Notes

Chapter - 5

Exploration and Production

5.1 Introduction

India's GDP is growing at about 8-9% annually. Current projections are that this trend will continue. High growth rate demands enhanced energy inputs, particularly for a country like India where the per capita oil and gas consumption is almost one-fifth of the global average. At the present rate of consumption, it is expected that India's crude oil reserves will exhaust in less than 20 years from now while its natural gas reserves will last for about 40 years. An additional strain is placed by the fluctuating price of crude. Currently, we import over 73% of our crude oil requirements.

5.1.1 Sedimentary Basins of India

India has 26 sedimentary basins of which only about 20% are moderately to well explored. The remaining sedimentary area remains to be intensively explored. Judging by the spate of recent discoveries, the areas that are yet to be explored hold enormous promise.

Table - 5.1: Total Sedimentary Area: 3.14 Million Sq.Km.

Level of Exploration	Area (Million Sq.Km.)			
	1995-96	1998-99	2004-05	2006-07
Unexplored	1.557	1.276	0.698	0.468
Exploration Initiated	0.556	0.837	1.155	1.376
Poorly explored	0.529	0.529	0.689	0.655
Moderate to well explored	0.498	0.498	0.598	0.641

Source : DGH

5.1.2 Production

Total oil production during 2007-08 was 34.11 MMT and that of gas 32.402 BCM. The contribution of Pvt/JV companies was about 18% of the total Oil & Gas production.

5.1.3 Drilling

Of the total of 415 wells drilled, 163 were exploratory and 252 were development wells. As in the previous year, the national oil companies contributed to the bulk of the drilling. A total of 1005050 meters were drilled which include 406960 meters of exploratory and 598090 meters of development drilling.

5.2 Energy Efficiency Improvement Scope In Upstream Sector

The upstream hydrocarbon sector can generally be divided into four distinct divisions:

1. Seismic survey, Exploration & development of hydrocarbon reservoirs which primarily comprise of drilling rigs and allied equipment

2. Production of Oil & Gas which may comprise of

   a. Oil collection stations
   b. Gas Compressor station
   c. Sucker Rod Pumps
   d. Water supply stations
   e. Power Station

3. Transportation of Oil & Gas which may comprise of

   a. Crude Oil Pumping Stations
   b. Gas Compressor Stations

4. Gas Based Petrochemical Complexes

   a. Petrochemical Plant
   b. LPG Recovery Plants
   c. LPG Bottling Plants

Effective and result oriented conservation methods adopted by the upstream undertakings include reduction of gas flaring by re-injection of gas to underground reservoir, installation of waste heat recovery systems, utilization of non-conventional energy sources, undertaking energy audits & efficiency up gradation of equipment & appliances, substitution of diesel with natural gas, deployment of solar-powered illumination panels, battery operated vehicles, bio-gas etc.

5.2.1 Enhanced Oil Recovery

Crude oil development and production in oil reservoirs can include up to three distinct phases: primary, secondary and tertiary (or enhanced) recovery. During primary recovery, the natural pressure of the reservoir or gravity, drive oil into the wellbore combined with artificial lift techniques (such as pumps), which bring the oil to the surface. But only about 10 percent of a reservoir's original oil in place is typically produced during primary recovery. Secondary recovery techniques to the field's productive life generally by injecting water or gas to displace oil and drive it to a production wellbore, resulting in the recovery of 20 to 40 percent of the original oil in place.

However, with much of the easy-to-produce oil already recovered from oil fields, producers have attempted several tertiary, or Enhanced Oil Recovery (EOR), techniques that offer prospects for ultimately producing 30 to 60 percent or more of the reservoir's original oil in place. Three major categories of EOR have been found to be commercially successful to varying degrees:

- Thermal recovery, which involves the introduction of heat such as the injection of steam to lower the viscosity or thin the heavy viscous oil and improve its ability to flow through the reservoir.
- Gas injection, which uses gases such as natural gas, nitrogen, or carbon dioxide that expand in a reservoir to push additional oil to a production wellbore or other gases that dissolve in the oil to lower its viscosity and improves its flow rate.
- Chemical injection, which can involve the use of long-chained molecules called polymers to increase the effectiveness of waterfloods or the use of detergent-like surfactants to help lower the surface tension that often prevents oil droplets from moving through a reservoir.

Each of these techniques has been hampered by its relatively high cost and in some cases, by the unpredictability of its effectiveness.

5.2.2 CO_2 Injection

The EOR technique that is attracting the most new market interest is carbon dioxide (CO_2)-EOR. First tried in 1972 in Scurry County, Texas, CO_2 injection has been used successfully at number of locations today.

The presence of an oil bearing transition zone beneath the traditionally defined base (oil-water contact) of an oil reservoir is well established. What is now clear is that, under certain geologic and hydrodynamic conditions, an additional residual oil zone (ROZ) exists below this transition zone and this resource could add further to oil resource in place and could be recoverable with state-of-the-art CO_2-EOR technologies.

Until recently, most of the CO_2 used for EOR has come from naturally occurring reservoirs. But new technologies are being developed to produce CO_2 from industrial applications such as natural gas processing, fertilizer, ethanol, and hydrogen plants in locations where naturally occurring reservoirs are not available. One demonstration at the Dakota Gasification Company's plant in Beulah, North Dakota is producing CO_2 and delivering it by a new 204-mile pipeline to the Weyburn oil field in Saskatchewan, Canada. Encana, the field's operator, is injecting the CO_2 to extend the field's productive life, hoping to add another 25 years and as much as 130 million barrels of oil that might otherwise have been abandoned.

A turning point in CO_2-EOR advances is a project funded by US DOE in the Hall-Gurney field in Kansas that seeks to demonstrate this technology's time has come - providing energy, economic and environmental benefits. A companion project underway in the Hall-Gurney field involves testing the feasibility of 4-D high resolution seismic monitoring of CO_2 injection in thin, relatively shallow mature carbonate reservoirs. Incorporating such time-lapsed monitoring data into CO_2-EOR programs could dramatically improve the efficiency and economics of using the technology in many Mid-continent fields.

Additional work has examined potential improvements in CO_2-EOR technologies beyond the state-of-the-art that can further increase this potential. This work evaluating the potential of "game changing" improvements in oil recovery efficiency for CO_2-EOR illustrates that the wide-scale implementation of next generation CO_2-EOR technology advances have the potential to increase oil recovery efficiency from about one-third to over 60 percent.

5.2.3 Other Areas

Crude Oil exploration is the most energy intensive operation and is explained in detail in this chapter. The other major areas where energy is consumed and opportunities for conservation exists are listed below:

5.2.3.1 Pumping Stations

The major energy consuming equipments generally are:

Electrical Motors: Improvement opportunity can be explored in appropriate Loading Pattern, Power Factor improvement, Mechanical Power Transmission Systems and other operational parameters.

Pumping System: Improvement opportunity can be explored by optimising the pumping and allied system pressures, RPM of the engines, engine efficiencies and other operational parameters for crude oil driven engines for pumping of crude oil or product and fire fighting pumps (Engine or Motor Driven) and feasibility of reduction in the Power Consumption.

Air Compressors: Improvement opportunity can be explored by analysis of various parameters like intake receiver capacity, operational Free Air Delivery (FAD) of the Air Compressors, leakages in the system, evaluation of the feasibility of Pressure Optimisation etc.

Illumination System: Improvement opportunity can be explored by use of energy efficient lighting systems.

DG Sets Performance: Improvement opportunity can be explored by operation of DG Sets to evaluate their average cost of Power Generation and subsequently identify areas wherein energy savings could be achieved after analysing the operational practices.

Specific Energy Consumption: SEC per throughput of each station and comparison of SEC of each station should be found out and benchmarked.

Diesel & Crude Oil Handling System: Improvement opportunity can be explored by monitoring energy consumption in heater in centrifuge unit, fuel forwarding modules, etc. and study the feasibility of energy conservation.

5.2.3.2 Gas Compressor Stations (GCS)

Study of Gas Compressors in GCS (Motor / Gas Engine Driven Unit): Improvement opportunity can be explored by Studying the Operational practices being adopted, Monitoring the Specific Energy Consumption, Scheduling of the Gas / Motor Driven Compressors, Formulation of specific recommendations for reduction in the overall Electrical energy/Gas Consumption. The major equipments are Motors, Air Compressors, Cooling Towers, Illumination systems.

Cooling Towers: Improvement opportunity can be explored by studying the operational performance of the Cooling towers through measurements of temperature differential, air/ water flow rate and then evaluate specific performance parameters like approach, efficiency etc.

5.2.3.3 Water Supply Station

The major equipments are motors, pumps and Illumination systems

5.2.3.4 Power Station

Improvement opportunity can be explored by evaluating the operational efficiency of turbines & alternators, Evaluation of the Specific Energy Consumption pattern of the Gas/Steam Turbine as well as allied equipment, Load rationalization & overall reduction in the Specific Energy Consumption, Evaluation of Specific Gas/Steam

Consumption vs. Power Generated and by improving performance with reduced specific electrical energy consumption.

The major equipments are electrical system network, motors, air compressors, Cooling Towers, Illumination systems, where energy conservation opportunities can be explored.

Electrical System Network: Improvement opportunity can be explored by study of all the Transformer operations of various Ratings / Capacities, their Operational Pattern, Loading, No Load Losses, Power Factor Measurement on the Main Power Distribution Boards and possible improvements in energy metering systems for better control and monitoring.

5.2.3.5 Sucker Rod Pumps

The major equipments are motors, DG Sets, Illumination systems, etc.

5.2.3.6 Gas Processing Plants

The major equipments consists of motors, pumps, steam systems, HRSGs, Boilers, Captive Power houses, Gas Turbines, Steam turbines, Gas Compressors, Air Compressors, Steam Traps, Illumination, Heaters, distillation/ separation columns, cooling towers, transformers, electrical system networks, air conditioning etc.

Case Study 1: Energy Audit of a major Gas based Petrochemical Complex

Brief

The Petrochemical Complex is designed to process 12 million metric standard cubic meter per day (MMSCMD) of natural gas to produce 440,000 TPA of Ethylene in the first phase and down stream products, such as the various grades of high density polyethylene (HDPE) and linear low density polyethylene (LLDPE). A LPG recovery unit is being installed and successfully producing 258250 TPA of LPG and 71,000 TPA of Propane from the natural gas.

The main energy sources of the plant are electricity and Natural gas. The plant consumes about 42 Million kWh electrical units per annum (from the grid), around 240 Million from in-house and natural gas quantity of 363 Million sm^3 per annum.

Energy savings

Summary of Energy Savings

Description	Unit	Quantity
Electricity @ Rs. 4.5/kWh	*Million kWh/annum*	*25.8*
Lean Gas @ Rs. 10/SCM	*MMSCM*/annum*	*13.0*

**** MMSCM = 10^6 Standard Cubic Metre***

Annual savings	*: Rs. 246.3 Million*
Investment required	*: Rs. 124.7 Million*
Payback period	*: 6 months*

Thermal Energy Systems

The Plant has three utility boilers UB#1, UB#2 & UB#3, each designed to generate VHP steam at 105 kg/cm^2 and 515°C. The VHP steam generated in the utility boilers *is used in utility steam turbines for power generation and subsequently for driving the boiler auxiliaries and for process heat applications. The recommendations pertaining to the operation of the two boilers (UB#1 & UB#3), which were in operation during the field visit of the audit are as follows:*

- ***Optimization of excess air in Utility Boiler UB#2***

The boiler was operating at a high excess air level of 68%, whereas the recommended level is 10%, resulting in high flue gas losses. As a result, the boiler efficiency dropped by 4 percent points to 91% (NCV basis) as against the design value of 95%. By maintaining the O_2% in flue gases always below 3% (in order to keep excess air level below 15%) by continuous monitoring of O_2% in flue gases and thereby regulating the combustion airflow to the boiler, a saving of 1 MMSCM of gas per year can be achieved.

Annual savings	*: Rs. 10.0 Million*
Investment required	*: Rs. 5.0 Million*
Payback period	*: 6 months*

- ***Optimization of excess air in Utility Boiler UB#3***

The boiler was operating at a high excess air level of 46%, whereas the recommended level is 10%, resulting in high flue gas losses. As a result, the boiler efficiency dropped by 6 percent points to 80% (GCV basis) as against the design value of 86%. By maintaining the O_2% in flue gases always below 3% (in order to keep excess air level below 15%) by continuous monitoring of O_2% in flue gases and thereby regulating the combustion airflow to the boiler, a saving of 0.9 MMSCM of gas per year can be achieved.

Annual savings	*: Rs. 9.1 Million*
Investment required	*: Rs. 5.0 Million*
Payback period	*: 6 months*

- ***Replacement of inefficient UB#2 FD Fan with that of energy efficient fan***

It was found that the efficiency of the steam turbine driven UB#2 FD fan was much below (23%) the desirable efficiency level (60%). Hence, by replacing the existing FD Fan of UB#2 with an energy efficient fan, a saving of 0.3 Million kWh per year can be achieved.

Annual savings	*: Rs. 1.4 Million*
Investment required	*: Rs. 3.5 Million*
Payback period	*: 29 months*

- ***Replacement of inefficient UB#3 FD Fan with that of energy efficient fan***

The operational efficiency of UB#3 FD fan was poor (13%) compared to the desirable efficiency level (60%). Hence, by replacing the existing FD Fan with an energy efficient FD Fan, a saving of 0.82 Million kWh per year can be achieved.

Annual savings	*: Rs. 3.7 Million*
Investment required	*: Rs. 3.5 Million*
Payback period	*: 11 months*

- ***Boiler feed water pump (Utility boiler#2)***

The feed water pump operating efficiency was much below (38%) the desired pump efficiency level (60%) for efficient operation. By replacing the existing pump with an energy efficient pump, a saving of 0.42 Million kWh per year can be achieved.

Annual savings	*: Rs. 1.9 Million*
Investment required	*: Rs. 5.0 Million*
Payback period	*: 32 months*

- ***Utility Steam Turbines***

The plant has installed two nos. of Steam Turbo Generators (STG#1 & STG#2); one is extraction type having a capacity of 15.5 MW and the other is condensing type of 25.5 MW, to meet the plant's electricity requirements.

STG# 1

- *The observations and measurements showed that, the specific steam consumption per MW power generation is higher than the rated/design condition. This may be due to leakage in labyrinth-gland packing between two stages or any other maintenance reason like corrosion/erosion in turbine blade surface. Hence it was recommended to consult the manufacturer to ascertain the possible reasons. After rectifying the same the steam consumption may be reduced nearer to the designed requirement. The steam consumption (T/MW) in the HP and LP side is 21.23 and 12.21.*
- *The measurements and analysis showed that Steam Turbine efficiency in both H.P. & L.P. stage was lower i.e. 61.8 % and 61.5 % than expected.*
- *The loading of the turbine was 59%.*
- *By enhancing the loading of the turbine, reducing the leakages, the operating efficiency of the turbine can be enhanced to 65% with an annual savings of 1.2 MMSCM per year.*

Annual savings	*: Rs. 11.9 Million*
Investment required	*: Rs. 5.0 Million*
Payback period	*: 5 months*

STG#2

- *The turbine was running at low operating efficiency of 57.8 % because of operation of turbine at part load of 59 %.*
- *By enhancing the loading of the turbine, reducing the leakages, the operating efficiency of the turbine can be enhanced to 65 % with an annual saving of 0.3 MMSCM per year*

Annual savings : *Rs. 3.3 Million*
Investment required : *Rs. 2.5 Million*
Payback period : *9 months*

- ***Heat Recovery Steam Generators***

By improving the efficiency of HRSG - I & II by de-scaling the water side surface, changing the layout of different components of the HRSG from the existing to the proposed i.e. in the sequence of Super Heater-II, Super Heater-I, Evaporator-II, Evaporator-I & Economizer, a saving of around 2% on a very conservative estimate can be achieved. The modifications will lead to increased steam generation. This increase will reduce the load on utility boilers, which will ultimately reduce the natural gas consumption by 1.8 MMSCM of natural gas per year.

Annual savings : *Rs. 17.8 Million*
Investment required : *Rs. 2.0 Million*
Payback period : *2 months*

- ***Cracked Gas (CG) Compressor***

The specific steam consumption per KW shaft power in H.P. Stage was higher with respect to the rated designed condition because of low efficiency of steam turbine. By increasing the efficiency of HP as well as LP steam turbine a saving of 1 MMSCM fo natural gas can be achieved.

Annual savings : *Rs. 10.2 Million*
Investment required : *Rs. 3.0 Million*
Payback period : *4 months*

- ***Condensing Steam Turbine of Propylene (C_3R)Refrigeration Compressor***

The condensing steam turbine of C_3R compressor was running at poor efficiency. This was due to leakage in labyrinth-gland packing between two stages or any other maintenance reason like corrosion/erosion in turbine blade surface. Hence it was recommended to consult the manufacturer to ascertain the possible reasons. After rectifying the same, a saving of 0.17 MMSCM of natural gas per year can be achieved.

Annual savings : *Rs. 1.7 Million*
Investment required : *Not ascertained*
Payback period : *NA*

- ***Replacement of damaged traps***

The plant had 44 faulty steam traps. By immediate replacement of these traps to arrest steam leakage and losses, a saving of 0.2 MMSCM of natural gas per year can be achieved.

Annual savings : *Rs. 2.1 Million*
Investment required : *Rs. 0.45 Million*

Payback period : *3 months*

- ***Maintenance of faulty steam traps***

By repairing the traps which are chocked and let the condensate flow smoothly out of the system to ensure effective heat transfer, a saving of 0.1 MMSCM of natural gas per year can be achieved.

Annual savings : *Rs. 1.0 Million*
Investment required : *Rs. 1.0 Million approx*
Payback period : *12 months*

- ***Performance evaluation of all steam traps***

The savings estimated above was based on the survey conducted on 170 traps, which form less than 20% of the total traps installed in the plant. The actual energy savings that can be achieved by steam traps maintenance would be several times higher than what has been estimated above. Therefore, it was recommended to get a survey done for all the steam traps in the plant and replace / repair the faulty traps immediately to arrest energy losses in the steam system.

- ***Steam Distribution System***

\- ***Condensate recovery***

A total of 7 TPH of condensate can be recovered and reused as boiler feed water from HDPE and LPG Plants. The investment required would be in terms of additional condensate pipes, condensate pump, and insulation of the network. In addition to the fuel savings, the other benefits would be reduced costs of water treatment of 7 TPH water. The net savings would be the 0.6 MMSCM of natural gas per year.

Annual savings : *Rs. 6.2 Million*
Investment required : *Rs. 3.0 Million*
Payback period : *6 months*

\- ***Arresting steam leakages***

The plant had steam leakages at a number of areas. By arresting the steam leakages from the identified areas (by replacing the damaged valves, pipefittings, flanges, traps, etc), a saving of 0.09 MMSCM of natural gas per year can be achieved.

Annual savings : *Rs. 0.9 Million*
Investment required : *Rs. 0.5 Million*
Payback period : *7 months*

\- ***Improve insulation of pipes***

A number of areas in the steam lines had high surface temperatures. The high surface temperatures of insulated steam headers / pipes indicate the damaged or inadequate insulation. It was recommended to replace the insulation to arrest the heat losses thereby saving 0.04 MMSCM of natural gas per year.

Annual savings : Rs. 0.35 Million
Investment required : Rs. 0.03 Million
Payback period : 1 months

- ***Installation of back pressure steam turbine in place of PRDS***

To meet HP steam requirement, a PRDS was installed to convert VHP steam to HP steam. It was recommended to install a backpressure steam turbine in place of the PRDS. The turbine would facilitate power extraction to the extent of 2 MW and simultaneously expand the steam to the required level of 40 kg/cm². A saving of 9.1 Million kWh per year can be achieved.

Annual savings : Rs. 40.9 Million
Investment required : Rs. 37 Million
Payback period : 11 months

- ***Furnaces***

- ***Improve the furnace insulation***

The surface temperature at various portions of the operating furnaces were found to be high. By improving the insulation at hot spots, a saving of 0.22 MMSCM of natural gas per can be achieved.

Annual savings : Rs. 22.3 Million
Investment required : Rs. 1.75 Million
Payback period : 1 month

- ***Reduce blow down from Furnace # 3 and # 4***

The blow down rate of Furnace#3 and Furnace#4 was high compared to that of Furnace#1 & 2. The excess blow down from these two furnaces is estimated to be 6 TPH. By reducing the blow down rate of these two furnaces to the optimum level, a saving of 0.3 MMSCM of natural gas per year can be achieved.

Annual savings : Rs. 3.3 Million
Investment required : NIL
Payback period : Immediate

Electrical Systems

- ***Transformers***

A complete loading analysis of the transformers was carried out. The loading pattern showed that in most of the cases, the loading was on the lower side. For most of the transformers the best efficiency point was in the loading range of 40-50%, but the transformers were found to be operating at a lesser load. This has basically been done so as to have high plant operating reliability. For the sake of reliability, the plant has compromised on higher transformer losses, which is justified owing to the critical & continuous operating schedule of the plant.

- ***Capacitors:***

The billing from the state electricity board was based on kVAh and hence it becomes imperative for the plant to keep a good power factor on the main incomer. For this, the plant has installed capacitors. The average PF being maintained was very close to unity, which is a good practice.

- ***Motor Load Study:***

A complete motor load survey was carried out during the energy audit so as to assess the motor loading pattern and assess the potential for motor down-sizing, application of VFD, soft starter etc. In all about 170 motors above 25kW were studied and the basis for categorising the motors as under-loaded was loading less than 50%. In all 44 motors were found to be under-loaded (26% of the motors studied). For the motors loaded less than 50%, an exercise was done to analyze the feasibility of replacement of these motors by suitably sized energy efficient motors (EEM). Few motors where the payback was less than 5 years are being recommended for such replacement. For motors that offer a payback of 5 years or less, the reduction in motor losses will be to the tune of 38.5 kW. An annual saving of 0.31 Million kWh per year can be achieved by replacing the under loaded motors.

Annual savings : Rs. 1.4 Million
Investment required : Rs. 0.5 Million
Payback period : 5 months

- ***Power Factor Study:***

During the audit of the electrical motors, the PF profiling was also done. For most of the motors it was found that the PF was quite healthy but for a few motors (20 in number out of a total of 170 studied), the PF was below 0.7, which may be due to the low loading at the point of measurements. It was advised that, for all motors, the PF should be kept as high as possible (ideally 0.95) so as to have reduced line losses, to ensure better voltage regulation at the motor end & healthy motor load performance, to take proper care regarding the loading pattern, over-hauling and re-winding practices.

- ***Compressors:***

- *It was recommended to operate 3 HT compressors in place of operating 2 LP air and 2 nitrogen compressors. The maximum air requirement for the plant is around 18400 CFM at a pressure of around 8 kg/cm². Since three HT compressors alone can meet this requirement if scheduled properly, it is advised to operate only three HT compressors. This will save 5.7 Million kWh electrical units annually.*

Annual savings : Rs. 25.7 Million per annum
Investment required : Rs. 4.0 Million
Payback period : 2 months

- *Presently, the Khosla compressors are being used to supply air at 8 kg/cm² to the boiler/instrumentation. During the audit it was found that the LP air compressors were also operating at 8 kg/cm² and since there was surplus capacity of these compressors, seldom the excess air compressed by these air compressors is vented out at high pressure. It was recommended that instead of venting this high-pressure air, which represents energy loss, this air should be used to* *supply boiler/instrumentation purposes & thus avoid the operation of the Khosla compressor. This will save 0.13 Million kWh electrical energy per year.*

Annual savings	*: Rs. 0.6 Million*
Investment required	*: Rs. 0.1 Million*
Payback period	*: 2 months*

- *As service air application require air at low pressures, it was recommended to use transvector nozzles for cleaning & service air requirements. This exercise will help save 0.09 Million kWh electrical units per annum.*

Annual savings	*: Rs. 0.42 Million*
Investment required	*: Rs. 0.2 Million*
Payback period	*: 6 months*

- ***Lighting:***

- *It was found that lighting transformers were all under-loaded. It was advised to explore the possibility of supplying adjacent areas by a single lighting transformer so as to improve the transformer loading.*

- *Replacement of the conventional tube-lights, presently operating with copper chokes, around 3500 in number, by the energy efficient T-5 tube -lights and with electronic ballast was recommended. This measure will save 0.23 Million kWh units of electrical units annually.*

Annual savings	*: Rs. 1.04 Million*
Investment required	*: Rs. 1.93 Million*
Payback period	*: 22 months*

Water Pumping System & Cooling Towers

The Plant has several water pumping systems such as cooling water supply, raw water supply, DM water system in addition to three large cooling towers.

- ***Rationalisation of CT # 1 water pumps operation***

GCU (Gas Cracker Unit) section has a separate set of pumps while GPU (Gas Processing Unit) & IOP (Integrated Oxide Plant) has different set of pumps with dedicated headers. It was recommended to replace the impellers of pumps and operate as a common system thereby resulting in reduction of power consumption by 5.0 Million kWh per year.

Annual savings	*: Rs. 22.64 Million*
Investment required	*: Rs. 10.0 Million*
Payback period	*: 5 months*

- ***Reduce the discharge pressure of pumps (or) replace the pumps with suitable capacity (head and flow) for CT# 2***

It was recommended to verify the actual water pressure requirement and accordingly initiate the steps either to reduce the water pressure or replace the pumps with suitable head, resulting in an annual energy saving of 1.2 Million kWh per year.

kWh per year.

Annual savings	*: Rs. 5.3 Million*
Investment required	*: Nominal*
Payback period	*: Immediate*

- ***Installation of variable speed drives for pumps in DM plant and CPU plant***

Recirculation valves are installed to degasser water pump, condensate feed pump and polished condensate transfer pump. It was recommended to install VSD to these pumps to avoid recirculation thereby saving 0.33 Million kWh per year.

Annual savings	*: Rs. 1.5 Million*
Investment required	*: Rs. 2.1 Million*
Payback period	*: 17 months*

- ***Replacement of DM water transfer pumps with one large pump coupled with VSD***

DM water transfer pumps were operating at poor efficiency and recirculation was observed across the valve. It was recommended to replace the present pumps with one large pump coupled with VSD, saving 0.34 Million kWh per year.

Annual savings	*: Rs. 1.52 Million*
Investment required	*: Rs. 1.5 Million*
Payback period	*: 12 months*

- ***Replacement of raw water transfer pumps***

Raw water collected in Reservoir # 3 is transferred to Reservoir # 1 with the aid of two pumps. It was found that the actual head was too high compared to rated head and efficiency was low. It was recommended to replace the present pumps with required head pump (32 m) and thereby achieve energy savings of 0.2 Million kWh per year.

Annual savings	*: Rs. 0.9 Million*
Investment required	*: Rs. 0.6 Million*
Payback period	*: 8 months*

- ***Installation of variable speed drive to the cooling water make up pump***

During the audit study it was observed that there is wide variation in flow and pressure of cooling water make up pump. It was suggested to install variable speed drive to the motor and control the speed by monitoring the pressure, thereby saving 0.12 Million kWh per year of energy.

Annual savings	*: Rs. 0.54 Million*
Investment required	*: Rs. 0.7 Million*
Payback period	*: 16 months*

- ***Interconnection of RWTP # 1 and RWTP # 2 tanks and avoid the pump operation***

Filtered water is stored by the plant in two tanks. Both the tanks are at the same ground level. Water is transferred from one tank to the other using a pump. It was recommended to interconnect these two tanks at the bottom level to avoid the operation of pumps and result in annual energy saving of 0.3 Million kWh.

Annual savings	*: Rs. 1.3 Million*
Investment required	*: Rs. 0.5 Million*
Payback period	*: 5 months*

5.3 Energy Efficiency In Exploration Activity (Rigs)

Crude oil exploration is a very costly operation. The main equipment for oil exploration is a drilling Rig.

Generally the Rig consists of the following machineries:

1 Main Derrick consisting of a drilling platform, cat walk platform and two big pulleys. The upper pulley is called the Crown Block and the lower one called Traveling Block, through which, the winch is moved by Draw works. The Draw works may be electric driven or mechanical driven. The Draw works drills the well with the help of drilling bits and shrouded pipes.
2 DG Sets, which are the heart of the Rig supplying power during drilling as well as Rig building phase.
3 Mud pumps for the circulation of mud during drilling and well formation and as and when required.
4 Supercharger pumps to supply mud to the suction of mud pumps
5 Desilter pump for the purpose of desilting from dirty mud coming out from the well.
6 Desander pump for the purpose of removing sand from the dirty mud coming out from the well
7 Air compressors to cater air to winch, clutch and Twin stop cam counter of Draw works.
8 Agitators for the purpose of mixing of mud
9 Shale shakers
10 Degasser
11 Fuel Tanks & Fuel pumps
12 Eddy current Brake for control of Draw works
13 Bunker Lab for the testing of mud quality
14 Bunker housing
15 Cranes
16 For floating rigs - anchors or dynamic positioning system. For self propelled drill ships - propulsion system.
17 Water maker to produce drinking water on the rig
18 Cementing unit - to cement casing against formation.
19 Blow out preventor - to control well pressure.

Total operation of the Rig consists of following three phases:

Rig building phase: During this phase, the skid mounted portable machineries are transported to the site by tailor trucks and are being installed. This stage takes around 20 days. For offshore operation rig moves from one location to another location either by towing or self propelled. Time taken depends on the distance to be moved.

Spudding / Drilling phase: During this phase, almost all the machineries of the Rig are run and this phase consumes the maximum energy in terms of HSD. This phase continues for a period of about 100 to 120 days depending upon the depth of the well.

Production Testing phase: During this phase, the samples of the well are tested and then Rig is dismantled. This stage takes about 60 days.

5.3.1 Energy Consumption

Energy used in a Drilling rig is Electrical energy. This electrical energy is produced using captive mobile power generation units. In very rare cases, grid power is also used. The fuel for these power generation units is either HSD or Natural gas.

The primary source of energy in a Drilling Rig is the Diesel Oil for DG sets. Most of the DGs in the exploration rigs in India are old and de-rated and are expected to consume higher fuel as compared to the design.

5.3.2 Basic Process Flow Diagram

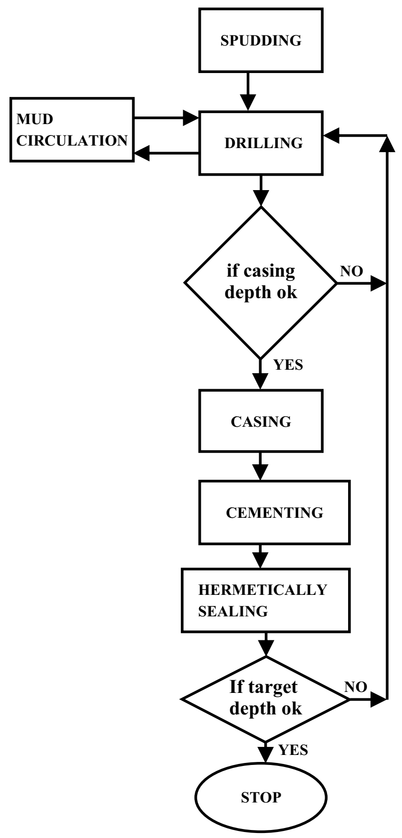


Figure - 5.1

5.3.3 Energy Management Plan

The measures identified may be short term, medium term or long term requiring nil to high investments. Medium & Long term efforts are structured and normally implemented without much efforts. One example of long-term efforts is the replacement of outdated, energy inefficient DG engines like D 399 by new energy efficient models like CAT 3516 requiring high investment of the tune of Rs 250 Crores.

However short term programs are basically voluntary and needs to be push forwarded by:

- Awareness generation
- Leadership demonstration
- Top management support

A good energy management plan for a Rig should generally comprise of:

- Fuel consumption to be compared with specific energy generation.
- Proper log sheet for regular energy monitoring
- Instrumentation / software to facilitate energy logging and evaluation of specific energy generation.
- Energy monitoring based on norms developed.
- Energy monitoring to be based on drilling depth and soil condition.
- Segregation of AC and DC loads and have power packs dedicated to AC and DC operation.

5.3.4 Best Operation Practices in Rigs

Best Operating Practices (BOP) is referred to operating procedures and good house keeping habits for reducing the wastage of energy, reducing & preventing environmental pollution. The overall philosophy of BOP is to conduct every day activity in more efficient, safe and environmentally sound manner.

5.3.4.1 Efficient Operation of DG sets

- When the total running load during non-drilling days is small (in the range of 50 KVA), a smaller rating (say 63 KVA) DG set should be used during non-drilling days
- Monitoring of specific energy generation ratio (SEGR). SEGR of a DG set is a performance indicator, which is proportional to the extent of loading of the set. At part load operation, the efficiency of the DG set drops with consequent decrease in the SEGR value. Proper monitoring of SEGR will help in conserving energy.
- Monitoring of Lube oil quality. The drain interval of lube oil specified by the manufacturer is based on worst operating conditions and a high factor of safety.
  By follow of good operating and maintenance practices, there is a distinct possibility that the condition of the lube oil remains good and usable even after the specified period.
- Testing of lube oil for certain physicochemical properties like viscosity, total base number, water content, insoluble build up etc, may extend the drain interval for lube oil.

5.3.4.2 Efficient Operation of Mud Pumps

This is the single largest load on a Rig consuming 50 to 60% of total energy consumed on a rig.
These have an operating pressure of 5000 to 7000 psi and hydraulic efficiency is normally more than 90%.
Reciprocating Pump operates at constant efficiency levels and hence has constant losses. Below are some general measures for energy conservation in a mud pump operation:

- The biggest culprit for energy wastage in mud pump is idling during lunch & shift changeover and higher discharge rate.
- Under loading of the prime mover is another fuel wasting situation.
- Suction starvation can cause performance loss and failure of pump.
- Entrained gas may reduce suction Efficiency
- Each pump should feed Separate Mud Processing Equipment.
- Mud temperatures of 66^0C can present critical suction problems
- A poorly designed discharge manifold can cause shock waves and excessive pressure peaks
- Excessive solids can:
  1) cause wears on drilling equipment
  2) reduce ROP (Rate of Penetration)
  3) cause a thick and permeable filter cake and fluid loss
  4) cause unwanted pump exertion

5.3.4.3 Efficient Operation of Agitator

The following information must be known to properly size an agitator system:

- Tank and compartment dimensions
- Compartment shape
- Compartment duty (solids removal, testing, suction, storage, or pill/slug)
- Maximum mud density expected
- Coupling of multiple agitators to one motor
- Agitator & mud gun combination gives better agitation

5.3.4.4 Efficient Operation of Air compressors

- In a rig, compressed air is used for pneumatic control; start up operation of DG sets etc.
- Regular maintenance should be undertaken as per schedule
- All air leakages must be plugged
- In many installations, the compressors are manually switched on/off at the required pressure. Installation of automatic pressure switch with predetermined setting can save wastage of energy.
- Use of automatic drain valve in the air receiver. By using the auto drain valve, water would only be allowed to pass intermittently depending on the water level in the air receiver, thereby minimising the wastage of compressed air.

5.3.4.5 "Deep Trek" and Other Drilling R&D

The U.S. Department of Energy's Office of Fossil Energy kicked off the 'Deep Trek' Program in 2002 to help develop high-tech drilling tools that industry needs to explore the deeper deposits of hydrocarbons. The goal was to develop a "smart" drilling system tough enough to withstand the extreme temperatures, pressures and corrosive conditions of deep reservoirs, yet economical enough to make the hydrocarbons affordable to produce. The projects include advancing drilling performance, developing "smart" communication systems, instrumentation, novel drill bits and fluids, and novel pipe systems that are able to withstand the severe temperatures (over 400°F) and pressures in deep horizons.

These "smart" drilling systems can report key measurements - temperature, pressure, fluid content, geology, etc. - as a well is drilled. Sophisticated electronic systems can identify potential trouble spots on a real-time basis, allowing operators to make adjustments without interruption or costly work stoppages.

5.3.4.6 Other Drilling Advancements

a) Mud Pulse

It is the first system to transmit drill bit location by sending pressure pulses through drilling mud, which was developed by the US Energy Department and Teleco, Inc. Today, this "mud pulse" measurement-while-drilling telemetry has become standard in the industry.

b) IntelliPipe

A new technology system in downhole telemetry, sponsored by US DOE called IntelliPipe turns an oil and gas drill pipe into a high-speed data transmission tool capable of sending data from the bottom of a well up to 200,000 times faster than mud pulse and other downhole telemetry technology in common use today. Potential benefits include decreased costs, improved safety, and reduced environmental impacts from drilling.

c) New drill bits

The polycrystalline diamond (PDC) drill bit, now the industry standard for drilling into difficult formations, is a Revolutionary new drill bit developed by US Energy Department's research program. Scientists at the Energy Department's Sandia National Laboratories have successfully developed a "diffusion bonding" approach. More recently, Penn State University, working under an Office of Fossil Energy contract, developed a way to use microwaves to harden the tungsten carbide of deep drilling bits, resulting in a 30 percent increase in strength.

d) Advanced composite drill pipe materials (Carbon fiber)

The drilling system of the future may also employ new advances in drill pipe materials as a result of the Energy Department's research program. In mid 2004, the Department announced the development of a new "composite" drill pipe that is lighter, stronger and more flexible than steel, which could significantly alter the ability to drain substantially more oil and gas from rock than traditional vertical wells.

The carbon fiber drill pipe is likely to weigh less than half the weight of steel drill pipe, and the lighter the pipe, the less torque and drag is created, and the greater distance a well can be drilled both vertically and

horizontally.

e) The Microhole Technology

The Microhole Technology drills small diameter boreholes (approximately two-inch diameter), using smaller sized equipments to complete microholes, and advanced diagnostic tools to measure important reservoir characteristics. The cost reduction using this technology is estimated to be nearly one-half the cost of traditional drilling rigs. The feasibility of microhole technology has been demonstrated by pioneering work conducted by Los Alamos National Laboratory (LANL) in collaboration with Maurer Technology. The team has successfully used coiled-tubing-deployed micro drilling to drill wells as small as 1-3/4-inch in diameter and as deep as 800 ft.

5.3.5 Energy Conservation Measures In Drilling Rigs

The heart of the drilling rig is the Power Packs i.e., the DG sets which are generating power for the entire Rig by using HSD in diesel engines .The consumption of HSD in the DG sets varies between 500 lits per day to 2500 lits per day depending upon the following factors:

1. Location (formation type)
2. Drilling hole diameter
3. Drilling depth
4. Health of the DG engines
5. Pull out practice (operation of drillers foot, pull out time per pipe)

The most important factor out of the above points is the health of the DG engines. The health of engine plays the major role in the oil (HSD) consumption in the Rig. For example one of the Rigs operating in India in the north east part of India is being operated with maximum 3 nos. of DG sets for a drilling depth of about 2500 Meter and at the same time with almost same formation and same drilling depth the other Rig is being operated with 4 nos. of DG sets (both the places the ages of the engines are almost same). The reason for the same is better maintenance prevailing in the first site.

Good Maintenance Practices

Checking schedule

1. **Name of the parts** / **Checking after**

Name of the parts	Checking after
Liner	200 Hrs
Piston	200 Hrs
Valve insert	24-36 Hrs
Valve spring	24-36 Hrs
Valve cover gasket	24-36 Hrs
Water Valve	24-36 Hrs
Valve Sheet	24-36 Hrs

Daily Checking

- Lube oil
- Radiator water & Radiator cap
- Bearing condition (visually)
- Belt
- Leak of Fuel
- Oil
- Air cleaner box indicator

Quality of Radiator water plays a very important role. If possible DM water may be used and 20% coolant to be used along with the radiator water. This will ensure at least 0.5 % saving of fuel (HSD) in DG engine

Fluid end part

Name of the parts	Checking after
Valve insert	24-36 Hrs
Valve spring	24-36 Hrs
Valve cover gasket	24-36 Hrs
Water Valve	24-36 Hrs
Valve Sheet	24-36 Hrs

Lube Oil

Lube oil selection and use plays an important role in the efficiency of DG engines

- Lube oil consumption tells about the health of engine. Appropriate specific lube oil consumption for D-399 Caterpillar engine is 0.5 lit/hr. If the oil consumption goes higher than this value, engine needs attention.
- Lube oil to be changed after every 1000 Hrs (of course after checking the quality as mentioned below)
- Use 15 W-40 after talking to OEM, in place of SAE30 as recommended by OEM.
- Condition monitoring may be started after every 250 Hrs with the help of portable analyzer kit (cost around Rs 35000/-)
- Lube oil to be changed when the following conditions appear
  - TBN (Total Base Number) : Variation of 50% of original value.
  - Flash point : 50 Degree below the original value.
  - Viscosity (centistokes) : 25 ± original value.

Maintaining the condition of lube oil of DG set will ensure increased efficiency of the engine and a saving minimum 0.5 % HSD consumption as compared to deteriorated lube oil.

Case Study 2: Energy Audit at an Onshore Drilling Rig

About The Rig

All the DGs / Alternators are totally overhauled during July/ August 2004 and put back for use in THE RIG in March 2005. The Power Control Room (PCR) of the rig is absolutely new and its make is National Oil Well (Model 2001). The rig is unique as it is the only rig where Variable Frequency Driven TOP Drive system has been implemented in place of Rotary Drive System for the first time in Assam Region. The

advantage of this is that at a time 3 strands can be put together for drilling operation. Hence the total time for drilling can be reduced considerably. But at the same time fuel consumption will increase during drilling phase because of additional load of electrical TOP DRIVE in place of conventional mechanical Rotary Drive. However overall energy saving is envisaged to be less in such rig operation due to less no of days required for drilling. As per GTO (Geo Technical Order) the total number of days envisaged was 368 days but as per actual status this rig operation has been estimated to be 300 days that too including 45 days of idling due to problem in the newly installed TOP DRIVE system.

Study Of Energy Consumption Pattern - Preceding Three Years

Parameters	YEARS		
	2002 - 2003	2003 - 2004	2004 - 2005
HSD (LT) Consumption	762098	1228036	**147420**
POL (LT) Consumption	14910	28560	1100
MTR DRILL	7869	4752	2335
kWh/MTR	352.53	940.67	134.76
TOTAL kWh	2774058	4470064	314673
SFC	0.2747	0.2747	0.468

Rig was commissioned in March 2005 after total overhauling of DGs.

Details Of DG Engines

Sr No	Item	DG 1	DG 2	DG 3	DG 4
GENERAL					
1	Engine serial no.	2XJ00014	36Z02060	36Z01988	36Z01525
2	Peak Load (kVA)	600	600	600	600
3	Total Working hrs. (Present Well)	276	276	276	276
FUEL					
4	Type of fuel	HSD (Diesel)	HSD (Diesel)	HSD (Diesel)	HSD (Diesel)
5	Fuel Density	0.865 at 15^{0}C	0.865 at 15^{0}C	0.865 at 15^{0}C	0.865 at 15^{0}C
6	Method of checking fuel quantity	Manual By Tank Dip	Manual By Tank Dip	Manual By Tank Dip	Manual By Tank Dip
17	Fuel Consumption of Present Well (as on 11.08.05 in Lts.)		991037 Lts		

SFC (Specific Fuel Consumption, lit/kWh) of DGs of the rig

NO. OF DG SETS IN RIG: 04 (FOUR)													
ENGINE PARTICULARS													
S.no.	DG ID	Make	Model	Engine sl. No.	Capacity	Present status (SFC) *				Design parameter (SFC)			
						25%	50%	75%	100%	25%	50%	75%	100%
1	DG 1	CATERPILLAR	D 399	2XJ00014	1215	0.35	0.31	0.30	NA	0.324	0.2743	0.2617	0.2674
2	DG 2	CATERPILLAR	D 399	36Z02060	1215	0.37	0.325	0.329	NA	0.324	0.2743	0.2617	0.2674
3	DG 3	CATERPILLAR	D 399	36Z01988	1215	0.34	0.31	0.30	NA	0.324	0.2743	0.2617	0.2674
4	DG 4	CATERPILLAR	D 399	36Z01523	1215	0.385	0.365	0.355	NA	0.324	0.2743	0.2617	0.2674

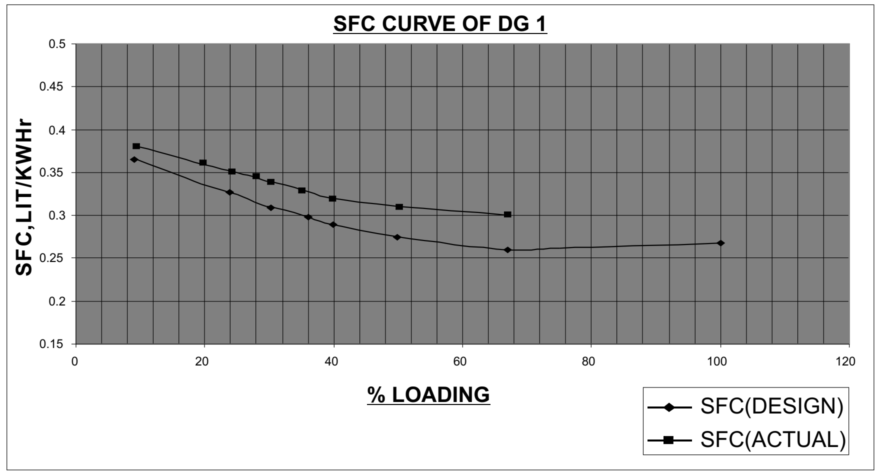
* *Trials were taken by isolating DGs from the existing fuel oil system and using half cut drum for supplying HSD fuel to DG set and recording the dip before and after the trial.*

Present Fuel Consumption Of DG Sets

SFC of DG 1 (at 35% loading) : 0.33
SFC of DG 2 (at 35% loading) : 0.33
SFC of DG 3 (at 35% loading) : 0.345
SFC of DG 4 (at 35% loading) : 0.37

SFC Curve of DG 1

Actual vs Design SEC CURVE (% Loading of DG vs consumption of HSD) of DG engine will give the clear picture about the health of DG set at a particular point of time. More the gap between the actual and the design curve, more the aging of the engine and more care is required in terms of maintenance.



Energy savings

No Cost Option

SL. NO.	DESCRIPTION	SAVINGS POTENTIAL		INVESTMENT (Rs. in lakhs)	PAYBACK MONTHS
		KLOE / MONTH	Rs. (Million/ month)		
1	Running of each DG at minimum loading of 35%	21.2	0.678	-	Immediate

Medium Cost Option

SL. NO.	DESCRIPTION	SAVINGS POTENTIAL		INVESTMENT (Rs. in lakhs)	PAYBACK MONTHS
		TOTAL KLOE	Rs. Millions		
1	To install one no. of 125 KVA DG set to run during production testing, logging and rig building phase	13.5	0.432	8	22 months

High Cost Option

SL. NO.	DESCRIPTION	SAVINGS POTENTIAL		INVESTMENT (Rs. in lakhs)	PAYBACK MONTHS
		TOTAL KLOE	Rs. Millions		
1	To run DG at 50% load min. in stead of 25% by installing 4 nos. of APFC at the PCR, 2 nos. of fixed capacitor bank at the DBs of 1000 HP DC motor and to install 6 nos. of soft starters	45.6	1.459	9	22 months

Estimation Of Saving Potential During Drilling Phase

Basis:

1. *Average SFC estimated at an average loading of 25% (including drilling and idling period) during the drilling phase at 1400-23 Rig = 0.4249 lit/kWh (DG 1: 0.4219, DG2: 0.4295, DG3: 0.4269, DG4: 0.4212)*
2. *Average loading of DG set is increased to minimum 35% from the present average loading of 25% so as to decrease the average SFC from 0.4249 to 0 .3675 (DG 1: 0.36, DG2: 0.3675, DG3: 0.3825, DG4: 0.36)*
3. *Monthly average kWh measured during the trial = 370800 kWh.*

Estimation:

Hence if the DGs are run at minimum loading of average 35% instead of average 25% loading monthly saving = 370800 (0.4249 - 0.3675) = 21284 lit
= 21.2 KL of HSD = Rs. 0.678 Million

Savings Due To Installation Of One 125 kVA DG Set For Running During Rig Building, Production Testing And Logging Operation And Simple Pay Back Period.

Basis:

1. Load during day time : 60 kW
2. Load during night time : 90 kW
3. No. of days of duration for production testing and logging and Rig building phase : 75
4. SFC with 125 kVA DG set with 75 % loading : 0.300 (at 75% load)
5. SFC with existing big DG with 10% loading during production testing, logging operation : 0.40

Estimation For The Energy Saving

1. Total Energy required during 75 days at day time = 75 (days) x 60 (kW) x 12 hrs
= 54,000
2. Total energy required during 75 days at night time = 76 (days) x 90 x 12 = 81,000
Hence total energy required during 75 days of production testing, logging period = 54000 + 81000 = 135,000 kWh
3. HSD consumption to generate 135,000 kWh of energy by big caterpillar engine with SFC of 0.4 lit/KWhr at an average loading of 10% = 135,000 x 0.40
= 54,000 lits of HSD
4. HSD consumption to generate 135,000 kWh of energy by 125 kVA DG set with SFC of 0.3 lit/KWhr at an average loading min 75% =1,35,000 X 0.3
= 40,500 lits of HSD
5. Hence total saving of HSD = 54,000 - 40,500 = 13,500 lits
= Rs. 0.432 Million

Pay Back Period For The Installation Of 125 kVA Smaller DG Set

1. *The investment required = 0.8 Million*
2. *Savings expected = 0.432 Million*
   (during 75 days of production testing logging)
3. *Payback period = (0.8 / 0.432) x 12 = 22 months*

Installation Of Capacitor Bank

The main problem of a drilling RIG is the power factor of power generated by the DG engines. Due to sudden change of load in the RIG due various reasons the DC load of Draw works and mud pump (AC load of DG is getting changed to DC with the help of SCRs to supply DC power to Draw works and Mud pump). As the DC load increases or decreases the power fluctuates from as low as 0.2 to 0.65 resulting KVA demand (KW/PF) fluctuation. The poor factor actually force the electrical man in the RIG to run additional engines for safety factor so as to avoid black out situation. This results in poor loading of individual DGs resulting high consumption of HSD at poor loading.

One solution for improving and sustaining the power can be installation of automated power factor controller. But globally there is no instance for adopting such APFC. However efforts can be made in this direction on experimental basis.

Estimation Of kVAr Requirement For The Capacitor Banks

Calculation of KVAR for APFC (for installation at the common outlet of all the DGs)

kVAr requirement = *Maximum load (kW)* $[\tan(\cos^{-1} Ø 1) - \tan(\cos^{-1} Ø 2)]$

Where $Ø1 = 0.4$ *(av. PF of the system)*

$Ø2 = 0.7$ *(max. PF that can be achieved)*

$= 1250 [\tan(\cos^{-1} 0.4) - \tan(\cos^{-1} 0.7)]$

$= 1250 [\tan(66.42) - \tan(45.57)]$

$= 1250 [2.29 - 1.02]$

$= 1587 \approx 1600$

Hence four nos. of APFCs of each 400 kVAr capacity in series can be put at the PCR (Power Control Room) to improve upon the PF.

Estimation Of Savings Potential By Improving The Power Factor (From 0.4 To 0.7) And Reducing The kVA Demand Of The Rig

Basis:

1. *Existing avg. PF of Rig = 0.4*
2. *Improved PF of Rig after installation of APFCs and fixed type Capacitor Bank = 0.65*
3. *Present average loading of DGs is 25%*

Estimation For Saving

1. *One DG can be stopped by reducing the peak demand from 1250 kW max (3125 kVA) to 1925 kVA with the help of capacitor (Automated and fixed). By this in extreme situation, instead of running 4 DGs (each DG can take care 970 kVA max (80% of 1215 kVA limited to alternator). 2 DGs can cater the same load.*
2. *On the safer side if 3 DGs run in place of 4 DGs during the entire period of the rig operation, operation of 1 DG can be stopped.*
3. *Considering stopping of one DG throughout the rig operation thereby increasing the loading by around 25% (from 25% loading to 50% loading) the SFC can be reduced from 0.3220 to 0.3025 (refer actual SFC curves of DGs)*
4. *Considering the total power requirement of 2340200 kWh (estimated earlier) during the entire period of Rig Operation and a reduction of SFC by 0.0195 lit/kWh.*

Total Saving = 45634 lit/kWh of HSD

= 45.6 KL/HSD = Rs 1.459 Million

5. The payback period for the above investment

$= \frac{0.9 \text{ Million (investment)} \times 12}{1.459 \text{ Million}} = 7$ *months*

5.4 Activities of Conservation of Oil and Gas in ONGC

ONGC has taken many steps for conservation of energy. One of the examples of its long-term efforts is the plan for replacement of all D-399 engines by new energy efficient engines model CAT 3516 at a cost of about Rs. 250 Crores. These CAT 3516 engines are 5% more efficient.

5.4.1 Year wise consumption in ONGC

Year	2006-07	2007-08
HSD in KL	196440.7	215419.4
Natural Gas in MMSCM	1602.5	1739.6

5.4.2 Steps initiated to conserve Petroleum products

ONGC's program of oil conservation is briefly summarized as below:

(A) Action Taken In-house For Conservation

a) Awareness Program is held every year under OGCF (Oil & Gas Conservation Fortnight)
b) Seminar / Conference is organized for deliberation of issues on petroleum conservation.
c) ONGC Energy policy is already framed
d) Energy Conservation tips are continuously scrolled on ONGC's house portal.
e) E.C. Committee has issued two policies on conservation as under
- Use of Solar Water Heating Systems in ONGC
- Use of Energy Efficient Lighting System in ONGC

f) On line quiz being held every year for ONGC employees and their wards.
g) Three booklets are issued on conservation of Oil & Gas.
- Urja Udai
- Energy Conservation Techniques
- Quest

h) A company wide training drive as "Energy Conservation Techniques Training" has been taken up with the help of PCRA for training about 20000 officials of ONGC.

i) All models of engines have been audited and corrected for their running efficiency.
j) 285 CAT D-399 Engines being replaced in phased manner by CAT D-3816 Energy Efficient Engines.
k) Solar Water Heating Systems of different capacity has already been installed on following locations in ONGC.
   1. 1300 Litres Per Day (LPD) at ONGC Guest House Tel Bhawan, Dehradun.
   2. 9000LPD at ONGC Hospital Dehradun.
   3. 7200LPD at GT Hostel in ONGC Academy.
   4. 7200LPD at ONGC Colony Dehradun.

5. 800LPD at Officers Club ONGC Dehradun.

l) 50MW Wind Power Project has been installed in Gujarat, near Bhuj. With a saving potential of Rs. 29.86 Crores/Year.

m) More then 200 Energy Audits Carry outs on the different ONGC Installations.

(B) Expected reduction in consumption (from major initiatives)

1.	"Energy Conservation Techniques Training"	3- 5%
2.	Solar Water Heating Systems in ONGC	5-10%
3.	Wind Power Projects	10-15%
4.	By Energy Efficient Engines (Caterpiller)	14-17%
5.	By Energy Efficient Engines (Cummins)	3-7%

(C) Strategies for Conservation In Future

II. Additional awareness program in the organization to be taken up.
III. More policies of Energy Conservation are to be put up for application.
IV. Additional Solar/Thermal systems to be installed on more areas.
V. Additional new Wind Power Plants to be set up in future.
VI. First time Geothermal Energy project to be taken up.
VII. Replacement of inefficient equipments.
VIII. Tapping up waste heat recovery from exhaust of engines.
IX. Waste heat recovery from Engines Jacket Water/Radiator
X. Solar Electric System
XI. Ocean Energy

5.5 Energy conservation measures in Oil India Limited (OIL)

5.5.1 Present Level Of Energy Consumption By OIL(During 2007-08)

Energy	Unit	Qty	Eqvt.kWh	Approx. Monetary value (Rs. in Lakh)
Crude Oil Consumed for Transportation of OIL's & ONGC's crude Oil to refineries, etc.	kL	8069.00	78.269×10^6	1690.50
Natural Gas (industrial & domestic uses)	MMSCUM	370.07	4266.90×10^6	11842.24
Diesel oil (HSD) (Drilling & W.O. operations, prime mover operations, power generation, transport fleet, etc.)	kL	13397.64	107.964×10^6	4342.175
L.D.O.	kL	7.20	0.07×10^6	2.70
Petrol	kL	68.77	0.65×10^6	32.72
K.Oil	kL	0.942	0.09×10^6	0.015
Lube Oil	kL	771.061	***	652.93
Electricity	kWh	-	111.00×10^6	2053.50
TOTAL			4564.947×10^6	20616.78

5.5.2 Various Measures Adopted By OIL For Conservation Of Energy During The Year 2007-08

5.5.2.1 Conservation Of Crude Oil

A total quantity of 4431 kL of Crude oil has been saved/retrieved from different operational activities during the year under review by adopting the following measures:

- Use of Aluminium paint in all crude oil storage tanks to minimize evaporation loss.
- Use of Oil Soluble De-emulsifier (OSD).
- Use of dual fuel (Natural Gas and Crude Oil as fuel) engine in Crude Oil Dispatch Pumps in PS-1 & PS-2 since natural gas is available.
- Regular & proper maintenance of Crude Oil Transportation Trunk/ Branch Pipelines to minimize pumping power requirement. This is further reduced by treating the crude oil with flow improver chemical / heat treatment.
- Water Clarification Plant and use of De-Oiler.
- Retrieved from various pits and sumps.

5.5.2.2 Recovery of Condensate

Total volume of condensate recovered during the year was about 65604 kL, which in terms of money amounts to Rs. 13744 lakhs (approx.)

- By the operation of condensate recovery plant (CRP) at Moran, a total quantity of 3957 kL condensate recovered.
- Condensate recovered from Duliajan field -61236 kL
- Condensate recovered from Rajasthan project- 356 kL

5.5.2.3 Conservation Of Natural Gas

Reduction in natural gas consumption in COCP's at Duliajan and Moran

During the year, the crude oil of both OIL & ONGC was treated with Flow Improver chemical instead of thermal conditioning and thereby the consumption of natural gas in COCPs at Duliajan has been reduced considerably and as a result the total saving of natural gas was around 6.84 MMSCM (amounts to Rs.218.8 lakhs approx.) during the year 2007-08.

Reduction of Gas flare

The following steps were taken for the reduction of natural gas flare during 2007-08.

1 Gas flare in Moran field has been reduced to 0.05 %.
2 A total of 1.1 MMSCM very low pressure gas (about 0.7 kg / cm^2 stabilizer gas which is normally being flared in many OCSs) is being utilized from Moran OCS as domestic fuel in housing area.
3 After commissioning of stabilizer compressor and water seal system at OCS-5, utilized 1.1 MMSCM low pressure stabilizer gas (0.7 kg / cm^2) as housing fuel which otherwise would have been flared.
4 After commissioning of two nos. gas distribution pipeline to utilize associated gas produced at Brekuri EPS and NKL/NKL QPS, resulted in reduced gas flaring and saving of 2102500 SCM of natural gas.
5 During the year 160392 SCM low-pressure gas (30 psig) of Deroi EPS sold to Moran Gas Grid. When there is no demand of gas from Moran Gas Grid, 20892 SCM of 30 psig low pressure gas from Deroi EPS was diverted to Moran GCS-2, which otherwise would have been flared.
6 Gas Holder: With the commissioning of the 30 psig Gas Holder the gas flaring caused by surging effect of the gas lift has been restrained.
7 Setting of Flare Controller: Periodic (weekly) flare controller setting at 35 psig is being carried out to avoid flaring of 30 psig gas at various OCSs.

5.5.2.4 Supervisory Control And Data Acquisition (SCADA)

The SCADA project commissioned on 15 March 1998 is presently being used to control the gas flare, accurate gas measurement, monitor consumption of gas as fuel in both Oil Collecting Station (OCS) and Gas Compressor Station (GCS) and for maximum utilization of produced gas, etc.

5.5.2.5 Conservation Of Diesel (HSD) And Petrol

Total quantity of about 406 kL (amounts to about Rs. 132 lakhs) of diesel has been conserved during the year under review by adopting the following measures:

1 By installation of Gas Engine driven Crude Oil Dispatch (COD) pump in place ofDieselEngine Driven Bowser loading pump at Barekuri EPS about 25.55 kL of HSD are being saved.

2 Eight nos. of work over wells were provided with electrical power from nearest available source, resulted in saving of 9.6 kL of HSD.

3 Use of solar lighting at Tanot-GGS (Rajasthan) & Pilot Plant at Baghewala (Rajasthan), resulted in saving of 2.84 kL of HSD

4 In pipeline operation 45 Nos. of old Dorman engines of generating sets having fuel (HSD) consumption in the range 3.6 to 4.0 Ltr/Hr, at various repeater stations have been replaced by Koel engines having fuel consumption rate of 2.6 to 2.8 Ltr/Hr., which resulted in saving of about 150 kL of HSD.

5 By using PDC Bits that cuts down the round trip time and resulting in reduction of the rig hours consequently there is considerable reduction in HSD consumption.

6 By adopting and continuing cluster-drilling techniques, consumption of fuel (particularly HSD) is reduced considerably. Rig dragging were carried out at five different locations whereby a rig was moved onto next cluster location without any rigging down operation. This additionally eliminates rig movements, which resulted in considerable saving in HSD consumption.

7 By adopting Horizontal Drilling technique, three full plus three part horizontal well were completed. Production from a horizontal well is three times than of a conventional well thereby saving in construction cost of two well as well as considerable saving in HSD consumption.

8 By using motor driven hydraulic power unit instead of engine driven hydraulic power unit for torque up casings during drilling operation resulted in considerable saving in HSD consumption.

9 Minimized workover and swabbing operation wherever feasible by using Coil Tubing Units (CTU) - Nitrogen Pumping Units (NPU). During the year 2007-08 total 129 nos. of work-over equivalent job were carried out by deploying CTUs & NPUs, resulted in saving of 218.4 kL of HSD

10 By replacing diesel engine driven centrifugal pump by motor driven pump in drilling rig for pumping gauging water, considerable amount of HSD was saved.

5.5.2.6 Conservation Of Lube Oil

1 By using Lube oil analysis kit, carrying out Chemical analysis from time to time and revising and setting up of lube oil standard, the lube oil consumption has been optimized which in fact contributed to the conservation of lube oil. The lube oil change period for caterpillar engine has been re-scheduled from 500 Hrs. (manufacturer's recommendation) to around 1000 Hrs. (OIL's practice) without any adverse affect on the engine, which resulted considerable saving of lube oil.

2. Due to use of improved quality of gland packing of the plungers of the injection pumps in Water Injection operations the consumption of lube oil was reduced considerably.

5.5.2.7 Utilisation Of Non-Conventional Energy

I. A total of about 244 nos. of Multi Access Radio Telephone (MART) terminals were provided with Solar Photo Voltaic Panels to achieve energy saving and cost reduction. By adopting these measures about 0.61 kL of HSD was saved during 2007-08.

II. Use of solar lighting at TANOT Gas Gathering Station and at Pilot plant, Baghewala resulted in saving of 2.84 kL of HSD.

References

1. Petroleum exploration and production activities, 2006-07, Directorate General of Hydrocarbons, Ministry of Petroleum & Natural Gas, GoI
2. Annual Report (2007-08) of Ministry of Petroleum & Natural Gas, GoI
3. World Energy Outlook 2007
4. TERI Energy Directory and Yearbook 2007
5. Statistical Abstract 2007-CSO
6. Report from Technical Services & Energy Conservation Cell of ONGC
7. Report from Technical Audit Department, OIL INDIA LIMITED
8. Energy Audit Reports of ONGC & OIL conducted by PCRA
9. BP Statistical Review, June 2008
10. PPAC Ready Recokner, April 2008
11. www.netl.doe.gov
12. www.fossil.energy.gov