Irrigation Pumping Plant Efficiency and Affects on Costs

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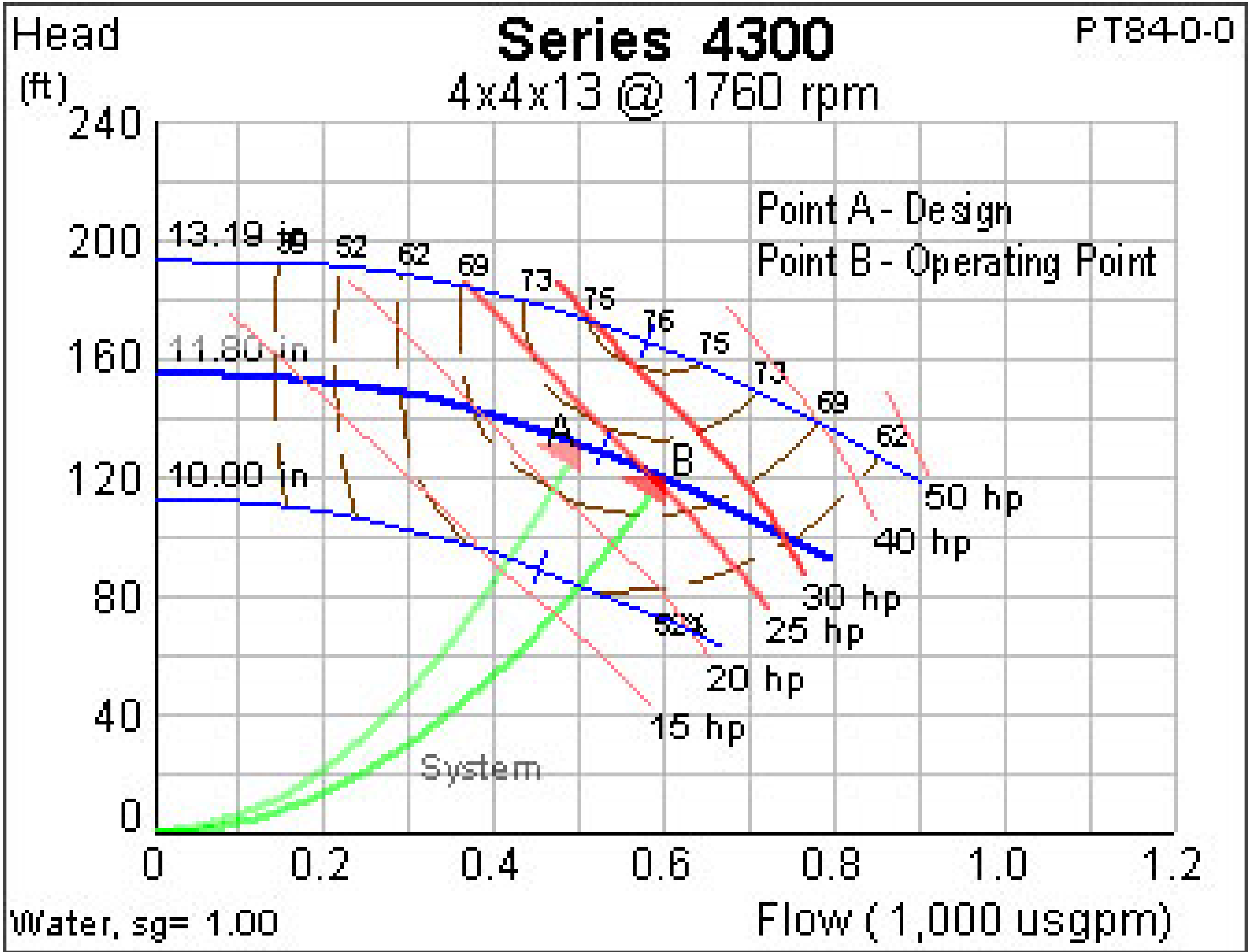
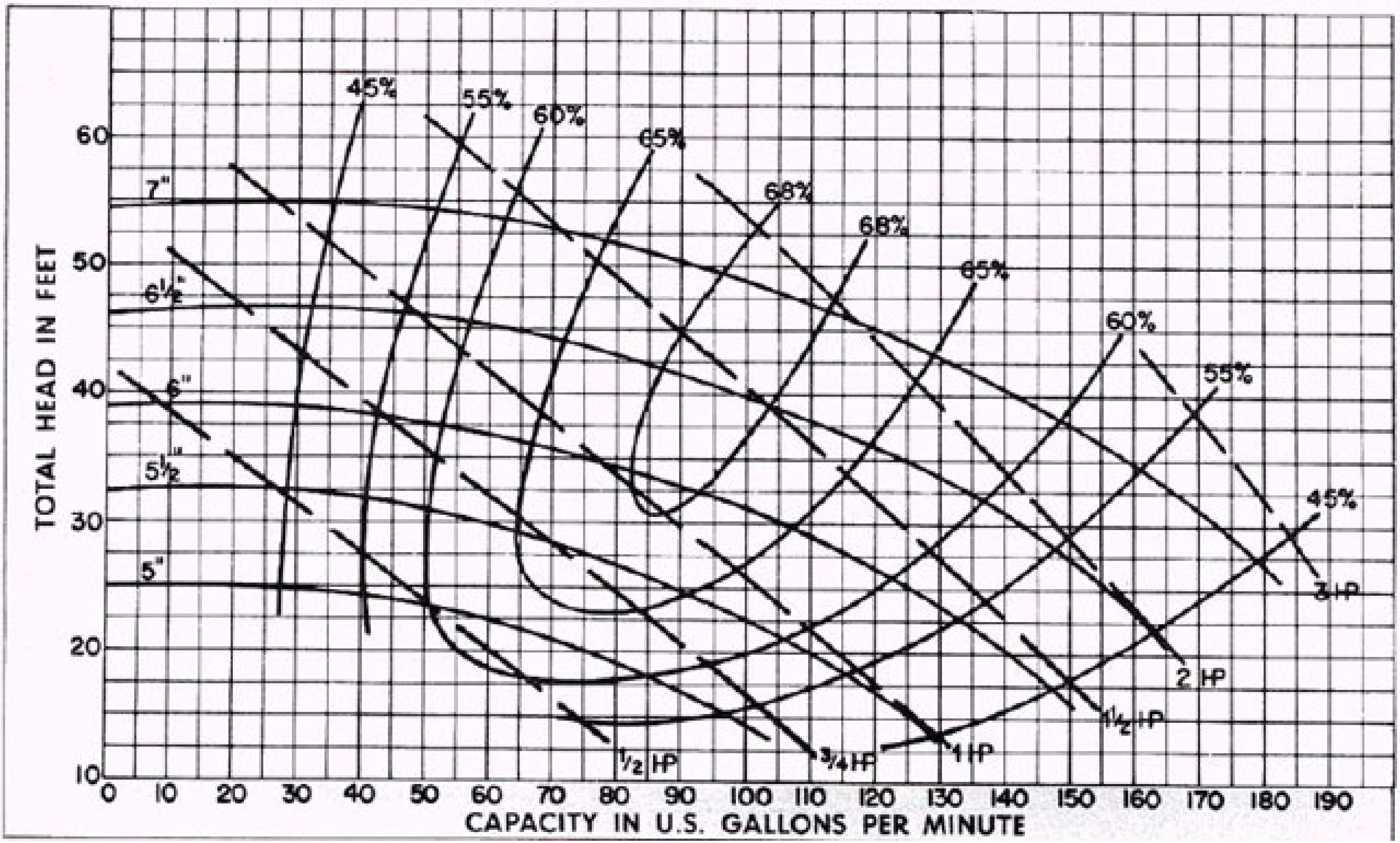
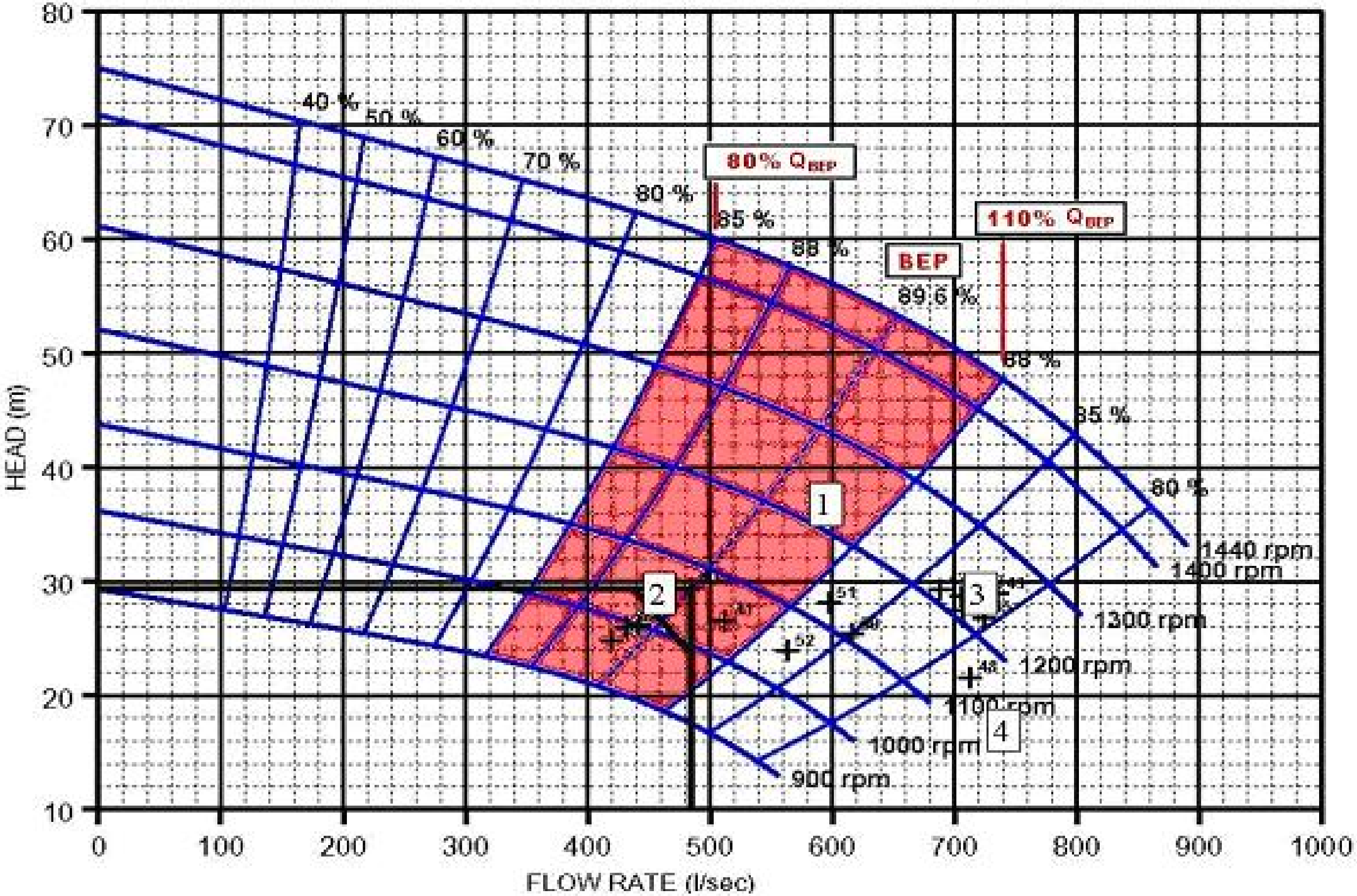


Head
(ft)
Series 4300
4x4x13 @ 1760 rpm
PT84-0-0
Point A - Design
Point B - Operating Point
13.19 in
11.80 in
10.00 in
52
62
69
73
75
76
75
73
69
62
52%
A
B
50 hp
40 hp
30 hp
25 hp
20 hp
15 hp
System
240
200
160
120
80
40
0
0
0.2
0.4
0.6
0.8
1.0
1.2
Water, sg= 1.00
Flow (1,000 usgpm)


TOTAL HEAD IN FEET
CAPACITY IN U.S. GALLONS PER MINUTE
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
7"
6½"
6"
5½"
5"
45%
55%
60%
65%
68%
68%
65%
60%
55%
45%
½ HP
¾ HP
1 HP
1½ HP
2 HP
3 HP



1 Pump Best Efficiency Point (BEP)	2 Ideal pump duty
3 Pump operating to the right of BEP	4 Pump cavitating (very far right of BEP)

Nebraska Irrigation Pumping Plant Efficiency Criteria		
Type	Power Unit Efficiency	Overall Efficiency
Electric	88%	66%
Diesel	33%	24%
Natural Gas	24%	17%

Results from the Project:
IRRIGATION PUMPING PLANT EFFICIENCY TESTING RESULTS IN SOUTH TEXAS

Report

- Fipps, Guy and Byron Neal. 1995. *Texas Irrigation Pumping Plant Efficiency Testing Program. Final Report submitted to the State Energy Conservation Office. April 7, 1995. Texas Agricultural Extension Service.*

- This report is posted at http://itc.tamu.edu under *Irrigation Literature*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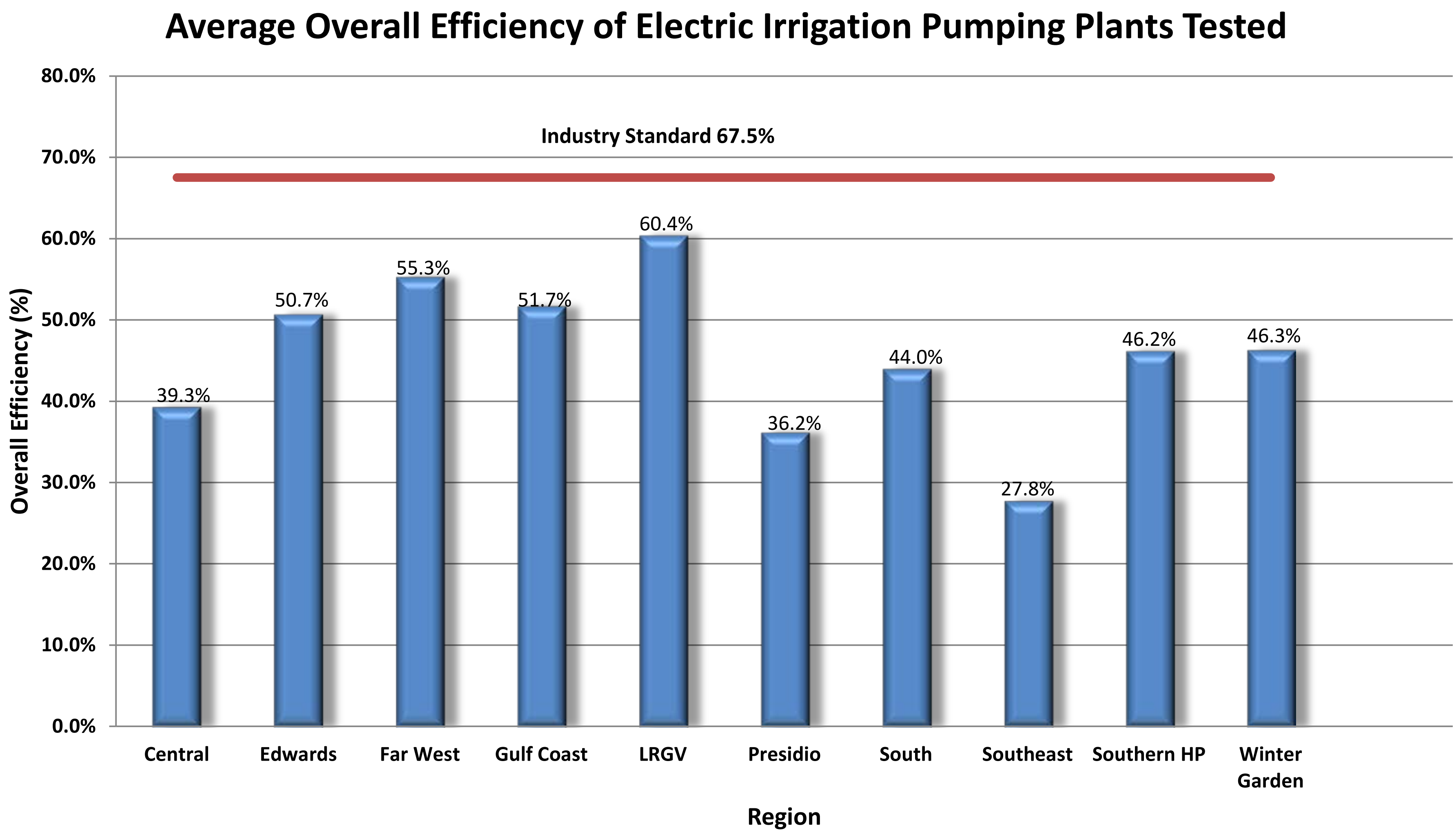
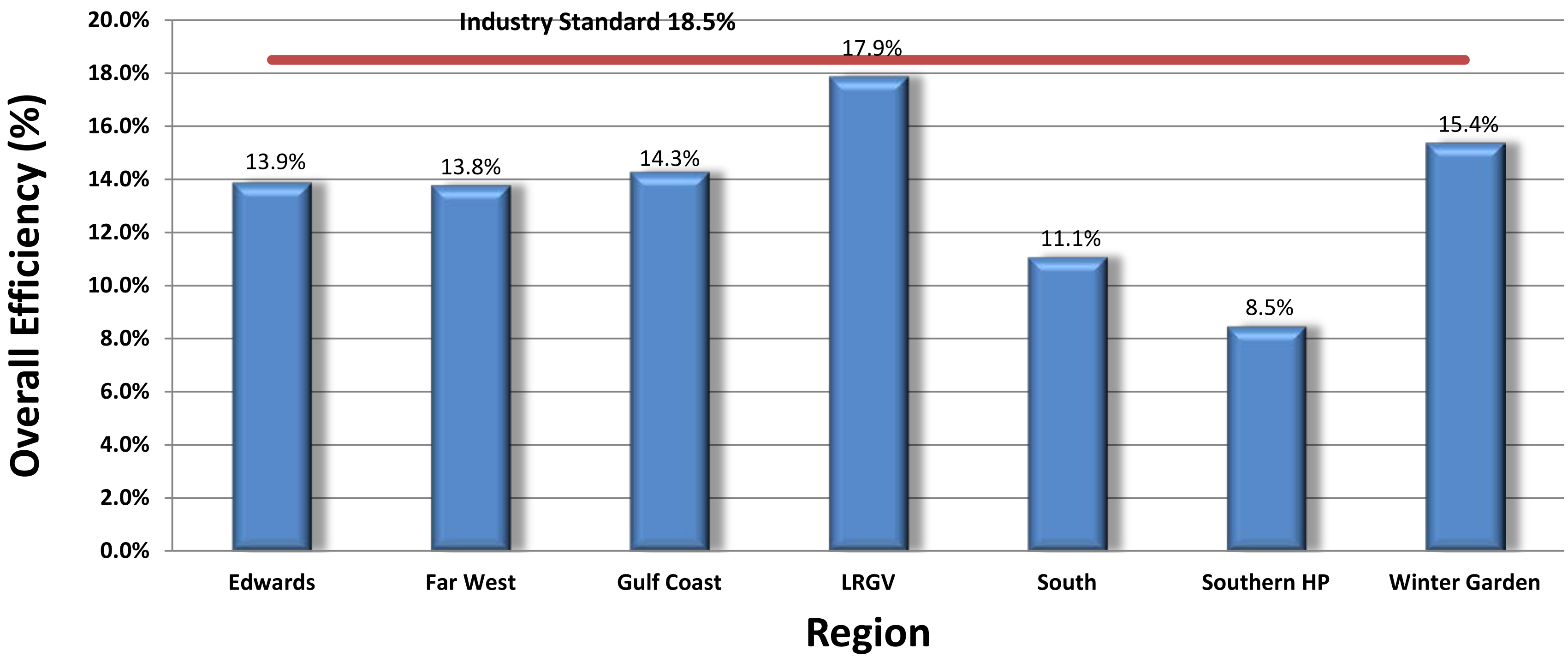
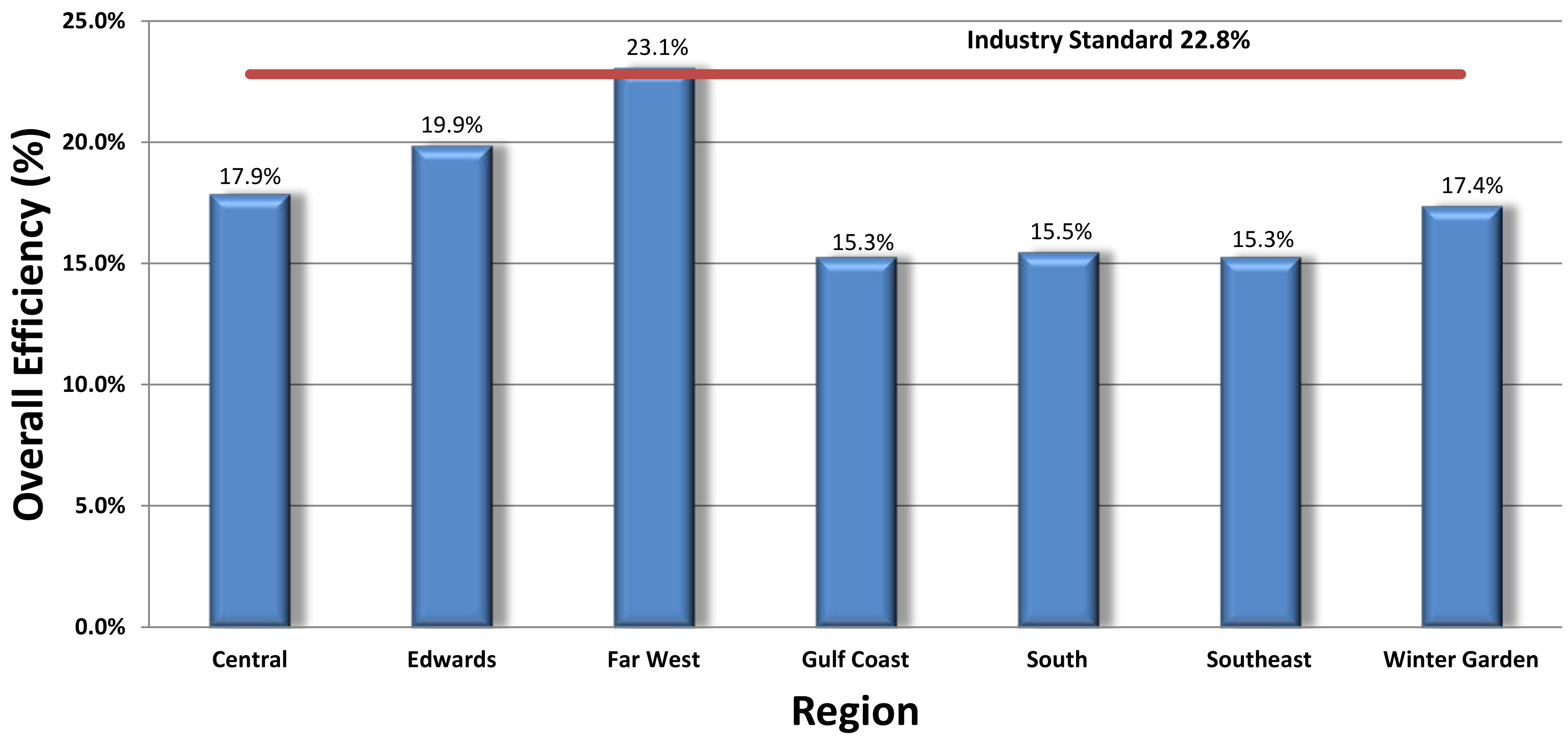


Average Overall Efficiency of Electric Irrigation Pumping Plants Tested
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Overall Efficiency (%)
Industry Standard 67.5%
39.3%
50.7%
55.3%
51.7%
60.4%
36.2%
44.0%
27.8%
46.2%
46.3%
Central
Edwards
Far West
Gulf Coast
LRGV
Presidio
South
Southeast
Southern HP
Winter Garden
Region

Average Overall Efficiency of Natural Gas Irrigation Pumping Plants Tested



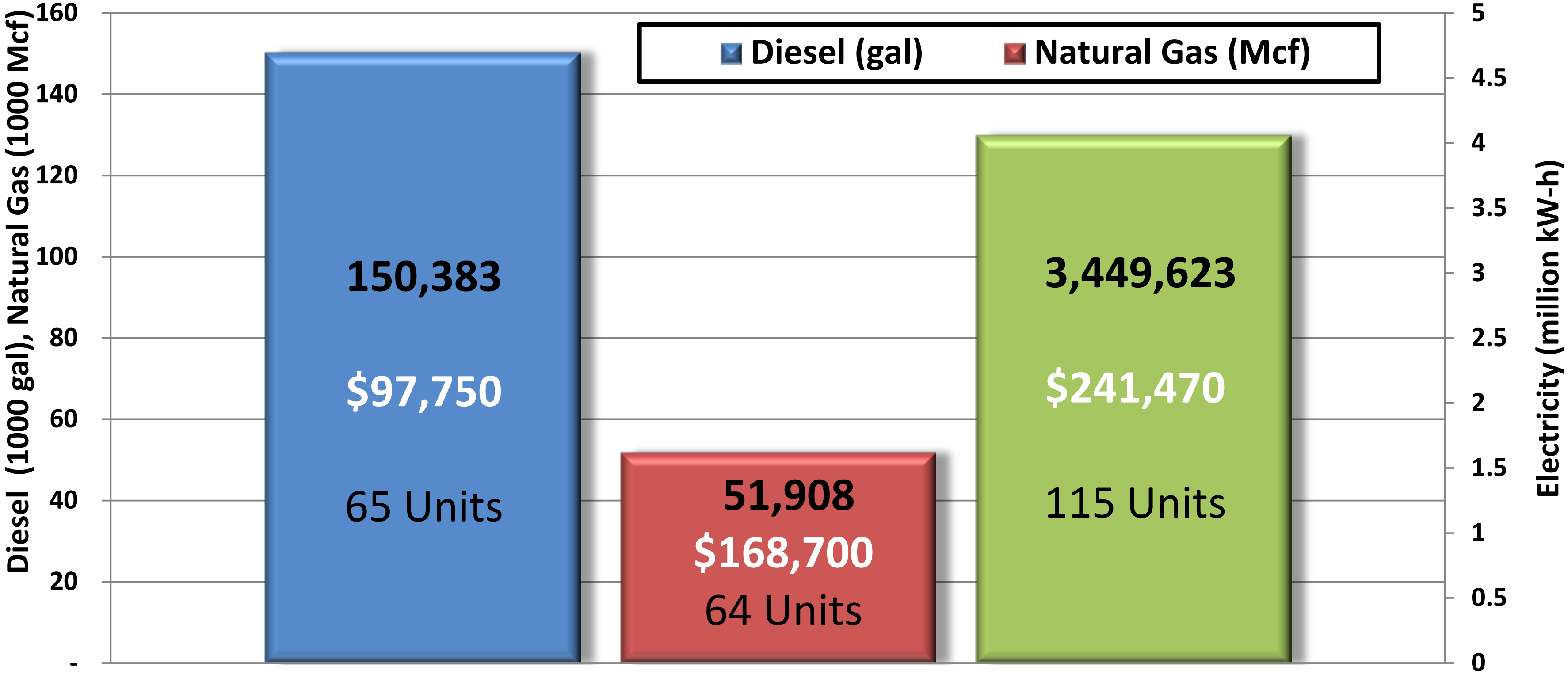
Average Overall Efficiency of Diesel Irrigation Pumping Plants Tested



Fipps Test Results
Range in Efficiencies

	Natural Gas	Electricity	Diesel
Engine/motor			
H	27%	94%	42%
L	16%	80%	29%
Pump			
H	79%	91%	88%
L	40%	26%	37%
Overall			
H	21%	86%	30%
L	5%	18%	5%

Potential Yearly Energy Savings for 244 Irrigation Pumping Plants Tested



Based on 2000 hours per year operation
Diesel $.65/gal Natural Gas $ 3.25/Mcf Electricity $ .07/kW-h

Explanation:

Costs of fuel	***1995***	***2013***
diesel	$0.65/gal	$3.65
Natural Gas	$3.24 Mcf	$4.25Mcf
Electricity	$0.07 kw-hr	$0.12 kw-hr

Total Savings from bringing all 244 units test to industry efficiency standards

	1995	2013	Avg $/unit
Natural Gas	$168,700	$179, 200	$2800/unit
Electricity	$241, 500	$362,200	$3150/unit
Diesel	$150,400	$548,900	$8444/unit

Texas Agricultural Extension Service

People Helping People

Pumping Plant Efficiency and Irrigation Costs

L. Leon New*

Inefficient pumps and power units are major contributors to excessively high irrigation costs. To minimize fuel consumption and pumping cost, pumping equipment must be carefully selected, properly maintained and replaced when necessary to maintain high efficiency. Efficient pumping plants with their lower pumping cost combined with efficient application of carefully timed irrigations can make the difference between profit and loss in irrigated crop production.

Factors which affect the amount of fuel required to pump a given quantity of water (a gallon, an acre-inch, an acre-foot, etc.) are: (1) the pumping lift or vertical distance from the water surface to the point of discharge, (2) the pressure required at the pump discharge to operate the irrigation system and (3) the efficiency of each component (power unit, pump drive or gear head and pump) of the pumping plant. Fuel requirements are lower when pumping lift is lower, discharge pressure is lower and pumping unit efficiency is higher. Pumping unit components in good condition and carefully selected to match requirements of a specific pumping situation can operate at efficiencies as high as those shown in Table 1. However, many pumping units on farms operate at efficiencies far below those shown.

Table 1. Irrigation pumping equipment efficiency.

Equipment	Attainable efficiency percent
Pumps (centrifugal, turbine)	75-82
Right angle pump drive (gear head)	95
Automotive-type engines	20-26
Industrial engines	
Diesel	25-37
Natural gas	24-27
Electric motors	
Small	75-85
Large	85-92

Reasons for low efficiency include wear, improper adjustment or failure to select equipment to match the specific pumping conditions. An engine operating at 8 percent efficiency will use three times as much fuel to do the same amount of work (pump the same amount of water at the same total head) as one operating at 24 percent efficiency. A pump that is 25 percent efficient requires three times as much power (fuel) to do the same amount of work as a pump that is 75 percent efficient. From the standpoint of pumping cost, a very serious condition exists when both the engine and the pump operate at low efficiency. For example, if the engine operates at 8 percent efficiency and the pump at 25 percent efficiency, the pumping plant would use nine times as much fuel to pump the same amount of water as one with an engine efficiency of 24 percent and a pump efficiency of 75 percent.

*Extension agricultural engineer—irrigation, The Texas A&M University System.

Pumping Plant Components

An irrigation pumping plant has three major components: a power unit, a pump drive or gear head and a pump. The pump lineshaft and the motor shaft of electric powered pumping plants are usually direct-connected which makes a pump drive or gear head unnecessary.

Pump. A pump properly selected to match specific conditions of pumping rate, pumping lift and discharge pressure can operate at 80 percent efficiency, or more. However, many pumps operate at much lower efficiency because of failure to select the pump to match pumping conditions, changes in pumping lift or discharge pressure, improper adjustment and wear. Pump wear occurs rapidly and efficiency declines when the water contains sand or other abrasives. The effect of pump efficiency on annual fuel cost is illustrated in Table 2.

Irrigation pumps should be selected to match specific well characteristics of well yield and pumping lift. Add any required discharge pressure (pounds per square inch converted to feet of head) to pumping lift to obtain total pumping head. If the water source is a lake, pond or stream, substitute desired pumping rate for well yield. Use pump manufacturer's performance ratings and the well pumping test results to obtain the best match for high pump efficiency. Pump performance ratings or curves are available from the dealer or manufacturer, Figure 1. The pump described would operate at 77 percent efficiency, or higher for any pumping situation between 600 gallons per minute with

Leon News Testing Program

Costs are given in $/ac-in/100 ft head for 1990’a energy costs

- 617 units tested

	O.E	$/ac-in	Costs with improvements
Natural Gas	11.6%	$1.08	$0.78
Electricity	52%	$1.45	$0.80
Diesel	19%	$1.10	$0.95
In 2013 Prices			**% Reduction in costs**
Natural Gas		$1.15	27%
Electricity		$2.18	31%
Diesel		$3.84	14%

Attainable Irrigation Pumping Equipmenet Efficiencies. (New, 1986)	
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Large	85-92

How’s Your Pumping Plant Efficiency?

- Easy way is to look at your fuel consumption
- Will need to know:
  - Amount of fuel used
  - Per acre-inch of water pumped
  - Per 100 feet of head
- What is *head*??

Head

- Includes total vertical distance water is pumped (in feet)
- Includes friction losses in pipes and fittings
- Includes the operating pressure of irrigation system if water is pumped directly into the system

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Calculating Horsepower Requirements and Sizing Irrigation Supply Pipelines

Guy Fipps*

Pumping costs are often one of the largest single expenses in irrigated agriculture. Table 1 shows typical fuel use and costs of pumping in Texas as measured in irrigation pumping plant tests conducted by the Texas Agricultural Extension Service. Properly sizing pipelines for the particular situation will help minimize these costs. This publication outlines how to calculate the horsepower requirements of irrigation pumps and how to use this information in sizing supply pipelines.

Pumping Plant Efficiency

An irrigation pumping plant has three major components:

1. a power unit,
2. a pump drive or gear head, and
3. a pump.

For electric powered plants, the pump lineshaft and the motor shaft are usually directly connected, making a pump drive or gear head unnecessary.

The *overall pumping plant efficiency* is a combination of the efficiencies of each separate component. Individual pumping unit components in good condition and carefully matched to the requirements of a specific pumping situation can have efficiencies similar to those given in Table 2. However, many pumping units operate at efficiencies far below acceptable levels (Table 3). Additional details on pumping plant efficiency are given in L-2218, "*Pumping Plant Efficiency and Irrigation Costs*," (available from your county Extension agent).

Performance Standards

There are two commom methods of determining the efficiency of pumping plants. One is to measure the efficiency of each component of the plant (motor, shaft and pump). Once the efficiencies of the components are known, the overall efficiency is easily calculated. This requires specialized equipment and considerable expertise.

Another method is to calculate the load on the motor or engine and then measure how much fuel is used by the power unit. The fuel usage can then be compared to a standard. The most widely used standards were developed by the Agricultural Engineering Department of the University of Nebraska (Table 4). The fuel consumption rates in Table 4 indicate the fuel use which can be *reasonably expected* from a properly engineered irrigation pumping plant in good condition. The actual fuel usage of a new or reconditioned plant should not be larger than that shown in Table 4.

Calculating Horsepower

Horsepower is a measurement of the amount of energy necessary to do work. In determining the horsepower used to pump water, we must know the:

1. pumping rate in gallons per minute (gpm), and
2. total dynamic head (TDH) in feet.

The theoretical power needed for pumping water is called **water horsepower** (whp) and is calculated by:

(equation 1) $$\text{whp} = \frac{\text{gpm} \times \text{TDH (ft)}}{3{,}960}$$

Since no device or machine is 100 percent efficient, the horsepower output of the power unit must be higher than that calculated with equation 1. This horsepower, referred to as **brake horsepower** (bhp), is calculated by:

(equation 2) $$\text{bhp} = \frac{\text{whp}}{\text{(pumping plant efficiency)}}$$

Total Dynamic Head (TDH)

TDH may be viewed as the total load on the pumping plant. This load is usually expressed in feet of "head" (1 psi, or pound per square inch = 2.31 feet of

*Extension agricultural engineer, The Texas A&M University System.

Fuel Use from Leon's Extension Fact Sheet

Your fuel usage should be less than this

- Natural Gas *MCF*

  272/acre-inch/100 ft head

- Electricity *KWH*

  17.3/acre-inch/100 ft head

- Diesel *Gallons*

  1.16/acre-inch/100 ft head

Copy of this presentation will be posted at:

http://gfipps.tamu.edu