THE HUBER MILLS power report
Powering Your Investments in the Electron Age

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INAUGURAL ISSUE

The PowerChip Paradigm

Hundreds of billions of dollars per year are going to be invested in new technologies to move, condition, store, and distribute electrons for the Internet Economy.

We are entering the century of the electron.

Not the information century? The communications age? The bit era?

Well, bits are electrons: small buckets of them stored in silicon capacitors, or propelled through metal wire, or (transformed into photons) oscillating through glass or air. Bits are, at bottom, packets of energy that have to be sifted, herded, and propelled across planes of silicon and through tunnels of copper, coax, and glass. This takes electricity: flows of electrons.

Not much electricity—not for just one bit. But the number of bits in motion is growing at big-bang speeds. One result is that while electricity accounted for 25% of our energy consumption 25 years ago, it accounts for 37% today. It will account for more than half U.S. energy use by early in the next century. Most of those additional electrons will flow into information devices. But far more important than the sheer increase in the volume of electrons demanded by information technology is the type of electricity the information economy requires. Bits demand unusually clean, stable, reliable electrons. Electrons for bits cannot be reliably provided by the same old technologies on the same old power grid that powers our light bulbs, electric motors, or air conditioners, or at the same old price.

To accommodate this great energy shift, much of the sprawling infrastructure of the U.S. power grid will have to be rebuilt. Unlikely though it may seem, your century-old power company—stolid and plodding, funded by ratepayer bonds and entangled in sclerotic commissions—is now hitched to the dot-coms. It may prosper with them, or it may end up as road kill, but either way its destiny is now linked to theirs. Hundreds of billions of dollars per year are going to be invested in new technologies to move, condition, store, and distribute electrons. The companies that will do this range from the familiar to the unknown: Caterpillar, Cummins, GE, ABB, American Superconductor, Siemens Westinghouse, Silicon Power, American Power Conversion, Generac, Hitachi, Active Power, Cutler Hammer, Williams, Capstone, Allied Signal, and dozens—or if we include component makers and utilities themselves, hundreds—more.

The New Chip

Compare two silicon chips, side by side. One—call it SmartChip—contains 100 million gates. Each gate operates at one microwatt of power; the entire chip consumes 100 watts. The other—call it PowerChip—contains just one, mammoth gate. But it is big enough to switch a megawatt.

SmartChip is, of course, the building block of the Internet Economy, spanning companies like Cisco, Intel, AOL, and Microsoft; Sun and IBM; E-trade, Yahoo!, and Cnet; Amazon, eToys, and WSJ.com. SmartChip has taken apart and put back together mainframes and micros, switches and routers, banks and brokerage houses, bookstores and newspapers, radio stations and televisions.

And PowerChip? It is now poised to take apart and put back together the trillion-dollar U.S. network of central power stations and transmission distribution lines, and the $500 billion-a-year kilowatt-hour economy.

PowerChip is in fact the older sibling in the solid state family. Selenium diodes, used as switches in power supplies and amplifiers, entered commercial production in the 1950s. International Rectifier—a founding company of solid-state technology—went public in 1958. As IR's founder observes, "selenium diodes begot germanium diodes, which in turn begot silicon diodes, which then resulted in commercial transistors and thyristors, and then begot ICs which begot memory and microprocessors."

Though PowerChip was the first born, SmartChip grew up a lot faster, propelled up the steep curve of Moore's Law by technological advances that etch ever-finer gates, pushing circuits ever closer together, ramping up processing speeds even while pushing down power requirements. As our colleague George Gilder summarizes in the law of the Microcosm, "the less the space, the more the room."

PowerChip lives in a different world altogether. For PowerChip the goal is not to make ever smaller gates requiring less and less power, but ever bigger ones that can switch more and more power, faster and faster. Denied all the rich paradoxes of miniaturization that drove the silicon learning curve for SmartChip, PowerChip technology has proved even more challenging. PowerChip does exactly what a transistor does, uses a smaller current to switch a larger one. But in this case, a much larger one. That turns out to be a very big difference indeed.

The millions of tiny gates in a microprocessor perform their switching at micro-watt power levels. A PowerChip switching "gate," which can switch an entire office building from the utility grid to a backup power source, has to handle kilowatts, or even megawatts. Power-wise, that's about the difference between a hang glider and the space shuttle. At that power density the electrons literally push the atoms of the conductor around and create their own circuits. If you let them.

With a PowerChip, speed is everything. The slower your PowerChip switches, the more heat gets generated while it's flipping from open to shut. Ten milliseconds is no big deal when you're switching 10 watts. In a 10 MW switch, however, a 10 ms switching time means your chip is toast. Today's high-power thyristors meet 1,000 V/microsecond and 400 Amps/microsecond standards. That's fine for switching 6 MW, but still chump change compared to the power levels in the backbone of the electric power grid.

To handle higher power levels, you pile 8 kV/8 MW silicon thyristors into a very tall stack—up to 50 feet high, with lots of extra space for heat sink and cooling. Now, you're set to switch 80 MW—if you can fire all those thyristors exactly simultaneously. But if one of those stacked thyristors goes off even microseconds early, it takes all the power by itself, and explodes.

The pre-history of the PowerChip spanned the two decades between 1975 and 1995. During that period, power ratings of individual PowerChips barely doubled. Nevertheless over the past ten years, the market has grown at a compound annual rate of better than 15%, until by 1997 power conversion semiconductors comprised an $8 billion market.

In the late 1990s, advances in PowerChip technology began to accelerate very rapidly. Today, PowerChip technology is crouched at the sweet spot of its learning curve, at about the same point Intel occupied in its business in 1979: poised for three-digit annual growth, with production volumes doubling or redoubling inside a year, yielding Moore's-Law-like accelerations in switching capacity per dollar. As that happens, PowerChips will seize control of the MWs, as inevitably as SmartChips seized control of Mips.

Today only about 12% of the world's electricity is switched by PowerChip. But 100% penetration is inevitable, as PowerChip accelerates up the learning curve. And the most crucial, and profitable, market will be satisfying the power requirements of the SmartChip. The PowerChip is the one technology that can satisfy the surging demand for something altogether new in the power business: "Ten Nines" of reliability.

The Tenth Nine

A remarkable number of bad things can happen to a power system woven out of tens of thousands of miles of lines: "car-tree interactions," and Mother Nature being just two. Solar electric storms induce huge currents in the grid's long wires. Such storms follow a predictable 11 year sunspot cycle. The last peak, which began at the end of 1989—back in pre-Cambrian Internet time—put six million people in the dark on Quebec Hydro's systems. The next peak starts in 2001.

Worse yet, the network is as much a part of the problem as part of the solution. Every time a big motor starts up at a water plant, or an electric welder fires up, power spikes surge and ripple up the grid. A few years back a Stanford computer center found its power fatally

Editors	Peter W. Huber
	Mark P. Mills
Publisher	Richard Vigilante
Managing Editor	David S. Dortman
Business	Mark T. Ziebarth
Design	Dori Miller

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polluted by an arc furnace over a hundred miles away. With only a couple of prototypical exceptions, all switching on the grid is still electromechanical. A spring helps speed-up the switching, which minimizes—but does not eliminate—arcing, and a concomitant burst of electrical noise. Such Rube Goldberg devices fire up and down the length of the grid, hundreds of times a day.

For all that, our trillion-dollar electric network is a remarkable achievement. Some 15,000 central power plants deliver over 3 trillion kWh per year, with (roughly) 99.9% reliability. That's "Three Nines"—or about 8 hours of outage a year for a typical consumer.

Before SmartChip, that was good enough. The electricity system was built in response to three main waves of demand, each a function of a new invention: the light bulb, the electric motor, and the air conditioner. For each of these technologies 99.9% reliability was acceptable—considering the high cost of further improvement. It gets very expensive, very fast, to boost reliability much above that.

Hospitals, airports, and military bases have demanded better than Three Nines for years, and have deployed their stand-by generating systems accordingly. Phone companies deploy huge battery banks and gas-fired stand-by generators alongside their large central offices, to keep phone lines up even when the lights are out. But SmartChip has changed the power world in two ways. As microprocessors and Web links penetrate deep into the economy, in to the facilities of even "ordinary" manufacturing and commerce, power quality and reliability become as important to "old economy" companies as they are to Bell Atlantic and Amazon. Residences are next, as SmartChips come to permeate the home. The sheer magnitude of devices and users that depend on SmartChips is unprecedented, and accelerating.

SmartChips, the devices that use them, and the networks that connect them, create a new standard far beyond Three Nines. Reliability demands start at Six Nines for the telecom and dot-com world—99.9999% up time. At the fifth Nine we're into minutes of down time a year, tolerable for a home-owner, unacceptable for any serious dot-com company. At Six Nines, we're talking 30 seconds outage a year.

But Six Nines is still orders of magnitude away from the reliability required to power SmartChip industries and companies. At the seventh nine, several seconds a year, we're protecting against a spectrum of minor distortions on power lines; common occurrences that last less than a minute, but are still seen by SmartChips as network crashing events. At the eighth nine—99.999999%—interruptions are measured in hundreds of milliseconds—a trivial flicker for a light bulb, but still enough to crash a SmartChip. It's only around the ninth and tenth Nine that the power can really be labeled clean enough for SmartChip purposes.

Here's the rub. Practically speaking the traditional power grid will never be able to provide much better than Three, perhaps Four Nines of quality. The grid, distributing power over vast distances, is necessarily too exposed to catastrophic events to ever satisfy SmartChip's real needs. Rebuilding it to do so would make it too expensive to support the economy power needed by the dominant 'dumb' appliances on the grid. To add Nines, we must turn to an array of systems, ranging from capacitors and inductors mounted on a motherboard or in a UPS (uninterruptible power supply) to fix problems of milliseconds duration; to batteries, flywheels, and super-conducting coils to compensate for outages of seconds to minutes; to diesel generators and turbines to supply back-up for hours or weeks. Every step requires a switch that can operate fast and cleanly enough to make the switching process invisible to the SmartChips. That's PowerChip's job.

Information-quality power is one of the greatest business opportunities of our time.

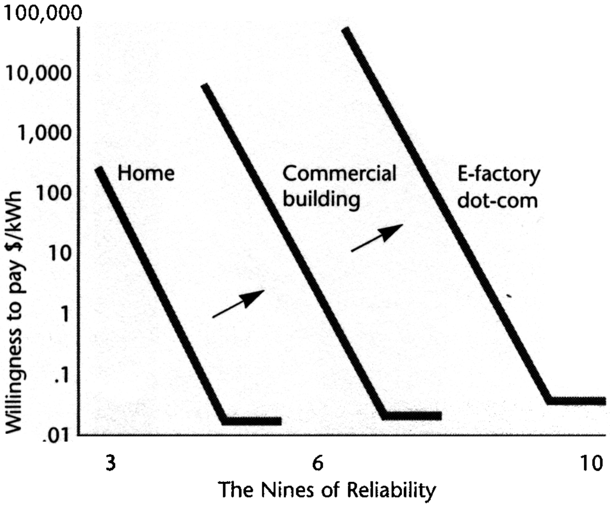
Building in reliability is expensive and it gets more expensive for every additional Nine. But SmartChip companies have no choice. Clean power, information-quality power, is becoming a sine qua non of the information economy and thus one of the greatest business opportunities of our time.

How much will people pay for the next Six Nines? Well, what does it cost a company like Schwab to go off-line for an hour? Or a day? What does it cost the cell phone company that loses a cell site in mid-town Manhattan? What does it cost the harried home-office worker, on a deadline to complete a report? That's how much the extra Nines are worth. Which is why information-quality power is already being sold at rates and in volumes that make clear this market will yield profits far surpassing anything dreamt of in the electric industry for decades.

True, the volume remains in the Three Nines market, the market for regular old grid power now increasingly traded coast to coast as a true commodity. But as we add Nines the cost, and the value, of the electrons rises rapidly. A single central power plant up 99% of the time delivers Two-Nines electricity wholesale into the grid at 2¢/kWh. A number of such plants woven into the grid allows utilities to deliver 99.9% reliability at about 10 ¢/kWh retail at your plug.

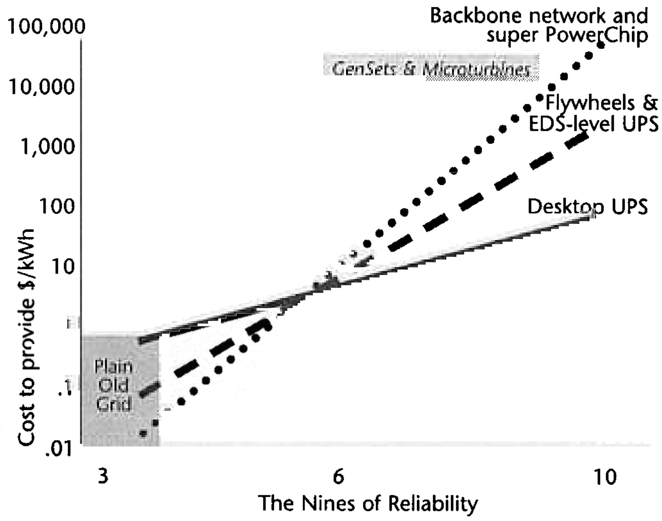
For every Nine after that, the costs soar. Three extra Nines can bring a 200 to 1000 fold price premium. But that's a premium that chip-centered businesses—

Demand Curve for Nines



All sectors are moving up an inexorable demand curve towards higher reliability (High Nines), and higher willingness to pay for that quality.

Supply Curve for Nines



The grid is the low cost supplier only for Low Nine power. Distributed generation and power electronics beat the grid for Higher Nine supply.

which will soon mean all viable businesses—will readily pay. Information-based businesses have been doing so for some time. You have almost certainly done so yourself, though you probably didn't think of it that way. When you buy an American Power Conversion (**APCC**) UPS to keep your desktop PC isolated from ubiquitous line voltage sags, what you're really doing is paying $20/kWh; roughly 200 times retail. True, you buy only one kilowatt-hour per year at that price—spread out over 20 five second events each using 0.05 kWh. But with millions of customers APC is a $1 billion a year power company. The challenge and the costs are modest at the desktop though. Costs and value rise exponentially with power.

Companies at the core of the SmartChip economy require very large quantities of High Nines power. At the semiconductor manufacturing plant level, or the major dot-com level, the per kWh cost of more Nines hits the stratosphere.

If a voltage sag becomes a sustained outage, you kick into an on-site diesel generator, in effect a Five Nines device. The imputed electric cost can be as high as $5/kWh for a few hours of annual use.

But to make a seamless transition from the grid power to the diesel generator, a transition measured in milliseconds, requires batteries (sometimes flywheels) and PowerChips. The resulting Six Nines reliability comes at a cost of perhaps $1,000/kWh.

At the high end, factory-power levels, PowerChips combine with superconducting storage devices to supply the capability to pump megawatts into the power curve in fractions of a 60-cycle wave. The implicit cost of power delivered at these Nine and Ten Nines levels ranges beyond $100,000/kWh.

Clearly, there will always be a lot more Three Nines kWh sold than those at Six Nines and up. But with these price spreads, you don't have to sell a lot of High Nines kWhs. Caterpillar (**CAT**) in selling diesel generators is really selling Five Nines. APC is selling Six Nines. American Superconductor (**AMSC**) sells Seven Nines. Silicon Power sells Nine Nines. At each successive tier of Nines stands another multi-billion-dollar market.

In aggregate, the total market for kilowatt-hours above Three Nines is already 20% of the Three Nines market and growing at double-digit rates.

As SmartChip continues to reorder the economy, the aggregate profits in premium power and PowerChip companies will soon exceed those in the Three Nines market. This transition will turn the electric industry upside down.

One finds High Nine companies falling into three categories: Clean Power Systems; Ride-Through Systems; and Stand-Alone Local Generators.

Clean Power Systems

PowerChips clean up power by switching it fast, mediating between electrons coming off a primary power source and electrons temporarily stored in good-sized capacitors and inductors alongside the PowerChip itself. It's impossible to store much total energy on a circuit board, but you don't need a lot to clean up blips and dips. What you do need is very fast, accurate, and intelligent electronics to mediate between the dirty source and the on-premises reserves. PowerChips do the job.

On a motherboard the small amount of power needed for a few milliseconds can be handled by finger-sized capacitors. But at the megawatt local network level, even a few milliseconds entails the use of capacitors the size of a stack of oil drums, or American Superconductor's refrigerator-sized superconductors. At the network level, Siemens Westinghouse Power (**SMAWY**) has developed a power-electronic based "Dynamic Voltage Restorer" (DVR) that can fix high power voltage sags in real time for loads in the 2 to 26 MW range, enough to keep, e.g., a semiconductor fab humming.

Clean Power Players

Here is a sampling of companies focusing on the millisecond clean power mission. This list is just FYI for now. In future issues we will nominate our choices for leaders in this technology.

American Power Conversion (APCC)	The brand and market leader in UPS (uninterruptible power supply) devices from the desktop to the data center.
American Superconductor (AMSC)	Technology leader in superconductor magnetic storage and transmission systems used to control power fluctuations at the megawatt level.
Eaton Corporation (ETN)	Cutting edge power control through its Cutler Hammer subsidiary, a former Westinghouse unit.
Emerson Electric (EMR)	A leader in a number of PowerChip functions through such subsidiaries as LeRoy-Somer, Asco Switch, Liebert, and Advanced Power Systems.

Ride-Through Systems

Clean Power Systems take care of blips lasting from milliseconds up to about a second. Ride-Through Systems take care of events lasting seconds to minutes, and occasionally hours.

Most home and small office PCs already use the increasingly ubiquitous American Power Conversion products which use a battery (controlled by PowerChips) that can keep your PC up for several minutes if the power hiccups.

A dot-com or net-bank with a power appetite hundreds or thousands of times greater may use enormous banks of batteries for ride-through. Batteries present maintenance, reliability, and longevity constraints that have not fundamentally improved in decades. But they are now responding to dot-com needs, as new materials and computer-aided design capabilities are finally beginning to yield real progress.

Most power secure operations have two redundant battery banks. But an electro-mechanical flywheel can replace one, using one-tenth the floor space of batteries and requiring essentially zero maintenance. An electric motor runs, when there's power, to spin up to a one-ton steel flywheel. When the power fails, the motor reverses and becomes a generator, powered by the flywheel's inertia—good for 250 kW and more, for as long as it takes to power up the back-up generator. This past summer, for example, Constellation Energy (the Baltimore Gas and Electric parent) installed an Active Power CleanSource CS 200 as part the UPS serving Comcast's critical cable and Internet hub facility.

Stand-Alone Local Generators

Electronics and batteries take care of the milliseconds and the minutes; beyond those lie the outages that last hours or days. On-premises generating capacity boosts the reliability of the power mainly by shortening the wire between the generator and the user.

We project a huge surge in demand for on-premises generators. The estimated world market today is $5 billion a year for diesel generators. Standard wisdom forecasts a tripling over the next five years. We think a ten-fold increase will be closer to the mark. The hockey stick will be driven by four factors.

1.The demand for High Nines power is altogether new; the Internet Economy is here and growing.

2. The power electronics required to bring stand-by generators on line quickly and cleanly only matured in recent years. Safely and economically interfacing half-megawatt generators with the utility grid required switching gear that was almost impossible to find as recently as five years ago. It is readily available today.

3. The deregulation of the power industry is accelerating just as PowerChip makes deregulation relevant.

The deregulation of the electric market and the disassembly of the "natural" monopoly system began in earnest in 1992 with the Energy Policy Act that opened up competition at the wholesale level. Over one-half of all electricity produced at utility and merchant central station generating plants is already sold several times over, through broker contracts, before it is ultimately consumed. Now the retail side of deregulation is in full swing, with 22 states under legislative "restucturing," or deregulated (except for transmission; more about this in future issues). Federal legislation is likely to accelerate the movement once we get past the next presidential and congressional elections.

4. The stealth revolution in materials science and engineering for diesel engines has almost doubled efficiency and boosted reliability. A 1981 Caterpillar 3500 series produced 900 kWh; the same block and geometry now produces 2,200 kWh.

PowerChips are eliminating the mechanical governor,

Ride-Through Roundup

The battery companies, Bolder and Evercel, are cutting edge with great potential for UPS, but not yet strongly focused on that market. The flywheel companies are all primarily playing in the UPS space. Once again this list is FYI, we'll nominate our technology leaders in future issues.

Flywheel Companies	
Active Power	Makers of a fully integrated flywheel energy storage system.
International Computer Power (ICP)	Their RotoUPS flywheel system provides uninterruptible power to a battery that provides the ride-through power.
Trinity Flywheel Power	Manufacturers of the world's smallest and most powerful flywheel.
Cutting Edge Battery Initiatives	
Bolder Technologies (BOLD)	Make a high power rechargeable battery system based on thin metal technology.
Evercel (EVRC)	A spinoff from ERC, Evercel is well-positioned to make ride-through systems

alternator and voltage regulator. Windows-compatible software controls startup, fuel economy, and voltage stability. Thin servers and neural networks allow real-time and remote monitoring and diagnostics, boosting reliability and dropping costs. In short, the venerable diesel has come a much longer way technologically than the much hyped windmill or fuel cell; and it's cheap.

On the horizon are mini- and micro-turbines; tiny versions of airplane engines. Mini-turbines are already commercially viable, poised to take market share as the monopoly regulatory structure unravels. On the horizon, a 100 pound machine producing 400 kW. Turbines like to run flat out round-the-clock. One thing dot-coms need, is lots of power round-the-clock.

All three of these technologies, Clean Power Systems, Ride-Through Systems, and Stand-Alone Local Generators, are practical only because of PowerChip. PowerChip is as central to the transformation of the power industry as the microchip was to the transformation of the computer industry. Thus we put forward two propositions:

1. Solid-state devices will take over all power switching at all power levels and all speeds. And it will happen far faster than most analysts suppose. PowerChips will permeate the grid, from the central power station down to the motherboard.

2. As PowerChips proliferate, they will expose the entire generating and service infrastructure of the conventional power industry to competition. A tidal wave of new storage and generating alternatives will respond to a huge reservoir of unmet demand for High Nines power. In so doing, they will thrust competition into the bowels of the industry, and transform it beyond recognition.

The Implications for Utilities

The PowerChip will disrupt established utilities in much the same way as the SmartChip disrupted the mainframe industries, except that this time there is more to disrupt. SmartChips arrived just two decades after the mainframe; the PowerChip arrives to disrupt an electric utility business that has been growing for more than a century. It is coincidentally an industry now poised on the brink of enormous collateral disruption by regulators.

The worst utilities will go the way of Pan Am. Or the way of Digital Equipment, or Control Data, Wang, Burroughs, Univac, Tandem, Data General, or Prime. Over time—and huge though they are—they will see their core businesses wither and vanish. Others will limp along, the way of a TWA or a Continental. A third group, the IBM equivalents, will get smart or lucky. And there will be a fourth group, new entrants that don't exist today, the equivalent of America West, or Dell, or AOL, that will build up from scratch, seize new opportunities, and prosper.

The weak players will be destroyed by a technological pincer movement. Their base of Three-Nines commodity kWhs will be stolen by more efficient providers transporting electrons on upgraded or new backbones. At the same time, peak loads—and peak prices and margins—will be flattened by back-up generation systems whose owners start wheeling their excess power back on to the grid. Most back-up systems, installed to support High Nines quality, will run too expensively to make it worth while to wheel their power back on to the grid—most of the time. But when spot prices spike they will be there to pick up some of the windfall that now goes strictly to the utilities. Even more likely they will find it profitable to leave their systems up and sell High Nines power to other nearby SmartChip companies.

As the number of local generators grows, installed originally to provide High Nines insurance to their owners, the architecture of the grid itself will begin to change. Rather than a series of virtually identical Three Nines plugs, the grid will take on a lego-block architecture: with a variety of components highly adapted to different functions, yet also standardized and perfectly interconnectable, analogous to both the fragmentation and the interoperability of telecommunications networks. The forces of dispersion are by no means identical, but the main currents are the same: new interfaces, made possible by new switches and new 'pipes', that permit competition to get established all around the periphery of the old monopoly network.

Once established, competition will inevitably bore its way inward. Clean, 100 to 1000 kW diesel generators, mini- and micro-turbines will first become standard fixtures alongside the buildings that house ISPs, dot-coms and network POPs. Not long thereafter they will appear in every other major business and factory, and finally in apartment buildings and residential developments.

How soon will this market be significant? Today more than 95% of all electricity consumed comes from utility sources. The nation's grid has about 760,000 MW of capacity. About 10%—some 80,000 MW—is used ("dispatched") only hours per year to support Three Nines grid reliability.

Sitting off the grid, uncounted by the official counters, and unnoticed by ordinary rate-payers—there already stands another 80,000 MW or so of non-utility standby-generating capacity. It too is on only hours a year—right now.

None of this capacity is included in official government data, appropriately enough since the raw capacity figures do not begin to tell the whole story:

1. This capacity is privately owned; it is entirely free of price regulation.
2. Nevertheless, when regulatory conditions are favorable, it can pump power back into the grid, for sale to others.
3. It offers short-wire, Six Nines reliability and can command prices and margins to match.

The first two factors alone would spur very healthy growth in generator sales. But the third will push things way over the top. All the standard projections about the prospects in this market are far too low, underestimating both the progress in PowerChip technology, permitting the efficient and safe interfacing of small generators with the grid, and the demands of SmartChip.

Half of the electric system will be anchored in the Internet Economy within the next decade. The last government report that comes close to assessing IT-driven kWh demand was published in 1995. At that time, the study estimated computers and faxes in commercial buildings accounted for about 3.5% of U.S. electricity demand. (This is comparable to the total electricity output of Taiwan.) That was four Internet years ago. Last year, U.S. electric supply rose nearly 4%, roughly twice what forecasters had predicted. If that number sounds small in the hyperbolic world of the Internet, recall that is calculated against an enormous denominator, a full century of accumulated demand from other applications.

That's why we certainly don't predict the demise of most utilities, nor of their big central power stations. In fact, we predict the opposite. The Pan Ams of the industry will fold, but the industry as a whole will prosper and grow. A decade or so ago, mainframes were being written off entirely; even IBM was supposed to be headed nowhere because of the PC. Yet today there are 60,000 more mainframes running in the U.S. The best utilities are on IBM-like trajectories of their own. Dispersion and duplication of power supplies won't kill the central power plant, no more than it killed the mainframe.

A New Power Paradigm

Whether in telecom, computing, or the power industry it is new interfaces and interconnections that undermine monopolies and replace them with vibrantly competitive new marketplaces. In telecom, four

Mini and Micro Turbines enter the market

Again we'll nominate our leaders in future issues, but we admire Capstone's focus and entrepreneurial passion and note Cat's decision to box the market through Solar Turbines.

Minis	
Solar Turbines	Now a division of Caterpillar, dominates the world in mid-markets.
Teledyne Continental Motors	They mostly make aircraft engines; a subsidiary of Allegheny Teledyne (ALT)
Williams International	Pioneered micro-turbine technology especially the propulsion for the first cruise missiles
Micros	
Allied Signal (ALD)	Their Parallon 75 has deeply impressed the market.
Capstone Turbine Corporation	A technology leader, and a pure play, totally focused, and funded by a who's who of tech savvy VC firms.

Diesel Generator Makers

Already a $5 billion global market, we say it will be $30 billion within five years.

Caterpillar (CAT)	The market leader, second only to GE in worldwide shipments of power generation machinery.
Cummins (CUM)	$1.2 billion in sales under brand names Petbow, Agreba, Stamford, and Markon.
Generac	Strong in the consumer and small commercial market, now entering the large commercial market.

The Power Panel

Welcome to the first edition of the Power Panel, our selection of companies whose ascendant technologies will help fulfill the PowerChip paradigm and create the new market for information-quality power.

A few words on what the Power Panel is and is not. When we make a decision to place a company on the panel it's not based on share price or market timing, or company fundamentals. Our mission is to uncover the technologies which will dominate the new information power market, and companies that lead in providing those technologies. Such companies may take years to fulfill their potential.

One thing we promise. It will be hard to make it on to the Power Panel, in token of which, we have chosen only one company for our first issue. We will, however, discuss many companies of interest in the main text every month.

Our first choice was easy. It had to be a clear leader in cutting edge technologies that put it at the very center of the paradigm. American Superconductor qualifies on all counts.

Technology Leadership	Company (Symbol)	Reference Date	Reference Price	Current Price	52 Week Rang	Market Cap
Super conductor storage and transmission	American Superconductor (AMSC)	9/21/99	13	13	6 $^1/_8$-16 $^3/_4$	200.8M

American Superconductor (www.amsuper.com)

Utilizing high temperature superconductor (HTS) technology (a breakthrough that earned the two scientists who discovered it a Nobel Prize in physics in 1987), ASC has developed Superconducting Magnetic Energy Storage (SMES). The resulting products, two of which were launched in 1998, are refrigerator-sized superconducting storage systems.

SMES uses high temperature superconducting coils which store vast amounts of energy with negligible loss. When a power fluctuation occurs, even on the order of a millisecond, the SMES accounts for it and continues to deliver clean power. Importantly, SMES is unprecedented in the ability to do so at multi-mega watt power levels. American Supercondutor's super-conducting cables, a technology we will look at in future issues, provide for High Nines power transmisson, too.

The company has forged relationships with several influential players within the electric power industry including: Electricite de France (EDF), one of the world's largest electric utilities, Asea Brown Boveri (ABB), the world's leading manufacturer of power transformers, Pirelli Cavi e Sistemi SpA, one of the world's largest cable manufactures, and Rockwell Corporation's Reliance Electric motor manufacturing unit.

With a track record of consistently hitting performance targets and predetermined milestones, and a portfolio of over 170 US patents and patents pending, American Superconductor is poised to create new bounties of High Nines power.

generations of regulatory and technological change created new interfaces between the phone line and the "customer premises equipment," the local switch and the long-distance network, the local switch and wireless network, and—more recently—between the local switches of "incumbent" and "competitive" local phone companies. The result has been to transform a sleepy utility sector long dominated by one "Grandma" stock into the central nervous system of a new economy and the most vibrant of investment sectors.

Just up the street, the PowerChip is now coming of age. It will create affordable, reliable interfaces between a constellation of new sources of electric power, from batteries to diesel generators, from flywheels to turbines, transforming ducklings as ugly as thousand-pound flywheels and reciprocating diesel generators into the swans of High Nines power. It creates the clean interface between musty basement and greasy coverall-clad building engineer, and the clean room of the chip fab or server factory.

Empowered by the PowerChip, these technologies can collectively deliver the power of the information age with a standard of reliability so far beyond the capabilities of the old grid that it defines a new market, and a constellation of new industries with glittering margins.

At first this new constellation may seem a hopeless confusion of uncatalogued albeit possibly combustive opportunities. But every investment opportunity in the market for Internet Economy power can be analyzed by reference to three questions:

Does the company contribute crucially and competitively to the function of the switch, the PowerChip itself?

Or is it an integral part of the distributed storage and generating opportunities that the PowerChip empowers?

Does it deliver High Nines competitively?

Among the companies that fit that profile there will be better and worse. But when a new, disruptive technology like PowerChip, or SmartChip before it, first begins to redefine an industry or an era, the resulting updraft can render trivial reams of the workaday analysis so crucial in more ordinary circumstances. PowerChip yields a technological and investment paradigm of great clarity and enormous power, an alternate and, happily, lesser-known path to the vital center of the information economy, the exploration of which is the central purpose of this letter. Welcome aboard.

Peter Huber and Mark Mills