WEBINAR
June 30, 2011

USING & MEASURING THE CHP ADVANTAGE

Guest Speaker: Tommy John

GULF COAST
U.S. DOE
CLEAN ENERGY APPLICATION CENTER

Krishnan Umamaheswar
U.S. DOE Gulf Coast Clean Energy Application Center

Before we start…

Presentation

E-mailed to all attendees within 24 hours

Posted to www.GulfCoastCleanEnergy.org

Questions

Submit via chat feature

Answered offline, emailed and posted

Continuing Education Units (CEU)

Available upon request

About Us

Develop regional strategies to support:

Combined Heat and Power

Waste Heat Recovery

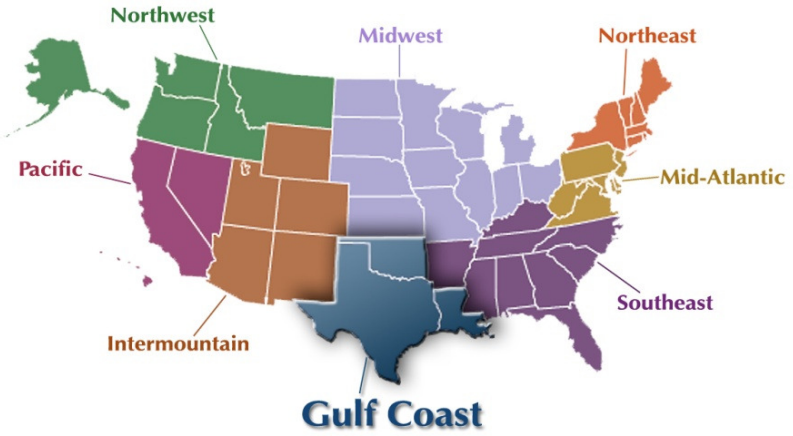
District Energy

1) Education and Outreach
Website, workshops, webinars

2) Policy Development Initiatives
Legislative and regulatory issues

3) Project Specific Support
Audits, feasibility studies, assistance

Clean Energy Application Centers:



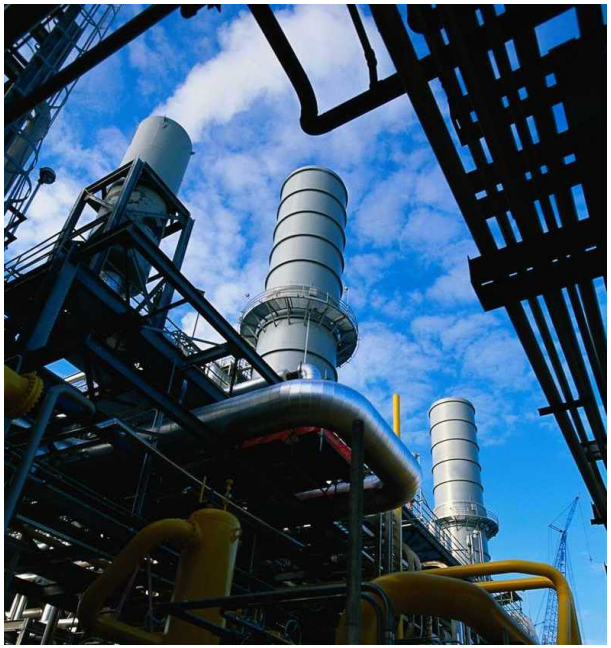
Partners:

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

TX CHPI

HARC

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



Using and Measuring the CHP Advantage

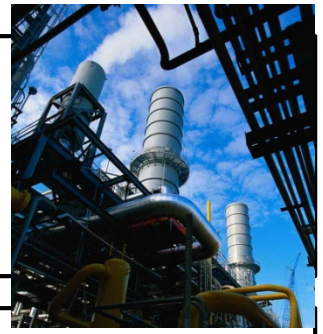
June 30, 2011

Tommy John tjohn@indian-creek.net 830-796-7574

Using and Measuring the CHP Advantage

- CHP Benefits
- Efficiency
  - Power Plants
  - Combined Heat & Power
  - Combined Cooling & Power
- Biomass CHP
- Paradigms & Conclusions

Combined Heat & Power (CHP)



- Two outputs (heat and electricity) in any sequence
  - Topping cycle most common
  - Bottoming cycle converts waste heat to power
- Also called Cogeneration
- Can use many fuels
- Minimizes heat rejection to atmosphere
- Important for the process industries
- 15 to 20% of generating capacity in Louisiana & Texas

Energy Conservation Steps

COMBINED HEAT & POWER

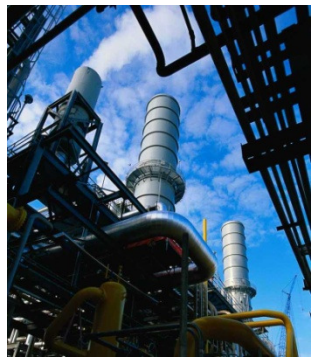
UTILITIES

CONTROLS

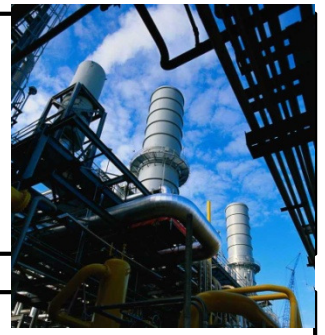
INTEGRATION

EQUIPMENT

PROCESS



CHP Benefits

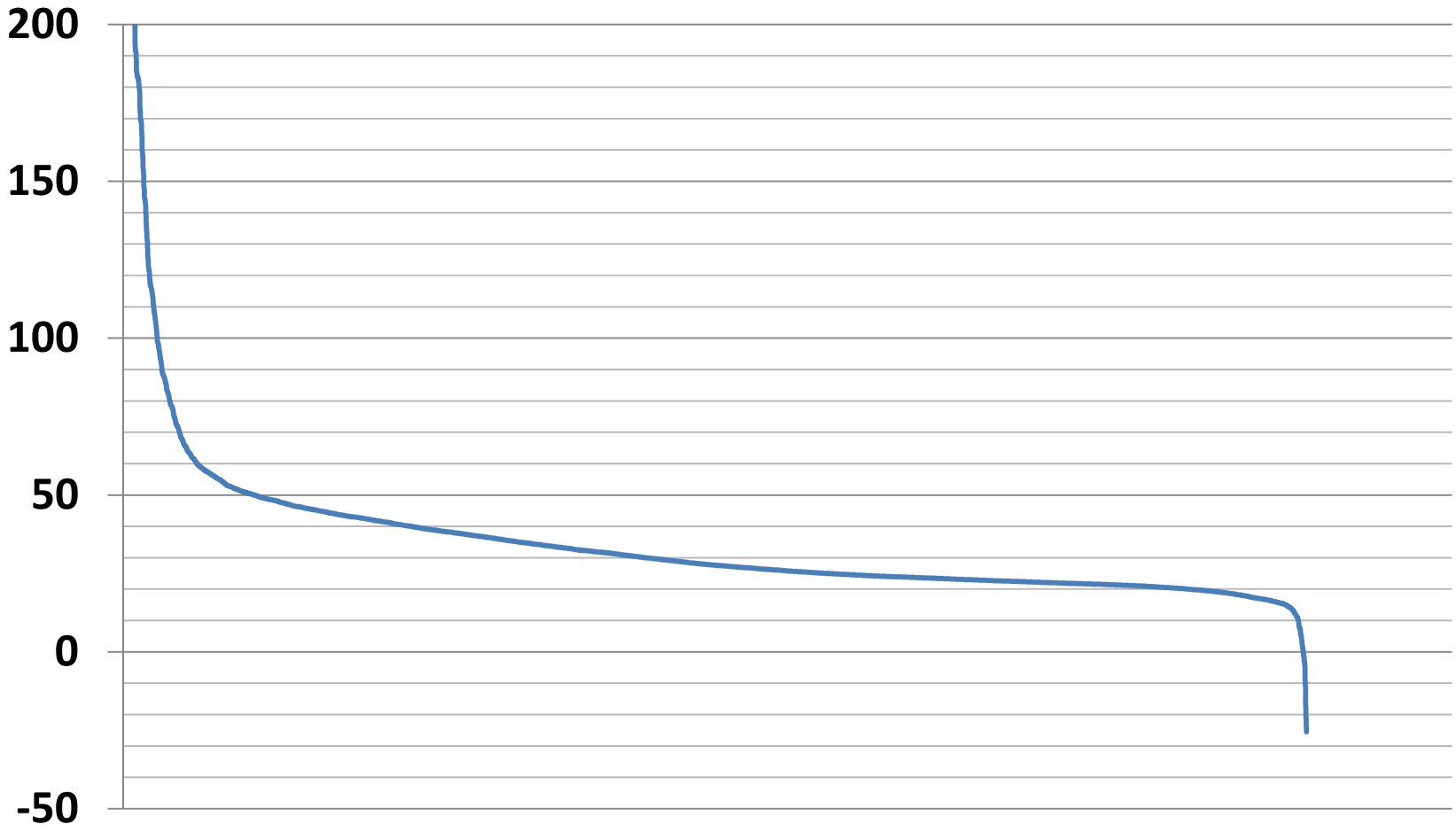


- Aggressive energy conservation program can save 10 to 40%.
- Adding CHP can save up to 3 times as much energy considering grid savings.
- Improves reliability (energy security)
- Reduces emissions.
- Saves water.
- Reduces costs (economic stability)

Typical Process Enterprise

- Thermal generation
  - Boiler, heater, dryer
  - Fuel: natural gas, propane, process fuel
- Purchase power
  - Open (Restructured) market
  - Regulated utility
    - IOU
    - Municipal
    - Coop or other entity

2010 ERCOT Hourly Market Clearing Price
Houston Zone $/MWH



Power Plant Efficiency

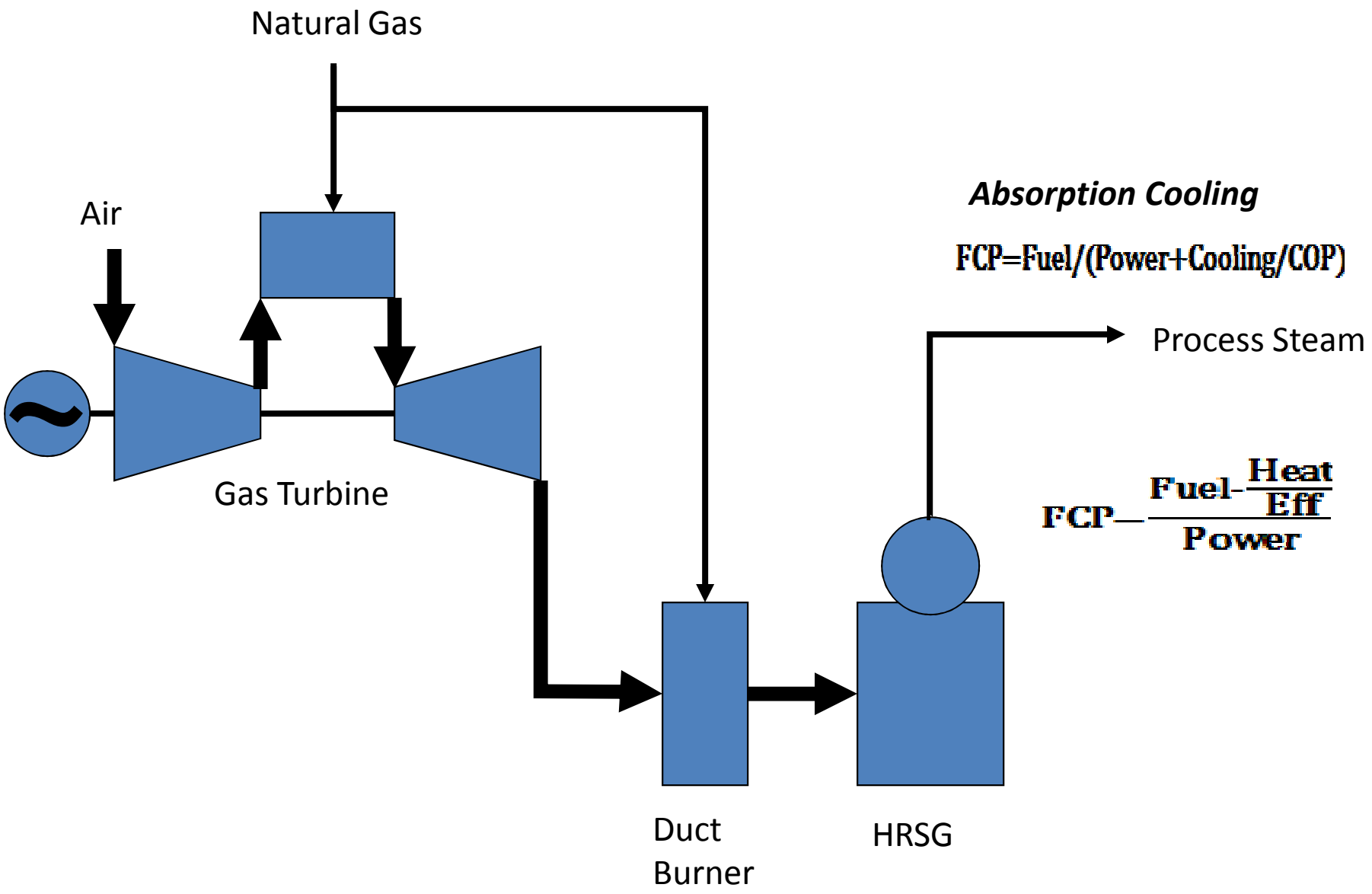
- Heat Rate, Btu/kwh Higher Heating Value (HHV)
  - Efficiency= 3412/ Heat rate
  - Natural Gas Higher Heating Value= 1.11 X LHV
  - HHV/LHV increases with Hydrogen content of fuel
  - Turbine and engine specifications often use LHV
- Heat Rate net of auxiliary load & generator losses

CHP Efficiency

- CHP Eff. or Total System Eff.
  = (Net Power+Thermal)/Fuel
- PURPA Efficiency
  (Power + 0.5*Thermal)/Fuel $\geq$ 42.5 %

- Fuel Charged to Power (FCP) or Effective Electrical Efficiency
  = Net Fuel/ Power
- Distributed Generation and Combined Heat and Power Field Testing Protocol ; Association of State Energy Research and Technology Transfer Institutions
  http://www.dgdata.org/pdfs/field_protocol_nov08.pdf

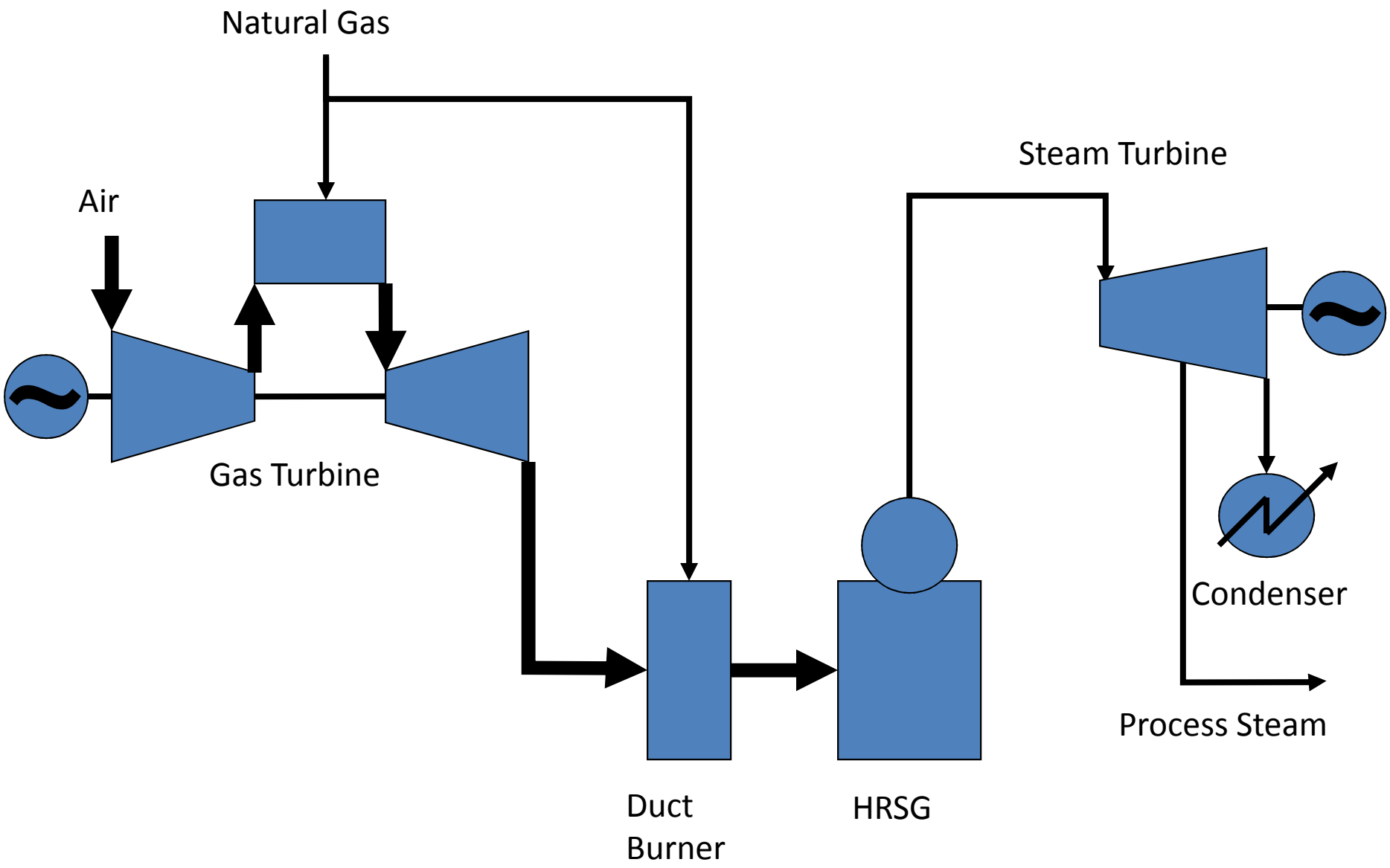
Gas Turbine CHP



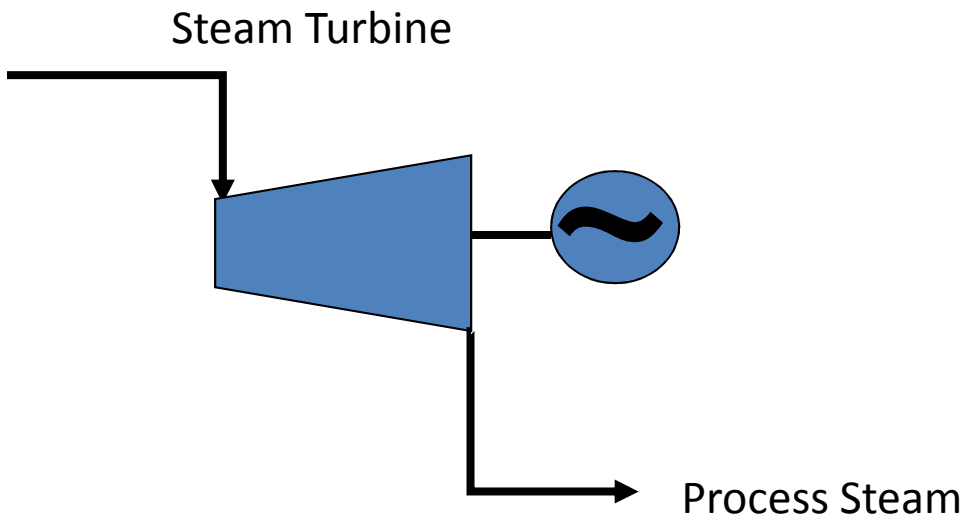
Combined Cooling & Power

- Absorption Cooling
  - FCP=Fuel/(Power+Cooling/COP)
  - COP= Cooling Output/ Energy Input
    - Single Effect Absorption = 0.7
    - Double Effect Absorption = 1.4
    - High Eff. Water Cooled Electric Centrifugal= 7.8
  - High Auxiliary Load
    - Cooling Tower
- Condensing Steam Turb Centrifugal
- Beneficial for Critical Infrastructure

Combined Cycle CHP



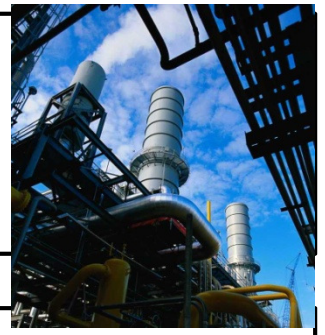
Back Pressure Steam Turbine



FCP=3412/Blr Eff/Gen Eff

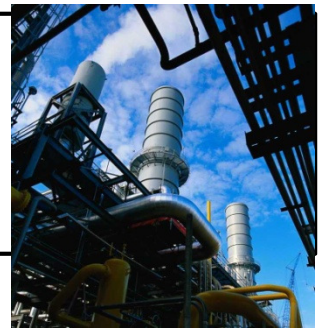
Natural Gas Heat Rate

BTU/KWH (HHV)



• Steam Plants & Peakers	9,500 – 15,000
• GE LMS 100 Simple Cycle	8,500
• Combined Cycle (F-Class)	6,900
• Combined Cycle (H-Class)	6,300
• Gas Turbine CHP (FCP)	4,300
• Gas Engine Jacket Water CHP (FCP)	3,900
• Gas Engine/Turbine TAC (FCP)	9,600-14,500

Representative Baseload Power Costs
(Not including incentives or emissions)



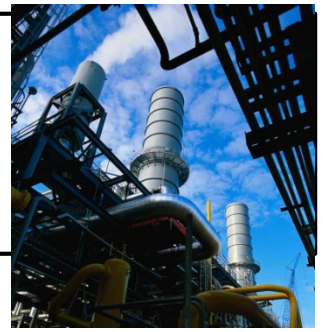
Fixed Charge Rate	15%
Line Loss	7%

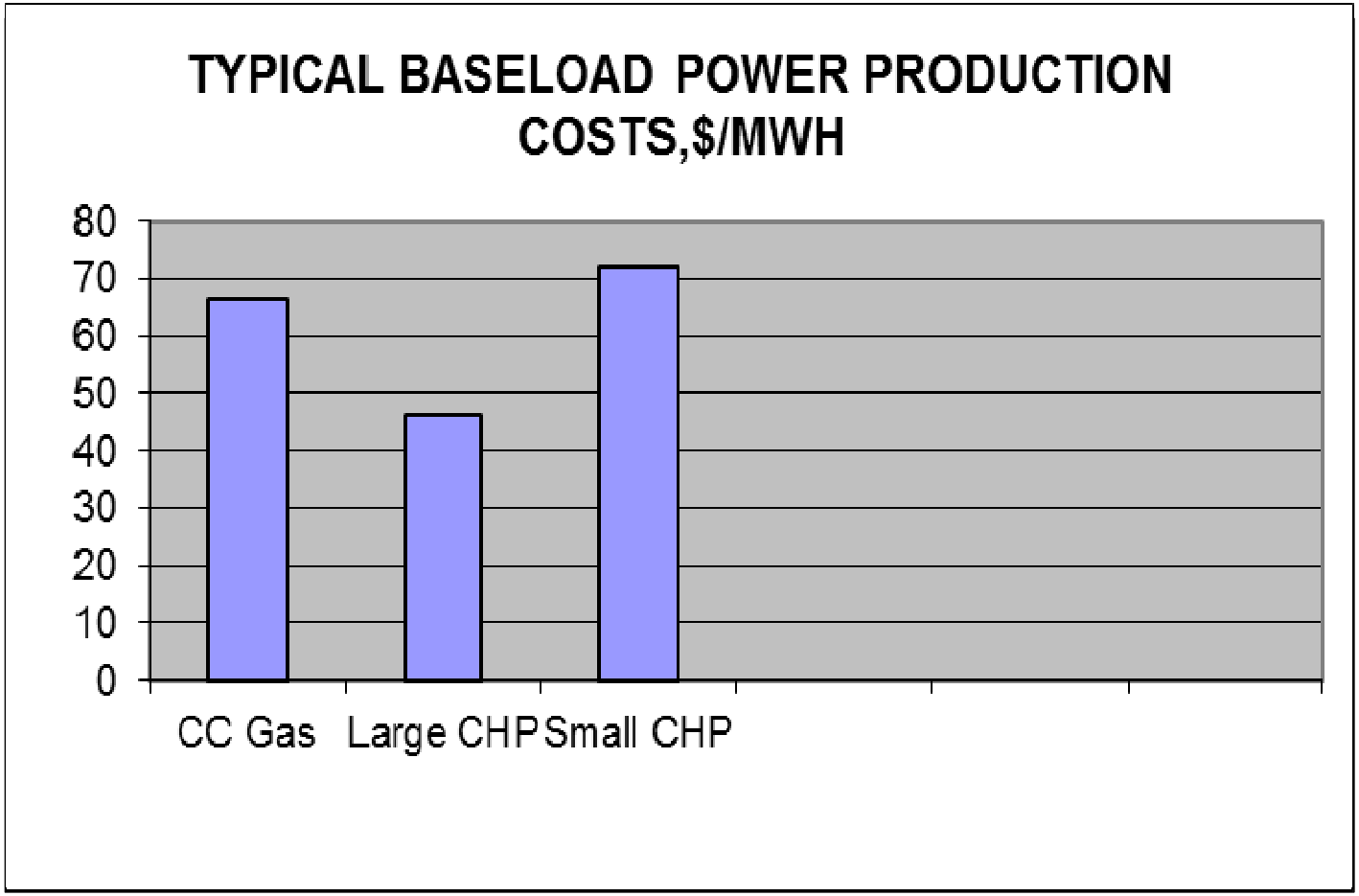
	CC Gas	Large CHP	Small CHP
Unit Cost,$/kw	950	900	2000
Heat Rate, Btu/kwh	6750	4200	4200
Fuel,$/MMBtu	5.00	5.00	5.50
O&M,$/kwh	0.011	0.009	0.013
Capacity Factor,%	95%	95%	95%

TYPICAL POWER PRODUCTION COSTS,$/MWH

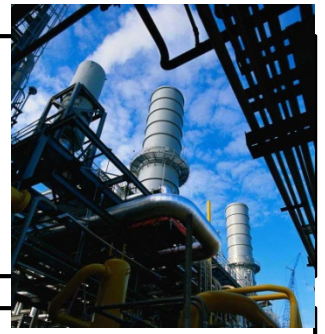
Capital	17	16	36
Fuel	34	21	23
O&M	11	9	13
Generating Cost	62	46	72
Line Loss	4	0	0
Total	66	46	72

Representative Baseload Power Costs
(Not including incentives or emissions)





NGL Fractionation Plant CHP



- Combustion Turbine Power Output, 14 MW
- Steam Output, 260 kpph of 450 psig , 635 F
- Supplemental Firing above 2700 F
- Fuel Charged to Power 3672 Btu/kwh

Design for Maximum Combustion Turbine Power

- Combustion Turbine Power Output, 60 MW
- Capital Cost 2.5X, ROI Higher
- Additional Fuel Savings 1.6TBtu/yr, $8 million @ $5/MMBtu
- Additional CO_2 reduction 93,000 tons per year

Biomass Steam Turbine CHP

CASE STUDY
BIOMASS STEAM POWER PLANT

Biomass Fuel Consumption	100,000 tpy (dry)
Capacity Factor	85%
Biomass Heating Value (LHV)	7,866 Btu/lb
Steam Conditions	850 psig,800^{o}F
Steam Generation	116,000 pph
Boiler Efficiency	73%
Biomass	$2.9/MMBtu
Natural Gas	
–Cost	$5/MMBtu
–Combined cycle heat rate	6,750 Btu/kwh
–Boiler efficiency	83%
Renewble Energy Credit (REC)	$10/MWH
Power Credit	$66/MWH

CASE STUDY
BIOMASS POWER PLANT

	POWER ONLY	CHP
Net Power, KW	10,370	4,358
Exh Pressure, psia	1.0	165
Heat Rate/FCP, Btu/kwh	20,302	4,817
Thermal Energy, MMBtu/Hr	0.0	149
Water Use, mmgpy	107	-
Nat Gas Saved, mmcf/Yr	520	1283
Nat Gas Saved, $mm/Yr	2.7	6.7
Rec Value, $mm/Yr	0.9	0.3
Power Revenue, $mm/Yr	5.8	2.4
Thermal Revenue, $mm/Yr	0.0	7.8
EBITDA, $mm/yr	0.2	4.1
Payout, Years	48.3	2.1

Conversion Efficiency
(HHV)

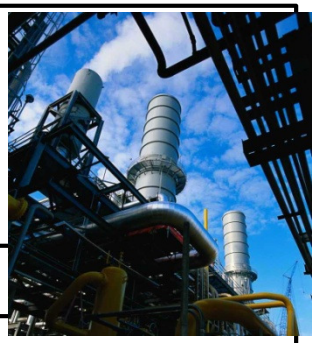
Power Generation

• Steam Plants & Peakers	23% to 36%	9,500-15,000
• Combined Cycle (F & G Class)	49% to 54%	6300-6900
• Biomass Steam Plant	17%	20,000
• Natural Gas Turbine CHP (FCP)	79%	4320
• Biomass CHP (FCP)	70%	4874

Boilers & Heaters

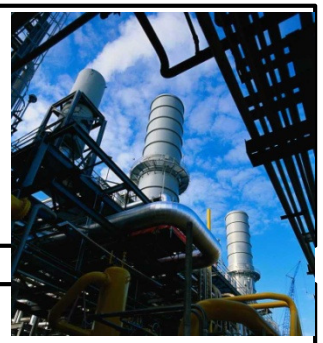
• Natural Gas	84%
• Biomass	75%

Cogeneration Paradigms



- Reduce thermal energy use and temperature
- Size system to match reduced thermal load
- Maximize heat recovery
- Maximize efficient power output
- Design for flexibility
- Maximize unit size
- Utilize available fuel

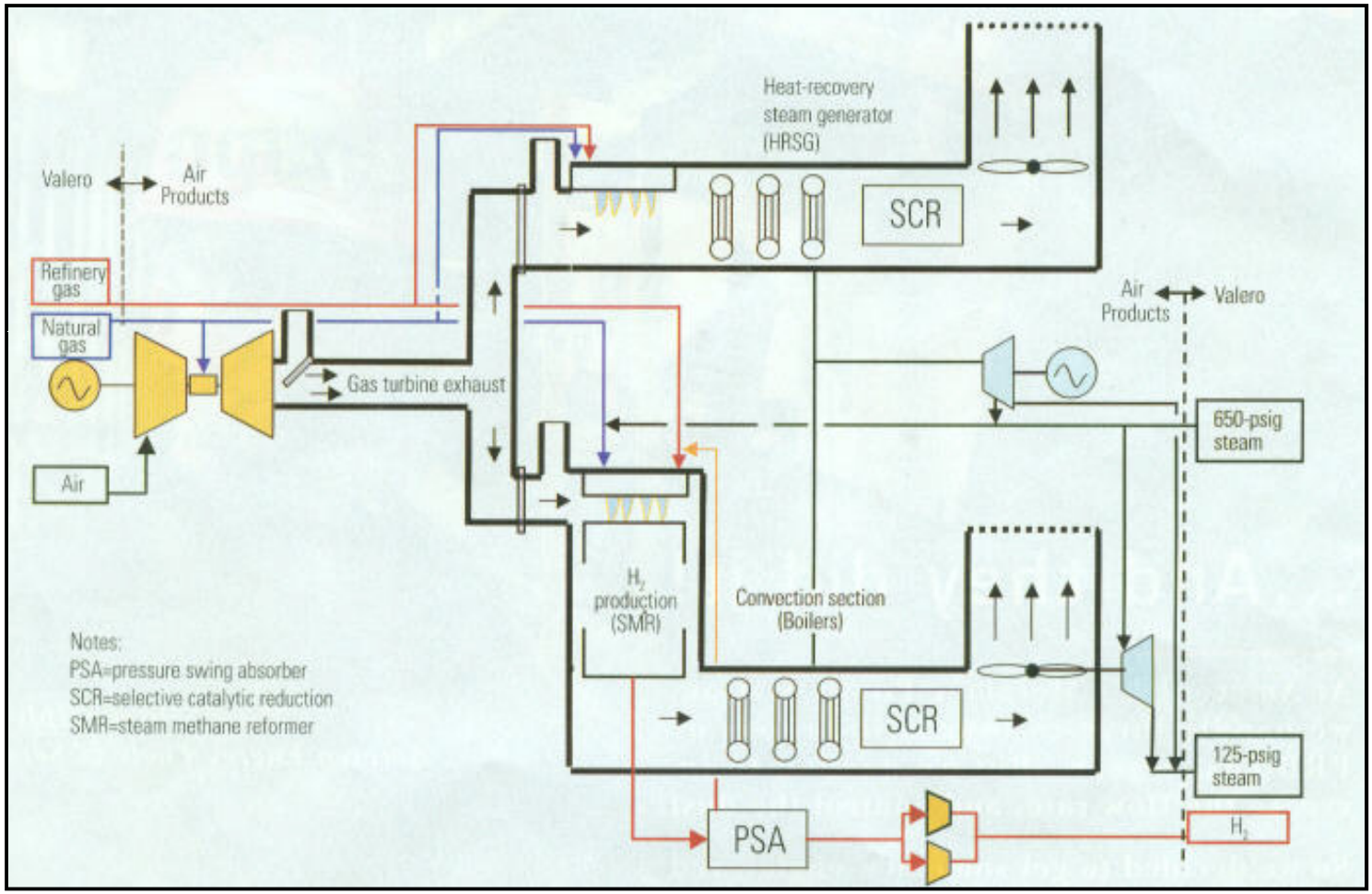
Conclusions



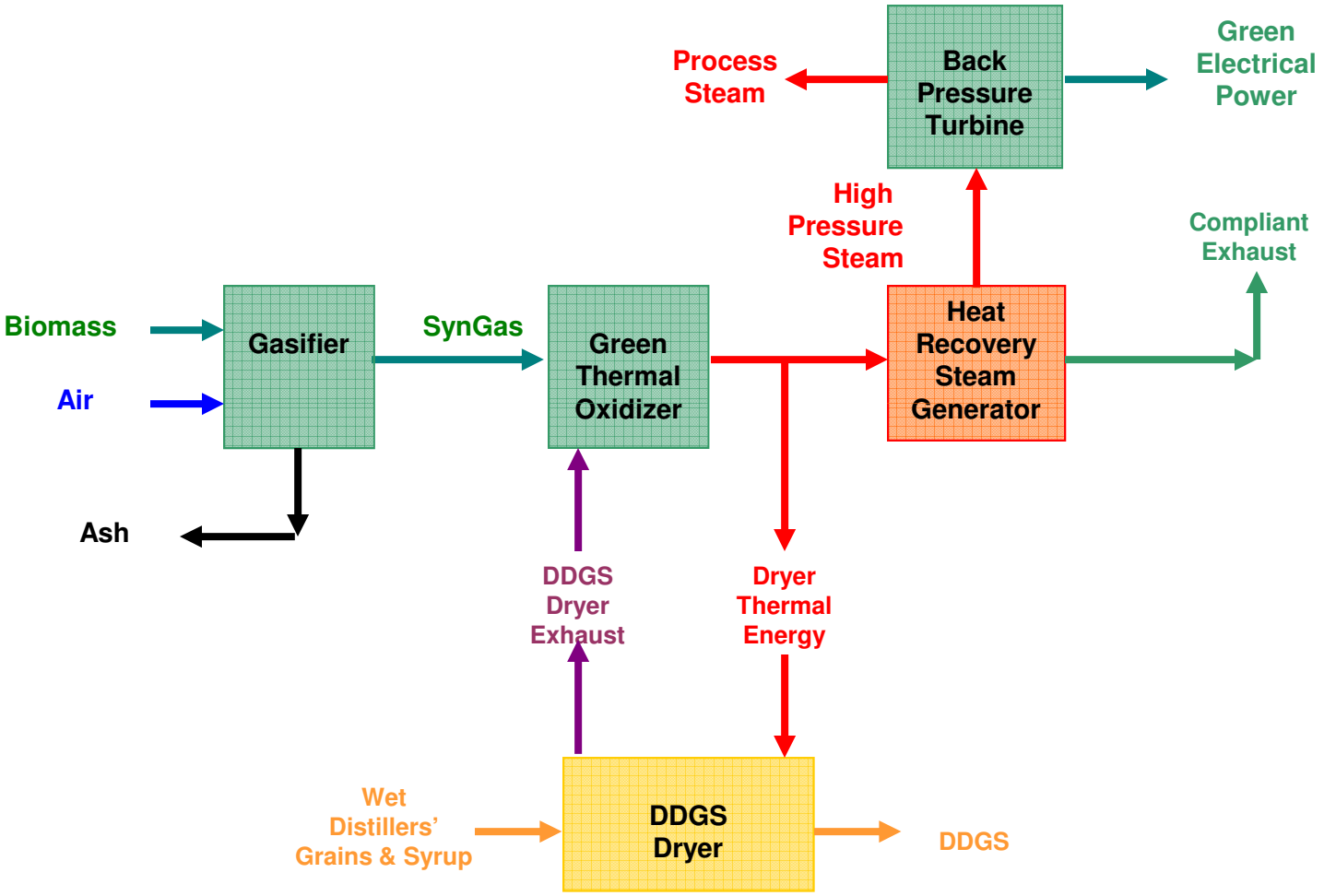
- CHP significantly reduces fossil fuel use and emissions
- Well proven technology
- CHP improves power reliability and is dispatchable
- Reduces cost and stimulates economic development
- Eliminates water use for cooling
- Beneficial for biomass to power
- Realistic analysis comparing to alternative energy sources assure energy and emission reduction

Air Products Hydrogen Cogeneration Plant

Port Arthur, TX



Green Thermal Oxidizer Block Flow Diagram



Wrap-up

- **Questions**
  - Submit via chat feature
  - Answered offline, emailed and posted

- **Presentation**
  - E-mailed to all attendees within 24 hours
  - Posted to www.GulfCoastCleanEnergy.org

- **Continuing Education Units (CEU)**
  - Available upon request

Upcoming Webinars

7/14 – Louisiana Legislative Recap

7/27 – CHP using Biomass Feedstocks

August Webinars (check back for dates)

- EPA: CHP and GHG Regulations
- CHP Fuel Cell Technology
- Financing CHP Projects
- Using CHP in Hospitals

GC RAC webinars

- Frequent
- Free
- CEUs upon request
- Archived
- Suggest a topic

Visit www.GulfCoastCleanEnergy.org/webinars to register and access our archives.

CHP2011 COMBINED HEAT AND POWER
CONFERENCE & TRADE SHOW

October 17-19, 2011 • Westin Galleria Hotel • Houston, Texas

- ***Plenary and breakout sessions***
- ***Trade show exhibit hall***
- ***TXCHPI Awards Ceremony***
- ***CHP Site Tours***
- ***Call for Abstracts***
- ***Joe St. Pierre Scholarship Awardees***
- ***Sponsorship Opportunities***

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

Resources

U.S. DOE Gulf Coast Clean Energy Application Center
Independent CHP assistance, resources, information and Links
www.gulfcoastcleanenergy.org

U.S. Department of Energy CHP Program
www.eere.energy.gov/de/

U.S. Environmental Protection Agency CHP Partnership
www.epa.gov/chp

Texas CHP Initiative (TXCHPI)
www.txchpi.org

US Clean Heat and Power Association (USCHPA)
http://uschpa.admgt.com

International District Energy Association (IDEA)
www.districtenergy.org

Contacts

U.S. Department of Energy Clean Energy Application Center
www.GulfCoastCleanEnergy.org

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, *MS, LEED AP, CEM, CDSM, DGCP*
Project Support
281-363-7906
ukrishnan@harc.edu

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