CHP Combined Heat & Power in Kentucky

Kentucky CHP Program Workshop –November, 2014

DEDI KENTUCKY DEPARTMENT for ENERGY DEVELOPMENT & INDEPENDENCE

KENTUCKY ASSOCIATION OF MANUFACTURERS

U.S. DEPARTMENT OF ENERGY
CHP Technical Assistance Partnerships
SOUTHEAST

KPPC
Kentucky's Resource Center for Environmental Sustainability

CHP
Combined Heat & Power
in Kentucky

CHP 101 and Opportunities

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Outline

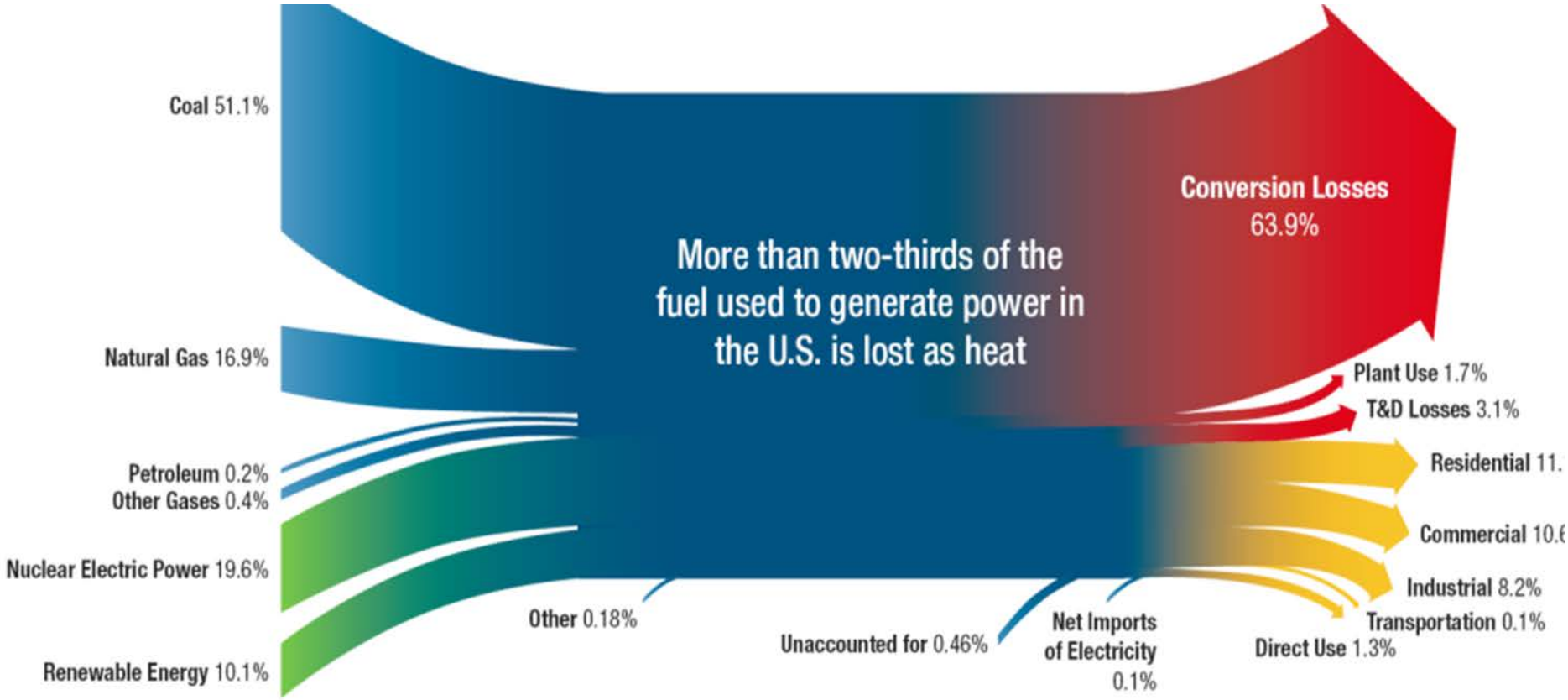
- CHP 101
  - What is CHP and Benefits?
  - Technical Potential for CHP in Kentucky
  - Case Studies
  - Barriers to CHP
- Win-Win Strategies for CHP

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 or
  - dehumidification
- Can utilize a variety of technologies and fuels

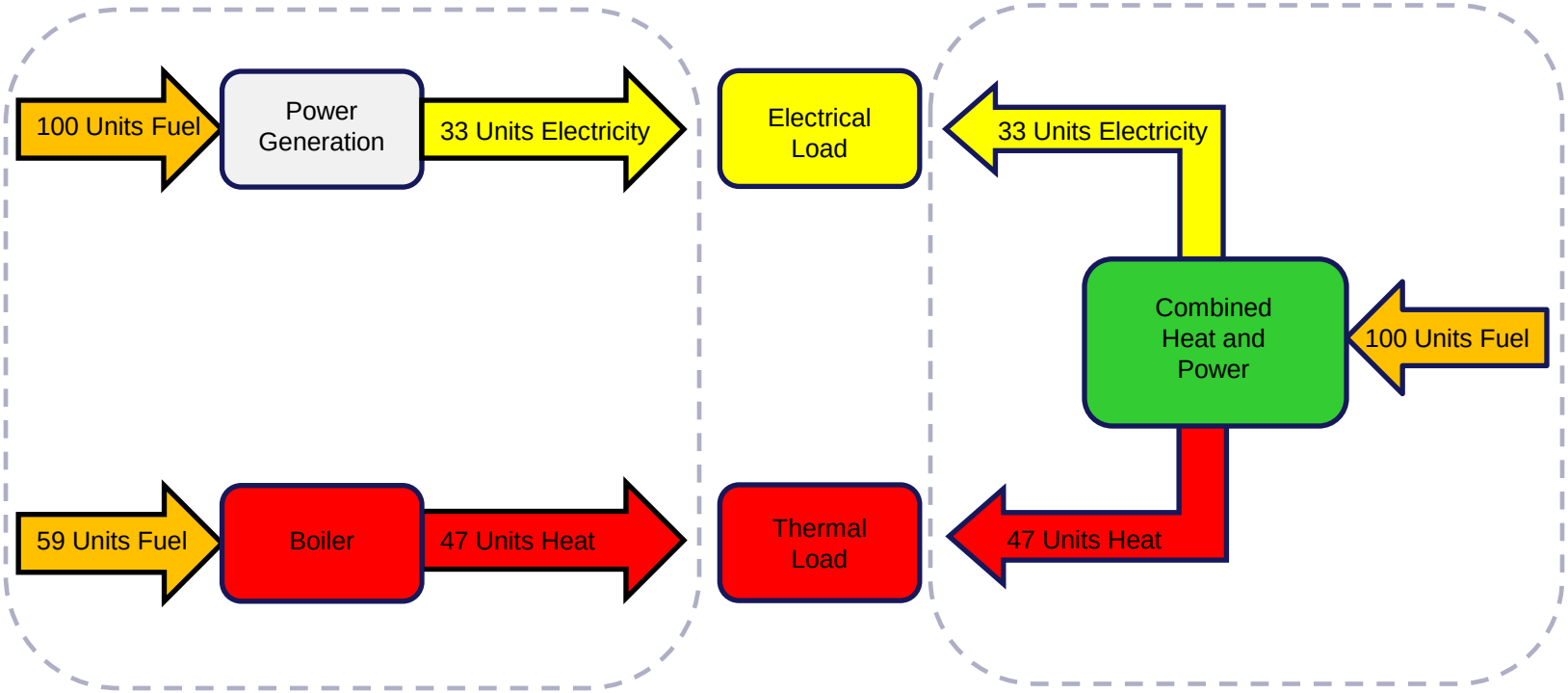
Fuel Utilization by US Utility Sector



Source: http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_report_12-08.pdf

Traditional Generation vs CHP

Combined Heat & Power (CHP) is the simultaneous generation of both electricity and useful heat



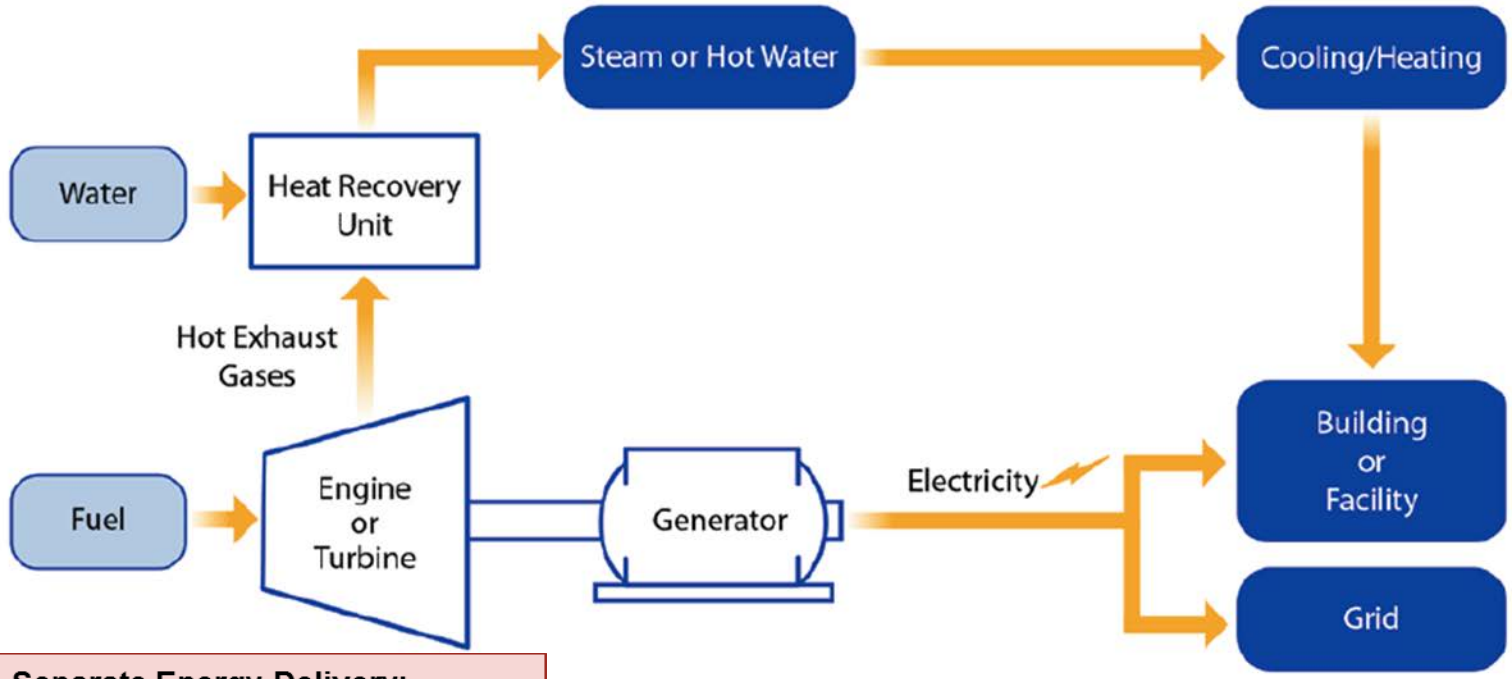
50% EFFICIENCY

80% EFFICIENCY

Defining Combined Heat & Power (CHP)

Conventional CHP

(also referred to as Topping Cycle CHP or Direct Fired CHP)



Separate Energy Delivery:

- **Electric generation – 33%**
- **Thermal generation - 80%**
- **Combined efficiency – 45% to 55%**

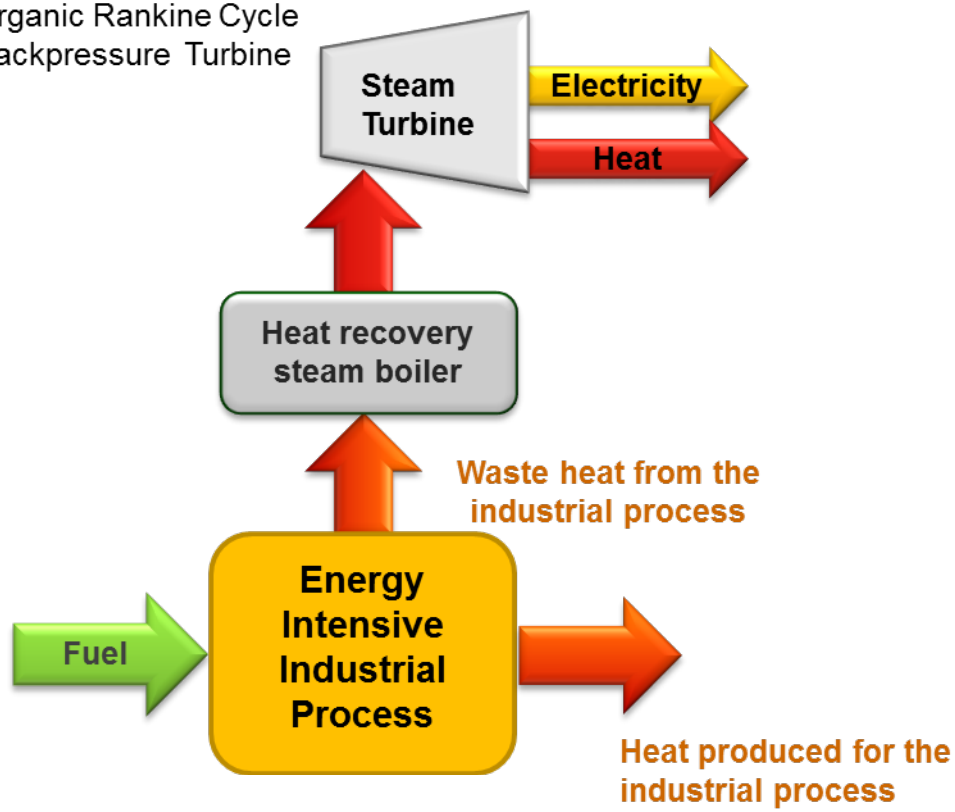
CHP Energy Efficiency (combined heat and power)
70% to 85%

Defining Combined Heat & Power (CHP)

Waste Heat to Power CHP

(also referred to as Bottoming Cycle CHP or Indirect Fired CHP)

HRSG/Steam Turbine
Organic Rankine Cycle
Backpressure Turbine



- Fuel first applied to produce useful thermal energy for the process
- Waste heat is utilized to produce electricity and possibly additional thermal energy for the process
- Simultaneous generation of heat and electricity
- No additional fossil fuel combustion *(no incremental emissions)*
- Normally produces larger amounts electric generation *(often exports electricity to the grid; base load electric power)*

What are the benefits of CHP?

- CHP is *more efficient* than separate generation of electricity and heat
- Higher efficiency translates to *lower operating cost,* (but requires capital investment)
- Higher efficiency *reduces emissions of all pollutants*
- CHP can also *increase energy reliability and enhance power quality*
- On-site electric generation *reduces grid congestion and avoids distribution costs*

Attractive CHP Markets

Industrial

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

Commercial

- Data centers
- Hotels and casinos
- Multi-family housing
- Laundries
- Apartments
- Office buildings
- Refrigerated warehouses
- Restaurants
- Supermarkets
- Green buildings

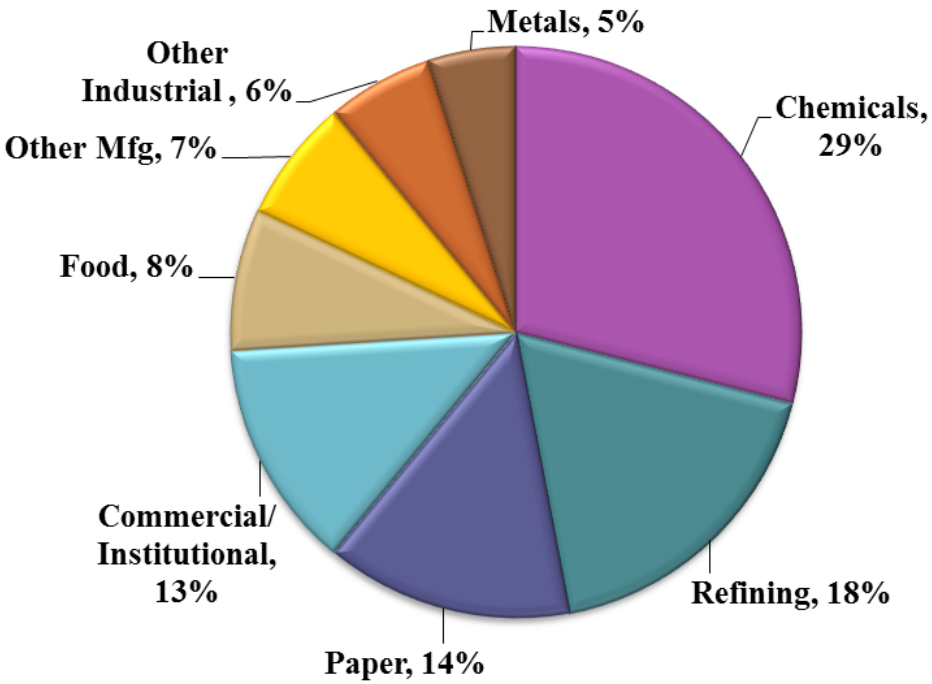
Institutional

- Hospitals
- Schools (K – 12)
- Universities & colleges
- Wastewater treatment
- Residential confinement

Agricultural

- Concentrated animal feeding operations
- Dairies
- Wood waste (biomass)

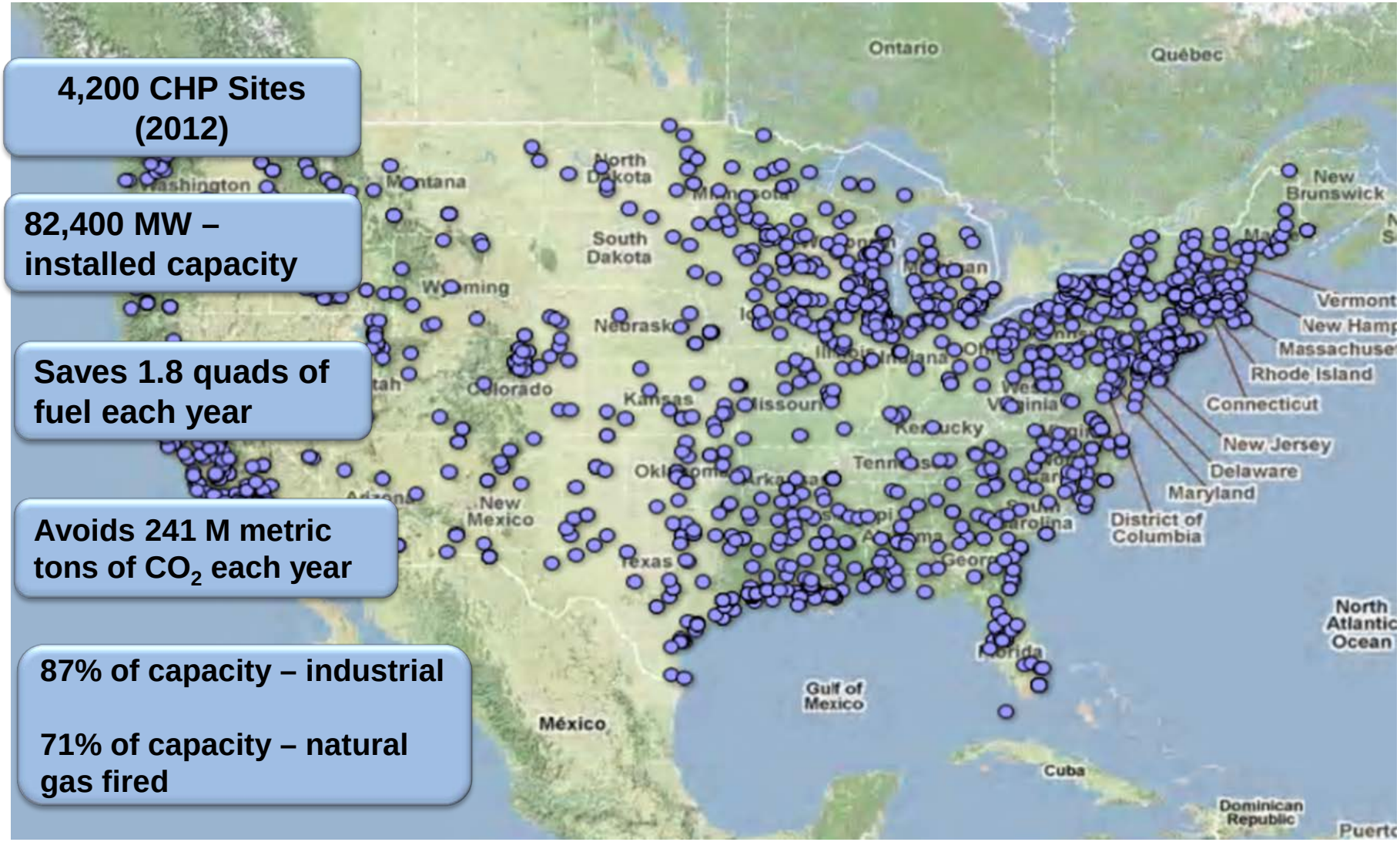
CHP Today



Source: ICF CHP Installation Database, 2012 Data

- **82.4 GW** of installed CHP over 4,200 industrial and commercial facilities (2012)
- 87% of capacity in industrial applications
- 71% of capacity is natural gas fired
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO_2** compared to separate production

CHP is used at the point of demand



4,200 CHP Sites (2012)

82,400 MW – installed capacity

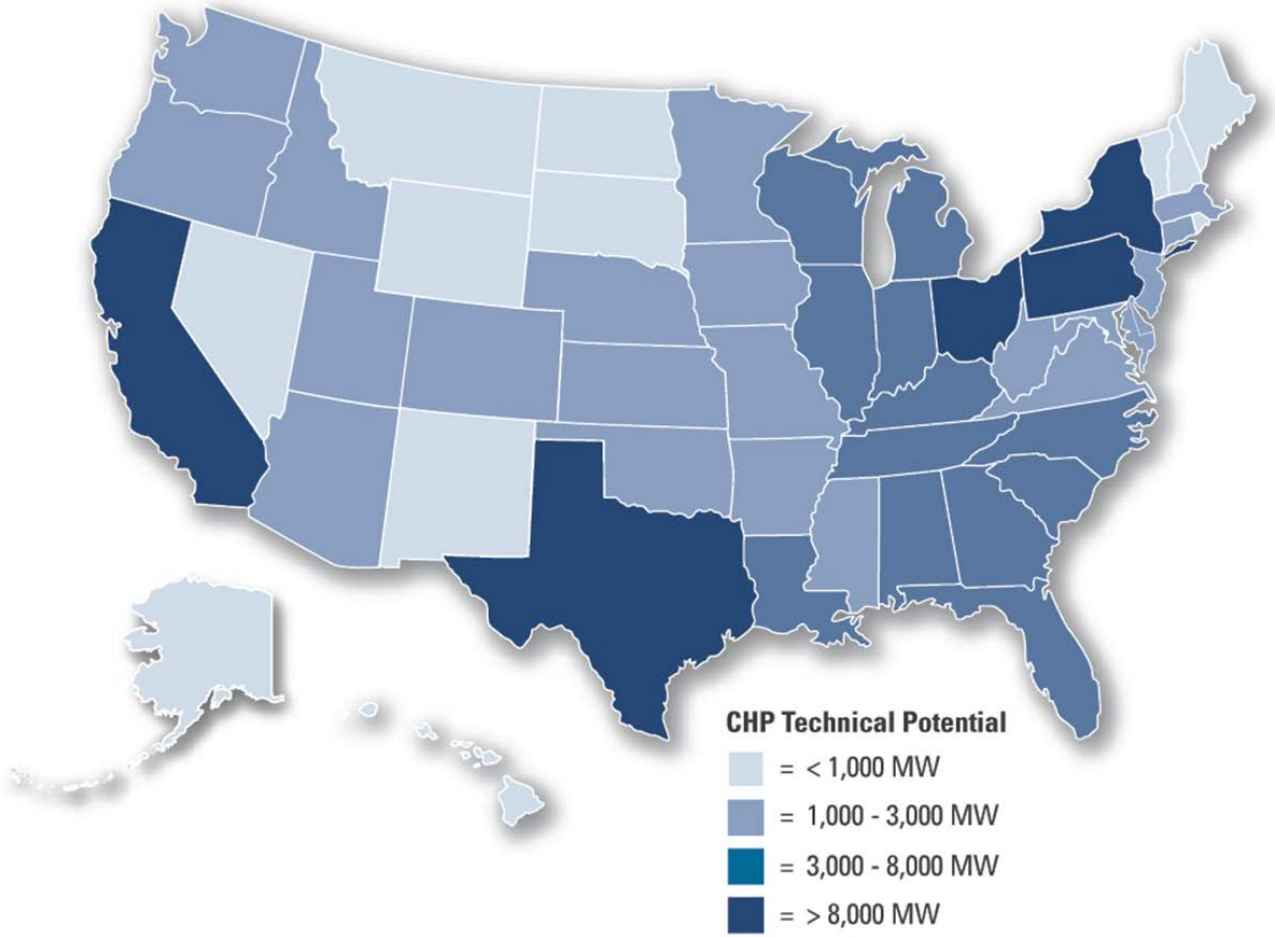
Saves 1.8 quads of fuel each year

Avoids 241 M metric tons of CO_2 each year

87% of capacity – industrial

71% of capacity – natural gas fired

CHP Technical Potential is nationwide

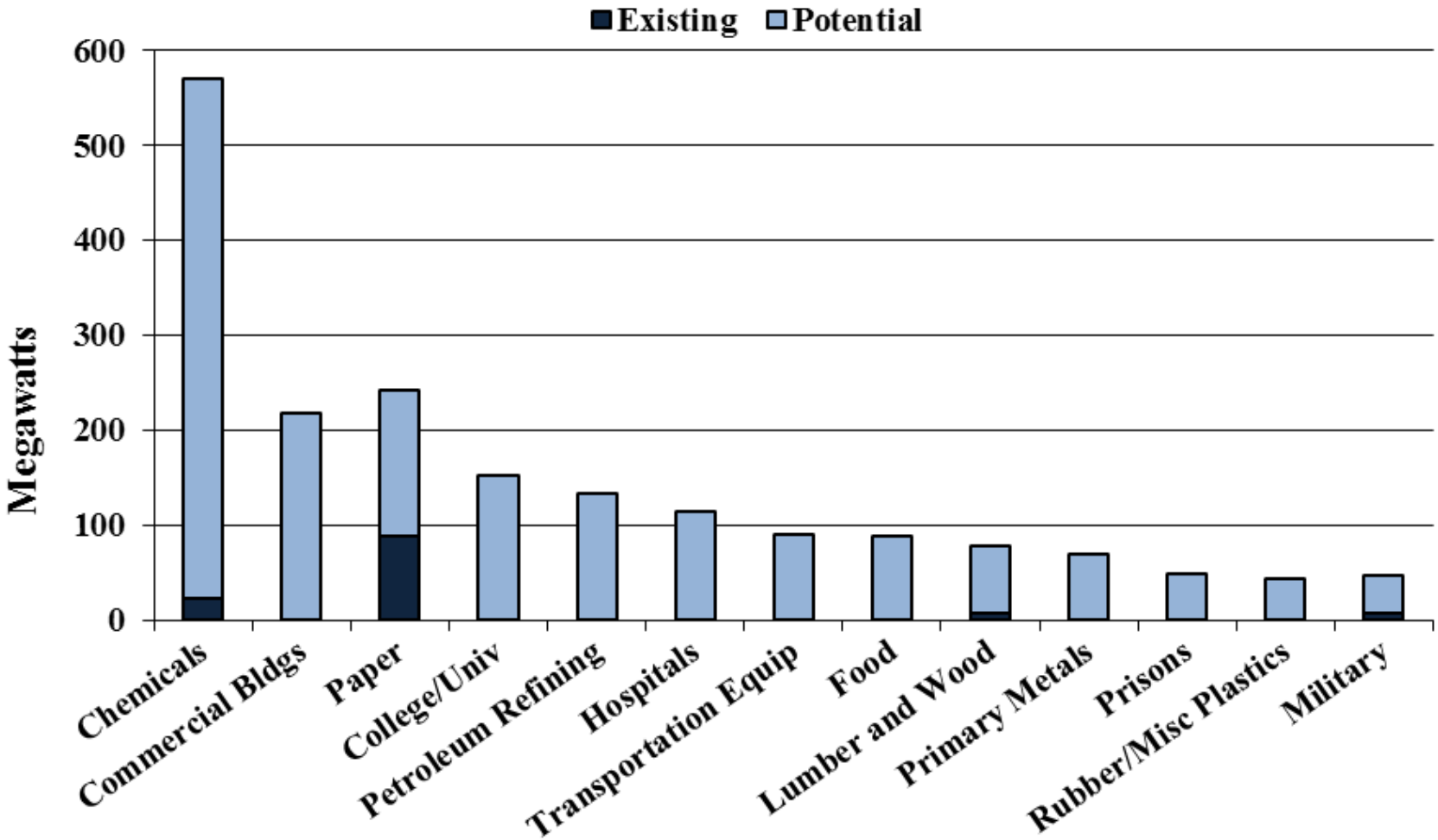


CHP Potential in Kentucky

SIC	Application	50-500 kW (MW)	0.5-1 MW (MW)	1-5 MW (MW)	5-20 MW (MW)	> 20 MW (MW)	Total MW
20	Food	11	16	44	17	0	88
22	Textiles	1	4	6	14	0	25
24	Lumber and Wood	27	19	25	0	0	71
25	Furniture	1	0	0	0	0	1
26	Paper	11	10	33	70	31	155
27	Printing	1	1	0	0	0	2
28	Chemicals	13	15	87	243	190	548
29	Petroleum Refining	0	4	11	0	118	133
30	Rubber/Misc Plastics	21	8	14	0	0	43
32	Stone/Clay/Glass	0	0	0	7	0	7
33	Primary Metals	9	7	20	33	0	69
34	Fabricated Metals	3	0	0	0	0	3
35	Machinery/Computer Equip	0	0	1	0	0	1
37	Transportation Equip	14	18	45	13	0	90
38	Instruments	0	1	0	0	0	1
39	Misc Manufacturing	1	0	0	0	0	1
49	Gas Processing	0	0	8	0	0	8
	Total	**113**	**103**	**294**	**397**	**2,184**	**3,223**

Source: ICF International-via SE CHP TAP September 2013

Existing and Technical Potential for CHP in Kentucky



Existing CHP Systems in Kentucky

Company	City	Application	Operating Year	Capacity (MW)	Technology	Fuel
Cox Interior, Inc.	Campbellsville	Wood Products	1994/2002	6.2	Boiler/Steam Turbine	Biomass
Domtar Paper	Hawesville	Wood/Paper Products	2001	88	Boiler/Steam Turbine	Biomass
Young Manufacturing	Beaver Dam	Wood Products	1988	0.55	Boiler/Steam Turbine	Biomass
Perdue, Inc.	Beaver Dam	Poultry Processing	2001	1	Reciprocating Engine	Biogas
Air Products & Chemicals	Calvert City	Chemicals	2000	23	Combustion Cycle	Natural Gas
Owensboro Grain	Owensboro	Soybean Oil	2014	9	Reciprocating Engine	Natural Gas
Total Energy Plant	Owensboro	Office Buildings	1966	0.4	Reciprocating Engine	Natural Gas
US Army	Ft. Knox	Military Base	2014	8	Reciprocating Engine	Natural Gas
Total				**136**		

CHP
Combined Heat & Power
in Kentucky

Barriers and Case Studies

Jason Volz

Energy Engineer

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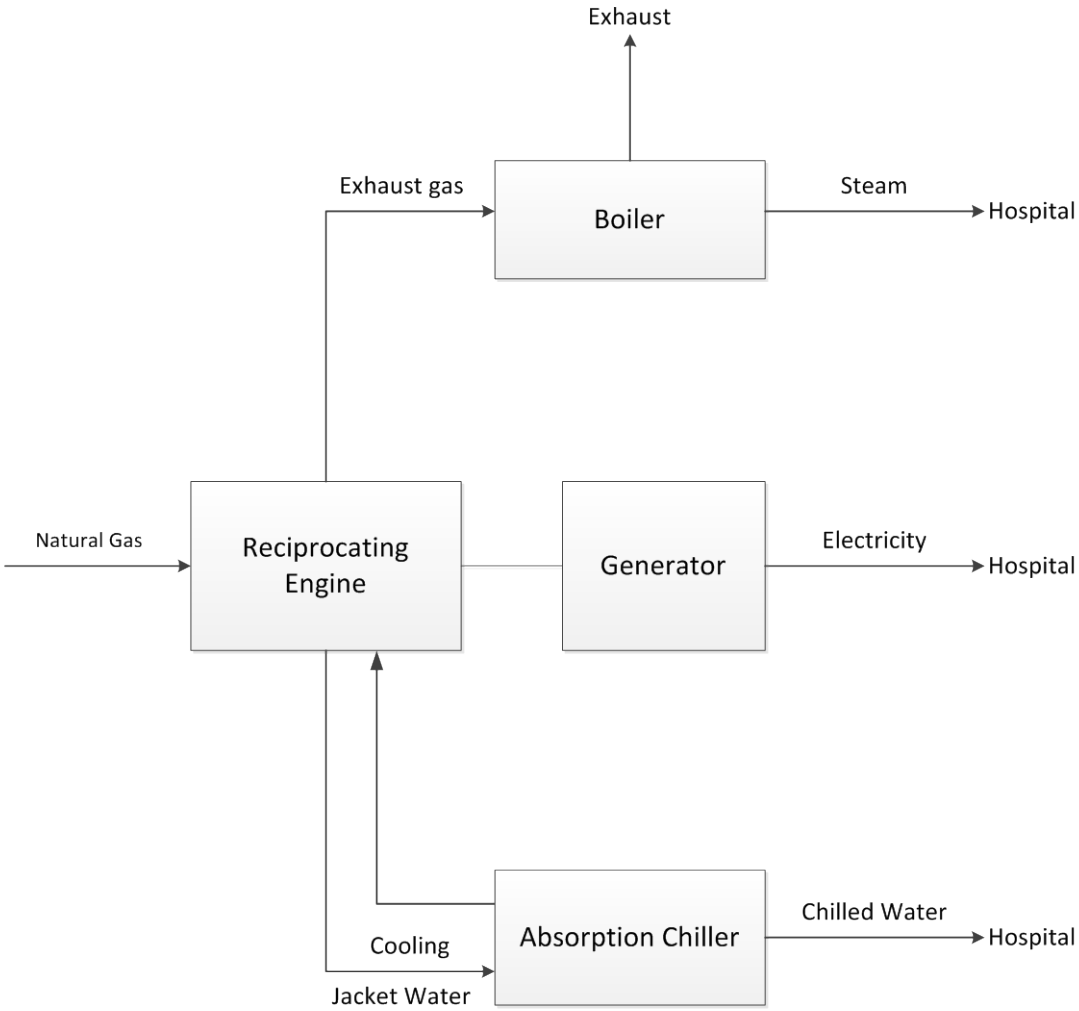
CHP Case Studies

- CHP is not always sold on economics alone
- Multiple fuel sources can be used
- Heat can be used for multiple purposes
- Case Studies (Project Profiles) located at

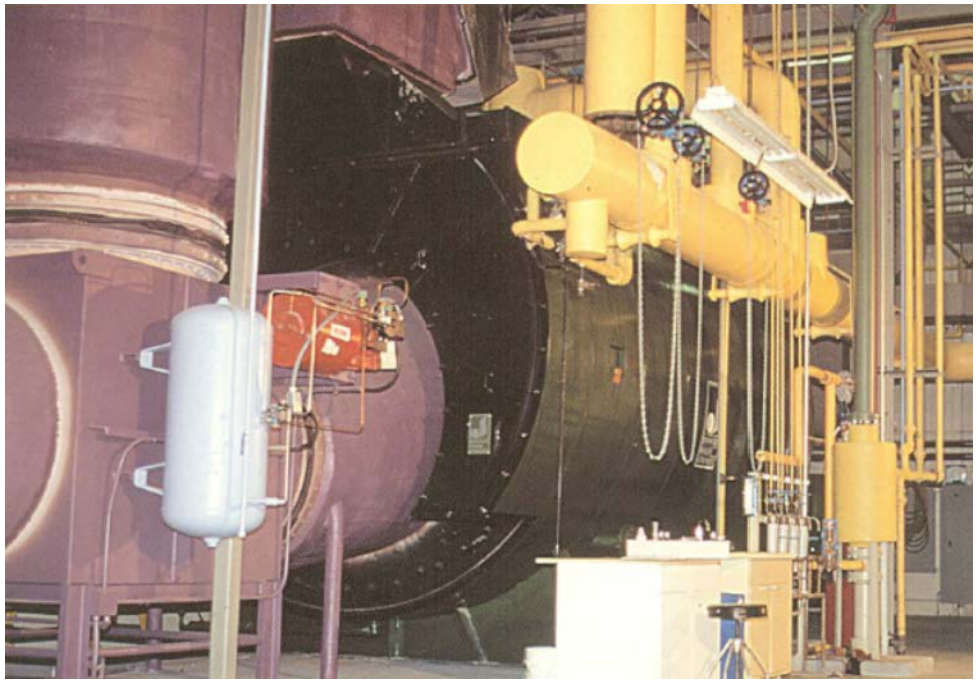
http://www1.eere.energy.gov/manufacturing/distributedenergy/projects_sector.html#healthcare

Application - Hospital



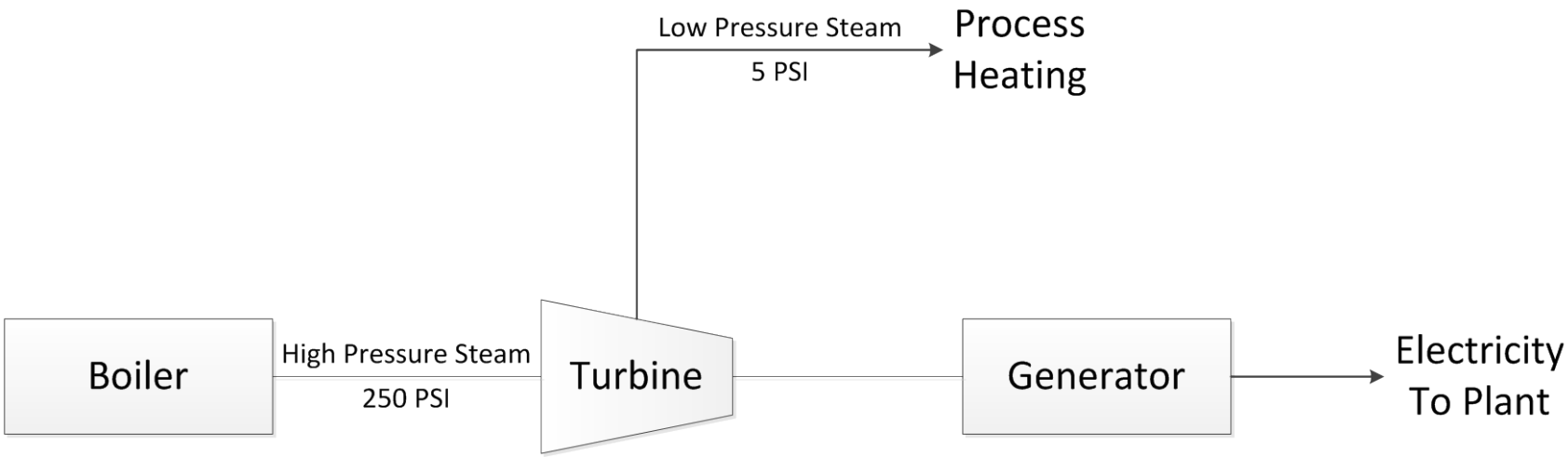
Ireland Army Community Hospital – 4MW

- 4.0 MW Lean Burn Reciprocating Natural Gas Generator
- Exhaust recovery produces 7,600lb/hr of medium pressure steam
- 640 tons of absorption cooling produced from hot water recovery
- Installed to create fully redundant heat, chilled water and power production for hospital



Waste heat boiler-exhaust driven

Application - Industry



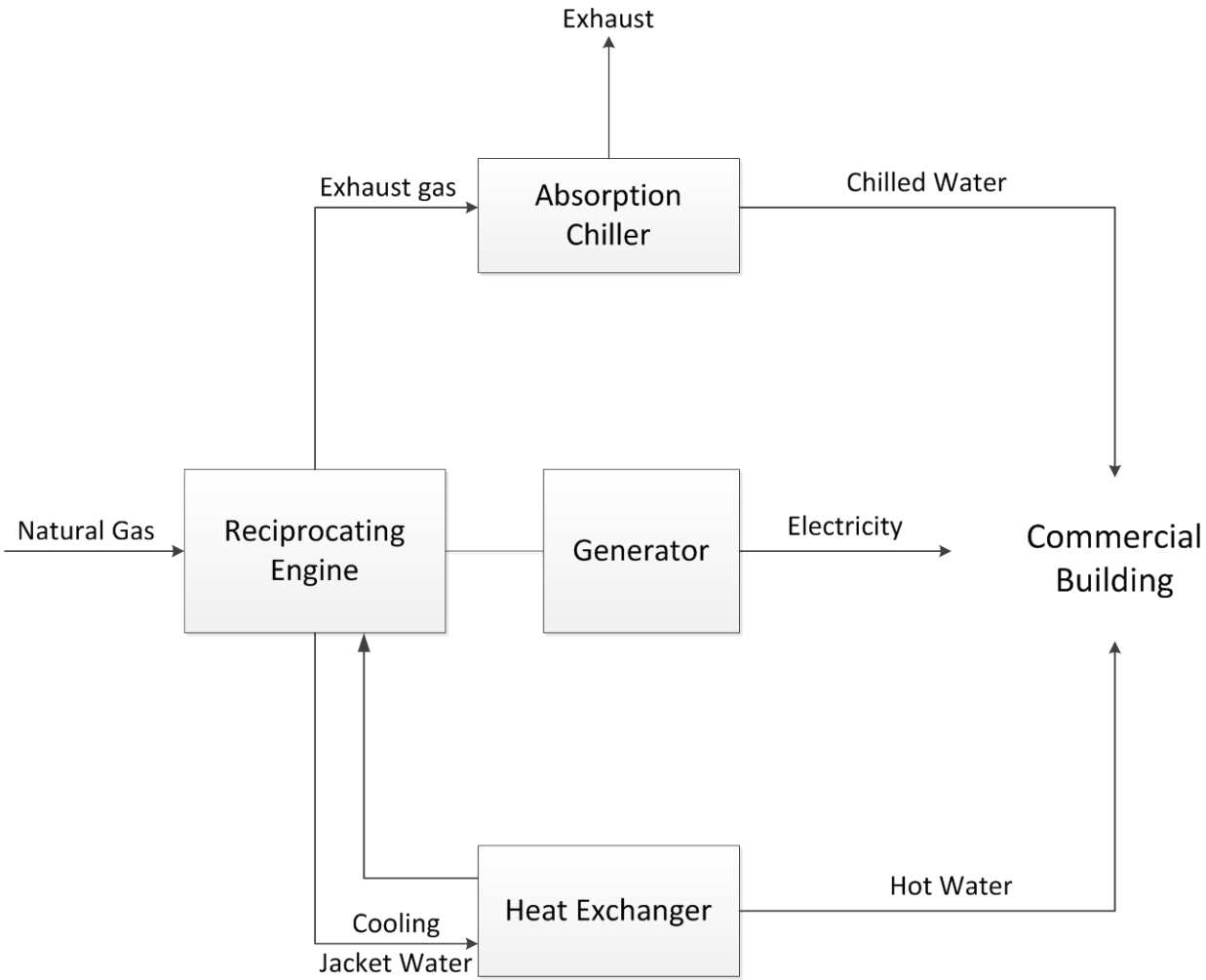
Young Manufacturing – 550 kW

- Steam was initially present for mill processes
- 2 steam turbines were installed to be powered by excess heat from steam boilers
  - 200 kW
  - 350 kW
- Boilers are fueled by mill waste

Biomass Boiler

Generator (200 kW) and turbine

Application - Commercial



US Army Retail Center – 2MW

- 2.0 MW Lean Burn Reciprocating Natural Gas Generator
- Exhaust recovery produces chilled water
- 495 tons of absorption cooling
- Hot water recovery from engine produces 6.5 MMBtu/hr
- BACT significantly reduces emissions versus traditional system

US Army Data Center

- 2,0 MW Lean Burn Reciprocating Natural Gas Generator
- Exhaust and hot water recovery produces chilled water
- 705 tons of absorption cooling serves data center CRAC units
- **CHP system serves both day-to-day and emergency power**

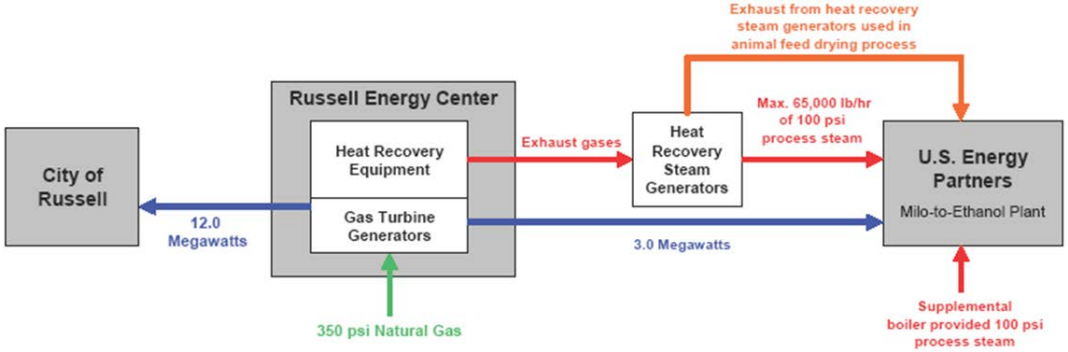
705 ton Absorption Chiller – Exhaust and hot water driven

Domtar Paper - Hawesville

- Steam produced by burning waste pulp liquor and wood biomass
- High pressure steam used to power turbine
- Turbine generates electricity at 12.47 kV
- Remaining steam used in industrial process
- 70% of plant power produced on site

Russell, KS Municipal Partnership – 15 MW

- (2) 7.5 MW combustion turbines
- Fuel by natural gas
- Heat recovery steam generators (HRSG) provides 65,000 lb/hr steam
- Exhaust from HRSG used in drying process



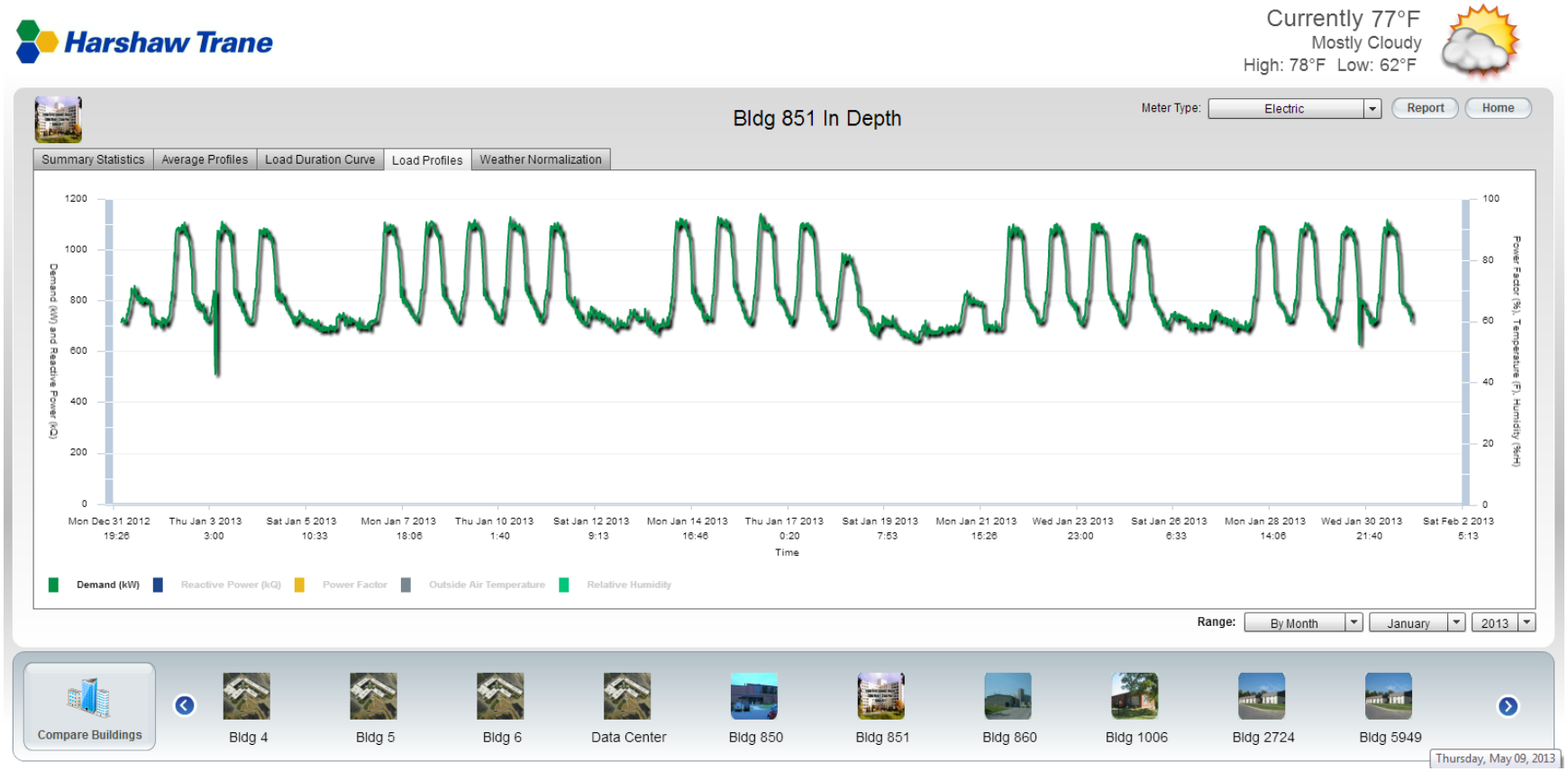
Source: http://www.midwestchptap.org/profiles/ProjectProfiles/USEnergyPartners.pdf

University of Cincinnati – 47MW

- District Heating and Cooling serving 6 hospitals and entire university
- Natural Gas Turbines and steam turbine
- 610,000 lb/hr peak steam production capacity
- 3,400 tons of absorption cooling available
- Matches grid electric reliability rating of 99.98%

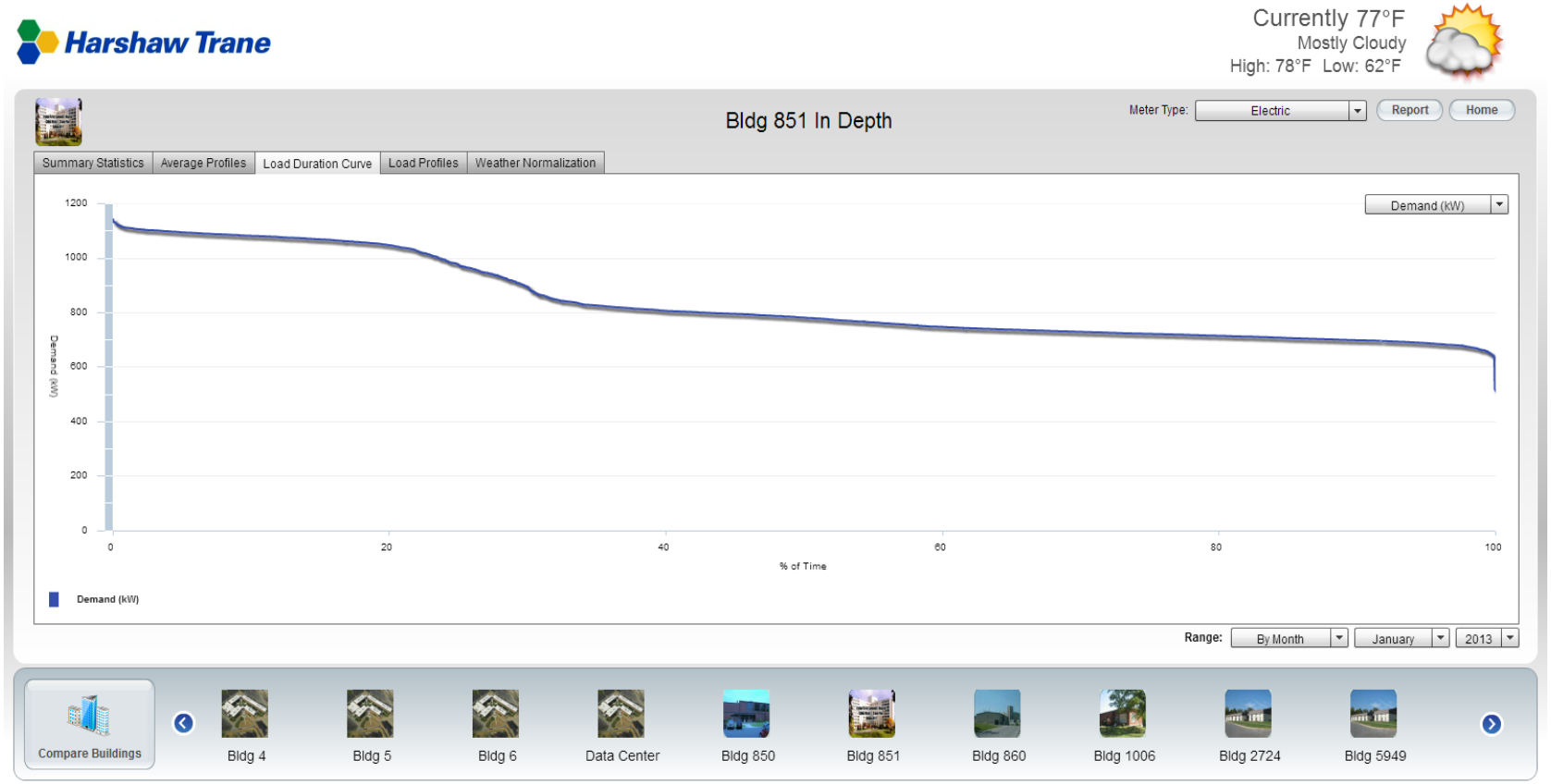
CHP Sizing and Applications

Electric Peak Load – The maximum power consumption in a 15 minute window at any point in time for a billing period. Many consumers have to pay a fee based on this maximum power demand.



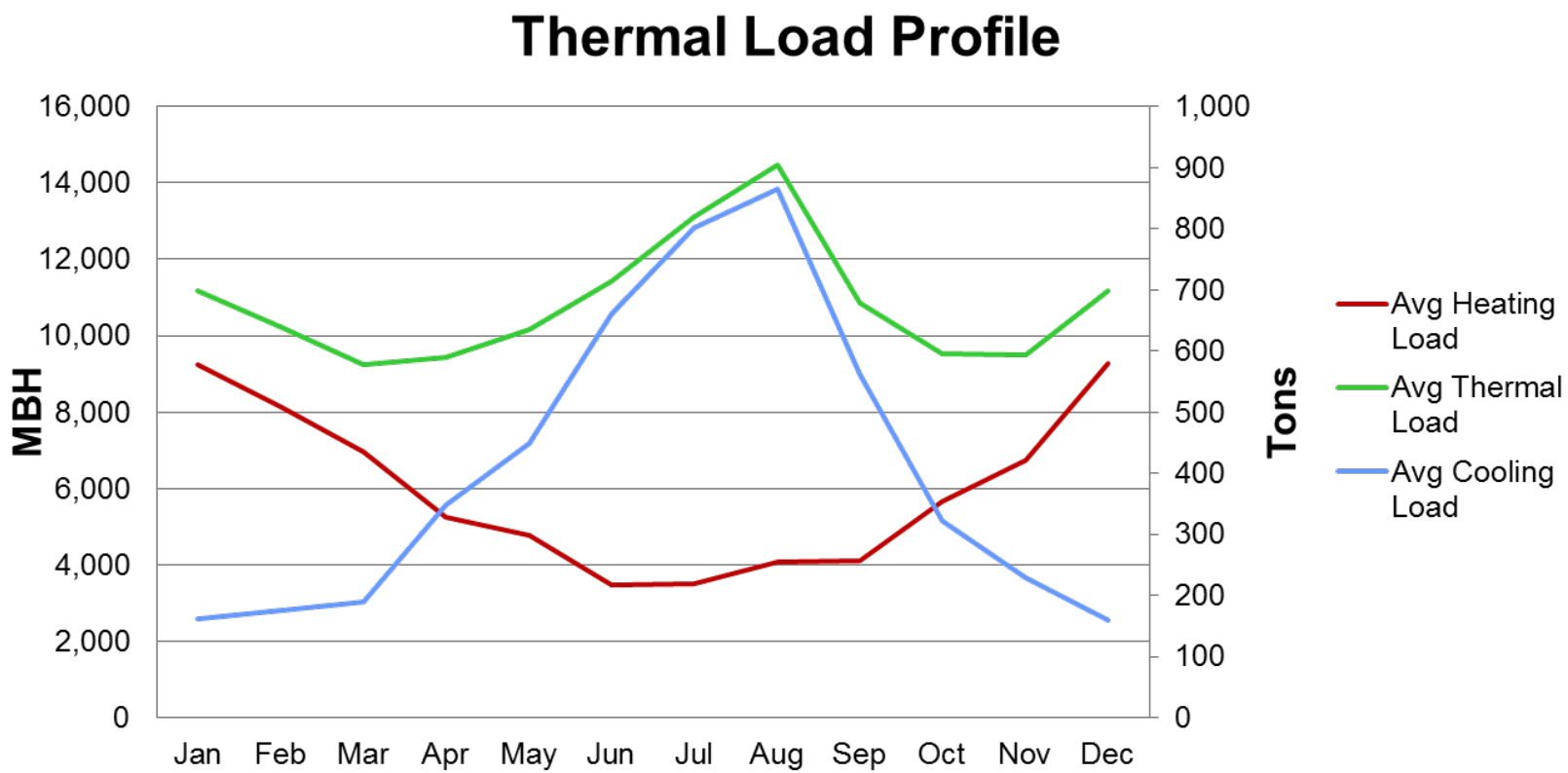
CHP Sizing and Application

Electric Base Load – The minimum power demand at any point in time. If generator capacity exceeds base load, sell excess to grid. If base load exceeds generator capacity, self consume.



CHP Sizing and Applications

Thermal Loads – It is important to understand the annual profile of the heating and cooling loads. If CHP thermal capacity exceeds thermal loads, energy is wasted or the generator unloads. If thermal loads exceed CHP thermal capacity, cycle is maximized for efficiency.



Where CHP Works

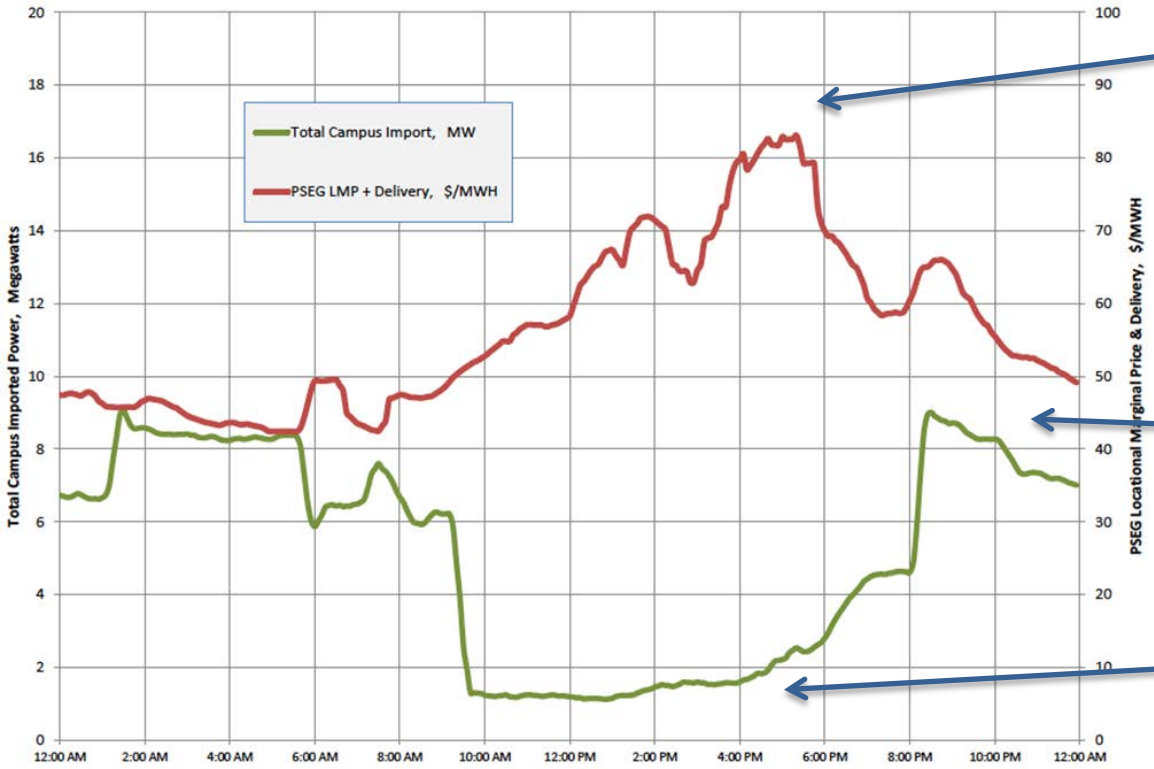
- Consistent and High Thermal Load
- High Electric Load and Demand
- High Number of Annual Operating Hours
- Need for protection against power and production interruptions

Prominent Barriers to CHP

- Large Capital Investment which many companies are not ready to make
  - Long payback periods by industrial standards
  - Not directly related to their main area of business
- Discouraged by many electric utilities
  - Utility regulatory framework often does not encourage CHP and there is poor understanding of risks/rewards
  - Utilities encouraged to invest in central station power and upgrading the present grid structure (larger rates of return on their investments)
- Increases site emissions while reducing overall
  - No credit given for emissions reduction from power plants

Win-Win Strategy

Princeton University has a 15 MW gas turbine CHP system, operated to maximize savings by reducing demand on grid during peak pricing times.



Peak utility power pricing

CHP operated at baseload to meet thermal demands

CHP operated at peak to reduce grid demand

Benefits of CHP

- Efficiency Benefits
  - CHP requires less fuel to produce same energy output
- Reliability Benefits
  - Helps mitigate risk of electrical power outages
- Environmental Benefits
  - Lower Emissions by over 60% from traditional system
- Economic Benefits
  - The increase in efficiency can save facilities considerable money on their energy bills. The change in fuel can provide a hedge against unstable energy costs.

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Bowling Green, KY
Date 11/6/14

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