

POWER ELECTRONICS TECHNOLOGY<sup>™</sup>

## Inverter Power Consumption

### Energy Savings

One of the most common questions asked when considering an equipment upgrade is "what is it going to cost me?"

We understand that keeping up with technology can be a financial strain. That's why we do our best to make new products more cost efficient. But we think it's important to define what "more cost efficient" means. A lot of products tout "new and improved", but how do you know that's true?

Companies often overlook the potential for savings in utilities like gas and electric. A lot of people don't know what exactly they are being charged for. This paper teaches you how to understand what your electrical costs are, and how using Lincoln inverters can provide energy cost reduction. We'll define what "more efficient" means for Lincoln equipment, and we're confident that once you see the evidence you'll agree.



*The Power Wave<sup>®</sup> and Invertec<sup>®</sup> family of inverters increase energy efficiency and decrease energy consumption.*

### a d v a n t a g e s

#### REDUCED POWER CONSUMPTION

- Reduction of power consumption lowers energy/demand charges from utility companies, providing substantial cost savings.
- Incentives are offered by utility companies to adopt higher end technologies that require less energy demand.

#### INCREASED POWER FACTOR

- Improving power factor increases electricity capacity.
- Less current is required for the same reliable output.
- Reduced stress on distribution equipment leads to longer life of equipment.

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Energy Savings

## What

**Affects the Input Rating of a Machine?**

### Efficiency

Efficiency is the ratio of output power to real input power. Efficiency is the most important factor when considering the cost of electricity. A machine with a higher efficiency converts more of the power it draws from the input line, which reduces the amount of wasted energy (given off in the form of heat). Efficient machines run cooler, draw less power, and cost less to operate.

It is important not to mistake the measure of a machine's "apparent power" (kVA: Input Amps X Input Volts), with the "real power" (kW) the utility company charges for. The "real power" takes the machine's power factor into consideration. In comparing two machines it is possible for a machine that draws higher input currents to have higher efficiency and therefore lower operating costs.

### Power Factor

The combination of increasing electrical loads and an aging power distribution system has resulted in more emphasis on electrical power factor. Power factor is defined as the ratio of real power to apparent power. Not all of the current that is drawn by a machine is used by the machine. In a regulated utility environment, power factor does not significantly affect charges.

Higher power factor indicates that a higher percentage of the apparent power drawn from the power line is used by the machine. A rating of 0.95 means that 95% of the apparent power is converted to real power. A poor power factor level requires a higher current to be drawn to perform the same amount of work. Optimizing power factor can reduce the load on the electricity distribution system. This simple solution increases electrical capacity, without the cost of additional infrastructure.

### POWER FACTOR EXAMPLE

*A plant uses 40 welding systems, and each system uses 10 kW of power. Compare the kVA capacity requirements for the same bank of welders with a power factor rating of 0.95 and 0.70.*

- $kVA = 400 kW / 0.95 = 421 kVA (421,000 VA)$  for 0.95 power factor
- $kVA = 400 kW / 0.70 = 571 kVA (571,000 VA)$  for 0.70 power factor

*Capacity required for 460V three-phase service:*

- $421,000 VA / (460 V \times 1.73) = 529 Amps/Phase$  (for 0.95 power factor)
- $571,000 VA / (460 V \times 1.73) = 718 Amps/Phase$  (for 0.70 power factor)

### ADVANTAGES OF HIGH POWER FACTOR

- Increased Power Supply Capacity
- Reduced Heat Load on Electrical Cables
- Reduction of kVA Demand Decreases Electricity Delivery Charge
- Reduced Voltage Drop on Cables
- Improved Equipment Operation



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## Energy Savings

### Power Factor (cont.)

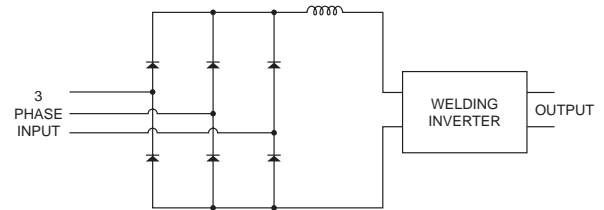
There are two general causes of poor power factor: reactive loads and electronic power supplies. Poor power factor caused by reactive loads, such as big motors, can be corrected by adding a capacitor in parallel to the load. Electronic power supplies, (for example, inverters) on the other hand, cannot be corrected by adding reactive components in parallel. In order to improve power factor, the machines have to be designed with power factor correction (PFC).

For three phase inputs, passive power factor correction is the best method for improving power factor. The other alternative is active power factor correction. As the names imply, the passive approach uses passive components and the active approach uses active components. Both approaches give 95% power factor.

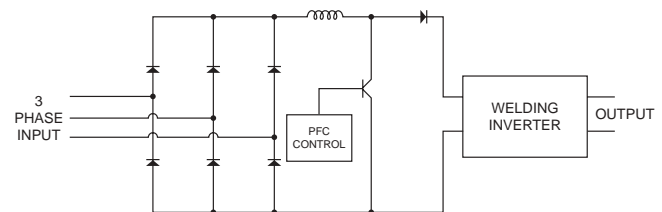
The advantages of passive PFC are:

- Passive PFC is less complex and more reliable.
- Passive PFC has lower losses and higher efficiency.

The Power Wave® 455M, Power Wave® 655 Robotic, and Power Wave® AC/DC 1000™ are designed with passive power factor correction.



Passive Power Factor Correction



Active Power Factor Correction

## What

### is the Electric Company Charging You?

There are a couple of basic charges that the energy company uses in their invoices.

### Energy Charge

This is the charge for amount of energy used in kilowatt hours (kWh). The amount charged per kWh may vary depending upon the time of day that the energy is consumed. More energy is consumed during certain hours of the day (peak hours) and, similar to minutes in cell phone plans, there is a premium placed on usage during those times.

### ENERGY CHARGE EXAMPLE

A welder consumes 6 kW for 8 hours. The rate per kWh between 8 a.m. and 9 p.m. is \$0.10, and the rate per kWh between 9 p.m. and 8 a.m. is \$0.05.

**How many kWh has the welder used?**

**48**

**How much would you be charged for running the welder from 8 a.m. to 4 p.m.?**

**\$4.80**

**How much would you be charged for running the welder from 10 p.m. to 6 a.m.?**

**\$2.40**

**How much would you be charged for running the welder from 4 a.m. to 12 p.m.?**

**\$3.60**

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## Energy Savings

### Demand Charge

Industrial customers usually pay lower energy charges than residential customers. While a residence is charged on average \$0.11 per kWh, a typical industrial customer will pay an average of \$0.05 per kWh. However, industrial customers incur an additional cost, called the demand charge. This charge is based on the customer's highest demand for electricity. Demand charges are almost always the largest part of an industrial company's electric bill.

For example, if two companies use the same amount of energy, but one uses it gradually while the other uses electricity erratically, the customer using high amounts of electricity in shorter time intervals will be assessed a higher demand charge. This is to cover the power company's expense for having more equipment ready to service the customer who required a higher electrical current. In short, it is better to use lower constant levels of power than occasional surges of power.

The demand charge is based on the peak amount of power being consumed in the plant at any given instance (industrial companies often refer to this as "peak" time). This is the point when power demand is the highest and ultimately sets the billing rate. Only the welding machines that are running at the "peak" demand time contribute to the demand charge. If multiple welding machines are being used they will not all contribute to demand charge (unless 100% of the machines are welding 100% of the time). This is why energy calculations are more complicated than multiplying a single machine's energy costs by the total number of machines.

## Comparing

### Energy Consumption Costs

Lincoln inverter machines such as the Power Wave® 455M and 655 Robotic have shown a significant reduction in power consumption. Due to the higher operating frequencies, inverters yield higher, more economical output power. This increased power source efficiency translates to decreased utility costs.

When compared with rectifier power sources like the DC-600 and the CV-655, the inverter power sources can save thousands of dollars per year in energy costs. When compared to other machines in the marketplace like the Miller Axxess, or XMT inverters, the Lincoln Power Wave inverters are consistently more energy-efficient and less expensive to operate.

### DEMAND CHARGE EXAMPLE

*A plant runs 40 welding systems, each using 10 kW of power. The equipment operates with a 50% duty cycle for two shifts per day (one shift is during peak energy charges), 22 days per month. At a 50% duty cycle, only 20 welding systems are drawing current at any one time. The energy charge is \$0.05/kWh during peak hours, and \$0.025/kWh during off peak hours. The demand charge is \$10.00/kW of additional demand.*

**How many kWh has the plant used per shift?**

**$40 \text{ systems} \times 10 \text{ kW} \times 4 \text{ hours} = 1,600 \text{ kWh}$**

**What is the Energy Charge per month?**

**Peak consumption:**

**$1,600 \text{ kWh} \times \$0.05 \times 22 \text{ days} = \$1,760 \text{ per month}$**

**Off peak consumption:**

**$1,600 \text{ kWh} \times \$0.025 \times 22 \text{ days} = \$880 \text{ per month.}$**

**What is the Demand Charge?**

**Additional demand:**

**$20 \text{ systems} \times 10 \text{ kW} = 200 \text{ kW}$**

**Demand charge:**

**$200 \times \$10.00 = \$2,000 \text{ per month}$**

**What is the Total Energy Cost?**

**Total energy cost:**

**$\$1,760 + \$880 + \$2,000 = \$4,640$**

# Inverter Power Consumption

Energy Savings

## Head to Head – Lincoln Invertec® V350-PRO vs. Miller XMT 350, Miller XMT 304, Miller Dimension 302



Experiment Specifications: 300 Amps / 29 Volts / 8.4 hours arc time / 15.6 hours idle time / 250 days per year				
	Lincoln Invertec® V350-PRO/ Power Wave® 355M	Miller XMT 350	Miller XMT 304	Miller Dimension 302
Idle Watts*	125	60	40	600
Efficiency*	0.88	0.86	0.83	0.75
Power Factor*	0.69	0.95	0.77	0.65
Demand Charge (\$10.85/kW)/year	\$1,287	\$1,317	\$1,365	\$1,510
kWh Charge (\$0.02306/kWh)/year	\$490	\$484	\$511	\$616
Total Annual Costs (industrial method)	\$1,777	\$1,801	\$1,876	\$2,126
Annual Savings Compared to a Dimension 302	\$349	\$325	\$250	---
Input Amps (460 input)	18	13.4	17	22

## Head to Head – Lincoln Power Wave® vs. Miller Axxess 450, Miller XMT 456, Miller Dimension 452



Experiment Specifications: 450 Amps / 38 Volts / 8.4 hours arc time / 15.6 hours idle time / 250 days per year				
	Lincoln Power Wave® 455M	Miller Axxess 450	Miller XMT 456	Miller Dimension 452
Idle Watts*	160	241	50	700
Efficiency*	0.90	0.89	0.85	0.79
Power Factor*	0.95	0.95	0.91	0.70
Demand Charge (\$10.85/kW)/year	\$2,474	\$2,502	\$2,619	\$2,818
kWh Charge (\$0.02306/kWh)/year	\$934	\$952	\$979	\$1,111
Total Annual Costs (industrial method)	\$3,408	\$3,454	\$3,598	\$3,929
Annual Savings Compared to a Dimension 452	\$521	\$476	\$331	---
Input Amps (460 input)	25	25	28	39

## Head to Head – Lincoln Power Wave® 655 vs. Lincoln CV-655, Miller Dimension 652



Experiment Specifications: 650 Amps / 44 Volts / 8.4 hours arc time / 15.6 hours idle time / 250 days per year			
	Lincoln Power Wave® 655	Lincoln CV-655	Miller Dimension 652
Idle Watts*	225	880	760
Efficiency*	0.92	0.84	0.82
Power Factor*	0.95	0.93	0.70
Demand Charge (\$10.85/kW)/year	\$4,048	\$4,433	\$4,541
kWh Charge (\$0.02306/kWh)/year	\$1,526	\$1,728	\$1,757
Total Annual Costs (industrial method)	\$5,573	\$6,161	\$6,298
Annual Savings Compared to a Dimension 652	\$725	\$138	---
Input Amps (460 input)	41	46	63

\*Efficiency, Power Factor, and Idle Watts were obtained through measurements or published data.

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Energy Savings

## Head to Head – Lincoln Power Wave® AC/DC 1000™ vs. Lincoln AC-1200, Lincoln DC-1000



Experiment Specifications: 1000 Amps			
	Lincoln Power Wave® AC/DC 1000™	Lincoln AC-1200	Lincoln DC-1000
Idle Watts*	300	2500	2000
Efficiency*	0.86	0.80	0.78
Power Factor*	0.95	0.81	0.73
Demand Charge (\$10.85/kW)/year	\$6,661	\$7,161	\$7,345
kWh Charge (\$0.02306/kWh)/year	\$2,505	\$2,888	\$2,912
Total Annual Costs (industrial method)	\$9,166	\$10,049	\$10,256
Annual Savings Compared to a DC-1000	\$1,090	\$207	---
Input Amps (460 input)	68	148 (1 phase)	97

## Comparing

### Energy Consumption Costs

As illustrated in the previous section, high-efficiency welding machines produce substantial cost savings. Lincoln Electric inverters consistently achieve higher efficiency, and thus, lower cost.

The Power Wave® 655 Robotic is the most efficient inverter machine available, followed by the Power Wave® 455M. Due to variations in billing by the power company, the cost savings will fluctuate. However, the investment made in purchasing a Lincoln inverter may pay for itself with the money saved by reduced energy consumption.

## Additional Savings

In addition to lower operating costs, incentives to use high-efficiency inverters may be available from your local utility company. Utility companies offer "Demand Side Management" programs to encourage customers to adopt new highly efficient technologies. This is a cost effective way for the utility companies to defer the need for more power capacity. Some of the Demand Side Management programs are:

- Rebates for high-efficiency inverters
- Low interest rate loans for purchasing high-efficiency inverters
- Assistance in calculating potential savings for switching over to high-efficiency inverters

To find out more about the programs that are available, contact your local electricity provider.

\*Efficiency, Power Factor, and Idle Watts were obtained through measurements or published data.

# Inverter Power Consumption

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## Energy Savings

### Six Questions

#### To ask yourself about your energy costs

Lincoln Electric understands that utility costs are important and understanding all of the intricacies that are involved in calculating electricity costs can be confusing. There is no simple equation or “efficiency calculator” that can accurately calculate energy costs. Lincoln Electric is here to assist in these calculations. It is our goal to train and inform our customers about energy costs so they can make educated decisions that can save them money. The following questions will get you started.

#### 1) Who pays the electricity bill?

Finding this person is an important first step. Someone must be paying the bills. That person can recognize, document, and “claim” the cost savings. In most larger companies, this will be someone in purchasing or supply management. In small companies, this person may be the accountant, manager, or owner.

#### 2) Who reviews the electricity bill?

This person will know the rate structure and how the bill is calculated. In most large organizations, this position will be in the facilities maintenance or operations department. In small companies, this person may be the same person who pays the bill.

#### 3) Who are the electricity suppliers?

This is important because it raises the issues associated with future energy costs, especially if deregulation or contract changes are pending. Contract renewal is often a catalyst for reviewing energy costs. Billing structures are often ambiguous and even experienced people must sometimes contact the supplier to understand the contract.

#### 4) What is the history of electrical billing?

The power bill is overlooked in many companies, but when the cost becomes visible, it gets attention. Energy is a pure cost and is often equal to 5 - 10% of operating profit in an industrial operation. Once understood, power costs get the attention of management. This attention helps drive investments.

#### 5) What are the facts related to the welding load and the equipment to be replaced?

The welder load factors, efficiency, and power factor of the equipment to be replaced is needed to make a correct assessment of power savings.

#### 6) What is the billing structure?

Deregulation has further complicated the terminology and structure of electrical utility bills. As the electrical industry is deregulated, utilities no longer sell power directly to consumers. The new structure involves companies that make the power (generation), companies that own the power distribution infrastructure (transmission), companies that maintain the system (service), and companies that connect consumers with power and service providers (marketing). With the new terms on electricity bills, it is important to understand the billing structure before making cost comparisons.

### Lincoln Welding Systems featuring Inverters

#### Power Wave® 455M/STT

#### Power Feed® 10M

The Power Wave 455M/STT is a high performance, digitally controlled inverter power source designed to be part of a modular, multi-process welding system. Optional DeviceNet™ and Ethernet modules provide networking capabilities to create a highly integrated, flexible welding cell. Power Feed 10M is a compact wire feeder designed for use with Power Wave power sources.



#### Invertec® V350-PRO

The V350-PRO has new features that make it easy to set up and easy to weld. These features allow plug and play operation. Plug in an accessory and the V350-PRO recognizes it and switches to it automatically. The rugged construction will give the V350-PRO a long life, even in tough conditions. Skids and roll bars shield the case. Recessed controls are protected. Potted circuit boards stand up to the environment.



# Inverter Power Consumption

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## Energy Savings

### Lincoln Welding Systems featuring Inverters

#### Power Wave® 655 Robotic

The Power Wave 655 Robotic was designed for Robotic and Hard Automation applications that require extra power (650 Amps at 100% Duty Cycle).

- Digital Communications enable the Power Wave to connect seamlessly to robot controllers and hard automation PLCs. Semiautomatic applications are also supported.
- The Ethernet/DeviceNet Gateway provides networking capabilities and allows process and production monitoring.
- Software-based controls can be upgraded as new features become available.
- The Power Wave 655 Robotic has an output range of 220 to 880 Amps.



#### Power Wave® AC/DC 1000™

The Power Wave AC/DC 1000 is a modular welding system with a single range of control from 100 to 1000 Amps per arc at 100% duty cycle.

The Power Wave AC/DC 1000 provides:

- DC+, DC- and variable frequency up to 200 Hertz.
- 100% software control.
- Flexible Waveform Control:
  - Variable Frequency
  - Variable independent amplitudes
  - Variable timing
- The ability to be paralleled for higher output current.



#### Customer Assistance Policy

The business of The Lincoln Electric Company is manufacturing and selling high quality welding equipment, consumables, and cutting equipment. Our challenge is to meet the needs of our customer and to exceed their expectations. On occasion, purchasers may ask Lincoln Electric for advice or information about their use of our products. We respond to our customers based on the best information in our possession at that time. Lincoln Electric is not in a position to warrant or guarantee such advice, and assumes no liability, with respect to such information or advice. We expressly disclaim any warranty of any kind, including any warranty of fitness for any customer's particular purpose, with respect to such information or advice. As a matter of practical consideration, we also cannot assume any responsibility for updating or correcting any such information or advice once it has been given, nor does the provision of information or advice create, expand or alter any warranty with respect to the sale of our products.

Lincoln Electric is a responsive manufacturer, but the selection and use of specific products sold by Lincoln Electric is solely within the control of, and remains the sole responsibility of the customer. Many variables beyond the control of Lincoln Electric affect the results obtained in applying these types of fabrication methods and service requirement.

*Subject to change* - This information is accurate to the best of our knowledge at the time of printing. Please refer to [www.lincolnelectric.com](http://www.lincolnelectric.com) for any updated information.

#### WHAT IS NEXTWELD?

*The challenges facing industrial fabricators today are growing in number and complexity. Rising labor, material and energy costs, intense domestic and global competition, a dwindling pool of skilled workers, more stringent and specific quality demands all contribute to a more difficult environment today.*

*Through our commitment to extensive research and investments in product development, Lincoln Electric has established an industry benchmark for applying technology to improve the quality, lower the cost and enhance the performance of arc welding processes. Advancements in power electronics, digital communications and Waveform Control Technology™ are the foundation for many of the improvements.*

*NEXTWELD brings you a series of Process, Technology, Application and Success Story documents like this one. NEXTWELD explains how technologies, products, processes and applications are linked together to answer the important questions that all businesses face:*

- *How can we work faster, smarter, more efficiently?*
- *How can we get equipment and people to perform in ways they've never had to before?*
- *How do we stay competitive?*

*NEXTWELD is the future of welding but its benefits are available to you today. Ask your Lincoln Electric representative how to improve the flexibility, efficiency and quality of your welding operations to reduce your cost of fabrication.*



**LINCOLN**  
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