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PEARL

Professional Electrical Apparatus Reconditioning League

Reconditioning: The Ultimate Form of Recycling

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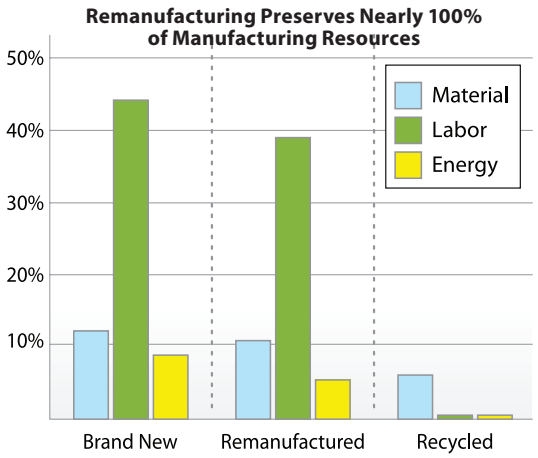
The world is overlooking a simple answer to many of our global economic, socio-political, and environmental concerns: Reuse it, stupid.

Reuse may sound like another car on the 'green' gravy train, but its benefits are real, tangible, and ready for prime time. Simply put, reuse — also referred to as reconditioning or remanufacturing — is better than recycling when it comes to saving jobs, energy, raw materials, and the environment. Reuse also applies to more products than recycling, including many industrial and commercial products, in contrast to recycling, which focuses on consumer goods such as newspapers, plastic bottles, and aluminum cans.

For recycling to work, you need a product that is essentially made from one material, easy to collect, sort, and convert back into raw materials. Because of the extra steps of sorting, shredding, and reconstituting the raw material, it's harder for recycling processes to be cost effective in tough economic conditions.

Reuse, on the other hand, returns a product to 'as good as new' condition without breaking it into basic raw materials. Reuse applies to more products than recycling because the product can be more complex than a homogenous beverage container or newspaper circular. As one might expect, returning complex products to new condition takes skill. Because the products are often electrical or mechanical, reuse requires testing to guarantee public safety. What it doesn't take are kilowatts of electricity, as does recycling, or produce tons of CO_2. Reused products are all around us: laser printer ink cartridges, automotive parts, electric motors, and furniture, and that's why in 2003, the U.S. remanufacturing industry employed half a million skilled workers, generating $53 billion in annual revenue[1] — more workers and revenue than the U.S. steel, computer, or pharmaceutical industries.

In short, unlike recycling, reuse is not just about sustaining the environment. Reuse is about saving money, saving skilled jobs, saving raw materials, saving energy, and yes, helping out the environment in the bargain.



Remanufacturing preserves more than 80% of the material, labor and energy used to manufacture new product.

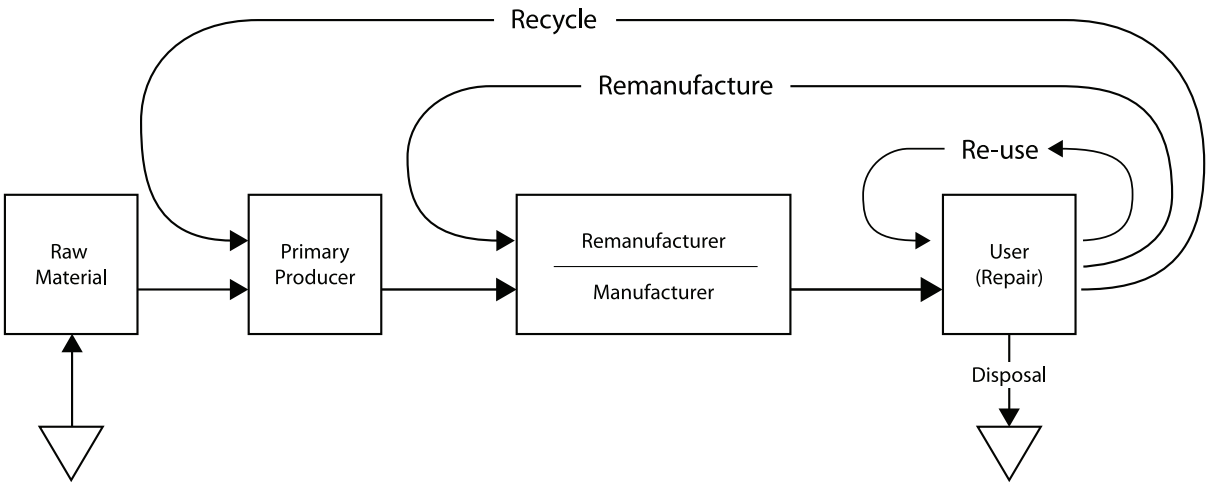
Reuse: Good for Jobs, Business

Throughout modern history, crises prompt societies to reevaluate how they create and use natural resources. After World War I, Britain created the world's first paper-recycling program. During WWII, countries around the world collected and recycled aluminum, iron, rubber, and copper, amongst others. In the 1970s, the U.S. government promoted State-run aluminum and plastic recycling programs in response to high commodity prices.

Today's world has no shortage of crises. The global economy is struggling with the worst recession in 80 years, while trying to incorporate emerging nations that will triple the number of people demanding modern conveniences. The U.S. manufacturing sector has lost 5 million jobs during the past 30 years, employing only 11% of the U.S. population in 2006 compared to 20% in 1976. At the same time, there is a shortage of skilled manufacturing workers because a decline in vocational training programs — a problem that reconditioning trade associations address through required on-the-job training, similar to the requirements for teachers and nurses[2].

[1] *"The Remanufacturing Industry: Anatomy of a Giant, A View of Remanufacturing in America Based On A Comprehensive Survey Across the Industry,"* William Hauser, Robert T. Lund, Department of Manufacturing Engineering, Boston University, June 2003

[2] Volume 12, Number 2, February/March 2006, FEDERAL RESERVE BANK OF NEW YORK, www.newyorkfed.org/research/current_issues



Concerns for the Earth's environmental health are compounding the employment crisis, which, in turn, inhibits international efforts to develop a unified global energy policy. This 'perfect storm' is not likely to change soon because as long as non-polluting renewable energy sources cost more than fossil fuels, the world will struggle to support an energy revolution in advanced nations without penalizing emerging countries with higher energy costs. The flip side allows emerging markets to use 'dirty' energy sources, such as coal, which then further encourages outsourcing to markets with cheap labor and cheap energy.

Offshoring is part of the energy-environment-jobs puzzle too. Offshoring, or moving jobs from domestic markets to low-cost labor markets, has been described as both the destroyer of jobs in developed countries, and the deliverer of emerging markets by lifting the standard of living in poor countries. Offshoring has saved U.S. consumers billions (or more) of dollars in recent years, but it has also created strains on domestic labor markets. In countries with developed economies, domestic manufacturing's answer to offshoring has been to use energy-intensive automation to cut labor costs and improve yields to compete with manufacturing in low-cost labor markets. This approach replaces "human" energy with "electrical" energy, which levels the labor cost issue to manufacturers, but further reduces available jobs while increasing energy consumption and greenhouse gas production. Today, this is a problem for developed countries, but inevitably, emerging markets will feel the employment pressures too as local living standards reach parity with standards in developed countries.

If one considers these interconnected global forces — emerging markets, energy conservation, environmental protection, job creation and social unity — today's challenges compare with the great conflicts and challenges of yesteryear. Whether someone personally believes in global warming or not, the world is undeniably caught in a period of significant economic and cultural change that will not be equally kind to all parties. The question remains, what can both emerging and developed countries do today that will help solve these energy, economic, employment and environmental issues without waiting for technological breakthroughs or massive government spending?

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Reconditioning, Greenest of the Green

Unlike recycling which uses energy to turn simple products like sheet metal, aluminum and copper wire into bulk materials that can be manufactured into something else, reconditioning doesn't use energy to convert working products back into raw materials. And it doesn't consume more energy or pollute the environment by manufacturing recycled materials back into finished products. Reconditioning cleans, plates,

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replaces parts (when necessary), upgrades and tests products to make sure they work 'as good as new.' Safely reconditioning products takes skill, acceptable international standards, and trained technicians. This is why in 2003 the Boston University professors William Hauser and Robert Lund's conservatively estimated that the U.S. reconditioning industry employed 480,000 skilled workers and machinists generating $53 billion in annual revenue[3] — more workers and revenue than the U.S. steel, computer, or pharmaceutical industries.

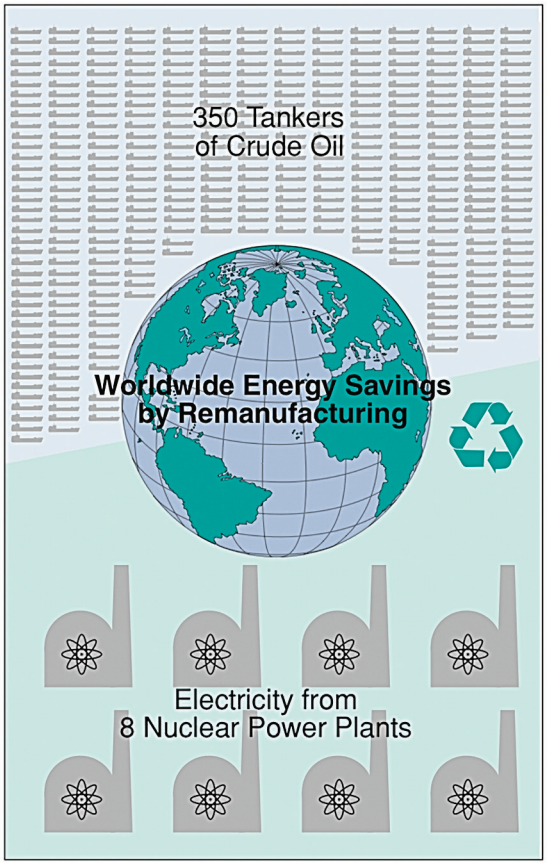
Is this an argument against recycling? Not at all. But just as the energy debate has wisely turned away from inefficient ethanol production and towards abundant, environmentally-neutral natural gas, wind, and solar power, industrial sustainability needs to accept that recycling is only part of the answer to a sustainable future, especially when reality — in terms of cost effectiveness and employment — are added to the equation.

Reconditioning: Transforming Sustainability

Today, industrial motors are the most commonly reconditioned electrical apparatus, but what about other industrial and commercial electric apparatus, such as transformers, switches, panels, relays, and circuit breakers? Are there opportunities for safely reconditioning these devices, while saving customers money and protecting OEM's deserved profit margins? Of course.

A recent market analysis by Electronics.ca Publications predicts global electrical transformer market revenues will reach $36.7 billion by 2015[4], or about the same as industrial electric motors. A transformer, like an electric motor, is a good candidate for reconditioning because the bulk of the material resides in the core and coils which is made from laminated steel, and the metal windings, again, either aluminum or copper. These characteristics make transformers potential candidates for both reconditioning and recycling. To determine whether buying a new transformer, building a transformer from recycled materials, or reconditioning a transformer is the more sustainable alternative, one must consider all the hidden costs from raw material to finished product.

Consider a 3000kVA transformer, which can be found in every utility company from Albuquerque to Zibo. A 3000kVA transformer weighs 22,000 lbs, out of which the steel base and enclosure weight about 3,000 lbs, aluminum coils weigh 3,800 lbs, and laminated steel core weights 15,200 lbs.



The savings of energy by remanufacturing amounts worldwide to 120,000,000,000,000 BTU`s (British Thermal Units) a year. This is an amount of energy equal to 16,000,000 barrels of crude oil, which equals a fleet of 350 tankers; the lifetime fuel consumption of 75,000 car owners; the electricity generated by eight average size nuclear power plants; or the energy needed for industrial and commercial activities of 1.8 millions employees in total. Illustration courtesy of Fraunhofer IRB.

For this analysis, we'll combine the steel in the enclosure and base with the laminated core of silicon steel because the U.S. Department of Energy does not have detailed energy and pollution figures for electrometallurgical ferroalloy products, such as silicon steel. The average U.S. ton of steel requires 657.6 kWh of electricity to manufacture. Therefore, the steel components of our transformer, weighing 18,200 lbs or 6.1 tons consumes 4,011.4 kiloWatt hours (kWh) of electricity to extract the ore and smelt the steel. Again, using U.S. government statistics, generating 1 kWh of electricity on average produces 2.3 lbs[5] of carbon dioxide (CO_2), the most common greenhouse gas. Therefore, the steel components of the transformer added 9,226 lbs of CO_2, or 4.6 tons.

Aluminum takes a lot of electricity to extract the metal from the raw ore. In 1997, the U.S. Department of Energy[6] estimated that it takes between 5.9 and 6.5

[3] *"The Reconditioning Industry: Anatomy of a Giant, A View of Reconditioning in America Based On A Comprehensive Survey Across the Industry,"* William Hauser, Robert T. Lund, Department of Manufacturing Engineering, Boston University, June 2003

[4] *"Global Electricity Transformers Market is Expected to Exceed $36.7 Billion by 2015,"* http://www.electronics.ca/presscenter/articles/981/1/Global-Electricity-Transformers-Market-is-Expected-to-Exceed-367-Billion-by-2015/Page1.html

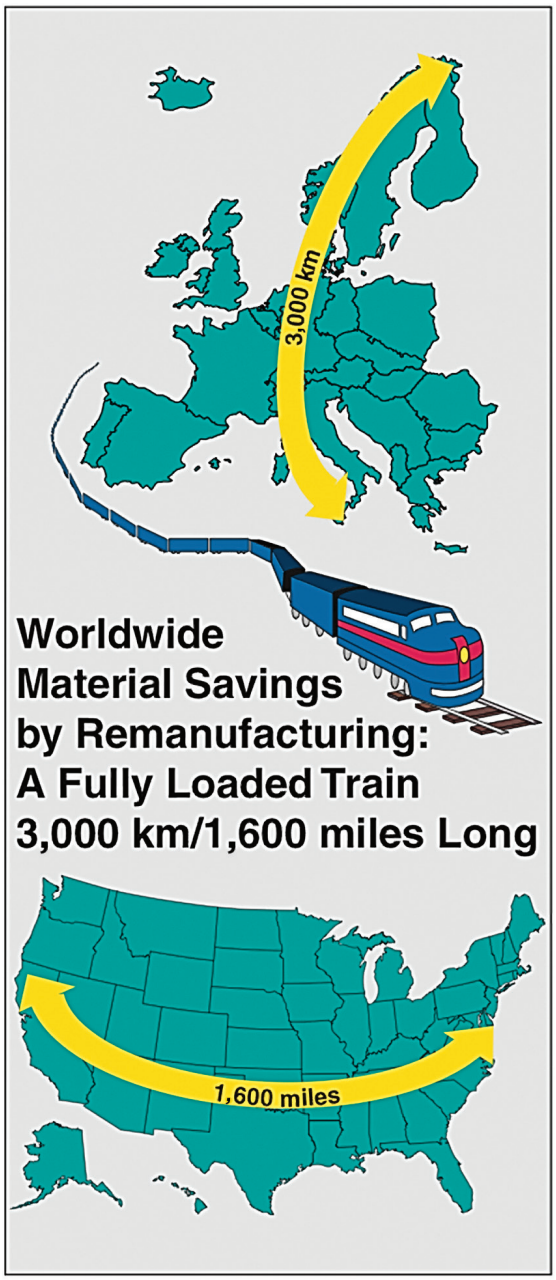
[5] Carbon Dioxide Information Analysis Center, Frequently Asked Global Change Questions http://cdiac.ornl.gov/pns/faq.html

[6] *"Energy and Environmental Profile of the U.S. Aluminum Industry,"* July 1997, http://www1.eere.energy.gov/industry/aluminum/pdfs/aluminum.pdf

kWh to produce one pound of aluminum. That means the 3,800 lbs of aluminum in the 3,000 kVA transformer required an average of 25,560 kWh to extract from the mined ore. Just the electricity to extract the metal from rock cost the aluminum smelter an average of $1,507.84[7], which of course must be passed along to the consumer, but what about costs to the environment?

As stated, generating 1 kWh of electricity on average produces 2.3 lbs[8] of CO_2. (This amount will change depending on whether the electricity was supplied by a coal-fired plant, which produces more CO_2, or nuclear plants, which are clean alternative as far as greenhouse gases are concerned.) Based on 2.3 lbs of CO_2 per kWh, extracting the aluminum for the transformer added 58,788 lbs, or 29.4 tons of CO_2 to the atmosphere. Unfortunately, aluminum processing is a dirty process, and the extraction produces roughly the same amount of CO_2 as it took to generate the electricity to run the smelter. This means to create the aluminum for the transformer added about 58.8 tons of CO_2 to the environment. That's before the aluminum was shipped to the OEM manufacturer and manufactured into wire for windings. Unfortunately, this is as far as we can take this part of the analysis because manufacturers don't share how much energy it takes to stamp metal into cores, or wind cores into transformers.

Materials saved by worldwide remanufacturing amount to 14,000,000 tons a year. This quantity of raw materials is equal to a railway train with 230,000 full cars, occupying a track of 1,650 miles in length. Illustration courtesy of Fraunhofer IRB.



Together the raw steel and aluminum used in the 3000 kVA transformer consumed just under 30,000 kWh, and produced 63.4 tons of CO_2.

A Lot of Hot Air

So is 63 tons of CO_2 a lot or a little? To put these pollutants in context, the average car in the U.S. produces 6 tons of CO_2 per year, which means that producing the metals for the transformer added the same amount of pollution to the environment as 10.6 cars driven for 1 year. If melting and forming the raw metals into a transformer only required half the energy as smelting the aluminum, then the environmental cost of the new transformer is approximately 95 tons of CO_2, or the equivalent of 16 cars driven for one year.

The numbers improve when using recycled aluminum. If the transformer manufacturer used 100% recycled aluminum, they would only use 5% of the electricity, or 1,278 kWh, adding 2,939 lbs of CO_2 (1.5 Tons) to recycle the raw aluminum. The electricity consumed and pollutants generated from turning the aluminum into transformers stays the same; however, even if a manufacturer could use 100% recycled materials, which is unlikely. The recycled aluminum would have to come from aluminum cans since few recyclers have the ability or are willing to take apart large, complex apparatus like electrical transformers to extract aluminum coils and steel parts.

Now consider the costs to the customer and the environment from reconditioning the same transformer. To inspect, clean, test, verify and perform all other reconditioning steps spelled out in industry standards, such as those available from the Professional Electrical

[7] U.S. Energy Information Administration, Official Energy Statistics from the U.S. Government, http://www.eia.doe.gov/cneaf/elec tricity/epm/table5_6_a.html

[8] Carbon Dioxide Information Analysis Center, Frequently Asked Global Change Questions http://cdiac.ornl.gov/pns/

Apparatus Reconditioning League (PEARL)[9], two technicians would spend about 56 man-hours to return the transformer to pristine condition at a labor cost of $3,000. A minimal amount of electricity would be used in the bake oven to dry the transformer out, and to power the test equipment to make sure the transformer is safely operating to the original specification. The reconditioner would also use a gallon of solvents to clean the parts, and some insulating material to refurbish the housing.

Reuse critics could say that new designs offer energy savings over older designs. For instance, new TP1 transformers use less energy during low peak periods than older designs. However, new energy efficient transformer designs are entering their second decade of use, which means there are now more 'used' transformers that could be returned to service through reconditioning than 'new' transformers in the market place — and the gap grows each year. Finally, lead times for a 3,000 kVA transformer range from 16 to 20 weeks, while a reconditioned transformer can be ready in a week or less. If a company is losing $10,000 a day because of a down transformer, a safe and reliable reconditioned replacement is the only answer to a desperate customer. As more and more OEMs adopt lean operations with minimal inventories, long lead times become more common across wider range of products.

When you consider other industrial and commercial electrical apparatus that are designed for repair and maintenance — such as disconnects, fuses, relays, circuit breakers, panels, etc. — recycling is not an option because there isn't enough recyclable material to make the effort cost effective. This is why a single OEM last year crushed more than a million pounds of new, perfectly good equipment and buried it in a landfill last year. Now, how is that good for the environment?

Customers could always 'buy new' when something breaks, but the costs can be significantly greater than replacing a single part. That's what Allied Signal, operator of NASA's Fort Irwin, CA radio telescope facility faced when they needed to replace a 2000A, 4160V Federal Pacific air circuit breaker that was no longer available from the manufacturer. "We couldn't find a replacement breaker anywhere," said Larry Wilson, operations engineer at Allied Signal. "Our only option was a total upgrade of our electrical system. This meant installation of a new breaker, switchgear cabinet, new pads, cables, and accessories." The upgrade would cost up to $80,000, but Wilson was able to find a reconditioned breaker for $13,000 while cutting downtime from weeks to days. For most manufacturers, downtime translates to thousands of dollars — or more — in lost revenue every day.

Reuse: Challenges and Potential

As Albert Einstein once said, "We can't solve problems by using the same kind of thinking we used when we created them." Mass-produced products have raised the standard of living for billions of people around the world, but these benefits have brought their own challenges too.

People need energy and raw materials to manufacturer products, but the creation and use of traditional fossil fuels for manufacturing products and extracting raw materials has negatively impacted the environment. At the same time, major new environmental initiatives aimed at reducing the use of fossil fuels threaten job expansion at a time of great economic uncertainty.

A day will come when the world gets most of its energy from renewable energy sources, but it will not be tomorrow, next week, next year, or even within the next several decades.

Remanufacturers typically recoup 85% to 95% of the energy and materials in the products they rebuild. If a product with a normal lifetime of eight years can be given an additional eight-year life, the demand on energy and material resources to maintain the population of that product can be cut by 40% to 45%.

As Professors Lund and Hauser write in their 2003 study, "If a durable product can be made to have a longer useful life, several benefits accrue to society. The value of the labor, materials, energy, and capital equipment that goes into making the product is not prematurely discarded. The drain on human, natural, and technological resources is thereby reduced. The costs of solid waste disposal are reduced. Living standards can be higher for the same amount of resource use ... Remanufacturers typically recoup 85% to 95% of

[9] Professional Electrical Apparatus Recyclers League, http://www.pearl1.org/PEARL_reconditioning_standards.htm

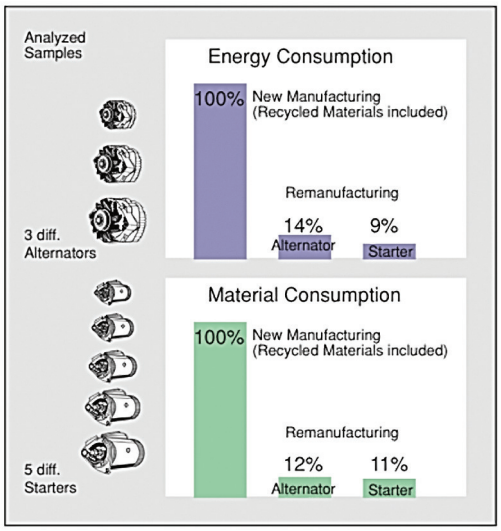
the energy and materials in the products they rebuild. If a product with a normal lifetime of eight years can be given an additional eight-year life, the demand on energy and material resources to maintain the population of that product can be cut by 40% to 45%. The doubling of the lifetime of any durable product is likely to accomplish savings of this magnitude."

Certainly not all products are good candidates for reconditioning. The product needs to be durable and tested to guarantee safe operation that meets or exceeds original performance specifications. Industrial products are excellent candidates because, as Lund and Hauser point out, "…buying reconditioned goods is best accomplished by a buyer with some expertise." Automotive mechanics regularly specify reconditioned alternators, tires, engine parts, etc., because they are experts in automotive repair and understand the benefits and risks. Are electricians any less expert in their own field?

Risks and liability concerns are major challenges for remanufactured products. Who has the liability, the manufacturer, the distributor, the remanufacturer? Fortunately, many industries are developing technical standards to assist remanufacturing, including groups like PEARL and EASA in the electrical industry. These groups require certified remanufacturers to have adequate training, test equipment, documentation, and follow established best-practices. A consumer can feel confident buying from these certified suppliers of remanufactured equipment just as they can feel confident in the remanufactured alternator on the shelf of your neighborhood NAPA store.

Unfortunately, the one group likely to lose the most from encouraging remanufacturing is also one of the most influential — the original equipment manufacturers (OEM) themselves. Some OEMs use patent and copyright laws to impede remanufacturing efforts, even though they often offer remanufacturing services themselves.

In some cases, the government actually discourages reuse as part of regulations designed to increase the use of recycled materials. For example, The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC) and adopted by the U.S. government, encourages the use of recycled materials and energy efficient systems in new building construction, and offers with tax incentives for compliant projects. Since its inception in 1998, LEED has grown to encompass more than 14,000 projects in the United States and 30 countries covering 1.062 billion square feet (99 km²) of development area. Unfortunately, under MR Credit 4: Recycled Content, LEED specifically excludes the reuse of "mechanical, electrical, and plumbing components" and suggests that LEED credits only include "materials permanently installed in the project." However, recycled furniture — not generally considered a permanent fixture — is accretive to the LEED tax credit.



Regarding energy and material consumption, remanufacturing is far ahead of manufacturing.

Technology advances in energy production and distribution hold the potential to drastically improve the world, but we should never fail to act today because of the promise of a better tomorrow. As Lund and Hauser write, "Lack of public sensitivity to the economic and ecological contributions of the industry makes it difficult to garner legal or regulatory support to counter these threats."

Hopefully, with more education and outreach by key industry trade groups, companies and governments will learn of the easy benefits of reuse, and that 'new' doesn't automatically mean 'energy efficient.'

PROFESSIONAL ELECTRICAL APPARATUS RECONDITIONING LEAGUE
4255 South Buckley Road, #118, Aurora, CO 80013

Tel: 877-AT-PEARL (877-287-3275) | Fax: 888-996-3296
Email: pearl@pearl1.org

www.pearl1.org