

Power Currents

Monthly Coverage of the Energy Technology Industry

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Turning Darkness Into Dollars

The August 2003 blackout may have been bad news for 50 million people in the Northeastern US and Canada, but it sure was good for energy tech. Stocks were up anywhere from 10% to 360%.

In answering the question of who might turn the recent darkness into real dollars, the experience of California may be useful. In 2000-01, the Golden State was hit by a series of rolling blackouts. There was heavy buying in fuel cell stocks, on the premise that the power failures would spur the purchase of fuel cells.

Unfortunately, there were no fuel cells to buy, or at least not on commercial terms. The big

beneficiaries were companies with trusted names like CAT and Cummins that sold dull but wonderfully predictable diesel-fueled gensets. Demand was particularly strong for systems sized at 1 MW and up. At the same time, the combination of the rolling blackouts plus generous state subsidies created a brisk market for solar power systems.

The California power crisis was to a large extent the result of aging and inadequate transmission (sound familiar?). Efforts to upgrade the wires network have edged forward slowly, but should ultimately deliver revenue to transmission equipment suppliers.

In short, the private sector response was quick—buy generators—while the public sector response has been slow—expand transmission. (To be fair, the state moved quickly on other fronts by entering into a series of long-term power purchase deals)

The broad pattern in the Northeast appears to be similar. Onsite power systems providers we contacted generally reported a surge in customer inquiries, at least some of which should convert to sales. Meanwhile, for all the loud public harrumphing about transmission investment, results will likely arrive slowly—but arrive they will.

Publication Information

Power Currents is written, edited and published by James LoGerfo of Vortex Energy. Please address questions and comments to:

jlogerfo@vortexenergy.com

Please see p. 54 for important disclosures and notices.

In This Month's Issue

Perhaps foreshadowing the August blackout, news flow from May to July prominently featured the topic of transmission. Technological advances, funding awards, favorable regulatory rulings, strategic partnerships, private investment and public securities offerings are covered throughout this issue.

Our electricity infrastructure, from the central power plant

to the wall socket, is based on alternating current (AC). Prone to instability and in some ways difficult to control, AC power has important limitations.

This issue's *Inductance & Reactance*, starting on p. 45, introduces the first installment of what will be a series on direct current (DC). A viable alternative to alternating current in a growing range of applica-

tions, DC power offers greater stability and control, as well as its own limitations..

Lastly, in *DataWerks* we continue to document the attempts at recovery in the technology industry. While shipment and order activity shows communications equipment continuing to lag, computing and semiconductor sales appear to be settling into a period of modest growth.

GridWatch

Energy and Power Industry Announcements and Developments

Overview. Notable industry developments in May and June focused on the transmission and distribution network. Two of the largest and most progressive utility grid management organizations approved significant T&D asset investment and upgrade programs; a for-profit transmission network company announced a substantial increase in its proposed expansion plans; and two companies developing next-generation T&D power cable technologies announced advancements in their efforts to bring their solutions to commercialization.

News flow in July primarily involved renewable energy and emissions-related policy initiatives. And of course, headlines in August have been dominated by one of the biggest blackouts in the history of the world (*more on that in our next issue*).

July 12. Scientists at Hiroshima University have developed a new substance capable of storing three times more hydrogen than an existing alloy. The research team states that since the new substance is able to hold greater quantities of hydrogen than conventional substances, hydrogen can be stored more efficiently and lighter tanks can be used for fuel cells. In addition, the substance can store hydrogen at lower temperatures, making fuel-cell vehicles and other fuel-cell based devices safer. To make the new substance, the group ground two types of lithium powders into tiny particles inside a pressurized container holding hydrogen along with a metal catalyst. The substance was found to be quick to react and easy to control so it could improve the safety of hydrogen storage devices, and was able to discharge hydrogen at temperatures between 150-200 degrees Celsius if atmospheric pressure was lowered.

July 2. The **European Parliament** approved a proposal to launch the world's first international emissions trading market by capping European industry's carbon dioxide output and allowing companies to trade the right to pollute.

Beginning January 2005 many plants in the oil refining, smelting, steel, cement, ceramics, glass and paper sectors will need special permits to emit carbon dioxide (CO₂). The establishment of an emissions trading scheme is part of the EU's efforts to meet its commitment under the Kyoto Protocol to reduce the emissions many scientists say are causing global warming.

July 2. The Ontario government is introducing a **Green Power Standard** that would require its electricity system to secure an additional one per cent of its current electricity needs from renewable sources per year for eight years, starting in 2006. According to Ontario officials, the program will add a total of about 3,000MW of renewable energy to the regional system. The Ontario Green Power Standard will be among the biggest commitments to renewable power by any jurisdiction in North America. The Ontario government has also committed to purchasing 20 per cent of the electricity used in government buildings from renewable sources.

GridWatch (cont'd)

Energy and Power Industry Announcements and Developments

A Tale of Two Federal Governments — US and German

July 25. Congress has begun to consider a stricter approval process for wind farm projects. The legislation, a brainchild of Sen. Edward Kennedy and crafted with Sen. Lamar Alexander of Tennessee, would require local or state governments to approve wind power projects. Lawmakers are also considering a role for the FERC in assessing how a project fits into a region's energy needs.

One effect of Kennedy's initiative is the creation of a potential obstacle to the \$700 million **Cape Wind** plant planned for Nantucket Sound, off Massachusetts' Cape Cod. Congressional sources insist the bill is not an attempt to derail any specific proposal.

July 1. Congressional resistance is mounting to Bush's "**Clear Skies**" initiative, which aims to reduce mercury, nitrogen oxide and sulfur dioxide pollution at coal-fired power plants by setting caps on allowable emissions, while allowing companies to buy and sell rights to pollute within those limits.

Sen. Tom Carper, D-Del., has forwarded a plan that also addresses carbon dioxide, a greenhouse gas. Using the same modeling used for "Clear Skies," the EPA found that Carper's bill could cut pollution much more than Bush's bill for only nominal extra cost. Carper calls for about \$2 in additional compliance costs to deliver an incremental \$47 in benefits. His bill would also result in 17,800 fewer premature deaths from power plant pollution than would "Clear Skies," yielding \$140 billion in health benefits a year, or \$50 billion more than "Clear Skies."

July 10. Germany's Environment Minister, Jürgen Trittin, announced that the already generous net metering tariff payable under **Renewable Energy Law** would be increased in 2004 to reflect the termination of low-cost loans under the **100,000 Roofs** program. Other loan financing for solar systems purchase will be made available, but at a slightly higher interest rate. Over the last several years, Germany's 100,000 Roofs program has been a major driver of growth for the solar power industry. The increase in the tariff paid to solar system owners for power sold back into the grid means that the purchase of new systems will remain attractive even at a higher interest rate.

Comment. These three news articles illustrate a key difference between the federal governments in the US and Germany — renewable energy and clean technologies struggle for support in the US but receive generous subsidies in Germany and elsewhere. Siting wind power projects in the US has not generally been an issue; the **Cape Wind** project that is planned for a location off the shores of Cape Cod is the first high-profile battle. Every few years, the US wind power industry has faced the possibility that the federal Production Tax Credit (PTC), crucial to the economics of wind projects at numerous sites, would not get renewed. The on-again, off-again nature of the PTC and other federal supports for wind have created significant uncertainties surrounding the viability of particular wind power projects, and restrained the

GridWatch (cont'd)

Energy and Power Industry Announcements and Developments

growth of a promising renewable energy technology. The Senator from Massachusetts, home of the proposed Cape Wind project, could end up adding layers of regulatory complexity at every level of government to the wind power project approval process.

As for the Clear Skies “cap and trade” policy, the level of permissible emissions and the rate at which emissions caps are lowered under Bush’s plan are far more forgiving on pollution producers than the existing regulatory framework. The EPA’s own analysis suggests that Carper’s proposal would entail an extra \$2 of implementation and compliance costs but yield an additional \$47 in benefits and reduce pollution-related deaths by close to 20,000 per year. Interestingly, the EPA had analyzed Carper’s bill last November and reached these favorable conclusions, but did not release the results to Carper until this July when he insisted on an EPA assessment of his proposal. The more stringent emissions standards sought by Sen. Carper would be good news for providers of clean combustion and pollution control technologies.

Leaving the land of stop-and-go support for renewables and the easy-going approach to pollution to arrive in Europe, we find a much more welcoming environment for things environmental. Germany’s 100,000 Roofs program has been a resounding success, adding close to 300MW of solar power capacity at a total cost below the allocated budget. The program has two components — low-interest loans for solar power systems purchase, and an extremely attractive tariff rate for extra electricity from the solar system sold back into the utility grid. Basically, a residential solar power system owner gets paid roughly twice as much for solar fed into the grid than he or she draws.

The 100,000 Roofs program is but one of a number of federal-level supports for renewable energy in Europe. Additionally, many European nations are signatories to the Kyoto Accord, and more importantly, are taking action to implement its mandates. All of this stands in marked contrast to the US, which did not sign the Kyoto Accord, imposes relatively loose controls on power plant pollution and offers only limited support for renewable energy. The US vanguard for renewable energy (as well as vehicular emissions controls) is at the state, not the federal level (*see p. 10 for examples*).

GridWatch (cont'd)

Energy and Power Industry Announcements and Developments

Putting Money on the Line(s)

T&D Investment Flows Poised to Increase

June 23. The Board of Directors of the **Midwest Independent Transmission System Operator** endorsed the region's first comprehensive transmission expansion plan, which includes \$1.32 billion in utility grid improvements to help ensure system reliability and support capacity expansion. Part of this transmission grid investment will open up opportunities to generate power with the region's abundant coal and wind resources, yielding an estimated savings in wholesale power costs of \$300 million to \$1.6 billion per year.

June 10. The Board of Managers of **PJM Interconnection** approved \$147.6 million in additional improvements to the regional electric transmission system. The investment will allow more generation projects to connect to the electric grid. In an important industry first, the transmission improvements will also allow a number of merchant transmission projects to connect to the PJM electric grid. The PJM region includes seven states and the District of Columbia.

Comment. These two articles point to a critically important development — increasing investment in the transmission and distribution (T&D) network, not just in support of traditional utility infrastructure projects, but also to enable the construction of new kinds of assets, including:

- generation capacity that exploits unconventional energy sources like wind, and
- merchant transmission power lines.

T&D investment in general has been woefully inadequate for at least a decade now, and the process of liberalizing the regulatory framework regarding operating and owning transmission assets has been halting at best. Regulatory changes in the last couple years have made ownership of transmission lines both possible and attractive. However, the overseers of the utility grid still must find the will and the way to finance and install the hardware necessary to enable new transmission projects to connect to the existing infrastructure. From the standpoint of the energy technology industry, the approval of T&D investment of any kind is a plus; the approval of projects that open up new energy resources and reduce wholesale power costs is even better because the benefits of T&D investment become demonstrable and quantifiable; and the approval of investment in equipment to support merchant power lines is especially positive because merchant developers will likely move forward with new transmission lines more quickly than regulated utilities. Case in point is the recent announcement by the for-profit **American Transmission Co.** of a planned network upgrade that could cost up to \$1.5 billion (*see p. 9*).

GridWatch (cont'd)

Energy and Power Industry Announcements and Developments

Getting Wired — Next-Generation Conductor Technology

A Step Forward

June 17. **Composite Technology Corporation** (CTC) has signed a letter agreement with **Aquila** for testing of its proprietary aluminum conductor composite core (ACCC) cable on a segment of Aquila's transmission system. CTC will provide ACCC cable and hardware; Aquila will install CTC's products on a designated portion of its transmission system and will operate and monitor the line. Aquila, based in Kansas City, Missouri, operates electricity and natural gas distribution networks serving 1.3 million customers in seven states.

A Step-Function Forward

May 28. **American Superconductor Corp.** (AMSC) announced its first delivery of second generation (2G), high-temperature superconductor (HTS) wire. The 2G wire was shipped to **Ultera**, a joint venture between two of the world's leading wire and cable companies, **Southwire Company** and **nkt cables**, which will work with **Oak Ridge National Laboratory (ORNL)** to fabricate and test a multi-wire HTS power cable conductor. AMSC is designing its 2G wire as a form-fit-function replacement for its first generation wire. The Oak Ridge-Ultera 2G HTS cable conductor is expected to be the first in the world to achieve a commercial performance level (i.e., AC carrying capacity greater than 2,000 amps).

Comment. As much as the transmission and distribution network has suffered from over a decade of underinvestment, bringing capacity up to the levels needed to support current demand and future growth is not simply a matter of a couple of years of extra spending. One of the principal obstacles to expanding transmission capacity is the Not In My Backyard phenomenon. Siting a new transmission line, obtaining the necessary rights of way and winning regulatory and community approval can take years, and the reward for those years of effort is simply that construction can finally begin. Actually constructing the line will take yet more time. The entire process can take 5-10 years from start to finish. Here is where next-generation conductors come in.

The communications industry was transformed by the widespread deployment of fiber-optic cable, invented in 1967 and first installed for a nationwide telecom network by MCI in 1982. The massive increase in communications transmission bandwidth was made possible by the discovery of a new conductor with carrying capacity many times that of copper. As it turns out, a similar process is underway in the world of electric power. The news items about **Composite Technology Corp.** (CTC) and **American Superconductor** (AMSC) above illustrate two approaches to next-generation conductor development.

GridWatch (cont'd)

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CTC's aluminum conductor composite core (ACCC) cable represents a significant incremental improvement over traditional copper or aluminum cable systems. The company's ACCC cable is a form-fit-function replacement of the steel core usually found in the center of an overhead wire with a composite material that is stronger and lighter and has better thermal characteristics. Benefits claimed for ACCC include less line sag, reduced magnetic fields and lower line losses. As a result, power throughput is reported to be 50%-100% higher than standard cables. The target application is primarily overhead transmission lines rather than underground distribution cables.

Meanwhile, American Superconductor is a leader among the dozen or so companies developing high-temperature (HTS) superconducting materials for use in power transmission. High-temperature superconductors carry electricity with basically no losses. "High temperature" here is relative — HTS materials superconduct at a balmy 273F below zero, as compared to low-temperature superconducting materials, which must be chilled to about 450F below zero before they lose their electrical resistance. A single strand of first-generation HTS wire can conduct as many amps of current as a copper wire bundle 140 times its size (based on cross-sectional area), and second-generation HTS wire promises even greater performance gains.

A crucial benefit of these and other next-generation conductors is greater electricity throughput along existing rights of way. By replacing traditional copper and aluminum cables with cable made with composite materials or superconductors, transmission capacity can be expanded, and utility grid stability can be enhanced; meanwhile, by using existing rights of way, regulatory approval is easier to secure and years can be shaved off the time to complete the project. (*see page 12 for news from **Intermagnetics General** about an HTS cable project in Albany, New York*)

In terms of the choice between various next-gen conductor technologies, tradeoffs between cost, conductivity and installation complexity are among the factors that will determine which should be deployed in any particular project. As an example, while high-temperature superconductors are probably best suited for shorter-distance underground distribution cables, aluminum conductor composite core cables appear to be most appropriate for long-haul transmission. The pressing need for capacity upgrades at every point of the network suggest that there should be substantial business opportunities for developers of a range of advanced conductor technologies.

June 16. **European Union (EU)** research commissioner Philippe Busquin and U.S. Department of Energy (DOE) secretary Spencer Abraham signed an agreement to strengthen public and private sector efforts in Europe and the U.S. to develop fuel cell technology. The agreement calls for joint fuel cell initiatives in seven areas, including the demonstration of fuel cell vehicles (FCVs) and fueling infrastructure; the use of fuel cells as auxiliary power units; and the harmonization of relevant codes and standards.

GridWatch (cont'd)

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Hydrogen Hullabaloo Gets Hot

June 13. The debate about the costs and benefits of a hydrogen-based economy took an unexpected twist with the release of a study suggesting that widespread hydrogen use could wreak havoc on the atmosphere and damage the ozone layer.

POINT. A study published in the June 13 issue of *Science* by the **California Institute of Technology** found that leakage from a future hydrogen infrastructure could have serious and previously unanticipated consequences. If 10 to 20 percent of the hydrogen stored and shipped leaks along the way, the effects could include stratospheric cooling, changes in atmospheric chemistry and accelerated destruction of the ozone layer. The Caltech group was careful to note that hydrogen's behavior in the atmosphere is not well understood, and the predicted ozone effects could be a worst-case scenario.

COUNTERPOINT. The Schatz Energy Research Center at Humboldt State University quickly questioned these findings, claiming that the actual losses of hydrogen from storage and pipelines is expected to be much lower than the 10 to 20 percent assumed by the Caltech group. The research center also noted that any hydrogen that is intentionally vented could easily be destroyed by catalytic oxidation to prevent its release to the atmosphere.

June 11. The United Kingdom's **Department of Trade and Industry** (DTI) has announced £2 million (US\$3.3 million) in funding for 21 new solar renewable energy projects, including a solar powered gas station and what will be the country's largest planned solar power installation. The funding is part of the DTI's £20 million (US\$33 million) Photovoltaic Major Demonstration Program. The 21 projects, the fourth set to be approved since the program was launched in 2002, are expected to add nearly 600kw of installed solar capacity.

June 9. **Westport Innovations** of Vancouver, BC announced that it has developed a transit bus engine fueled by a blend of hydrogen and natural gas that will be delivered to **SunLine Transit Agency** of Thousand Palms, CA. This initiative enables commercial fleets to begin making the transition to the use of hydrogen in internal combustion engines. Tests carried out on a Cummins Westport engine running on a blend of 20% hydrogen and 80% natural gas demonstrated dramatic reduction in oxides of nitrogen (NOx) of over 60% compared to the newest diesel engines, and over 80% cleaner than the average transit bus on the road today in North America. The engine's torque and fuel efficiency were unaffected.

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Comment. Fuel cells are not the only device that can convert hydrogen into useful work. As this and other demonstrations are showing, traditional internal combustion engines, with a little modification, are capable of using hydrogen as a fuel. This is a key point. Fuel cells are a long ways off from commercial viability. In relative terms, hydrogen-powered internal combustion engines are much more economic. One of the obstacles to creating a hydrogen infrastructure is lack of broad-based hydrogen demand. At the risk of oversimplifying, nobody will build out a massive hydrogen fueling network because there is no mass hydrogen market, and there is no mass hydrogen market because there is no ready supply of hydrogen fuel.

The cost and technology issues fuel cells still face mean that they are unlikely to be a major source of hydrogen demand for some years to come. To the extent that internal combustion engines begin to run on pure or blended hydrogen fuel, they can create early demand for H₂ and hasten the rise of the hydrogen economy.

June 2. **Nevada Power Company** and **Invensys** announced that they will conduct a three phase marketing pilot of the Invensys **GoodWatts** energy management system in southern Nevada this summer and through 2004. GoodWatts allows utilities to remotely control air conditioning systems and other appliances over a managed and secure IP network. Additionally, homeowners can view their electricity consumption and control their in-house systems. The pilot, primarily focused in Las Vegas, will occur in three phases over two years and will ultimately include more than 1000 residences. The first phase this summer will include approximately 50 homes in the Las Vegas area.

May 3. **American Transmission Co.** (ATC), an independent transmission asset operator, has significantly upsized its proposed Wisconsin network upgrade, from one new 345kV line to as many as four. The cost of the projects is estimated to range between \$500 million and \$1.5 billion, depending on routes, rights of way and final project selection. According to ATC, many of the pathways carrying power into and across Wisconsin are outdated and stressed; meanwhile, electricity use keeps rising.

GridWatch (cont'd)

Energy and Power Industry Announcements and Developments

Thinking Globally, Acting Locally — States Remain the Vanguard of Renewable Energy Support

July 21. The **State of Hawaii** recently extended its 35 percent income tax credit for solar energy until January 1, 2008. A study carried out by the State of Hawaii found that residential solar water heaters generate \$1.82 in tax revenue for every \$1 that the State invests through tax credits, providing a solid economic rationale for the subsidy.

Hawaii is the nation's per-capita leader in solar water heating with 85,000 systems installed, with each system saving an estimated 4.6 barrels of imported oil.

June 6. The state of New Jersey launched a \$60 million package of initiatives to spur the growth of solar energy. The program will make \$45 million available for long-term loans through the **NJ Economic Development Authority** to support large-scale renewable energy production; \$10 million for low interest loans for renewable energy and energy efficiency projects for businesses; and \$5 million for an innovations fund to enable renewable energy companies to bring their products and technologies to market.

June 3. The **Massachusetts Technology Cooperative (MTC)** has launched a \$30 million project to encourage renewable energy projects within the state. The program will begin with a competition for \$20 million in price supports for renewable power projects, which the MTC hopes will enable the project developers to obtain financing for constructing 200 megawatts of renewable generating capacity.

June 2. A new law in Minnesota requires **Xcel Energy** to double its contribution to a renewable energy fund, install at least 300MW of new wind power capacity, and install renewable energy technologies whenever they are the most cost-effective resource. In turn, Xcel Energy has been awarded additional nuclear waste storage rights. Additionally, the state will provide \$4.5 million to subsidize small wind turbine installations totaling 100MW of capacity, and extend \$1.5 million of subsidies for biogas projects on farms.

Comment. As these news items illustrate, the nexus of action in renewable energy in the US continues to be at the state, not the federal, level. The US House of Representatives and Senate have been fighting over national energy policy for over two years, and resolution remains elusive. Regardless of the compromise that emerges at the national level, the result will not be particularly friendly to renewable energy interests. To the extent that federal policy is supportive of alternative energy of any sort, the focus has been on hydrogen and fuel cells, both very long-term propositions, rather than on technologies such as biomass, geothermal, wind and solar that are either economically viable now or not terribly far from commercialization. It is the states that have been critical to the advancement of the domestic renewable energy industry.

GridWatch (cont'd)

Energy and Power Industry Announcements and Developments

Relative neglect of alternative energy at the federal level has important competitive consequences. The wind and solar power systems industries represent about \$10 billion in annual worldwide sales. The major producers are generally not US companies; they are mostly based in Europe and Japan. The secular growth rate of demand for traditional power generation equipment is roughly 5%. Meanwhile, wind and solar have been growing at 25% - 35% per year for over a decade now. Because the federal government has failed to provide the generous support for renewables proffered in Germany, Japan, Denmark, Spain and elsewhere, the core segments of growth in the power generation equipment industry are dominated by non-US companies. More importantly, the US is not availing itself as fully as these other countries of the numerous benefits of renewable energy, including fewer pollution-related health problems, better fuel diversification and enhanced grid stability.

Energy Techline

Company News Releases

July 30. **Sharp** became the third major foreign solar power inverter producer to enter the US market in recent months. Sharp's JH-3500U Sunvista inverter targets the residential sales market. Sharp already holds the number one position in Japan with 65 percent of the market share. Sharp has designed the Sunvista inverter to match its solar power modules and mounting hardware, which makes Sharp the industry's only manufacturer of complete residential solar energy systems.

Comment. Sharp's introduction of a residential solar power system complete with module, mounting hardware and inverter, could mark a turning point in the US solar market (and eventually elsewhere as well). If Sharp gains share by selling fully integrated packages, simplifying the purchase process and possibly offering a price discount, the result could be a noticeably more competitive market and pressure on other producers of solar power modules and inverters to team up or consolidate. An alternative scenario is that Sharp may not benefit from doing two things if it does neither well; however, given the success the company has enjoyed in its own market and more recently in Europe, the likelihood is greater that the rest of the industry will have to respond to Sharp rather than Sharp rethink its strategy.

July 14. **Intermagnetics General Corp.** announced that the US Department of Energy (DOE) will contribute \$13 million toward the \$26 million cost of a high-temperature superconductor (HTS) power cable demonstration project its subsidiary, **SuperPower**, will lead. The New York State Energy Research and Development Authority has already committed an additional \$6 million to the project. Intermagnetics and its major partner for the project, **Sumitomo Electric Industries**, will equally share the remaining \$7 million project cost. **Southern California Edison** will participate in an advisory capacity.

The 350-meter underground cable will be installed between two substations in the Albany, New York distribution system operated by **Niagara Mohawk**. The cable will be installed underground on the Niagara Mohawk distribution system with a first-of-its-kind splice 30 meters from one end. Successful demonstration of the splice is critical for validating the installation and use of HTS cables in longer lengths in commercial applications. During the latter stages of the project, the 30-meter cable section will be replaced with an identical length using second-generation HTS conductor. The cable is expected to begin operation with first-generation HTS conductor in 2005, which will be replaced by second-generation conductor in 2006.

Energy Techline (cont'd)

Company News Releases

June 26. **Dow Corning** plans to explore opportunities in the photovoltaic industry by developing materials that will contribute to the improvement of raw material supply availability, cost competitiveness, and durability of solar power modules. Dow Corning is building on its expertise in this sector in order to expand its role from being a pure raw material supplier to offering a number of competitive silicon based total solutions. The company is developing material and processing solutions, such as new encapsulation and frame sealing solutions.

June 12. **Comverge** announced that it has signed a long-term Virtual Peaking Capacity contract to provide significant peak load reduction to **PacifiCorp**. Comverge will market, own, and maintain a residential air conditioner load management program, designed to provide peak period relief in PacifiCorp's Utah Power service area and take some of the burden off the region's transmission and distribution grid. Comverge's long-term agreement with PacifiCorp is expected to generate in excess of \$40 million in revenues over the life of the contract.

June 5. The San Francisco Board of Supervisors approved a proposal to test a system developed by **HydroVenturi** that will use the energy from tides that flow through the Golden Gate to potentially power the entire city. HydroVenturi will commit \$4 million for design, construction and operation of the pilot, which could be up and running within three years. Since HydroVenturi's system involves no moving parts underwater and has no blades, it should avoid the marine life kill problems of other tidal power generation technologies. In addition, it will be hidden from view beneath the waves. The HydroVenturi system will operate by funneling the tidal current to create suction, pulling air down pipes, which would activate onshore turbines.

June 3. **First Solar** announced that it has broken ground on a \$20 million expansion of its thin-film solar power module manufacturing facility in Perrysburg, Ohio. The expansion will increase annual plant capacity to 25 megawatts in 2005. First Solar produced 1.5MW of solar modules in 2002, and expects to achieve volume of 3MW in 2003 and 6MW in 2004.

May 9. **Fronius International** announced that it will be introducing its grid-tied solar power inverters in the United States this year. Fronius is a leader in the field of high frequency power electronics and welding technology and one of the largest suppliers of grid-tied solar power inverters in Europe.

Comment. The US solar power market is not large compared to those of Germany or Japan, the global solar market leaders, but the US market is growing rapidly and increasing state government support should ensure that demand remains robust. Fronius joins the ranks of major solar industry players like **Sharp** and **SMA** that have recently established or expanded their US presence to secure a position in an increasingly important market.

Hybrid-Electric Vehicles in the Fast Lane; Fuel Cell Vehicles on the Scenic Route

May 20. **The FedEx Corp.** announced that it planned to replace 30,000 of its delivery trucks with hybrid-electric vehicles. It has already purchased 20 such trucks to begin building what will become one of the first big commercial fleets of hybrid vehicles. The new trucks—powered by both diesel engines and electric motors in a mix controlled by onboard computers—will be introduced over the next several months in four American cities. **Eaton Corp.** will provide the hybrid electric technology.

FedEx plans to use the HEVs to replace its medium-size delivery trucks. While the new trucks will be more expensive to purchase, their fuel efficiency will be about 50% higher, and they will be less costly to maintain. They will reduce particle emissions by 90% and smog-causing nitrogen dioxide by 75%. FedEx hopes to break even over the 10-12 years that the trucks are expected to last. Also, the shift to hybrids should reduce the company's sensitivity to fuel prices.

May 19. **Toyota** said it would recall all six of its hydrogen-powered vehicles after it found a leak in the fuel tank of one of the cars. Toyota had begun leasing the million-dollar-plus cars to four Japanese government ministries and two California university campuses last December. The leak reportedly occurred while the high-pressure hydrogen tank was being refilled. The tank was manufactured by a foreign parts maker.

The recall underscores the difficulty in building marketable and fault-free FCVs, especially as it comes from a company reputed to be at the forefront of the technology. Only a handful of automakers worldwide have managed to build hydrogen-powered FCVs, and most are still at the testing stage. Toyota said it would recall the six fuel cell cars, as well as postpone the lease of six more to two local governments and four private companies. Toyota had intended to lease a total of about 20 FCVs in Japan and the United States by the end of the year.

May 20. Later this year, **United Parcel Service** drivers in Ypsilanti, Mich., will begin delivering express letters in a Mercedes-Benz compact powered by a hydrogen fuel cell. The test is a joint effort by **DaimlerChrysler**, **UPS** and the **U.S. Environmental Protection Agency**. UPS plans to add a fuel-cell powered Dodge Sprinter van to its delivery fleet in 2004 after a hydrogen refueling station is built at the government's National Vehicle and Fuel Emissions Laboratory in Ann Arbor. The Sprinter will become the first medium-duty fuel cell vehicle in commercial service in the United States. The fuel-cell program will allow Chrysler engineers to evaluate how fuel cells perform in Michigan's cold weather and give the EPA and UPS operational experience with a hydrogen refueling station.

Comment. These three articles highlight one key difference between hybrid-electric vehicles (HEVs) and fuel cell vehicles (FCVs): HEVs are a proven and economically viable technology, while FCVs are still experimental and face significant technical challenges. On the one hand, FedEx is buying 30,000 HEVs that can be refueled anywhere diesel is available and are expected to have the same life-cycle cost of ownership of its standard delivery trucks. On the other hand, UPS will operate exactly one medium-duty fuel cell vehicle, which will require a specially-constructed hydrogen refueling station and whose cost of ownership is probably over 100 times higher than that of an HEV or a traditional truck.

Energy Techline (cont'd)

Company News Releases

The other key difference between HEVs and FCVs, at least today, is that HEVs significantly reduce particulate and greenhouse gas emissions versus standard cars and trucks, while FCVs are actually net greenhouse gas contributors. Depending on configuration, an HEV offers fuel efficiency improvements of 50% or more and 90%+ reductions in a variety of pollutants compared to the equivalent standard vehicle. Meanwhile, typical media coverage of FCVs trumpets the fact that they use only air and hydrogen and produce only electricity and water, but neglect to discuss the source and method of hydrogen production.

More than 80% of global hydrogen production occurs by way of reforming (refining) natural gas, a process that creates substantial amounts of CO₂, a greenhouse gas. While natural gas (CH₄) is an excellent source of hydrogen (greenhouse gas effects aside), one alternative is water (H₂O). In this case, electricity is run through water to split off the hydrogen atoms from the oxygen. Electricity and water go in, hydrogen and oxygen come out—a fuel cell in reverse. Sounds clean, until you consider how the electricity is generated.

Unless it comes from a hydroelectric dam (whose construction entailed significant ecological destruction) or a nuclear power plant (with the associated problems of safety and radioactive materials disposal), then the source of the electricity is a massive turbine driven by the combustion of coal, oil or natural gas. And fossil fuel combustion means the emission of greenhouse gases and other harmful pollutants. As a result, the fuel cell vehicle that produces nothing but “electricity and water” can end up creating more ozone-eroding CO₂ than the “dirty” car or truck it is intended to replace.

We believe the day will come when hydrogen is truly a clean fuel, and FCVs are an improvement over automobiles using an internal combustion engine. Massive amounts of inexpensive renewable energy are necessary to make the possible the real. Since we suspect that the clean hydrogen future is still decades away, in the meantime, we remain big supporters of HEVs. They're here, they work, they are economically viable, and they boast high fuel efficiency and low emissions.

May 5. **Black & Veatch** announced the formation of its global **Renewable Energy Group**, which provides comprehensive project services for wind, solar, biomass, hydroelectric, geothermal and ocean energy projects. Black & Veatch has been involved in renewable energy projects since designing a hydroelectric project in 1915. The Renewable Energy Group will target both domestic and international markets with a portfolio of services that includes strategic analyses, feasibility studies, design-build, owner's engineering and independent engineering.

Comment. This news is a real positive for the renewable energy industry for two reasons. First, Black & Veatch will bring nearly a century of project design and management experience to bear on renewable energy projects around the world. Its presence should help raise the level

Energy Techline (cont'd)

Company News Releases

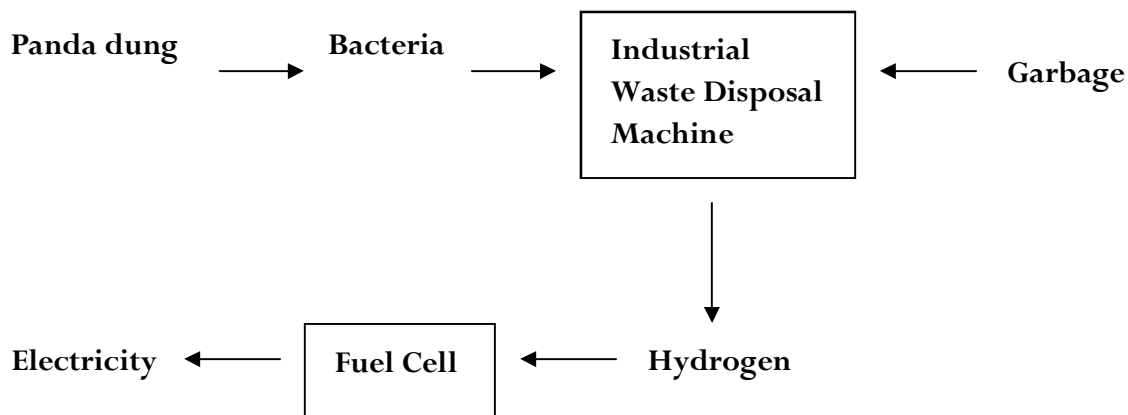
of professionalism and expertise in what has been an underserved area of the overall energy industry. And second, this news is an indication renewable energy is reaching enough mass and maturity to attract serious players.

“You’ll Never Look at Pandas the Same Way Again...”

May 1. Fumiaki Taguchi, emeritus professor of Kitasato University in Tokyo, Japan, and director of **H2Japan**, announced that he has developed an invention that uses panda dung to create hydrogen, which is then used to generate electricity. Professor Taguchi’s team identified 270 micro-organisms in panda refuse that are produced in the animal’s digestive system to help break down the tough bamboo leaves and shoots that are its dietary staples. Of that total, five micro-organisms were selected for their efficiency in breaking down organic matter and their ability to reproduce easily, even under high temperatures.

The research team mixed the panda’s bacteria with 70kg to 100kg (150lbs to 220lbs) of raw garbage, such as vegetable stems, for 17 weeks in an industrial waste disposal machine. The result was that only 3kg of waste remained, with the rest becoming water and carbon dioxide, from which hydrogen could be extracted. The 95%+ efficiency claimed for the panda-based process is substantially higher than the 80% efficiency of most commercial disposal bacteria. For every 1kg of waste, Taguchi’s system can extract about 100ltrs (26gal) of hydrogen. H2Japan hopes to create an integrated hydrogen fuel cell and waste disposal unit to sell to food processing companies across Japan.

In scientific terms, the H2Japan process looks something like this:



TapeTalk

Energy Tech Company Share Price and Earnings Performance

Overall energy tech stock returns for the last three months have been solid (+19%), tracking ahead of both the Nasdaq and S&P 500 indexes. While trading in July was generally unimpressive, returns for certain stocks in the first half of August were nothing short of spectacular. The reason is simple — the blackout. FuelCell Energy, Intermagnetics and Plug Power were up 17-18%, Capstone Turbine gained 47%, and American Superconductor soared 64%. Meanwhile, shares of AstroPower have been delisted.

Company	Price 15-Aug-03	Mkt Cap (\$MM)	Share Price % Change				Price/Earnings		Price/ Book	Price/ Cash	Price/ LTM Sales
			2003 YTD	August	July	Last Yr.	FY 03	FY 04			
Distributed Generation											
Ballard Power	12.85	1,363	16.1%	-1.2%	-4.6%	-62.6%	n/a	n/a	1.9	3.6	11.4
Capstone Turbine	1.74	97	93.3%	47.5%	5.4%	-83.4%	n/a	n/a	0.9	0.8	6.8
Energy Conversion Devices	10.39	219	6.0%	3.6%	6.7%	-48.3%	n/a	n/a	1.9	1.7	3.3
Evergreen Solar	1.55	16	20.2%	9.9%	5.2%	-62.1%	n/a	n/a	0.7	2.9	1.8
FuelCell Energy	9.40	277	43.5%	16.9%	-1.8%	-63.9%	n/a	n/a	1.6	1.5	6.2
Hydrogenics	4.62	245	30.9%	11.9%	-7.4%	-52.7%	n/a	n/a	2.6	4.4	9.6
Millennium Cell	1.80	49	-24.7%	-1.1%	0.0%	-54.2%	n/a	n/a	8.2	10.1	81.0
Plug Power	5.16	252	14.9%	17.0%	-5.6%	-48.6%	n/a	n/a	2.1	2.9	20.3
Proton Energy Systems	2.49	63	-17.0%	15.3%	-8.9%	-63.6%	n/a	n/a	0.5	0.4	20.4
Average			20.4%	13.3%	-1.2%	-59.9%			2.3	3.2	17.9
Clean Fuel & Combustion Technology											
Catalytica Energy Systems	3.15	53	14.1%	5.0%	11.1%	-39.6%	n/a	n/a	0.9	0.9	11.8
Fuel Tech N.V.	5.10	103	21.7%	-13.7%	5.5%	-30.7%	40.4	17.5	6.1	12.4	2.8
Headwaters	13.99	381	-9.8%	-2.6%	-1.3%	35.3%	10.6	8.7	3.0	24.4	1.2
Methanex Corp.	9.84	1,123	17.4%	6.3%	-13.3%	51.3%	n/a	n/a	1.4	3.9	0.9
Quantum Fuel Systems Tech	3.51	74	49.4%	13.2%	39.0%	-59.5%	n/a	n/a	1.8	6.4	3.1
Syntroleum Corp.	2.67	82	54.3%	5.5%	-5.2%	-75.6%	n/a	27.0	(5.7)	5.7	3.9
Average			24.5%	2.3%	6.0%	-19.8%			1.2	9.0	3.9
Energy Information Technology											
Intergraph Corp.	23.91	996	34.6%	13.1%	0.0%	29.3%	69.7	48.0	1.8	2.0	2.0
Itron	20.00	377	4.3%	-5.3%	-1.7%	-36.7%	15.4	12.8	2.4	38.1	1.2
Average			19.5%	3.9%	-0.9%	-3.7%			2.1	20.0	1.6
Energy Storage											
Active Power	2.30	78	29.2%	36.1%	0.6%	-73.8%	n/a	n/a	1.0	1.0	8.0
Beacon Power	0.38	12	81.0%	40.7%	-3.6%	-83.8%	n/a	n/a	1.0	0.7	n/a
C&D Technologies	17.49	377	-1.0%	16.2%	4.8%	-22.7%	25.9	18.4	1.7	46.5	1.1
Electric Fuel Corporation	0.98	36	53.1%	-7.5%	32.5%	-61.4%	n/a	n/a	3.5	18.8	3.7
Medis Technologies	9.76	225	95.2%	5.7%	28.9%	-32.0%	n/a	n/a	3.5	33.6	n/a
Ultralife Batteries	12.88	167	248.1%	10.8%	16.2%	-17.6%	21.7	16.2	7.3	83.5	3.3
Valence Technology	3.44	214	164.6%	-2.8%	18.4%	-61.4%	n/a	n/a	(15.0)	32.4	82.2
Average			95.7%	14.2%	14.0%	-50.4%			0.4	30.9	19.7
ENERGY TECHNOLOGY INDUSTRY											
Mean			53.6%	9.2%	8.4%	-46.4%			1.9	11.3	7.6
Median			30.0%	5.3%	5.3%	-53.1%			1.9	4.4	2.7

Note: Sources for data presented in *TapeTalk* and *Capital Markets Monitor* are I/B/E/S, Market Guide and Vortex Energy LLC estimates

TapeTalk (cont'd)

Energy Tech Company Share Price and Earnings Performance

July was a breakout month for the power electronics segment. Magnetek led the way (+59%), and other notable gainers included Power-One (+49%), Artesyn (+28%), and Powerwave (+25%). Most power electronics companies have lost money for several years, and face further losses in 2003. The power semiconductor stocks are up smartly for the year, but lagged power electronics last month as investors favored companies without current earnings. This mirrors a broader trading pattern in the technology world.

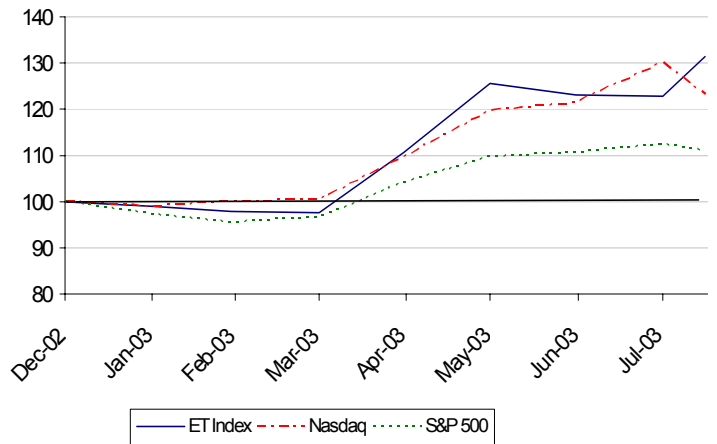
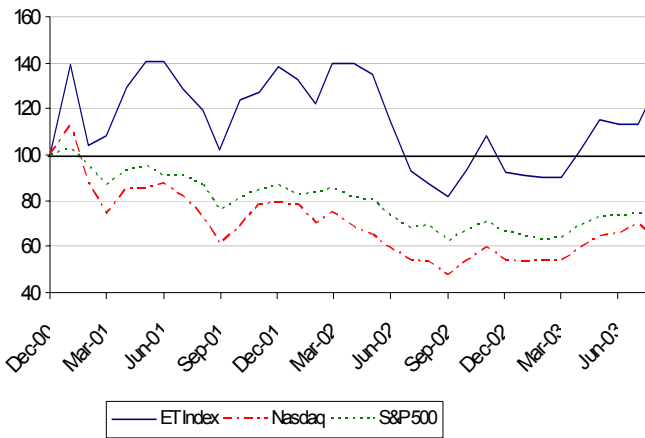
Company	Price 15-Aug-03	Mkt Cap (\$MM)	Share Price % Change				Price/Earnings		Price/ Book	Price/ Cash	Price/ LTM Sales
			2003 YTD	August	July	Last Yr.	FY 03	FY 04			
Power Semiconductors											
Advanced Power Technology	7.89	74	143.5%	-3.8%	8.6%	-72.1%	n/a	31.0	1.2	4.1	1.5
AVX Corporation	11.00	1,750	12.2%	0.5%	-0.4%	-58.5%	n/a	72.0	1.3	2.6	1.6
Fairchild Semiconductor	13.30	1,429	24.2%	4.3%	-0.3%	-62.0%	76.2	23.4	1.4	2.3	1.0
International Rectifier	33.84	1,931	83.3%	22.6%	2.9%	-47.1%	22.5	13.8	2.2	2.8	2.2
IXYS Corporation	7.75	215	9.8%	4.7%	-7.4%	-12.7%	37.5	15.0	1.8	5.4	1.6
KEMET Corporation	10.43	872	19.3%	22.0%	-29.0%	-50.8%	n/a	126.3	1.1	2.9	2.0
Maxwell Technologies	7.44	94	23.0%	5.1%	22.9%	-38.3%	n/a	n/a	2.2	9.2	1.8
Microsemi Corp.	15.98	450	162.4%	-6.1%	6.8%	-79.5%	111.0	43.1	2.6	19.9	2.3
O2Micro International	14.12	512	45.0%	-5.6%	-7.3%	-59.5%	49.8	26.9	4.0	4.4	7.0
ON Semiconductor	3.70	601	170.1%	26.7%	8.1%	-33.8%	n/a	113.3	(0.9)	3.3	0.6
Power Integrations	29.67	793	74.5%	4.0%	17.4%	-25.6%	47.1	35.9	5.4	6.8	6.8
Semtech Corp.	16.55	1,108	51.3%	0.3%	15.8%	-69.3%	34.3	24.8	3.5	2.6	5.9
Siliconix	48.30	1,272	106.4%	12.5%	18.9%	-14.7%	29.2	21.3	3.6	6.9	3.3
Average			71.2%	6.7%	4.4%	-48.0%			2.3	5.6	2.9
Power Electronics											
Artesyn Technologies	6.82	244	77.6%	-5.0%	28.2%	-58.8%	n/a	52.5	2.3	4.6	0.7
Magnetek	4.37	95	-1.6%	8.2%	59.1%	-50.7%	n/a	n/a	0.9	56.1	0.5
PECO II	0.85	19	32.8%	23.2%	11.3%	-89.3%	n/a	n/a	0.2	2.1	0.3
Power-One	10.87	809	91.7%	2.6%	48.7%	-45.5%	n/a	488.5	3.2	8.0	3.2
Powerwave Technologies	7.31	449	35.4%	-5.1%	25.0%	-68.8%	n/a	n/a	1.6	2.8	1.7
SatCon Technology	0.60	8	-57.1%	9.1%	-11.3%	-73.1%	n/a	n/a	0.8	7.3	0.2
UQM Technologies	3.25	61	28.5%	-5.8%	15.0%	-53.4%	n/a	n/a	7.7	27.9	4.4
Vicor Corp.	9.99	400	21.1%	-0.9%	3.9%	-49.1%	n/a	n/a	1.8	3.6	2.5
Average			28.5%	3.3%	22.5%	-61.1%			2.3	14.0	1.7
Power Quality											
American Power Conversion	17.98	3,098	18.7%	3.5%	11.3%	4.8%	20.7	17.5	2.6	4.3	2.3
American Superconductor	13.20	165	338.5%	64.2%	31.2%	-75.4%	n/a	n/a	3.2	8.2	6.4
Intermagnetics General	23.91	315	21.7%	18.0%	2.2%	-24.2%	20.1	15.5	2.5	3.6	2.1
Average			126.3%	28.6%	14.9%	-31.6%			2.8	5.4	3.6
ENERGY TECHNOLOGY INDUSTRY											
Mean			53.6%	9.2%	8.4%	-46.4%			1.9	11.3	7.6
Median			30.0%	5.3%	5.3%	-53.1%			1.9	4.4	2.7

TapeTalk (cont'd)

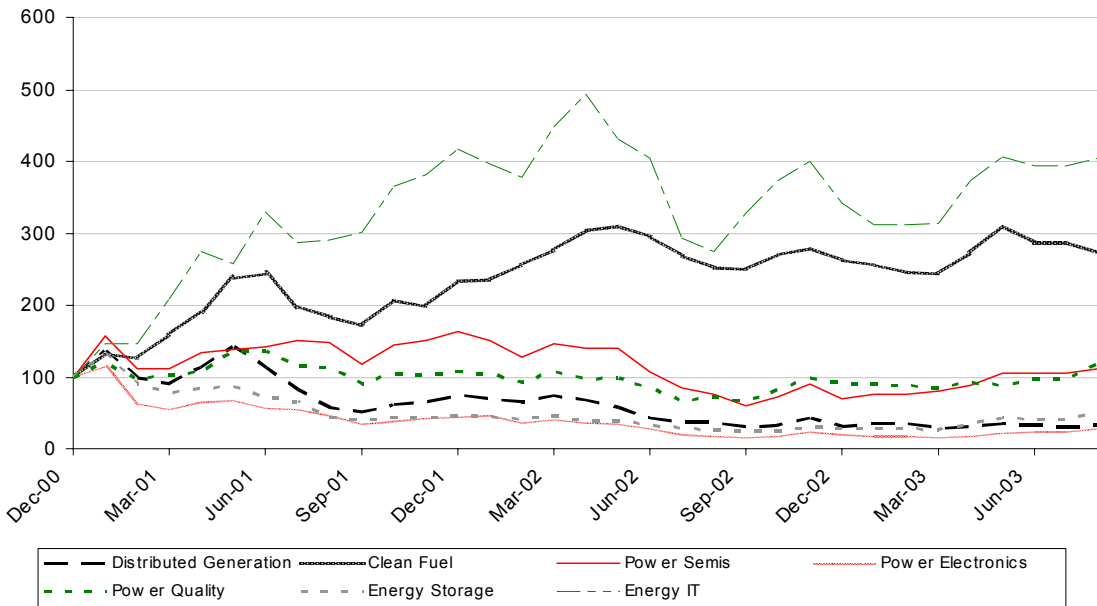
Energy Tech Company Share Price and Earnings Performance

The first two graphs below, plotting the stock price performance of the overall energy tech industry versus the major indexes, show that energy tech shares held up relatively well over the course of two difficult years (2001-02), and have remained strong in 2003. The third graph below shows energy tech share price performance by segment, and underscores the importance of stock selection. Energy IT (topmost green dashed line) and clean fuel & combustion technology shares have outperformed the others by a wide margin.

VORTEX ENERGY TECH INDUSTRY INDEX



VORTEX ENERGY TECH SEGMENT INDEXES



TapeTalk (cont'd)

Energy Tech Company Share Price and Earnings Performance

Taken as a whole, technical stock indicators are sending mixed signals. Insider buying and selling were roughly equal. Short interest declined several basis points versus previous months, but was up slightly in July relative to June. Lastly, 13-week relative strength versus the S&P 500 was strong, but turned negative in July on selling in distributed generation and power semiconductor shares.

Company	Insider Trading		Short Interest - July		Short Interest - June		Average Volume		Beta	Relative Strength	
	Buys	Sells	Shares	% of Float	Shares	% of Float	Daily	Monthly		4-week	13-week
Distributed Generation											
Ballard Power	-	-	8,515	7.5%	10,002	8.8%	318	9,926	1.9	-13	-5
Capstone Turbine	-	-	1,442	1.9%	1,510	2.0%	593	20,599	4.1	9	36
Energy Conversion Devices	1	15	535	2.9%	527	2.9%	27	833	1.2	1	-11
Evergreen Solar	-	-	110	1.3%	116	1.4%	36	897	2.2	7	-13
FuelCell Energy	-	-	4,536	13.5%	4,436	13.2%	237	9,835	1.7	-18	-1
Hydrogenics	-	-	296	2.9%	299	3.0%	92	1,887	3.7	18	-4
Millennium Cell	-	200	468	2.1%	383	1.7%	80	3,440	1.2	-18	-10
Plug Power	-	761	3,657	14.2%	3,432	13.3%	175	6,045	1.7	-15	-21
Proton Energy Systems	1	-	324	2.8%	479	4.2%	85	3,779	3.1	-16	-38
Mean				5.5%		5.6%					
Median				2.9%		3.0%					
Clean Fuel & Combustion Technology											
Catalytica Energy Systems	-	-	113	0.7%	91	0.5%	13	369	-0.3	7	14
Fuel Tech N.V.	2	8	1	0.0%	7	0.1%	20	1,014	0.0	-6	20
Headwaters	-	-	1,676	6.4%	1,847	7.0%	294	11,035	0.6	-7	-26
Methanex Corp.	-	-	169	0.2%	555	0.5%	200	6,749	0.2	-7	-9
Quantum Fuel Systems Tech	-	-	1,023	5.9%	1,308	7.6%	247	4,176	0.0	6	51
Syntroleum Corp.	648	243	80	0.4%	193	0.9%	40	2,226	0.1	-11	16
Power Semiconductors											
Advanced Power Technology	4	-	85	1.4%	216	3.7%	28	726	2.9	-15	68
AVX Corporation	-	-	2,568	4.8%	2,772	5.2%	256	5,454	1.8	-11	-7
Fairchild Semiconductor	-	5,732	5,319	6.6%	4,433	5.5%	1,029	29,028	2.1	-13	-7
International Rectifier	-	32	4,485	7.3%	4,135	6.8%	1,284	19,537	2.7	7	20
IXYS Corporation	-	-	427	2.3%	412	2.2%	41	922	2.3	-16	-19
KEMET Corporation	-	869	3,577	4.2%	2,944	3.4%	447	10,238	1.6	-6	2
Maxwell Technologies	5	22	631	4.7%	692	5.2%	16	356	1.3	5	7
Microsemi Corp.	-	-	1,755	6.4%	1,766	6.4%	237	8,812	2.1	-4	22
O2Micro International	-	-	2,760	12.1%	3,402	14.9%	465	6,966	3.3	-24	4
ON Semiconductor	180	10	193	0.3%	137	0.2%	577	9,803	3.5	12	83
Power Integrations	-	268	3,255	11.3%	3,269	11.4%	487	13,072	1.9	3	8
Semtech Corp.	-	50	6,016	8.6%	2,936	4.2%	1,310	28,918	1.5	-7	-16
Siliconix	-	-	108	1.9%	68	1.2%	38	889	1.7	4	37
Power Electronics											
Artesyn Technologies	-	10	169	0.6%	113	0.4%	1,155	7,895	2.7	-6	53
Magnetek	10	-	334	1.5%	491	2.1%	147	5,695	1.2	22	49
PECO II	-	-	20	0.1%	22	0.2%	162	1,118	1.5	45	24
Power-One	239	1	1,456	2.3%	1,024	1.6%	729	12,525	3.5	8	47
Powerwave Technologies	-	-	1,675	2.6%	1,419	2.2%	1,331	36,761	2.9	-9	34
SatCon Technology	50	-	783	6.1%	883	6.9%	214	2,835	1.2	-42	-51
UQM Technologies	4	-	11	0.1%	8	0.1%	19	842	0.9	5	42
Vicor Corp.	-	2	147	0.8%	183	1.0%	58	1,408	1.9	-3	12
Power Quality											
American Power Conversion	-	824	2,555	1.5%	2,761	1.6%	1,303	27,831	1.8	-3	-7
American Superconductor	-	-	2,146	10.3%	1,898	9.1%	241	3,933	1.9	37	110
Intermagetics General	-	128	455	2.8%	334	2.1%	103	2,271	1.0	-3	-8
Energy Storage											
Active Power	113	-	1,362	3.9%	1,921	5.4%	114	4,364	3.5	15	35
Beacon Power	-	-	15	0.0%	6	0.0%	1,541	22,409	2.5	-11	23
C&D Technologies	4	3	407	1.6%	487	2.0%	87	2,593	1.8	0	-2
Electric Fuel Corporation	-	125	1,667	6.0%	1,742	6.2%	1,130	14,028	1.6	8	-7
Medis Technologies	-	-	930	9.9%	927	9.9%	40	730	2.1	16	26
Ultralife Batteries	2	151	237	1.9%	241	2.0%	285	4,965	0.9	34	145
Valence Technology	5,947	-	5,035	11.3%	4,465	10.0%	158	7,518	2.7	-10	-24
Energy Information Technology											
Intergraph Corp.	-	37	553	1.2%	558	1.2%	270	5,401	0.8	-4	-3
Itron	10	49	1,420	7.1%	1,296	6.5%	277	4,363	0.4	-19	-14
Total	7,210	9,491	74,081	4.3%	71,850	4.1%	17,759	382,653	1.8	-1.5	12.9
Average							395	8,466			

All share data in thousands

Insider trading data covers the last 6 months of activity

Daily trading volume based on 10-day average; monthly volume based on 3-month average

Relative strength indicates how well a stock has performed versus the S&P 500 over a specified time

TapeTalk (cont'd)

Energy Tech Company Share Price and Earnings Performance

EPS remain largely negative. Revenues at many companies are trending higher both sequentially and year over year. Median revenues in power semiconductors and power electronics, by far the largest sectors by revenue, are flat to down -15% sequentially, in part due to seasonality. Year/year sales are generally higher, with sizable and broad-based growth evident in distributed generation, clean fuels, energy IT and power semis.

Company	Revenues			Last Q Revs - % Chg		Diluted Continuing EPS			Last Q EPS - % Chg	
	Last Q	2002	2001	Q/Q	Y/Y	Last Q	FY2002	FY2001	Q/Q	Y/Y
Distributed Generation										
Ballard Power	29.1	90.9	36.2	-12.1%	35.3%	(0.19)	(1.29)	119.50	n/a	n/a
Capstone Turbine	4.1	19.5	36.0	46.4%	-44.6%	(0.12)	(0.95)	(0.61)	n/a	n/a
Energy Conversion Devices	13.6	91.7	71.4	-26.5%	-44.5%	(0.41)	(0.96)	(0.27)	n/a	n/a
Evergreen Solar	1.4	6.7	2.5	-36.4%	27.3%	(0.28)	(1.16)	(1.10)	n/a	n/a
FuelCell Energy	8.9	41.2	26.2	-13.6%	3.5%	(0.53)	(1.25)	(0.45)	n/a	n/a
Hydrogenics	6.8	15.8	7.4	-19.0%	94.3%	(0.10)	(0.44)	(0.11)	n/a	n/a
Millennium Cell	-	0.7	-	n/a	n/a	(0.17)	(0.58)	(0.72)	n/a	n/a
Plug Power	3.0	11.8	5.7	-11.8%	3.4%	(0.27)	(0.93)	(1.56)	n/a	n/a
Proton Energy Systems	0.2	4.7	3.0	-77.8%	-77.8%	(0.14)	(0.40)	(0.15)	n/a	n/a
Clean Fuel & Combustion Technology										
Catalytica Energy Systems	1.0	4.8	5.5	100.0%	-9.1%	(0.20)	(1.02)	(1.33)	n/a	n/a
Fuel Tech N.V.	8.0	32.6	17.7	-29.8%	53.8%	(0.03)	0.14	(0.09)	n/a	n/a
Headwaters	106.4	119.3	45.5	23.6%	232.5%	0.37	0.94	0.87	54.2%	42.3%
Methanex Corp.	371.5	1,041.8	1,195.5	10.3%	66.1%	0.38	0.16	0.45	-34.5%	216.7%
Quantum Fuel Systems Tech	7.4	23.6	23.4	23.3%	4.2%	(0.17)	(1.00)	(3.07)	n/a	n/a
Syntroleum Corp.	13.0	11.6	6.7	766.7%	209.5%	-	(1.98)	(0.91)	n/a	n/a
Power Semiconductors										
Advanced Power Technology	11.2	43.4	36.9	-1.8%	36.6%	(0.10)	(0.36)	0.19	n/a	n/a
AVX Corporation	256.7	1,134.1	1,250.0	-1.7%	-13.0%	(0.09)	(0.07)	(0.04)	n/a	n/a
Fairchild Semiconductor	347.1	1,411.9	1,407.7	-1.1%	-3.7%	(0.54)	(0.02)	(0.42)	n/a	n/a
International Rectifier	214.4	720.2	978.6	2.3%	20.0%	0.12	0.75	1.35	n/a	-36.8%
IXYS Corporation	37.8	136.1	82.8	6.5%	85.3%	(0.23)	(0.39)	0.07	n/a	n/a
KEMET Corporation	105.4	447.3	508.6	-1.0%	-15.0%	(0.04)	(0.65)	(0.32)	n/a	n/a
Maxwell Technologies	10.2	58.0	77.9	-34.2%	-20.3%	(0.28)	(2.88)	(0.82)	n/a	n/a
Microsemi Corp.	48.2	212.6	243.4	5.0%	-12.4%	0.07	(0.16)	0.59	n/a	n/a
O2Micro International	19.3	70.2	45.8	4.9%	19.9%	0.04	0.27	0.16	-33.3%	-50.0%
ON Semiconductor	256.2	1,084.5	1,214.6	-4.9%	-8.7%	(0.34)	(0.82)	(4.21)	n/a	n/a
Power Integrations	29.8	108.2	94.1	2.4%	10.0%	0.13	0.33	0.23	0.0%	85.7%
Semtech Corp.	44.0	193.0	191.2	-1.1%	-10.6%	0.11	0.44	0.34	n/a	-15.4%
Siliconix	88.2	372.9	305.6	-9.8%	-7.1%	0.31	1.55	0.51	-8.8%	-18.4%
Power Electronics										
Artesyn Technologies	87.6	350.8	494.0	7.0%	-3.6%	(0.19)	(2.84)	(0.83)	n/a	n/a
Magnetek	53.2	188.2	298.3	3.7%	19.8%	(0.23)	0.06	0.39	n/a	n/a
PECO II	11.1	62.1	106.7	3.7%	-34.7%	(0.33)	(1.85)	(0.31)	n/a	n/a
Power-One	69.3	230.7	363.7	23.1%	23.3%	(0.01)	(2.63)	(2.36)	n/a	n/a
Powerwave Technologies	51.5	384.9	300.3	-1.3%	-54.6%	(0.23)	0.06	(0.33)	n/a	n/a
SatCon Technology	5.5	41.6	41.7	-20.3%	-46.6%	(0.69)	(1.25)	(1.51)	n/a	n/a
UQM Technologies	3.2	15.5	21.4	10.3%	-33.3%	(0.02)	(0.18)	(0.36)	n/a	n/a
Vicor Corp.	38.7	152.6	195.9	2.7%	5.2%	(0.14)	(0.38)	(0.01)	n/a	n/a
Power Quality										
American Power Conversion	331.5	1,300.0	1,404.8	7.3%	7.6%	0.17	0.59	0.58	13.3%	13.3%
American Superconductor	10.9	21.0	11.7	289.3%	240.6%	(2.54)	(4.21)	(2.79)	n/a	n/a
Intermagnetics General	37.7	147.4	153.3	-0.3%	1.9%	0.26	0.88	1.19	4.0%	30.0%
Energy Storage										
Active Power	1.9	13.5	22.6	18.8%	-38.7%	(0.14)	(0.67)	(0.70)	n/a	n/a
Beacon Power	-	-	-	n/a	n/a	(0.05)	(0.49)	(0.62)	n/a	n/a
C&D Technologies	77.4	335.7	471.6	-3.0%	-8.0%	0.11	0.74	1.35	-45.0%	-31.3%
Electric Fuel Corporation	4.0	6.4	2.1	90.5%	566.7%	(0.04)	(0.15)	(0.22)	n/a	n/a
Medis Technologies	-	0.2	-	n/a	n/a	(0.11)	(0.60)	(1.76)	n/a	n/a
Ultralife Batteries	15.4	15.6	32.5	75.0%	73.0%	0.02	(0.24)	(2.11)	n/a	n/a
Valence Technology	1.2	2.6	4.9	100.0%	200.0%	(0.13)	(0.65)	(1.53)	n/a	n/a
Energy Information Technology										
Intergraph Corp.	120.6	501.2	532.1	-1.1%	-2.0%	0.17	7.48	0.39	-90.8%	112.5%
Itron	80.3	284.8	225.6	7.6%	10.9%	0.19	0.41	0.75	35.7%	-32.1%

All revenue data in millions

For companies with non-calendar fiscal years, revenue and EPS data is for FY2002 and FY2001

Diluted continuing EPS as reported in SEC filings; excludes extraordinary items but includes "above the line" gains and charges

TapeTalk (cont'd)

Energy Tech Company Share Price and Earnings Performance

The latest EPS results continue to surpass consensus, although the ratio of upside to downside surprises came in at about 1.5:1, down from 2:1. Estimate revisions remain weighted to the downside, and down sharply in some cases for the current quarter

Latest Quarter Earnings Surprises		Total Estimate Revisions ↑/↓		
		Current Q	Next Q	Current Year
Upside	18	4 ↑	14 ↑	17 ↑
Downside	13	10 ↓	18 ↓	24 ↓

Company	Earnings Surprises - Latest Q			EPS Estimate			EPS Est. % Chg		
	Actual	Estimated	Variance	Current Q	Next Q	Current Year	Current Q	Next Q	Current Year
Distributed Generation									
Ballard Power	(0.26)	(0.20)	(0.06)	(0.29)	(0.29)	(0.99)	--	-0.3%	-1.0%
Capstone Turbine	(0.12)	(0.12)	-	(0.12)	(0.11)	(0.45)	--	-0.1%	-0.5%
Energy Conversion Devices	-	-	-	-	-	-	--	--	--
Evergreen Solar	-	-	-	-	-	-	--	--	--
FuelCell Energy	(0.53)	(0.42)	(0.11)	(0.39)	(0.40)	(1.78)	--	-0.1%	-0.5%
Hydrogenics	-	-	-	-	-	-	--	-0.1%	-0.5%
Millennium Cell	(0.12)	(0.13)	0.01	(0.13)	(0.13)	(0.51)	-5.3%	-0.2%	-0.9%
Plug Power	(0.21)	(0.20)	(0.01)	(0.20)	(0.20)	(0.87)	16.7%	-0.1%	-0.4%
Proton Energy Systems	(0.10)	(0.13)	0.03	(0.10)	(0.10)	(0.43)	16.7%	-0.1%	-0.4%
Clean Fuel & Combustion Technology									
Catalytica Energy Systems	(0.20)	n/a	n/a	-	-	-	--	--	--
Fuel Tech N.V.	0.03	0.02	0.01	0.04	0.08	0.13	--	0.1%	0.1%
Headwaters	0.37	0.35	0.02	0.39	0.34	1.30	-7.1%	0.3%	1.3%
Methanex Corp.	0.38	-	-	-	-	1.79	--	--	1.8%
Quantum Fuel Systems Tech	(0.17)	(0.22)	0.05	(0.19)	(0.17)	(0.66)	--	-0.2%	-0.7%
Syntroleum Corp.	(0.18)	(0.12)	(0.06)	-	-	(0.48)	--	--	-0.5%
Power Semiconductors									
Advanced Power Technology	0.01	-	0.01	0.01	0.03	-	-66.7%	0.0%	--
AVX Corporation	(0.07)	(0.03)	(0.04)	(0.05)	(0.02)	(0.15)	-400.0%	0.0%	-0.2%
Fairchild Semiconductor	0.03	0.03	-	0.01	0.08	0.16	-83.3%	0.1%	0.2%
International Rectifier	0.24	0.23	0.01	0.27	0.32	1.34	--	0.3%	1.3%
IXYS Corporation	(0.18)	-	(0.18)	0.01	0.04	0.18	--	0.0%	0.2%
KEMET Corporation	(0.04)	(0.03)	(0.01)	(0.06)	(0.04)	(0.16)	-200.0%	0.0%	-0.2%
Maxwell Technologies	(0.25)	(0.07)	(0.18)	0.02	0.12	-	--	0.1%	--
Microsemi Corp.	0.05	0.04	0.01	0.06	0.07	0.14	--	0.1%	0.1%
O2Micro International	0.06	0.06	-	0.08	0.09	0.27	--	0.1%	0.3%
ON Semiconductor	(0.14)	(0.16)	0.02	(0.12)	(0.07)	(0.51)	--	-0.1%	-0.5%
Power Integrations	0.13	0.12	0.01	0.15	0.17	0.58	--	0.2%	0.6%
Semtech Corp.	0.11	0.11	-	0.09	0.11	0.44	--	0.1%	0.4%
Siliconix	0.31	0.41	(0.10)	0.39	0.43	1.46	-13.3%	0.4%	1.5%
Power Electronics									
Artesyn Technologies	(0.07)	(0.10)	0.03	(0.05)	(0.01)	(0.26)	16.7%	0.0%	-0.3%
Magnetek	(0.09)	(0.09)	-	(0.07)	(0.06)	(0.27)	--	-0.1%	-0.3%
PECO II	-	-	-	-	-	(0.70)	--	--	-0.7%
Power-One	(0.01)	(0.06)	0.05	(0.04)	(0.02)	(0.13)	--	0.0%	-0.1%
Powerwave Technologies	(0.14)	(0.09)	(0.05)	(0.08)	(0.04)	(0.37)	-33.3%	0.0%	-0.4%
SatCon Technology	(0.32)	(0.09)	(0.23)	(0.18)	(0.23)	(0.89)	--	-0.2%	-0.9%
UQM Technologies	(0.02)	-	-	-	-	-	--	--	--
Vicor Corp.	(0.14)	(0.13)	(0.01)	(0.11)	(0.10)	(0.51)	-10.0%	-0.1%	-0.5%
Power Quality									
American Power Conversion	0.17	0.17	-	0.22	0.23	0.76	--	0.2%	0.8%
American Superconductor	(0.39)	(0.45)	0.06	(0.36)	(0.30)	(1.48)	--	-0.3%	-1.5%
Intermagetics General	0.26	0.26	-	0.02	0.26	0.95	--	0.3%	1.0%
Energy Storage									
Active Power	(0.14)	(0.15)	0.01	(0.13)	(0.13)	(0.57)	7.1%	-0.1%	-0.6%
Beacon Power	(0.05)	-	-	(0.07)	(0.07)	(0.27)	--	-0.1%	-0.3%
C&D Technologies	0.11	0.11	-	0.13	0.16	0.57	--	0.2%	0.6%
Electric Fuel Corporation	(0.06)	n/a	n/a	-	-	-	--	--	--
Medis Technologies	(0.11)	-	-	(0.12)	(0.12)	(0.48)	--	-0.1%	-0.5%
Ultralife Batteries	0.02	0.02	-	0.10	0.20	0.60	--	0.2%	0.6%
Valence Technology	(0.13)	(0.14)	0.01	(0.14)	(0.13)	(0.51)	--	-0.1%	-0.5%
Energy Information Technology									
Intergraph Corp.	0.06	0.08	(0.02)	0.07	0.10	0.31	-30.0%	0.1%	0.3%
Itron	0.28	0.27	0.01	0.30	0.34	1.20	-3.2%	0.3%	1.2%

Capital Markets Monitor

Overview. While May was a relatively quiet month, activity picked up in June as the stock market's spring rally held up and investors gained confidence in the economic recovery. The momentum carried over into July, during which time at least eight companies representing a wide range of energy technologies announced or closed financings. Transaction size picked up a bit, with two completed deals topping \$10 million and one pending deal targeting \$50 million.

July 30. **Westport Innovations** announced that it has entered into a bought deal financing agreement with a syndicate led by **Raymond James Ltd.** The syndicate has agreed to purchase 8.75 million common shares of Westport from the company at a price of \$1.90 per share, for gross proceeds of C\$16.7 million, or about US\$12.5 million. (Note that the underwriters ended up purchasing a total of 10.9 million shares on August 21, then exercised an option to purchase an additional shares on August 29, for a total of 12.4 million shares purchased for gross proceeds of C\$22.3 million, or roughly US\$16.7 million). Westport is a developer of fuel systems that allow diesel engines to run on gaseous fuels such as natural gas, resulting in reduced emissions without compromising performance.

July 24. The management of **SMA Regelsysteme GmbH** has acquired the shares of its company held by **FLABEG GmbH & Co. KG**, and is now sole owner of the company. SMA Regelsysteme GmbH was founded in 1981 to target the growing market of distributed systems. The company, based in Niestetal, Germany, specializes in the manufacture of inverters for plants and energy systems for railway coaches, as well as electronic solutions for industrial applications. In 2002, SMA achieved sales of 66 million Euro. SMA is a leading supplier of grid tied solar powered inverters in Europe. SMA America is now operating in the United States to offer its inverters and services to the American solar and wind markets.

July 23. **IndX Software Corp.**, a provider of real-time operations intelligence solutions, announced that **SAP Ventures** and **Cargill Ventures** have made strategic investments as part of a \$1 million round of financing. **Siemens Venture Capital** led the overall funding. The additional funding from Cargill and SAP will be used by IndX to extend its position in the oil and gas sector, where it has secured enterprise-wide contracts with several multi-national energy companies. The company also plans to expand its presence in chemical, power generation and other process and manufacturing industries.

July 21. **Power Paper Ltd.**, a developer of thin and flexible micro-power technology and devices, closed a \$15 million round of fundraising, the company's fourth. **Amadeus Capital Partners Ltd**, a UK-based technology investor, led the round, which also includes investments from **Banc America Capital Partners** (US), the **PolyTechnos Funds** (Germany), **Millenium Materials Technologies Funds** (Israel), **Toppan Forms** (Japan), **Yasuda**

Capital Markets Monitor (cont'd)

Enterprise Development Co. (Japan) and other current shareholders. Current applications of Power Paper's technology include active cosmetic patches, smart toys, and active radio frequency identification (RFID) labels.

July 11. **Anuvu**, a developer of fuel cells for the transportation industry, has raised \$2.6 million in its third round of financing. **ASK Group** was the sole investor. The financing included both debt and equity, with the breakdown between the two not disclosed. The proceeds from the round are being used for operations and product development. The company plans to enter into production in two months with its partner **Celerity**, in which Celerity will be building the company's fuel cell stacks. Anuvu raised \$2 million in its second round of financing from undisclosed investors in 2000.

July 7. **ARISE Technologies Corporation** has completed the first tranche of its IPO financing, and also completed a planned merger with **Intercedent Ventures Ltd.** (IVL) following approvals by the shareholders of both companies. The initial closing of the ARISE IPO raised gross proceeds of C\$907,329 (about US\$681,000). ARISE provides a range of solar energy solutions, from portable systems to customized residential systems to solar hot water systems. In 2002, the company had sales of approximately C\$1.2M (about US\$900,00), which represented a growth of 142% over the prior year.

July 2. **Electric City Corp.**, announced that it recently closed on the sale of securities to **Cinergy Ventures II, LLC** along with two of its existing strategic investors raising a total of \$1,500,000 in preferred stock. Cinergy Ventures II, LLC is a wholly owned subsidiary of **Cinergy Corp.**, a diversified energy company based in Cincinnati, Ohio, with over \$13 billion in assets. The terms of the new issuance are similar to the \$16 million issuance the Company closed in September 2001 with a group of strategic investors that included **Newcourt Capital USA**, a subsidiary of **CIT**, **Duke Capital Partners**, a wholly-owned subsidiary of **Duke Energy**, **EP Power Finance**, a wholly-owned subsidiary of **El Paso Corporation**, and affiliates of **Morgan Stanley Dean Witter**.

July 1. **American Superconductor Corporation** (AMSC), a developer of superconducting and power electronics solutions for the utility grid, announced that it has signed non-binding letters of intent with three groups of investors to provide up to \$50 million in financing. The financing was expected to consist of a five-year term loan of up to \$30 million, \$10 million in convertible subordinated notes, and up to \$10 million in the form of a working capital credit facility. Note that on August 25 the company withdrew from this agreement and filed an offering of 4 million common shares. In either case, the intended use of proceeds is for

Capital Markets Monitor (cont'd)

working capital, general corporate purposes and scale-up of pilot manufacturing for the company's second generation (coated conductor composite) high temperature superconductor wire.

June 30. In a secondary offering that closed June 5, **NOVA Chemicals** sold about 38 million of its 46 million shares in **Methanex Corp.** At US\$9.85 per share, aggregate proceeds totaled US\$373.8 million. Methanex did not receive any proceeds from the offering. On June 30, Methanex announced it had purchased and retired NOVA's 9 million remaining shares. Prior to these transactions, NOVA owned about 36% of Methanex.

June 30. **SmartSynch**, a provider of smart metering solutions to the energy and utility industry, announced that it closed an additional round of funding with its existing investors. The syndicate of investors included **JPMorgan Partners, Kinetic Ventures, Lime Rock Partners, Nth Power, OPG Ventures, Siemens Venture Capital** and members of the company's management team. To date, SmartSynch has raised over \$35 million in venture capital financing. The proceeds from the current round will help the company expand its product line and move into Canada and Mexico. In addition to its equity financing, SmartSynch increased its line of credit with Silicon Valley Bank to \$3 million, to be used to fund capital expenditures and working capital.

June 18. **Exelon**, parent company of **InfraSource Inc.**, announced that it has agreed to sell the electric construction and services, underground and telecom businesses of InfraSource to **GFI Energy Ventures** and **Oaktree Capital Management**. The sale price is expected to consist of \$250 million in cash and a \$30 million subordinated note maturing with interest in 2011. The InfraSource companies being divested are **MJ Electric, InfraSource Underground, Electric Services Inc., Dashiell and Dacon, Blair Park Services/Sunesys** and **RJE Telecom**.

Comment. Given the recent blackout and the likelihood that sizable investments in the transmission grid are on the way, the acquisition by GFI and Oaktree of a major electric infrastructure contracting service requires only this comment—smart and extraordinarily well timed.

June 10. **Valence Technology** a developer of lithium-ion polymer rechargeable batteries, announced that it has arranged financial commitments that it expects will take it to cash flow breakeven. Specifically, Valence obtained a waiver from Berg & Berg, an investor, that enables it to have continued access to the \$10 million remaining on an existing equity line of credit. In a separate arrangement, Berg & Berg committed to provide the Company an additional \$10 million in 2004. A week prior, Valence completed a \$10 million private placement of Series C convertible preferred stock.

Capital Markets Monitor (cont'd)

June 9. **ISOPur Fluid Technologies**, developer of industrial fluid cleaning technology, said it has raised another \$3.5 million in Series A funding, bringing the round to a close with \$8.5 million. Investors included Advent International, FA Technology Ventures and Siemens Venture capital.

June 2. **Aspen Technology**, a leading provider of operations management software and services for process manufacturers, announced that **Advent International**, a leading private equity firm, will invest \$100 million in a new issue of Series D convertible preferred stock. AspenTech will use the cash to retire its Series B preferred shares, for working capital and for repurchase of a significant portion of its convertible subordinated debentures which mature in 2005. In connection with the financing, AspenTech also announced it will seek shareholder approval for a 1-for-3 share reverse stock split.

May 28. **Metallic Power Inc.**, a leading developer of zinc regenerative fuel cells, announced that it has closed its fourth round of venture capital funding, with \$13.5 million in new investment and two new investors: **CDP Capital – Technology Ventures** and **Norsk Hydro Technology Ventures**. Metallic Power will use the new capital to commercialize its zinc regenerative fuel cells. All of the company's major current investors participated in the round, including **Aretê Corp.**; the **Beacon Group Energy Investment Fund II LP**; **Cinergy Ventures LLC**, the venture capital arm of **Cinergy Corp.**; **Teck Cominco Ltd.**; **Hydro-Québec CapiTech**; **MP Investments Inc.**; **Nth Power**; and **Perseus LLC**.

Capital Markets Monitor (cont'd)

Looking at both average and median returns for energy tech IPOs, certain of these stocks appear unlikely to trade above their deal price for a long, long time. On the other hand, valuations on a price / cash basis improved considerably over the past three month. The median price / cash ratio stood at 3.1 as of August 15, versus a reading of 2.0 in mid-May.

Energy Technology IPO Aftermarket Performance

Company	Ticker	Market Cap	Price / Cash	Price 15-Aug-03	Offering Price	% Change	Date of Pricing
Beacon Power	BCON	16.3	1.0	0.38	6	-94%	16-Nov-00
Evergreen Solar	ESLR	17.7	3.2	1.55	14	-89%	1-Nov-00
Hydrogenics	HYGS	243.9	4.5	4.62	12	-62%	26-Oct-00
Proton Energy Systems	PRTN	83.3	0.6	2.49	17	-85%	28-Sep-00
02Micro International	OIIM	537.8	4.6	14.12	9	57%	22-Aug-00
Peco II	PIII	18.0	2.0	0.85	15	-94%	17-Aug-00
H Power	HPOW	44.6	1.0	4.14	16	-74%	8-Aug-00
Millennium Cell	MCEL	52.9	11.0	1.80	10	-82%	8-Aug-00
Active Power	ACPW	96.3	1.2	2.30	17	-86%	7-Aug-00
Advanced Power Technology	APTI	82.1	4.5	7.89	15	-47%	7-Aug-00
Capstone Turbine	CPST	141.3	1.1	1.74	16	-89%	28-Jun-00
Caminus	CAMZ	160.8	4.1	9.00	16	-44%	27-Jan-00
Plug Power	PLUG	266.6	3.1	5.16	15	-66%	28-Oct-99
Avg. IPO Performance			3.2			-66%	
Median IPO Performance			3.1			-82%	

Note: Caminus and H Power have both been acquired. The price shown for H Power is the stock's last trade; Caminus was taken over in an all-cash tender offer at \$9.00 per share.

The (De-)Construction Site

Strategic Deals, M&A, Restructurings, Bankruptcies and the Birth & Death of Companies

Overall Comment. Consolidation continued in the energy IT segment, with Itron acquiring Schlumberger Energy Metering. There was considerable activity in power electronics. Faced with prospects that appear modest at best, several companies chose to exit the market and deploy their capital elsewhere. At the same time, a trend may be emerging—two joint efforts to develop integrated power & logic ICs were announced within a month or so of each other.

Consolidation and restructuring were key themes in distributed generation, as Energy Conversion Devices lost two key joint venture partners, Ballard Power abandoned its efforts to develop an advanced genset, and AstroPower was delisted and restructuring specialists were put in charge of the company. There was a flurry of strategic partnering activity in the fuel cell space, as fuel cell developers chose to focus on core technical competences and conserve precious capital by teaming up with companies offering product integration and distribution capabilities.

The energy storage segment saw similar levels of strategic partnering deal-making, but generally involving products closer to commercial viability.

STRATEGIC DEALS

July 30. **INCEP Technologies** announced that it has signed an agreement with **Hewlett-Packard** (HP) to develop power supplies for use in high-performance systems that use Itanium microprocessors, including HP's Integrity enterprise servers. INCEP has developed a microprocessor power delivery architecture that co-packages the microprocessor and its power supply. Under the terms of the agreement, INCEP has made its power delivery technology available to HP for multi-processor power modules, and will be working with HP over the next three years on enterprise server microprocessor power delivery applications.

INCEP has developed a patented approach of applying power to the surface of a microprocessor package that supports traditional pin-grid array as well as land-grid array configurations. INCEP claims that its solutions will offer reductions in cost compared to alternatives of up to 50% the voltage regulation circuitry, 16% for device package and over 20% on power delivery components at the system-level for the OEM.

Comment. INCEP's announcement follows on the heels of a similar press release a month or so prior from **Motorola** and **PowerDsine** about an integrated microprocessor and power supply for communications hardware (*see page 32 for details*). The relentless push toward ever-faster microprocessors has been creating substantial challenges for power supply designers. Delivering large amounts of power in a small space without melting the circuit board requires high-efficiency power conversion and sophisticated thermal management strategies. The joint development efforts of INCEP with Hewlett-Packard and Motorola with PowerDsine represent what may be a growing trend—the integration of the microprocessor design process with the design of the power supply, rather than the current approach in which a logic chip is developed by Company X, while Company Y is left to figure out how to power it.

The (De-)Construction Site (cont'd)

Strategic Deals, M&A, Restructurings, Bankruptcies and the Birth & Death of Companies

July 29. **Solar Grade Silicon** (SGSil) and **Sumitomo** jointly announced a long-term agreement to develop polysilicon production processes, expand capacity and market and distribute polycrystalline silicon to solar cell ingot and wafer manufacturers in Asia. The agreement includes marketing and sales in Japan, China, Taiwan, and Korea. Strong solar power market in Asia and worldwide growth is expected to keep demand for polysilicon feedstock ahead of supply in the near future.

SGSil, located in Moses Lake, Washington, is the first major polysilicon production plant to be wholly dedicated to the supply of feedstock to the PV industry. Solar Grade Silicon LLC is a joint venture of **Advanced Silicon Materials**, a subsidiary of **Komatsu Ltd.**, Japan, and **Silicon Technologies AS**, a subsidiary of **Renewable Energy Corp.**, Norway.

July 22. **International Rectifier Corp.** and **SANYO Semiconductor**, a wholly owned subsidiary of **SANYO Electric Co. Ltd.**, announced that they are forming a 50/50 joint venture, **IR-SA Integrated Technologies**, to develop and market electronic motor drive power modules for energy-efficient appliances and light industrial applications. The new company will pair International Rectifier's motion control product expertise with SANYO's packaging integration technologies. The markets for variable speed, motion control technology are being driven by government mandates as well as consumer demand.

July 21. **FuelCell Energy** announced that **RWE AG** will establish a joint venture with **MTU Friedrichshafen**, FuelCell Energy's European technology and distribution partner, to market molten carbonate fuel cells to a broad European market. The joint venture, **MTU CFC Solutions GmbH**, will seek to develop a leading market position for high-temperature stationary fuel cells. MTU will contribute its technology for siting, installing and operating stationary fuel cells, while RWE will provide market access.

July 9. **American Superconductor Corp.** (AMSC), a leading developer of superconductor-based power equipment, announced that it and **Sumitomo Electric Industries Ltd. (SEI)**, a leading producer of electric wires and cables, have agreed to license to each other North American and European patents for first-generation high temperature superconductor (HTS) wires, electromagnetic coils, electromagnets and current lead devices.

Under the agreement, AMSC and SEI each pay royalties when selling first generation HTS wire involving the other's patents. Neither party disclosed additional details or financial terms of the agreement. Separately, the two companies signed a letter of intent to market Sumitomo power cables that utilize AMSC's HTS wire.

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Strategic Deals, M&A, Restructurings, Bankruptcies and the Birth & Death of Companies

Energy Storage Gets Energized

May 12. **Millennium Cell**, a developer of hydrogen generation and storage technology, announced an agreement with **Samsung Advanced Institute of Technology** (Japan) to develop a fuel cell system to power portable computers and communications devices. The collaboration will combine Millennium Cell's hydrogen fuel technology with Samsung's expertise in fuel cell and MEMS technologies, and its leading position in the consumer electronics industry.

June 11. **Power Paper Ltd**, a provider of thin and flexible micro-power technology and devices, and **Toppan Forms**, a business communications and printing solutions company, announced that they have entered into a long-term strategic relationship. Toppan Forms will receive an exclusive license to manufacture Power Paper's cosmetic patches in Asia-Pacific and Japan, with initial production expected in 2004. Toppan Forms has also made a \$2 million investment in Power Paper.

June 17. **EaglePicher Technologies LLC** has signed a supply agreement with **GS Battery**, a wholly owned US subsidiary of **Japan Storage Battery Co. (JSB)**. GS Battery will supply its large (50Ah to 190 Ah) lithium-ion cells for EaglePicher to package into custom battery systems for military and special-purpose applications. The Li-Ion supply agreement complements EaglePicher's existing nickel-hydrogen and silver-zinc technology.

June 17. **Voller Energy (UK)** and **Palcan Fuel Cells Ltd.** announced that Voller Energy has selected Palcan's PC-150 fuel cell stack as the power source in the Voller Energy VE100 portable fuel cell system. Voller Energy designs battery rechargers and mobile generator products. The new Voller Energy VE100 hand-held recharger is roughly the size and weight of a laptop computer, and provides both AC and DC output.

July 2. **ConocoPhillips**, Maribor, Slovenia, is closing a deal with the Croatian company **Utilitas** for the purchase of a new electrolyte technology. Utilitas has developed a self-regenerating and environmentally safe electrolyte for long-lasting direct current. The electrolyte is claimed to have practically unlimited durability in a battery or power station, potentially making battery charging or replacement unnecessary.

July 21. **ENER1 Inc.** recently signed a letter of intent with **ITOCHU Corp.**, which calls for ITOCHU to invest \$3.5 million in ENER1 with options to increase ITOCHU's ownership in stages. The two companies expect that ITOCHU will also become a technology and marketing partner with ENER1. ENER1 produces lithium-metal batteries and advanced materials for batteries, solar cells and fuel cells.

Comment. Energy storage is difficult and expensive. Conventional batteries deliver performance that is generally satisfactory at best and aggravating at worst (cell phone batteries being one of the biggest offenders), and their cost per unit of energy stored is dear. The numerous strategic tie-ups represented on this page reflect the growing recognition of the rewards available for building a better battery. Some of these companies are focusing on improving existing

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technologies, particularly lithium-ion and lithium-polymer, while others are developing new architectures and electrolytes.

One new approach is the micro fuel cell, and a modest but growing number of companies are working on various micro fuel cell flavors. While we believe the widespread adoption of fuel cells for stationary power generation is roughly 4-5 years away and something like 15-20 years out for automotive applications, the commercialization of micro fuel cells for portable devices is probably not terribly far off. The reason is simple—the competitive bar is set much lower. As the challenger technology, fuel cells face a much less daunting opponent when they take on batteries; competing against the vast electric power grid or the highly engineered and cost-effective internal combustion engine remain beyond the near-term reach of current fuel cell technology.

July 3. **UTC Fuel Cells**, a **United Technologies** business unit, has signed an agreement with **Hyundai** to jointly develop a new automotive fuel cell power plant capable of operating in freezing conditions, and integrate it into a Hyundai sport utility vehicle platform. Financial terms of the agreement were not disclosed. UTC Fuel Cells and Hyundai have worked together on fuel cell vehicle development since 2000, when the companies unveiled the first Hyundai Santa Fe fuel cell SUV at the California Fuel Cell Partnership opening ceremonies. A total of six Hyundai fuel cell Santa Fe prototypes were produced under the previous agreement.

July 3. **Hoku Scientific** announced that it has formed a joint development relationship with **Sanyo Electric Co.** to work on a new membrane electrode assembly technology for use in Sanyo's proton-exchange membrane (PEM) fuel cell. The membrane electrode assembly will incorporate Sanyo electrode technology and the Hoku Membrane product. The joint development relationship includes financial, service and technical contributions of both companies totaling more than \$6 million. Joint development work is planned for the next 18 months, and a successful outcome would likely serve as the basis for a long-term customer-supplier relationship between the two companies.

June 26. **Avista Corporation** subsidiary **Avista Labs** recently announced it has entered into a collaborative agreement with Scottish fuel cell integrator **SiGEN** to develop and sell fuel cell systems. Under the agreement, which runs through May 2005, SiGEN will be a non-exclusive distributor and service agent in the U.K. for Avista Labs' fuel cells. Avista Labs said SiGEN has agreed to purchase a "small number" of Independence fuel cells this year, and a larger number next year.

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June 24. **American Superconductor** and **GE's Industrial Systems** division announced the renewal and expansion of their joint marketing and sales agreement. The two companies have jointly marketed and sold AMSC's power electronics-based transmission reliability systems since 2000. Customers include **Alliant Energy, BC Hydro, Entergy, PacifiCorp, Tennessee Valley Authority,** and **Wisconsin Public Service.**

Under terms of the new agreement, GE Industrial Systems will see its exclusive rights to market American Superconductor's transmission reliability systems expand from North America to include South America as well. GE will also market AMSC's industrial and utility-grade power quality solutions in certain other geographies.

June 16. **Fuel-Tech N.V.** and **Peabody Energy** agreed to jointly market Fuel-Tech's Targeted-In-Furnace Injection technology. FuelTech's Targeted-In-Furnace Injection controls slagging and fouling in furnaces and boilers using a variety of fuels. Fuel-Tech stated that the agreement will help it penetrate the coal-fueled utility market. Peabody Energy is one of the largest coal companies in the U.S.

June 11. **Waukesha Electric Systems** and **Cooper Power Systems** have announced an agreement in which Waukesha's service organization will provide field retrofill services using Cooper Power Systems' new environmentally friendly Envirotemp FR3 coolant for transformers and substation equipment. FR3 is a biodegradable vegetable oil-based dielectric (i.e., insulating) coolant formulated for use in electrical distribution and power equipment. FR3 is advertised as offering cost savings and fire and environmental safety benefits compared to standard petroleum-based coolants, as well as extending the transformer's operating life.

June 9. **Motorola** and **PowerDsine Ltd.**, a developer in power-over-ethernet (PoE) solutions, are jointly developing an application-specific integrated circuit (ASIC) for the emerging PoE market. The 802.3af-compliant chips will be based on Motorola's SMARTMOS technology and PowerDsine's Power-over-LAN technology. The first chip will integrate power, analog and logic functions into one device. Using the ASIC, networking OEMs will be able to directly integrate power supply into chip design. PowerDsine is expected to sample products to customers by the end of 2003, with volume production expected in early 2004.

June 6. **Pacific Hydro** of Australia recently announced it has formed a joint venture, **Seapower Pacific Pty, Ltd.**, with marine engineering research and development company, **Seapower Pty, Ltd.**, to develop a wave energy system capable of producing both electricity

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and desalinated water. The underlying technology has been under development since 1999 by **Carnegie Corporation** and Seapower Pty, Ltd. In-sea testing is scheduled to commence in early 2004.

June 5. **Kyocera Corporation** announced that it will invest \$2.2 million to construct a new solar module assembly plant in Tianjin, China. Kyocera will set up a joint venture, **Kyocera (Tianjin) Solar Energy Co. Ltd.**, with partner **TianjinYiqing Group Co. Inc.** which will take a 10 percent stake. Operations will commence in October and will include module assembly, systems design, sales, maintenance and service. The Tianjin plant is expected to have a production capacity of 12MW by the end of 2004.

June 2. **FuelCell Energy** signed an agreement with **Alliance Power** to integrate FuelCell Energy's Direct FuelCell power plants into Alliance Power's portfolio of distributed generation solutions. Alliance Power is a developer of distributed generation facilities ranging in size from 1MW to 49MW. Alliance Power will focus its marketing efforts in California to take advantage of high electric rates, a favorable regulatory environment for fuel cells and state incentives.

May 23. **Metallic Power** and the Outside Plant, Power and Services group of **Marconi** announced a partnership to provide zinc-based backup power sources for telecom equipment. The turnkey power systems will be marketed in the US, Canada and Mexico. As part of the agreement, Marconi will install and maintain the systems through its services group.

May 14. **Nuvera Fuel Cells**, a developer of fuel cell systems, fuel processors, and fuel cell stacks, and **FIAMM S.p.A.**, one of the world's largest lead acid battery manufacturers, announced they will jointly develop a 7 kW class hybrid battery/fuel cell power pack for forklifts. The new hybrid power pack consists of Nuvera's H2e power module, FIAMM batteries, a hydrogen fuel system, a battery management system, and balance of plant components. Advantages claimed for the system include lower operating costs, lower capital costs if amortized over a 10-year period, reduced maintenance, and improved productivity due to high performance and reduced operator downtime.

The two companies will engage in a 2-year, 3-phase product development effort that is expected to yield commercially available products as early as 2005. FIAMM will receive exclusive rights to market and sell the hybrid power packs in Europe. FIAMM and Nuvera believe that other potential offroad applications for the hybrid system could include industrial hauling equipment, baggage tractors, tow tractors, and belt loaders.

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May 13. **Manhattan Scientifics** announced that the company has issued a non-exclusive patent license of its NovArs fuel cell technology to **Ballard Power Systems**. Manhattan Scientifics received an initial payment of \$300,000 concurrent with the execution of the license agreement, which provides unlimited use rights to Ballard of its proprietary technology. Ballard is obligated to make an additional payment of \$200,000 upon commercial launch of a product using the technology. The NovArs fuel cell is a hydrogen/air PEM system that has been demonstrated in a variety of applications requiring power outputs from 2W to 3,000W.

May 9. **Dow Chemical** and **General Motors** have formed an agreement in which GM will supply fuel cells to power one Dow plant, with the possibility left open for Dow to buy or lease 500 more units (35MW) by the end of the decade. If the initial phase of the agreement works out and Dow proceeds to buy more fuel cells, it could become the largest user of fuel cell-powered electricity globally. The test is expected to begin during the fourth quarter of 2003 and to run through 2005, with plans to commercialize starting in 2006. Dow will supply the hydrogen to drive the fuel cells, which will come as a byproduct of its chlorine manufacturing processes.

May 6. **DTE Energy Technologies** and **European Power Systems (EPS)** announced today the signing of its third European distributor agreement in the last thirty days. DTE Energy Technologies will provide its broad portfolio of onsite energy system technologies for energy monitoring and management to EPS for distribution in Italy. European Power Systems has over 20 years experience in the onsite power system industry, as well as a broad knowledge of co-generation and renewable energy systems.

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M&A ACTIVITY

July 28. **Volt Inc.** announced that it has purchased all the outstanding shares of Michigan-based utility **Wolverine Power** for cash and preferred stock. The major assets acquired include hydro-electric turbines which generate over 10 megawatts of power, the Federal Energy Regulatory Commission (FERC) License and the Power Purchase Agreement (PPA) with Consumers Energy which runs through the year 2022. Historical revenue from the PPA is approximately \$1 million dollars annually. Volt Inc. provides and markets alternative energy and financial services.

July 18. French cable maker **Nexans** announced that it was in talks with cash-strapped heavy engineering firm **Alstom** over the sale of its transmission and distribution equipment unit. Nexans has not yet made a firm offer for the unit, although the *Les Echos* newspaper reported that Nexans had offered 1.05 billion euros for the unit to be financed with bank loans, a capital increase and a share issue underwritten by Alstom.

July 17. **Itron, Inc.** announced that it has agreed to acquire the **Schlumberger Electricity Metering** business (SEM) for \$255 million, or about 1.1 times 2002 sales with SEM's strong position in digital. The acquisition combines Itron's leading position in automatic meter reading technology (AMR) electricity metering units. Bear, Stearns acted as financial advisor to Itron and is providing committed financing for the acquisition.

Itron expects that SEM will significantly increase its revenues, earnings and cash flow. The strategy driving the deal is that it should enable Itron to offer greater integration of data collection, management and application. SEM, based in Oconee, South Carolina, has been serving the electricity metering industry for over 100 years and is a leading manufacturer of electricity meters for the North American market. In North America, SEM has approximately 3,400 utility customers and an installed base of 35 million meters, representing approximately 30% of all meters in use. SEM had revenues of \$229 million and EBITDA of \$33 million in 2002.

June 24. **Energy Conversion Devices (ECD)** announced that it has acquired the interest of **Texaco Energy Systems LLC (TES)** in **Texaco Ovonic Fuel Cell Company LLC** for \$1.00, effective as of December 31, 2002. Energy Conversion Devices and TES, a unit of **ChevronTexaco**, formed the 50/50 joint venture in September 2000 to develop ECD's regenerative fuel cell technology. The company, which is now owned 100 percent by ECD, will be renamed **Ovonic Fuel Cell Company LLC**. The new entity will continue to focus its efforts on designing cell systems for portable and stationary applications (50W – 1,000W). Work on fuel cells for transportation is also underway.

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ECD and ChevronTexaco continue to support two other joint ventures, **Texaco Ovonic Battery Systems LLC**, a manufacturer of nickel metal hydride (NiMH) batteries for both automotive and non-automotive applications, and **Texaco Ovonic Hydrogen Systems LLC**, to develop and advance the commercialization of ECD's solid hydrogen storage technology.

Comment. This is the second ECD joint venture to unravel in recent months, the first being a partnership to develop solar power technology with Bekaert NV (*see page 38 for details*). Bekaert pulled out of the solar power JV because the time and cost involved to bring ECD's technology to commercialization was proving to be too long. While no reason was given for ChevronTexaco's decision, we note that ChevronTexaco remains committed to Texaco Ovonic Battery Systems which is shipping product already, as well as to the Hydrogen Systems joint venture which is developing hydrogen storage solutions using similar metal hydride technology to the commercially producing battery systems business. In other words, ChevronTexaco is remaining engaged with those joint ventures that are either generating revenue already or that are developing products based on technology that has proven commercial in other applications.

As with Bekaert in solar, it could be the case that the fuel cell development road was too long, and ChevronTexaco simply ran out of gas. ChevronTexaco may have backed out of the Fuel Cell partnership because the time to market and the cost to get there appeared too high—the same reasons that led Bekaert to abandon an \$84 million investment in its solar power JV with Energy Conversion Devices.

May 29 **Arch Coal** announced its purchase of **Vulcan Coal Holdings LLC** for \$364 million. This deal follows on the heels of several others in the coal industry—**Questor Management** bought two coal mines from **U.S. Steel Corp.** for \$50 million, and **Peabody** acquired full control of **Black Beauty Coal Co.** for \$90 million.

The outlook for coal is strong. High natural gas prices have encouraged power generators to switch to coal where they can, and coal inventories are low. Prices for coal are expected to rise 30 to 40 percent over the next 12 months.

May 27. **Infineon Technologies AG** announced that it plans to acquire **SensoNor ASA** of Norway, a provider of tire pressure and acceleration sensors, for about \$56 million, aiming to strengthen its position in semiconductor sensors for the automotive business. As part of the offer, Infineon wants to purchase 138.5 million shares from institutional and private investors at a price of about \$0.29 per share, an investment of about \$41 million. SensoNor will also issue 100 million new shares to Infineon for a cash contribution of \$0.15 per share, making an equivalent total of about \$15 million.

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Comment. This is the second acquisition of an automotive power electronics company in recent months. There is a reason why a large strategic player like Infineon wants to increase its presence in this segment. The electrical requirements of the automobile is rising rapidly, from around 1kW in 2000 to an estimated 5kW-10kW by the end of the decade. The replacement of mechanical drives and switches with electric-powered systems, and the growing use of communications equipment, GPS trackers and entertainment systems, are among the factors behind this change. The result is that the value of power electronics per vehicle could increase from about \$10 - \$20 today to as high as \$100 over the next 5 - 10 years. A smart company like Infineon does not intend to miss this opportunity.

May 22. **Proton Energy Systems, Inc.**, a developer of hydrogen generators and regenerative fuel cell systems, announced that it will acquire **Northern Power Systems, Inc.**, a leader in the design, manufacture, and installation of integrated on-site power systems for stationary commercial and industrial applications. Proton will pay \$27.5 million to Northern's security holders, approximately two-thirds in cash and the balance in Proton common stock. Northern's security holders will also receive warrants to purchase approximately 2.5 million shares of Proton stock. Proton also made a special cash distribution of \$1 per share, or about \$33.5 million, on June 20, 2003 to shareholders of record as of June 6, 2003.

Comment. This deal offers a number of positives to both sides. For Proton, which has been focused on technology and product development, Northern Power adds significant sales and marketing capabilities. In addition, its cash burn should be reduced by cash flow contributions from Northern Power, which has a long history of cash flow generation and profitability. For Northern Power, benefits include access to a large cash pool for use as working capital to grow the business more rapidly, access to potentially important technology for power generation and power reliability applications, and liquidity for the company's owners.

May 15. **Ind. Int. Inc.** (INDI) entered into an agreement to purchase all issued and outstanding shares of **Li Sun Power Int. Ltd.** The transaction will make INDI the beneficial owner of about 72.83 percent of **Wuhan Lixing Power Sources Co. Ltd.** (Wuhan, China), a lithium and lithium-ion battery manufacturer.

Wuhan Lixing employs about 860 employees. In 2002, it produced about 82.5 million disposable lithium batteries, 3.5 million rechargeable lithium-ion batteries, and 54,000 units of chemical composition equipment and testing equipment for lithium-ion batteries.

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May 14. **Energy Conversion Devices** announced it has entered into agreements with **N.V. Bekaert S.A.** and an affiliate (Bekaert) whereby ECD has acquired all of Bekaert's interests in their **United Solar Systems Corp.** and **Bekaert ECD Solar Systems LLC (Uni-Solar)** joint ventures, established in April 2000 by ECD and Bekaert to manufacture and sell solar power systems. ECD will pay Bekaert \$6 million and assume certain liabilities totaling about \$25 million, and Bekaert will receive rights to technologies outside the field of solar power and rights limited to build sputtering machines outside the field of triple-junction solar power.

May 1. **Ferrotec Corp.** recently acquired **Teledyne Energy Systems'** line of thermoelectric power generation modules and its Telan series of power generation systems. Thermoelectric power generation systems convert natural gas or propane to electrical power using small solid-state devices that convert thermal energy to electrical energy. They are typically used in remote locations where power is required but solar energy is intermittent or insufficient.

RESTRUCTURINGS

July 31. **Energy Conversion Devices** (ECD) announced a series of initiatives aimed at focusing on its solar power and NiMH businesses and reducing operating costs. Workforce reallocation and reductions of up to 20%, along with salary freezes and discretionary spending cuts are being implemented. The cost containment initiatives will start immediately and should be fully implemented by Jan. 1, 2004. In aggregate, they are expected to save the company from \$19 - \$25 million annually. ECD also continues to search for potential strategic partners to help shoulder the cost of development of its fuel cell technology in the wake of **Chevron Texaco's** exit from the ECD-Texaco fuel cell joint venture.

July 29. **Ballard Power** wrote off its equity investment in **MicroCoating Technologies** (MCT) by taking a charge of \$7.3 million (or \$0.06 per share). The decision was made based on management's review of MCT's financial condition and future prospects. Additionally, Ballard's management indicated that its in-house catalyst coating technology was chosen over that of MCT. Ballard and MCT had entered into a collaboration, supply and license arrangement in May 2001 for next-generation catalyst application technology as one of a number of catalyst reduction pathways. Ballard retains a non-exclusive license for MCT's proprietary catalyst application processes.

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July 25. **AstroPower's** common stock was delisted from the Nasdaq National Market effective July 25, 2003. The delisting was a result of AstroPower's previously announced failure to timely file its Annual Report on Form 10-K for the December 31, 2002 fiscal year and its Quarterly Report on Form 10-Q for the first quarter of 2003 because of its ongoing review of revenue recognition matters. AstroPower's common stock will not be eligible to trade on the OTC Bulletin Board until the company becomes current in all of its periodic reporting requirements under the Exchange Act of 1934, and a market maker thereafter makes an application to register in and quote the company's common stock in accordance with applicable SEC requirements.

In addition, AstroPower announced that it has engaged Bridge Associates LLC, a restructuring, turnaround management and expanded capabilities firm, to take charge of day-to-day operations, stabilize the company's financial position and make recommendations on strategy. Carl Young, a founding member and Managing Director of Bridge Associates, will serve as AstroPower's new interim Chief Executive Officer. Eric Glassman, another Bridge Associates professional, will serve as AstroPower's new interim Chief Financial Officer.

May 29. **Ballard Power Systems** announced that it is discontinuing the development of its natural gas- and hydrogen-powered internal combustion engine gensets after only a year of effort. According to the company, there were system-related issues with the high-speed natural gas genset, and the cost to resolve them would have made the gensets uncompetitive. Therefore, the hydrogen fueled genset, with its more limited market potential, would have had to carry the entire cost of development.

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Powering Down — Two Companies Exit the Power Electronics Industry

May 18. **Minebea Co. Ltd.**, parent company to **NMB Technologies Corp.** (NMB), has announced its withdrawal from the power supply industry by the end of 2003. In response to rapid changes in the business environment, Minebea is focusing all efforts and resources on the company's core business areas of electro-mechanical components (ball bearings, cooling devices, and motors), keyboards, and audio speaker components. Minebea will continue to maximize its competitive advantage of ultra-precision machining and mass production technologies in the manufacturing industry. The company will also continue to provide Global Product and Account support to address the technical and operational needs of each customer.

May 9. **Ascom Energy Systems AG** (Switzerland) has agreed to sell its Energy Systems Business Unit to **Delta Electronics (Thailand) Public Co. Ltd.** (Taiwan) for a net cash consideration of approximately CHF150 million (about US\$110 million) plus the assumption of certain long-term liabilities of about CHF30 million (about US\$20 million). With this acquisition, Delta picks up three of Ascom's product lines—telecom power systems, board-mounted power supplies and custom power systems.

The sale of the Energy Systems Unit is part of Ascom's strategy to focus on "a few core markets with good growth potential and profitability as well as low capital intensity." The divestment will allow Ascom to further reduce debts and streamline its balance sheet structure. The Energy Systems Business Unit complements the offerings and global presence of Delta Electronics.

Comment. Over the last six months, there have been a number of segment divestitures and company sales in the power electronics industry covering specific product areas such as defense power electronics, board-mounted power converters, and power quality devices such as power factor corrections systems and harmonic filters.

Although defense-related power electronics companies have continued to see solid demand, the long depression in computing and communications spending has strained the financial resources of most power electronics companies. In such times, it is not surprising that there has been consolidation in the large but fragmented power electronics industry. What is noteworthy is the exit of a major player like Ascom at a time when tech and telecom demand appears to be stabilizing.

Barring the introduction of a new paradigm-shifting, we believe the secular growth rate of computing and communications industry (and therefore the growth rate of the broad power electronics industry) will be about 5-10%. Certain market segments may outperform; defense power electronics should be one. Apparently, looking at the glasses in front of them, Ascom and Minebea saw half-empty rather than half-full.

The DataWerks

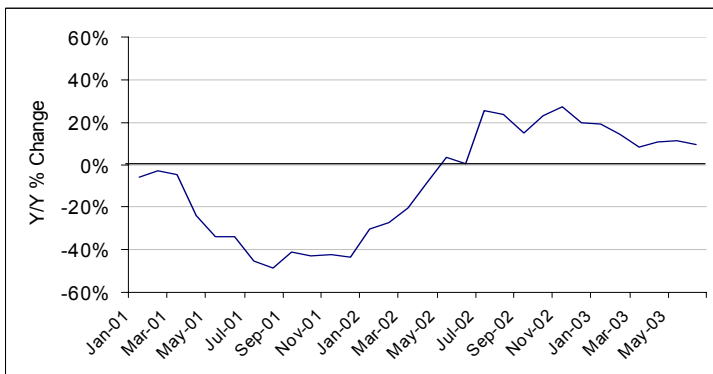
A Statistical Look at Energy Tech Industry Trends

Semiconductor Shipments

(Semiconductor Industry Association unadjusted monthly data)

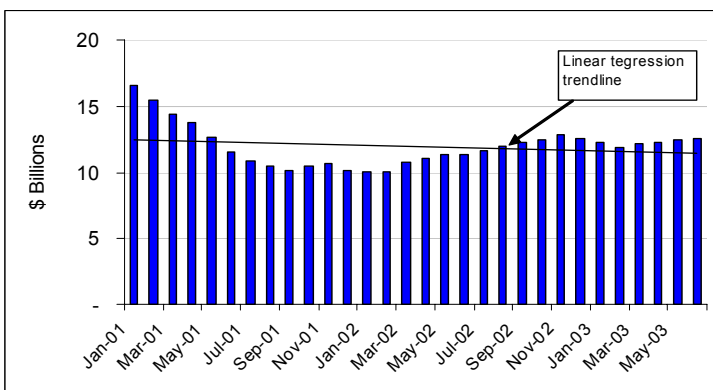
A broad measure of technology industry health. Given that virtually every information processor—logic chip, DRAM, DSP, integrated circuit (IC), etc.—requires a power conversion device—a power semiconductor, embedded power supply, rectifier, and so on, and possibly power quality protection as well—semiconductor shipments also reflect demand for a range of power technologies.

Monthly Shipments—Y/Y % Change, Jan 2001 - Jun 2003



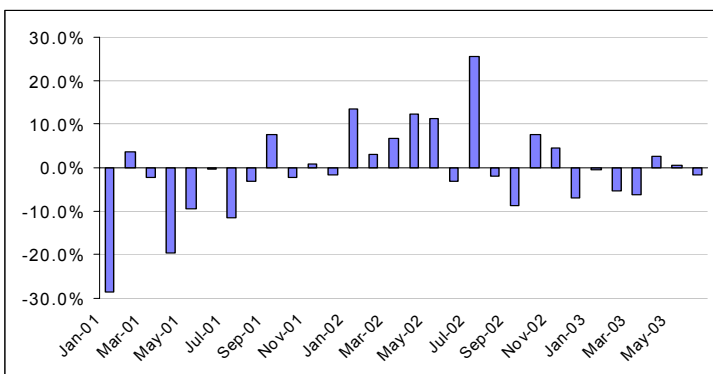
The recovery in year-over-year semiconductor shipment growth began last July. However, the rate of growth has been slowing, and the comparisons become yet more difficult soon. Recent semi shipment trends could be read as a signal that the big rebound in sales is behind us, and the industry is settling into a period of modest growth.

Shipments—3-month moving average, Jan 2001 - Jun 2003



The semi industry often looks at data on monthly shipment values by using a 3-month moving average to smooth out the characteristic spike in shipments in the third month of the quarter. The data shown here, fitted with a linear regression line to establish a rough trend, suggests the same scenario of modest but flattening recovery from the lows of 2H01-1H02.

Shipments—Change in Y/Y % Growth, Jan 2001 - Jun 2003



This graph, showing the change in the rate of semi shipment change, is a simple momentum indicator — is the rate of growth or decline accelerating or decelerating? Here again we see an industry that made a big move up beginning in the first half of 2002, but saw its growth trajectory stabilize in more recent periods.

The DataWerks (cont'd)

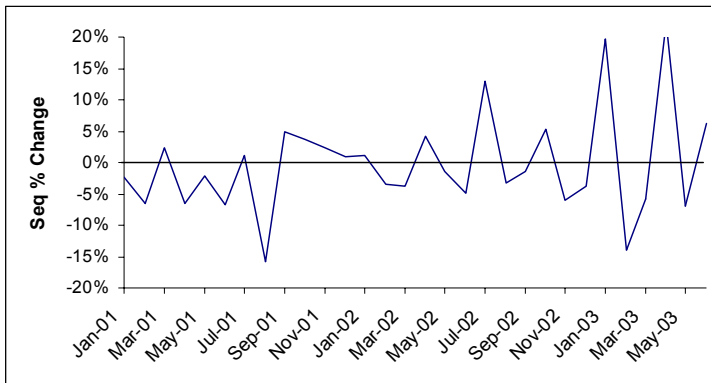
A Statistical Look at Energy Tech Industry Trends

Computers, Storage Devices & Peripherals

(US Census Bureau, seasonally adjusted monthly data)

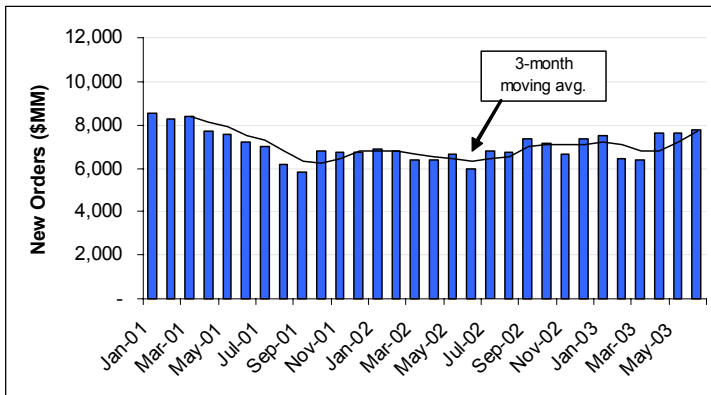
Computer, server, storage device and peripherals sales create pull-through demand for certain types of power conversion systems, such as ac/dc power supplies, voltage regulation modules, point-of-load converters and uninterruptible power supplies.

Monthly Shipments—Sequential % Change, Jan 2001 - Jun 2003



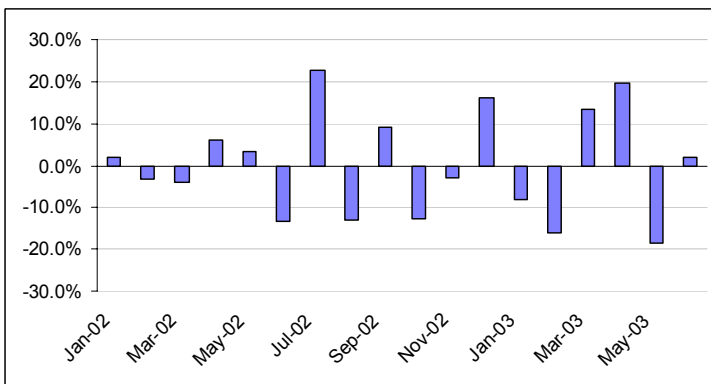
This first graph, showing the sequential change in shipments of computers and related devices, shows considerable volatility in recent months. The underlying trend has been modestly positive, with the swings in growth remaining wider than the swings back down.

Monthly New Orders, Jan 2001 - Jun 2003



Order activity in the last several months appears to have broken out of a long stretch of weakness. June orders finally topped the level set in April 2001, the point at which the real breakdown of computer-related spending began.

New Orders—Change in Seq. % Growth, Jan 2002 - Jun 2003



This graph, showing the change in the rate of monthly orders change, is a simple momentum indicator. The positive momentum of the first couple months of the year has faded, suggesting for now at least that further growth will be more steady-state than spectacular.

The DataWerks (cont'd)

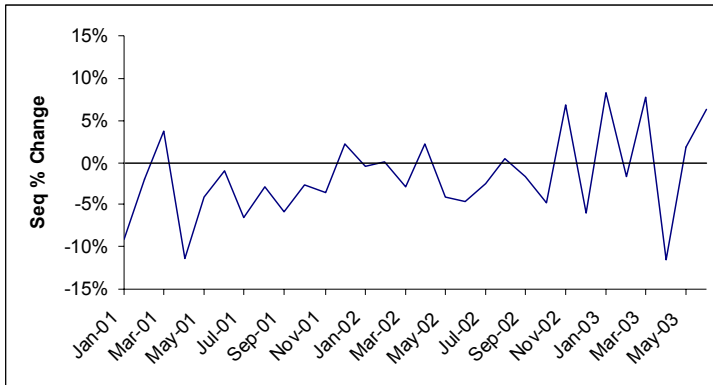
A Statistical Look at Energy Tech Industry Trends

Communications Equipment (non-defense)

(US Census Bureau, seasonally adjusted monthly data)

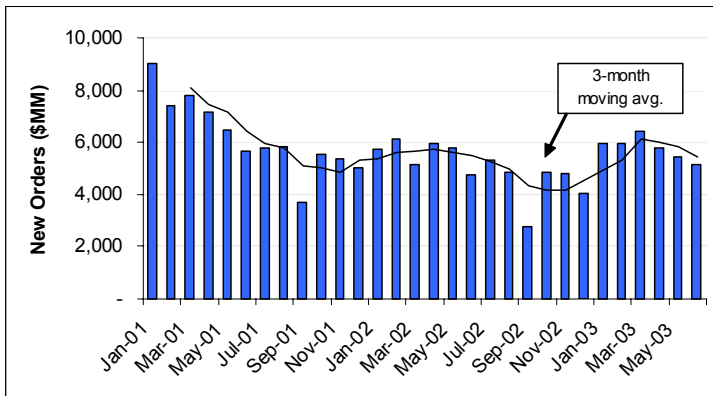
Sales of communications hardware such as switches, routers, wireless base stations and repeaters, generate demand power conversion systems such as power semiconductors, ac/dc front ends, board-mounted dc/dc bricks, and dc power plants.

Monthly Shipments—Sequential % Change, Jan 2001 - Jun 2003



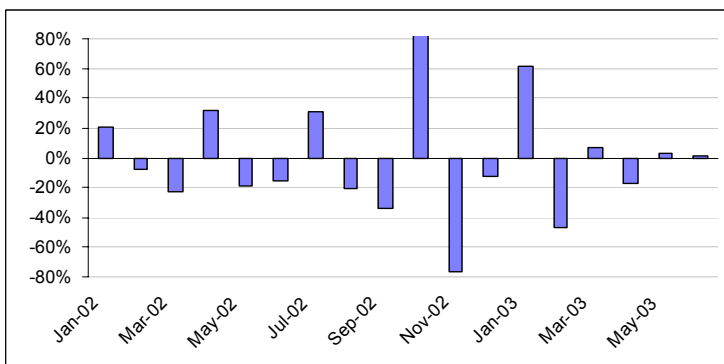
After nearly two years in which sequential changes in communications equipment shipments were overwhelmingly negative, early signs of life appeared in November 2002. However, shipment growth remains uneven, and the industry has not yet established clear positive momentum.

Monthly New Orders, Jan 2001 - Jun 2003



New order activity bounced off its lows in the late 2002, but after peaking in March 2003 it has rolled back over. We expect the falloff in new orders will soon erase the gain in shipment growth of the last month or two. Growth in this industry remains elusive.

New Orders—Change in Seq. % Growth, Jan 2002 - Jun 2003



This graph, showing the change in the rate of monthly orders change, is a simple momentum indicator. The readings here show that the decline in new orders that began in April has decelerated.

The DataWerks (cont'd)

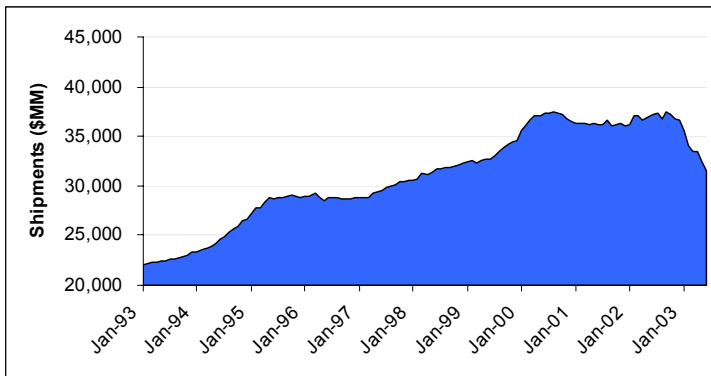
A Statistical Look at Energy Tech Industry Trends

Turbines, Generators & Other Power Transmission Equipment

(US Census Bureau: seasonally adjusted monthly data)

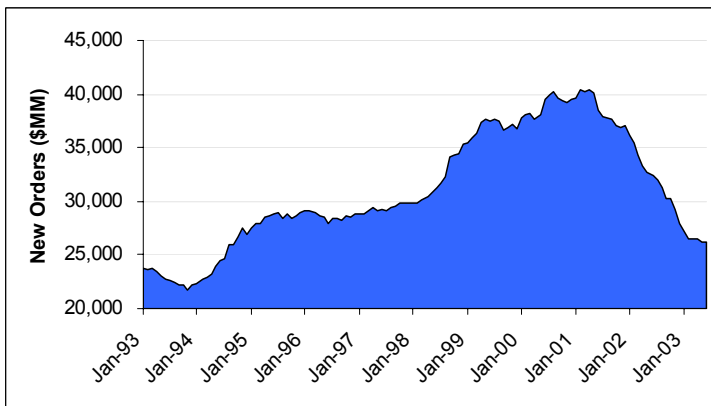
A measure of utility industry investment in large capital equipment. Reflects the spending required to maintain the installed power infrastructure and build the new capacity needed to meet demand for electricity.

Rolling 12-Month Shipments, Jan 1993 - Jun 2003



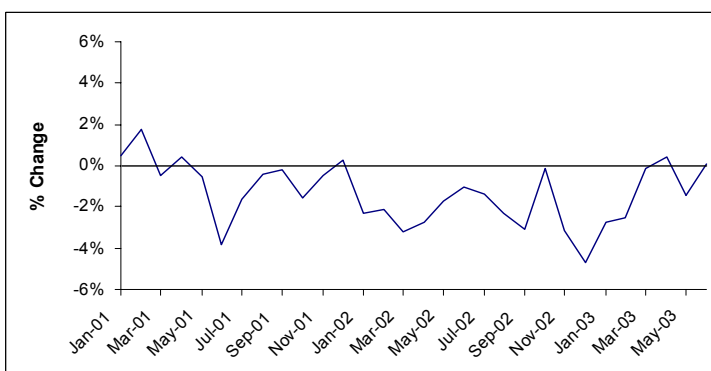
The long-term look at power equipment shipments points to a sharp fall-off in shipments after a strong multi-year run.

Rolling 12-Month New Orders, Jan 1993 - Jun 2003



The long-term data on new order activity shows that after a steep decline, the worst may be over. Since orders for power equipment are placed as long as 2-3 years before shipment is expected, new orders data is a key leading indicator of future shipment value.

Sequential Change, Rolling 12-Month New Orders, Jan 2001 - Jun 2003



Zooming in on new order activity within the last 2 years, we see that the trend has been clearly negative. The recent spike in orders is intriguing, but must be confirmed by additional data.

Inductance & Reactance

Occasional Comments and Random Observations

“A revolution is not a tea party.”
-- *Mao Zedong*

REVOLUTIONARY POWER

The Relentless Rise of Direct Current

A revolution is underway. The century-long supremacy of alternating current is under attack from a growing army of direct current devices. The rise of the microprocessor over the last half century has created widespread and growing demand for direct current (DC). Since basically every chip is a DC device, computers, telecom equipment, printers, DVD players, microwave ovens, anything with a chip, requires direct current. At the same time, technologies for direct current power generation, such as solar panels and fuel cells, are reaching commercialization, and DC has become the current of choice among the merchant transmission companies building their own power lines.

The growth of both DC demand and supply has profound consequences, all the way from the electric utility network down to the printed circuit board. In this issue, we introduce the basic concepts of alternating current (AC) and direct current, and point to important uses and sources of DC power. Over the next several issues we will discuss in more detail the implications of the DC power revolution—including the growth of a \$25+ billion power electronics industry, the emergence of DC-based power generation and storage, the case for creating DC “microgrids” in commercial and industrial facilities, and the possibility of sophisticated control over utility grid power flows. Along the way we will share our thoughts on the potential beneficiaries (and losers).

Current, Voltage and Power

Current and voltage are the basic building blocks of power. If electricity is like a shower, then current is the amount of water flowing, and voltage is the pressure of the flow. Power is measured in watts, and equals current (denominated in amperes, or amps) times voltage.

$$\text{Amps} * \text{Volts} = \text{Watts}$$

Current – Two Flavors

Just as water flows downhill, so does electrical current flow from the point of higher potential (the positive terminal) to the point of lower potential (the negative terminal). In a **direct current** (DC) circuit, energy flows continuously in a single direction, from the positive terminal

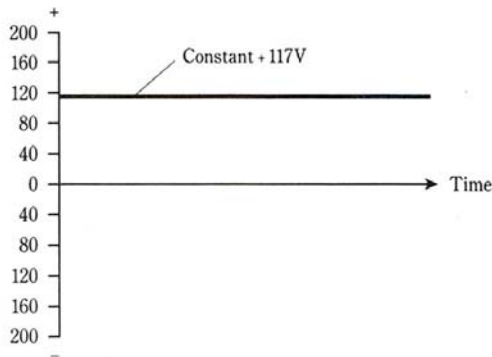
Inductance & Reactance (cont'd)

Occasional Comments and Random Observations

to the negative terminal (technically, electrons flow from the negative terminal, where they have accumulated, to the positive terminal, where their numbers are smaller, but the convention is to speak of current flowing from plus to minus). With DC, voltage across the two terminals does not change polarity (switch from positive to negative)—voltage stays constant over time. The world's first utility network, installed in lower Manhattan by Thomas Edison, ran on direct current. As a historical aside, Edison's Pearl Street utility company actually sold lighting, not electricity, and many of the power companies founded in the early days of the industry have names that reflect this legacy – Florida Power & Light, Carolina Power & Light, etc.

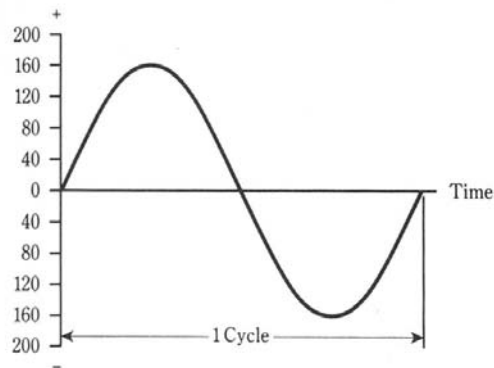
With **alternating current** (AC), on the other hand, the electron stream flows through a circuit first in one direction, then in the other. The voltage in an AC circuit is changing continuously, from positive to zero to negative to zero to positive and over again. Each round trip from positive back to positive is a cycle, and the number of cycles per second is the AC frequency (expressed in Hertz, or Hz). Standard alternating current in the US is 60Hz, and in Europe it is 50Hz.

Figure 1. Direct Current and Alternating Current



Direct Current

Voltage remains constant over time



Alternating Current

Changing voltage forms a sine wave

It's an AC world...

Although the original utility grid delivered direct current, wall sockets everywhere in the world today serve up alternating current. Why the switch? The choice between DC or AC was the subject of fierce debate, with Thomas Edison taking one side and Nicola Tesla and George Westinghouse the other. The issue of voltage transformation determined the winner. Edison's

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DC power networks turned out to be impractical at the time, because the technology did not exist to economically transform (raise or lower) DC voltage (see Figure 2 on p. 48).

The question, then, is why ease and cost of voltage transformation mattered. The answer lies in the power distribution strategy of the nascent utility industry. To achieve economies of scale, electricity infrastructure planners drew up blueprints for massive central power plants to generate electrons billions at a time. Long-distance transmission lines would then carry and distribute the power to the ultimate point of use. Here is where voltage transformation becomes important.

Virtually all materials resist electricity. Wood, glass and most gases are highly resistant, for example, while copper and silver offer very little resistance—in other words, they are highly conductive. Resistance means loss. Electric power resisted by the conductor converts to waste heat, and does not do the work for which it was intended.

Resistance is a function of voltage times the square of the current, so high current / low voltage power means high resistance and large losses. To limit line transmission losses due to the inherent resistance of the copper conductor, power carried over long distances would have to be high voltage and low current. Utility power plants generate electricity at about 24 kilovolts (kV), but efficient transmission requires voltage levels roughly an order of magnitude higher. Typical long-haul transmission voltages include 138kV, 345kV, 500kV and even 768kV.

Of course, power flowing at 345,000 volts would basically vaporize 110-volt household appliances. Thus, the 24kV power from the utility generator, that was transformed to 138kV – 768kV for long-distance transmission, at some point must be transformed back down to distribution-level voltages (such as 14kV), then to industrial-grade (480V) and finally household voltages (110V / 220V).

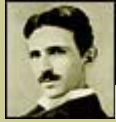

The chain of logic that concluded with the triumph of AC was therefore the following.

- Electric utilities preferred to generate power in massive central plants to achieve economies of scale and keep cost low.
- The power generated at these central facilities would be carried for tens or possibly hundreds of miles and distributed to their final point of use.
- To contain line losses to acceptable levels, power coming off the generator would be transformed from about 20kV to 155kV - 765kV, then transmitted long distances. For this power flow to be usable by household device as it drew closer to the point of use, its voltage would be gradually reduced in a series of steps to 110 volts.
- The need to raise and lower the voltage in a step-like fashion placed a premium on ease and efficiency of transformation. In a contest on those terms, based on available technology, DC could not compete. Edison's localized DC grids were soon displaced by large-scale AC networks.

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Occasional Comments and Random Observations

Figure 2. Tesla versus Edison: An Electrifying Debate

 Nicola Tesla	 Thomas Edison
"Alternating Current will allow the transmission of electrical power to any point on the planet, either through wires or through the air, as I have demonstrated."	"Transmission of AC over long distances requires lethally high voltages, and should be outlawed. To allow Tesla and Westinghouse to proceed with their proposals is to risk untold deaths by electricide."
"How will DC power a 1,000 horsepower electric motor as well as a single light bulb? With AC, the largest as well as the smallest load may be driven from the same line."	"The most efficient and proper electrical supply for every type of device from the light bulb to the phonograph is Direct Current at low voltage."
"A few large AC generating plants, such as my hydroelectric station at Niagara Falls, are all you need: from these, power can be distributed easily wherever it is required."	"Small DC generating plants - as many as are required - should be built according to local needs, after the model of my power station in New York City."

Source: Nextek Power Systems

Or is it a DC world?

For much of the twentieth century, an AC utility network powered AC loads. Almost all electrical equipment plugged into that network was in some way either a light, a motor or both, and those lights and motors were well-suited for an AC world. The supremacy of AC began to erode with the expansion of the wireline and wireless telecom infrastructure, the advent of fluorescent lighting and the rise of the microprocessor, all of which operate on DC power.

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Occasional Comments and Random Observations

Figure 3. A Shift in Power – Electrical Devices Compared

AC Devices 1958	DC Devices 1998
<ul style="list-style-type: none">• Electric Typewriters• Adding Machine	<ul style="list-style-type: none">• Computers• Printers• CRTs• Scanners• CD-ROMs• Photocopier
<ul style="list-style-type: none">• Wired, Rotary Telephones• Teleprinter	<ul style="list-style-type: none">• Wired, Cordless & Touch Tone Telephones• Answering Machines• Modems• Faxes• Videoconferencing• Internet & Intranet
<ul style="list-style-type: none">• Early Fluorescent Lighting	<ul style="list-style-type: none">• Advanced Fluorescent Lighting with Electronic Ballast• Gas Discharge Lighting (Sodium Vapor, Mercury Vapor, Metal Halide, HID)
<ul style="list-style-type: none">• Radios• Early TVs• Record Player	<ul style="list-style-type: none">• IRadios• HTVs• Cassette Recorders• CD Players• Cable & Satellite Decoders• Videocassette Recorders• Games Console
<ul style="list-style-type: none">• Electric Range	<ul style="list-style-type: none">• Microprocessor-controlled Conventional Ovens• Microwave Oven
<ul style="list-style-type: none">• Fans• Furnace	<ul style="list-style-type: none">• Electronically Controlled Central HVAC System

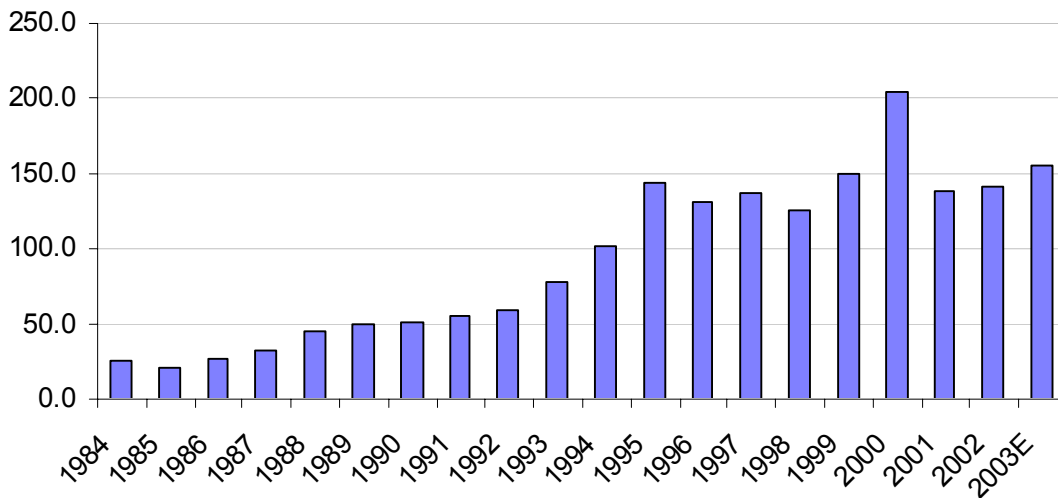
Source: Nextek Power Systems

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Occasional Comments and Random Observations

Except for lighting, common to essentially all members of this growing DC-powered army is the semiconductor-based microprocessor. And microprocessors require direct current. Supplying a logic chip with AC power would disrupt its functions each time the AC voltage passes through zero, which occurs 120 times per second with utility-supplied power. Thus, computers, servers, routers, communications equipment, consumer electronics and other such devices must come equipped with internal or external power supplies that convert the incoming AC from the grid to the DC power they require. These power supplies typically include semiconducting components as well; these semiconductors are designed to manage power rather than 1's and 0's. Therefore, we can use worldwide semiconductor shipments as a very rough proxy for the growth in demand for DC power.

Figure 4. Global Semiconductor Shipments, 1984—2003E
(\$ Billions)



Source: Semiconductor Industry Association

DC Power on Tap

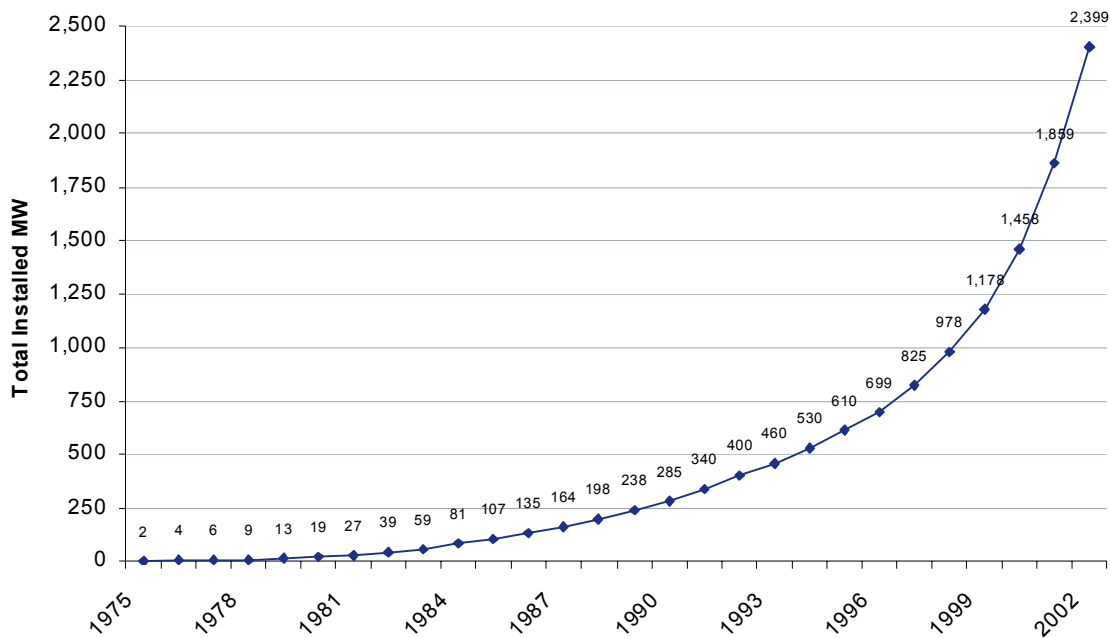
At the same time, the global installed base of DC power generation is growing rapidly (admittedly, from a very small base). Solar power systems and fuel cells of all sizes generate DC, not AC power. Figure 5 below shows the dramatic increase in solar power capacity over the three decades. Additionally, the numerous advanced energy storage technologies on their way to commercialization such as zinc-air, aluminum-air and vanadium-redox batteries and high-speed carbon-fiber flywheels are all DC-based; the same is true for more common battery

Inductance & Reactance (cont'd)

Occasional Comments and Random Observations

chemistries such as lead-acid, nickel-metal hydride and lithium-ion.

Figure 5. Global Installed Solar Power Capacity, 1975 - 2003
(In Megawatts)



Source: Photon International, PV News

DC Power Transmission – Direct and to the Point

Ever backwards into the future, we seem to be inching our way back to Edison's DC infrastructure. Just as new technologies are driving growth in the generation and consumption of DC power, so too are advances in power electronics enabling the increasing use of DC as a means of power transmission.

The first high-voltage DC (HVDC) power cable was commissioned in 1954—a 96km cable conducting 20MW at 100kV, installed in the Swedish electricity grid. The technology used for rectifying AC into DC for transmission across this and other early HVDC cables, the mercury arc valve, was already half a century old at the time. The development of high-voltage semiconductor-based rectifiers around 1960 (the silicon-controlled rectifier, or thyristor) made HVDC transmission feasible in more places and at higher voltages. Figure 6 below provides examples of recent and forthcoming HVDC projects.

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Figure 6. Selected High-Voltage Direct Current Transmission Projects

LOCATION	POWER RATING	DISTANCE	DC VOLTAGE	COMPLETED
Tianshengqiao - Guangzhou, China	1800 MW	960 km	+/- 500 kV	2000
Khlong Ngae, Thailand – Gurun, Malaysia	300 MW	110 km	+ 300 kV	2001
Ballycronan More (Northern Ireland) - Auchencrosh (Scotland)	250 MW	64 km	+250 kV	2001
Talcher - Kolar, India	2000 MW	1450 km	+/- 500kV	2003
Ontario - Lake Erie	1000 MW	120 km	345 kV	2003 (est.)
New South Wales - Queensland	180 MW	59 km	+/- 80 kV	n/a
New Brunswick - Boston - New York - New Jersey	1200 MW	1200 km	500 kV	2003 (est.) - Initial phase permitting
Guizhou - Guangdong, China	3000 MW	980 km	n/a	2005 (est.)

Source: ABB, Siemens, TransEnergie, various regulatory filings

Naturally, there are both advantages and drawbacks to DC power transmission. The positives include increased transmission capacity through the same cross section of conductor; higher active power transfer, especially at long distances; greater operating stability; and smaller line tower requirements. Other things being equal, one mile of DC transmission line is less expensive than one mile of AC, and DC performance is superior. Most importantly, DC transmission enables precise control over the flow of power. This is the main reason why virtually every merchant transmission project announced in recent years uses direct current—the transmission

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line owner must know and be able to demonstrate that it delivered its customers' power in the agreed-upon amount and time of day.

The principal drawback of DC transmission is the cost of the converters that rectify the AC to DC at one end of the power line and invert it back to AC at the other. These converters are a fixed cost—they are required regardless of the line's length. In contrast, a relatively inexpensive transformer is all that is needed at each end of an AC line. Therefore, AC line is usually cheaper for short hauls, but after a certain distance the lower cost of DC line per mile overwhelms the high initial cost of the converters. For overhead lines, the breakeven distance of DC is roughly 500km, with particular projects varying widely around this figure. For underground and undersea cables, the breakeven distance is dramatically shorter—something like 25km – 50km — again, with the actual number ranging widely, depending on specific system parameters. (See J.R. Lucas, *High Voltage Engineering*, 2001).

Summing Up (but not Concluding)

The world of electricity began with direct current, and to direct current it returns. There were good reasons for designing and building a large-scale infrastructure using AC, and those reasons remain valid today. Bulk generation and voltage transformation of AC power still remains simpler and cheaper than DC. However, the champagne days of AC are over, as demand for DC power increases with the sale of every chip, the installed base of DC generation capacity grows, and miles of DC transmission are added.

There is much more to say about direct current. Over the next couple issues, we will look in more detail at specific aspects of DC – the challenges of delivering DC to increasingly power-hungry microprocessors; the emergence of new DC power generation technologies; the opportunities for DC power transmission and even the possibility of real revival of Edison's DC microgrids. Stay tuned.

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Banking on the future of power

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Contact:

James LoGerfo, Principal
Vortex Energy LLC
10 East 29th Street, #37-D
New York, NY 10016
212.252.1883 Phone
646.935.0781 Fax
jlogerfo@vortexenergy.com
info@vortexenergy.com