10 Energy Conservation

10.1 Basis for the Compilation

(1) Energy Conservation Statistic Index and Calculation Method of China National Petroleum Corporation (Trial), CNPC Statistics No. (2008) 479;

(2) Standard for Calculation of Energy Consumption in Petrochemical Engineering Design (GB/T 50441-2007)

10.2 Principles of Energy Conservation

(1) To select advanced reliable process technologies and equipment for the project;

(2) To integrate the heat between units and between plant and system in light of the practical situation and tech- economic conditions of the project;

(3) To generate and use steams in terms of quality; the power generation will be based on steam demand; the HP steam consumption is calculated based on LP steam consumption. This facilitates the cascade recycling and balance of steam to prevent any waste case of steam venting due to imbalance between generation and use of the steam.

(4) To recover waste heats from flue gas and process materials on economic and practical basis. Develop an integrated plant-wide program for recovering and utilizing low temperature exhaust heat;

(5) To use new and efficient pumps and efficient heat transfer equipment to improve energy conversion and energy efficiency;

(6) The layout of equipment and piping shall be configured practically to minimize heat losses and pressure losses.

10.3 Energy Efficiency

10.3.1 Energy Consumption Calculation

The energy factor calculation of the refining section and the plant-wide energy consumption involved in the project are shown in Tables 10.4-1 and 10.4-2 respectively.

Table10.3-1 Plant-wide Refining Energy Factors

No.	Unit description	Unit	Nominal unit capacity	Ci	Ki	Ci X Ki

1	Atmospheric distillation unit	kt/a	3,000	1	1.018	1.018
2	CCR unit	kt/a	500	0.183	9.091	1.667
3	Diesel hydrorefining unit	kt/a	1,300	0.417	1.55	0.646
4	Isomerization unit	kt/a	150	0.020	3.5	0.070
5	Hydrocracking unit	kt/a	900	0.300	4.018	1.205
6	Hydrogen production unit	kt/a	25	0.008	118.18	0.985
8	Sulfur recovery unit	kt/a	26	0.009	2.727	0.024
9	Delayed coking unit	kt/a	700	0.233	2.27	0.530
10	Amine regeneration unit	kt/a	1600	0.533	0.82	0.437
11	Sour water stripping unit	kt/a	480	0.160	1.18	0.189
12	Gas & LPG treatment unit	kt/a	10	0.033	0.3	0.010
	Subtotal					6.780
	Auxiliary system energy factors					0.25
	Total					7.030
	Temperature correction factor		1.01			7.10

Table10.3-2 Refining Energy Consumptions

Item	Unit	Q'ty	Unit	Index	MJ/h	Percentage
Fuel	t/h	20.60	MJ/t	41868	862481	73.09%
Electrical power	kWh	28955	MJ/kWh	10.89	315320	26.72%
Fresh water	t/h	357	MJ/t	6.28	2242	0.19%
Total					1180043	100.00%
Comprehensive energy consumption					78.92kg standard oil/ton crude	
Energy consumptions by factor					11.11kg standard oil/ton crude·factor	

10.3.2 Energy Consumption Analysis

It is identified from Table 10.1-2 that the refining energy factor of the project is 78.92kg standard oil/ton crude and the energy consumption by unit energy factor is 11.11kg standard oil/ton crude.

The above energy consumption comparison and analysis indicate that the project energy consumption is normal and the energy efficiency may reach the relatively advanced level, indicating that the aforementioned energy conservation measures are effective.

10.3.3 The overview of energy conservation

In order to improve energy efficiency , a variety of practical energy conservation measures are taken in the project.

10.3.4 Refinery energy-conservation measurements

The project design clearly focuses on the overall benefit, especially on what energy-conservation technique measures considered for the high energy efficiency levels of the whole plant and its large systems. For instance, heat integration between units and the cascade reuse of steam and power systems and low temperature heat recovery & utilization throughout the plant. The energy conservation measures are outlined as follows:

(1) Optimize the process units; reasonably determine process units' sizes, feedstocks, processing schemes and finished products to improve desired products' yields and minimize losses.

(2) Use energy efficient process technology and efficient catalysts.

Selection of energy efficient processes and efficient catalysts is the key means to reduce the overall process energy consumptions and improve the plant energy efficiency. For example, the hot high fractionation process is selected for the hydrocracking unit; the continuous reforming regeneration process is selected for the CCR unit, etc.

(3) Improve the energy recycling rate and reduce the energy waste

The emphasis is placed on the plant energy efficiency, including such measures as the use of advanced technologies and the optimization of heat exchange networks, and the introduction of efficient heat transfer equipments to boost their heat exchange efficiencies for raising final heat exchange temperatures. Taking the atmospheric and vacuum unit for instance, the pinch technology is adopted to optimize the design for heat exchanger networks to achieve the optimal balance between investment and energy conservation.

(4) Improvement in energy conversation efficiency

Flue gas exhaust heat recovery systems are provided for all process unit heaters; select efficient pumps for process units to reduce power consumptions.

(5) Achieve the cascade reuse of steam power systems to achieve the balance between steam output and consumption.

A MP steam pipe network and a LP steam pipe network across the plant are considered whose temperatures and pressure are stated as follows:

The MP steam pipe network: pressure: 3.5MPa; temperature: 435°C;

The LP steam pipe network: pressure: 1.0MPa; temperature: 250°C;

A steam pipe network at 0.4 MPa is a local line. As a result, the 0.4 MPa saturated steam generated from units will be captive consumed by units or by nearby users while the remaining steam will be supplied from the steam pipe network at 1.0MPa.

For practical utilization of steam levels and to avoid venting balance LP steam, the exhaust heat recovery from units is designed to allow the steam generators to generate high quality steam as much as possible at heat source temperature levels. The steam users are supplied with lower quality steams provided that process conditions permit.

Back pressure turbines are used between steam pipe networks at different levels to drive large capacity compressors (e.g. back pressure turbines on diesel hydrorefining unit, and hydrocracking unit). Any steams from turbines at back pressures may supply to the nest pipe network so as to achieve the cascade reuse of steam energy, reducing units' energy consumptions.

(6) Recovery and utilization of low temperature exhaust heats resources

Low temperature heat loads

The plant-wide low temperature loads are mostly from the atmospheric distillation unit, delayed coking unit, hydrocracking unit and hydrorefining unit. To smoothly operate the plant, an exhaust recovery station is considered to utilize the low temperature exhaust sources from the whole plant, so that most of those heat resources can used to refrigerate in office areas.

10.3.5 The energy conservation measures for main plants, units or systems

Based on energy conservation principles, the main energy conservation measures for units and systems are shown in the following table.

Table10.3-3 List of Energy Conservation Measures

No	Units	Measures	Measure description
I	Atmospheric distillation	Optimize fractionating column heat consumption	The unit operating conditions and reflux heat removal will be optimized through the integrated process simulation. On the basis of the fire use analysis and simulation analysis, the optimal process conditions are determined to maximize the energy efficiency, providing that the product quality and process conditions are available. This will improve the quality of the heat stream into the energy recovery system, reduce any losses from process fire use to allow the process pinch points to be at more favorable position for maximizing the heat recovery.
		Optimize the heat exchange processes	The "Pinch Design Method" is used to optimize heat exchanger network, while efficient heat exchangers are provided to maximize their work efficiencies for higher heat recycling efficiencies and lower cold & hot utilities consumptions.
		Use the heat integration process	The heat integration between units may allow side-draw products to directly go to downstream units so as to reduce heat duties while minimizing the heating (heat exchanging) duties of downstream units.
		Raise heaters' efficiencies	The increase in heater's efficiencies may decrease the use of fuel. This may get 90% of calculated thermal efficiencies atmospheric and vacuum heaters.
		Reduce heat losses & pressure losses from the equipment & piping	The arrangement of equipment and pipelines should be made as close as possible to each other; and their heat/cold insulation means should be provided to minimize any possible heat and pressure losses.
II	Continous Catalytic Reforming	Improve heaters' efficiencies	Maximize the utilization of exhaust heat resources. Because the "Four in One" reaction furnace (an all radiant type furnace) is used in the plant's continous catalytic reforming unit, of which the flue gas emission temperature is high, the convection section at its heater top is used to heat the process media to recover its waste heat, achieving more than 90% of the total heater efficiency.
		Use efficient heat exchangers	For maximizing the heat exchanger efficiency and reducing the hydroforming system pressure, a welded plate type heat exchanger is used as the reforming feed heat exchanger. A two shell-side heat exchanger is used as the prehydrogenation feed heat exchanger. This may improve their heat transfer efficiencies and reduce the fuel consumptions by heaters, while lowering the load of product cooler.
		Use efficient pumps	Select efficient pumps with appropriate motor powers to minmize their energy consumptions.
		Reduce any possible heat and pressure losses from equipment items	In the plant layout, the distance between high temperature hot medium pipelines shall be kept as short as practical. The insulation shall be provided for the

No	Units	Measures	Measure description
		and pipelines	equipment and piping to mitigate possible piping heat losses.
III	Hydrocracking	Use advanced processes	The plant will use a high pressure hot separation system which is characterized by advanced and reliable process, flexible operation and low energy consumption.
		Increase its separation efficiency	Use efficient tower trays and stuffing to improve its separation efficiency and reduce its energy consumption.
		Improve the heater efficiency	The heater will be provided with oxygen analyzer to control the oxygen content in flue gas; also a waste heat recovery system will be provided for improving its efficiency.
		Use efficient energy-conservation pumps	Where possible, energy-conservation pumps are used on the plant to improve their conversion efficiencies.
		Optimize heat exchanger networks	Optimize heat exchanger networks; use new heat exchangers to maximize the heat recovery.
IV	Gasoline/diesel hydrorefining	Use efficient catalysts	Use advanced catalysts so that the reactors are operated at lower temperatures and pressures.
		Increase heaters' efficiencies	The air repeaters are considered for feed heaters to reactors and fractionating towers to reduce their exhaust gas temperatures. Also, oxygen analyzers will be provided for heaters to control the oxygen content in flue gas, thereby improving the heater efficiency.
		Optimize the heat exchange process	Optimize heat exchanger network to maximize the heat recovery.
		Use efficient pumps	Use efficient and energy-conservation pumps to improve their conversion efficiencies, thus reducing their energy consumptions.
		Use efficient tower internals	Use efficient tower internals and pickings for high separation efficiencies.
V	SRU (incl Acidic water stripping, solvent tripping and solvent regeneration)	Recover waste heat resources	The acidic gas combustion furnaces' waste boilers & the waste heat boilers at off gas incinerator will generate 3.5MPa MH steam.
			The 3-stage condenser will generate 0.4MPa steam.
		Recover the condensate	Condensate recovery systems are considered for the plant to collect the condensates from unit drains. The collected condensate will be fed to the SRU waste boiler & the condensers at 1/2/3 stages to generate the steams and fed to desuperheaters. The remainder will be sent to the plant's condensate pipe network.
		Reduce fan power losses	Roost blowers are used for acidic gas combustion furnaces to reduce air vents, reducing the blower power loss.

No	Units	Measures	Measure description
VI	H_2 making	Select practical process parameters	Use a higher converter outlet temperature to maximize the conversion level so that the hydrogen yield per unit of the feedstock increases to minimize their material consumptions and energy consumptions.
		Select PSA purification process	Select a high-performance PSA purification process, of which the process is simple at low energy consumptions & high pure industrial H_2. In this case, it may generate high purified industrial H_2 products such that its hydrogen recovery can achieve so high as it is. This facilitate reducing the energy consumptions by H_4 making unit & its downstream H_2 users' energy consumptions.
		Use a lower ratio of water to carbon	A reduced ratio of water to carbon may lower the converter load, this reduces the converter fuel consumption and the load of downstream heat recovery equipment, thereby the cost for H_2 generation & energy consumption is minimized.
		Optimize heat exchanger processes	Optimize heat exchanger processes; use energy levels in a rational way to maximize energy efficiencies.
			①Use the high waste heat of the flue gas and converted gas from the converter to preheat the raw gas for generation of 3.5MPa medium-pressure steam.
			②Use the high waste heat of the gas from the medium-pressure converter to preheat the water supplied to the boiler so as to increase the medium-pressure steam output.
		Improve the process furnace efficiency	Use the low waste heat of the flue gas to preheat the combustion air so as to reduce the flue gas temperature and improve the converter's heat efficiency while maintaining a rational temperature difference for heat transfer. This can allow the converter's overall heat efficiency to be 92% or above.
		Use U-tube double-shell heat exchanger	Use U-tube double-shell heat exchangers to increase their heat exchange severities to increase their heat recoveries.
		Recover process condensates	Recover the condensate from converted gas cooling process to allow it to directly flow to the deaerated water system via the stripper. After deoxygenization, it may used as BFW for reducing the demin water to the plant and the load to WWT.
VII	Power supply	Use automatic opto-electrical control systems for outdoor lighting fixtures	An automatic photoelectric control or centralized control system is used for road lighting fixtures & outdoor plant lighting fixtures. Energy conservation voice operated switches will be used for staircase lighting fixtures.
			Luminaries should be of green lighting fixtures, such as metal halide lamps and efficient energy-conservation lamps.
		Use energy-conservation	Use energy-conservation electric installations. For example, low-loss power transformers and Y-series

No	Units	Measures	Measure description
		electrical installations	motors.
		Reduce electric energy losses	On the LV sides at the plant-wide substations, provide automatic adjustable power factor compensation devices to increase their power factors, reducing power consumptions.
		Select speed regulating devices of frequency conversion	The frequency control technology will be used for pumps at larger flow rates and powers to reduce their energy consumptions.
		Select an rational power supplier	Select a rational power supply mode. HV systems shall supply power in a appropriately central way, and meanwhile LV systems shall supply power to adjacent localities, so as to reduce line and transformer losses.
VIII	Delayed coking	Improve process heaters' efficiencies	Use efficient air preheaters on heaters to reduce exhuast gas temperatures, thereby increasing heaters' efficiencies.
		Optimize the heat exchange flow rates	Optimize heat exchanging processes; utilize the surplus heat from dephlegmation towers to generate the steam, and provide the heat source for the stable absorption. Raise the final temperature of residual oil heat exchange to reduce the heater's duty, conservation the fuel consumption.
		Use efficient pumps	Select suitable pumps to save electricity consumptions.
		Optimize operating conditions	Optimize operating conditions to reduce steam consumptions. However, the emphasis should be put on reducing the steam consumptions of the coke tower & steam reciprocating pump.
		Reduce the service factor of air cooler	Reduce the service factor of air cooler; however, generating low temperature hot water can be assumed as the means of reducing the plant energy consumption.
IX	Isomerization		Select efficient and new electromechanical devices;
			Optimize operating parameters; use viable reaction severity and moisture carbonization.
	Steam system	Optimize the steam system	Three-level steam pipe networks at 3.5MPa, 1.0 MPa, 0.4MPa are considered for the whole plant to use the cascade steam reuse.