Optimization of Utility Operation to Attain Lower Energy Cost

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1. Introduction

With increase in crude oil prices, energy costs have become a significant proportion of operating costs. Process industries, which are comprised of a complex network of process equipment & involve numerous utility streams offer excellent opportunities for the energy cost optimization through prioritization of usage of energy according to the relative cost and through maximization of high efficiency equipment operation.

2. Concept of Utility Optimization

Manufacturing plants which use energy from different sources would contemplate various means to curtail high cost energy consumption. Also, it is important to take into account of the energy efficiency of the systems that use the different energy while making decision to prioritize the different usage. For example, using of high cost fuel in high efficiency boiler with low auxiliary power consumption could be more economical compared to using of low cost fuel in lower efficiency boiler with higher auxiliary power consumption. Some examples of the application of such optimization analysis are;

- Choice of operational equipment when steam drive turbo drives are available as an alternative to electric motor driven drives.
- Choice of operational equipment when electric chillers are available as an alternative to steam used vapour absorption chillers.
- Choice of operational loading of different heating/cooling equipment that utilizes the different energy sources and technology.

Systematic assessment of individual energy cost together with understanding of end use energy efficiency of various equipments at various operating conditions is essential for establishing the optimized operating scenario. Such operational optimization demands rigorous analysis and necessitates usage of appropriate simulation analysis technique. Comprehensive analysis of whole plant/system is essential to perform various “what-if” scenarios taking into account the heat and mass balance interactions between utilities.

Multiple “what-ifs” are run to determine the combination of utilities and equipment loading that give the minimum cost (fuel, power and water treatment) operation.

3. Methodology

Approach to utility optimization should involve following steps:

- **Energy Mapping of Process & Utilities**

  In order to get the necessary data like flow, pressure and temperature that is required for the analysis, complete energy mapping of process and utility need to be carried out. This can be done by understanding the existing instrumentation in the plant and by performing heat and mass balance checks at various headers in the plant for identifying the reliable measurement points. Equipment performance curve that are either supplied by vendor or generated in-house would be considered for assessing the performance of the same at different operating scenario.

- **Identification of Costing and Price Structures**

  Variable energy cost that changes in proportion to the consumption of energy need to be established for the individual sources of energy. This calculation need to be performed as and when the price of purchased energy changes.

- **Configuration of Optimization Model**

  An optimization model need to be set up which would be customized for utilizing the available measurement data. The optimization model would be configured to utilize the data collected online (DCS system, Plant Information system or others) and perform the analysis. The results of this optimization analysis can be used to compare the energy consumption at present operating setting with that of the optimized setting. Also, the results generated on every optimization calculation run can eventually be logged as history.

- **Implement In an Online Information Systems Platform to Provide Data and Publish Results**

  In general, the optimized operating setting changes with the variations in plant/system load and with variation in plant/system operational characteristics. Hence, it is necessary to perform these analyses frequently to take timely action. Most importantly, the results of such optimization analysis should be made available to the individual operators of the plant/system, in-time and with proper training to facilitate timely action that would eventually result in realization of “real” benefits.

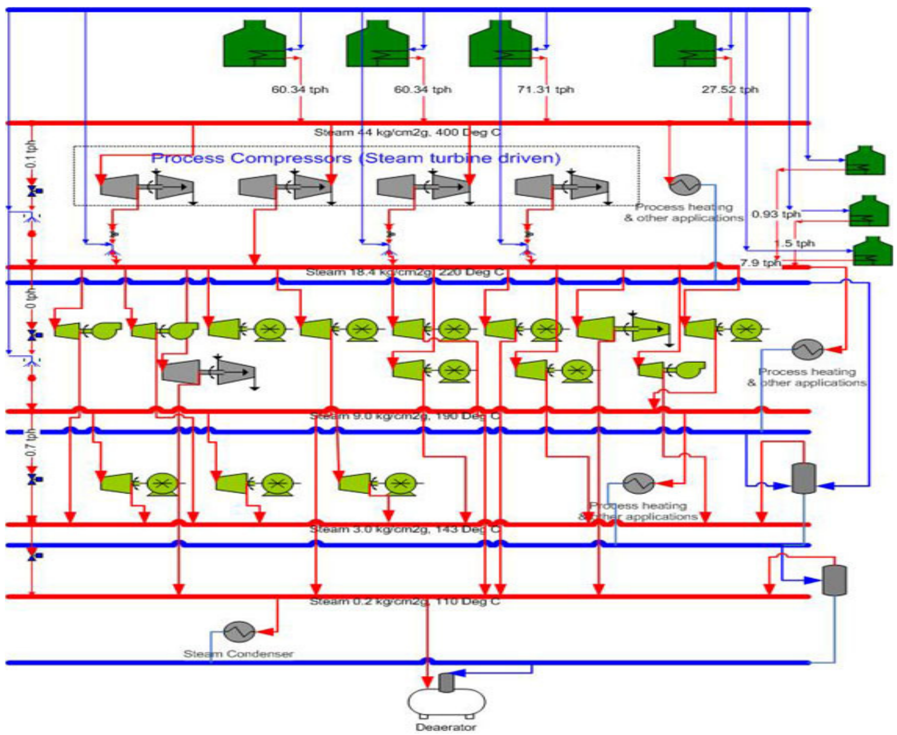
4. Case Illustration

In this case of utility optimization, energy cost is minimized through selective operation of steam turbine driven equipments and motor driven equipments. The process plant has utilities generation plants which are integrated with the process units. There are many turbine driven equipments (can be identified by green colour icon in the following picture) which are having motor drive as an alternative. The main challenge for the utility operator is to select those turbine and motor driven equipments that would lead to “lowest energy cost”. Following table explains the total number of equipments available for the optimization.

Equipment	Turbine Driven Equipment	Motor Driven Equipment
Boiler Feed Pump for High Pr Boiler	PT 24101C , PT 24101D	PM 24101A, PM 24101B
Cooling Tower Pump	PT 24401C, PT 24401D	PM 24401A, PM 24401B
Air Compressor	PT 24501B	PM 24501A, PM 24501C
Condensate Transfer Pump	PT 24201B	PM 24201A
Condensate Lift Pump	PT 24202B	PM 24202A
Demin Water Pump	PT 24203B	PM 24203A
Circulating Water Pump for WHR Boiler	PT 22304A	PM 22304B
Boiler Feed Pump for Low Pressure Boiler	GT 4002A	GM 4002B
Circulating Water Pump at WHR boiler 2	GT 4003A	GM 4003B
FD Fan of Low Pressure Boiler	FT 4001A	FM 4001B

In order to cater for the whole plant steam demand, six boilers (4 fossil boilers and 2 waste heat recovery boiler) are in service – shown in dark green icon in the picture. Various steam headers are shown in red colour horizontal line. To manage the steam demand and supply among the various steam headers, different pressure reducing stations are provided. Improper selection of steam driven equipments for operation results in high steam flow through the pressure reducing stations and unnecessary steam venting or steam condensation.

4. Case Illustration **(Cont'd)**



The choice of turbine driven equipment and motor driven equipment are to be based on several parameters such as:

- Ongoing Utilities Demand
- Fuel Cost
- Electricity Import or Export Price
- Operational Constraints such as Availability of Equipment and Reliability of the Plant Operation
- Plant Equipment Efficiency at Various Operating Condition

Real time online optimization case is shown in the following picture. This snap shot of optimization result compares the actual plant operation mode and recommended plant operation. It can be seen in the picture that the Optimizer clearly suggests a different set of motor and turbine driven drives in order to attain the lower energy cost. It is also clearly seen the optimizer minimizes pressure reducing steam letdowns and steam condensation.

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4. Case Illustration (Cont'd)

Utilities System Optimization 06-Sep-06 12:24:23 AM

Tag	Description	Current T/H	Optimized T/H	Current On/Off	Optimized On/Off	Operating Setting
F-24101	HHP Boiler # 1	63.10	68.52	ON	ON	MustRun
F-24102	HHP Boiler # 2	86.12	68.52	ON	ON	MustRun
F-24103	HHP Boiler # 3	87.59	68.52	ON	ON	MustRun
M-24101A/B	KR2 HHPS Letdown to HPS	34.39	0.00			
M-24102	KR2 HPS Letdown to MPS	44.39	0.00			
	KR2 MPS Letdown to LPS	48.99	0.64			
	KR2 LPS Letdown to LLPS	44.06	4.99			
	KR2 LLPS to LL Condensate	70.67	31.90			
PM-24101A	Boiler Feedwater Pump - Motor Driven			ON	OFF	OnOffOK
PM-24101B	Boiler Feedwater Pump - Motor Driven			OFF	OFF	OnOffOK
PT-24101C	Boiler Feedwater Pump - Turbine Driven			ON	OFF	OnOffOK
PT-24101D	Boiler Feedwater Pump - Turbine Driven			OFF	ON	OnOffOK
PM-24401A	Cooling Water Pump - Motor Driven			ON	OFF	OnOffOK
PM-24401B	Cooling Water Pump - Motor Driven			OFF	ON	OnOffOK
PT-24401C	Cooling Water Pump - Turbine Driven			ON	ON	OnOffOK
PT-24401D	Cooling Water Pump - Turbine Driven			OFF	OFF	OnOffOK
KM-24501A	Air Compressor - Motor Driven			ON	OFF	OnOffOK
KT-24501B	Air Compressor - Turbine Driven			ON	ON	OnOffOK
KM-24501C	Air Compressor - Motor Driven			OFF	ON	OnOffOK
PM-24201A	Condense Transfer Pump - Motor Driven			ON	ON	OnOffOK
PT-24201B	Condense Transfer Pump - Turbine Driven			OFF	OFF	OnOffOK
PM-24202A	Condense Lift Pump - Motor Driven			ON	OFF	OnOffOK
PT-24202B	Condense Lift Pump - Turbine Driven			OFF	ON	OnOffOK
PM-24302A	Demin Water Transfer - Motor Driven			OFF	OFF	OnOffOK
PT-24302B	Demin Water Transfer - Turbine Driven			ON	ON	OnOffOK
PT-22304A	Circulating Water Pump - Turbine Driven			OFF	ON	OnOffOK
PM-22304B	Circulating Water Pump - Motor Driven			ON	OFF	OnOffOK
	Calculation Status	Satisfied	Satisfied			

Also, the following summary of present and optimized cost comparison gives clear indication on the level of energy cost reduction that would be possible through the optimized operating mode.

4. Case Illustration (Cont'd)

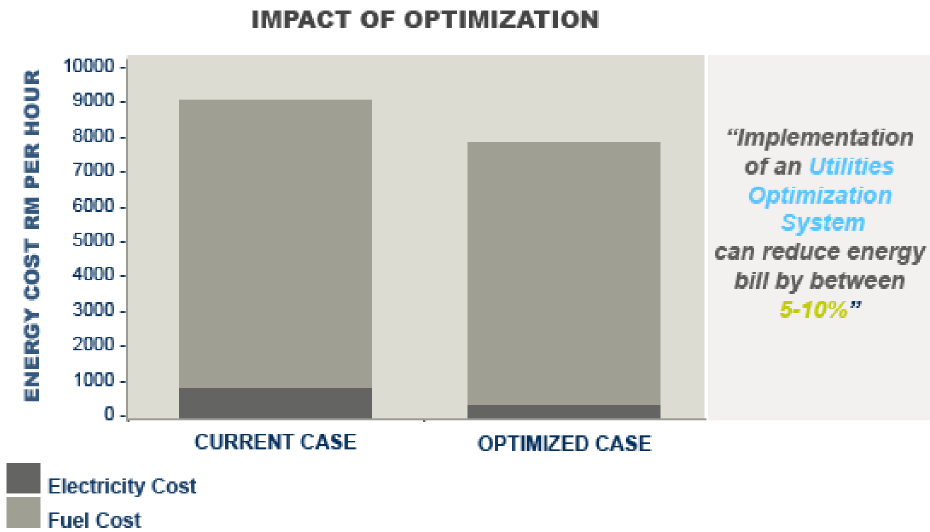
Utilities Cost Summary 06-Sep-06 11:35:53 AM

				Current Operation			Optimized Operation		
Tag	Description	Fuel Gas RM/GJ	Power RM/kWh	Fuel Gas GJ/h	Power kW	Cost RM/h	Fuel Gas GJ/h	Power kW	Cost RM/h
F-24101	HHP Boiler #1			199.59		3,193.41	218.15		3,490.33
F-24102	HHP Boiler #2	16.00	0.20	257.50		4,120.02	218.15		3,490.33
F-24103	HHP Boiler #3			280.16	201.92	4,522.96	218.15	182.53	3,526.84
F-4001	HP Boiler #1	16.00	0.20	18.90	0.00	302.47	4.38	3.47	70.79
PM-24101A	Boiler Feedwater Pump				381.75	76.35		0.00	0.00
PM-24101B	Boiler Feedwater Pump				0.00	0.00		0.00	0.00
PM-24401A	Cooling Water Pump				429.31	85.86		0.00	0.00
PM-24401B	Cooling Water Pump				0.00	0.00		0.00	0.00
PM-24501A	Air Compressor				368.77	73.75		0.00	0.00
PM-24501C	Air Compressor		0.20		0.00	0.00		368.77	73.75
PM-24201A	Condense Transfer Pump				39.78	7.96		39.78	7.96
PM-24202A	Condense Lift Pump				88.89	17.78		0.00	0.00
PM-24203A	Demin Water Transfer				0.00	0.00		28.35	5.67
PM-22304B	Circulating Water Pump				91.74	18.35		91.74	18.35
GM-4002B	Boiler Feedwater Pump		0.20		0.00	0.00		21.12	0.00
GM-4003B	Circulating Water Pump				0.00	0.00		0.00	0.00
	Total Cost					12,418.91			10,684.02
						Satisfied			Satisfied

As the analysis is done in the online system, the results are made available to the respective operators so as to take necessary timely action. The difference between the current total cost and the optimized total cost serves as an important operational key performance indicator.

Application of such energy optimization study in a refinery plant revealed significant potential for energy cost reduction as shown in the following picture.

4. Case Illustration (Cont'd)



Operational Implementation involves operator training, engineer training for maintenance and support, formulation of agreed operational procedures and setting up of management reporting system.

5. Reference Projects

Our first successfully completed refinery wide Utilities Optimization System is in the Petronas Penapisan Terengganu Sdn Bhd Refinery in Kerteh, Terengganu Malaysia.