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Powering the Telecosm
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Lighting up the Powercosm Hotel

Silicon Power Plants

Only two companies can be said to be aiming squarely and unerringly to dominate the DC power plant space. One of them, Power-One, is already on our Power Panel. Emerson is the other.

The room literally hums with power. We are standing in Liebert's fully operational Nines demonstration facility in Delaware, Ohio. Its floor is crowded with innocuous gray cabinets. Each one occupies just three square yards of floor space, and stands just slightly taller than a refrigerator. And each one is a half megawatt electrical power plant. They're here for testing: this is Liebert's flight simulator, the place where it throws electrical trouble at its power plants to show how they perform.

But we're getting ahead of the story. How did a megawatt of power plants–enough power to light up one thousand conventional homes–come to be packed on to six square yards in almost fab-clean space? Where's the heat, the noise, the dirt? It's back up the line, where it's always been. These new silicon power plants don't burn oil, natural gas, or coal–they burn electricity itself, delivered from the old economy's power plants.

A neat trick, that: burn electricity to generate electricity. What is this, perpetual motion? A cold-fusion scam? Not at all. The electrically fueled electric power plant is the power plant of the future. Real customers are clamoring to buy it.

The silicon chip spawns the new power plant as inevitably as the light bulb spawned the old. Edison worked out the bulb on October 21, 1879; three years later, on September 4, 1882, his Pearl Street Station power plant dispatched the nation's first power to four hundred outlets of eighty-five customers in New York City. Now, a century later, new Edisons are racing to occupy an altogether new space. Electricity is the primary fuel; better electricity the primary product. The technology is cool (not hot), short wire (not long), compact (not sprawling), high-9s–not low.

The new Edison distributes power–both DC and AC–and lots of it. Extremely reliably. Doing so takes new building-level grids, a new monitoring and servicing infrastructure, a radically new design philosophy, and new types of power plants. The silicon power plant is where the junk power from the grid, and from backup generators, gets combined and transmuted into the gilded power of the digital Powercosm. The new Edison is, in sum, a mirror image of the old–just six-9s and better.

The new Edison, however, sets its own, unregulated price. It sells high-9s electrons at prices two to three orders of magnitude higher than the cost of the low-9s electrons it buys from the grid. Its business is to transform cents per kWh into dollars per kWh by adding 9s.

In homage to the new Power Paradigm, Emerson Electric (EMR) recently regrouped all its Powercosm-related operations (Liebart, Astec, ASCO) under a new Emerson Network Power Group with the simple name, eEmerson. But this is one of those rare companies in which the technology and business are way out ahead of the marketer's magic "e". Emerson leads the small handful of companies that are going to own the markets for the new, high-9s power plant.

Power plants new and old

Picture a gargantuan steam locomotive, with everything but the track. Super-heated steam from a coal or uranium boiler drives turbine blades on a shaft connected to an electric generator. That's a "power plant" for old economy electrons, the thermodynamically-limited Carnot world–a 250,000 to 1,000,000 kW beast pouring power down the grid to light up hundreds of thousands of homes and buildings. Dirt-cheap, two-9s electrons. If the plant is "down" for essential maintenance only ten days, it is having a great year.

In contrast, the "power plant" of the Powercosm is made of wires and silicon instead of pipes and steam. Clean, not dirty. Its fuel is electricity, drawn from the grid, or huge banks of batteries, or a backup generator. Its output is electricity, too–expensive, high-9s electrons. In every year, not just great years, its stays up around the clock, millisecond to millisecond. If it fails, its load has to be taken up instantly by another identical unit, with the hand-off so clean that the silicon it powers doesn't notice.

Powercosm

Old Economy Power	↓	Telecosm/Microcosm
Carnot		Moore
Copper		Silicon
Gigawatts		Microwatts
AC		DC
Three 9s		Sixteen 9s
Macro-scale		Micro-scale
Long wire		Short wire
Hot		Cold
Analog		Digital
Carnot plant		Electron brick

The old power plant converts low grade raw resources–coal, crude oil, dirty gas, uranium ores, wood, trash–into a much higher grade of energy, the three-9s electrons of the twentieth-century economy. The new silicon power plant converts the raw resource of three-9s electrons-trash from the microprocessor's perspective–into nine-9s electrons, the high-grade fuel of the twenty-first century's Powercosm. The old power plant serves the grid, which serves everyone. The new serves the new real estate where Microcosm and Telecosm converge, the places too new even to have a commonly accepted name. The real estate of the Powercosm is comprised of buildings where rooms are filled with racks, and the racks are packed with silicon–the all-digital premises packed with Cisco gigabit routers and Nortel Centillion chassis switches, and rooms filled with 3Com gigabit ethernet hubs. These are the homes of CLECs, ILECs, data hubs, head-ends, ISP farms, and terabyte storage area networks, the buildings occupied by Exodus, Global Centers, and Intel ISP Hotels. Call them the "Powercosm Hotels."

What we call the "power plant" market is so young, so poorly tracked, and growing so fast, that it is difficult to gauge its size. The old-economy Edisons call this the "power quality" market–defining it to include standby generators, test & measurement equipment, and various associated services on the AC side of the business. Measured in this limited way, it was an estimated $4 billion market in 1997 and is forecast to reach $8 billion by 2003. But these numbers exclude much of the "power quality" engineering that has, until recently, come bundled with the telecom or computing systems that needed it. The DC power plants alone are already a $2.5 billion-plus industry, with $500 million of it currently anchored in the highest-power end.

However measured, the market is growing apace with the infrastructure of the Telecosm. Emerson is currently designing and managing the power for dozens of Powercosm Hotels including ten sites for Equinix and five mega sites for PSInet, ten Worldcom central offices, twenty-four gateway sites for Level 3–as well as power for wireless networks in Italy, Brazil, Mexico, South Africa and the UK. In the pipeline are a still secretive Web hosting venture with $210 million in Powercosm electronics, another with twenty-one sites ranging from 10,000 to 40,000 square feet and $168 million in power equipment, and a coyly couched to-be-finalized $750 million in eEmerson equipment and services for thirty large (300,000 square feet) Powercosm Hotels. Emerson is effectively sold out of the high-end power plants in 600 kW-plus sizes; a single Powercosm Hotel could gobble a couple of dozen. Its delivery backlog for such units was six to eight weeks not long ago; it's eighteen to twenty weeks today. Orders have doubled in the past year alone. The company's bottleneck is now building out space fast enough to manufacture more.

DC and AC convergence

Roughly speaking, there are two major types of new-generation 9s power plant. The AC plant–typically called a "super UPS" (uninterruptible power supply)–serves the computer world. The DC "power plant" serves telecom. The AC/DC schizophrenia reflects technological history. As we discussed in our May DPR, all the smartchip silicon of both computing and telecom ultimately runs on low-voltage DC power, but the two platforms evolved with different solutions to get that DC.

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The modern computer world evolved from the desktop on up–from the plug-it-in-the-wall PC, powered by the standard 110 V AC mains. Thus evolved the universal "power supply" in every computer–a small box with a (typically) noisy fan that converts AC into the DC fuel of the CPU. When the great racks of servers arrived, they came so quickly nobody gave much thought to redesigning power supplies; the server makers simply assumed that AC power would continue to be distributed right down to the racks, and so therefore it was.

The telecom world–the world of ATM, circuit switches, and RF microwave amplifiers, transmitters, and lasers–has a longer history anchored in Ma Bell's motherly concern for always-on dial tone and 911 (the latter a very high-9s imperative). The telecom industry came to grips early with the power reliability issues of super switches that were the equivalent of mainframe computers and settled on a 48 V DC bus for distributing power through its "central office" buildings to its racks.

Today such divisions–"central offices" for telecom, "data processing" rooms for the big computer–are collapsing as telecom and computing equipment converge into the same space.

Emerson does not own the entire market, of course (although they're the largest, with 23 percent of the global business on the AC side). Making and moving electricity is a huge business, and countless companies claim they are involved in helping to deliver AC or DC power with higher 9s than the Plain Old Grid. Many provide lower-quality "uninterruptible power supplies" to all manner of buildings and industrial operations, to maintain power for non-digital loads. Remarkably few, it turns out, serve the unique, crucial and accelerating combined AC/DC demands of the Powercosm Hotel.

Serving both the AC and DC side of the house requires power plants that deliver enormous power levels with individual power plants, or modules up to 100 kW (DC), and 1,100 kW (AC). And they must be deployable in scaleable architectures, with multiple units to accommodate massive loads–up into the megawatts demanded at the epicenter of a Powercosm Hotel. The companies have to offer design and engineering in the build-out, and remote monitoring and on-site maintenance. Follow-up is essential. Nines have a half-life. All engineering systems decay. Trust, and therefore brand, are crucial because the high-9s power requires levels of reliability far beyond the bounds of easy testing or verification by the customer.

Above all, the winning power paradigm will ultimately center on DC. The alternative–the AC-centered architecture–makes sense for historical reasons alone.

Recall (May DPR) that the silicon at the end of the line is all energized by low voltage DC (from 1 to 12 V typically). In a PC, the DC current is created within the PC itself, in a commodity "power supply" that takes 110 V AC from an outlet and converts it to DC. It's typically not very reliable, because its fans and cheap capacitors often fail. In the telecom world, there are no AC outlets; instead, a 48 V DC "bus" sends power directly to the racks. But most of the data-centered servers packed into a Powercosm Hotel still run on AC power, reflecting their desktop roots. Most of the pure "telecom" equipment on the premises, by contrast, draws its power from a 48 V DC bus. Cisco, the one company that has straddled the telecom and computer sides of the house from the get go, is one of the few players that will deliver its boxes configured for either AC or DC inputs (expect others to follow soon).

We wish all these AC-focused companies well. But unable to serve the high-power DC market, or simply unwilling to put DC technology front and center, they just don't fit the new power paradigm.

The companies that will own the power plant market will heed the imperative of the 9s. At the level of the individual room, that means DC power plants, not AC UPSs. Only two companies can be said to be aiming squarely and unerringly to dominate the DC power plant space. One of them, Power-One, is already on our Power Panel. Emerson is the other.

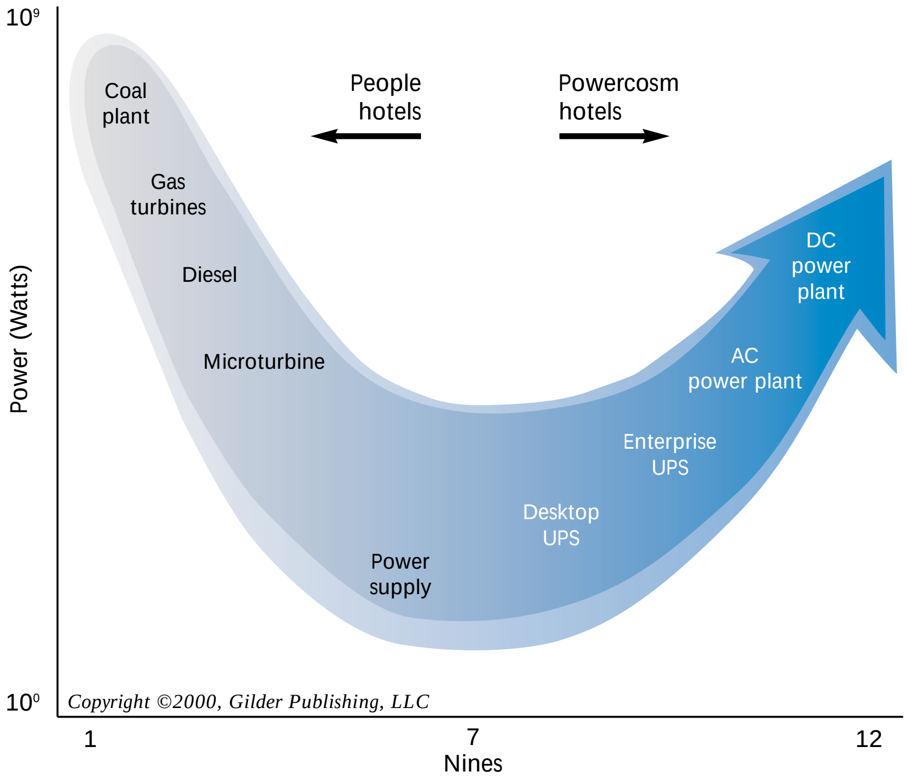
Lucent, Nortel and Ericsson sell out

Before we get to why DC power plants will prevail, let's see who sells them. That alone reveals a lot.

Until very recently, all the major manufacturers of DC power plants were telecom companies. The power engineers of the telecom industry–who were sweating high-9s reliability long before anyone else–standardized decades ago on a 48 V DC bus. If this letter had been written eighteen months ago, our focus would have been on major vendors of telecom equipment, most prominently Lucent, Nortel, Ericsson, and Marconi. But as noted in the May DPR, Nortel and Ericsson sold their power operations–in late 1998 and April 2000, respectively–to Emerson. Lucent's entire power division went on the block in April of this year. Siemens, Germany's main vendor of telecom equipment, has effectively sold out to Emerson, too–through the Ericsson acquisition, Emerson is an OEM to Siemens. If by chance Emerson should grab Lucent Power as well, they would attain a truly commanding position in the DC power plant market.

Who does that leave? Marconi (London exchange, mni.l), the $8 billion European telecom giant, has, buried deep within its labyrinthine divisions, its own cap-

Powering the Powercosm



The old economy's crowning achievement, the sprawling electric grid, is fed by low-9s power plants ranging in size from fractions to hundreds of megawatts. The digital economy's high-9s electron appetite is satisfied by a new class of modular silicon power plants capable of delivering into megawatts range at the epicenter of Powercosm Hotels.

tive DC power plant business–RelTec, a Columbus, Ohio, DC power plant firm that Marconi acquired in 1998. But 60 percent of Marconi's business remains in the explosive wireless market; that leaves Marconi's power division trying to sell power plants to companies that compete directly against Marconi on the telecom side. We expect to see Marconi (sooner rather than later) follow Ericsson, Nortel, and Lucent and put its power group on the block. Alcatel (France) is the other major European telecom manufacturer that still makes its own DC power plants. It too will be hard pressed to divest.

The future of power plants belongs to the pure 9s plays. The most widely recognized consumer name in "power reliability" is American Power Conversion (APCC) with their aggressive marketing. But APC comes late to DC–it acquired Advanced Power (United Kingdom) in May, as this letter was being written. Most of APC's business remains centered on AC UPSs for the low-power desktop, the small business, or business unit. If APC were to buy Lucent's power plant operations–and buy before Lucent suffers too much of a brain drain–APC would become an instant contender in the high-end Powercosm Hotel space; if it doesn't, it probably won't.

Coming to the Powercosm Hotel space firmly anchored in DC competency is Power-One (PWER). Buying HC Power this spring, Power-One acquired one of the technology leaders in high-end DC power plants. Established in 1984 by power supply pioneer Wallace Herson (who remains president of the new Power-One division), HC today has 290 engineers. Its toughest competitor was Nortel, but it's now eEmerson, along with whoever ends up owning Lucent Power.

There are others in the DC power plant business, but none in the major league or pure plays. Peco II (Galion, Ohio) and Transistor Devices (Hackensack, NJ) are niche players. Then there are the unleveraged inscrutables such as Fujitsi, NEC and Yuasa. In a logical turn on the "if you have a hammer, everything looks like a nail," Yuasa, one of the world's largest battery companies serving virtually every heavy duty stationary and transportation application, offers the big DC power plants, but sees them as quite simply, battery chargers. Inelegant, but in effect true enough insofar as the product's historical telecom roots are concerned.

All the rest of the hundreds of players in the "power quality" business remain focused on AC, and mostly at the lower end of the power curve. They serve a large and growing global market: desktop computers continue to multiply, as do microprocessors embedded in industrial machines, and almost all require higher quality power than they can draw directly from the grid.

A smaller group among them builds the very-high-power AC UPSs that can provide building-level power quality to offices and buildings that continue to accumulate AC digital equipment. MGE (Les Milles, France), is a leading builder of very large (up to 1,300 kW) AC UPSs with something like 14 percent of the world market. (Their mid-market 13 kW product for small dot-coms is promoted as having a "tasteful design" available in four colors. Hardly paradigmatic, but vive la difference.) Powerware (formerly Exide Electronics Group, Raleigh, North Carolina) and Best Power (formerly a unit of General Signal Corp., Necedah, Wisconsin) are both global players that have been absorbed into the $15 billion (revenues) sprawling Invensys conglomerate (London Stock Exchange: ISYS). But Invensys, even with comparable UPS market share to MGE, has a diverse muddle of over four dozen different companies under its wing, with power lost in the crowd. APC pulls up the rear with about 3 percent market share, and only just pushed its way to the high power range (500 kW) of the AC power curve with its 1998 acquisition of Silcon Power (Denmark), though the company's business remains dominated by much smaller units.

We wish all these AC-focused companies well. But, unable to serve the high-power DC market, or simply unwilling to put DC technology front and center, they just don't fit the new power paradigm.

More power...more units

From a high-9s perspective, here's the best thing about DC power plants: When you need more power, you just plug in more units. Just like batteries, basically. The more units you pile on, the more power you get–and the more 9s, too.

AC power plants, by contrast, don't plug together nearly so cooperatively. It's easy enough to make just one a lot bigger–that, indeed, is how utilities worked their way up to megawatt-sized generators plugged into thousand-mile grids delivering abominably unreliable three-9s power. But casually just plugging two or more of them together is quite another matter. The most likely outcome? Boom.

Why should there be such a stark difference? The simple answer: timing. DC power doesn't have any. AC power is as much timing (the 60 Hz "clock speed") as it is power. Plug two sources of AC power together, and either you synchronize them perfectly from the get go, or the two power sources start fighting each other (to their mutual detriment), sending out-of-phase current and voltage surges crashing back and forth like waves, up and down the length of your wires. Out-of-phase power plants dump lots of power into each other, instead of the load–an electron food fight with both the sources and the smartchips on the loosing end. AC flips back and forth 120 times a second, so "perfectly" here means getting things synchronized in fractions of milliseconds.

All the high-end UPS players have contrived ways to synchronize multiple AC units by adding arrays of hardware and software. Emerson's 1,000 kW AC units can be paralleled up to 4 MW. But it isn't easy, and any failure of the control unit can become a failure of the whole system. Raising the power, thus, almost inevitably lowers the 9s.

With DC power plants–with batteries, to take the most familiar example–adding power is the easiest thing in the world: just plug in another unit in parallel with the ones already on line. (The original telecoms and navy submariners figured that out long ago.) Adding a source disturbs the system no more or less than subtracting a load. Everything adds or subtracts cleanly because it is a one-dimensional process–more power or less. Timing doesn't matter because there is no demanding chronometer embedded within the DC power itself.

The statistics of large numbers work in your favor in a DC system. Phone companies mount hundreds of batteries, arrayed row after row, to provide "ride through" power to make up for random voltage "sags," and supply short-term power. More batteries somewhat increase the risk that one will short and bring down the whole array, but shorts are very rare, and easy to isolate. And a failure from a mere shortfall of electrons grows less probable as more batteries are added to the system. DC power plants, in short, are inherently scaleable. Their strengths reinforce. Their weaknesses compensate.

Moreover, in a room or building wired around DC, the backup batteries can link directly to the DC side of the power plant–the batteries themselves simply deliver 48 V DC power directly to the DC bus, which feeds 48 V bricks on circuit boards. In a room on an AC bus, by contrast, the DC power from the batteries feed into the middle of the UPS, to get converted into AC, then delivered on AC-wired networks to the AC loads (where it is converted, once more, back to DC). The AC network creates potentials for harmonics and faults; indeed most problems occur in AC networks in between the UPS output and the AC load.

...the power plant of the Powercosm is made of wires and silicon instead of pipes and steam

Perhaps the dirtiest little secret of the super UPS universe is their inability to handle their own downstream faults, or inevitable power hiccups created when a technician improperly executes a maintenance step, or fails to turn off an isolation breaker, or drops a screwdriver on a hot circuit. An AC UPS can typically handle only 150 percent over current, or over voltage on the demand side; in practice, the surge can jump 1000 percent, which makes them too large for the UPS to handle.

So it doesn't. Instead, the UPS trips a silicon switch and links the critical in-house wiring directly back to the grid. Only for a few dozen AC cycles, of course–just long enough to use the enormity of the grid to handle the overload. No big deal, unless the grid itself happens to have a coincident problem, just the kind of event the UPS is supposed to isolate. And how likely is that? Not very, but still far too likely for premises that need high-9s. An average data center will generate over six hundred "events" a year that require a UPS to expose the load briefly to the grid. As the number of devices increases in the Powercosm Hotel, the number of "events" increases, and so too does the number of exposures–even as the frequency of potentially coincident problems in the public grid increases.

The one certainty with DC, by contrast, is that the power plant is never deliberately bypassed. All of the critical CPU load runs all of the time from the DC bus in the building. The noisy, erratic, raw three-9s fuel from the shared grid is utterly, simply, and permanently isolated from the hypersensitive DC load.

And the better the power plant, the less it demands of the upstream systems that supply its raw power. But why should anyone care much about what burdens one of the new power plants imposes on one of the old economy ones further up the line? Because it isn't always the Hoover Dam that's up the line–some of the time it's the standby generator. The implications are hugely important in overall Powercosm design, because standby generators are expensive, troublesome, and most importantly, occupy a lot of real estate.

The silicon power plant is where the junk power from the grid, and from backup generators, gets combined and transmuted into the gilded power of the digital Powercosm

Viewed from upstream, the silicon power plant is just another electricity-consuming load. But these power plants are not puny loads, even from the local grid's perspective, and they are certainly not puny from the perspective of a backup generator. The power plant either synchronizes its AC demand very precisely with the AC supply, or it creates very serious problems when one end is pulling while the other end is pushing. When that happens, waves of current are sent crashing back and forth along the wires, and when they get big enough they overload backup generators and fry equipment. The grid is not much of a concern perhaps to Powercosm Hotels, but (selfishly speaking), they do care about silicon power plants that minimize the amount of electrical pollution sent back upstream to their own standby generators and associated gear. A power plant with 30 percent "total harmonic distortion" (THD) on the backup generator that feeds it requires a generator twice the size of a 5 percent THD alternative.

Emerson's high-end Helios unit operates at under 5 percent THD. So do Power-One's big Densepack units. The current crop from Lucent, though, hit 30 percent THD, pointing to the legacy attitude of the old-world telecoms towards low-cost power plants (which create high THD) and an absence of interest on grid impact. Power plant efficiency is important, to minimize the heat dumped into the delicate silicon CPU space, and to reduce the size of the backup generator required. The Liebert and Power-One power plants both boast 90 percent-plus efficiencies.

In sum, the AC UPS–and the architecture that goes with it–is an inherently lower-9s configuration compared to the DC-centered alternative. An Ericsson-lead team several years ago calculated the difference as at least an order-of-magnitude better for DC. No one listened, it was still a pre-Powercosm Hotel era. They're listening today.

Desktop legacy

Why then does the AC UPS still dominate sales in the power reliability market? The persistence of AC power in the inherently DC silicon universe reflects nothing more profound than silicon's short and imperfect history. To keep costs down, the original PC manufacturers simply installed the cheapest power supplies they could find, and pulled their electrons from the nearest outlet. Companies like APC simply followed along that trail–which, it turned out, lead from the 1 kW desktop all the way to the 1 MW and up Powercosm Hotel.

So long as big servers come with nothing but an AC plug, that's what the bus on the rack will have to deliver, of course. As an AC/DC bridging strategy, Emerson employs an architecture that puts big AC plants supporting the Powercosm space with distributed DC power plants located downstream adjacent to the expanding DC loads. But DC's enormous inherent advantages are irresistible, and this architecture will ultimately be reversed. A DC bus can accommodate any legacy AC loads for as long as they last (and over time they will decline). Redundant hot-swappable arrays can be deployed where needed to convert DC back to AC right next to the legacy loads. Nines actually increase. Emerson already uses this approach as does Power-One. Power-One uses it exclusively.

Even so, the AC universe isn't going away. It isn't even in decline. It will continue to grow, and fast. But it will largely serve either smaller digital consumers with increasingly commodity products, or less demanding non-paradigmatic industrial needs. Sooner rather than later, in our view, the AC loads will become DC loads in Powercosm Hotels as others follow the Cisco lead, offering products without the AC power plug. The power user group recently formed by Intel is entirely focused on improving the DC architecture. It should be both easy and attractive for server and other datacom manufacturers to follow in Cisco's footsteps, and offer a stripped-down version of their boxes that simply omits the commodity AC/DC power supply at the front end, and instead accept 48 V DC straight from the rack power bus to the circuit board.

As the telecom world grasped decades ago, that's the high-9s architecture, and that will be the architecture of the Powercosm. The opportunity for radical change, and for profits to match, lies in the center of the new paradigm: DC power, not AC, at power levels defined by the monstrous demands of the Powercosm Hotel.

Emerson dominates DC

The new Edison's roots run as deep as the old's. Emerson was founded in 1890 in St. Louis, Missouri, as a manufacturer of electric motors and fans. It grew by finding new uses for new motors and fans: sewing machines, dental drills, player pianos, and hair dryers. Its HVAC business unit still cools people spaces, but the ascendant focus is on cooling silicon spaces with "precision air conditioners." CPUs dislike heat.

Outside the hermetic world of the old telecom-equipment vendors, Emerson was the first major player to grasp the broader importance of the DC power plant. Emerson had moved into the AC UPS business with its 1985 acquisition of Franklin Electric. In 1998 Emerson acquired Nortel's Advanced Power System business followed by the completion this April of the acquisition of Ericsson's power business. Emerson now has corporate sales of $350 million in AC UPS and $500 million sales in DC power plants. Customers include wireline and wireless service providers (AT&T, MCI Worldcom, Alcatel, Sprint, Motorola, Nokia), datacom companies (Cisco, 3Com, Sun Micro), telecom equipment manufacturers (Lucent, Nortel, Ericsson), and Internet infrastructure companies (Level 3, Qwest, Exodus). Emerson's total revenue growth from Powercosm ("telecom and electronics") was over $1 billion from 1997 to 1999–closely matching the total combined revenue growth of all four divisions that make up the rest of Emerson, each of which is a multibillion dollar business in its own right. Their Powercosm business grew 33 percent in the first quarter of the year 2000.

Who else is anchored in the DC paradigm of the Powercosm Hotel? There are other credible DC products, but precious few with any degree of focus. Marconi and Alcatel are, as noted above, serious DC players, but not pure plays and locked in to the wrong business model for the accelerating pace of the Telecosm. The pure AC UPS companies will do fine in the temporarily rising AC market (and can increasingly migrate to a growing, but less demanding, non-CPU power quality market), but in the long run, they are not positioned to play in the powercosmic DC space. Lucent Power: we'll wait and see where it lands.

Experience counts

Much of Emerson's most valuable intellectual property resides in its engineering history, and the real-world experience Emerson reflects. And there is strong reason to expect this business to exhibit strong economies of scale and scope, rewarding first movers and squeezing out laggards.

Remote monitoring capabilities, common in geographically distributed power nodes for fiber and wireless networks, are increasingly important for Powercosm Hotels, too. Equipment performance and maintenance is critical to maintain 9s. Indeed, remote monitoring–of such basics as battery status, replacement schedules, duty cycles, load changes, and environmental factors like temperature and humidity–can do more to boost overall reliability than almost any amount of superior engineering in the hardware on the premises. Remote monitoring is then combined with remote troubleshooting, often as basic as rebooting systems or remotely controlling loads.

Emerson operates centers for monitoring all power equipment 7x24 from redundant operation centers in Columbus, Ohio; Stockholm; Italy; Sao Paulo; Kuala Lumpur; and Hong Kong.

Historical experience is as important and valuable as real-time monitoring, and here, too, first movers and market-share leaders have all the advantage. Assessing the overall reliability of a system, and then raising it, depends on developing a detailed knowledge base of blueprints and failure statistics–the key tools for increasing reliability in comparable industries like aviation, nuclear power, and navy submarines. As Steve Fairfax, president of MTechnology (Saxonville, Massachusetts) points out, the main choke-points, most of the time are basic: simple ignorance about how much a power outage will cost an enterprise (and therefore what it's worth to avoid), how likely it is to occur, and how much different engineering configurations will change the odds. Fairfax notes wryly that the first and most fundamental challenge for the 9s industry is "to start to really keep score"–i.e., get systematic in tracking failures and near failures, and learn from them, in much the same way as airlines, the nuclear industry, and their overseers already do.

The importance of such databases strongly favors the largest players, because they accumulate experience the fastest. Some independent system integrators (e.g. the privately held SurePower, Danbury, Connecticut) endeavor to do the same, drawing on the databases of cooperative equipment vendors. But, so far, few can match Emerson's ability to create these databases and mine them in-house, simply because no other company is as deeply involved in engineering and deploying both AC and DC power plants and the countless switches and related hardware (silicon and otherwise) that surround them nearby. On this basis alone, Emerson ranks far ahead of the rest of the field, with approximately one-third of its $15 billion annual sales realized in these key markets.

The new economy is nine 9s

Within the Powercosm Hotel, some 80 percent of electrical infrastructure failures come about as a result of problems between the power plant and the load. As a result, distributed, redundant dual power plant, dual-bus configurations are essential and standard. As digital real estate rises and spreads, power plants will multiply apace, becoming as ubiquitous as transformers. Indeed, they perform much the same function, converting electricity that suits the grid to electricity that suits the load.

The Power Panel

Ascendant Technology	Company (Symbol)	Reference Date	Reference Price	5/31/00 Price	52wk Range	Market Cap	Customers
Silicon Power Plants In-the-room DC and AC Power Plants	Emerson (EMR)	5/31/00	59	59	40 1/2 - 69 7/8	$25.2b	Citicorp, NTC, GTE Wireless, Nokia, Motorola, Cisco, Exodus, Qwest, Level 3, Lucent, etc.)
	Power-One (PWER)	*(see below)*					
Motherboard Power Bricks, High-end DC/DC converters	Power-One (PWER)	4/28/00	68 1/4	87 5/8	12 1/2 - 94 5/8	$2.13b	Cisco, Nortel, Teradyne, Lucent, Ericsson
Powerchips: Insulated gate bipolar transistors (IGBTs)	IXYS (SYXI)	3/31/00	13 9/16	19 13/16	3 1/16 - 32 1/4	$237m	Rockwell, ABB, Emerson, Still GmbH Eurotherm Ltd. (UK), Alpha Technology
IGBTs	International Rectifier (IRF)	3/31/00	38 1/8	41 1/4	10 1/4 - 51 5/8	$2.53b	Nokia, Lucent, Ericcson, APC, Emerson, Intel, AMD, Ford, Siemens
Network Transmission and UPS: High-temperature superconductor	American Superconductor (AMSC)	9/30/99	15 3/8	26 1/2	11 13/16 - 75 1/8	$507m	ABB, Edison (Italy), ST Microelectronics, Pirelli Cables, Detroit Edison, Electricite de France

Note: This table lists technologies in the Powercosm Paradigm, and representative companies that possess the ascendant technologies. But by no means are the technologies exclusive to these companies. In keeping with our objective of providing a technology strategy report, companies appear on this list only for the core competencies, without any judgement of market price or timing. Reference Price is a company's closing stock price on the Reference Date, the date on which the Power Panel was generated for the Digital Power Report in which the company was added to the Table. All "current" stock prices and new Reference Prices/Dates are based on the closing price for the last trading day of the month prior to Digital Power Report publication. Though the Reference Price/Date is of necessity prior to final editorial, printing and distribution of the Digital Power Report, no notice of company changes is given prior to publication.

Demand for three-9s power is growing at under 3 percent per year; demand for nine-9s power at 80 percent per year, and more. Profit margins on low-9s power are dropping; margins on the high-9s power are going up. Overall, the high-9s power plant business is already $21 billion a year in hardware sales (never mind related installation, operations, and peripheral equipment sales). It will be $30 billion in two years, and we project $100 billion in five years. Exodus observes that it spends three times as much for the power-related systems in its Powercosm Hotels as it does on bricks, mortar, real estate, and even bandwidth.

The proliferation of silicon power plants is already pushing the limits of what engineers traditionally design within buildings. A new era of micro- (building) and nano- (room) grid experts in the 9s fields is rapidly emerging. Further, the proliferation of multiple redundant arrays of megawatt-level silicon power plants, along with backup multiple generation and grid connections, puts new demands on yet another layer of intermediate electronics–the high-end silicon switches. All are subjects for future exploration.

Of equal interest perhaps is the potential for profound disruption of the native old economy utilities. How long will it take for an eEmerson, or equivalent, to find out that their turnkey feature–out-sourced 9s 'utility'–is easily moved into the last remaining part of this space–the acquisition of the trash wholesale three-9s electrons? Once they move there, they start gobbling up the high-margin, high-value (customer) side of the old utility business. They are best positioned to move there because they sell value (9s) while utilities sell lower 9s for what? Lower prices?

The end game? There will remain enormous business in the old economy's three-9s power plants of GE and competitors. (Remember, even a paltry 2 percent annual growth in three-9s in the U.S. economy is the entire capacity of Taiwan built every two years.) But it's a commoditized, cutthroat business where money is made in volume, the agri-business of the twenty-first century. The high marginal value, the profits, and the disruptive long-term growth lie in the Powercosm Hotels' appetite for megawatts of 9s. Just as Edison was forced to build the first power plant to fuel the light bulb, so too have today's Edisons been forced to build their own silicon power plants to fuel the digital age.

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