A Better Approach To Energy Performance Benchmarking

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Texas Technology Showcase 2006
Galveston, TX

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Current Industry Challenges

- High energy costs driving need for improved efficiency
- The industry is asking:
  - What is the best I can do with my existing plant?
  - How do I design energy efficiency into new expansion projects?
- Effective energy performance benchmarking & analysis required to develop sound energy saving strategies

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Limitations In Typical Methods

- Typical energy benchmarking approaches have inherent limitations:
  - Not based on any fundamental or intrinsic definition of energy efficiency
  - Do not indicate your best, economic attainable level of energy performance
  - Heavily influenced by process plant utilization
  - Do not take into account the correct interrelationship between a site’s actual marginal fuel and power costs

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Best Energy Technology (BT)

- KBC developed a "Best Energy Technology" (BT) benchmark for refineries and petrochemical plants
  - Allowance equations for individual processes and offsites
  - Ratios actual energy consumption to allowance
    - All energy converted to fuel equivalence (MMBTU/hr)
    - Actual marginal energy economics used to convert steam and power to fuel basis
  - 100% BT is ultimate achievable level of energy efficiency
    - Grass roots refinery
    - Four year or better payback hurdle, site might economically achieve 140-150 % BT
    - Less than 100% unit BT possible with latest technology

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BT Characteristics - Process

- Best Technology is based on the following *Process Unit* characteristics:
  - Fired heater efficiency (LHV) of 92%
  - Optimum heat integration approach temperatures (delta T_{min})
  - Site Power/Heat ratio <0.6
  - No cross-pinch configurations
  - Inter-process heat integration
  - No lost heat to cool down and reheat unit feed streams
  - Favor waste heat recovery to feed versus steam generation
  - Stripping and reboiling steam rates optimized

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BT Characteristics - Utilities

- Best Technology is based on the following *Utility System* configuration:
  - 1500 psig steam system letdown to lower pressures through efficient backpressure turbines
  - Gas turbine depending on fuel and power prices
  - No steam letdowns between headers
  - No steam venting
  - Lower pressure headers supplying all process steam requirements
  - 100% plant-produced electric power
  - Optimized fuel gas composition (no excess H2 or C3+)

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BT Benchmarking Methodology

KBC's Development Work

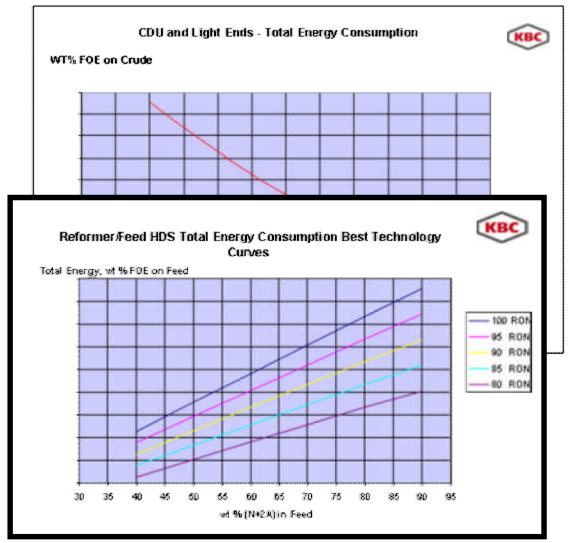
BT Configuration Development

All economically justifiable ENCON built in (4 years payback on last piece of equipment):

- Furnaces 92% eff.
- Optimised heat integration (pinch) and process features
- Efficient Steam&Power system
- All power generated at 80% eff.
- Yield efficient

Correlations Development

- BT process modelled
- Parameters affecting energy performance varied
- Sensitivity found
- Correlations using important parameters developed



Collect Process data:
- BT parameters
- Energy Balances

Calculate BT Target for all units

Apply KBC Energy Costing methodology
- PEE for power
- Steam costing

Calculate Total energy consumption for each process

Calculate BT index for each process and whole refinery

Application

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Refinery Energy Balance

MMBTU/HR	Consumption							Supplies		
Unit Name	**Fuel**	**Electric**	**Steam**	**FCC Coke**	**Unit Total**	**Allow.**	**BT**	**Source**	**FOEB/KW**	**MMBTU/HR**
Crude #1	575	38	79		692	414	167%	Produced Fuel	299,064	2,252
Crude #2	367	2	56		425	281	151%	Vaporizer	50,004	406
Hydrocracker	50	81	(55)		77	54	143%	Fuel Oil	27,957	227
HDS	26	18	11		55	20	271%	Purch Nat Gas	-	-
Aromatics	-	3	10		13	5	242%	Cracker Coke	186,838	1,520
SRU	11	2	(2)		11	18	63%			
Isom	-	3	24		27	9	290%	**Purch Power KW**	49,245	443
FCCU	-	5	88	289	382	207	185%	@37.9% PEE		
Resid Cracker	188	59	(113)	1,231	1,365	583	234%			
Alky	-	41	95		136	94	144%	Total Supplied Energy		**4,848**
Hydrogen Plant	178	8	(29)		158	117	135%			
Naphtha HT	175	30	45		250	62	401%			
Reformer #1	45	1	88		134	54	249%			
Reformer #2	218	5	(88)		135	140	97%			
Offsites Area	4	145	840		989	147	675%		**Supply BT**	
Facility Total	1,838	441	1,049	1,520	**4,848**	**2,206**	**220%**	Energy Balance	**220%**	**100.0%**

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Price Equivalent Efficiency (PEE)

$$PEE = \frac{\text{Cost of 1 MMBTU of refinery marginal fuel}}{\text{Cost of 1 MMBTU of imported power}} * 100$$

- Example, if fuel at 3.50 $/MMBTU and power at 70 $/MWh (1 MWh = 3.414 MMBTU/hr)

$$PEE = \frac{3.50}{70*(1/3.414)} * 100 = 17.1\%$$

- The cost of imported power is equal to the cost of generating own power at efficiency of 17.1 %.

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BT Steam Costing Methodology

- Costing steam on an enthalpy basis is in most cases incorrect
  - It over-estimates the cost of the LP steam - this may lead to incorrect energy strategies
- High pressure steam marginal cost is equal to the cost of producing it, i.e. cost of fuel / boiler efficiency
- Low pressure steam should be given a credit for generating power at the cost of marginal power
  - The marginal cost of LP steam is equal to the cost of HP steam less the value of the power produced from it
  - LP steam cost can be very low, even negative

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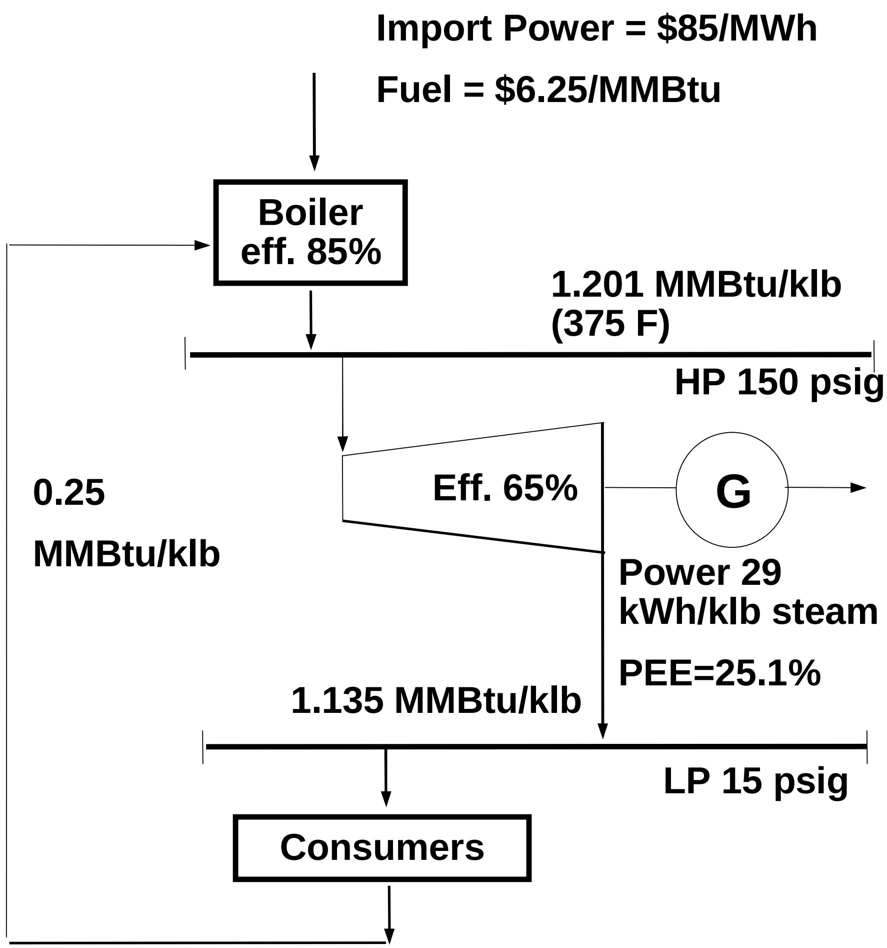
Steam Costing Example



__Price Equivalent Efficiency:__

Cost of Fuel/Power

6.25 / (85/3.414) *100 = 25.1%

(1 MW = 3.414 MMBtu)

__HP steam value:__

(1.20-0.25)/0.85 = 1.12 MMBtu/klb,
Or: 6.25*1.12 = 7.00$/klb

__Power credit (MW/PEE):__

0.029*3.414/.251 = 0.40 MMBtu/klb

__LP steam value:__

HP value – Power Credit =

1.12-0.40 = 0.72 MMBtu/klb

Or: 6.25*0.72 = 4.50 $/klb

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Gap Analysis

- BT Gap generally broken-down into four categories:
  - Steam Usage vs Best Practice
  - Fired Heater Efficiency
  - Shaft Work Efficiency
  - Heat Integration Effectiveness

  Remainder is intrinsic inefficiencies due to design
- Analysis performed on overall basis, can be on unit by unit basis

	Base Case	Eliminate Flaring	Furnaces at 92 %	Power generation at 80%	Heat integration
Total Energy, Gcal/h	515	506	491	448	395
BT allowance, Gcal/h	287	287	287	287	287
Refinery BT index	**179%**	**176%**	**171%**	**156%**	**137%**

Furnaces 5 pts

Power 15 pts

Process 19 pts

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Case Study

Questions?