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OPTIMIZING ENERGY IN ORBEL II OIL PIPELINE

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ABSTRACT

Energy is the major operating expense in a pipeline company. There is considerable incentive to optimize energy utilization to reduce losses as much as possible. This article presents a study of the process and economic effects of substituting traditional pressure control valves by medium voltage frequency variable drives in the ORBEL II oil pipeline. Three drive configurations were chosen and their implementation costs were investigated. Pipeline flow simulation software was used to study the process effects of the drive configuration application and to calculate the amount of energy spent using control valves and using velocity variable control systems. The differences in energy savings were quantified in financial terms using energy supply contract data and operational data. Finally, an investment analysis was carried out in respect of the energy savings and an estimation of overall implantation costs of the drives.

INTRODUCTION

The main role of pipeline companies is to transport products for costumers. For that service, it charges a fixed tariff over the amount of product transported. In this context there are two ways of increasing profits: increasing the amount of product transported, which depends on costumer demand, or optimizing operational costs, where energy is the highest element.

The objective of this article is to study methods of optimizing energy expenses in product transfer at ORBEL II, the principal Brazilian southeast oil pipeline. In this case, energy represents over 50% of operational costs [1]. One important requirement is that energy optimization must not compromise the pipeline's functionality.

The main energy expense to be optimized is in the use of control systems based on pressure control valves that cause flow restrictions and energy losses. To optimize pipeline operations, the use of variable frequency drives in existing electric motors will be analyzed in order to alter the pump's head versus flow curves [2]. This solution has been adopted in many sites around the world [3,4].

The method of estimating energy savings is different from traditional methods [4] that are based on historical data of pressure drops in control valves. Instead, the proposal is to simulate pipeline behavior and compare the usual operating condition with three different motor drive configurations and control systems. The simulation software used was Stoner Pipeline Simulation and ORBEL II computational model representing the pipeline behavior.

By observing the impacts of the new drive and control systems in the pipeline, it is possible to analyze changes in factors like fluid friction, and also changes of efficiency rates of centrifugal pumps that contribute to energy expenses. Besides that, it is possible to observe the influence of the new drive and control system in all intermediary pumping stations. The results from all this interacting elements show the overall real energy savings due to the utilization of the new system.

Finally, hydraulic simulation results were analyzed and an economic investment analysis was carried out, based on accurate implementation costs, with the parameters and methodology [5] used in Petroleo Brasileiro S.A., in order to choose the best drive system proposal. Due to the positive results from a very low energy saving potential pipeline, the methodology used and results reached can be generalized for the benefit of other new and existing pipelines.

PLANT AND PROCESS OPERATION

The function of ORBEL II is to transport oil petroleum from TECAM base in Rio de Janeiro state to the REGAP refinery at Minas Gerais state. The pipeline characteristics are presented in table 1.

ORBEL II	
Length	358 Km
Diameter	24"
Max. Flow	1350 m^3/h
Medium Volume Transferred	650,000 m^3/month
MAOH (origin)	108 Kg/cm^2
Products	Petroleum and Diesel

Table1: ORBEL II characteristics

The main product transported is "Cabiunas" crude oil (around 95%). Its relative density is 0.902 and viscosity is 44 cp at 30º C.

The pipeline has three pumping stations: the initial station TECAM with four pumps (three 2800 HP and one 3000 HP); ESTAP with four 2335 HP pumps and ESMAN with five 1000 HP pumps. In all three cases the pumps are connected in parallel and have multiple stages. Table 2 presents the datasheet of the TECAM pumps .

TECAM PUMPS	
Manufacturer	Sulzer
Model	RP 37 ee + ee
Flow (Project)	509 m^3/h
Power	2800 HP
Speed	3500 Rmp
Minimum flow	70 m^3/h

Table 2: Datasheet of TECAM pumps

There are two main operational pumping configurations. One is called "2 2 0" and has two pumps working at the initial station TECAM and two at the second one, ESTAP. The average flow is 950 m^3/h in this case. The other configuration is called "3 3 4", where there are three pumps working at TECAM, three at ESTAP and four at ESMAN, the last pipeline station. The average flow in this case is 1350 m^3/h. The pumping configurations are illustrated in figure 1.

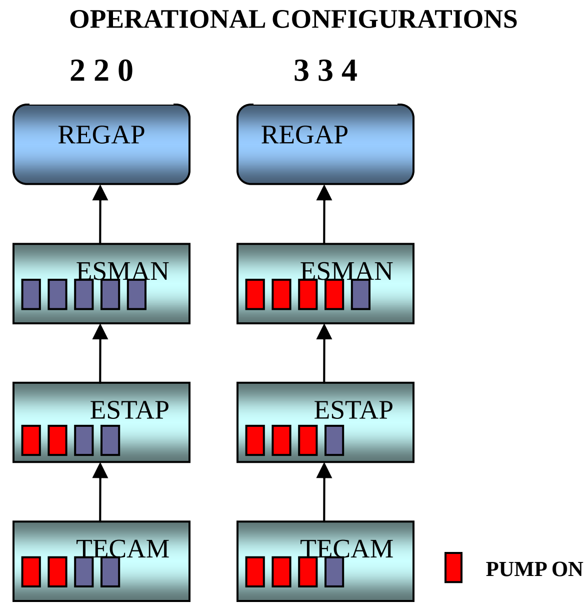

Figure 1: Operational configurations

The head and pressure profiles for both configurations are presented in figures 2 and 3.

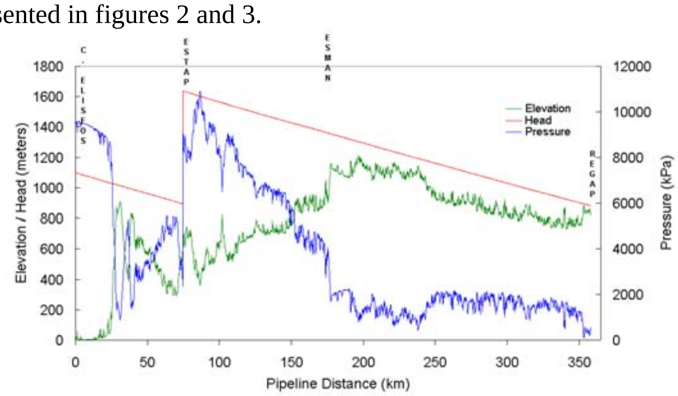

Figure 2: 2 2 0 head and pressure profile

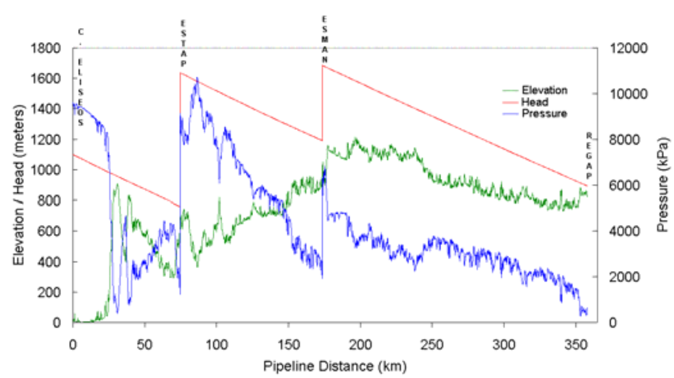

Figure 3: 3 3 4 head and pressure profile

According to data collected over seven months, the plant operates 45% of the time in 2 2 0 mode, 40% in 3 3 4 mode and is stopped for the remaining period. This pumping configuration allows flexibility in choosing the plant's operation points. Another aspect is that these pumps were tailor-made for this application due its high power rates and the predominance of only one pumped product. All these factors lead to a very efficient operation. Consequently, the energy saving potential is reduced, and the justification for the use of the more expensive frequency variable medium voltage drives will be a challenge.

DRIVE CONFIGURATIONS

The objective of using medium voltage frequency inverters to drive electric-motor pumps is to control pressure and flow in the pipeline by changing pump head versus flow curves through velocity modulation of the motors. The head versus flow curve of the association of parallel pumps can be changed by altering one, two or all-working pump curves. Frequency inverters will be used in the initial pumping stations of ORBEL II, because it is only in TECAM that a significant pressure drop in control valves was observed. Besides, the pressure drops of other pump stations can be enhanced by choosing optimal operational set points at TECAM. Three motor drive options for TECAM are described.

1) One pump driven

This configuration has just one inverter for the entire pump set. Held by a set of contacts, the inverter is aligned to the first pump to start it slowly. Then, the inverter drives the pump until the nominal operation point. After that, the drive control system synchronizes the voltage of the inverter's output bus with the voltage of the pump's input bus. This short circuits both buses and opens the inverter's output bus contact, supplying pump to input bus. From now on, the inverter is free to start another pump and repeat this operation as many times as necessary. When starting the last pump, instead of supplying it to the input bus, it keeps on driving to control the pipeline's pressure and flow. This configuration is commonly used [4]. Figure 4 shows the details.

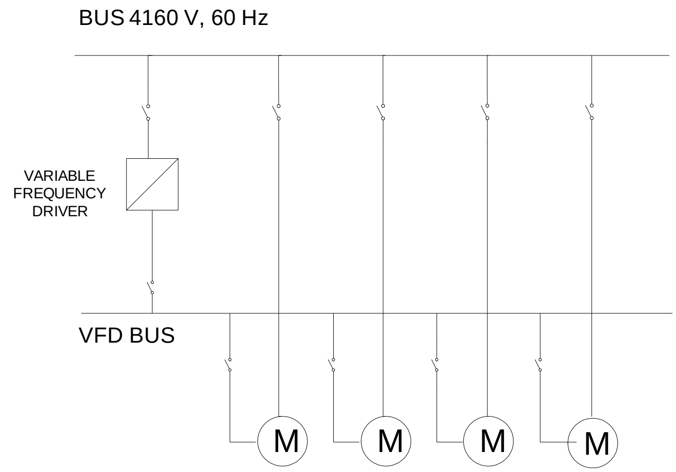

Figure 4: One pump driven electric scheme

The necessary equipment for this solution is one inverter and 2.n + 1 contacts, where n = number of pumps. This is the cheapest solution as contacts are about ten times cheaper than a 3000 HP inverter. Although the inverter can be by passed at any time, assuring pump availability, it is necessary to maintain a backup control system to make pipeline control redundant.

2) Two pump driven

To drive two of the four existing pumps, the "one pump driven" configuration can be applied to a subset of two pumps. Therefore, to cover the four pumps it would be necessary to have two sets of the "one pump driven" configuration. The total equipment is two inverters and 10 contacts. It is possible to add one more contact to link both inverter buses to make them available for all the pumps, if necessary. Redundancy of drives eliminates the need for a backup control system. Figure 5 details this configuration.

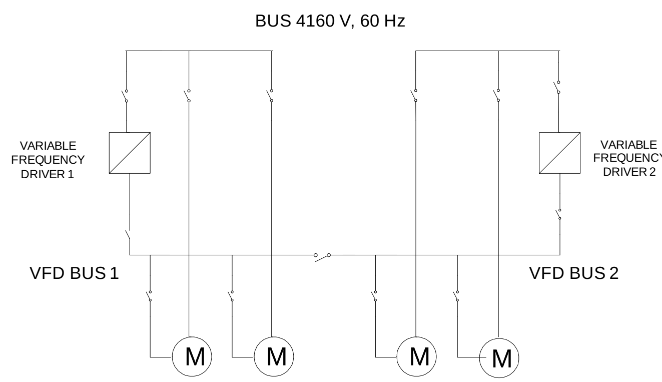

Figure 5: Two pump driven electric scheme

3) **All pump driven (two or three pumps)**

In this case, one inverter is used for each pump, giving a total of 4 inverters. There is no need for contacts and the existing circuit breakers are enough to isolate the pump + inverter set. This is the most expensive redundant configuration, even though it is not necessary to have a backup control system.

The three configuration costs summary is presented in table 3.

CONFIGURATION	INVERTER	CONTACT	TOTAL COST EQUIPMENT	TOTAL COST PROJECT
ONE PUMP DRIVEN	1	9	$611,960	$1,224,446
TWO PUMP DRIVEN	2	11	$964,760	$1,872,698
ALL PUMP DRIVEN	4	0	$1,325,120	$2,634,842

Table 3: Driving configuration costs (USD)

The "equipment costs" column includes installation material and spare parts. In the "project costs" column, all of the project costs are included, such as taxes, human resources, extra construction costs, profit and administration costs. Detailed cost breakdowns are included in annex A.

HYDRAULIC SIMULATIONS

Once the alternatives for motor-pump drives were presented, the next step was to compare their performance with current control system in terms of energy savings. Pipeline simulation software Stoner Pipeline Simulation was used to model the ORBEL II pipeline. This work was carried out by Petrobras Transporte S.A. and was futher developed by SIMDUT - Núcleo de Simulação Termo-Hidráulica at PUC (The Thermo-hydraulic Simulation Center of the Catholic Pontifical University, Rio de Janeiro). It has been used frequently to model the ORBEL II pipeline behavior showing very good correlation with operational data.

The current pipeline control set point for pressure is 98 Kgf/cm^2 and is manipulated by control valves. The speed of motor is 3500 Rpm. "2 2 0" and "3 3 4" modes were simulated under these conditions. Then, the pipeline flow and power data of each station were collected. With that information, it was possible to create indices that represent energy spent in pipeline by volume (m^3) of pumped product so as to enable comparison of every situation. The results of simulations for the current pipeline operations are presented in table 4. They will be used as benchmarks for the other simulations.

PUMPING CONFIGURATION	2 2 0	3 3 4
FLOW (m^3/h)	984	1308
PRESSURE TECAM (Kgf/cm^2)	98	98
PRES. DROP PV TECAM (Kgf/cm^2)	8.6	10.6
PRES. DROP PV ESTAP (Kgf/cm^2)	9.5	0.6
POWER TECAM (Kw)	5154	7335
POWER ESTAP (Kw)	3954	5631
POWER ESMAN (Kw)	0	3152
INDEX Kwh/m^3 TECAM	5.24	5.61
INDEX Kwh/m^3 ORBEL II	**9.26**	**12.32**
PUMP EFFICIENCY TECAM	0.709	0.683

Table 4: Simulation results for existing operation

In "2 2 0" mode, energy can be saved by substituting the control system and optimizing operational set points at TECAM, because ESTAP has no significant pressure drops in the control valves. In "3 3 4" mode, the energy saving potential is only possible by substituting the control system. As expected, losses due to fluid friction were higher than "2 2 0" losses. Knowing that, an operational set point that minimizes those losses can also be found. The findings of each of the simulation results are described below.

1) **One pump driven in "2 2 0" mode**

Table 5 summarizes the results.

SPEED	FLOW	PRES. TECAM	PRES. DROP PV ESTAP	ENERGY SAVINGS
3300 rpm	984	97.8	7.5	3.2%
3200 rpm	984	93.2	3.4	4.9%
3100 rpm	978	89.3	0.7	6.4%

Table 5: Simulation results

The pump speed was chosen as 3300 Rpm to operate with normal pressure settings for the pipeline, but the new drive system allowed the achievement of a more optimized pressure set point. At 3100 Rpm, energy savings are the result of decreases of speed in the TECAM pumps and a decrease of energy losses through the control valves in ESTAP. A decrease in the pressure drop in ESTAP control valves in the conventional system could only be achieved by increasing the pressure drop in the TECAM control valves. This does not result in any overall savings. In this case, the savings achieved are not better because the driven pump operates at a lower efficiency point as its flow decreases.

2) **Two pumps driven in "2 2 0" mode**

Table 6 summarizes the results.

SPEED	FLOW	PRES. TECAM	PRES. DROP PV ESTAP	ENERGY SAVINGS
3300 rpm	984	91.8	1.9	7.30%
3200 rpm	931	87	0.7	7.67%

Table 6: Simulation results

In this case, results are even better than the "One pump driven" case. The driven pumps operate at a better efficiency point as their flow is not very different from nominal flow rates.

3) One pump driven in "3 3 4" mode

In this mode, it was necessary to decrease pump speed to 3165 Rpm to reach the 98 Kgf/cm^2 pressure set point. In this situation, pump flow decreases excessively, far from the best efficiency point, which affected the energy savings, rated at **2.59%**. Table 7 shows TECAM pumps operating conditions.

TECAM	kW	FLOW	EFF.
PUMP 1	1399	182	0.449
PUMP 2	2737	563	0.716
PUMP 3	2737	563	0.716
Total	6873	1308	0.627

Table 7: TECAM operating conditions

4) Two pumps driven in "3 3 4" mode

When changing two pump curves, it is more effective to change the associated pump curve than changing just one. Therefore, with 3300 Rpm it was possible to reach 98 Kgf/cm^2 pressure set point. The best saving results was reached at 3200 Rpm, about **4.66%**, due to decrease of fluid friction losses as pipeline flow decreases. Pump flows were closer to nominal rates than the flow values of "one pump driven in 3 3 4 mode". Therefore, efficiency rates are better. Table 8 shows TECAM pumps operating conditions.

TECAM	kW	FLOW	EFF.
PUMP 1	1772	348	0.651
PUMP 2	1772	348	0.651
PUMP 3	2800	595	0.713
Total	6344	1291	0.672

Table 8: TECAM operating conditions

5) All pump driven in "3 3 4" mode

Driving the three pumps at the same time gives the best results since the best overall efficiency point is achieved. For 3250 Rmp, the energy savings reached **5.74%**. Table 9 shows TECAM pumps operating conditions.

TECAM	kW	FLOW	EFF.
PUMP 1	2001	424	0.693
PUMP 2	2001	424	0.693
PUMP 3	2001	424	0.693
Total	6003	1272	**0.693**

Table 9: TECAM operating conditions

RESULTS SUMMARY

The results summary in terms of energy savings are presented in table 10. The percentage results are related to the total pipeline energy expenses presented in table 4 (INDEX Kwh/m3 ORBEL II) in each operating mode. The energy losses [6,4] due to frequency inverter efficiency, rated at 2%, are included.

DRIVE CONFIGURATION	2 2 0	3 3 4
ONE PUMP	6.40%	2.59%
TWO PUMPS	7.76%	4.66%
ALL PUMPS	7.76%	5.74%

Table 10: Summary results

The energy savings increase with the complexity of the solution.

INVESTMENT ANALYSIS

Two things are necessary to make an investment analysis for each control and drive system proposal. One is the translation of energy savings into annual monetary values, and the other is creating a cash flow to make an economic investment analysis. Gathering this information allows us to calculate the investment performance of each proposal and, together with technical analysis, to choose the best solution.

The annual monetary values are calculated by this formula:

$ = C . (V2 . E2 + V3 . E3)

where,

$ = annual savings (USD)

C = kWh average costs in 2005, considering peak and non-peak tarrifs. (0.07 USD/KWh)

V2 = total volume pumped in 2005 in "2 2 0 "mode (4,151,468 m^3)

V3 = total volume pumped in 2005 in "3 3 4" mode (3,690,194 m^3)

E2 = absolute energy saving value in “2 2 0” mode (kWh/m^3)

E3 = absolute energy saving value in 3 3 4 mode (kWh/m^3)

Results are presented in table 11.

DRIVE CONFIGURATION	kWh/m^3 "2 2 0"	kWh/m^3 "3 3 4"	ANNUAL SAVINGS ($)
ONE PUMP	0.593	0.319	$254,510
TWO PUMPS	0.710	0.574	$354,701
ALL PUMPS	0.710	0.707	$389,148

Table 11: Annual energy savings

The results are included in the economic investment analysis. One cash flow is drawn up for each drive system according to Petroleo Brasileiro S.A. procedures [5]. In the cash flows, annual savings are revenues and the investments are based on values presented in section “DRIVE CONFIGURATIONS”. The cash flow also considers maintenance costs, Brazilian taxes and depreciation. The real and economic life of the investment is 20 years. Details can be seen in annex B.

The results are presented in table 12. The NPV (Net Present Value) was calculated for WACC (Weighted Average Capital Cost) of 12%, a reasonable value for transport and logistics investments in Brazil.

DRIVE CONFIGURATION	IRR	NPV	PI
ONE PUMP	15.68%	$248,615	20.30%
TWO PUMPS	14.28%	$232,653	12.42%
ALL PUMPS	10.90%	-$153,365	5.82%

Table 12: Investment analysis results

Results show that the two first configurations are economically viable because the NPVs are positive and IRR (Internal Return Rate) are higher than the supposed WACC rate. Choosing one of them, the first presents a better PI (Profit Index), which compares the amount of profit with the investment, in this case the lowest investment overall. **Therefore, the best choice for the new control and drive system for ORBEL II is the ONE PUMP DRIVEN SYSTEM.**

Extending the results, in the case of **new plant** with architecture similar to ORBEL II, the choice would be the “Two Pump Driven System” due to the fact that redundancy of inverters would eliminate the necessity of implementing a redundant traditional control system. Since the cost of a traditional system is estimated at $ 200,000, if considering it in the cash flow, the NPV would be $374,000 and IRR 16%. In conclusion, all facts gathered above confirm the viability of use of medium voltage frequency inverters and the recommended use is as follows:

- **Two Pump Driven System for new projects.**
- **One Pump Driven System for ORBEL II.**

CONCLUSIONS

After detailed economic and technical analysis, it is shown that the use of pipeline control systems based on medium voltage frequency inverters to drive moto-pumps in the ORBEL II pipeline is viable. The fact that ORBEL II has little energy saving potential suggests that these systems can be applied in other pipelines as well, probably with even better results. This is without considering the additional benefit of increasing the working life of the motors and pumps.

Another conclusion is that the use of these systems influences the whole pipeline. The loss efficiency in pumps must be considered. On the other hand, the system permits the search for optimal operational set points, leading to savings greater than energy losses due to pressure drops in control valves.

For all these reasons, the decision to install these systems must follow the methodology described in this article, instead of simply estimating energy losses by computing pressure drops in control valves.

Finally, after a complete technical analysis of the drive systems, a hydraulic analysis of each behavior in pipeline operation followed by a detailed economic analysis, we can conclude that the ‘One Pump Frequency Inverter Drive System” has enough technical and economic interest to be implemented in the ORBEL II oil pipeline.

ACKNOWLEDGMENTS

TECAM operation staff who provided operational data for many analysis validations and SIMDUT for technical support.

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ANNEX A

INVERTER'S PROJECT COST DETAILS

EQUIPMENT COSTS (REFERENCE – ROCKWELL AUTOMATION)

EQUIPMENT COSTS - ONE PUMP DRIVEN	USD	DELIVERY RATE	PRICE IN BRAZIL	QUANT.	TOTAL
3000 HP INVERTER	240,000	1.26	302,400	4	1,209,600
CONTACTS	20,000	1.26	25,200	0	0
INSTALLATION MATERIAL	50,000	1.26	50,000	1	50,000
SPARE PARTS	26,000	1.26	32,760	2	65,520
TOTAL USD					**1,325,120**

EQUIPMENT COSTS - TWO PUMPS DRIVEN	USD	DELIVERY RATE	PRICE IN BRAZIL	QUANT.	TOTAL
3000 HP INVERTER	240,000	1.26	302,400	1	302,400
CONTACTS	20,000	1.26	25,200	9	226,800
INSTALLATION MATERIAL	50,000	1.26	50,000	1	50,000
SPARE PARTS	26,000	1.26	32,760	1	32,760
TOTAL USD					**611,960**

EQUIPMENT COSTS - ALL PUMPS DRIVEN	USD	DELIVERY RATE	PRICE IN BRAZIL	QUANT.	TOTAL
3000 HP INVERTER	240,000	1.26	302,400	2	604,800
CONTACTS	20,000	1.26	25,200	11	277,200
INSTALLATION MATERIAL	50,000	1.26	50,000	1	50,000
SPARE PARTS	26,000	1.26	32,760	1	32,760
TOTAL USD					**964,760**

TOTAL PROJECT COSTS (BASED ON EXISTING BUDGETS)

PROJECT COSTS - ONE PUMP DRIVEN	**TOTAL USD**
EQUIPMENT COSTS	1,325,120
EXECUTION	397,536
OVERHEAD COSTS (20%)	265,024
TAXES OVER EARNINGS (34% over OVERHEAD COSTS)	90,108
TAXES OVER TOTAL COST (21,25%)	357,054
EXTRA BUILDINGS	200,000
TOTAL $ USD	**2,634,842**
PROJECT COSTS - TWO PUMPS DRIVEN	**TOTAL USD**
EQUIPMENT COSTS	611,960
EXECUTION	183,588
OVERHEAD COSTS (20%)	122,392
TAXES OVER EARNINGS (34% over OVERHEAD COSTS)	41,613
TAXES OVER TOTAL COST (21,25%)	164,893
EXTRA BUILDINGS	100,000
TOTAL $ USD	1,224,446
PROJECT COSTS - ALL PUMPS DRIVEN	**TOTAL USD**
EQUIPMENT COSTS	964760
EXECUTION	289,428
OVERHEAD COSTS (20%)	192,952
TAXES OVER EARNINGS (34% over OVERHEAD COSTS)	65,604
TAXES OVER TOTAL COST (21,25%)	259,955
EXTRA BUILDINGS	100,000
TOTAL $ USD	**1,872,698**

ANNEX B

CASH FLOW FOR “ALL PUMP DRIVEN SYSTEM”

YEAR	0	1	2	3	4	5	6	7	8	9
REVENUES (ENERGY SAVINGS)	0	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148
TOTAL REVENUES	0	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148
EXPENSES (INVESTMENT)	2,634,842									
MAINTENANCE EXPENSES	0	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
TOTAL EXPENSES	2,634,842	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
EBITDA	-2,634,842	387,148	387,148	387,148	387,148	387,148	387,148	387,148	387,148	387,148
DEPRECIATION	0	263,484	263,484	263,484	263,484	263,484	263,484	263,484	263,484	263,484
RESUDUAL VALUE	0									
REVENUES - DEPRECIATION		123,664	123,664	123,664	123,664	123,664	123,664	123,664	123,664	123,664
INCOME TAXES (33%)		40,809	40,809	40,809	40,809	40,809	40,809	40,809	40,809	40,809
NET PROFIT		82,855	82,855	82,855	82,855	82,855	82,855	82,855	82,855	82,855
DEPRECIATION (REVERSE)		263,484	263,484	263,484	263,484	263,484	263,484	263,484	263,484	263,484
NET CASH FLOW	-2,634,842	346,339	346,339	346,339	346,339	346,339	346,339	346,339	346,339	346,339

NPV	**WACC**	**IRR**
-$153,365	**12.00%**	**10.90%**

YEAR	10	11	12	13	14	15	16	17	18	19
REVENUES (ENERGY SAVINGS)	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148
TOTAL REVENUES	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148	389,148
EXPENSES (INVESTMENT)										
MAINTENANCE EXPENSES	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
TOTAL EXPENSES	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
EBITDA	387,148	387,148	387,148	387,148	387,148	387,148	387,148	387,148	387,148	387,148
DEPRECIATION	263,484									
RESUDUAL VALUE										526,968
REVENUES - DEPRECIATION	123,664	387,148	387,148	387,148	387,148	387,148	387,148	387,148	387,148	387,148
INCOME TAXES (33%)	40,809	127,759	127,759	127,759	127,759	127,759	127,759	127,759	127,759	127,759
NET PROFIT	82,855	259,389	259,389	259,389	259,389	259,389	259,389	259,389	259,389	259,389
DEPRECIATION (REVERSE)	263,484	0	0	0	0	0	0	0	0	0
NET CASH FLOW	346,339	259,389	259,389	259,389	259,389	259,389	259,389	259,389	259,389	786,358

CASH FLOW FOR “TWO PUMP DRIVEN SYSTEM”

YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
REVENUES (ENERGY SAVINGS)	0	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701
TOTAL REVENUES	0	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701	354,701
EXPENSES (INVESTMENT)	1,872,698																			
MAINTENANCE EXPENSES	0	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
TOTAL EXPENSES	1,872,698	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
EBITDA	-1,872,698	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701
DEPRECIATION	0	187,270	187,270	187,270	187,270	187,270	187,270	187,270	187,270	187,270	187,270									
RESUDUAL VALUE	0																			374,540
REVENUES - DEPRECIATION		165,431	165,431	165,431	165,431	165,431	165,431	165,431	165,431	165,431	165,431	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701	352,701
INCOME TAXES (33%)		54,592	54,592	54,592	54,592	54,592	54,592	54,592	54,592	54,592	54,592	116,391	116,391	116,391	116,391	116,391	116,391	116,391	116,391	116,391
NET PROFIT		110,839	110,839	110,839	110,839	110,839	110,839	110,839	110,839	110,839	110,839	236,310	236,310	236,310	236,310	236,310	236,310	236,310	236,310	236,310
DEPRECIATION (REVERSE)		187,270	187,270	187,270	187,270	187,270	187,270	187,270	187,270	187,270	187,270	0	0	0	0	0	0	0	0	0
NET CASH FLOW	**-1,872,698**	**298,109**	**298,109**	**298,109**	**298,109**	**298,109**	**298,109**	**298,109**	**298,109**	**298,109**	298,109	236,310	236,310	236,310	236,310	236,310	236,310	236,310	236,310	610,849

NPV	WACC	IRR
$232,652.68	**12%**	**14.28%**

CASH FLOW FOR "ONE PUMP DRIVEN SYSTEM"

YEAR	0	1	2	3	4	5	6	7	8	9
REVENUES (ENERGY SAVINGS)	0	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510
TOTAL REVENUES	0	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510
EXPENSES (INVESTMENT)	1,224,446									
MAINTENANCE EXPENSES	0	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
TOTAL EXPENSES	1,224,446	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
EBITDA	-1,224,446	252,510	252,510	252,510	252,510	252,510	252,510	252,510	252,510	252,510
DEPRECIATION	0	122,445	122,445	122,445	122,445	122,445	122,445	122,445	122,445	122,445
RESUDUAL VALUE	0									
REVENUES - DEPRECIATION		130,065	130,065	130,065	130,065	130,065	130,065	130,065	130,065	130,065
INCOME TAXES (33%)		42,922	42,922	42,922	42,922	42,922	42,922	42,922	42,922	42,922
NET PROFIT		87,144	87,144	87,144	87,144	87,144	87,144	87,144	87,144	87,144
DEPRECIATION (REVERSE)		122,445	122,445	122,445	122,445	122,445	122,445	122,445	122,445	122,445
NET CASH FLOW	**-1,224,446**	**209,588**	**209,588**	**209,588**	**209,588**	**209,588**	**209,588**	**209,588**	**209,588**	**209,588**

NPV	**WACC**	**IRR**
$248,615.17	**12%**	**15.68%**

YEAR	10	11	12	13	14	15	16	17	18	19
REVENUES (ENERGY SAVINGS)	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510
TOTAL REVENUES	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510	254,510
EXPENSES (INVESTMENT)										
MAINTENANCE EXPENSES	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
TOTAL EXPENSES	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
EBITDA	252,510	252,510	252,510	252,510	252,510	252,510	252,510	252,510	252,510	252,510
DEPRECIATION	122,445									
RESUDUAL VALUE										244,889
REVENUES - DEPRECIATION	130,065	252,510	252,510	252,510	252,510	252,510	252,510	252,510	252,510	252,510
INCOME TAXES (33%)	42,922	83,328	83,328	83,328	83,328	83,328	83,328	83,328	83,328	83,328
NET PROFIT	87,144	169,182	169,182	169,182	169,182	169,182	169,182	169,182	169,182	169,182
DEPRECIATION (REVERSE)	122,445	0	0	0	0	0	0	0	0	0
NET CASH FLOW	209,588	169,182	169,182	169,182	169,182	169,182	169,182	169,182	169,182	414,071