Dynamics of Power Factor, How to Improve it and the Minimization of kVa Demand Charges

Northeast Utilities System

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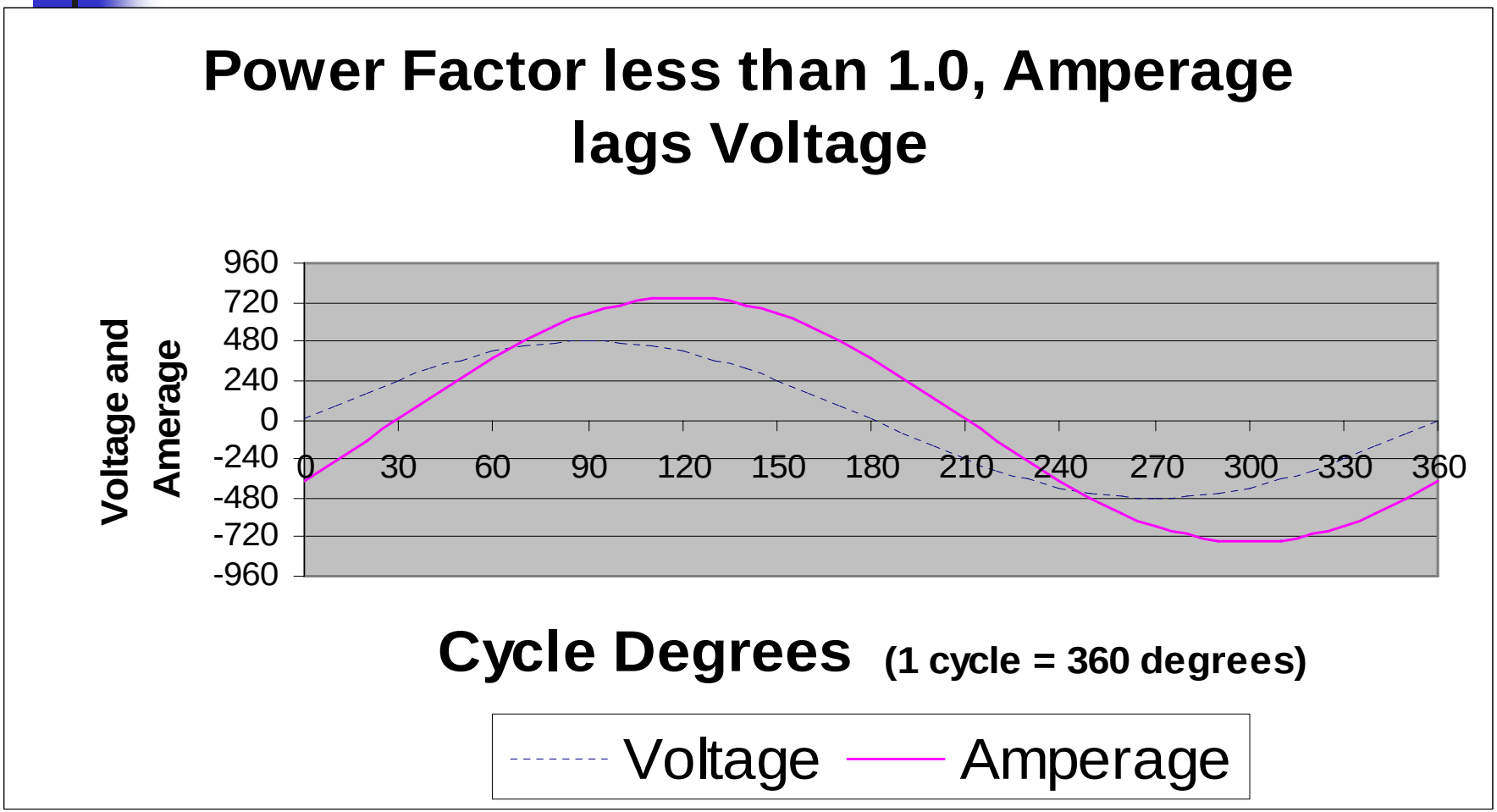
“Power Factor”, what does it mean?

- Power Factor is the ratio if kilo-watts (kW) to kilo-volt-amperes (kVa)…….
  Power Factor = **kW / kVa**

- Power Factor represents the extent to which the **amperage wave form** is out of phase with the **voltage wave form**

“Power Factor”, what does it mean?



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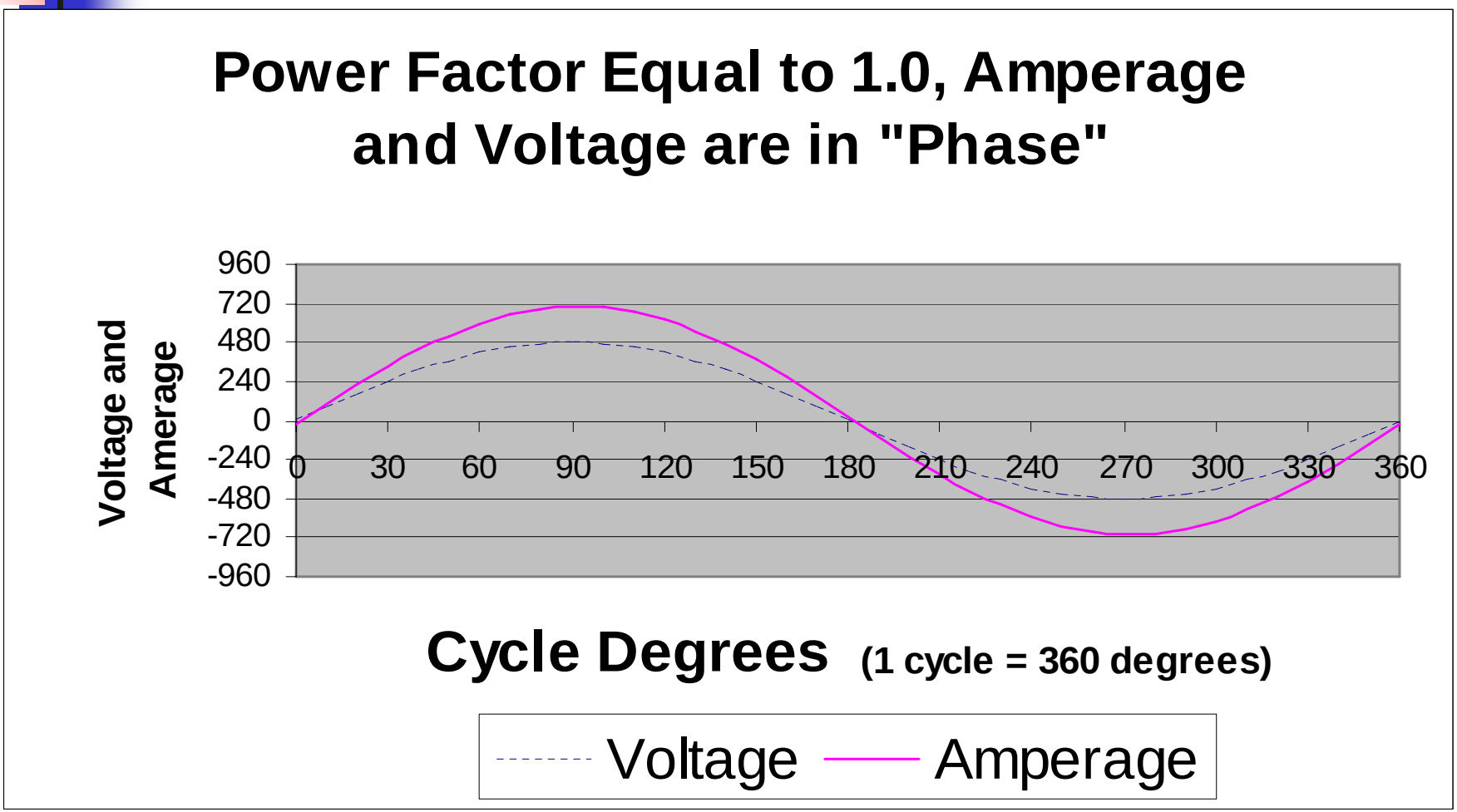
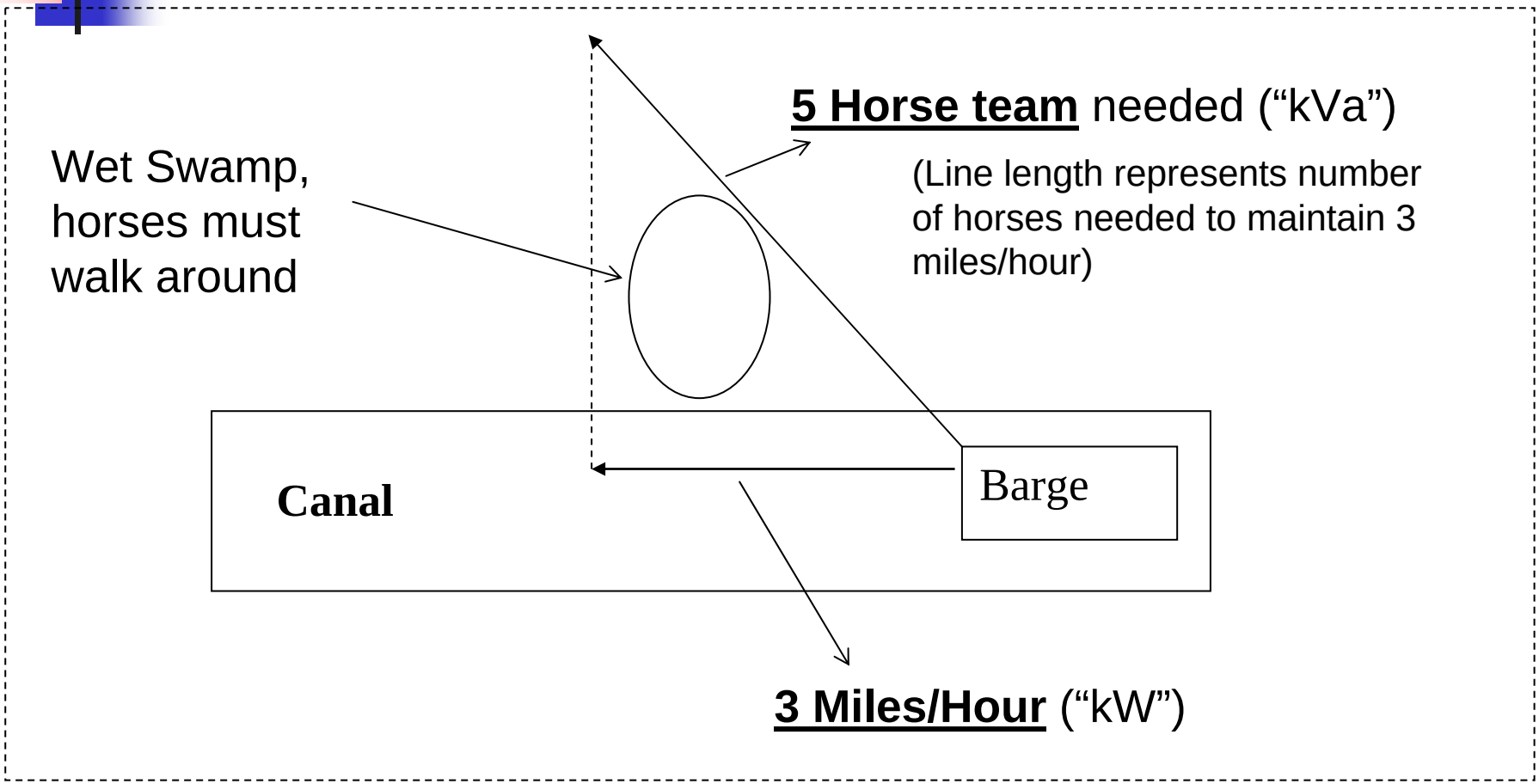
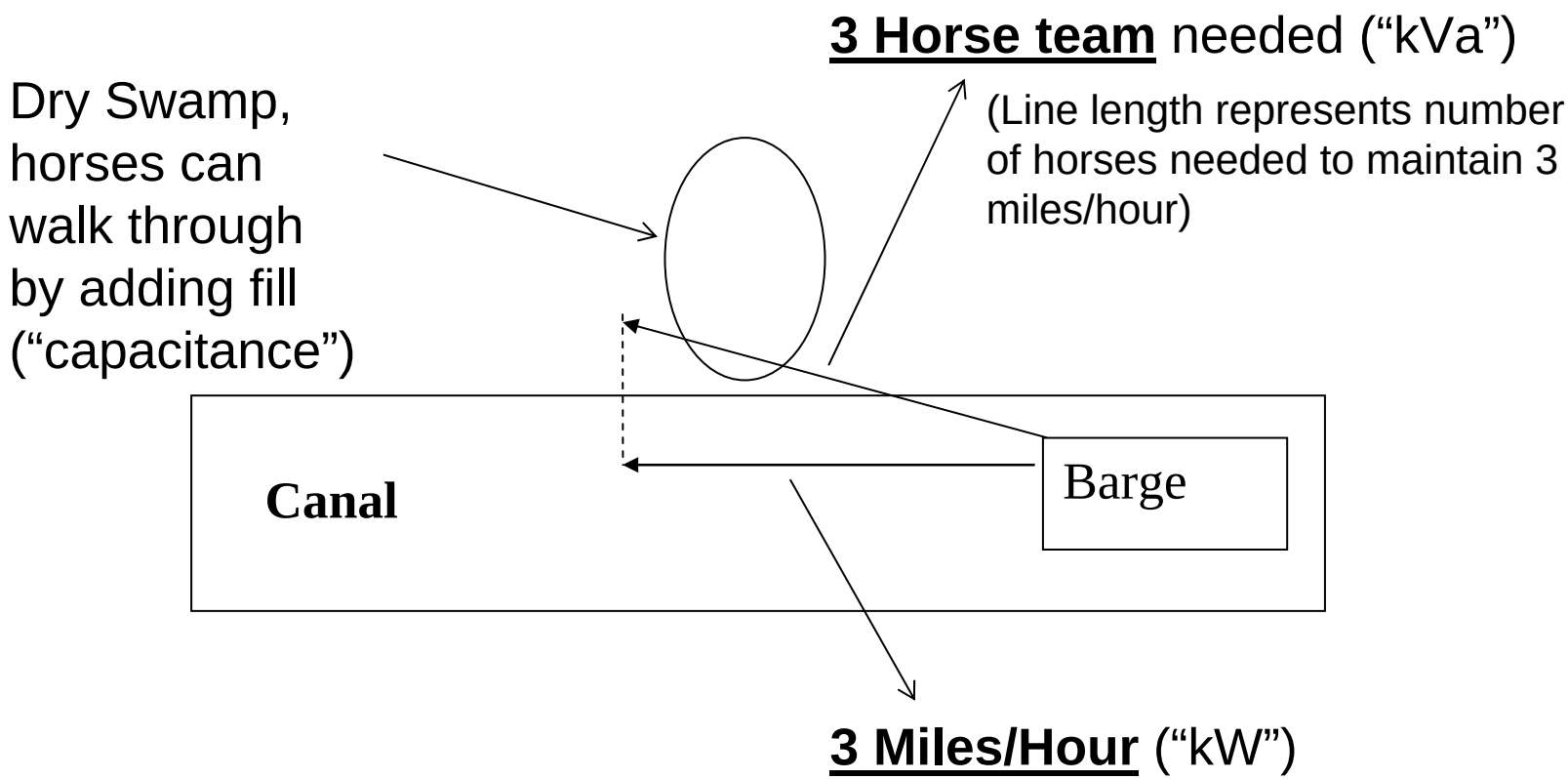


“Power Factor”, what does it mean?
(Horse Drawn Barge Analogy)



Example of **Poor** Power Factor

“Power Factor”, what does it mean? (Horse Drawn Barge Analogy)



Example of **Improved** Power Factor

How is Power factor Calculated?

1. Ratio of know values; **kW / kVa = PF**

kW is the “Real” power measured by a kW meter.

kW can be obtained from:

a. measured by a kW meter

b. value indicated on the electric bill

kVa is the voltage measured by a volt meter multiplied by amperage measured by an amp meter.(all divided by 1000 to obtain “Kilo” Va).

Which connected loads lower PF?

Loads that lower Power Factor

Any load that requires electricity to create a magnetic field:

1. Stator of a motor; elevator motors, process motors, HVAC motors
2. Magnetic ballasts used in pre-electronic ballast fluorescent lighting systems
3. Transformers
4. Induction heating equipment

Which connected loads raise PF?

Loads that raise Power Factor

Any resistive load tends to raise power factor because resistive loads inherently have a power factor of 1.0.

1. Resistance heating
    a. electric resistance space heating
    b. electric resistance heating of domestic hot water
2. Incandescent lighting

What is the relationship between Capacitance and Power Factor?

Adding capacitance to a circuit will **increase the power factor** of that circuit.

This happens because capacitance applies a force that **tends to make the amperage wave form lead the voltage wave form**.

Capacitance and Inductance have an opposite affect on power factor.

Why should I care about Power Factor?

For rates that have their demand billed on a kVa basis, having a **below average power factor will cost more than** rates that have their **demand billed on a kW basis.**

Lower power factors will result in **higher demand charges** (for rates billed on a kVa basis).

Why should I care about Power Factor?

Improving Power factor **reduces the amperage flowing through switch gear, feeder lines etc**,

therefore an improved power factor would **allow for additional equipment to be added** to an existing circuit with less chance of overload.

What is a ratcheted demand charge?

Transmission Demand Charge (**not ratcheted**):

Highest demand value **for a particular monthly billing period**, that occurred during on peak times (7am to 11pm).

Distribution Demand Charge (**ratcheted**):

Highest demand value **during any of the past 12 months**, that occurred during any time of the day.

Comparative billing and Ratchet Charge example

CL&P Rate 57

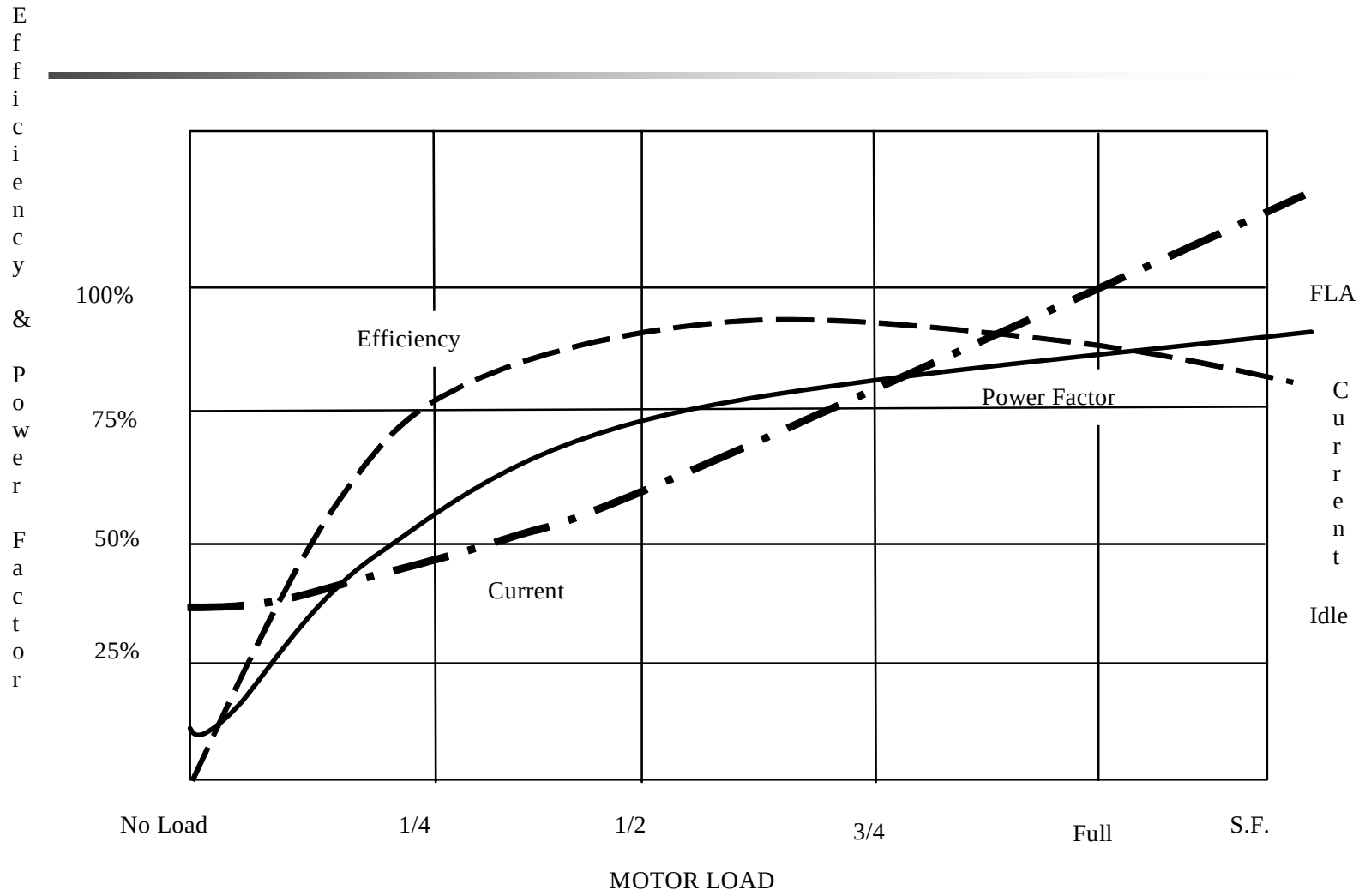
KVA/KW Billing Comparison Report

For Informational Purposes Only

				KW	KVA
Transmission Prod/Trans Demand Charge:					
On Peak KW	2896.6	KW	X $1.77	$5,126.98	
On Peak KVA	4665.9	KVA	$1.44		$6,718.90
Distribution Demand Charge:					
Maximum KW 12 Months	3282.1	KW	X $2.68	$8,796.03	
Maximum KVA 12 Months	5150.3	KVA	$2.19		$11,279.16
Competitive Transition Assessment:					
On Peak KW	2896.6	KW	X $3.20	$9,269.12	
On Peak KVA	4665.9	KVA	$2.61		$12,178.00
All Other Charges on Current Month's Bill				$95,416.13	$95,416.13
Total Bill				$118,608.26	$125,592.19

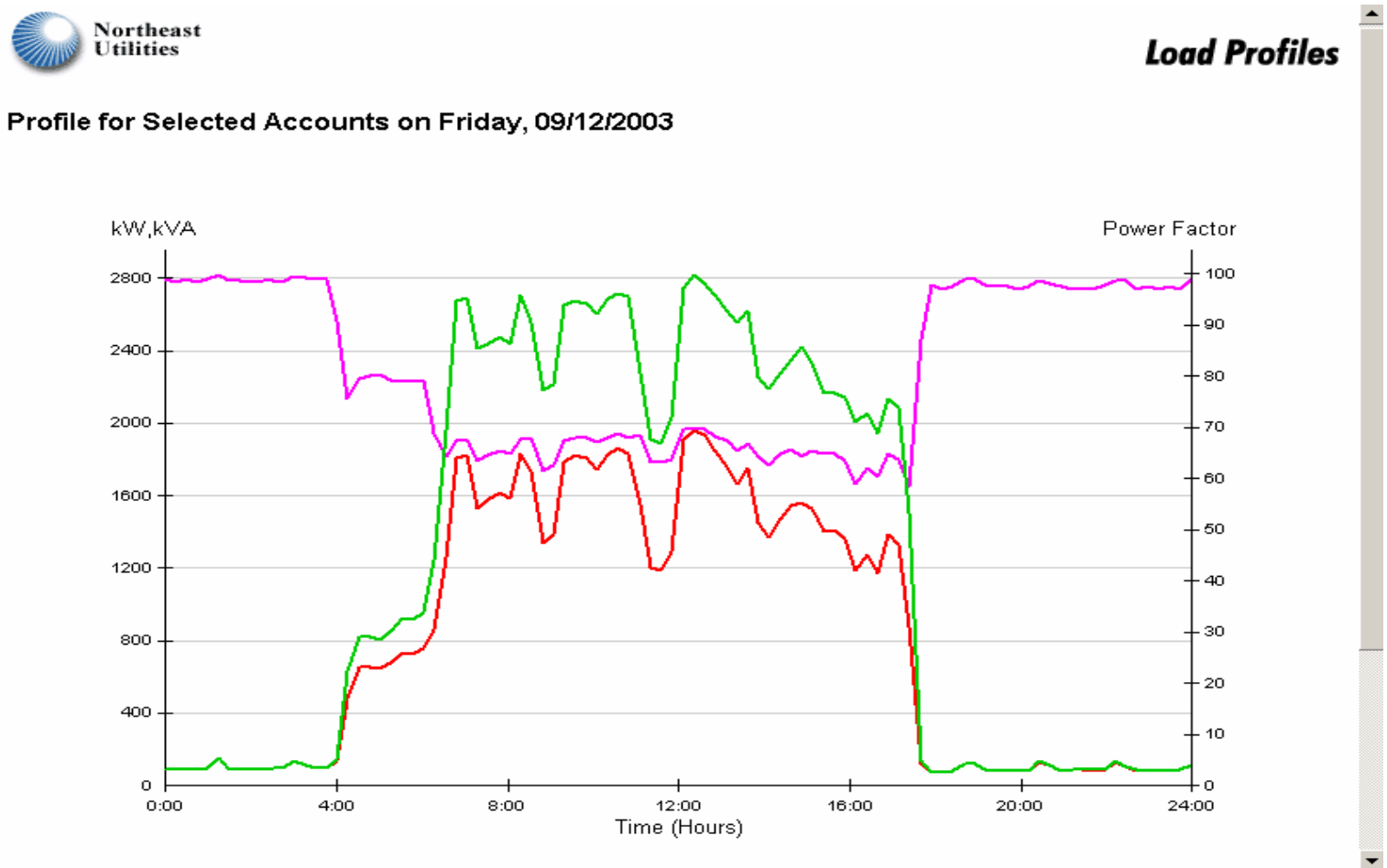
Difference in KVA Bill versus KW Bill	$6,983.93
Percentage Change Between KVA Bill and KW	5.90%
Coincident KW at Maximum On Peak KVA	2,896.60
Power Factor	0.621

Motor Loading and Power Factor



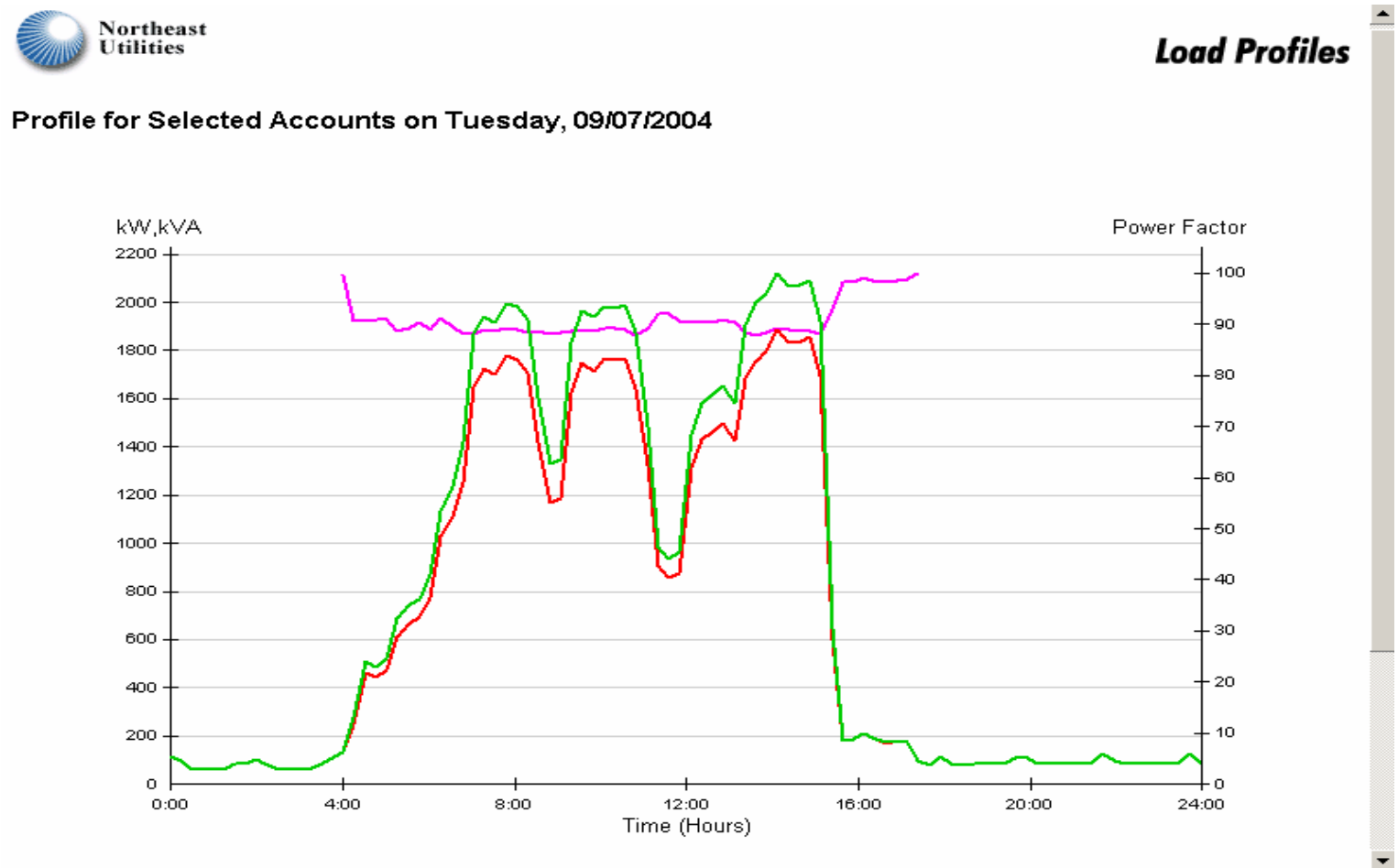
Power Factor during Peak Loads vs. non-Peak Loads "Pre-Improvement"

(kVa kW Power Factor)



Power Factor during Peak Loads vs. non-Peak Loads "Post-Improvement"

(kVa kW Power Factor)



Managing Power Factor at Various Facility Types

- For billing reduction purposes, managing Power Factor only makes sense if the facility is billed on a KVa basis
- Power Factor Improvement involves the consideration of several issues:
  - Determination of the amount of Capacitance need during peak load
  - On-site metering to determine level of harmonic distortion
  - Installation of filters to mitigate harmonic distortion (if warranted)
  - Capacitor installation location, at main service or at individual loads
  - Assessment of the need for capacitor switching

Costs associated with Optimizing Power Factor

- Total cost for Power Factor Improvement system depend on the cost per kVar and amount of kVar needed
- Typical Power Factor Improvement systems range in cost from $35/kVar to $65/kVar
- The amount of kVar needed depends on the peak load (kW) for a facility and the existing Power Factor

Determining amount of KVar needed for complete Improvement

The ABC Company

Input cells — Kvar input field===> 3800

Override formula if need to prevent over correction

	Existing Monthly Peak kW	Existing Power Factor Coincident with Monthly Peak kW	Existing (Calculate) kVa	Existing (Calculate) kVar	Kvar added to system	New kVa	New Power Factor
Jan	3045.6	0.619	4920	3864	3800	3046.3	1
Feb	3282.1	0.637	5152	3972	3800	3286.6	0.999
March	3227	0.635	5082	3926	3800	3229.5	0.999
Apr	2945.2	0.621	4743	3717	3800	2946.4	1
May	2857.7	0.593	4819	3880	3800	2858.8	1
June	2896.6	0.621	4664	3656	3800	2900.2	0.999
July	3191.4	0.622	5131	4018	3800	3198.8	0.998
Aug	3168.7	0.62	5111	4010	3800	3175.6	0.998
Sept	2951.6	0.619	4768	3745	3800	2952.1	1
Oct	2886.8	0.608	4748	3770	3800	2887.0	1
Nov	3013.2	0.617	4884	3843	3800	3013.5	1
Dec	2977.6	0.612	4865	3848	3800	2978.0	1
Existing Avg PF ==>		0.619			New Avg PF===>		0.9992

Applying typical costs for power factor improvement to 0.99

Lower End Estimate

3800kVar X $35/kVar = $133,000

High End estimate

3800kVar X $65/kVar = $247,000

Power Factor Improvement Incentives

- As of 10/28/04 only Rate 57 has been converted to kVa based demand billing
- As of 10/28/04 only Rate 57 has been approved for inclusion in the Power factor Improvement Program
- Incentives reimburse customers for 50% of the cost to improve their Power Factor to the Revenue Neutral value (Rate 57 is 0.816)

Determining amount of KVar needed for Revenue neutral Improvement

The ABC Company

Input cells

Override formula if need to prevent over correction

Kvar input field===> 1703

	Existing Monthly Peak kW	Existing Power Factor Coincident with Monthly Peak kW	Existing (Calculate) kVa	Existing (Calculate) kVar	Kvar added to system	New kVa	New Power Factor
Jan	3045.6	0.619	4920	3864	1703	3734.5	0.816
Feb	3282.1	0.637	5152	3972	1703	3990.0	0.823
March	3227	0.635	5082	3926	1703	3918.5	0.824
Apr	2945.2	0.621	4743	3717	1703	3568.2	0.825
May	2857.7	0.593	4819	3880	1703	3592.7	0.795
June	2896.6	0.621	4664	3656	1703	3493.5	0.829
July	3191.4	0.622	5131	4018	1703	3942.4	0.81
Aug	3168.7	0.62	5111	4010	1703	3919.5	0.808
Sept	2951.6	0.619	4768	3745	1703	3589.1	0.822
Oct	2886.8	0.608	4748	3770	1703	3550.3	0.813
Nov	3013.2	0.617	4884	3843	1703	3695.9	0.815
Dec	2977.6	0.612	4865	3848	1703	3669.6	0.811
Existing Avg PF ==>		0.619			New Avg PF===>		0.8160

Applying typical costs and incentive calculation, Improvement to 0.816

Lower End Estimate

(1703kVar X $35/kVar) X 50% = $29,803

High End estimate

(1703kVar X $65/kVar) X 50% = $55,348