Webinar
March 10, 2011

CHP & Green Buildings

GULF COAST

U.S. DOE

CLEAN ENERGY APPLICATION CENTER

Krishnan Umamaheswar, LEED AP, CEM, CDSM, DGCP
U.S. DOE Gulf Coast Clean Energy Application Center

Before we begin…

- Presentation
  - Emailed to all attendees within 24 hours
  - Posted to www.gulfcoastcleanenergy.org
- Questions
  - Submit via Chat Feature
  - Answered via email
- Continuing Education Units (CEU)
  - Upon request

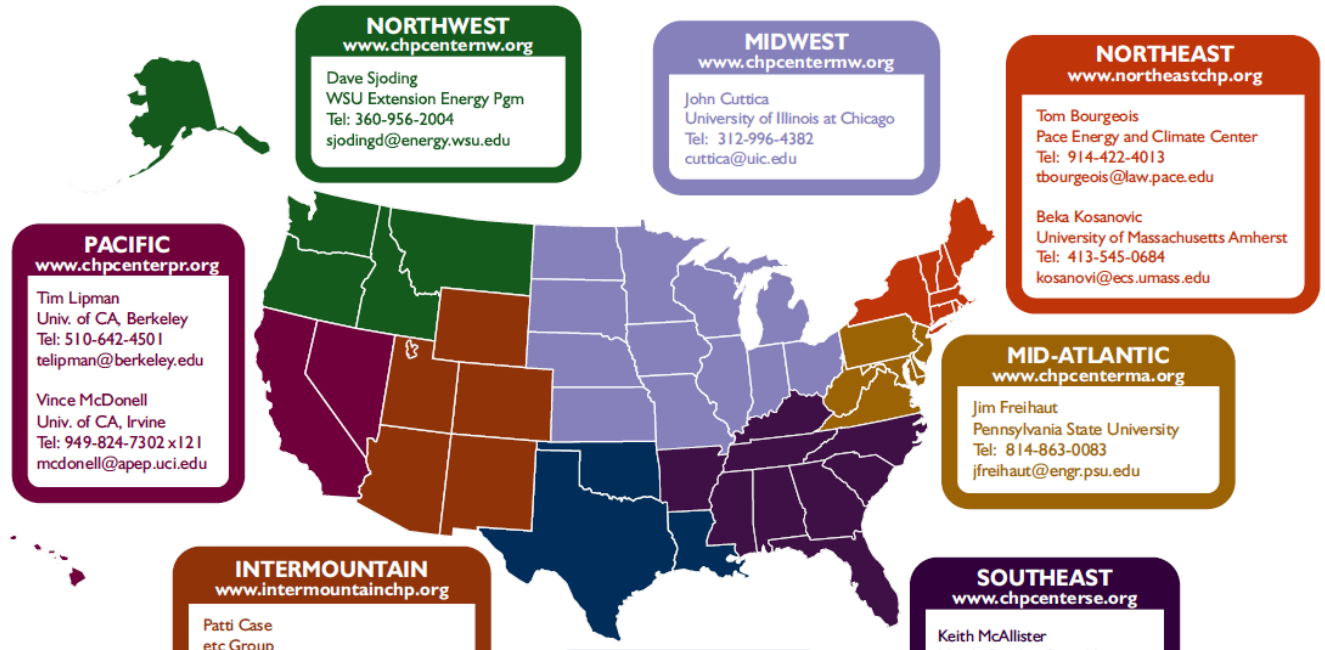
Agenda

- Background
- CHP Basics
- LEED & CHP
- Energy Star & CHP
  - Portfolio Manager
  - EPA CHP Partnership's Energy Star CHP Awards
- Renewable CHP
  - Biofuels
  - Solar

Background & Basics

Eight U.S. DOE Clean Energy Application Centers

DOE Clean Energy Application Center Locations, Contacts, and Web Sites



DOE Clean Energy Application Center Program Contacts

Ted Bronson
DOE Clean Energy Application Center Coordinator
Power Equipment Associates
Phone: 630-248-8778
E-mail: tlbronsonpea@aol.com

Bob Gemmer
Industrial Technologies Program (ITP)
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
Phone: 202-586-5885
E-mail: Bob.Gemmer@ee.doe.gov

Patti Garland
Distributed Energy/
CHP Program Manager
Oak Ridge National Laboratory
Phone: 202-586-3753
E-mail: Patricia.Garland@ee.doe.gov

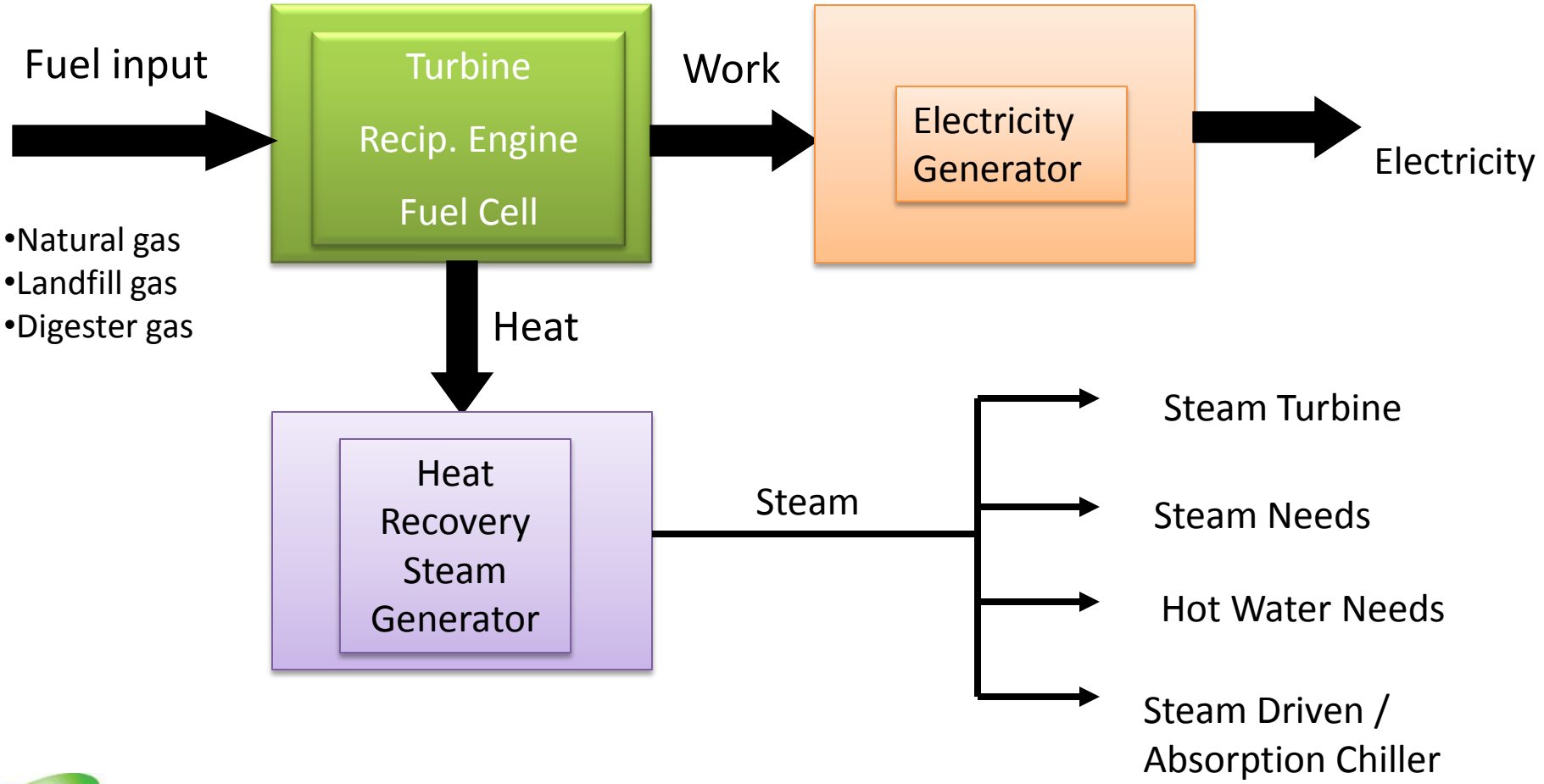
Primary Activities – Gulf Coast Application Center

- Promote CHP, Waste Heat Recovery & District Energy through
  - Education & Outreach
    - Website
    - Newsletters
    - Webinars
    - Workshops
  - Policy Initiatives
    - Educate legislators
    - Comment on dockets/rulings
    - Support TXCHPI (active CHP industry advocates in the region)
  - Project Support
    - Free or low cost CHP feasibility studies
    - Case Studies/Project profiles
    - Answer technical questions
    - Connect end-users to equipment manufacturers
    - Facilitate tours to CHP installations for prospective adopters
    - Manufacturer neutral and unbiased service

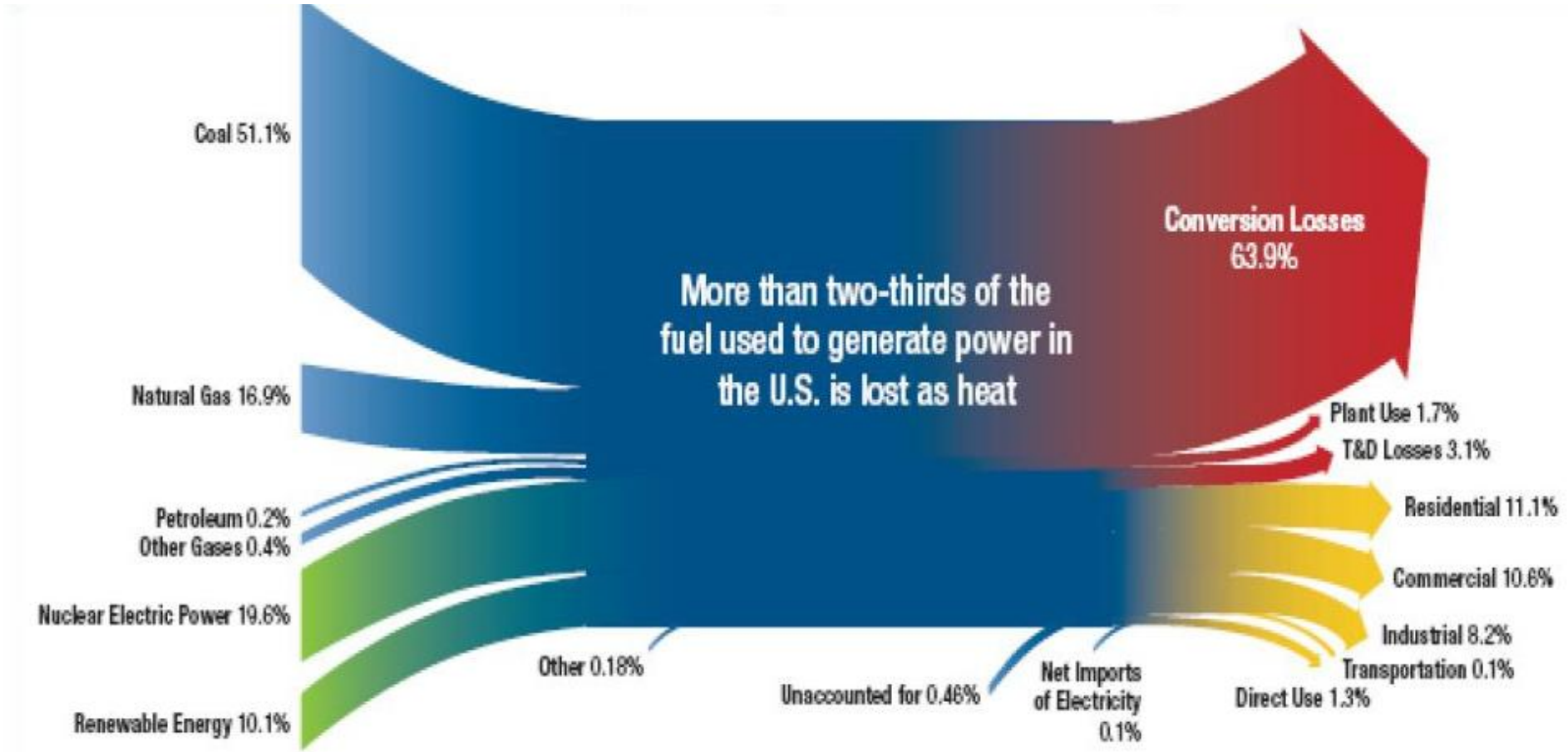
CHP is a type of DISTRIBUTED GENERATION that . . . .

- is located in close proximity to the energy consumer – building, campus or industrial
- provides at least a portion of the facility's electrical load
- captures thermal energy for use in:
  - Cooling
  - Dehumidification
  - Water and space heating
  - Process heat

CHP: Basic Components



Efficiency of the Grid



Why is CHP more efficient?

- ERCOT
  - 2010 ERCOT peak demand: ~ **69 GW**
  - 2010 ERCOT Transmission & Distribution loss: ~6% - **3.6 GW**

- CHP Systems
  - Form of distributed generation – located close proximity to building
  - Captures the waste heat
    - Energy Recycling
    - Each NG molecule used TWICE
  - Accepts diverse fuels (Natural Gas: most common)
    - Biogas, Municipal solid waste, landfill gas

CHP Efficiency cont'd

- Engine (Typical Electric Efficiency 40%)
  - 2.5 Btu fuel input
  - 1 Btu electricity output
  - ~70% of waste heat can be recovered: 1.2 Btu (Radiant loss, etc)
    - Domestic hot water
    - Space heat
    - Single effect or Exhaust driven Absorption Chiller
  - Efficiency = (1 + 1.2)/2.5 = 82%

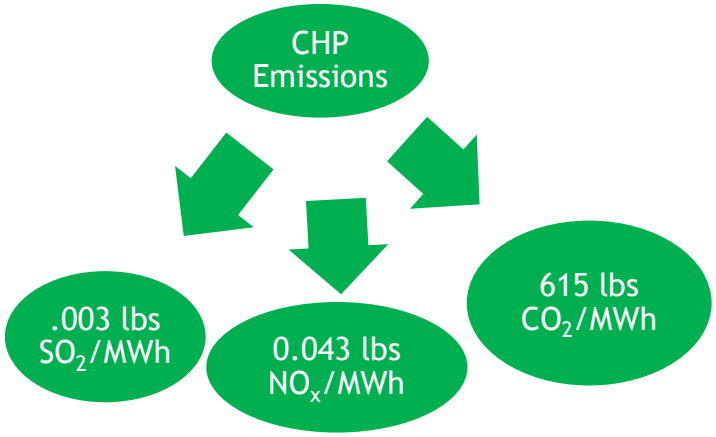
- Turbine (Typical 30% Efficiency)
  - 3 Btu fuel input
  - 1 Btu electricity output
  - 85% of waste heat can be recovered: 1.7 Btu (High Grade heat, HSRG eff)
    - Process heat loads
    - Double Effect or Steam driven Absorption Chillers
  - Efficiency = (1+1.7)/3 = 90%

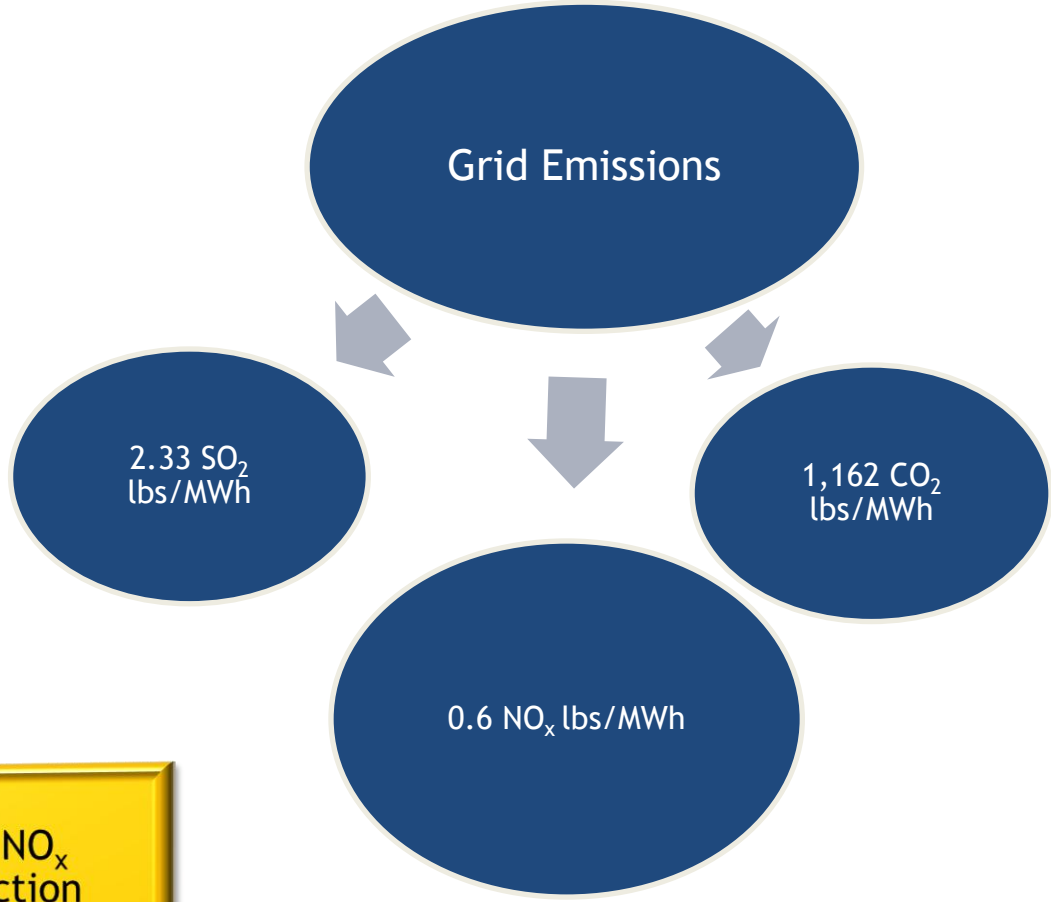
CHP Benefits

- Operates at a high efficiency
- Enhances energy security and reliability
- Reduces emissions and water use
- Increases energy choices
- Enhances power quality
- Reduces energy costs
- High Capacity Factor
  - Wind does not blow always & Sun does not shine always

•Smart, Proven & Efficient Use of Existing Fossil fuel stock
•Can be renewable

CHP & Greenhouse Gases





47 % CO_2 reduction

99 % SO_2 reduction

93% NO_x reduction

U.S. Department of Energy
Gulf Coast Clean Energy Application Center

LEED & CHP

LEED – introduction

- Developed by US Green Building Council (USGBC)
- Internationally recognized building certification system aimed at
  - Energy Savings
  - Water Efficiency
  - CO2 emissions reduction
  - Indoor air-quality
  - Stewardship of resources
  - Sensitivity of impacts of building's footprint

LEED – Variety of Rating Systems

- New Construction
- Existing Buildings
- Commercial Interiors
- Core & Shell
- Schools
- Retail
- Healthcare
- Homes
- Neighborhood

LEED - New Construction

- Components
  - Sustainable Sites : 26 points
  - Water Efficiency : 10 points
  - Energy & Atmosphere : 35 points
  - Materials & Resources : 14 points
  - Indoor Environmental Quality : 15 points
  - Innovation in Design : 6 points
  - Regional Priority : 4 points

- Ratings
  - Certified : 40 – 49 pts
  - Silver : 50 -59 pts
  - Gold : 60 -69 pts
  - Platinum : 80+ pts

Pertinence of CHP vis-a-vis LEED

- Energy & Atmosphere EA Credit 1
  - Optimized Energy Performance : Max 19 pts
  - Improved Performance over Baseline Building
  - Baseline is ANSI/ASHRAE/IESNA 90.1 - 2007

New Buildings	Existing Buildings	Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

CHP in LEED : Aug 13, 2010

- Either Monitor OR Model
- Modeling
  - Baseline Case modeled – ASHRAE 90.1 Appendix G (Performance Rating Method)
  - CHP Modeling Guidance – Treatment of District Energy in LEED v2 & LEED 2009 : Appendix D

LEED Guidelines for CHP (cont'd)

- Monitoring
  - Electric Output
    - Electric Generation
    - Parasitic Loads
  - Fuel Input
  - Waste Heat Recovered

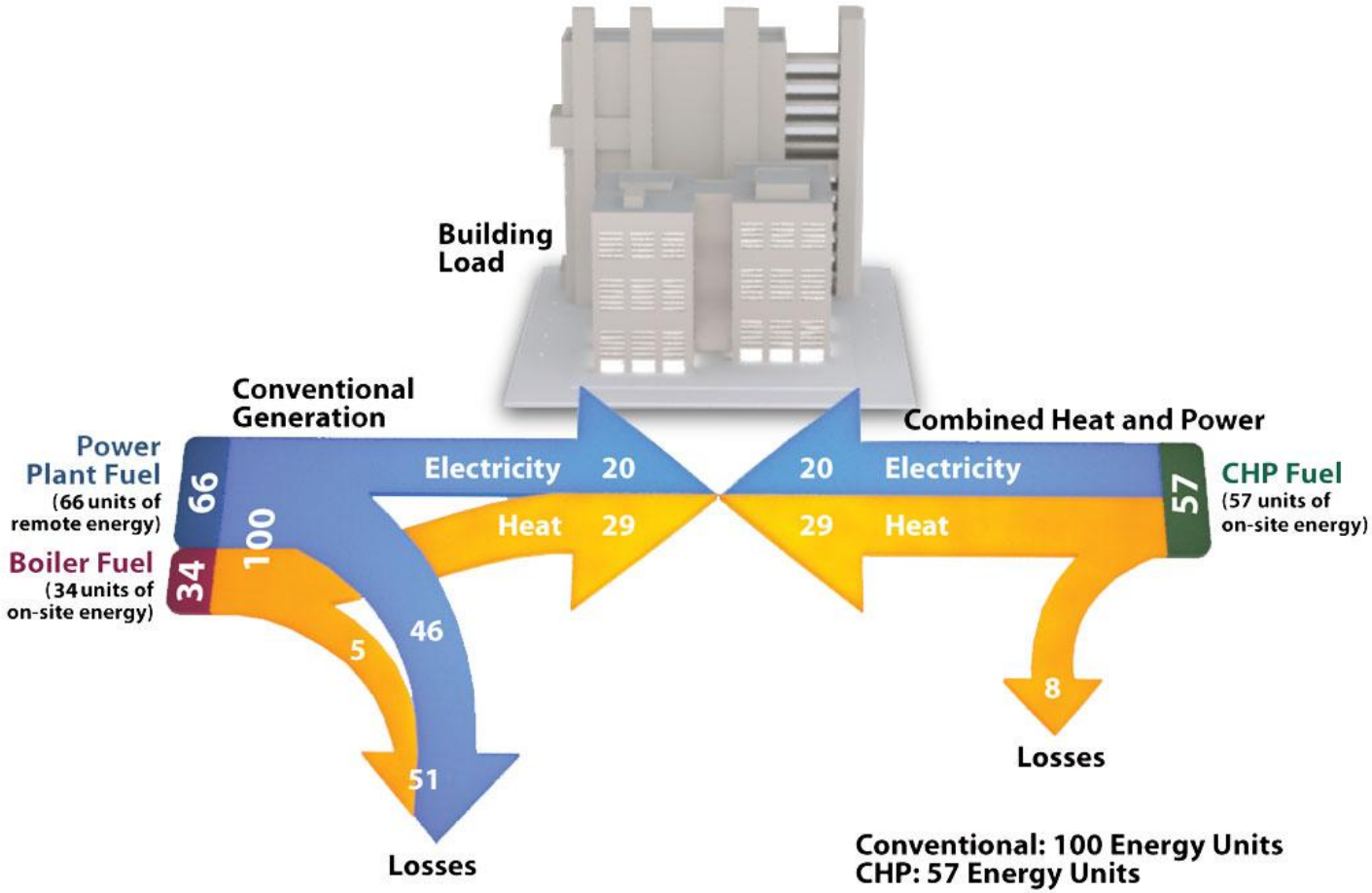
LEED Guidelines for CHP (cont'd)

- Modeling
  - Electric Output
    - Peak Electric Efficiency
    - Generator Curves
  - Fuel Input
    - Nameplate data & part load curves
  - Waste Heat Recovered
    - Nameplate capacity
    - Nameplate efficiency
    - Efficiency Curves

How do you get points??

- CHP outputs used within building
  - Input fuel charged to Design Building
  - Electricity & thermal outputs of CHP
    - Considered “free”
    - Can be subtracted
- CHP excess electricity sold to grid
  - Elec & Therm outputs consumed treated same as above
  - Excess electricity treated as “process”
  - Input fuel for **excess electricity** charged to both Design and Baseline Cases (So no Penalty!!)
  - Thermal output with this excess considered “free”

CHP Reduces Costs – key to LEED-NC EA Credit 1



LEED Consideration : Building in a Campus Setting/ District CHP System

- Bldg in a Campus CHP plant has benefits as well!

- Allocate electricity generation to the building based on
  - Fraction of the heat/cool provided by District CHP
  - Fraction of building heat/cool provided by District CHP
- Allocate fuel input to the building as a prorated amount
- Equations

$CHP_{elec} = (X_{heat} * Bldg_{heat}) * CHP_{Elec\text{-}District\ System}$

$Proposed_{BLDG\ fuel} = CHP_{elec} / CHP_{Elec\text{-}District\ System)} / CHP_{fuel}$

Energy Star & CHP

Why Energy Star for Buildings?

- Energy accounts for 1/3 of typical commercial building operating budget
- Commercial building sector spends $18 billion/yr on energy nationally
- Office Buildings
  - 1/3 of energy currently can be avoided without compromising comfort of occupant
  - Accounts for 20% of GHG emissions nationally

CHP & Energy Star

- ENERGY STAR label for Buildings
  - Given jointly by US EPA and US DOE
  - ENERGY STAR Awarded to Top 25% Energy Performers by Building Class Each Year (Portfolio Manager Score of 75 or above for 12-month period)
  - Onsite Cogeneration can increase a building's ENERGY STAR significantly (10 – 20 points) depending upon the overall system efficiency

- ENERGY STAR CHP Awards
  - Given by **US EPA CHP Partnership** to buildings with qualifying CHP Systems (after 5,000 hours ops)
  - Program Distinct from ENERGY STAR for Buildings
  - Separate Application, Does Not Involve Portfolio Manager Score

Energy Star Portfolio Manager

- Since 1999 U.S. EPA provided a means to benchmark energy performance with Energy Performance Rating System
- Normalizes variables affecting building energy consumption
  - Heating Degree and Cooling Degree Days (climatic effects)
  - Hours of operation
  - Occupant density
  - PCs/occupant
- Portfolio Manager is an online software tool that rates a building based on standardized statistical models to compare “similar buildings”
- Based on physical and operating characteristics (e.g. square footage, occupants, operating hours, PCs, etc.)
- Must be completed by a Professional Engineer

Energy Star for Buildings – Source Energy

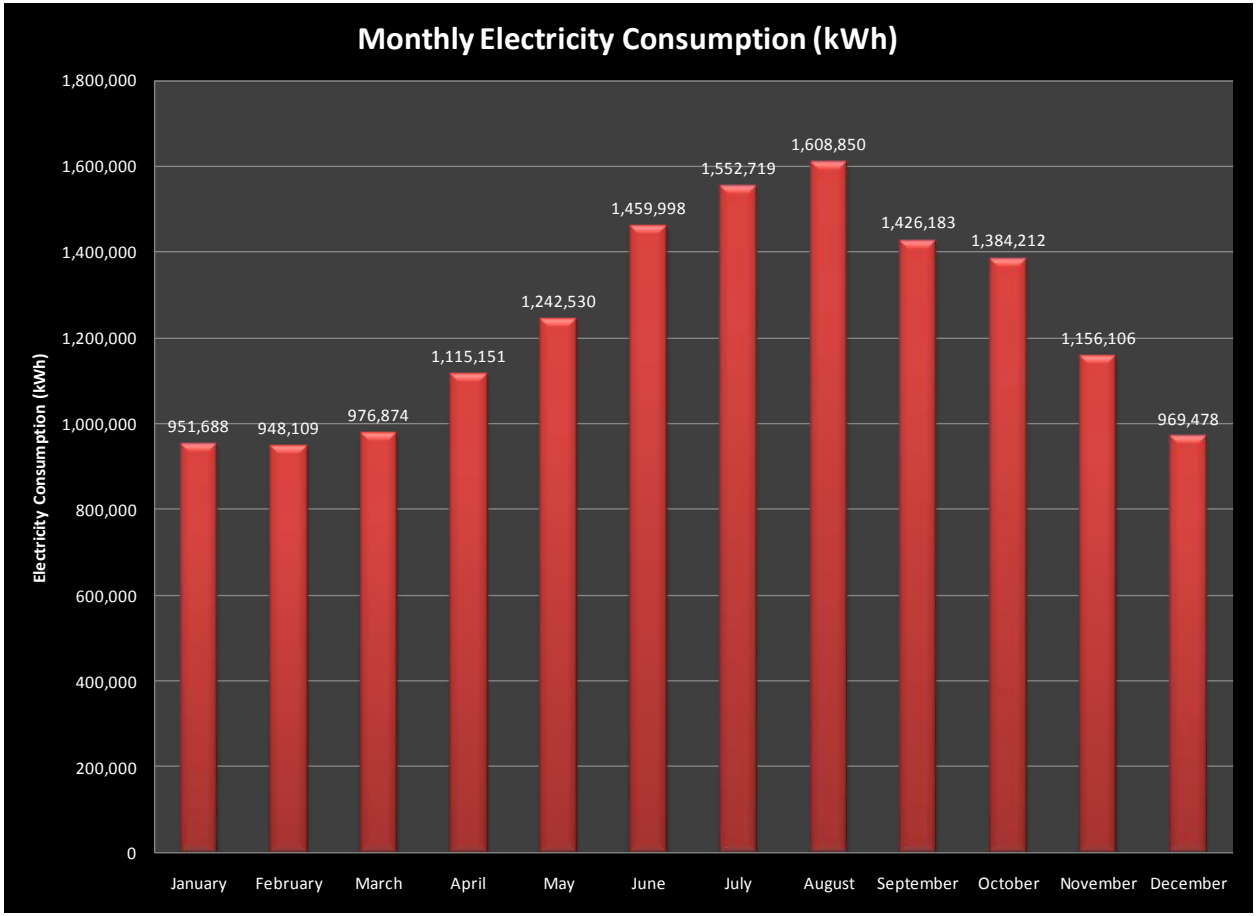
- ENERGY STAR divides building energy use into two categories
  - **Primary energy:**
    Raw fuel burned at the site to create – (e.g. natural gas)
  - **Secondary energy:**
    Created from burning a raw fuel at a remote site for delivery to a building (e.g. electricity,

Fuel Type	Source-Site Ratio
Electricity	3.34
Natural Gas	1.047
Fuel Oil	1.01
Propane	1.01
Steam	1.45
Hot Water	1.35
Chilled Water	1.05

Case Study : Hotel

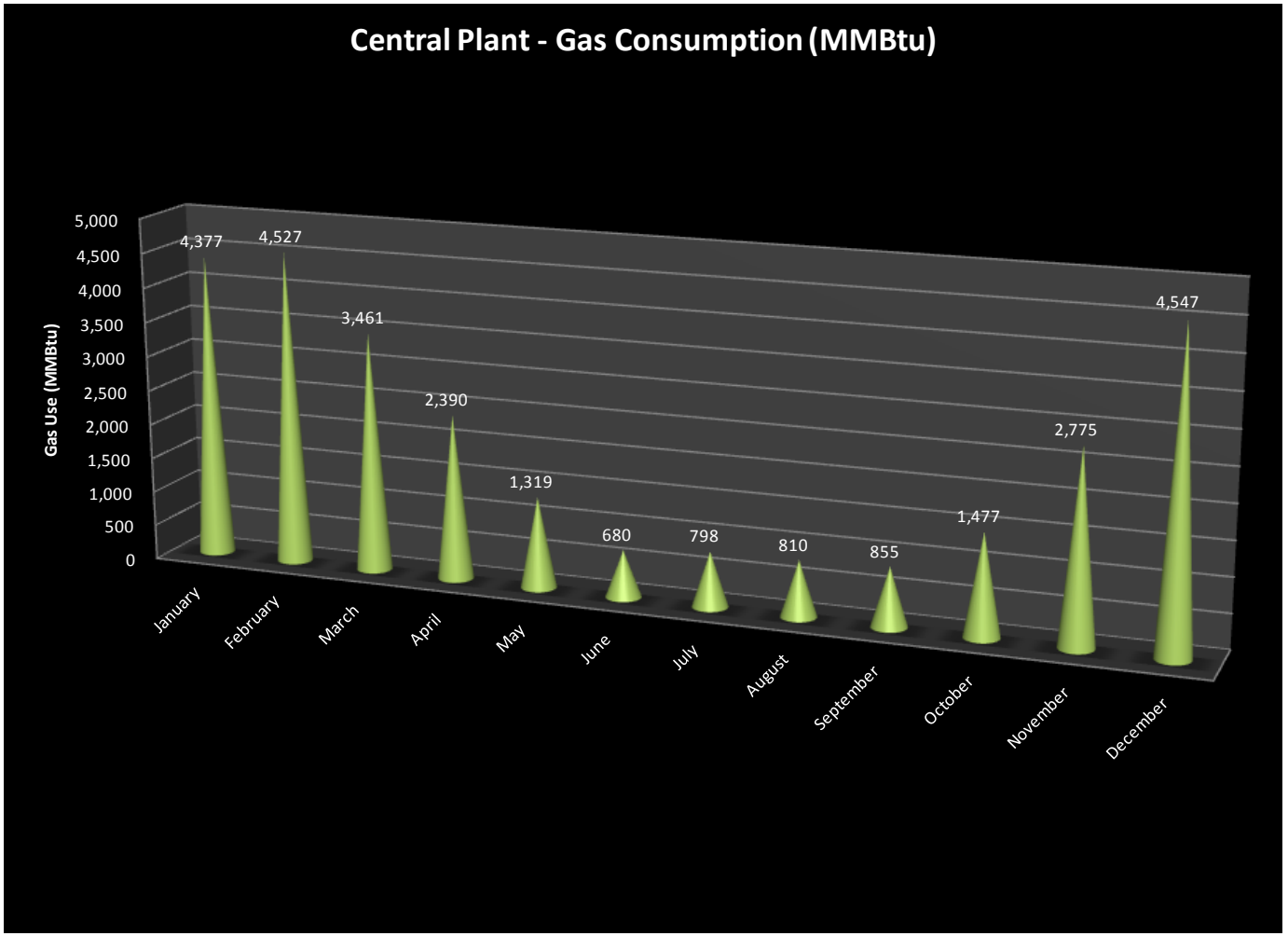
- Located in Houston
- Space
  - Guestrooms
  - Meeting Rooms
  - Restaurant
  - Function Space
- ~1.6 million square feet
- Year Built : 1970
- Commercial Refrigerators : 4

Hotel – Monthly Electricity Consumption

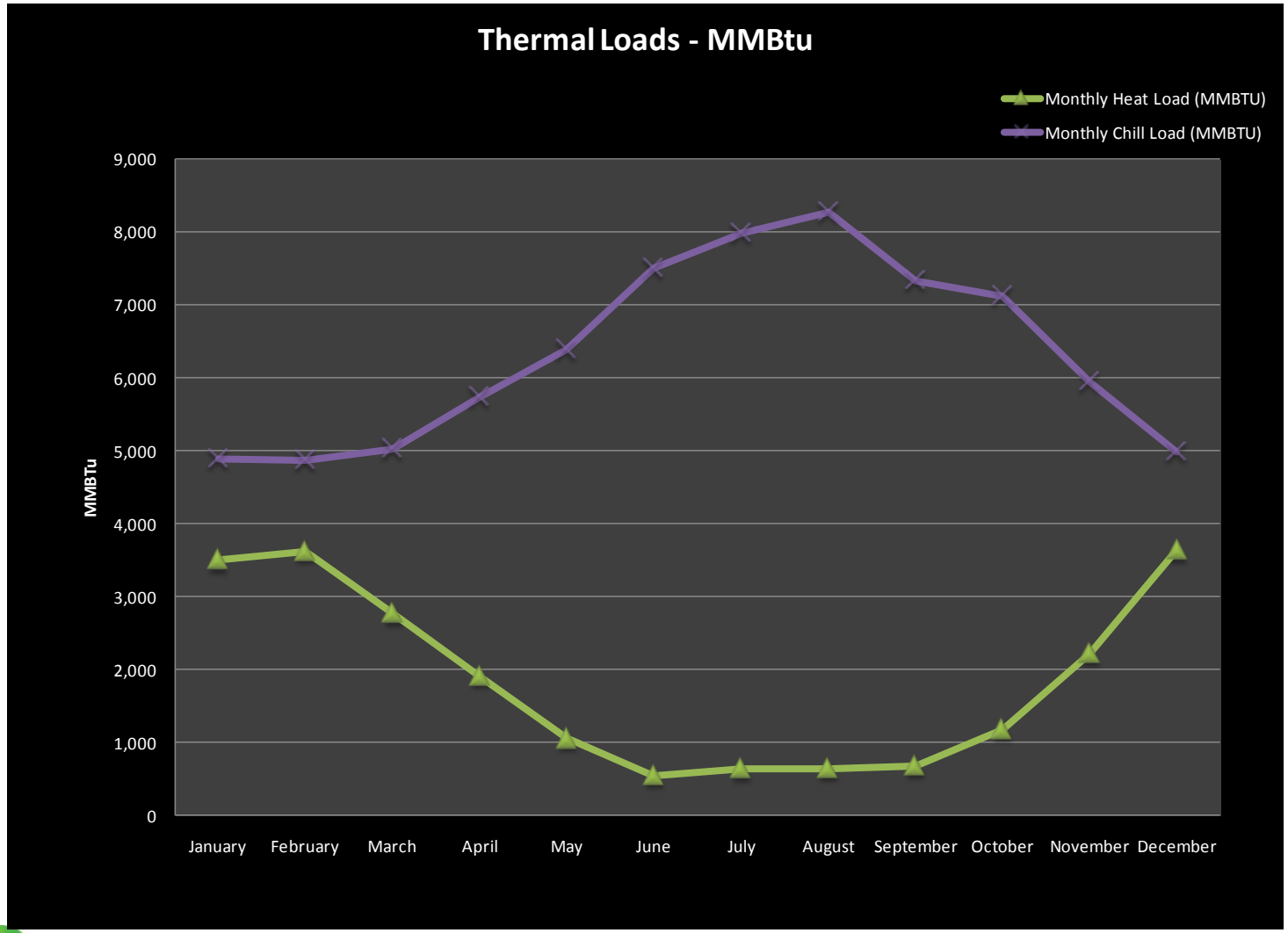


U.S. Department of Energy
Gulf Coast Clean Energy Application Center

Hotel – Monthly Gas Use



Hotel – Monthly Thermal Loads



Comparison in Energy Star Portfolio Manager

- Without CHP → Case 1
  - Grid Electricity
  - Onsite Boilers
- With CHP → Case 2
  - A 2,000 kW reciprocating engine (natural gas)
  - Heat recovery hot water generator and
  - 420 ton exhaust fired absorption chiller.

Energy Star Portfolio Manager Results

Without CHP

- Site Energy Intensity
  - 49.2 kBtu/sq feet
- Source Energy Intensity
  - 123.8 kBtu/sq feet
- Energy Star Rating
  - 62
- Eligible for Energy Star?
  - NO

With CHP

- Site Energy Intensity
  - 87.1 kBtu/sq feet
- Source Energy Intensity
  - 91.2 kBtu/sq feet
- Energy Star Rating
  - 86
- Eligible for Energy Star?
  - YES

Energy Star Rating & LEED EB

- LEED EB – Operations & Maintenance
  - EA Credit 1 : Optimized Energy Performance
  - Maximum of 18 points

Energy Star Rating	LEED-EB Points
71	1
73	2
74	3
75	4
76	5
77	6
78	7
79	8
80	9
81	10
82	11
83	12
85	**13**
87	**14**
89	15
91	16
93	17
95	18

ENERGY STAR CHP Awards

- The **ENERGY STAR CHP Award** recognizes highly efficient CHP systems that reduce emissions and use at least 5% less fuel than comparable, state-of-the-art, separate heat and power generation.

- To be considered for an ENERGY STAR CHP Award, a CHP system must:
  - Be in commercial operation.
  - Be affiliated with at least one CHP Partner.
  - Have a minimum of 12 months and 5,000 hours of measured operating data. (Because awards recognize contemporary performance, the operating period covered by the submitted data must begin within 14 months prior to the date of application.)
  - Be operating within the emission limits stipulated in their permits.

2010 ENERGY STAR CHP Awards

- EPA was pleased to present seven ENERGY STAR CHP Awards in 2010.

- Awarded CHP systems ranged from a 0.17 kW biogas-fired system at a wastewater treatment plant to a 30 MW system at a major U.S. university.

- One award was given to a waste heat recovery CHP system at a petroleum coke production facility that produces 5 MW and 450,000 pounds of steam per hour for a nearby petroleum refinery.

University of Massachusetts Amherst CHP System

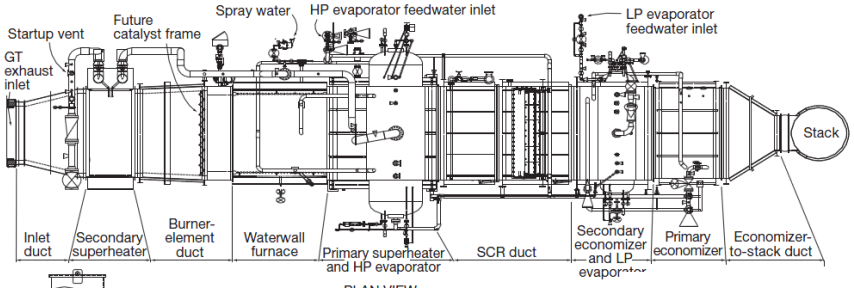
- **Prime mover :** 10 MW combustion turbine (operates in conjunction with a heat recovery steam generator, a steam turbine and three natural gas-fired boilers) - Replaces 80 yr-old coal-fired boilers
- **Total generating capacity:** 14 MW
- **Efficiency:** Nearly 75%
- **Fuel savings:** Uses 18% less fuel than typical separate production of thermal energy and electricity
- **CO2 emission reductions:** ~26,600 tons per year
- CHP system meets nearly all of the electric and steam demand for a campus comprising over 200 buildings and 10 million gross ft^2 of building space.
- Instead of using potable water to generate steam, plants use 60,000 gallons per day of treated effluent from the local WWTP.

University of Massachusetts Amherst CHP System

Cornell University CHP System

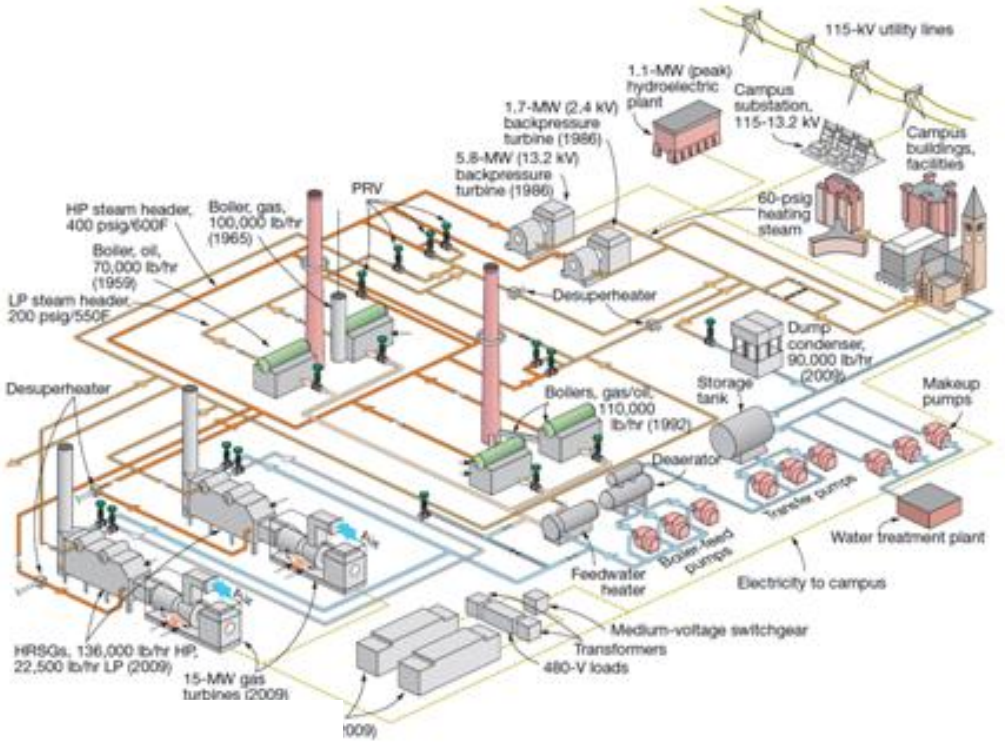
- **Prime mover:** Two 15 MW combustion turbines (operates in conjunction with two boilers and two backpressure steam turbines)
- **Total generating capacity:** 37 MW
- **Efficiency:** Nearly 79%
- **Fuel savings:** Uses 29% less fuel than typical separate production of thermal energy and electricity
- **CO2 emission reductions:** ~89,300 tons per year
- Provides nearly all of the University's 31,000 faculty, staff and students with electricity.
- The combined effect of the new CHP system and other energy modernization activities will allow the permanent retirement of two coal boilers in 2011.

Cornell University CHP System



15 MW gas turbine schematic

CHP system equipment network



National Institutes of Health CHP System

- **Prime mover:** 23 MW natural gas fired combustion turbine (operates in conjunction with a heat recovery steam generator)
- **Efficiency:** Over 76%
- **Fuel savings:** Uses 31% less fuel than typical separate production of thermal energy and electricity
- **CO2 emission reductions:** 51,400 tons per year
- CHP system produces 180,000 pounds per hour of steam that is used to provide space heating, space cooling, and support laboratory operations in its 75-building, 300-acre main campus in Bethesda, Maryland
- One of the largest U.S. government CHP systems
- Annual savings of over $4 million

National Institutes of Health CHP System

CHP plant facing east, looking down on combustion turbine package from heat recovery steam generator.

The CHP Plant only occupies a portion of the complex shown here. Two giant header pipes carry steam into the plant for distribution across the campus.

EPA CHP Partnership Resources

- Website → http://www.epa.gov/chp/
  - Wealth of CHP information, case studies, etc
  - CHP Emissions Calculator
  - EPA Energy Star CHP Award information
- Contacts
  - Neeharika Naik-Dhungel (naik-dhungel.neeharika@epa.gov)
  - Gary McNeil (mcneil.gary@epa.gov)
  - Helpline : (703) 373 - 8108

Renewable CHP

LEED NC Onsite Renewables – EA Credit 2

Percentage	Renewable Energy Points
1%	1
3%	2
5%	3
7%	4
9%	5
11%	6
13%	7

+

LEED NC Green Power – EA Credit 6 : 2 points

Biofuels/Opportunity Fuels

- Biomass
  - Wood wastes
  - Rice hulls
  - Sawdust
  - Agricultural wastes
- Landfill Gas
  - Municipal Solid Waste
- Digester Gas (Anaerobic Digestion)
  - Sewage
  - Wet organic matter
- Syn Gas (Gasification)
  - Dry organic matter

Biofuels & CHP

- Biomass
  - Can be combusted in a boiler – Produce Electricity and/or heat
  - Gasified to fuel a CHP system
- Bio-gases (landfill, digester & syn gas)
  - Captured & combusted in CHP system

- <u>RECENT Texas project</u>
  - City of Dallas Southside Wastewater treatment facility
  - Biogas Project: 4.3 MW
  - Electricity serves plant and hot water captured to heat digesters
  - Savings of $900,000 annually
  - Generation of 30,000 REC's per year

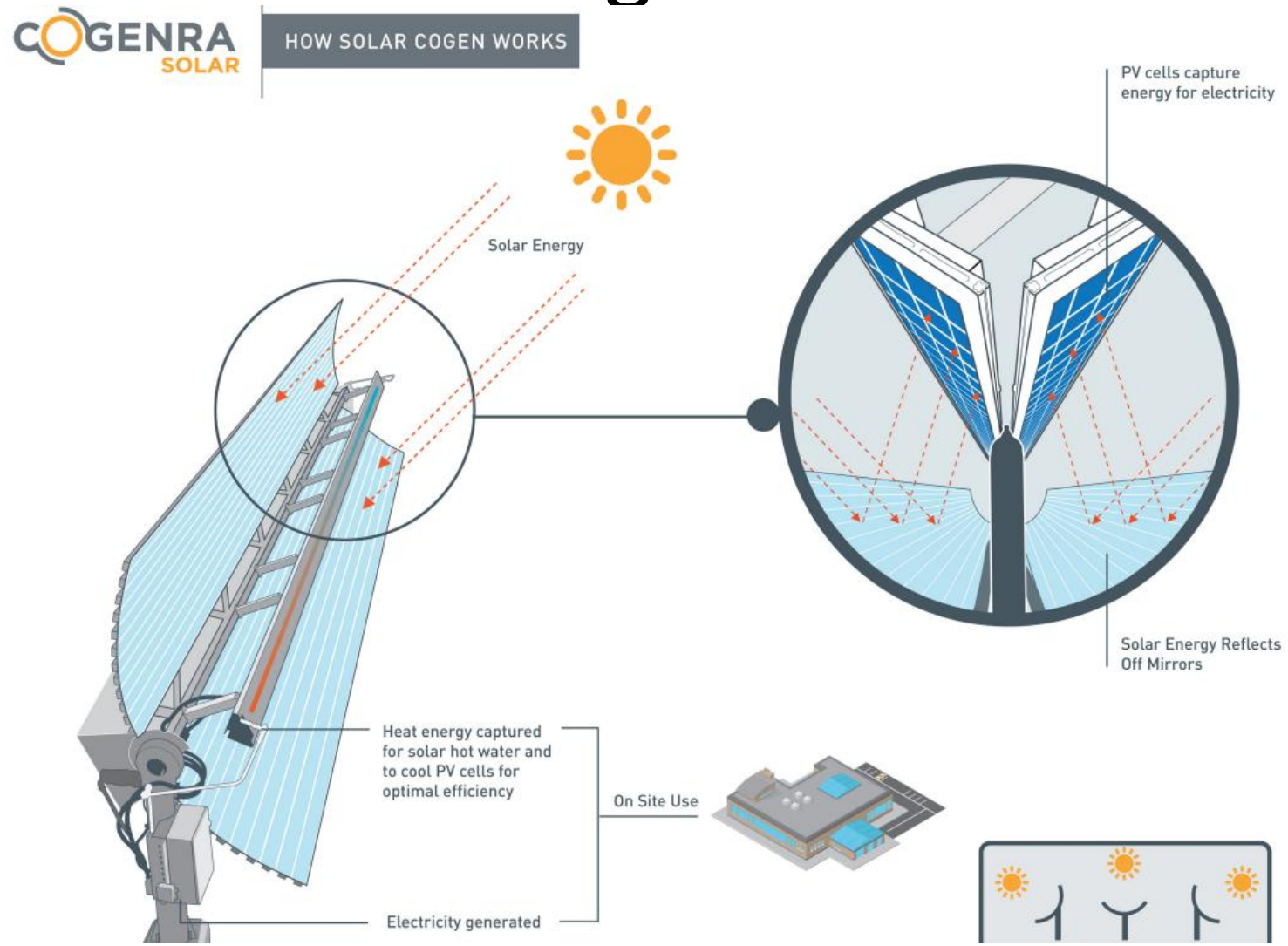
Solar CHP

- Traditional PV converts 16% of sun's energy to usable electricity

- Solar CHP
  - Captures waste heat and converts to hot water
  - Helps in cooling PV components
  - Enhances Efficiency
  - Boosts electricity generation
  - Claimed Efficiency – upto 80%

- Manufacturers
  - Cogenra Solar
  - Zenith Solar
  - More…

Solar CHP - Diagram



U.S. Department of Energy
Gulf Coast Clean Energy Application Center

Source : Cogenra Solar

Contact

Dan Bullock, *MS, MPAff*
Director
281-364-6087
dbullock@harc.edu

Ross Tomlin, *MPAff*
Clean Energy Policy
281-363-7922
rtomlin@harc.edu

Krishnan Umamaheswar, *LEED^{AP}, CEM, CDSM, DGCP*
Project Support
281-363-7906
ukrishnan@harc.edu

Ginny Jahn
Administrative Support
281-364-6051
gjahn@harc.edu

Upcoming Webinars - March

Prime Mover Technologies for CHP
Tues., Mar. 15; 2:00-3:00 p.m.
Speaker: *Krishnan Umamaheswar, GC RAC*

Waste Heat Recovery using Organic Rankine Cycle
Thurs., March 24; 10:00-11:00 a.m.
Guest Speaker: *Colin Duncan, Ormat Technologies*

Financing CHP Projects
Wed., March 30; 10:00-11:00 a.m.
Guest speaker: *John May, Stern Brothers*