Emissions Calculation for Cogeneration

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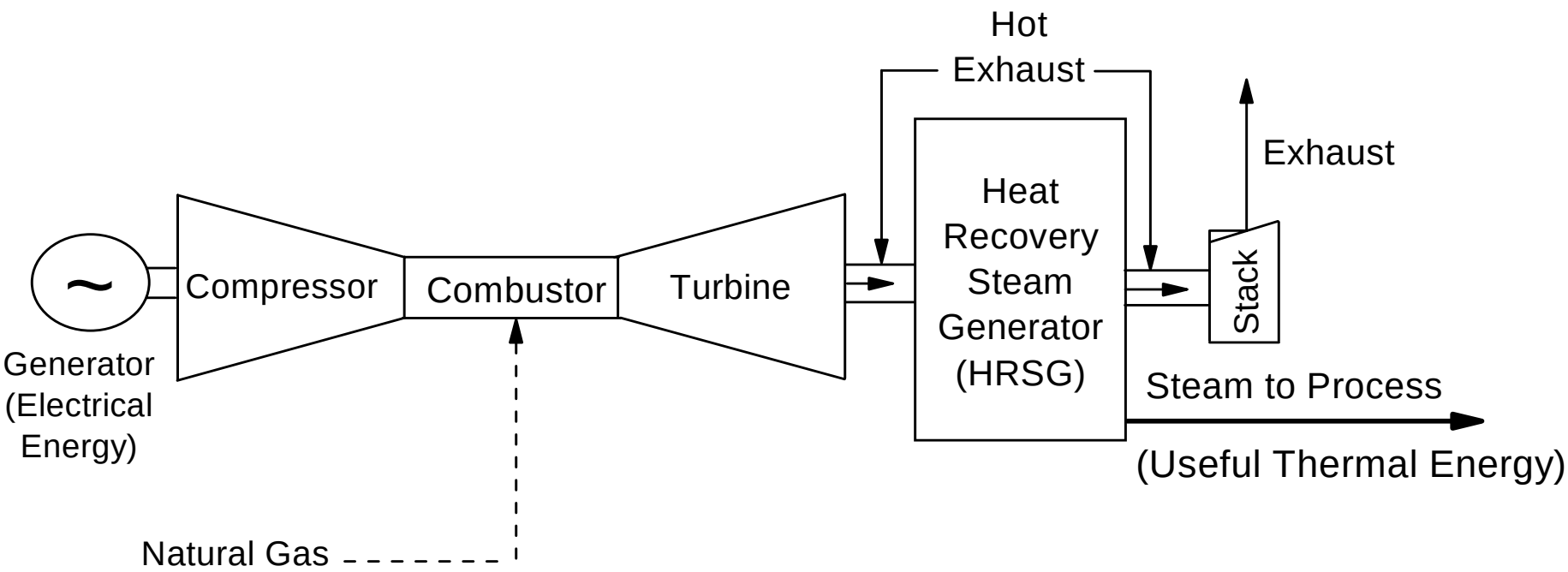
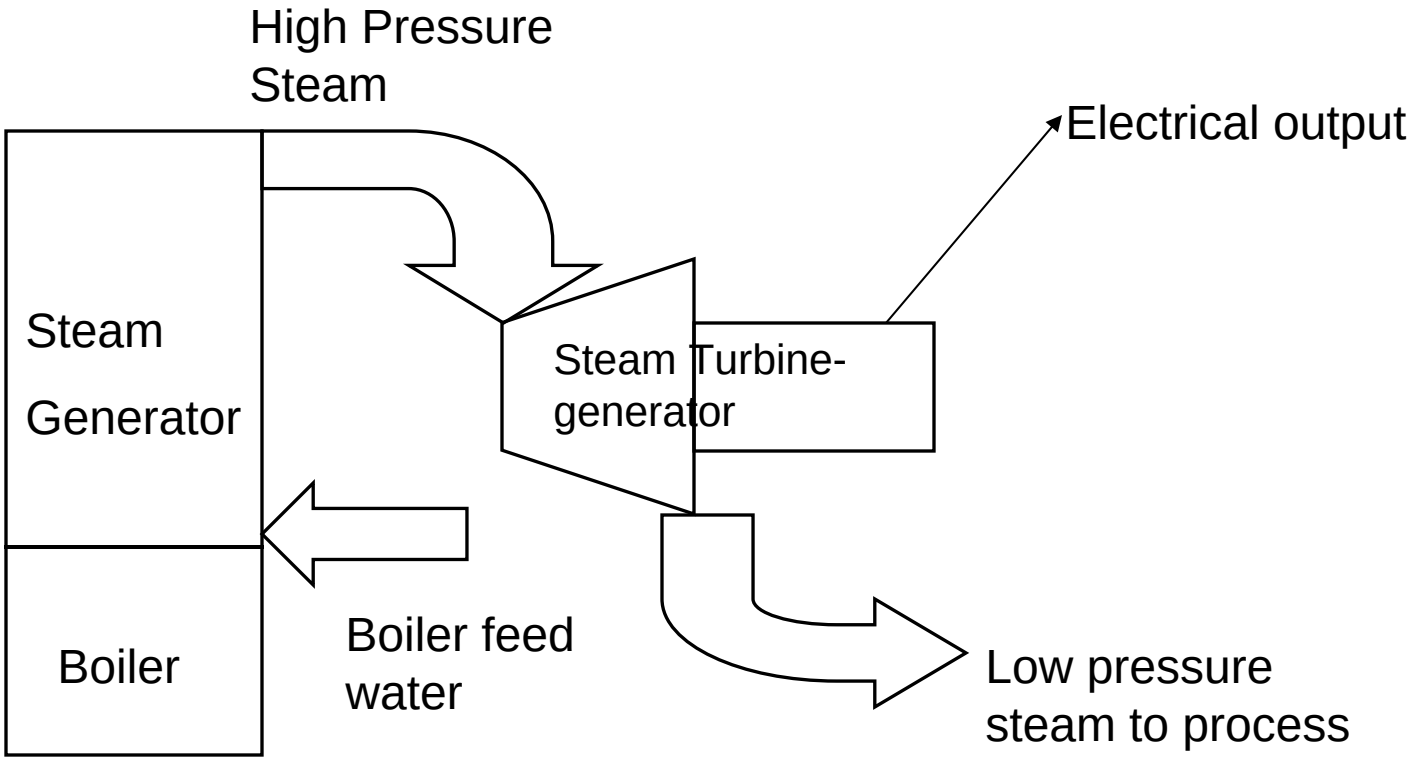
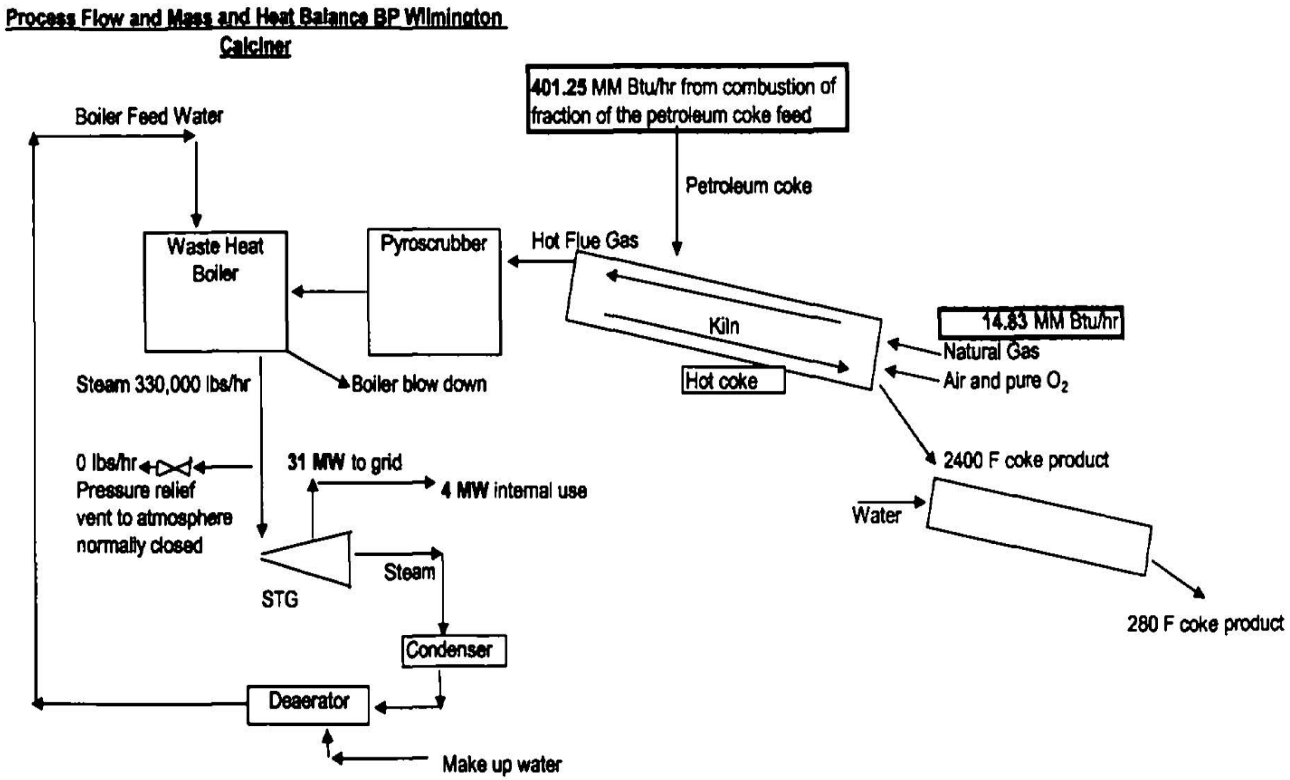
Illustrative Cogeneration Configuration



Boiler Based Cogeneration



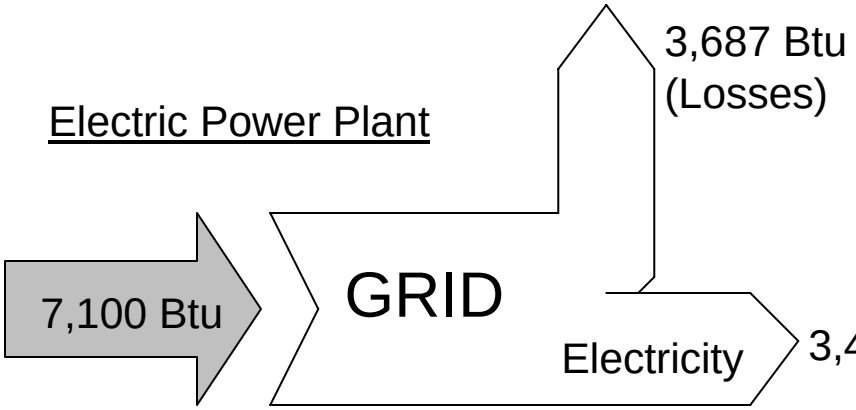
Bottoming-cycle diagram



Cogeneration (or CHP) versus Electric Power Plant Production

Electric Power Plant
Produces Only Electricity from a Single Fuel

Combined Heat and Power
Produces Electricity and Thermal Energy from a Single Fuel

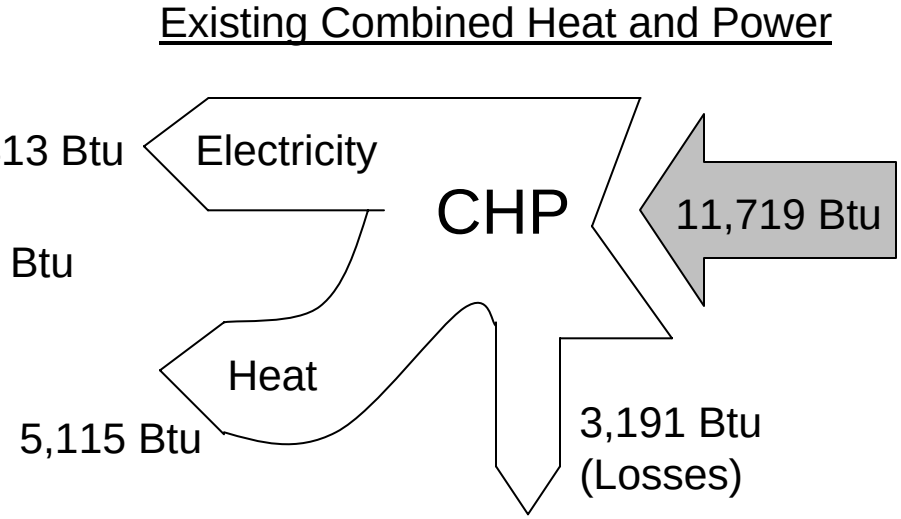


Overall Efficiency (HHV) = (3,413÷7,100)
= .481 or 48.1%

HHV Heat Rate (Btu/kWh) = $\frac{7,100}{(3,413/Fct^{1})}$

= 7,100

[1] Conversion Factor = 3,413 Btu/kWh



Overall Efficiency (HHV) = [(3,413+5,115)÷11,719]
= .728 or 72.8%

HHV Heat Rate (Btu/kWh) = [11,719÷(3,413/Fct[1])]
= 11,719

EPS for cogeneration

- All existing cogeneration fueled by natural gas or waste gas is deemed in compliance until ownership change or upgrade.
- EPS calculation methodology needed for new cogeneration and for existing units upon ownership change or upgrade.

Calculation methods

for topping cycle

- Energy content or Conversion method
  - Calculates BTUs in useful energy outputs and allocates emissions proportionately.
  - See next slide and Alan Newman's memo
- Efficiency method
  - Using efficiencies of processes, allocates input energy and emissions.
  - See CCAR suggested methodology, API Compendium
- Work potential method
  - Best for units that produce mechanical energy.
  - See API Compendium

ARN1

Illustrative Emission Rate Calculation

[using conversion method]

Power Plant

Assumptions:
LBS of CO_2 per Btu Consumed = 0.00012
Total Btu Consumed = 7,100
Total Useful Thermal Energy = 0.0 Btu
Net Electric Generation = 1 kWh
Conversion Factor (Btu/kWh) = 3,413

Combined Heat & Power

Assumptions:
LBS of CO_2 per Btu Consumed = 0.00012
Total Btu Consumed = 11,719
Total Useful Thermal Energy = 5,115 Btu
Net Electric Generation = 1 kWh
Conversion Factor (Btu/kWh) = 3,413

Calculation:

$$\text{Emission Rate} = \frac{\text{Total GHG Emissions}}{\text{kWh of Electricity + Btu Thermal Energy (Converted to kWh)}}$$

Power Plant Emission Rate (LBS/kWh)

$$\text{Emission Rate} = \frac{.00012 \times 7{,}100}{1 + (0.0/3{,}413)}$$

$$= \frac{0.852}{1}$$

$$= 0.852 \text{ LBS/kWh}$$

CHP Emission Rate (LBS/kWh)

$$\text{Emission Rate} = \frac{.00012 \times 11{,}719}{1 + (5{,}115/3{,}413)}$$

$$= \frac{1.406}{1 + 1.499}$$

$$= 0.563 \text{ LBS/kWh}$$

Slide 8

ARN1 For the cogeneration example, what happened to the dividethe useful thermal energy by 2 factor in the Part 292 rule? What rationale or grounds would we have to ignore that aspect of the rule?

Alan R. Newman, 9/27/2007

Calculation for bottoming-cycle

- Useful outputs may be industrial commodity and electricity. May have no useful thermal output.
- Alternatives:
  - treat electricity as carbon-neutral and allocate all emissions to process.
  - Allocate between electricity and industrial commodity.