What is Combined Heat and Power?

CHP is an *integrated energy system* that:

- Is located at or near a factory or building
- Generates electrical and/or mechanical power
- Recovers waste heat for:
  - *Heating*
  - *Cooling*
  - *Dehumidification*
  - *Process thermal needs*
- Can utilize a variety of technologies and fuels

CHP is a proven high-efficient alternative to separate power and thermal energy production.
CHP Enables Resilient Infrastructure

- CHP designed to provide continuous electric and thermal power for a host site and reduce operating costs
- When designed to operate independent from the grid, CHP systems can meet specific reliability needs and address the various risk profiles of different types of customers
- CHP systems designed for reliability will incur additional costs ($45 - $170/kW depending on complexity of system)
- These additional costs however provide important benefits to the site, and to the community at large
• Black start capability
  — allows the system to start up independently from the grid (even when the power is already out)

• Generators capable of grid-independent operation
  — the system must be able to operate without the grid power signal

• Ample carrying capacity
  — system size must match critical loads

• Parallel utility interconnection and switchgear controls
  — the system must be able to disconnect from the grid, support critical loads, and reconnect after an event
Overview

• Biomass feedstock

• Different feedstock require different CHP technologies
  — Woody biomass – steam turbine generators and gasifiers
  — Anaerobic digestion – biogas gensets, fuel cells

• Both CHP technology pathways use organic materials more efficiently than electricity generation alone

• Lessons learned from each technology pathway include environmental, economic development, emerging commercialization, and technology applications
Feedstock Perspectives

• Think creatively – What is available *locally*?
  • Transportation costs can kill a project. 50-mile radius is rule of thumb maximum distance

• Feedstock Sources?
  ▪ Clean urban wood waste
  ▪ Food waste

• Where does it go now? Avoid organic materials going to the landfill

• Biomass feedstocks – How reliable is the source? Price?
  ▪ Due diligence is needed for a long-term supply contract
  ▪ Do a biomass availability assessment
Feedstock Perspectives (continued)

• What if we lost the supply? How do we manage seasonal variation? Have alternatives.

• Feedstock competition is coming as bioenergy technology advances.

• What is the moisture content? It makes a difference in system design.

• What is the quality of the feedstock? Wood chips by hammermill or knife – avoid clogging of auger.
Environmental Considerations

- Think environmental concerns through early and deeply – there are a wide variety of concerns.
  - Examples: Evergreen State College and Thurston County

- Compared to what? This is a basis for showing improvements.
  - Example: Nippon Paper

- Air emissions – biomass portion of boiler MACT

- Nutrient overloading of digestate liquid
Environmental Considerations (continued)

• Preserving soil health – avoid over-harvesting biomass

• Solid waste avoidance – uses for the ash. What are the nutrients?

• Carbon footprint and greenhouse gas reductions
  – Biogenic carbon

• Water use and quality impacts

• Capture lessons learned and the story behind them on factsheets
EPA & Biomass

• A number of revised rules are in the works or recently completed: GHG and biogenic carbon (in process), Boiler MACT, & CISWI (Reconsideration 12/2/11 & Final 12/21/12)

• Biomass GHG: How carbon neutral is it? What do you measure? Time span? A tree or a forest?

• Clean cellulosic biomass: Hog fuel, wood pallets, wood pellets fall under CAA section 112 boiler regulations

• Not CISWI incinerators (Commercial/Industrial Solid Waste Incinerators) unless MSW included in the feedstock
When Does a Waste Stream Become a Revenue Stream and No Longer Waste?

- **When it’s taxed** – No solid waste permit needed
- **A question was asked of the WA Department of Revenue**
  - How do you tax logging slash coming out of the woods to the mills?
  - Legislation in 2009 set tax rates
  - Triggered an official rule interpretation by the Department of Ecology that forest biomass residuals are a product and not a waste
- **Decision has withstood a number of court appeals**
Technology: What Makes a Great Wood Waste Project?

A great wood waste CHP/district energy project has:

- Proper sizing
- High energy efficiency
- Covered storage area for the feedstock
- Quality requirements for the feedstock
- Strong moisture reduction system
- Strong environmental controls and well-understood environmental improvements
- Effective heating and cooling
Fuel Drying – Why?

• Significantly improves the efficiency of the boiler or gasifier

• For boiler:
  — 5% to 15% improvements in efficiency (Boiler is not an efficient dryer, so dry fuel before it goes to the boiler.)
  — 50% to 60% more steam production

• Improves combustion

• Reduces air emissions

• See *Biomass Drying and Dewatering for Clean Heat & Power, 2008*, available from the Northwest Clean Energy Application Center
Waste Heat Recovery for Drying Wood Waste

Heat recovery is key to a cost-effective dryer project
• Recover flue gas of power boiler or gasifier
• Recover heat from other waste heat sources
• Recover heat from dryer exhaust

Design a complete CHP system, including:
• Feedstock drying
• Waste heat recovery
What Makes a Great Anaerobic Digestion CHP Project?

• Maximizes revenue streams

• Uses co-digestion: It can flip the economics positive
  – Some co-digestion feedstocks are amazing producers of biogas
  – Track the pH balance & dose in the feedstock

• Has a proper design for the climate zone and solids content of the feedstock – good emerging technology

• Scrubs the biogas – major importance

• Strong O&M support
Anaerobic Digestion Economics

A moving target – maximize co-products

Dairy example – 10 potential revenue streams

- Power
- Green/renewable power adder (RECs)
- Carbon credit due to lagoon shutdown (methane reduction pathway)
  - WA HB 1154 just signed into law
- Digested fiber with proper pH balance and nutrients (peat moss alternative)
- Nitrogen fertilizer
- Phosphorous fertilizer
- Remaining liquid is excellent fertilizer
- Tipping fee for food processor waste
- Co-digestion increases biogas production
- Waste heat for greenhouses
Biogas Scrubbing

Wide variety of biogas mixtures – methane content, chemicals and water:

• Siloxanes – very hard on engines
  – Landfill gas and WWTF biogas

• Hydrogen sulfide – Can the sulfur be used elsewhere in the system?

• Know your biogas
Biomass/Biogas CHP Project Profiles

Cooley Dickinson
500 kW BIOMASS CHP Plant

Site Description
Cooley Dickinson Hospital in Northampton, MA is a 600,000
square-foot hospital with 140 in-patient beds that has been in
operation for 125 years. The facility has a central energy plant
which provides electricity, heat and cooling for the hospital
campus. The hospital facility has a 12 month consistent heat
load for heating, absorption chilled water, food preparation
and centralized steamfpiration. Cooley Dickinson has operated a
2.0 M - 300 HP biomass boiler with wet scrubber emissions
control since 1984, in 2004, an AF5 - 600 HP Water/Thermal
high pressure boiler was installed. To take advantage of the
higher pressure steam supply, two 5250 HP Carrier Emergent
Micro Steam Turbines and a 480 Ton Absorption Chiller
were added to the energy plant in 2009. One of the turbines
reduces the steam pressure from 250 psig to 75 psig for
distribution throughout the hospital. The second turbine reduces
the steam pressure from 75 psig to 15 psig for use in the
absorption chiller.

Quick Facts
LOCATION: Northampton, MA
FUEL: Virgin Wood Chips
MAX CAPACITY: 500 kW
POLLUTION CONTROL: Multitone separator
and Baghouse
ENVIRONMENTAL BENEFITS:
95.5% particulate removal
AVERAGE CAPACITY FACTOR: 90 %
IN OPERATION SINCE: 2006
EQUIPMENT: AF5 - 600 HP Water/Fire Tube
Boiler with 2, 250KW Carrier Emergent
Micro Steam Turbines
USE OF ELECTRICAL ENERGY: Displaces loads
previously supplied by the local utility

Reasons for installing CHP
The motivation for installing the second wood chip plant in
2006 was a 120,000 sq ft hospital expansion project and to
improve reliability and add redundancy to the existing 30 year
old wood boiler. The second wood boiler also eliminated the
need to burn oil during the 1-2 months of maintenance downtime each year. In 2009, the hospital implemented a formal
energy conservation program which included the installation of the turbines. To lower their operating costs, the CHP plant is
equipped with emissions controls meeting state requirements in accordance with the issued Air Permit. The two micro-steam
turbines reduce the hospital’s 2,000 kW peak load by 350 kW (17.5%) and produce approximately 2,000,000 kWh of
electricity per year (12.5%). The plant now has a utility approved electrical interconnect allowing power generation in parallel
with the electrical grid.

National Database on DOE AMO site
http://www1.eere.energy.gov/manufactur ing/distributedenergy/chp_projects.html
Example of Biogas CHP System

• Antioch Community High School in Illinois with 3,000 students 262,000 square feet
  – Feedstock: Scrubbed and compressed biogas from a landfill ½ mile away – Taking advantage of what is nearby
  – 360 kW system (12 microturbines) & 3.48 MMBtu/hr with heat exchangers
  – School savings of $165,000/year
  – Link:
    http://www.midwestcleanenergycenter.org/profiles/ProjectProfiles/AntiochHighSchool.pdf
Example of Biomass CHP System

- Cooley Dickinson Hospital in Maine with 140 patient beds
  600,000 square feet
  - Feedstock: Wood chips
  - 500 kW system (2 steam turbines) & 2 boilers with 75 psig for
    steam distribution throughout the hospital
  - Cooling via an absorption chiller
  - Link:
    http://www.northeastcleanenergy.org/profiles/documents/Cooley
    DickinsonCaseStudy.pdf
Conclusion & Next Steps

• Economic advantage – make your own power for on-site use or sell it/wheel it
• Long-term feedstock supply is crucial
• A long-term power purchase agreement is helpful
• Quality design is essential
• Use the feedstock efficiently
• BIOMASS CHP – A WINNER!
• The NW CEAC helps with next steps
  – CHP screenings (go/no go scan of potential)
  – Technical assistance
Questions & Contact Information

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Biomass Drying and Dewatering for CHP Guide Link: