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INVESTING IN SUSTAINABLE ENERGY SYSTEMS

By
Robert W. Shaw, Jr.
President
Aretê Corporation

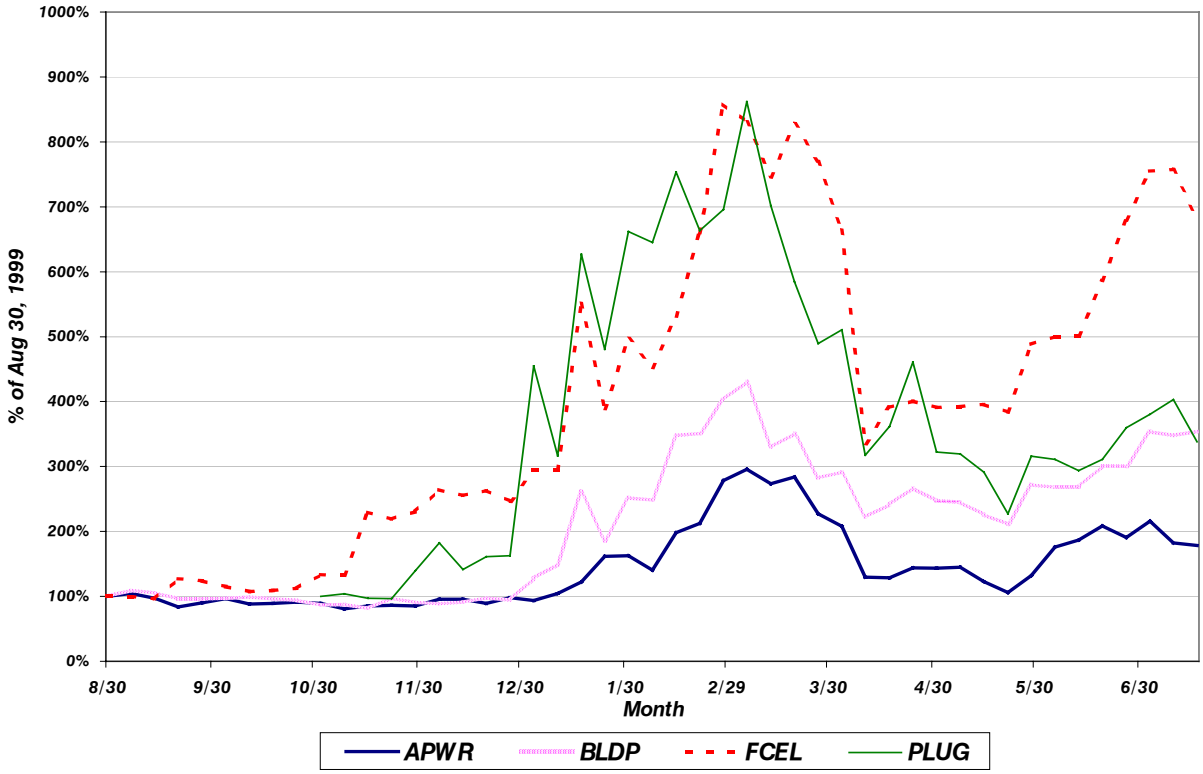
There has been a remarkable sea change in the attitude of investors toward energy technology stocks in the last six months. The sector is clearly 'hot'! Through most of 1999, the bellwether public stocks in the field: Ballard Power (BLDP), Fuel Cell Energy (FCEL), AstroPower (APWR) and American Superconductor (AMSC)--were largely flat or declining. On October 29, a new fuel cell company, Plug Power (PLUG), launched its IPO at what seemed at the time an astonishingly high market cap (approximately US$650M at US$15.00/share), but saw little immediate after-market interest in its stock.

Then, on January fifth, 2000, everything changed. A writer for MSN Financial, Jon D. Markham, predicted that Plug Power would grow dramatically in the years ahead, and suddenly the stock took off, reaching a high of over US$156/share -- a market cap of nearly $6.8B. Nearly simultaneously, all of the other energy technology stocks surged to all-time highs. Although the broad downturn in the markets in late spring adversely impacted energy technology stocks as well, they never dropped to their 1999 levels and in most cases are up three to five times for the year, although well below their highs of early March, 2000 (See Fig 1).

The excitement surrounding the limited number of energy stocks available to the public led a stream of private companies to go public. The first of those out of the gate was Capstone Turbine (CPST), a manufacturer of microturbines for use in distributed power applications, which completed its IPO as this article was being prepared and raced quickly to a lofty market cap. A string of new IPOs for other energy technology players, from fuel cells to flywheels, will be coming to market over the summer and fall. Indeed, by late 2000, a fully defined and rapidly growing energy technology market will undoubtedly be available to the investing public, a situation almost unthinkable only a year ago.

The private equity market for energy technology deals has also kept pace with the surge in the public markets. Energy companies setting out to raise modest private rounds in the spring found, to their amazement, that the rounds were over-subscribed, often by factors of three or four. This flood of private equity into energy technology has continued on into the summer.

Figure 1
Energy Stock Performance



There are several important implications in these trends for private equity players who are interested in energy technology investments:

- it is clear that a wide-open path to liquidity through the public market now exists, a path that was far less certain only a short while ago

- the flow of public and private capital to the field will attract more of the best and brightest talent to energy deals, and the quality and number of deals available will likely increase

- on the downside: valuations on the deals that come to the private equity market will almost certainly be much higher than has historically been the case

What exactly is driving the enthusiasm of investors for the energy technology sector, other than a simple herd effect spurred by the behaviour of the market early in 2000? Probably the single biggest factor is the recognition by financial analysts that key components of the 'new' economy – the Internet, communications and multimedia industries, as well as more traditional sectors, such as computerised banking – are dependent on continuous computer control and

information flow. Thus, analysts have realised, they are terribly vulnerable to an ageing and increasingly unreliable electric utility infrastructure. 'The 'e' in e-commerce is e-lectricity,' is one of the hype phrases circulating at the moment. George Gilder, a noted new economic analyst of 'telecosm' fame, coined the term 'powercosm' to capture the link between electricity and the new economy.

The utility grid with which we are all familiar was designed to achieve reliability of around 99.9%, or 'three nines'. That means one out of every thousand hours, or about nine hours a year, you can expect the grid to be down. That level of reliability was just fine in an analog age. But with computers and electronics controlling everything digitally, it is no longer tolerable. Cybercentres, information/data centres, and the communications infrastructure require at least 'six nines' (99.9999% reliability) – or only 30 seconds out per year – and often higher. The revenue lost from outages is so high for customers who need 'six nines' that they are willing to pay a substantial premium over the cost of grid electricity to achieve reliability.

In fact, the only way these customers can get the reliability they need is by installing distributed electric generation, that is, generators right at their location. And the new energy technology solutions they are turning to, such as microturbines, fuel cells, advanced batteries and flywheel storage, are exactly those technologies that are produced by the new darlings of the public market: the power technology companies.

The traditional electric grid, built for 'three nines' reliability and serving the economy well for many decades, is particularly vulnerable to all manner of weather-related outages, from ice storms, hurricanes, tornadoes and floods, to thunderstorms and heavy snow falls. In certain parts of the world, weather events have always been a risk. 'Freezing in the dark' is an ever-present risk for residents of the north-eastern United States following ice and snow storms – and it's no joke. Although scientists argue about whether global warming is responsible, it is clear that the frequency and severity of catastrophic weather events is on the rise. Even in France, where weather-related outages are a rarity, violent windstorms have created havoc with the grid twice in less than a year.

Distributed energy systems, generating electric power from small-scale power plants close to the customer, are widely considered attractive options to reduce, and eventually eliminate, the threat of weather-related electric outages. With many people working at home using computers and other electrical equipment, the need for high reliability in the residential sector is becoming almost as critical as it is in the commercial and industrial sectors, and new energy technologies may be the only real solution.

So due to a whole host of factors, the energy technology market is 'hot.' All of the major investment banks have created a powertech group, and their analysts, many of them repositioned from other sectors and learning the energy field as they go, are writing vigorously on the 'new' energy sector. The Venture Capital Journal declared power technology "the next big thing" and writers around the world have picked up the theme.

What does this new-found enthusiasm for energy technologies have to do with sustainability? Most of the investors focusing on the energy technology sector are doing so

because they expect exceptional returns. They are investing in winning technologies and strong management teams, and exercising the usual diligence of prudent investors. Sustainability criteria are, sadly, not a top priority for most of them, if they consider them at all.

Happily, for those seeking investments offering both attractive return potential and a high measure of sustainability, the energy technology sector offers a convergence almost unparalleled in other sectors. And those investing in new energy technologies strictly for return are, perhaps unknowingly, also contributing mightily to promoting a fully sustainable energy system on a world-wide basis. To understand why, we need to take a moment to examine these new energy technologies.

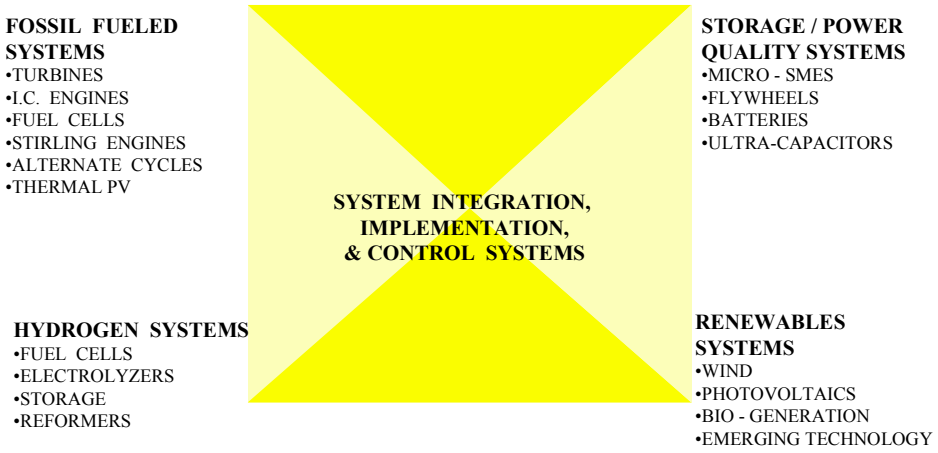
A useful taxonomy of the technical structure of the emerging power systems is given in Fig 2, which our investment team uses to evaluate the diversity and interconnection between investments in our recently formed Micro-Generation Technology Fund. Before going through the five classes of technology on the chart, we should point out that:

- Virtually all of the exciting energy deals we have cited are developing and marketing small-scale power systems – we coined the term 'micro-generation' to describe them. Traditional central station power plants deliver 100 to 1000 megawatts (MW) of power output: enough to provide power to loads from the size of a large industrial plant all the way up to a small city. They are also generally far from environmentally benign, even with state-of-the-art environmental controls that meet regulatory standards. The 'new' technology power plants are tiny by comparison, ranging in size from a few kilowatts (kW) -- enough power for a single residence -- to a few hundred kW -- enough to power a small commercial facility. These are power plants you could put in the backyard, right beside the air conditioner, or perhaps in the basement; and you would because they are environmentally friendly.

- These micro-generators are so small that they are often referred to as energy 'appliances.' They can be mass-produced, just like a kitchen appliance or an automobile. As a result, costs will be driven down as the number of units manufactured increases – the familiar 'experience curve' effect that has made computers ever cheaper, even as their computing power increases.

- Most (though not all) of the micro-generation technologies represent substantial technical advances over traditional power generation technologies. The companies developing them are building sustainable competitive advantage on the basis of strong intellectual property positions. These technologies use advanced materials, sophisticated power electronics and novel electrochemical processes. Many of these technical advances were initially developed by space and defence programs where cost was not important, and are now emerging in commercial form to reshape the old, and somewhat stale, electric power industry.

Figure 2
Classification of Micro-Generation Technologies



All of the micro-generation technologies that are highlighted in Fig 2 have an extremely important feature: they are environmentally friendly. Those that convert fossil fuels to electricity inevitably contribute CO_2 to the atmosphere, but the amount of CO_2 produced per unit of electrical output is often lower than would be expected from traditional power generation, since the efficiency of the micro-generator is higher. Without doing an exhaustive review of all the technologies, let's look at a few examples from Fig 2.

- Fossil Fuelled Micro-Generation systems range from dramatically re-engineered internal combustion engines, burning natural gas or propane, to the new micro-turbines, such as those produced by Capstone Turbine, to solid oxide fuel cells that internally reform gaseous and liquid fuels and produce electricity at 50-60 percent efficiency. The excess heat created by these various generators can be captured and yield system efficiencies from 70% to over 90%. The new micro-turbines, in particular, are very attractive from an environmental perspective. Capstone's unit, for example, is specified to produce only nine ppm of Nox, and in fact typically is under three ppm.

- Hydrogen-Based Systems use hydrogen fuel made by reforming fossil fuels or electrolysing water to run low-temperature fuel cells, such as the Proton Exchange Membrane (PEM) fuel cells produced by Ballard Power and many others. These PEM fuel cells can be used in stationary applications or to power automobiles. Amory Lovins of 'soft path' fame has suggested that the fuel cell power plant in a vehicle could be used to provide stationary power while the vehicle is parked in a garage or on a lot. If the starting fuel is hydrogen, the only effluent from the oxidation process in a fuel cell is chemically pure water – H_2O. Companies like Proton Energy Systems are manufacturing electrolysers to make highly pure hydrogen from water. Their product is about the size of

a dishwasher and could easily fit in a garage to fuel up the PEM-powered vehicle at night.

- Renewable Micro-Generators are, of course, intrinsically non-polluting. Perhaps the most exciting of the renewable technologies is photovoltaics (PV). PV systems produce electric power from sunlight shining on a photocell made from a semiconductor very like those used in integrated circuits. Again, mass production is driving costs down. Many large companies such as Siemens, BP Amoco, Shell and Kyocera are vigorously pursuing PV technologies. Entrepreneurial companies with innovative technical approaches, like AstroPower and Evergreen Solar, have attracted investment capital and are challenging the big players.

- Micro-Storage/Power Quality Systems such as flywheels and superconducting magnetic energy storage (SMES) systems are being coupled with traditional generators to assure high levels of voltage carry-over and stability for customers with 'six nines' requirements. One of the most exciting technical developments in this area is a novel form of electrochemical system called the zinc-air fuel cell. Pioneered by Metallic Power and several other entrepreneurial companies, this fuel cell uses zinc pellets or foils as fuel. Once oxidised in the cell, the zinc fuel can be regenerated and used again – a recyclable fuel.

- System Integration and Control Technologies are being introduced by numerous companies such as Northern Power Systems. These tie all of the other micro-generation technologies together into system solutions that meet specific customer needs.

All of these technologies have a remarkably light environmental footprint compared to traditional generating systems. But what is particularly exciting is that, with the emergence of these micro-generation technologies, one can envision for the first time a truly sustainable energy system, one that would combine:

- Photovoltaics – taking energy from the sun to generate electricity,
- PEM Electrolysers – using the electricity from the PV system to produce hydrogen gas, which can be stored, and
- PEM or Solid Oxide Fuel Cells – oxidising the hydrogen to make electricity when it is needed, and producing only pure water as an effluent.

Such a system would enable us to operate our electric economy using only energy from the sun and producing no pollutants of any kind. Investments in companies developing and commercialising these technologies can, over time, lead the world toward the ultimate in sustainability.

Investment in energy technology companies offers an exciting and potentially highly rewarding opportunity for sustainability investors. But it also carries with it substantial risk. Fledgling entrepreneurial companies, such as those who seek capital in private placements, are inherently risky. Even most of the public companies in the power technology sector are still in the

development stage. The only sensible investment strategy is to assemble a portfolio of investments with a diversity of deals, spanning all of the areas we have discussed.

Wealthy investors may be able to spread investments over enough deals to reduce portfolio risk, using their own resources. An alternative for those with fewer resources, or without the expertise to make the necessary technical judgements, is to invest in a venture capital fund focused on the energy technology area. The funds managed by Aretê Corporation over many years, especially the recent Micro-Generation Technology Fund, have invested in a large number of emerging energy technology companies (Fig 3) and have enjoyed extraordinary success with their focused strategy. There are several other venture funds that have targeted the energy technology sector as part of their investment strategy. They include:

- Nth Power Technologies
- SAM Private Equity Fund
- Commons Capital

Others certainly will be formed as a result of the attention investors are lavishing on the energy technology sector. It is my great honour and privilege to be associated with these three funds, as well as to have been entrusted over the years with the capital that was invested by the Aretê funds in nearly 80 companies, including the 17 extraordinary companies listed in Fig 3.

Figure 3
Energy Technology Investments by Aretê Funds

1. BALLARD POWER SYSTEMS, INC.*	P.E.M. FUEL CELLS
2. ASTROPOWER, INC.*	PHOTOVOLTAICS
3. AMERICAN SUPERCONDUCTOR CORP*	HTSC TECHNOLOGY
4. SUPERCONDUCTIVITY, INC.	MICRO - SMES (Acquired by ASC)
5. EVERGREEN SOLAR, INC.	PHOTOVOLTAICS
6. STATPOWER TECHNOLOGIES CORP	INVERTERS (Acquired by XANTREX)
7. NORTHERN POWER SYSTEMS, INC.	SYSTEM INTEGRATOR
8. PROTON ENERGY SYSTEMS, INC.	P.E.M. ELECTROLYZERS / REGENERATIVE P.E.M. FUEL CELL
9. CAPSTONE TURBINE CORP*	MICROTURBINES
10. METALLIC POWER, INC.	ZN - AIR FUEL CELL
11. ENCORP, INC.	CONTROLS & INTEGRATION
12. BURSTPOWER TECHNOLOGIES	ULTRACAPACITORS (Acquired by CELLTECH)
13. BEACON POWER CORP	FLYWHEEL UPS /PQ SYSTEMS
14. HYDROGENIC S, INC.	P.E.M. TEST STATIONS
15. BOWMAN POWER SYSTEMS, LTD	MICRO - TURBINE CHP
16. POWERZYME	ORGANIC BATTERY
17. CELLTECH POWER, INC.	SOLID OXIDE FUEL CELL

*NOW A PUBLIC COMPANY

While it now seems quite prescient to have launched an alternative energy investment strategy as early as the mid-1980's, at the time the decision to invest in companies like Ballard Power, AstroPower, American Superconductor and Superconductivity Inc., was widely regarded in the investment community as bordering on imprudent. While there were other venture funds that

joined us in those investments, there were only a few who saw the true promise of the energy technology future. As a result, filling out investment syndicates was difficult at best. We always made decisions on the investments we selected based on sound business criteria, but for many of us that stuck our necks out in the early days, the importance of doing something for the planet was never far below the surface.

Today the opportunity presented by energy technology investing is far more transparent than it was in those early days and the potential to achieve exceptional return while supporting a sustainable future is real indeed.