CUTTING LIFT COSTS IN OIL FIELD PRODUCTION

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ABSTRACT

This paper compares several different types of production prime movers, their operating costs, and how to cut costs. Examples are given of actual operations in Texas oil production.

INTRODUCTION

We have several types of prime movers which have been in use for many years. First, we have the gas engines. In this category we have the slow speed single cylinder engine, as well as the higher speed, multi-cylinder engine. We also have electric motors.

Prior to World War II, the slow speed single cylinder engine was the standard prime mover in the oil field. Following World War II, many operators chose the small, multi-cylinder engines, primarily because of a lower acquisition cost.

Along with the gas engines we also have the electric motor. In fact, over the last 30 years the electric motor has become the most popular. This has been due largely to inexpensive electric rates and moderate, if any, charges to get the power to the motor. Actually, 80% of producing wells were powered with electric motors.

DISCOURSE

Let's discuss the advantages and disadvantages of the prime movers just mentioned.

Multi-cylinder engines have a lower initial cost per horsepower. They are light in weight, and do not require a heavy base. However, they require skilled maintenance. They are uneconomical when operated on wellhead gas. Because of the lack of flywheel inertia, due to their small flywheels, they must be carefully sized to carry the engine over peak cyclic loads. Their useful life is relatively short.

Horizontal, slow speed engines are of a simple and rugged construction. They can, in most cases, be repaired on location without skilled labor. Their life expectancy is extremely high. They have a high flywheel effect, and they run smoothly under cyclical loads. However, their initial cost is higher, per horsepower, than multi-cylinder engines. They also require a rigid base.

Electric motors offer some advantages. Initial cost and maintenance costs are low. Life expectancy and salvage are fairly high. Downtime is low. They are well adapted to automatic operation. On the other hand, power costs are high and getting higher. The cost of getting the power to the well is also high.

Until 1974, electric rates dropped and many utility companies gave away the construction costs of the power drop, in order to secure a multi-year contract. It was cheaper to electrify until the oil embargo. Since 1974, electric rates have risen greatly everywhere, and seldom does power line construction cost less than $5-6 per lineal foot. In many cases, the cost of the electric motors, control panels, and power drops meet or exceed the cost of gas engines. The big difference is in the cost differential between electricity and wellhead gas. Both costs have been rising, but electricity has been rising at a far more rapid rate than gas; and this trend is deemed to continue. Every producing area has a different accounting system for the gas consumed, and in many cases, the gas is consumed by the producer at no charge. Certainly, when the gas is free and available, it is far less expensive to use gas engines as prime movers.

This chart (Figure 1) was published by the Society of Petroleum Engineers in February of 1986. As you can see, you realize only 25% of electrical BTU energy for the same dollar value in natural gas. Obviously, coal has the highest energy potential in BTU rating, with natural gas next. Electricity is last in this chart. To sum it up, you will pay four times as much for electrical energy as you would for the BTU equivalent in natural gas. The cost of energy is a function of supply and demand, ease of handling, fuel efficiency and government regulations. Electric company officials predict an annual rate increase of 10 to 18%. The Department of Energy in Washington forecasts a minimum annual rate increase of 10%. Since 1982, we have had an average rate increase of 15 to 25% with a current national average rate of .09¢ per KWH.

This chart (Figure 2) shows an increase predicated on 10% per year, and as you can see, by the year 2000, we will be paying 28.4¢ per KWH. This is quite a drastic change from the 1.3¢ to 1.4¢ per KWH we enjoyed through the 1950's, and all the way into the early 1970's. If we look at this with an 18% increase per annum, we are faced with over $1 per KWH in the year 2000. Presently, over 1/3 of all U.S. electric power is produced by petroleum products, and has a fuel surcharge included in the rate. This alone makes electricity more expensive than wellhead gas.

Every electric company has several rate structures, so they are not easily pinned down. Some power companies are requiring a 5 year guaranteed service contract with a monthly billing based on nameplate horsepower, rather than metering actual usage. With this type of contract, should the well not be turned on for a 30 day period or during a billing period, the consumer is still billed for 50% or more of his usual monthly bill.

Another note to remember is that the money paid for line construction is a dead expense, as the power lines still belong to the utility companies, and the consumer has no collateral for future financing, should he need it; whereas the money invested in a gas engine purchases equipment that does belong to the operator, and does have a good market value.

An examination of the costs of buying and operating both the electric and gas prime movers presents the following analysis which describes the factors every producer should consider when choosing a prime mover. These should include equipment costs, power availability and costs, routine maintenance, service, and annual energy usage. Assume, for the purposes of this comparison, that our sample well requires a constant 20 HP prime mover. Several slow speed, horizontal, heavy-duty gas engines on the market are in this horsepower range. Their heavy flywheels supply the momentum necessary to drive the pumping unit through peak loads. These horsepower ratings are based on API specs which have already been derated for oil well pumping service. Since electric motors do not have the inertia of the gas engines, a derating of horsepower is necessary. Based on Frick's Petroleum Production Handbook, Volume I, a derating of .6 to .7 is used on Class C motors and .7 to .8 on Class D motors. Using an average derating factor of .7, we arrive at a horsepower requirement of 28.57 HP. Since a 28.57 horsepower motor is not a standard size, we are forced to use the next larger size which is 30 HP. Since, at peak load, over 28 HP is required and, at minimum load, less than 20 HP is needed, let's assume that the average load is 20 HP.

More than 70% of all wells produce enough gas to fuel the gas engine. Most gas engines for oil well pumping service will run on virtually any gas, so they will operate on most of those gas producing wells. A gas volume tank is recommended with the gas engine to ensure a steady flow of gas to the carburetor and to provide as dry a fuel as possible. Dry gas greatly extends equipment life and considerably reduces servicing. In many fields, one well will produce enough gas to power several engines.

The most amazing decision, economically, is when the producer has sufficient gas for fuel, but no sales market and electrifies anyway. In this case, all that gas energy is just wasted by venting it into the air. This hazardous situation occurs frequently.

Some operators contend that it is profitable to run electric motors and sell any produced gas. However, the sale of gas will rarely offset the higher electric costs. It would be more economical to run a gas engine and sell any excess gas.

Let's look at this example. The average 20 HP four cycle slow speed gas engine will consume 5280 cu. ft. of gas per day at 100% load, with 1100 BTU gas.

By calculation, the electric motor must supply 28.5 HP at peak load and little HP at minimum load. We are assuming an average demand of 20 HP. At 20 HP, the electric motor consumes 358 KWH per day (20 HP x 0.746 KW/HP = 14.92 KW: - 14.92 KW x 24 Hrs - 358 KWH per day). An electric motor consumes .746 KW per HP/HR, based on Ohm's Law.

If you sell the 5280 cu. ft. of gas the gas engine would use for $2.50 MCF, your revenue per day is $13.20 or $4,818 annually.

Using a nominal rate of $0.062 per KWH, including fuel surcharge, the electricity costs $22.19 per day or $8,101.54 per year. These costs are sufficiently high so that wells which produce only small quantities of gas would never consider selling the gas. It is far more feasible to use that gas to fuel the prime mover than to sell it and buy electricity. So, if you sold the gas your engine would use and operated an electric motor instead, your additional costs would be $3,283.54 per year. This is ignoring the cost of selling gas, such as collection equipment and/or pipeline costs and compressors.

Now, let's look at routine maintenance. The electric motor usually costs little to maintain. If it is operated properly, the cost of maintenance is simply incurred by the pumper regularly tending the well and checking performance. His time at the well might typically be 15 minutes per day. So, the cost is basically the pumper's time at the well site.

However, operators of electrified production do concede that maintenance is required and failures do definitely occur due to electrical disturbances. The extent of damage can be as severe as to require replacement of motors and transformers.

With the gas engine, the pumper must usually spend 50% more time per day on the average. He checks oil and water levels, clutch lubrication, fan belt tension, etc.

Let's compare energy costs. The cost of electricity is high and will continue to rise, particularly in view of the eventual decontrol of gas prices and their corresponding effect on the fuel surcharge included in electrical rates. Also, it has just been announced that utilities may include in electrical rates, construction costs of plants to be built or expanded. This can affect rates by 7 to 14% per year. This is on top of projected annual rate increases!

Electric motor operating costs are based on the kilowatt-hour usage which is directly related to horsepower. Using the following formula, determine the cost of your motor per year:

HP x 0.746 KW/HP x (KWH rate + surcharge) x 8760 Hrs/yr = total cost of electricity per year

If you run your electric motor less than a full year, multiply the 100% figure by the percentage of the year you do operate the motor. For example, if you only operate the motor 12 hours per day, use 50% as an operating factor.

Wellhead gas can be considered a cost of operation. The gas used by the engine could be sold. The average price of gas is $2.50 per 1000 cu. ft. This cost is generally cheaper than the cost of electricity, and it is expected to remain so. Many operators consider the cost of their gas as zero, since it is not produced in sufficient quantities to be saleable. This is a key point in the cost analysis. If gas is not considered as a cost, the savings over electricity are 50% or greater.

In some cases, you may run the gas engine on LPG, until the fluid level in the well is lowered sufficiently to allow the gas to flow. In this case, you would have to determine that cost to compare such an installation with electrified costs.

Refer to gas consumption curves to determine what your usage would be. Use that figure with the price of gas to determine fuel costs.

Costs of service should also be compared. The electric motor is subject to electrical disturbances and power outages as previously mentioned. But the unpredictable nature of these problems makes them difficult to measure. Power line failures may occur as well. In addition, the life of an electric motor is only 2-2½ years under constant duty. At this time, it requires new bearings and the windings to be dipped and baked. This cost is about 1/3 of the cost of a new motor. This is an expense every third year of operation at best.

The gas engine will require servicing on a regular basis including oil changes and minor parts replacement. You can assume an average of 30 hours per year for engine service, plus the cost of parts. The 30 hours will also cover a limited overhaul after 30,000 hours or more of duty. With this service program, the gas engine will give many years of duty. The gas engine was once considered obsolete after 12 years of service, but today's engines last 30 years or more. High quality replacement parts and a good preventative maintenance program can make a slow speed gas engine last a lifetime.

Let's go step by step through computing annual cost comparison between gas engines and electric motors.

1. Determine the horsepower necessary to drive your pumping equipment. Let's assume the well load requires a 20 HP gas engine. To equip this well with an electric motor, it will require a 30 HP electric motor with a 20 HP average load.
2. Contact your utility company and determine if power is available. If it is, identify whether it is single or three phase. Assume three phase is available and we are below the utility established limit of 75 HP. Determine the quantity and quality of gas available at the wellhead. Also, include a scrubber type volume tank to insure a steady, clean, dry supply of gas.
3. Determine from the utility company the nature of your agreement or contract with them for the power drop. Say, we have a fixed rate and capital cost per ½ mile is $20,000. This sum can be depreciated out over 5 years, so the annual cost is $4,000. Estimate the cost of plumbing the gas engine to be $150. This depreciated over 5 years is $30 per year for 5 years.
4. Identify any supplemental charges. Do not assume that the transformers are included in the fixed rate charge for the power drop. However, for this example, we will. No supplemental charges for the gas engine.
5. Determine the cost of the energy. For this example, let's use a rate of $0.062 per kilowatt hour including the surcharge. A monthly base charge of $13.00 is also applied. Use an "opportunity cost" of $2.50 per MCF for the wellhead gas.
6. Determine the equipment cost for the electric motor.

A 30 HP electric motor costs	$ 2,029.00
The control panel costs	1,737.00
For a total of	$ 3,766.00

7. A popular 20 HP slow speed gas engine with volume tank, regulator, and muffler costs $11,374.00. Depreciated over five years, the cost is $2,274.80.
8. Determine the cost of regular well inspection, based on inquiries into producer's costs, we determined that it costs a producer approximately $1,000 per well per year for regular inspection, assuming 15 minutes per well per day. This figure would be true for both electric and gas prime mover installations. If a gas engine powered well requires an additional 7.5 minutes per day we would add $500 for gas engine operation.
9. Normal operation of the electric motor will require bearing replacement, dip and bake every 2½ years. This cost will usually be $600. For the purpose of comparison, this is expensed over 5 years. Of course, electrical disturbances could alter that cost dramatically by repeating this expense and the possible cost of replacing transformers.

10. Assume an average of 30 hours labor per year for service of gas engine. At $25.00 per hour, the total per year would be $750. Add $290.68 per year for parts based on a study by a leading manufacturer of slow speed gas engines.

11. At $0.062 per KWH, the 30 HP electric motor (with a constant 20 HP load) will have an annual power costs as follows:

20 HP x 0.746 KW/HP =	358 KWH per day
358 KWH/Day x 365 days =	130670 KW per year
130,670 KWH x $0.062/KWH =	8,101.54 per year
$13.00 per mo. base rate x 12 =	156.00 per year

Total cost of electricity for year 8,257.54 total.

12. Since we are including an "opportunity cost" for the wellhead gas, we will calculate an energy cost for the gas engine installation. However, if gas from this well is not marketed, this price is not actually paid. The gas engine consumes 5280 CFM gas per day at a cost of $2.50 per MCF. So your annual "opportunity cost" is $2.50 x 5.28 MCF/Day x 365 days = $4,818.00.

13. The total cost per year for the electric motor is:

Depreciated cost of motor & panel	$ 753.20
Depreciated cost of power drop	4,000.00
Depreciated cost of rebuilt	120.00
Annual cost of reg. well inspection	1,000.00
Annual cost of electricity	8,257.54
Total yearly cost	$ 14,130.74

14. Total cost per year for the gas engine is:

Depreciated prime mover cost	$ 2,274.80
Plumbing cost	30.00
Annual cost of reg. well inspection	1,000.00
Addit. cost/gas engine service	500.00
Yearly cost of labor	750.00
Annual cost of repair parts	290.68
Annual cost of fuel	4,818.00
Total yearly cost	$ 9,663.48

If you do not consider the wellhead gas as a cost, subtract $4,818 from the gas engine total. The total cost would then be:

$ 9,663.48
4,818.00
$ 4,845.48

In conclusion, the difference in prime mover costs become obvious when you study all the aspects of the installation.

Electric Motor	$ 14,130.74 per year
Gas Engine	$ 9,663.48 per year
Gas Engine (no fuel cost)	$ 4,845.48 per year

The gas engine costs $4,467.26 less per year than the electric motor, when gas is figured as an opportunity cost. That is a 33% savings over electricity. The gas engine costs $9,285.26 less per year than the electric motor when the wellhead gas is figured at no cost. This is a 66% savings over electricity. The gas engine shows a significant savings over the electric motor of 33 to 66%. In today's oilfield economy, these savings can have a tremendous impact on profit, especially, if these figures were multiplied by the number of wells. In a field of one hundred wells, the annual savings would be between $466,801 and $925,526. That is almost a half million to a million dollars a year.

Until just recently, one of the big inducements to electrify was the capability of putting automatic controls on a well. A field proven means of automating the gas engine has been developed, and quite a number of these units are in service. They have proven to be as reliable as electric motors on an overall basis.

Let's look at an actual example of this. A large independent oil company had a 32 well operation in the Alice, Texas area. Since these wells were going to have to go to artificial lift, they looked first at electrifying. It was established that each well would require a 40 HP electric motor. The utility company would charge $100,000 for bringing power to these 32 wells. The cost for the 40 HP electric motor with switch gear would be approximately $3,300. The utility company quoted a flat rate of $1,500 per month for the energy consumed by the 40 HP motor.

Their gas has a value of $2.00 per MCF.

Using the work sheet, Figure 3, we have the following costs. Since the utility company demanded a 5 year contract, let's use a 5 year depreciation schedule to arrive at annual costs.

First, since line construction costs are $100,000, the cost per well for the 32 wells would be $3,125. This figure amortized over 5 years would be $625 per year. The $3,300 cost for the 40 HP motor with necessary switch gear over a 5 year period would be $660 per year.

Since most slow speed engines carry an API rating on horsepower output, and using a .7 derating factor on the electric motor, we find that the same load on a 40 HP electric motor can be handled by a 28 HP slow speed gas engine. This is due to the cyclical nature of beam pumping units. The large flywheel on the slow speed gas engine will effectively handle the unbalance of these pumping units. Keeping this in mind, a popular 32 HP gas engine will very capably handle the same load as the 40 HP electric motor under these conditions.

A new 32 HP slow speed gas engine complete with volume tank, muffler, and automation package lists for $17,916. This, over a 5 year period, would be $3,583.20 per year. Approximately $150 is the cost to plumb the gas supply to the engine, making an annual cost of $30 per year for 5 years. Well inspection will run an average of $1,000 per year per well. Using gas engines, the pumper requires more time, since he needs to check oil, water and other items on the engine. Assuming he spends 50% more time at each well, we can then use a cost of $1,500 per well for inspection with gas engines.

An electric motor does require some maintenance, so it is a good practice to have the bearings replaced and the windings dipped and baked every 2½-3 years. The cost for doing this on a 40 HP motor is about $600. Let's say you are lucky, and can get by with this once in 5 years, the $600 cost spread over a five year period would be $120 per year.

Based on a series of studies, it has been determined the annual repair parts cost on a 32 HP engine to be $314 per year, on a 5 year plan. Using a labor cost of $25 per hour and taking 30 hours labor per year for service and repairs, we have a $750 labor cost. This will total $1,064 per year for service and repair on a 32 HP engine.

At a flat rate of $1,500 per month for energy for the 40 HP motor this would amount to $18,000 per year.

A 32 HP gas engine will use 8.5 MCF of gas per day and at $2.00 per MCF this will cost $6,205 per year (8.5 x 365 x $2.00 = $6,205). We used a value of $2.00 per MCF on gas, since that is their market price for gas on these wells.

In totaling this up, we have an annual cost of $20,405 for the electric, but only $12,382.20 for the gas. This is a savings of $8,022,80 per year with gas engines. If you don't consider the wellhead gas as a cost, this amounts to $14,227.80 saved per year. Figuring your gas cost at $2.00 per MCF, this amounts to a cost savings of 40% per year per well. On the 32 wells they have saved $256,704 per year.

CONCLUSION

The above example illustrates cost cutting methods which are due to equipment selection and operating costs of this equipment. Each location should be carefully analyzed and the equipment for the location selected to fit the circumstances. By taking all factors under consideration, operating costs can be drastically reduced. With our lower oil prices and higher energy costs this can have a terrific impact on the profit structure.

$100 Worth of	Conventional Units	MMBtu Energy	Average Cost Per Million Btu
Bituminous Coal	2.883 short tons	60.241	$ 1.66
Wood	0.91 cord	25.5	$ 3.93
Crude Oil	4.179 bbl	24.238	$ 4.13
No. 2 Diesel Fuel	135.5 gal	18.793	$ 5.32
No. 2 Heating Oil	134.4 gal	18.642	$ 5.36
Natural Gas	13.869 Mcf	14.299	$ 6.99
Average Gasoline	81.8 gal	10.237	$ 9.76
Electricity	1,222 kW-h	4.171	$23.97

- Average gasoline is the weighted average U.S. sales price for all types of gasoline, including tax.
- Crude oil costs are the average U.S. wellhead price.
- These figures do not consider the efficiency of fuel-consuming devices; for example, a heat pump vs. electrically radiated heat, or a tuned engine vs. an untuned engine.
- Coal costs are for contract deliveries to utilities for electric power generation.
- Natural gas costs are for gas supplied for residential consumption.

Sources: U.S. DOE *Monthly Energy Review*, Aug. 1985, TIC Facts, *JPT*, March 1983, Page 536

Figure 1—Chart comparing the costs of various sources of energy

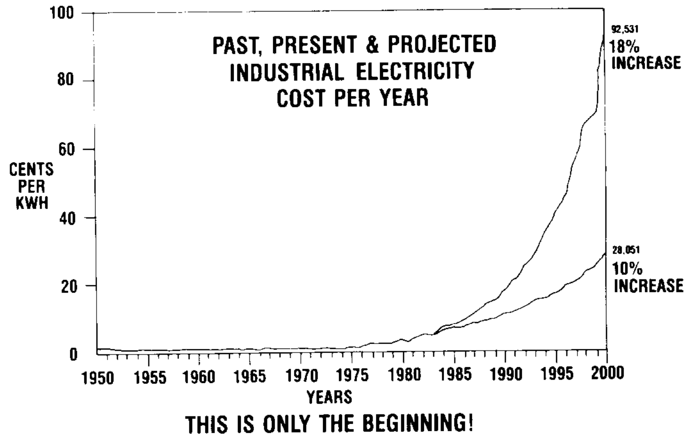

Figure 2—Graph showing power costs projected through the year 2000

INSTRUCTIONS FOR PRIME MOVER ANNUAL COST WORKSHEET

ITEM	ELECTRIC MOTOR		GAS ENGINE	
1. What is the cost of the prime mover & accessories?				
A. Total	$ 3,300		$ 17,916	
B. Depreciated (5 yr)		$ 660		$ 3,583.20
2. What power sources are available?		$100,000 ÷ 32 = $3,125 per well		
A. Horsepower (max.)	40 HP		32 HP	
Horsepower (min.)	HP		HP	
B. Type of power	1 or 3 Phase		Wellhead Gas	
C. Cost of power hook-up	$ 3,125		$ 150	
Depreciated (5 yr)		$ 625		$ 30
D. Supplemental charges	$		N/A	
E. Fuel cost per unit	$ KWH		$ MCF	
F. Electric surcharge	$ KWH		N/A	
3. What does routine maintenance cost?				
A. Regular well inspection	$ 1,000		$ 1,000	
B. Other maintenance	$		$ 500	
C. Total		$ 1,000		$ 1,500
4. What does service cost?				
A. Labor	$		$ 750	
B. Parts	$ 600		$ 314	
C. Total		$ 120		$ 1,064
5. What does the energy cost?		$ 18,000		$ 6,205
6. Total Cost - First Year		$ 20,405		$ 12,382.20

7. Savings = $ 8,022.80

NOTE: If you do not consider the wellhead gas as a cost, the total gas engine prime mover cost would only be $ 6,177.20 , and savings would be = $14,227.80 .

Figure 3—Worksheet comparing 32 HP engine and 40 HP motor