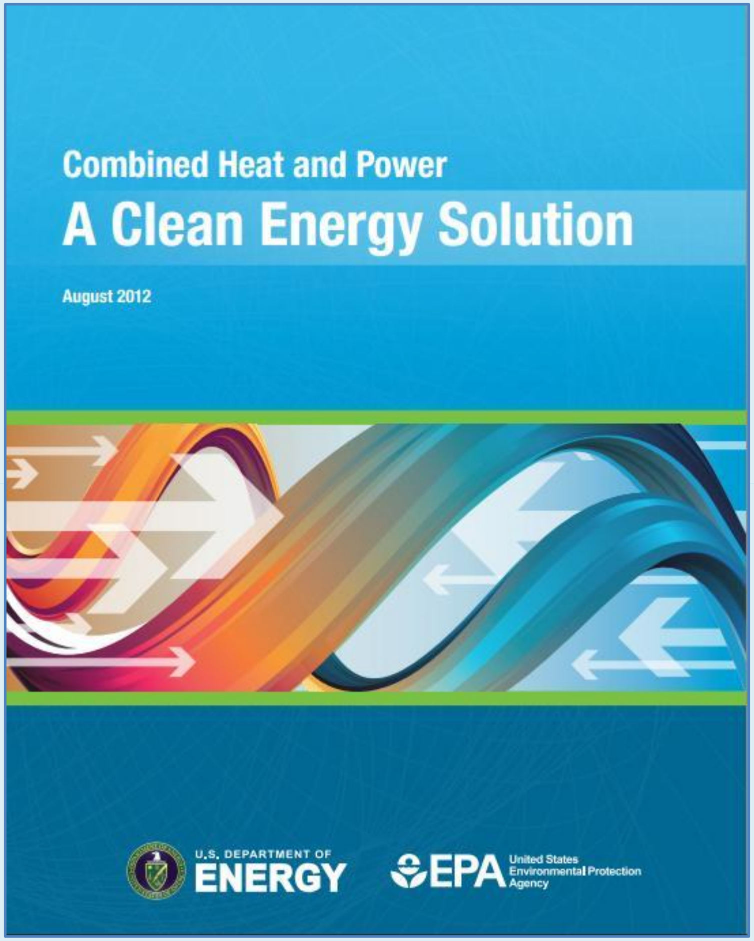

Combined Heat and Power and Biomass: Benefits and Economics

November 14, 2012

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Public Utilities Regulatory Policies Act (PURPA)

❖**Public Utilities Regulatory Policies Act**
1978 PURPA encouraged energy-efficient CHP and power production from renewables by requiring electric utilities to interconnect with "qualified facilities" (QFs). CHP facilities had to meet minimum fuel-specific efficiency standards to become a QF. PURPA required utilities to provide QFs with reasonable standby and backup charges, and to purchase excess electricity from them at the utilities’ avoided costs. Thermal energy requirements were as low as 5% resulting in a emphasis on grid electric sales.

❖PURPA also exempted QFs from regulatory oversight under the Public Utilities Holding Company Act and from constraints on natural gas use imposed by the Fuel Use Act. Shortly after enacting PURPA, Congress passed a series of tax incentives for energy efficiency technologies, including CHP. The incentives included a limited term investment tax credit of 10 percent and a shortened depreciation schedule for CHP systems. **PURPA and the tax incentives successfully expanded CHP—installed capacity increased from about 12,000 MW in 1980 to more than 66,000 MW in 2000.**

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Post-PURPA

- **Post-PURPA**

Power purchase provisions of PURPA, combined with the availability of new technologies, resulted in the development of very large merchant plants designed for maximum electricity production. For the first time since the inception of the power industry, nonutility participation was allowed in the US power market, triggering emergence of third-party CHP developers who had more interest in electric markets than thermal markets. Deregulation caused this market to adopt competitive pricing of electric power as opposed to PPA's based on utility straw or long term avoided cost.

- As a result, development of large CHP facilities (greater than 100 MW) paired with industrial facilities increased dramatically; **today almost 65 percent of existing US CHP capacity, 55,000 MW, is concentrated in plants more than 100 MW in size.**

- **PURPA CHP Current Status** Most of the grid PPA' have been bought out resulting in many PURPA QF plants becoming merchant plants operating in day ahead markets.

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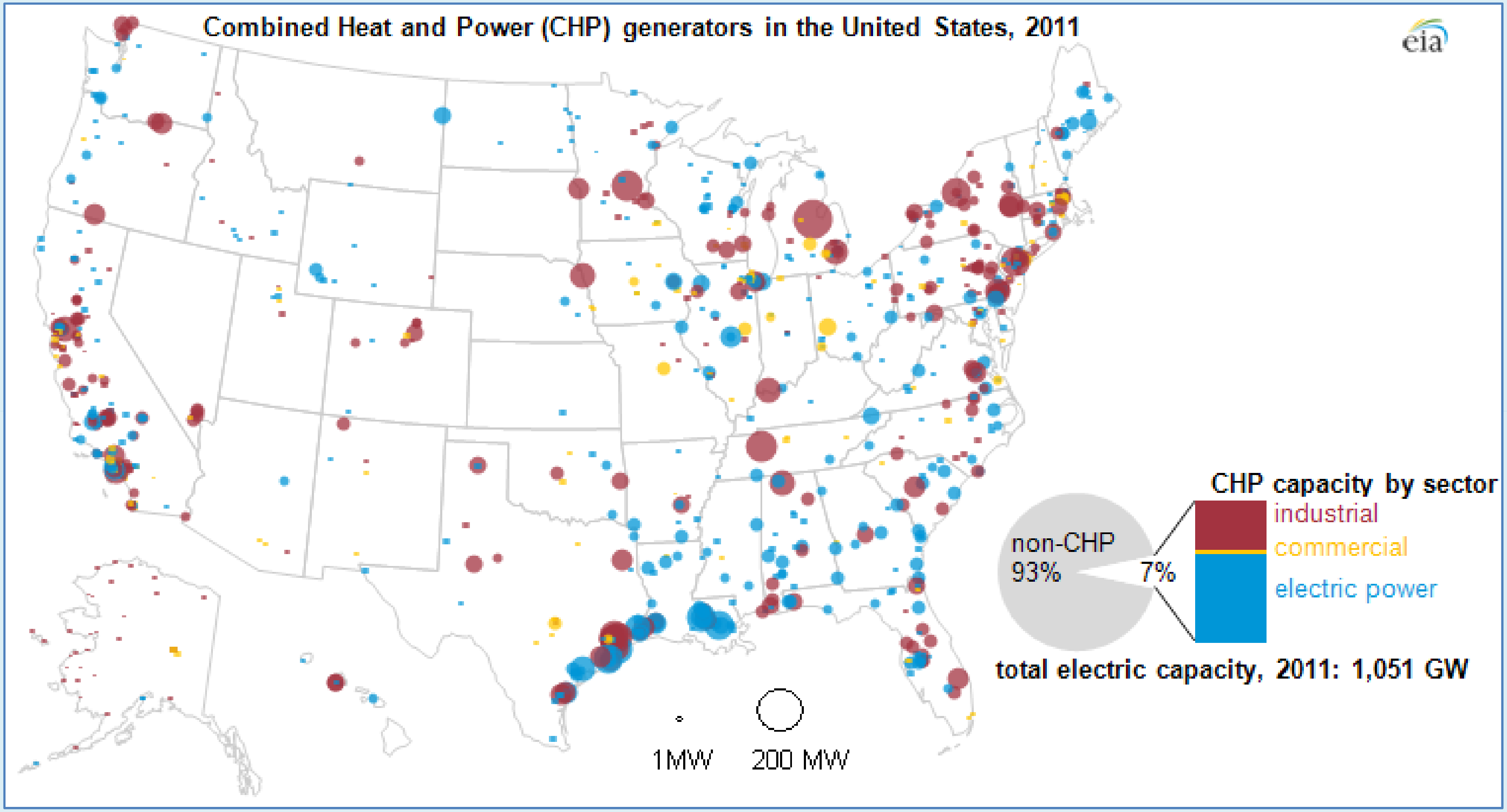
President's Executive Order – August 30, 2012

- Establishes a new national goal of 40 gigawatts of new combined heat and power capacity by 2020 – a 50% increase from today.
- Meeting this goal would save energy users $10 billion per year
- $40 to $80 billion in new capital investment in manufacturing and other facilities that would create American jobs
- Would reduce emissions equivalent to 25 million cars

2011 CHP Electric Capacity in US



What is CHP?

- **Combined heat and power (CHP),** also known as cogeneration, is the simultaneous production of electricity and heat from a single fuel source, such as: natural gas, biomass, biogas, coal, waste heat, or oil.

- **CHP is not a single technology, but an integrated energy system** that can be modified depending upon the needs of the energy end user.

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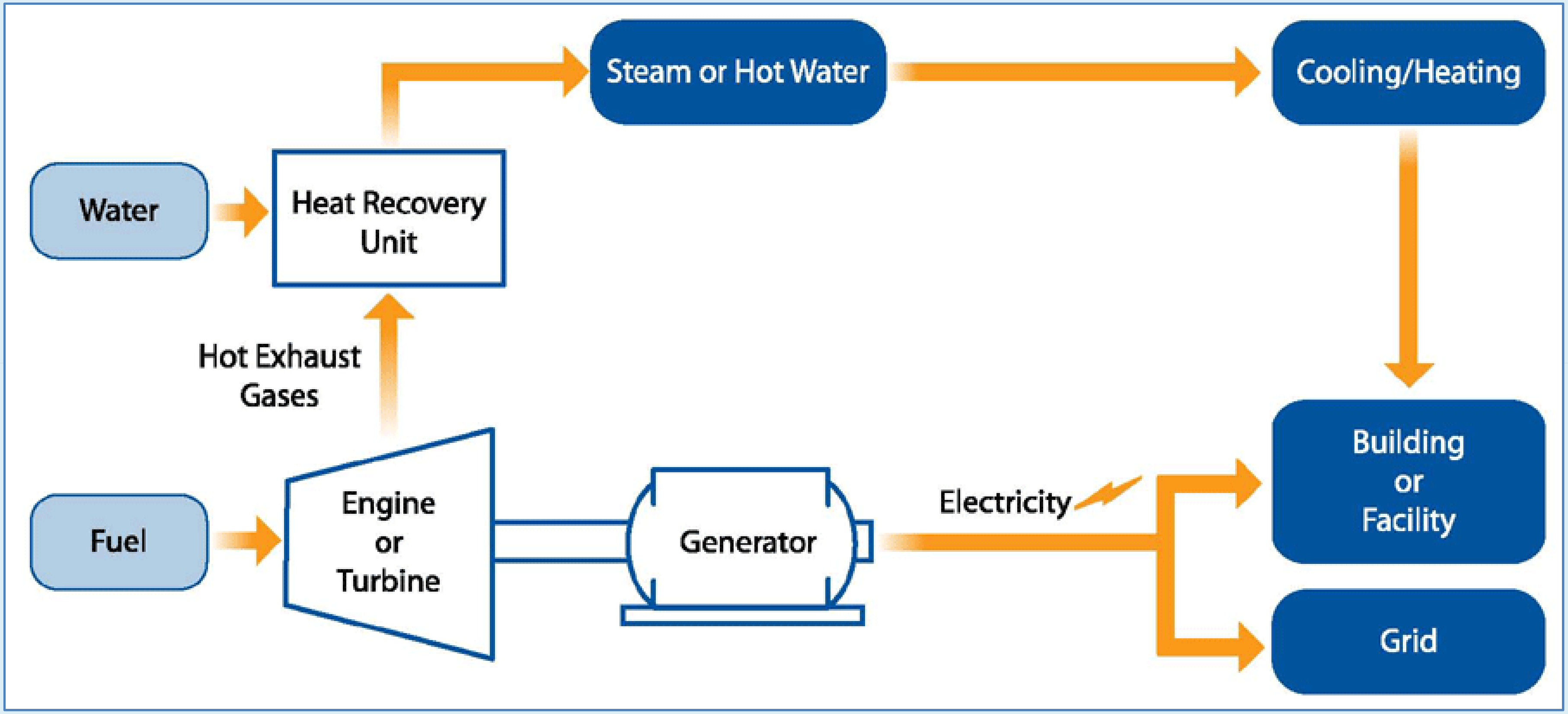
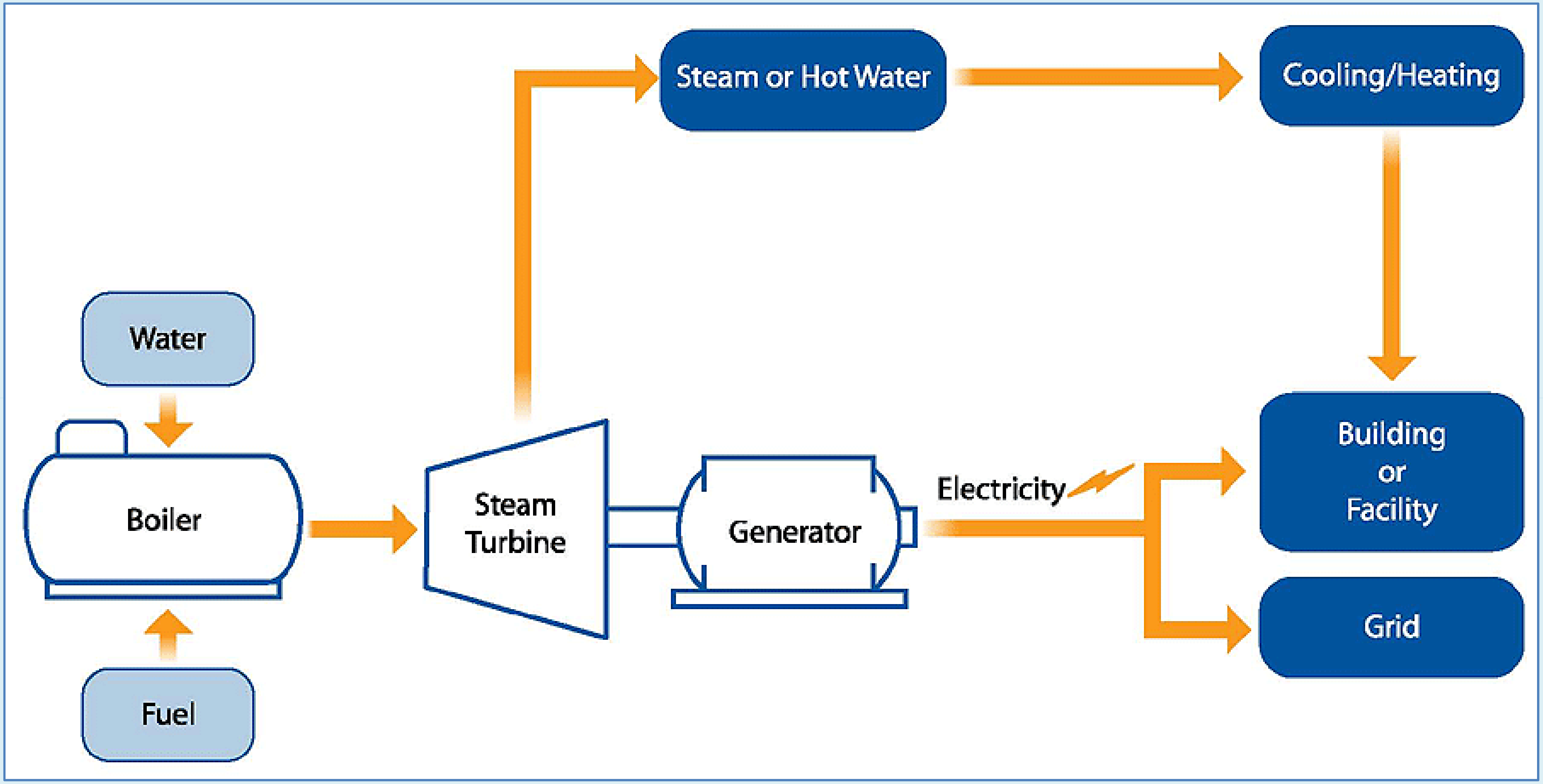
What Does CHP Produce?

- **Generation** of electrical and thermal energy for on-site utilization
- **Generation** of electric power for export to the electric grid and thermal energy for on-site or nearby utilization
- **Waste-heat recovery** for heating, cooling, dehumidification, or process applications
- **Seamless system integration** for a variety of technologies, thermal applications, and fuel types into existing building infrastructure

Gas Turbine or Engine With Heat Recovery Unit



Steam Boiler With Steam Turbine



Benefits of CHP

❖ **Efficiency**

CHP requires less fuel than separate heat and power generation to produce a given energy output. Efficiencies of 80% or more are typical. CHP also avoids transmission and distribution losses that occur when electricity travels over power lines from central generating units.

❖ **Reliability**

CHP can provide high-quality electricity and thermal energy to a site regardless of what might occur on the power grid, if sized for on-site loads can run in island mode eliminating the impact of outages and improving power quality for sensitive equipment.

❖ **Environmental**

Because less fuel is burned to produce each unit of energy output, CHP reduces emissions of greenhouse gases and other air pollutants.

❖ **Economic**

CHP can save facilities considerable money on their energy bills due to its high efficiency, and it can provide a hedge against unstable energy costs.

CHP Compared to Others

Category	10 MW CHP	10 MW Wind	10 MW Natural Gas Combined Cycle
Annual Capacity Factor	85%	34%	70%
Annual Electricity	74,446 MWh	29,784 MWh	61,320 MWh
Annual Useful Heat	103,417 MWh_t	None	None
Footprint Required	6,000 sq ft	76,000 sq ft	N/A
Capital Cost	$20 million	$24.4 million	$9.8 million
Cost of Power*	7.6 ¢/kWh	7.5 ¢/kWh	6.1 ¢/kWh
Annual Energy Savings	316,218 MMBtu	306,871 MMBtu	163,724 MMBtu
Annual CO_2 Savings	42,506 Tons	27,546 Tons	28,233 Tons
Annual NOx Savings	87.8 Tons	36.4 Tons	61.9 Tons

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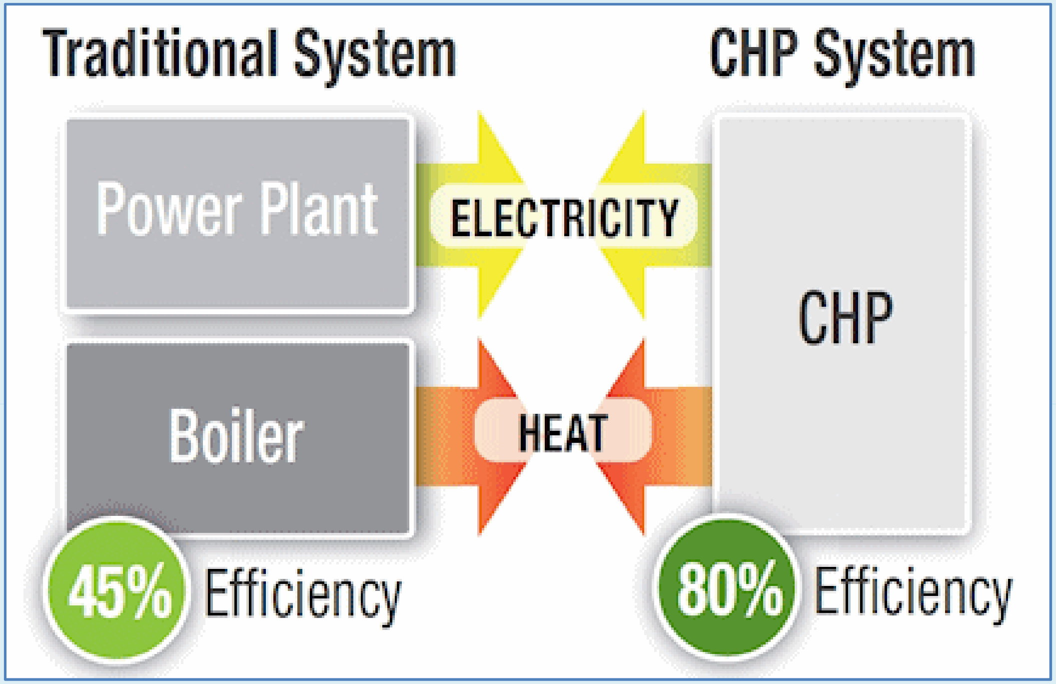
CHP System Efficiency



Reliability During Hurricane Sandy – Where the Lights Stayed On

- Princeton University, Princeton, NJ
- The College of NJ, Edison, NJ
- Salem Community College – Red Cross Disaster Relief Shelter, Carney's Point, NJ
- South Oaks Hospital, Amityville, NY
- CO-OP City, Bronx, NY
- One Penn Plaza, NY, NY

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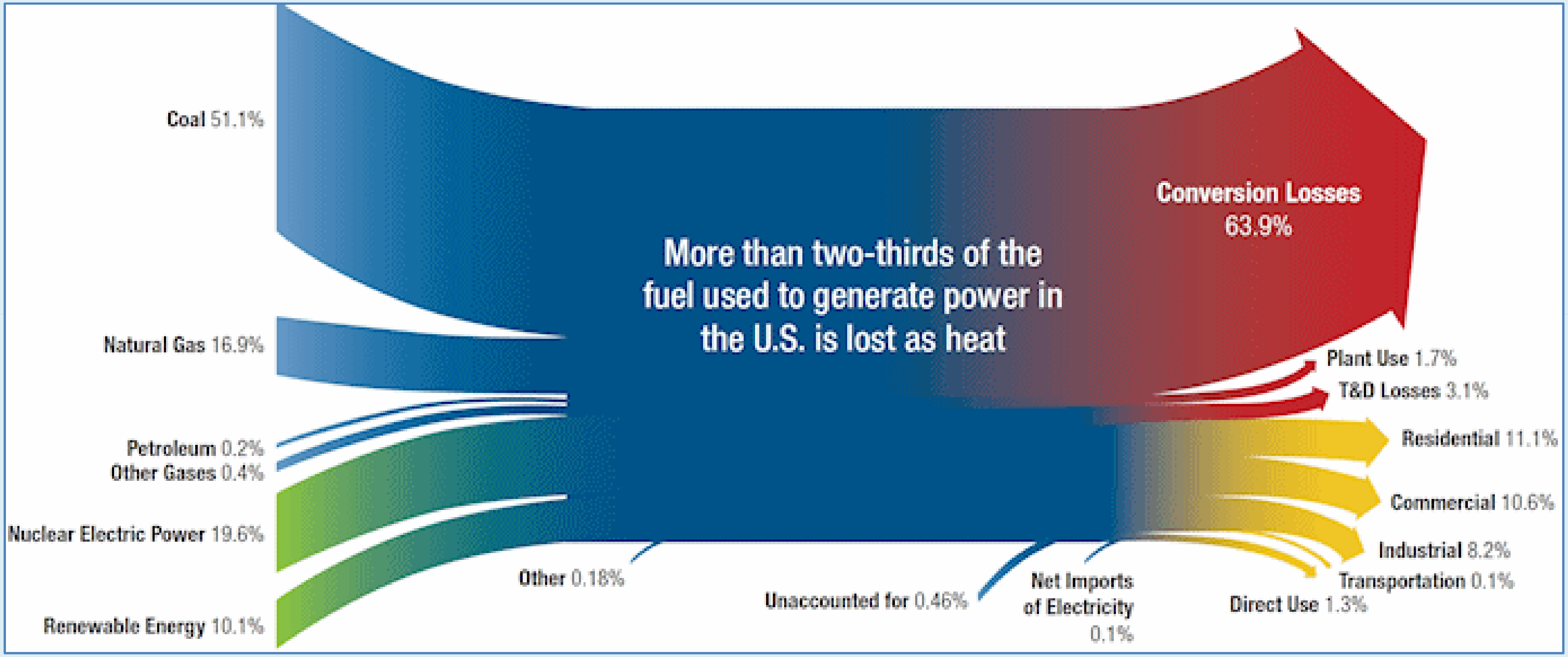
CHP Recaptures Wasted Energy



CHP Has Favorable Market Conditions in PA

New CHP Sites (2005-2010):
25 sites (#5)

New CHP Capacity (2005-2010):
80.9 MW (#9)

Average Capacity per Site (2005-2010):
3.2 MW

Total Primary Energy Consumption (2008):
3,900 trillion Btu (#7)

Average Gas Price (2009):
$12.10 per MCF (#14)

Average Electricity Price (2010):
10.42¢ per kWh (#16)

- 2008's Act 129 directed all large utilities in the state to develop energy efficiency plans and goals
- Pennsylvania's net metering laws are viewed as useful to smaller CHP systems
- Interconnection not a barrier, good experiences with PECO reported
- Developers capitalizing on good regulations, rising electricity costs and energy-intensive manufacturing sector
- Marcellus Shale can deliver cheap and steady source of natural gas

CHP Projects

- **SEPTA**, Wayne Junction, PA (8.4 MW)
- **University Medical Center of Princeton**, Plainsboro, NJ (4.6 MW)
- **Montclair State University**, Montclair, NJ (7.5 MW)
- **Revel Casino**, Atlantic City, NJ (5.6 MW)

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CHP & District Energy

- **District energy** refers to generating any combination of electricity, steam, heating, or cooling at a central plant and then distributing that energy to a network of nearby buildings.

- **Many district energy schemes use CHP**, recycling the thermal energy left over from electricity generation for heating or cooling. District energy is an efficient, reliable, and cost-effective option for any cluster or network of buildings.

- **District energy used by college campuses, hospitals, military bases, manufacturing facilities**, etc.

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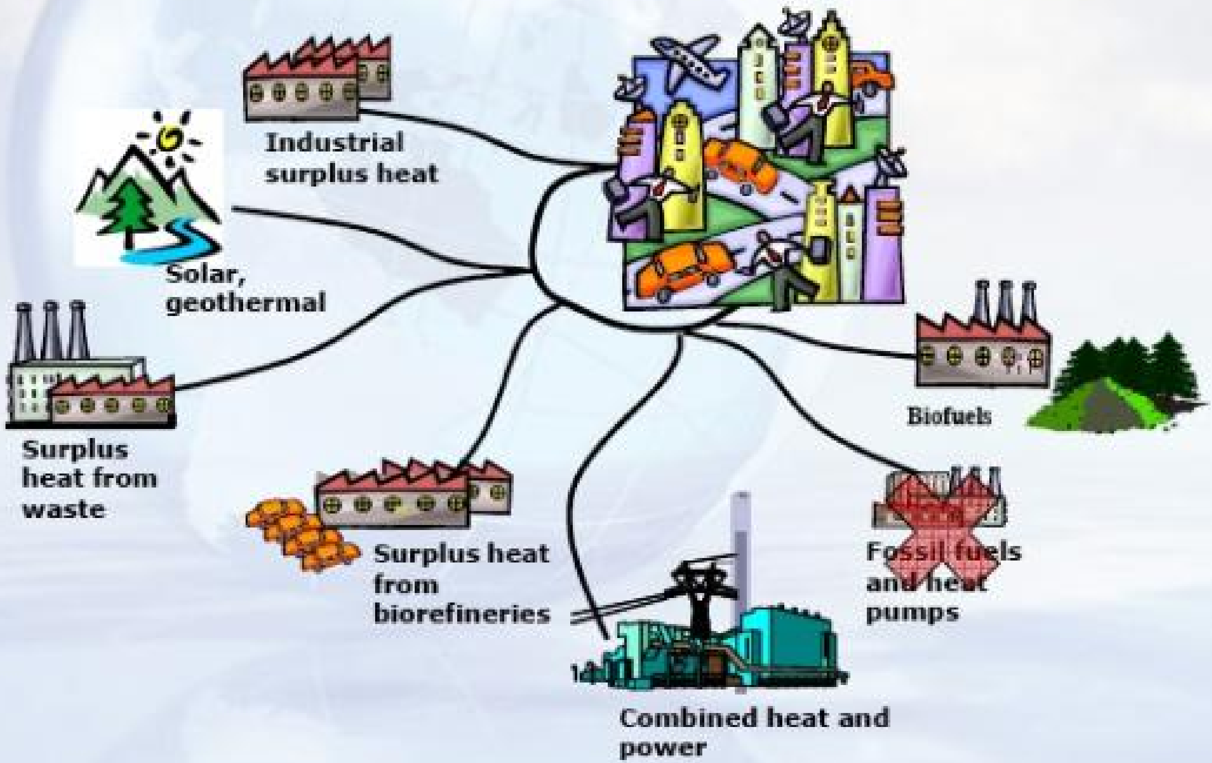
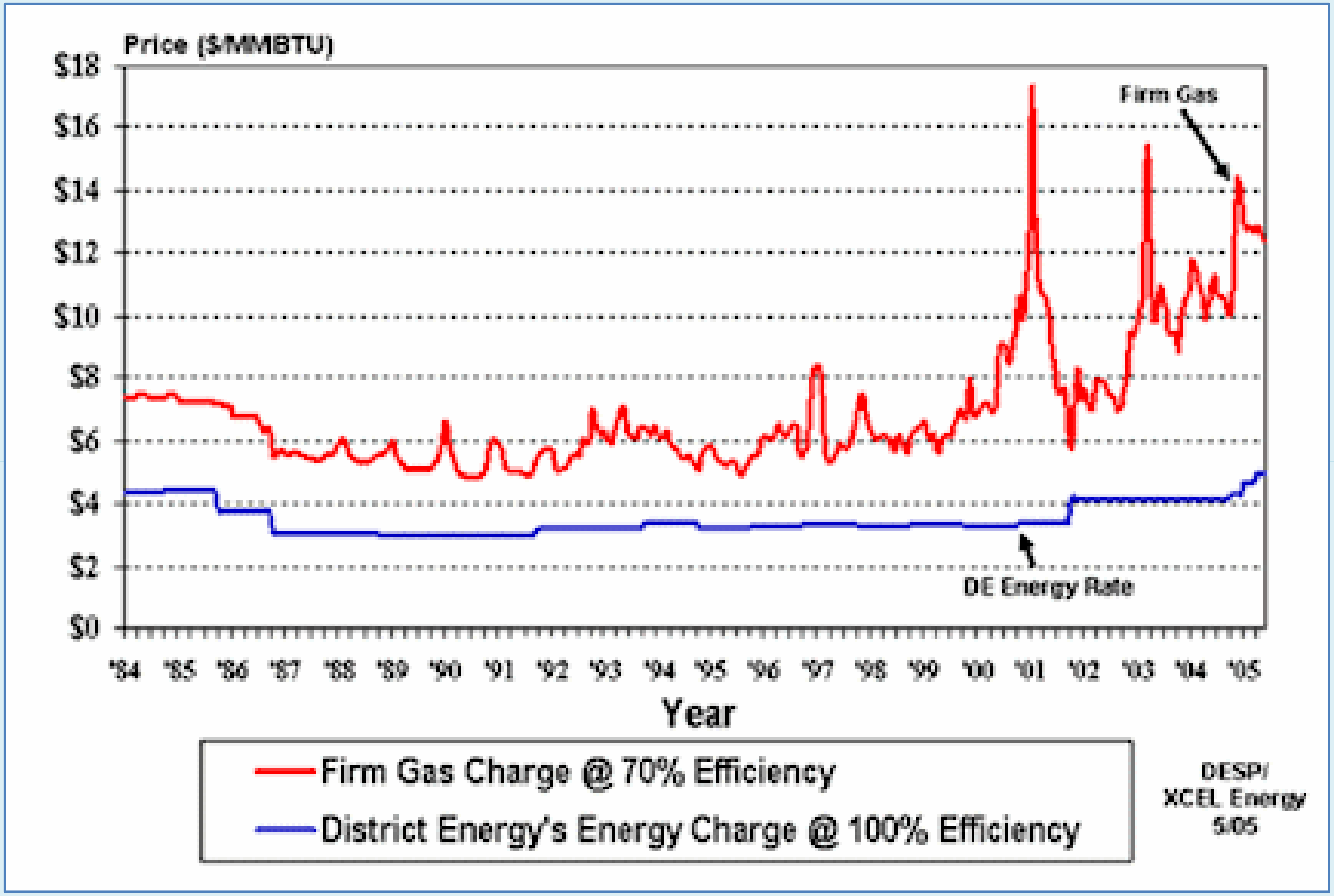
District Energy Networks Make Efficient Use of Local Renewable Energy Sources and Surplus Heat



Energy Charges: District Energy vs. Onsite Energy



CHP & Opportunity Fuels

- **Biomass is only renewable** that can be used to efficiently produce both heat and power, by fueling a CHP system.

- **Utilizing opportunity fuels may have additional benefits**, including displacing purchased fossil fuel, freeing up landfill space, and reducing tipping fees associated with waste disposal.

- **Opportunity fuels include:**
  - Biomass such as wood and wood wastes, sawdust, and combustible agricultural wastes
  - Biogas created in anaerobic digesters from the breakdown of organic matter such as wastewater sludge or farm waste
  - Black liquor - a byproduct of the pulping process
  - Biogas from unrecycled organic faction of MSW

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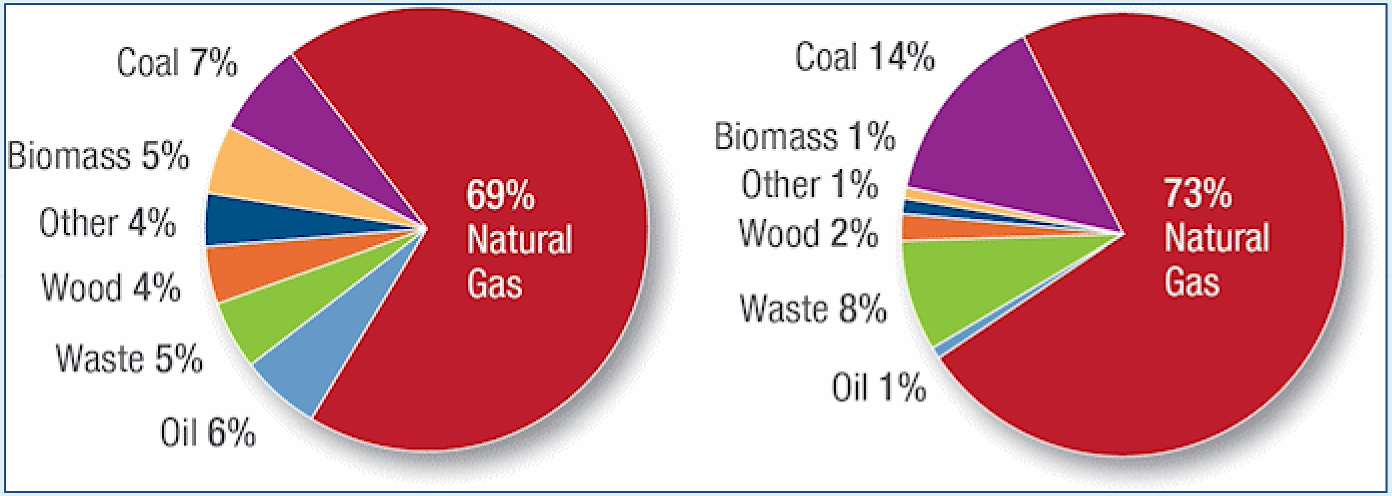
Opportunity Fuel Types

CHP Sites by Fuel Type **CHP Capacity by Fuel Type**



Considerations for a Successful Biomass CHP Project

- **Proximity to fuel source**: Biomass is most economical as a fuel source when the CHP system is located at or close to the biomass fuel stock

- **Renewable portfolio standards**: As of March 2009, 33 states and the District of Columbia had renewable portfolio standards, and in each of these states, biofueled CHP represents a permissible renewable energy resource. In some states, renewable energy credits can be generated from the use of biomass to power a CHP system, which can provide projects with an additional revenue stream. Class 1 REC's qualify throughout PJM

- **Grants, loans or tax credits**: Biofueled CHP projects often qualify for additional state incentives that traditional CHP systems are ineligible to receive. Financing is often available for biomass/biogas projects and/or CHP projects through federal, state, and local grants, loans, or tax credits.

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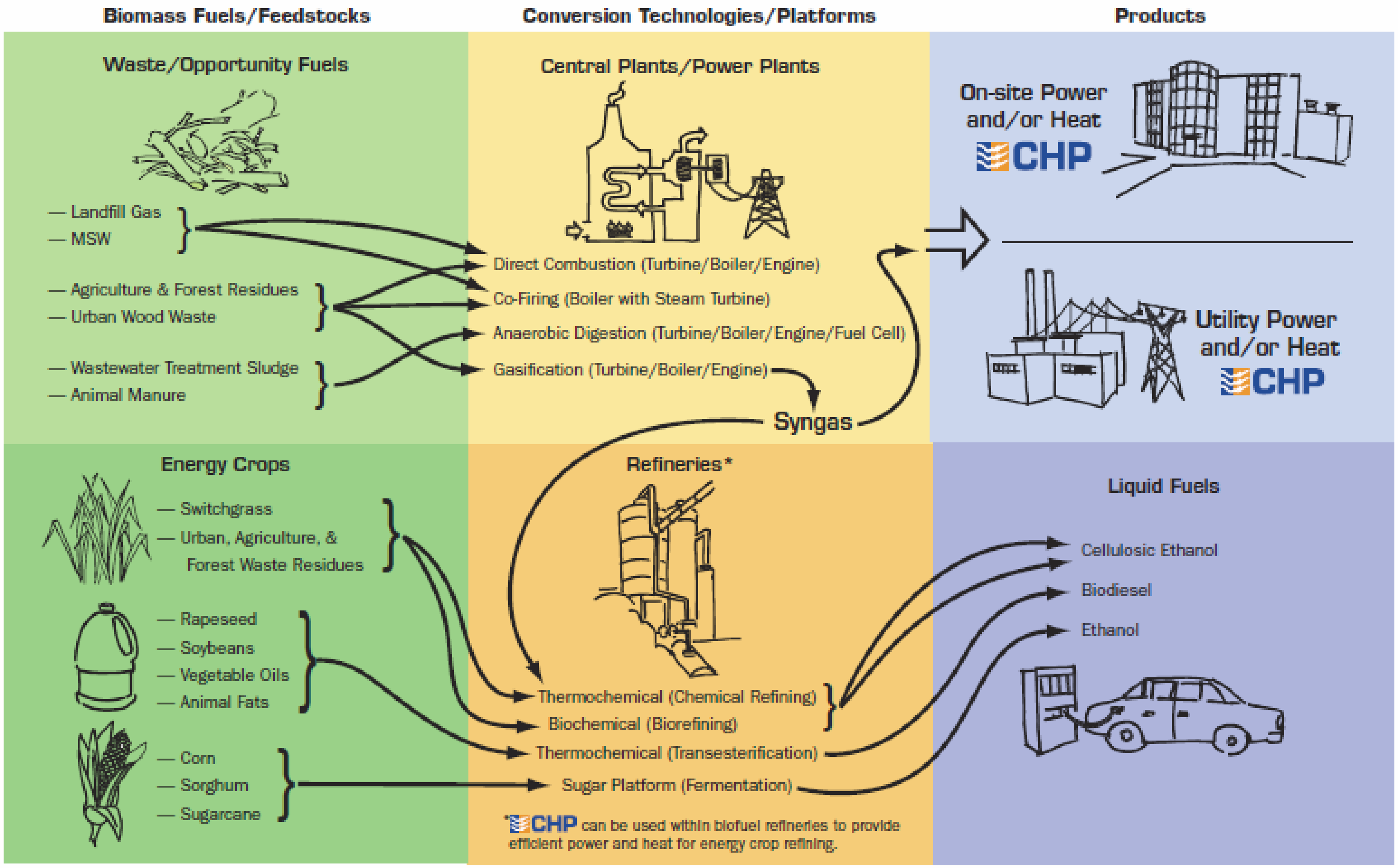
Biomass to Bioenergy

Bioenergy is becoming an increasingly attractive energy choice in the United States due to high fossil fuel prices, a desire to lessen the environmental impact of energy use, and concerns about national security. The benefits of increased biomass use can include enhanced energy independence, security, and reliability; economic development; and improved environmental performance. The following map illustrates the conversion of different biomass fuels/feedstocks into a variety of final products.



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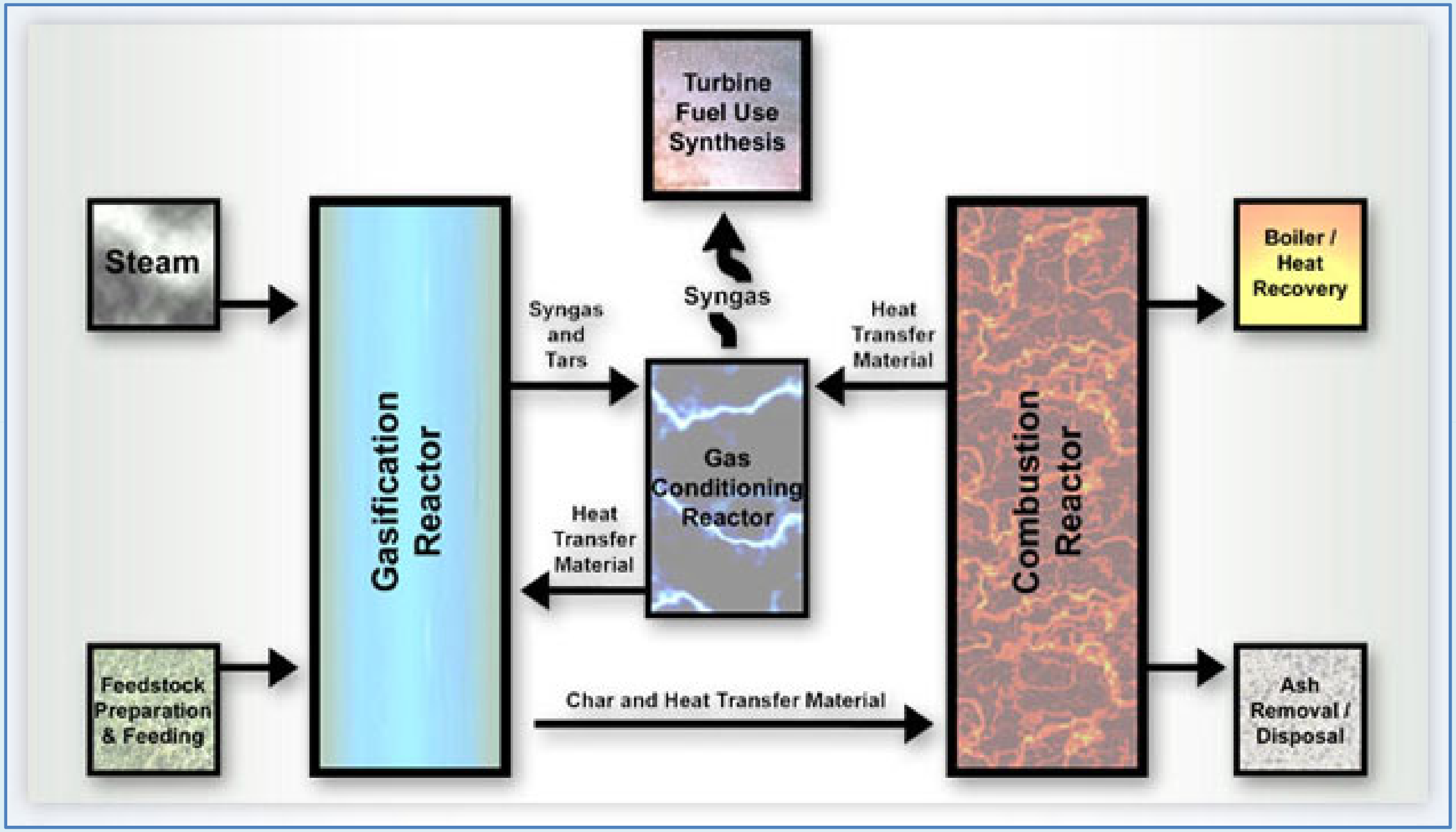
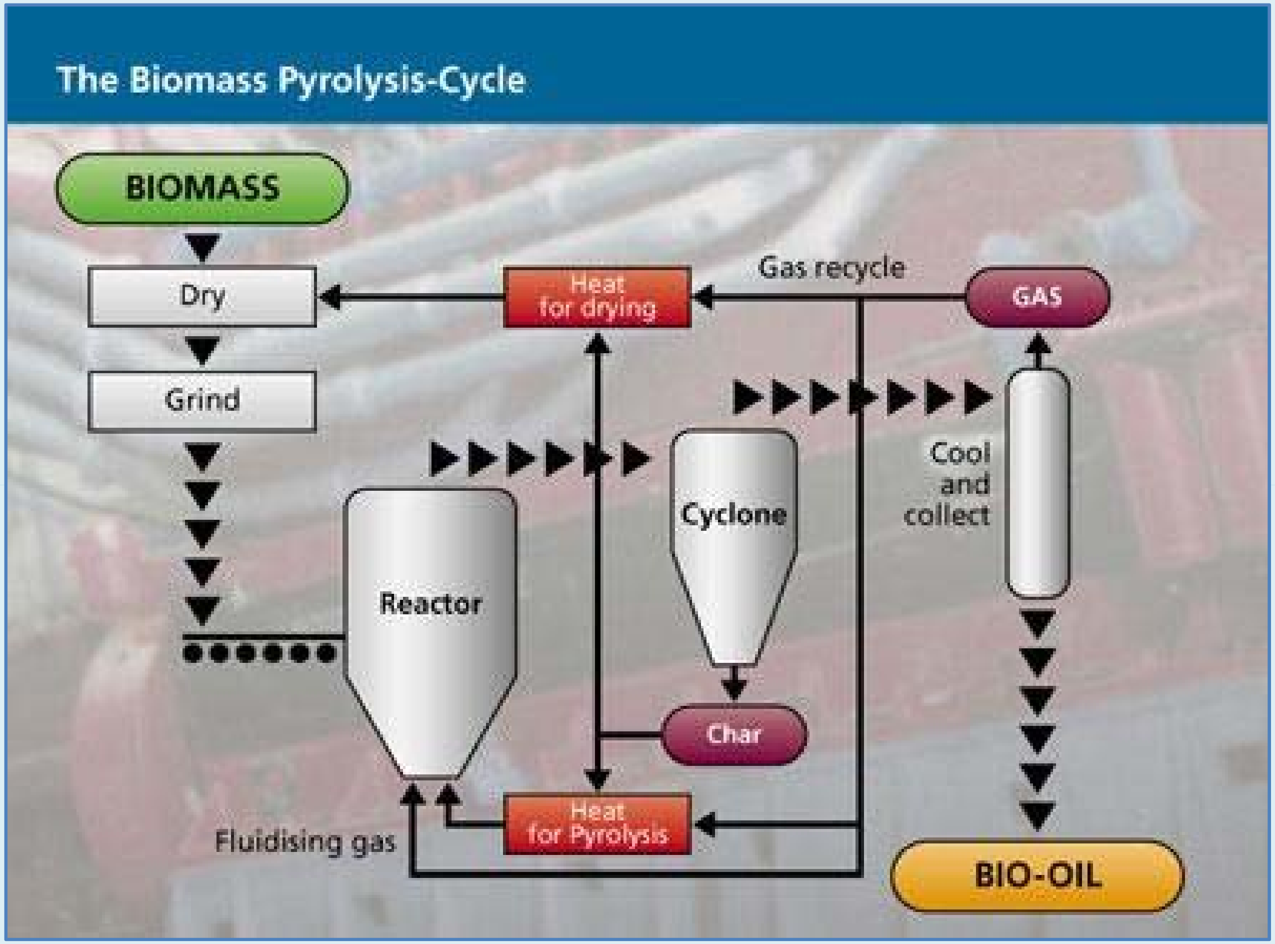
Biomass Plasma Gasification



Biomass Pyrolysis Cycle



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Benefits of CHP Using Biogas for WWTF

- Produces power at a cost below retail electricity
- Displaces purchased fuels for thermal needs
- Qualifies as a renewable fuel source under Fed ITC and MACRS as well as state renewable portfolio standards and utility green power programs
- Enhances power reliability for the plant
- Produces more useful energy than if the WWTF were to use biogas solely to meet digester heat loads
- Produces high value behind the meter electricity
- Reduces emissions of greenhouse gases and other air pollutants, primarily by displacing utility grid power

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Digester Gas Wastewater CHP Systems by State

State	Number of Sites	Capacity (MW)	State	Number of Sites	Capacity (MW)
AR	1	1.73	MT	3	1.09
AZ	1	0.29	NE	3	5.40
CA	33	62.67	NH	1	0.37
CO	2	7.07	NJ	4	8.72
CT	2	0.95	NY	6	3.01
FL	3	13.50	OH	3	16.29
IA	2	3.40	OR	10	6.42
ID	2	0.45	PA	3	1.99
IL	2	4.58	TX	1	4.20
IN	1	0.13	UT	2	2.65
MA	1	18.00	WA	5	14.18
MD	2	3.33	WI	5	2.02
MI	1	0.06	WY	1	0.03
MN	4	7.19	**Total**	**104**	**189.8**

Source: CHP Installation Database, ICF, June 2011

Allentown Wastewater Treatment Plant

- Developed its 360 kW microturbine CHP system under a Master Energy Savings agreement with its local utility.
- Under the arrangement, installation of the system was funded through a 10year lease/purchase agreement, and an O&M agreement with the utility provides for fixed O&M costs (with an escalator) through 2014.
- In exchange, the facility receives guaranteed energy savings achieved

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Biogas Projects

- PEI Power, Archbald, PA
- Bergen County Utilities Authority, Little Ferry, NJ (CHP)
- Apex Landfill, Las Vegas, NV

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Barriers of Recycled Energy

- Inconsistent interconnection requirements between states and even between utilities
- Potential interconnection delays
- Standby and back-up power charges from the utility that can adversely affect project economics
- Air regulations that do not recognize the environmental benefits of CHP]
- Non-standardized, time-consuming environmental permitting process
- Complex local ordinances regarding siting, zoning, fire code, etc...
- Volatile natural gas prices and "spark spread"
- Facility managers unaware of the benefits of on-site power generation
- On-site generation systems' lack of a specific tax depreciation category -- CHP systems can qualify for one of several categories depending on configuration and ownership resulting in a depreciation period ranging from 5 to 39 years
- Utilities' lack of standard data, models, or analysis tools for evaluating DG, or standard practices for incorporating DG into electric system planning and operation

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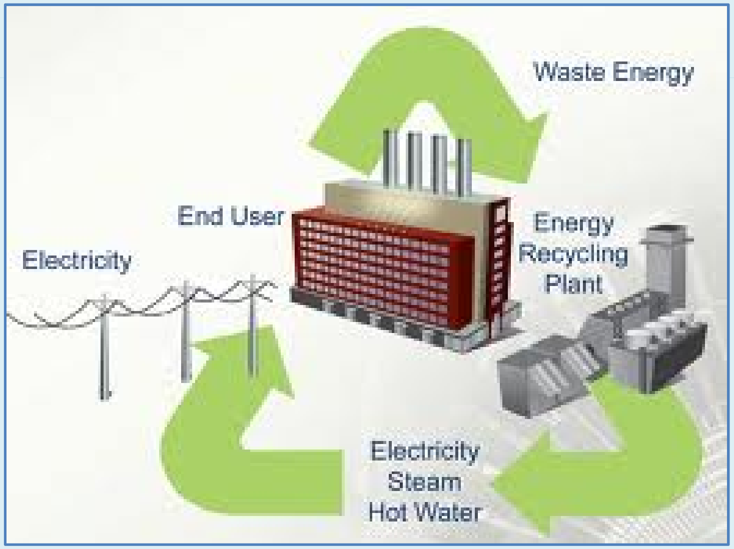
Overall Benefits of Recycled Energy

❖ **For Owners:**
- Improved fuel efficiency - *up to 2/3 savings in fuel costs*
- Improved power quality & reliability
- Improved energy cost predictability
- Business continuity
- Energy security



Overall Benefits of Recycled Energy

For Society:

- Reduced emissions per unit of useful output - *up to 33%-50% reduced emissions*
- No ratepayer investment required in generating, transmitting or distributing power
- Reduced land-use impacts and NIMBY objectives
- Reduced fresh water use
- Optimized natural gas and reduced price volatility - up to 40% greater efficiency than conventional units
- Creation of new high-tech manufacturing sector in domestic and export markets
- Support of competitive electricity market structure

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Overall Benefits of Recycled Energy

For Electric Utilities:

- Reduced energy losses in transmission lines - *current transmission losses are about 10%*. Clean energy requires no remote transmission and therefore sustains no transmission losses.
- Reduced upstream congestion on transmission lines
- Reduced or deferred infrastructure (line and substation) upgrades
- Optimal use of existing grid assets, including the potential to free up transmission assets for increased wheeling capacity
- Less capital tied up in unproductive asset
- Improved grid reliability
- Higher energy conversion efficiencies than central generation
- Faster permitting than transmission line upgrades
- Ancillary benefits including voltage support & stability, contingency reserves and black start capability

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Wrap-Up & Questions

Thank you for your time today.

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