Combined Heat and Power
Steam & Electricity

Work and the BTU

PA AQTAC meeting

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Council of Industrial Boiler Owners

What I Will do Today

- Consider the background for Combined Heat and Power (CHP)–
  The need for steam & electric energy to do work
- Look at how steam and electricity are used to do work –
  Try to answer the question of, Why Steam and Electricity?
  Address Energy, Work and the Thermal Reality.
- Discuss what Combined Heat and Power (CHP) is and why?
  Provide links to the technical details of CHP.
- Talk about the needs and drivers for CHP
- Have plenty of time for questions

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The Background for Combined Heat and Power (CHP)

It Takes Energy to make or do anything!

Dry cloths, make paper or textiles , evaporate water, make a cup of coffee, go to the store, keep warm in the winter or cool in the summer or clean up the environment.

Where does it come from?

The Sun, processed and stored sunshine (food & fuel) or geothermal heat converted into a usable energy product

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The Background for Combined Heat and Power (CHP)

STEAM

- Primarily used to replace horses and mechanical drives to do work
- Then came heating
- Then to make electricity
- Then came cooling

WHY ? To do work.

ELECTRICITY

- Primarily for lighting
- Then Mechanical energy – motors and drives
- Then for heating cooling and cooking

WHY? To see & do work.

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WORK and the BTU to do Work

The British Thermal Unit:

A unit of energy equivalent or the amount of heat needed to raise the temperature of 1 pound of water 1 degree F

Wikipedia Definition:

"The British thermal unit (BTU or Btu) is a unit of heat; it is defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. It is also part of the United States customary units. Heat is now known to be equivalent to energy. The modern SI unit for heat and energy is the joule (J); One BTU equals about 1055J."

Or, Relative to Exercise, 1 BTU equals about 252 calories.

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Why Steam & Electricity?

STEAM

- Relatively easy but not simple to make from available fuels
- 1000 BTU available for work for every pound of water evaporated
- Distribution piping, insulation and application systems needed
- High pressures and temperatures possible– efficiency 70 to 94%

Electricity

- Primarily used for lighting, motors, & comfort heating and cooling
- Wires instead of piping. Grid/Micro grid interconnection needed
- The convenient source of energy as long as it is there

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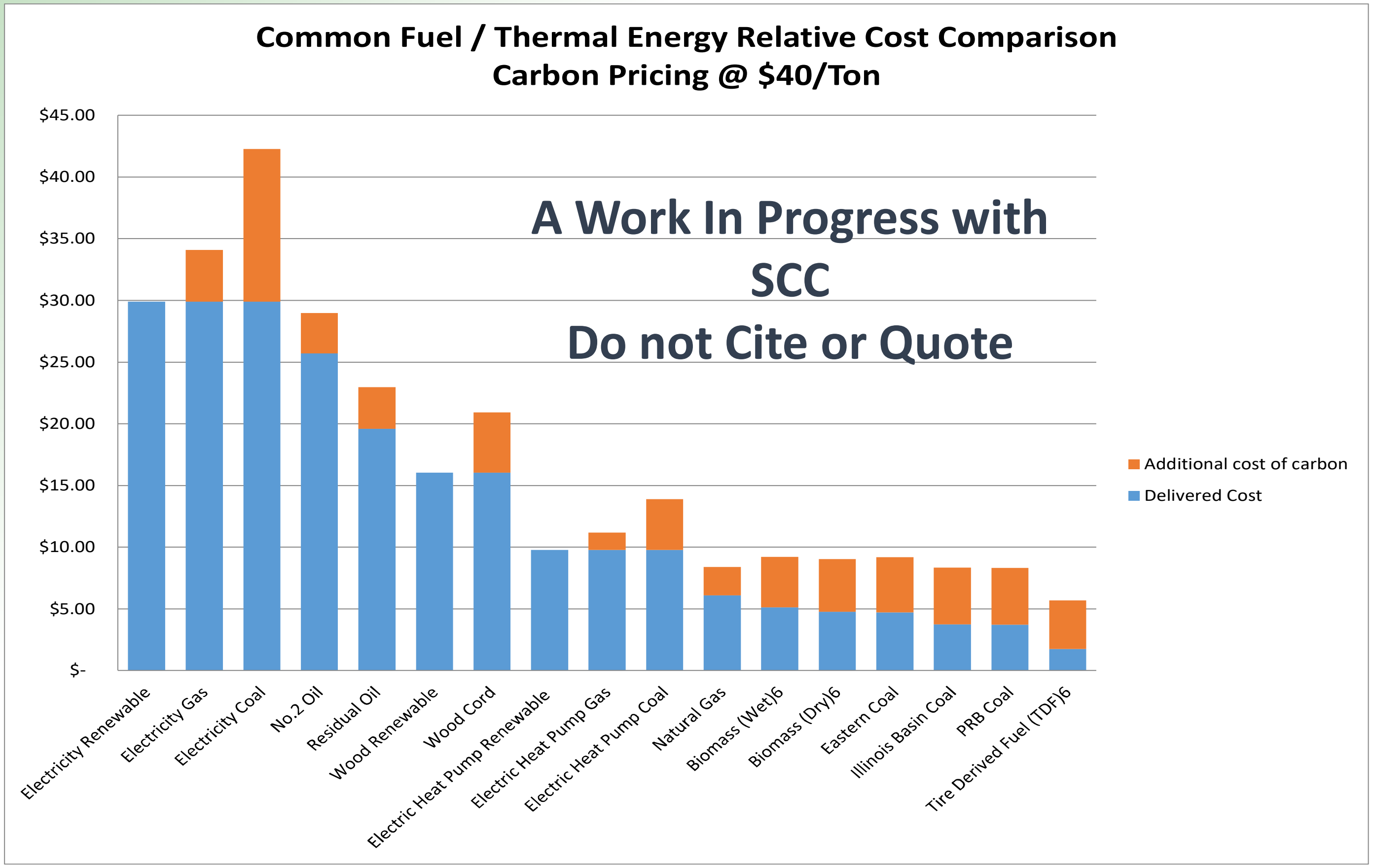
Work and Thermal Energy Reality



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Energy Costs Dollars

It takes energy and costs dollars to make or do anything.

When looking at the cost of thermal energy for doing work, it is easy to understand why some sources of energy are selected for different applications.

< https://www.cibo.org/wp-content/uploads/2020/03/Example-Fuel-Comparison-for-Thermal-Energy-R8.xlsx >

The addition of a Social Cost of Carbon (SCC), does not change that, other than the overall cost of energy goes up for everyone.

Wherever there is a Thermal Energy Demand there is a place to save energy and decrease the need for new electric generation or displace the use of high GHG emitting electric generation.

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Combined Heat and Power (CHP)

- Combined heat and Power (CHP) or cogeneration is the sequential production of two forms of useful energy from a single fuel source.
- In most CHP applications Chemical energy in fuel is converted into mechanical and thermal energy to do the work needed.
- In Boiler systems, fuel energy is converted to steam at higher temperatures and pressures than process needs to generate electricity without the need to condense the steam at a significant loss of efficiency.
- In Combustion Turbine systems, fuel is directly combusted to generate mechanical energy (electricity) and waste heat is used for additional electricity or Thermal Energy needs.

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Considerations for CHP Applications

Combined Heat and Power Technical Information

- Guide to Combined Heat and Power Systems for Boiler Owners and Operators (energy.gov)
- Combined Heat and Power: Effective Energy Solutions for a Sustainable Future (Technical Report) | OSTI.GOV
- A Thermodynamics Overview of Cogeneration and Combined Cycle Power vs. Conventional Steam Generation | Power Engineering (power-eng.com)

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The Needs and Drivers for CHP

PEOPLE!

The Needs and Drivers for CHP

ENERGY

- Energy is a commodity and not of concern. Energy is Electricity.

ENVIRONMENTAL

- Zero GHG emissions by 2050 is the goal of the ENGO and activist community.
- Fossil fuels are not welcome.

TECHNOLOGICAL

- The technology to do anything by 2050 will be there.
- Electrification with renewable energy is the answer to all energy questions.
- Thermal energy is what? Electricity?

SOCIETAL

- Millennials are here! "Social Responsibility" is demanded.
- Cost is of no concern.

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The Demand for GHG Action

The New Buzz Words

- Sustainability
- Resilience
- Mitigation
- Adaptation
- Net Neutral

- Renewable Energy
- Electrification
- Reliability
- Social Responsibility
- Environmental Justice

Policy Words

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The Functional Components of Sustainability

The seldom heard words…

Energy, Thermal Energy & Economics

&

How to do it

CHP has a positive impact on all the above

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Questions

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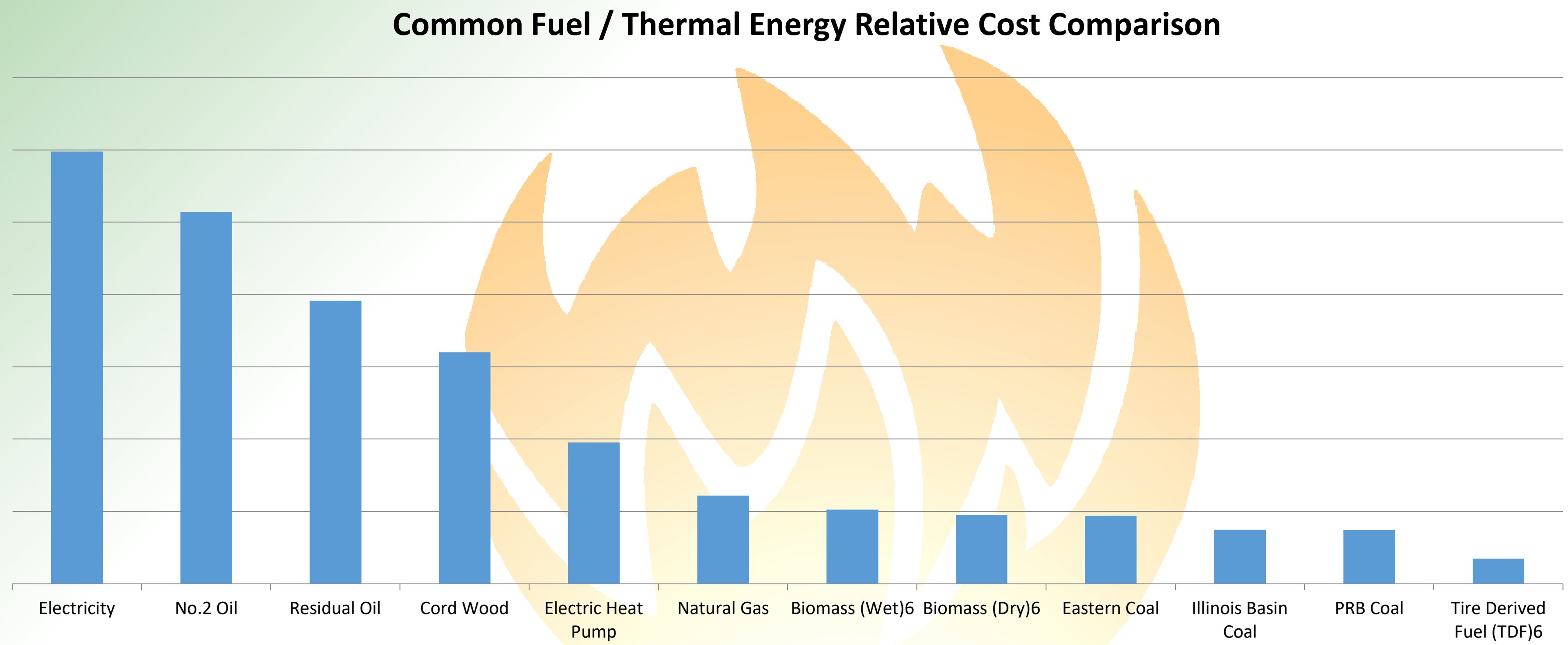
Thermal Energy Cost Comparison by Fuel



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9/2/2015

Common Fuel/ Thermal Energy Equivalent Comparison[1]

Industrial and Commercial Applications

Fuel	Delivered Cost[2]	Units[3]	BTU/Unit[4]	Conversion Efficiency[5]	$/MMBtu Thermal Energy
Electricity	$ 0.10	$/kwh	3,413	98%	$ 29.90
No.2 Oil	$ 3.00	$/Gal (139000 Btu)	139,000	84%	$ 25.69
Residual Oil	$ 2.50	$/Gal (152000 Btu)	152,000	84%	$ 19.58
Cord Wood	$ 150.00	$/cord (2600 lbs/cord)	15,600,000	60%	$ 16.03
Electric Heat Pump	$ 0.10	$/KWh Above 20 Deg F	3,413	300%	$ 9.77
Natural Gas	$ 0.50	Therm (100000 Btu)	100,000	82%	$ 6.10
Biomass (Wet)[6]	$ 30.00	$/Ton (4,500 Btu/lb)	9,000,000	65%	$ 5.13
Biomass (Dry)[6]	$ 40.00	$/Ton (6,000 Btu/lb)	12,000,000	70%	$ 4.76
Eastern Coal	$ 100.00	$/Ton (12,500 Btu/lb)	25,000,000	85%	$ 4.71
Illinois Basin Coal	$ 70.00	$/Ton (11,000 Btu/lb)	22,000,000	85%	$ 3.74
PRB Coal	$ 55.00	$/Ton (8,700 Btu/lb)	17,400,000	85%	$ 3.72
Tire Derived Fuel (TDF)[6]	$ 40.00	$/Ton (13,500 Btu/lb)	27,000,000	85%	$ 1.74

1. All information is given for relative comparison purposes. Site specific information can be inserted to obtain more accurate comparisons for an individual site.
2. Costs are considered as delivered to the burner for conversion to usable energy
3. Units are presented as normally seen with a typical "As Received" Higher Heating Value energy content.
4. Btu per unit are given as typical. Site specific information can be inserted to obtain more accurate comparisons for the individual site.
5. Efficiency percentages given are typical for conventional boiler/heating systems including moisture and flue gas losses at a boiler exit temperature of around 350 degrees F. Site specific information can be added to obtain more accurate results.
6. Considered opportunity fuels including fuel at $15.00/ton plus transportation, processing, handling, and delivery costs to the furnace. Fuel costs can vary widely based on demand and local availability. In some cases the cost of the fuel could be "free".