal power generation technologies
- Also supplies heat - A primary customer need not usually met by electric utilities.

Your #1 Takeaway : **CHP is likely the largest single net energy savings opportunity for thermal power generation.**

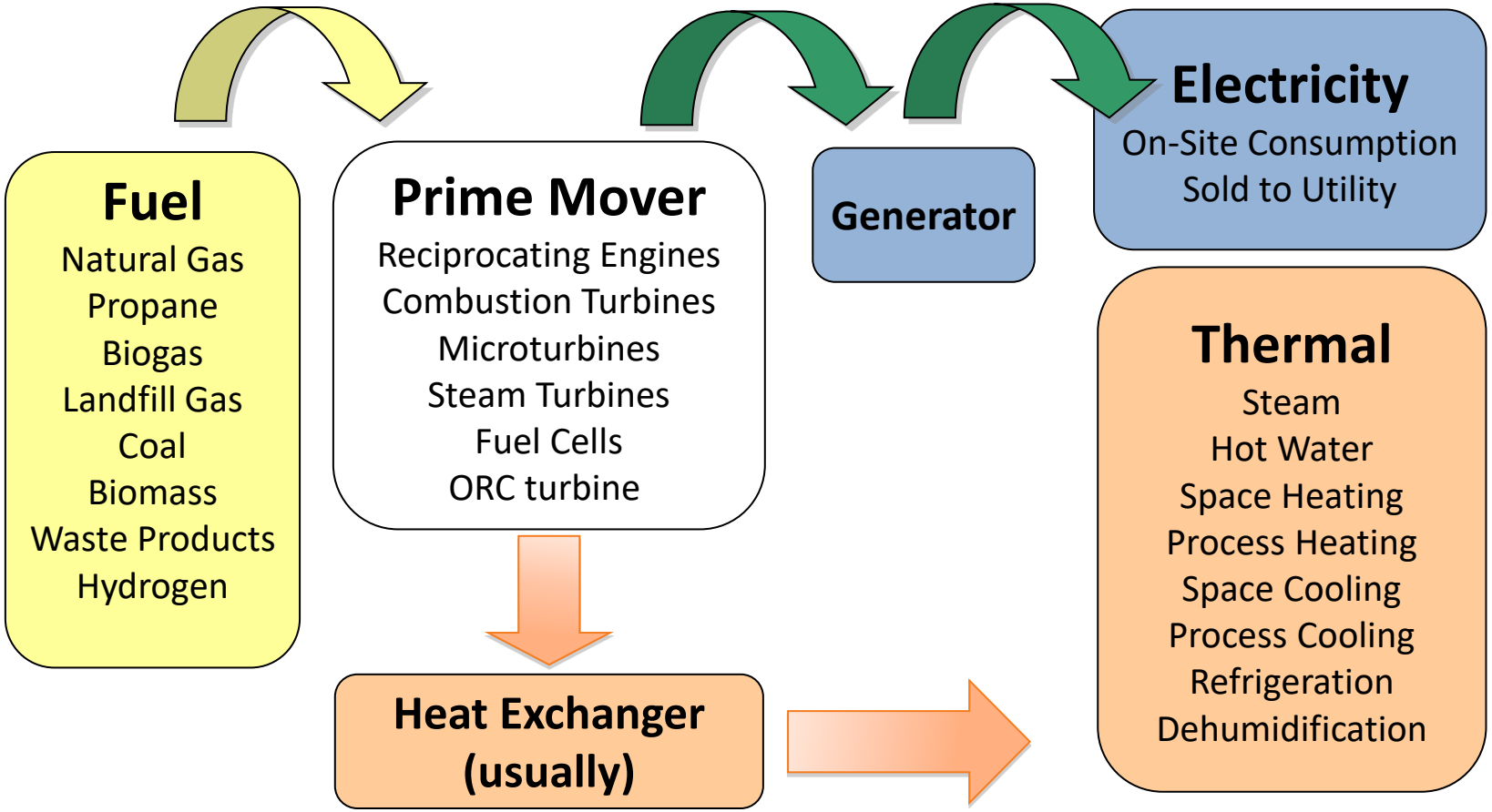
- CHP is capable of delivering large energy and operating cost savings
- CHP can substantially reduce net emissions immediately where baseload power still requires combustion-fueled generation

Here's Why It Works: CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing Emissions



Separate Heat and Power VS. Combined Heat and Power

CHP System Schematic



Common Uses for Recovered Thermal Energy

- Space heating at a single facility, or campus

  "District heating" project
- Domestic water heating, laundromat/washerteria
- Process hot water or steam at an industrial facility
- Hospitals: Steam for space and water heating, humidification and sterilization
- Pool or spa heating at hotels, schools, recreation or community centers, casinos
- Freeze protection for water supply and wastewater
- Absorption chilling for space cooling & refrigeration

Additional Benefits of CHP

- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs** (but requires capital investment)
- Higher efficiency **reduces emissions** of pollutants
- CHP can also increase **energy reliability; provide resiliency benefits at critical facilities** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.

Conditions Conducive for a CHP System

1) Necessary conditions

- ✓An Attractive Ratio of Fuel to Electric Power Costs ("Spark Spread")
- ✓High Electric Usage
- ✓Coincidental thermal load
- ✓High hours of operation

2) Equipment replacement

- ✓Older Back-up Generator
- ✓ Replacing Chillers
- ✓ Replacing Boilers

3) Customer motivation

- ✓ Utility cost
- ✓ Power reliability
- ✓ Waste heat or biofuel untapped resource
- ✓Sustainability & environmental
- ✓Plans to expand facility

4) Other factors

- ✓ EE measures already implemented
- ✓ Centralized HVAC

Attractive CHP Candidates

Industrial

Chemical manufacturing
Ethanol
Food processing
Natural gas pipelines
Petrochemicals
Pharmaceuticals
Pulp and paper
Refining
Rubber and plastics

Commercial

Data centers
Hotels/tourist complexes
Multi-family housing
Laundries/washeterias
Apartments
Office buildings
Refrigerated warehouses
Restaurants
Supermarkets
Green buildings
Pools and water parks

Institutional

Hospitals
Schools (K-12)
Universities & colleges
Wastewater treatment
Correctional facilities
Health clinics
Assisted care facilities

Agricultural

Dairies
Wood waste (biomass)
Animal feeding operations
Greenhouses/controlled environment agriculture

CHP in Greenhouse or Controlled Environment Agriculture (CEA) Applications

CHP and Controlled Environment Agriculture (CEA)

CEA Uses a Lot of Energy (And sometimes CO_2 as well)

Cornell Greenhouses Energy Use Summary (based on 2014 Data)					
Total Cornell Greenhouses Monitored:	144,624	Sq-ft			
Annual Heating Energy:	11,706,690	kWh equiv (steam)			
Annual Heating Cost:	$ 998,675				
Heating CO2 Emissions Impact:	3,365,905	lbs CO2 emissions			
Total Lighting Power (HID):	1,564,129	Watts			
Annual kWh (11 hr days):	6,279,978	kWh Electric			
Annual Lighting Cost ($0.07/kWh):	$ 439,598				
Annual Lighting CO2 Impact:	5,651,980	lbs CO2 emissions			
Total Annual Energy (kWh Equivalent):	17,986,668	kWh			
Total Annual Energy Cost:	$1,438,273				
Total CO2 Emissions Impact:	9,017,885	lbs CO2 emissions			
Per Unit Values:					
Annual Energy - kWh/sq-ft:	124				
- kBTU/Sq-ft-yr:	424				
Heating Fraction:	65%	or	276	kBTU/sq-ft-yr	
Lighting Fraction:	35%	or	148	kBTU/sq-ft-yr	

Source: https://cuaes.cals.cornell.edu/greenhouses/sustainable-greenhouses/energy-use
Credit/Permission: Cornell University Agricultural Experiment Station

Two Different Types of CEA

Semi-Closed Glass Greenhouse

Semi-closed Greenhouses * Lighting, heating, ventilation * Closed at night, recirculation

Vertical Farm

Fully enclosed * Greater biosecurity * No ventilation: only mechanical cooling and dehumidification * Higher loads, extensive running hours * Great ability to increase CO_2 concentrations inside * Reduced footprint & transportation costs

Many CEA Applications Worldwide

Examples:

- **Netherlands - Has *3,000 MW of CHP capacity in greenhouses:***
- *Prominent* - produces 20% of Dutch tomatoes at 35 sites - almost 741 acres, with CHP

Significant Benefits:

- *Reduced Transportation Costs*
- *Locally Grown Vegetables are Fresher with an Increased Shelf Life*
- *Improve Food Security and Quality*
- *Reduced Need for Imports*
- *Better Pest and Contaminant Control*

1: Examples from: https://www.cogenerationchannel.com/en/video/category/applicazioni-greenhouse/

What Crops are Being Grown in CEA Facilities? …Basically anything of Value

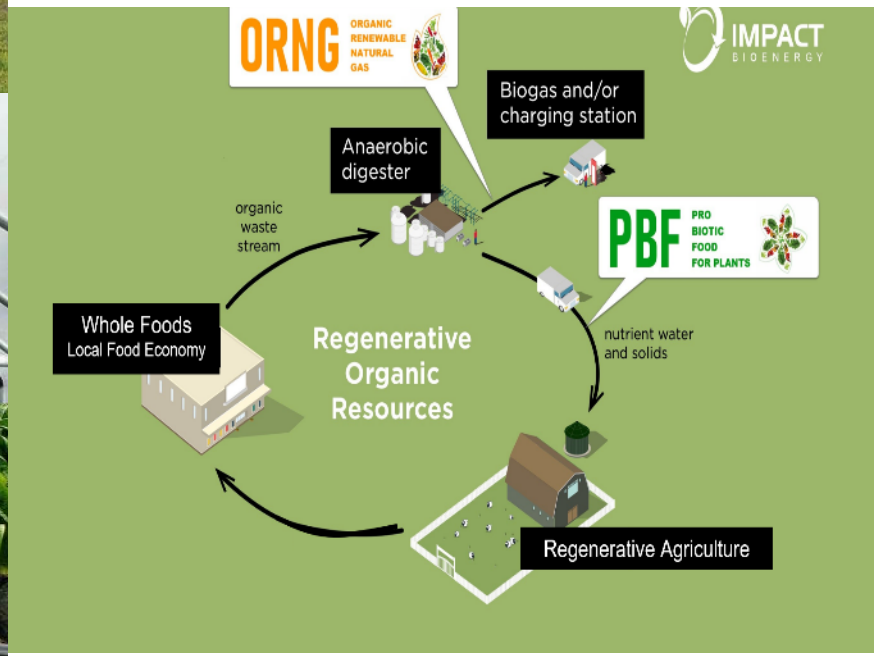
Source: Agritecture 2021 Global CEA Census Report

CHP and CEA: Is scalable – From Tiny…

Village Scale: This site uses a cottage industry's tofu production waste to produce biogas for heat and renewable natural gas for sale, as well as plant nutrients. A greenhouse is integrated on top of the biogas digester.

***Impact Bioenergy's Vashon Island, WA Bioenergy Farm*:**

- **Food wastes →**
- **Biogas as Fuel +**
- **Greenhouse nutrients and heat**
- **CHP option**



Images and Graphics Courtesy of Impact Bioenergy

… To Large, Yet can be very clean and Bio-Fueled

HoSt's 2020 State-of-Art Biomass CHP Plant:
Produces 15 MW thermal + 3.4 MW electrical power

- A biomass-fired combined-heat-and-power (CHP) plant recently commissioned in Andijk, Netherlands produces heat and electricity from ***prunings***.
- Provides renewable heat to six greenhouse companies.
- This biomass plant's NOx emission reduction is >99%. Achieved using ultra low-NOx combustion technology, precise combustion temperature control, and highly automated control.
- *CO_2 from flue gases can be captured for use in greenhouses for crop growth, for sales, or storage in liquid or gaseous form.*
- Residual heat and electricity can be used for industrial processes.

Source: Biomass Magazine, June 26, 2020

CHP in Wastewater Treatment Plants (WWTPs)

CHP at Wastewater Treatment Facilities

- Best when anaerobic digester present and biogas is flared
- Reduce energy cost/maximize revenue
- Provide energy resiliency
- Sustainability planning
- Enhanced reliability
- Emissions reduction
- Enhanced bio-solids management
- "Green" publicity
- Availability of Incentives

- Biogas production (co-digestion with animal or food processing plant wastes or FOG)
- Utility load shedding (demand charge reduction)

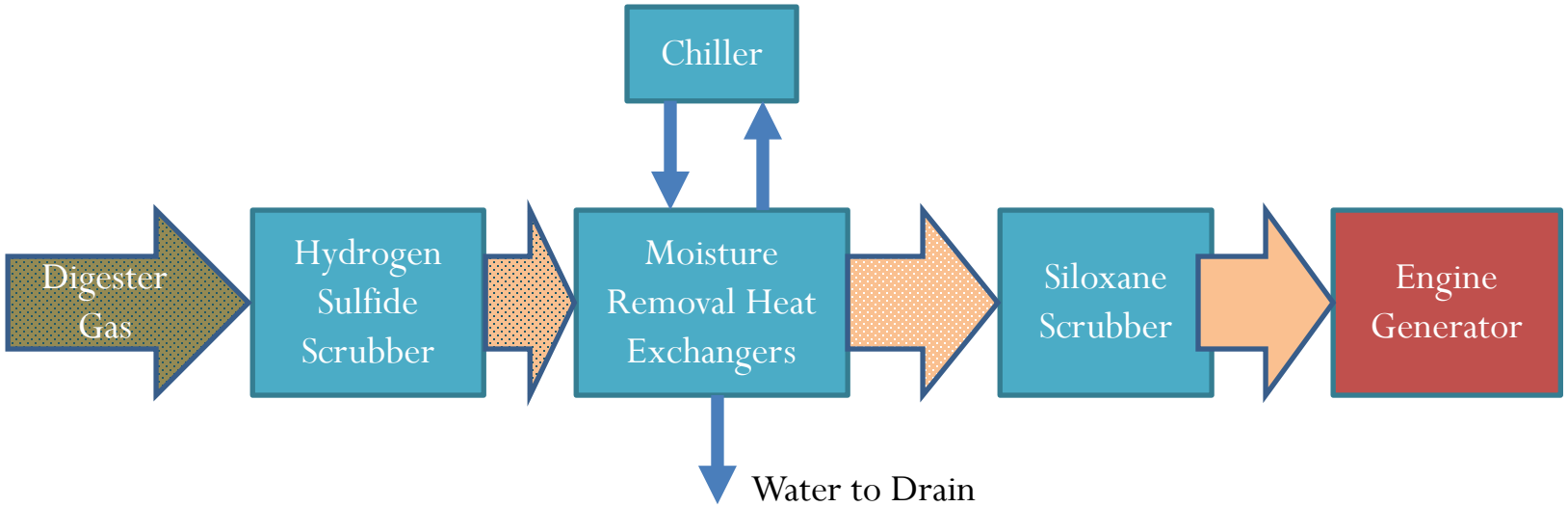
A typical WWTP processes 100 gallons/day of wastewater for each person they serve

Each million gallons per day (MGD) of wastewater flow can produce enough biogas in an anaerobic digester to produce 30 kW of electric capacity

Best Candidates for CHP at WWTPs

- Consistent source of organic matter to produce **biogas**
- High and constant **thermal load**
- **Electrical energy costs > $0.06/kWh**
- Need for high reliability
- Concern over future electricity prices
- Interest in reducing environmental impact
- Planned plant expansion or new construction; or equipment replacement within the next 3-5 years

Biogas Cleaning is Required



- Contaminants to remove
  - Hydrogen Sulfide
  - Moisture
  - Siloxanes and particulates

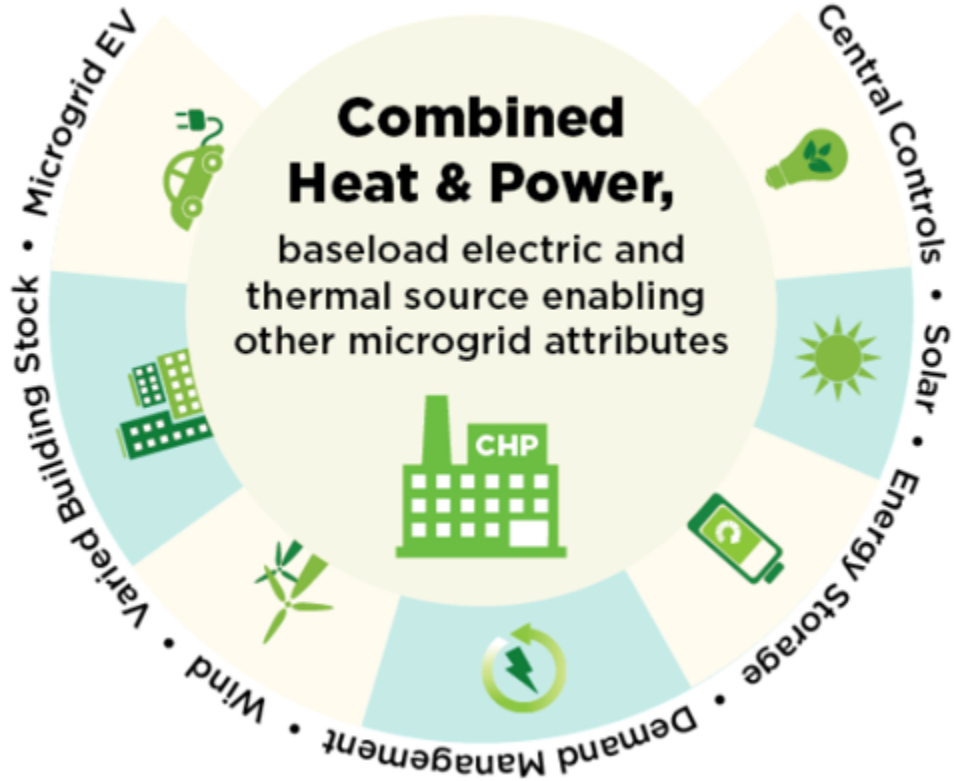
Emerging CHP Approaches
(Innovative or Under-Utilized)

Huge Market for Packaged CHP Systems

- CHP technology advancements allow for standardized packaged CHP systems
  - Most systems range from 10 kW to 2 MW
- Packaged systems expected to expand the CHP market to new customers
  - Avoid costs and delays associated with customized engineering and design
  - 26 GW of CHP technical potential in the 50-499 kW size range
- Packaged systems are increasingly including solar PV in addition to CHP equipment
- DOE Packaged CHP eCatalog seeks to increase package options up to 10 MW

Access eCatalog at https://chp.ecatalog.lbl.gov/

CHP is a Natural Anchor for Microgrids



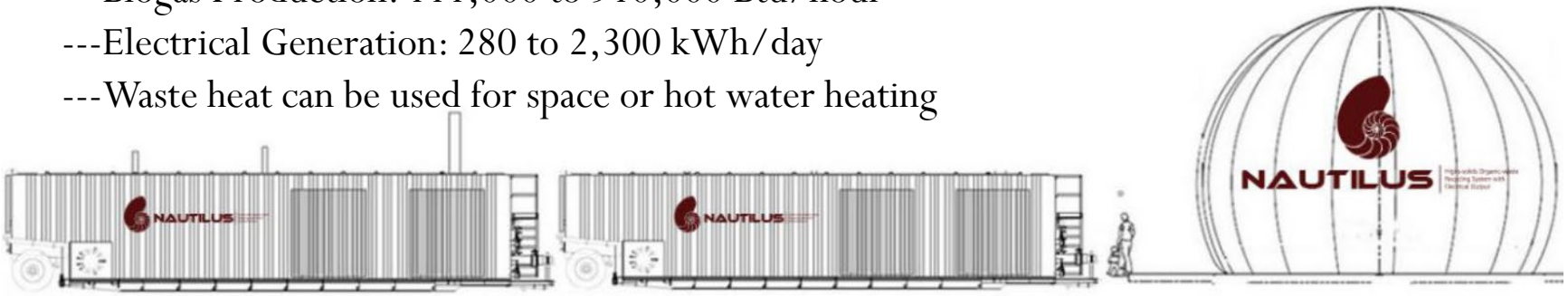
- With a CHP system providing baseload electric and thermal energy, microgrids can add:
  - Solar and wind resources
  - Energy storage
  - Demand management
  - Central controls
  - Electric vehicle charging
- Flexible CHP systems can ramp up and down as needed to balance renewable loads and provide grid services

On-site Food Waste to Energy

- Consider a modular bioenergy system if your food wastes amount to 1,000 to 8,200 lbs./day. Wastes can include kitchen trim, dining room scraps, meat, grease, oil, edible liquids, seafood, dairy products, fats, grease trap wastes, eggshells, fruits, vegetables, soiled paper products, grass clipping, and leaves. On-site treatment reduces transportation/disposal costs and yields valuable compost or fertilizer.

- Waste stream and energy inputs and outputs from a community-scale bioenergy CHP system range from:

---Organic Input: 1,000 to 8,200 lbs./day
---Biogas Production: 111,000 to 910,000 Btu/hour
---Electrical Generation: 280 to 2,300 kWh/day
---Waste heat can be used for space or hot water heating



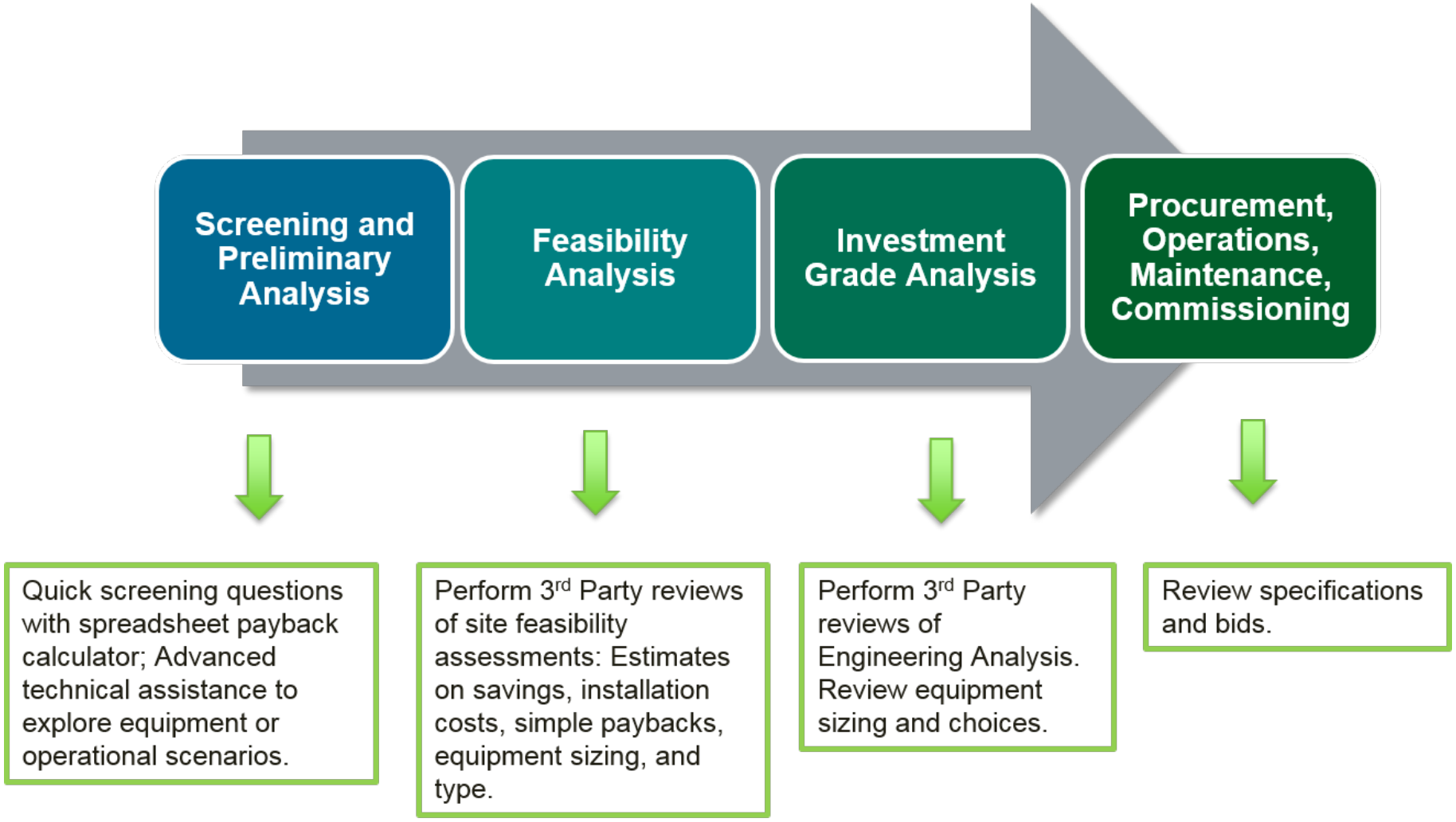
Pictured is an Impact Bioenergy Nautilus 185 System with biogas storage

Woody Biomass Gasification

- Woody biomass can be fed into a gasifier to generate heat, electrical power, fuels, or chemical products.
- Wood chip inputs must adhere to size and moisture content limits. Operator requirements are a consideration.
- Packaged micro (50 kW) and small-scale (500 kW and up) gasifier CHP systems are commercially available and have been successfully deployed to serve European markets

Implementing a CHP Project with the Help of the CHP TAP

We can help you determine your CHP potential: CHP TAP = Unbiased Technical Assistance. No Charge



What We Do: Maniilaq Health Center CHP Opportunity – A Typical Engagement:

U.S. Department of Energy
CHP Technical Assistance Partnerships
NORTHWEST

LT Adriel Perry, PE, CHFM
Maintenance Program Manger
Maniilaq Health Center
Kotzebue, AK

December 20th, 2017

Matt Bergan, PE
Kotzebue Electric Association
Project Engineer

Subject: Advanced Technical Assistance for Maniilaq Health Center CHP Project Alternatives

Introduction---Maniilaq Health Center Annual Energy Use and Costs: The Northwest CHP TAP recently completed a Combined Heat and Power (CHP) Qualification Screening study (QS) that found that a 250 kW reciprocating engine would be cost-effective when serving electrical energy and thermal loads at the Maniilaq Health Center in Kotzebue, AK. Based on follow-up discussions between Maniilaq Health Center, Kotzebue Electric Association (KEA), the Alaska Energy Authority and the Northwest CHP TAP, the Health Center and KEA requested a more detailed analysis be performed where a number of different CHP technology and ownership options were more deeply analyzed. This letter describes the outcome of those studies by the NW CHP TAP.

Kotzebue is a remote town with a population of about 3,245 located above the Arctic Circle. The Health Clinic is operated by the Indian Health Agency. Cost-effectiveness of the 250 kW CHP project is excellent, with a simple payback to the Health Center of about 2.7 years, due to both the high electrical rates ($0.37/kWh) and the high heating fuel prices (about $4.18/ for No. 1 fuel or kerosene) at the Health Center site.

The Health Center consumed about 2.44 million kWh of electrical energy in 2016 at a cost of $896,000 plus about 143,296 gallons of No. 1 fuel oil. Current cost for fuel oil is about $4.18/gallon indicating an annual expense of about $598,977. The fuel oil is combusted in hydronic boilers (3 at 4,250 MBH each) and steam boilers (3 at 1,100 MBH each). A 2007 Energy Audit concluded that 58% of the fuel oil is combusted in the hydronic boilers for hot water used for space heating with 42% used to provide steam for supply air humidification, autoclaves, and laundry needs. Steam use was later increased due to adding domestic hot water heating loads and then subsequently reduced as humidification loads decreased when relative humidity setpoints were reset to lower values. An inspection of daily average steam load estimates provided by the Health Center (15,618 lbs of 100-psig steam is used per day) and No. 1 fuel oil annual use indicates that approximately 39% of annual fuel consumption is currently used to raise steam. This calculation is dependent upon assumptions related to steam boiler efficiency, condensate return, and condensate return temperature.

Kotzebue's electrical energy needs are met through a microgrid operated by the Kotzebue Electric Association (KEA), a cooperative power producer. They meet winter loads of about 3.2-3.3 MW during

ating water pumps (conveying a
he clinic. It may be possible to run the
ct's fuel transfer pipeline.

ions for Kotzebue. They assumed that
at both supply and return piping is
cost about $200 x 2,325 feet =
ng alone of about 2.2 years. The simple
g/design, permitting, and construction
n year period generally considered as
rict heating loop could be beneficial to
nple construction of a waste-to-energy

er pipeline without the installation of a
t, but the heat transfer pipeline could
ve #3 i.e. 87,410 gallons of No. 1 fuel oil,
count to the Health Center, benefits to
r. This path would also eliminate the lost
perating a CHP project.

ent of alternatives helps you to
and the Health Center elect to develop a
natives offer simple paybacks on
project is likely to be selected based
vailability of capital, perceptions of risk,
district heating loop. It does appear that
ties, and so we recommend further, more
ts proposed here.

86 should you have questions or require

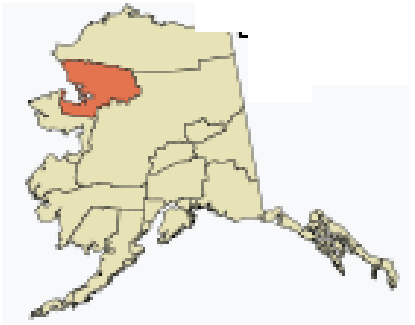
905 Plum St. SE, Bldg #3
P.O. Box 43165
Olympia, WA 98504-3165
Ph: 360-956-2071
Washington State University
www.energy.wsu.edu

cc: Dan Smith, Alaska Industrial Development and Export Authority (AIDEA)

- Initial contact through Alaska Energy Authority and Alaskan Native Tribal Healthcare Consortium
- Gather site information and energy data
- Initial "Screening" – does it look viable? –Yes. Initial Letter report
- Conversations with those involved, to review findings
- Request for advanced assessment – Done; still looks good
- More calls and conversations, etc.

Tribal Healthcare: Maniilaq Health Center's CHP Opportunity

Constant Loads, Need for Reliability & Price Stability in a Critical Facility



Problem

- $1.6M energy costs in 100,000 sf facility; 17 patient / 18 nursing home beds
- $0.367/kWh for electricity, $4.18/gallon for No. 1 fuel oil in 2018.
- Fuel oil prices change dramatically. In 2016, price was $5.48 per gallon

Proposed Solutions

- Consider 250-kW Reciprocating Engine or 200 kW Microturbine
- CHP shifts heat from No. 1 fuel oil (kerosene) to No. 2 (diesel) – Much lower price!
- Thermal recovery for potable hot water and steam for health center applications

Outcome of Screening and Technical Assessment

- Estimated payback 1.85 – 6.3 years, depending on options chosen
- Improved reliability of a critical facility,
- Hedge against rising energy costs

Strategy

Utility integration to address load loss and integration with existing generation

The CHP TAPs Like To See Projects Built and can offer assistance from the initial screening assessment through implementation and operation:

U.S. Department of Energy
CHP Technical Assistance Partnerships
NORTHWEST

8 April, 2016

Mr. Mike Conaway
Association Facilities Director
YMCA
1177 W. State St
Boise, ID 83702

Dear Mr. Conaway:

Thank you for your recent inquiry regarding a CHP Qualification Screening for a potential Combined Heat and Power (CHP) system at the YMCA facility located on State Street in Boise, Idaho. As a result of the Combined Heat and Power (CHP) system qualification screening we conducted, we find that there is good potential for CHP to meet your long term goals noted below. According to our discussion, the YMCA has substantial variations in high-volume vs low volume natural gas rate schedule pricing (at the 200,000 therm breakpoint), and is very much interested in reducing greenhouse gas emissions as part of a commitment to environmental stewardship at the facility. The site became interested in CHP based on initial conversations with Marcia Karr, P.E. at the U.S. DOE NW CHP Technical Assistance Partnership (NW CHP TAP).

This analysis is a first cut screening for CHP economic viability at the YMCA. It is based on a simple spark spread analysis and utilizing the minimal site information (e.g., average electric demand, average thermal demand, and average utility rates). The operating cost of a CHP system at your site - including fuel, maintenance, and credit for displaced thermal energy - is estimated assuming performance characteristics of a typical CHP system and prevailing fuel price assumptions for your site location. Qualitative information is also factored in to determine if your site is a potential candidate for CHP. One of the key factors in our assessment includes the implementation of no-cost and very low cost natural gas savings Energy Conservation Measures (ECMs) already identified by you that when combined with the increased gas used associated with the proposed CHP system will allow the YMCA to continue to benefit from the existing high volume natural gas rate schedule. The result is a reduction in total annual energy costs and environmental impacts.

Based on our review of the technical and economic data provided, we believe the TMCA qualifies as a potential candidate for CHP. The following factors are the basis for favoring the installation and operation of a CHP system:

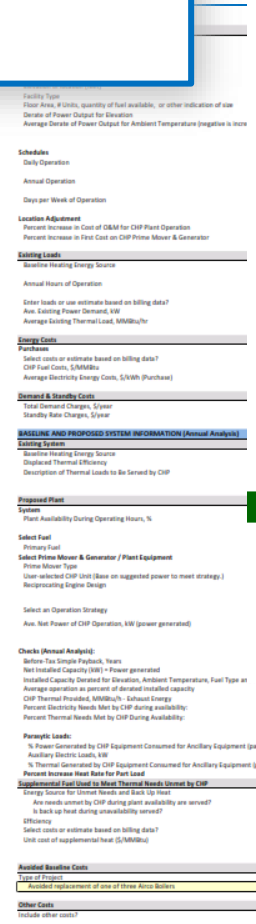
- Natural gas and electricity rates combined with electric and thermal loads that appear to support economic CHP operation – a typical CHP system in the size range matched to your plant thermal needs would have an estimated simple payback on investment as low as 5.2 years;

About CHP

Combined heat and power (CHP) systems generate electricity and thermal energy in a single, integrated system, located on-site or near where the energy is used. CHP is more energy efficient than separate generation of electricity and thermal energy because heat that is normally wasted in conventional power generation or industrial processes is recovered as useful energy, such as for steam, heating, or cooling. CHP systems help U.S. businesses reduce energy costs, improve efficiency, improve sustainability, and strengthen energy resiliency. (www.energy.gov/chp)

About the CHP TAPs

The U.S. DOE NW CHP Technical Assistance Partnership (NW CHP TAP) is one of seven partnerships established by the Department of Energy to promote and assist in transforming the market for CHP, waste heat to power, and district energy system CHP throughout the United States.



NORTHWEST
CHP Technical Assistance Partnerships

PROJECT PROFILE

Kwaan and Eklutna Medical Clinic Micro CHP Applications

5 kW and10 kW Propane-Fueled Projects

The Eklutna Village Medical Clinic's 5 kW Yanmar reciprocating engine-based CHP system
Photo from Eklutna Village Medical Clinic

Quick Facts

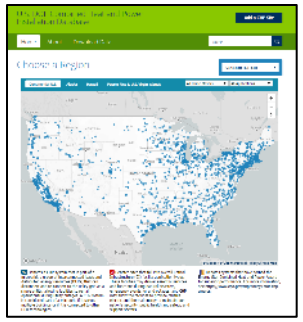
LOCATION: Yakutat and Eklutna, AK
MARKET SECTOR: Health clinics
FACILITY SIZE: 5,000 square feet (Yakutat)
EQUIPMENT: 1-10 kW Yanmar reciprocating engine (Yakutat); 1-5 kW engine (Eklutna)
FUEL: Propane
USE OF THERMAL ENERGY: Provision of hot water for building space and potable hot water heating
CHP TOTAL EFFICIENCY: About 82%
CHP IN OPERATION SINCE: September 2014 (Yakutat); January 2020 (Eklutna)

Site Descriptions

Yakutat (population 649) has a subarctic Pacific oceanic climate and receives about 140-inches of rainfall annually. Fishing is the largest economic opportunity in the area. The Yakutat Community Health Center's Kwaan, or 'people's', Clinic is owned and operated by the federally recognized Yakutat Tlingit Tribe. The clinic is comprised of a 5,000 square foot healthcare facility with an additional 5,000 square feet of office space. The clinic provides affordable high quality primary care medical and behavioral health services including counseling for patients of all ages.

Want to know more? Lots of US DOE CHP Program Resources Available at: energy.gov/chp

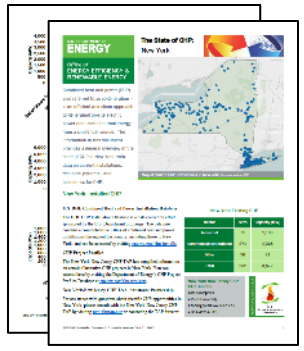
[CHP and Microgrid Installation Databases]



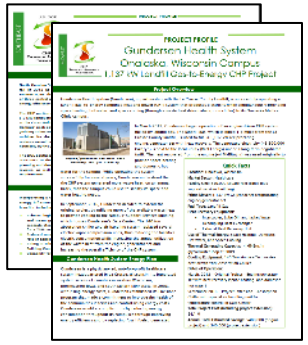
[Packaged CHP eCatalog]

[DOE CHP Technologies Fact Sheet Series]

[State of CHP Pages]

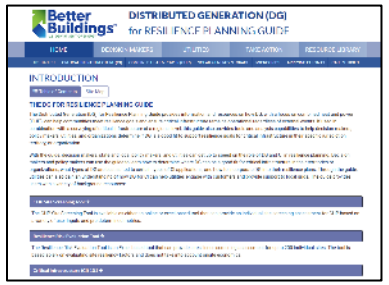


[DOE Project Profile Database]

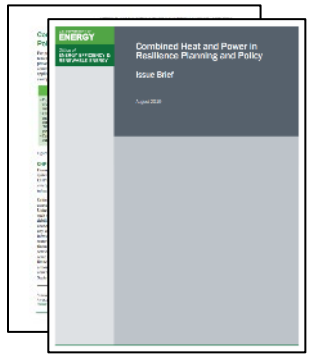


[DOE Policy/ Program Profiles]

[DG for Resilience Planning Guide]



[CHP Issue Brief Series]



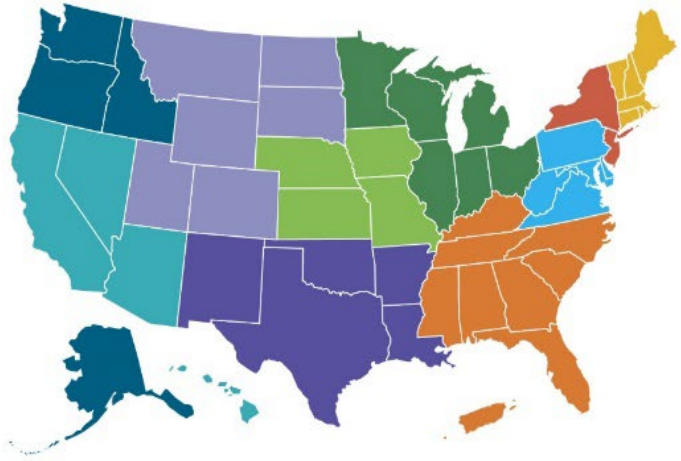
Next Steps

Resources are available at no cost to assist in developing CHP Projects at your site

Contact your CHP TAP to:

- Perform CHP Screening Technical Assistance study for a particular facility
- Identify existing CHP sites at similar facilities
- For Advanced Technical Assistance (emissions determination, life cycle cost analysis, sensitivity analysis)

DOE CHP Technical Assistance Partnerships (CHP TAPs)



Upper-West
CO, MT, ND, SD, UT, WY
www.uwchptap.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.og

Midwest
IL, IN, MI, MN, OH, WI
www.mwchptap.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefke1@uic.edu

New England
CT, MA, ME, NH, RI, VT
www.nechptap.org
David Dvorak, Ph.D., P.E.
University of Maine
207-581-2338
dvorak@maine.edu

Northwest
AK, ID, OR, WA
www.nwchptap.org
David Van Holde, P.E.
Washington State University
360-956-2071
VanHoldeD@energy.wsu.edu

New York-New Jersey
NJ, NY
www.nynjchptap.org
Tom Bourgeois
Pace University
914-422-4013
tbourgeois@law.pace.edu

Western
AZ, CA, HI, NV
www.wchptap.org
Carol Denning
Center for Sustainable Energy
530-513-2799
carol.denning@energycenter.org

Mid-Atlantic
DC, DE, MD, PA, VA, WV
www.machptap.org
Jim Freihaut, Ph.D.
The Pennsylvania State University
814-863-0083
jdf11@psu.edu

Southcentral
AR, LA, NM, OK, TX
www.scchptap.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.org

Central
IA, KS, MO, NE
www.cchptap.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefke1@uic.edu

Southeast
AL, FL, GA, KY, MS, NC, PR, SC, TN, VI
www.sechptap.org
Isaac Panzarella, P.E.
North Carolina State University
919-515-0354
ipanzarella@ncsu.edu

DOE CHP Deployment Program Contacts
www.energy.gov/CHPTAP

Robert "Bob" Schmitt
Technology Manager
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Robert.Schmitt@ee.doe.gov

Patti Garland
DOE CHP TAP Coordinator [contractor]
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Patricia.Garland@ee.doe.gov

Thank You!

Northwest CHP TAP

Gilbert McCoy, P.E., Senior Energy Systems Engineer
USDOE Northwest Combined Heat and Power Technical Assistance Partnerships

McCoyG@energy.wsu.edu
(360) 956-2086

Dave Van Holde, P.E., CEM Director
Northwest CHP TAP
VanHoldeD@energy.wsu.edu
(360) 956-2071