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CAMBRIDGE ASSOCIATES LLC

INVESTING IN CLEAN ENERGY AND TECHNOLOGY

2007

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C O N T E N T S

ABSTRACT

1. This paper provides an overview of the investment outlook for cleantech investing, including definitions of the main cleantech sectors and analysis of the following:
   - economics of the primary clean energy sources that seek to take market share from traditional fossil fuels;
   - market size and growth potential;
   - performance characteristics;
   - major risks;
   - diversification characteristics; and
   - implementation considerations.

   Cleantech includes several subsectors that behave with different dynamics, which we group into the following three categories:
   - **Clean/Alternative Electricity**—geothermal, hydro, landfill gas, solar, and wind.
   - **Clean/Alternative Fuels**—biodiesel, ethanol, cellulosic ethanol, and hydrogen.
   - **Other Clean Technologies**—advanced materials (nanotechnology), battery storage, carbon sequestration, energy efficiency, fuel cells, pollution control, recycling, waste management, water purification, and more effective use of fossil fuels.

2. Cleantech is an evolving investment opportunity that could potentially provide lower correlation to and different risk characteristics than traditional investments. The movement to lower carbon "21st century industrial technologies" has the potential to be the largest infrastructure transition since the industrial age. The recent confluence of extreme climatic events, new carbon regulatory regimes, high energy prices, technological advancements, and energy security concerns has led to increasing investment in cleantech. In fact, cleantech is now the third largest venture category after information technology and biotechnology, up from a small amount in 2001. Global venture investment in cleantech was $3.9 billion in 2006, up from $2.3 billion in 2005, of which North America constituted a majority. Cleantech venture capital has received only a fraction of global clean energy investments, which consist primarily of research and development and infrastructure investments. Total global clean energy investments have also increased rapidly, from $28 billion in 2004 to $71 billion in 2006.

3. The tremendous flow of capital to cleantech has increased valuations in recent years and left many wondering if we are in the middle of a cleantech bubble. Assessing valuations of new technologies is difficult in general, but particularly so for those cleantech sectors that rely not only on successful development of companies with leading technologies, but also on sustained high commodity prices and government regulations and subsidies. While the sector as a whole may be experiencing rising valuations, the cleantech market includes a diverse range of investment opportunities in which manager selection is critical. As in many other investment areas, investors should look toward managers that have the skill and discipline to find attractively valued opportunities relative to their returns.

4. Cleantech investments incorporate some characteristics of private energy, infrastructure, and technology and biotech venture capital, and as such can provide unique portfolio diversification attributes. In addition, alternative energy investments may also hedge the risks of "clean energy" conversion or new carbon regulations on other parts of the portfolio. For instance, investing in clean energy may offset the risk of marketable investments that have a high level of dependence on fossil fuels (i.e., airlines).

5. Government policies and subsidies coupled with rising fossil fuel prices have favored cleantech investments in recent years; however, these factors also present significant risks. As with health care and traditional energy investments, regulatory changes can drastically affect certain cleantech sectors, especially those whose business models are not yet viable without government subsidies, such as corn-based ethanol. While supply/demand dynamics appear to be supportive of higher fossil fuel prices than have prevailed over the last several decades, a decline remains a risk for certain alternative energy companies. In particular, oil prices affect the market demand to finance biofuels companies while natural gas and coal prices affect the level of investment in solar and wind companies.

6. The number of high-quality specialized non-marketable cleantech managers has increased markedly over the past couple years. In addition, generalist non-marketable funds have increased their cleantech exposure to gain access to the opportunity. It remains unclear whether diversified generalist funds with less cleantech industry expertise or newer dedicated cleantech managers will have stronger cleantech investing track records. Generalist funds offer longer track records, and typically have more expertise in successfully growing companies and unlocking value through successful exits. They offer more organizational stability than emerging managers, and can have the flexibility to opportunistically invest in cleantech based on the sector's attractiveness relative to other sectors. Investors may find the diversification of a cleantech fund-of-funds invested over several years in a broad range of sectors a welcome complement to direct plays, particularly where the universe of successful exits in cleantech is small but growing. Investors with smaller non-marketable programs may not be able to achieve appropriate sector and vintage-year diversification on the private side and may instead consider the growing number of public managers or cleantech indices.

7. Several cleantech investment options are available to investors. The best option will be dependent on the size, relative diversification, risk tolerance, and return objectives of each. For instance, investors with smaller non-marketable programs may not be able to achieve appropriate sector and vintage-year diversification on the private side and may instead consider public options. Compelling cleantech investment opportunities are more limited in the public markets and many of the most significant publicly tradable cleantech businesses are part of a larger, diversified conglomerate for which cleantech is only a small piece. Finding a cleantech public equity manager with a significant track record and relatively reasonable fees can be a challenge. However, there are some interesting cleantech long/short hedge funds available that can short overvalued cleantech sectors.

8. Due to the early-stage status of many potential investments in cleantech, more opportunities are available to investors in private cleantech companies. Only a small universe of pure-play, public cleantech companies are available to invest in the public market. Given this, this paper focuses on the private opportunities.

SUMMARY

Introduction

"Greentech could be the largest economic opportunity of the 21st century."—John Doerr, Partner, Kleiner Perkins Caufield & Byers.

"Driven by solar and biofuel deals, the energy segment looks overheated—there's no way that more than a fraction of the 930 energy start-ups operating worldwide can possibly succeed."—Matthew M. Nordan, President, Lux Research.

"Global warming, we judge, is likely to prove one of those tectonic forces that—like globalization or the ageing of populations—gradually but powerfully changes the economic landscape in which our clients operate, and one that causes periodic sharp movements in asset prices. …[W]e consider that climate change poses many challenges but also presents many business opportunities. Firms that recognise the challenge early, and respond imaginatively and constructively, will create opportunities for themselves and thereby prosper. Others, slower to realize what is going on or electing to ignore it, will likely do markedly less well."—Dr. John Llewellyn, Senior Economic Policy Advisor, Lehman Brothers.

It appears highly likely that the global economy will at some point implement a massive conversion either away from fossil fuels or toward a cleaner use of fossil fuels (or both). This movement away from carbon-intense energy sources has the potential to be the largest infrastructure transition since the industrial age. In recent years, record droughts, two standard-deviation warm winters, hurricanes, wild fires, and floods worldwide have brought climate change front of mind for the public, politicians, investors, executives, and board members (Table A). The confluence of these extreme climatic events, new carbon regulatory regimes, high energy prices, technological advancements, and concerns over energy security has led to increasing investment in clean energy and other technologies, or "cleantech." Cleantech loosely refers to "products, technologies, and processes [that] through improvements in the clean energy supply chain from the energy source to the point of consumption, result in a reduction in carbon dioxide" and other toxic emissions.[1] Mohr Davidow Ventures stated that the field could more accurately be called "21st century industrial technologies," which may better describe the scale of the opportunity set.

This paper provides an overview of the investment outlook for cleantech investing, including definitions of the main cleantech sectors and analysis of the following:

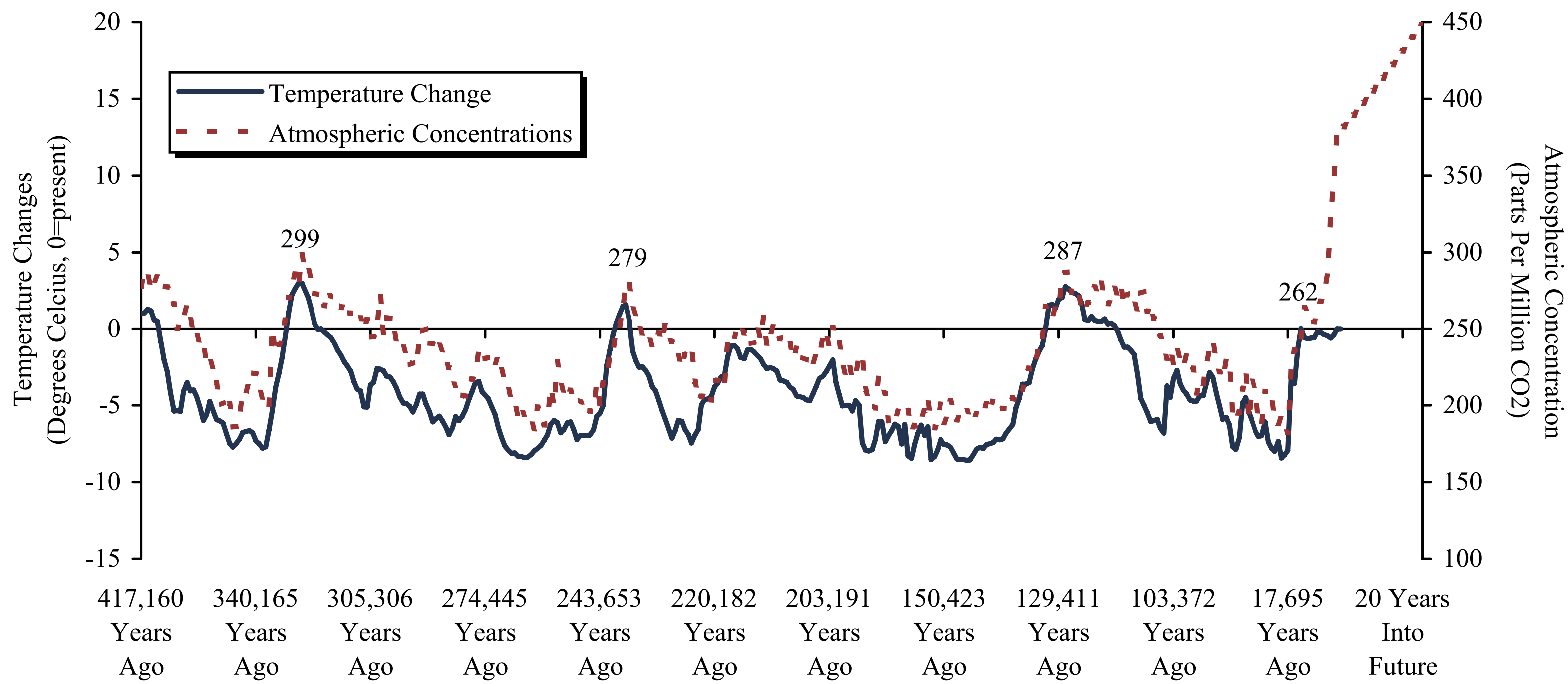
- economics of the primary clean energy sources that seek to take market share from traditional fossil fuels;
- market size and growth potential;
- performance characteristics;
- major risks;
- diversification characteristics; and
- implementation considerations.

[1] Roger Franklin, "Cleantech Goes Mainstream," *Library House*, p. 3, April 17, 2007, www.libraryhouse.net.

Table A

TEMPERATURE FLUCTUATIONS CORRESPONDING TO ATMOSPHERIC CONCENTRATIONS OF CARBON DIOXIDE

417,160 Years Ago – 2030



Sources: Alliance Bernstein, Arctic and Antarctic Research Institute, Laboratoire de Glaciologie et de Géophysique de l'Environnement, Laboratoire des Sciences du Climat et de l'Environnement, Oak Ridge National Laboratory, and The Woods Hole Research Center, courtesy of Michael Ernst.

Note: Estimated data are used for years beyond 2007.

Definitions and Drivers

We categorize cleantech into three main sectors: clean/alternative electricity, clean/alternative fuels, and other clean technology. More in-depth definitions can be found in Appendix A. In this section, we discuss key return drivers and define these market segments.

Clean/Alternative Electricity

Clean/alternative electricity sources include solar, wind, geothermal, hydropower, landfill gas, and nuclear energy. Coal and natural gas, the traditional fossil fuel electricity sources, set the market rate for electricity. Renewable electricity's competitiveness depends on this price, plus any relevant subsidy revenue. Unlike traditional coal and natural gas electricity plants that require ongoing feedstock, renewable electricity plants require a lot of capital up front, but then rely on free fuel (sun, trash, water, wind, etc.). The main driver of the electricity market has traditionally been utilities; however, on-site solar power enables the end user to bypass the utility. Developing new electricity generation without a guaranteed end buyer ("merchant generation") offers higher risk and often higher returns, whereas developing a new source with a guaranteed utility or other buyer offers a more certain, but lower return. Developing new electricity generation sites typically offers higher returns than simply providing the project finance capital to a third-party developer. More speculative new renewable electricity sources, such as Copper Indium Gallium Diselenide (CIGS) solar cells, offer a venture-like high-risk, high-return potential.

Solar Electricity. Solar electricity uses photovoltaic cells (solar cells), which use the photovoltaic effect of semiconductors to generate electricity directly from sunlight. Solar cells can be centralized and act like a power plant or more typically are installed on roofs at the point of use. Solar is vulnerable to subsidy cuts given its $0.35 per kilowatt hour (/kwh) unsubsidized rate ($0.07 after subsidies) (Table B). However, innovations in next generation solar technologies, such as CIGS thin cells that do not require scarce silicon, as well as cheap manufacturing from China, should continue to lower this price. Historically, the price of solar has been decreasing at 5% to 10% per year for the past decade.

Wind Power. Wind power generates electricity by converting the rotation of wind turbine blades into an electrical current through the use of an electrical generator. It is a renewable, plentiful, and widely distributed source of energy. Because wind power is intermittent, it is best used as part of a broader portfolio of energy generating assets. The costs of this energy source are entirely front-loaded. Once the wind power facilities have been constructed, the only input, wind, is free over the life of the generation. Wind power is evolving away from its reliance on subsidies and now costs between $0.04/kwh to $0.07/kwh, compared with $2.00/kwh in the 1970s, due to material and engineering improvements as well as scale. Natural gas price spikes in recent years have increased the competitiveness of wind power as a source of electricity.

Geothermal Energy. Geothermal technology uses geothermal heat from the earth's core to generate electricity or provide heating. This technology can provide power continually, as it is unaffected by changing weather conditions. It costs approximately $0.09/kwh before subsidies, and $0.05/kwh after U.S. state and federal subsidies.

Hydropower Energy. Hydropower is a broad term used to refer to any number of techniques that capture and focus the energy of moving water, such as through hydroelectric, tidal, or wave power plants. Hydropower is generally competitive in market price when compared to fossil fuels.

Landfill Gas Energy. Landfill gas, primarily in the form of potent methane gas, is a by-product of landfills that is captured before it escapes into the atmosphere. While combusting landfill gas does contribute greenhouse gases (GHGs) to the atmosphere in the form of carbon dioxide (CO_2), it uses a by-product of waste that would otherwise be released into the atmosphere in the form of more potent methane (20 times the greenhouse effect of CO_2). Landfill gas costs approximately $0.05/kwh and $0.03/kwh with subsidies.

Nuclear Energy. In contrast to these renewable sources of energy, nuclear power is technically a nonrenewable energy source because it relies on finite sources of uranium. However, the generation of nuclear power (through nuclear fission) does not result in CO_2 emissions, and costs approximately $0.07/kwh.

Clean/Alternative Fuels

Naturally renewable fuels derived from plants or animals, such as biodiesel, ethanol, and cellulosic ethanol, are primarily used for transportation. As concerns over energy security and GHG emissions continue to increase, these biofuels—such as ethanol from sugar cane or corn—and biogases—from anaerobic decomposition of waste—have become popular technologies and have benefited from state and federal mandates. The energy content of corn ethanol is only about two-thirds that of a unit of gasoline, which means more fuel is required per mile driven. There is a chicken and egg issue with biofuels in that producers blame oil supermajors for not installing enough ethanol pumps in gas stations and supermajors blame producers for not creating the infrastructure to bring ethanol to population centers. Biofuels compete with oil and are directly dependent on its price (absent government mandated use). Alternative fuel sources, such as oil sands and first generation ethanol, generally are able to compete with oil above $40 per barrel (bbl) to $45/bbl.

Biodiesel. Biodiesel is a renewable fuel derived from animal fats and/or vegetable oils that is processed to create a fuel similar in composition and potency to traditional diesel.

Ethanol. Ethanol is a motor fuel or fuel additive created from the fermentation of plant sugars, especially sugar cane and corn. Corn and sugar have many uses (including food and animal feed) and exhibit volatile prices. Ethanol cannot be transported in traditional pipelines and must be trucked or moved by rail. The price of ethanol derived from corn in the United States varies by region. Prices are highest in states farthest from the Midwest. Additionally, state regulation impacts the price of ethanol, as states that encourage the use of ethanol create higher demand and drive up the price. Ethanol also receives a $0.51 per gallon U.S. federal tax credit to refiners that has recently spawned an overbuilding of corn ethanol plants and a glut of supply. After accounting for this tax credit and the large supply, the retail price of ethanol is approximately equivalent to the retail price of gasoline in the United States. Many investors see Brazilian sugar cane ethanol as a superior investment because it has a higher energy content than corn ethanol and is less expensive.

Cellulosic Ethanol. Next generation ethanol, or cellulosic ethanol, uses less expensive cellulose waste and does not disrupt food supplies. Cellulosic ethanol reduces GHG emissions by over 85% compared to reformulated gasoline. In contrast, corn ethanol, which often requires natural gas or coal to produce, reduces GHG emissions by 18% to 29% compared to gasoline.

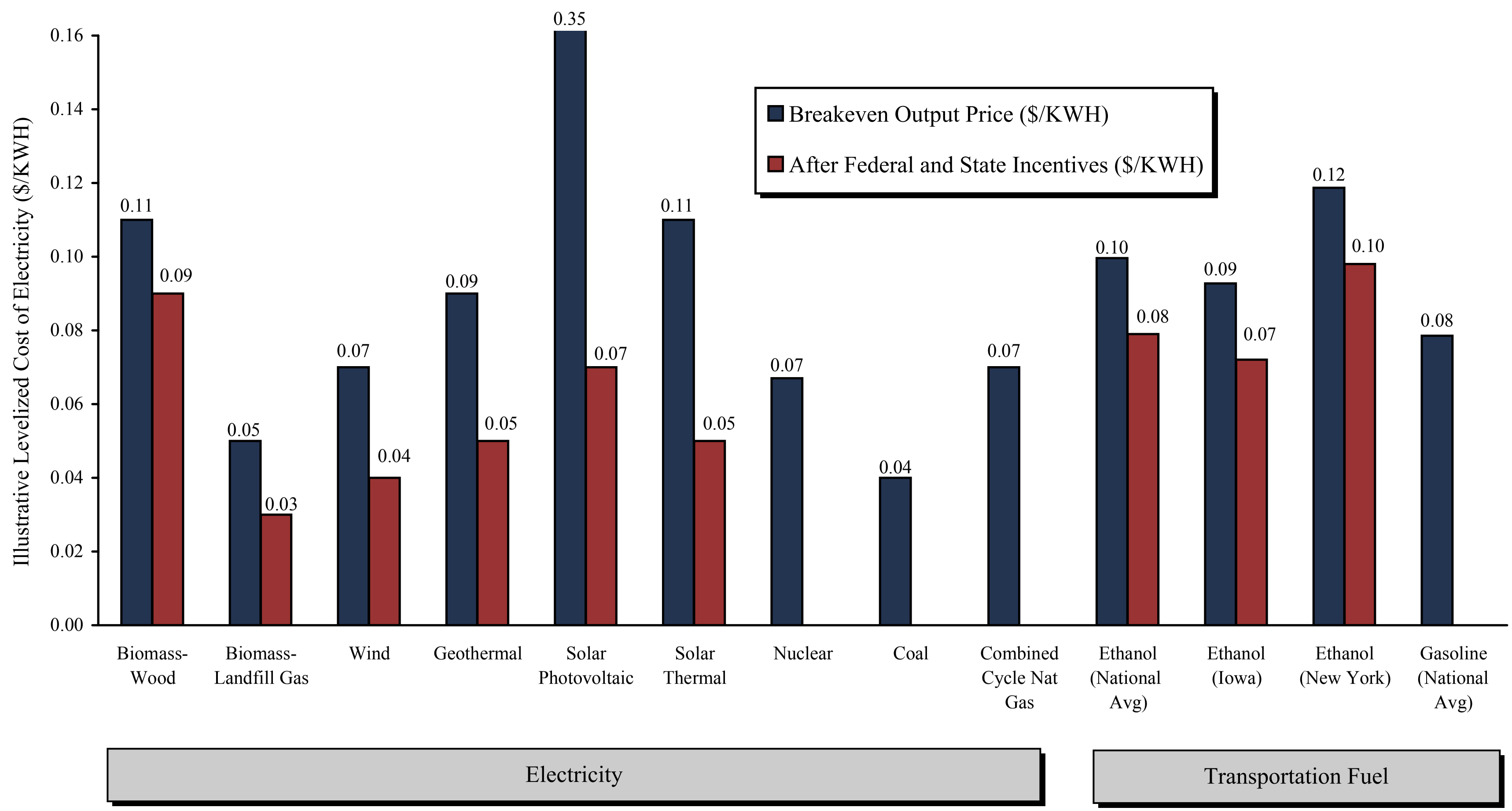
Other Clean Technologies

Other clean technologies include advanced materials (nanotechnology), battery storage, carbon sequestration, energy efficiency, fuel cells, pollution control, recycling, waste management, water purification, and more effective use of fossil fuels. These technologies do not receive as much attention as more popular sectors like wind and solar, but still offer enormous opportunity. For example, Lux Research, a research and advisory firm on emerging technologies, points out that waste treatment accounted for 32% of mergers and acquisition (M&A) activity, but only 1% of initial public offering (IPO) value and 4% of venture deals. Many of these technologies require an upfront investment that results in lower operating costs (such as energy efficiency technologies); however, it is not possible to make generalizations about return drivers for such a diverse suite of technologies.

Table B

U.S ENERGY PRODUCTION COSTS

2006–07



Sources: Cambridge Associates LLC estimates based on data provided by the Energy Information Administration, Environmental Protection Agency, Mineral Acquisition Partners, NEC, Pacific Gas and Electric Company, *The Economist,* and U.S. Department of Energy.

Notes: Ethanol and gasoline costs are calculated by converting btu/gal output at high heating to kilowatt-hours. Gasoline costs are based on conventional (regular) gasoline. Energy prices differ significantly by market. Data reflect U.S. production costs, as many of the venture capital investments in cleantech are based in the United States.

Current Environment

The cleantech market has matured substantially over the past three decades and is unlikely to wither as it did in the 1980s. The trajectory of fossil fuel costs has been upward in the last decade, while the cost of renewables has been decreasing at a rapid rate due to technological improvements (Table C). Renewable technology was too immature to stand on its own in the 1970s and offered little or no quality advantage relative to the incumbents. Today's cleantech companies have largely matured to meet higher technological standards at a lower cost, as well as provide a valuable hedge against volatile and uncertain fossil fuel supplies. In addition, today's companies meet the world's growing preference for carbon-free energy sources.

Market Sizing

The flow of funds into the broadly defined cleantech sector has been tremendous. This strong capital growth is high relative to the low levels invested in past decades, but more moderate when compared with the overall energy market. Many clean technologies have extremely low penetration within their market segments. Global clean energy investment (including research and development [R&D]) rose to $71 billion in 2006 from $28 billion in 2004, as reported by the research and information service New Energy Finance.[2] According to Lux Research, the Asia/Pacific region is the R&D leader in government funding (38% in 2006), corporate R&D spending (34%), and scientific publications. Global (North America, Europe, and Israel) venture capital investment in cleantech for 2006 was $3.9 billion, up from $2.3 billion in 2005.

While Europe is ahead of the United States in terms of the environmental policies of governments and corporations and Asia is ahead on R&D, the vast majority of venture capital investment in cleantech continues to be U.S. based. A record $2.9 billion for 2006 was invested in North American cleantech venture capital, according to the Cleantech Group, LLC, an umbrella organization for several activities related to cleantech investments. While U.S. venture investment declined 33% between 2001 and 2006, investment in cleantech increased by 243% over the same time period (albeit from a small base), according to the Cleantech Group, LLC. The $2.9 billion invested in 2006 represented a 78% increase over 2005's investment level and this growth came largely from the energy sector (rather than from other clean technologies like pollution control). As recently as 2005, cleantech investment lagged investment in medical devices, telecommunications, and semiconductors. Cleantech is now the third largest venture category after information technology and biotechnology, making up 11% of venture funds. Cleantech has moved squarely into the mainstream opportunity set for many public and private investors.

On the public side, applying the total market capitalization of the WilderHill New Energy Global Innovation Index (NEX), a global index of publicly traded companies that are active in renewable and low-carbon energy, as a proxy for the global publicly traded cleantech industry, the size of the industry is estimated to be approximately $404.9 billion (as of September 28, 2007). This index largely consists of pure-play clean energy companies and understates the total size of this sector given that many of the largest players are diversified companies (e.g., General Electric, BP) that have significant investments in sectors

[2] Theodore Roosevelt, "Investors Hunger for Clean Energy," *Harvard Business Review*, p. 38, October 2007.

such as solar, wind, hydro or other clean energies among their disparate businesses. In addition to the indexed approach, various global carbon-trading markets have been created around the world whereby buyers are paying for the right to create CO_2 pollution and therefore internalizing the cost of pollution, and sellers are being rewarded for reducing their emissions. This global carbon-trading market was worth $30 billion in 2006, up from $11 billion in 2005, according to the World Bank. Several funds are participating in this market by trading or actually buying and selling carbon-trading permits.

Growth Potential

Demand for energy recently has been and will continue to be fueled by industrialization in developing countries and the attendant higher standard of living. This decade has seen an unprecedented increase in wealth for hundreds of millions of people across the developing world. According to the management company City of London, if China and India continue to grow at their present rate, it would elevate 300 million people to a higher living standard by 2015, four times more people than saw such improvements in North America, Europe, and Japan between 1948 and 1963.[3] More wealth leads to a more resource-heavy lifestyle, requiring fuel for personal transport and goods; electricity for air conditioning, electronics, and lighting; and diversion of crops to biofuels as well as to animals to produce meat and milk. To date, this industrial transformation has largely followed the path of developed markets: growth fueled by coal, oil, and other fossil fuels. The strong global economy and this unprecedented development have manifested themselves in the form of higher prices for fossil fuels and other natural resources (Tables D and E). China actually exported subsidized oil, metals, and soft commodities until 2000, when it started importing these commodities to support its explosive growth. China now consumes 7% of world oil[4] and relies primarily on coal for electricity (Table F). Since 1994, despite the tripling of real energy prices and two recessions, global consumption has increased in every year. Over the past five years, real price increases and consumption have accelerated. The ensuing global scramble for these resources has created national security concerns, as energy resources tend to be located in politically unstable areas of the world. Coupled with global warming, these trends could present a significant growth opportunity for cleantech.

Unlike the response seen in the 1970s, Americans have so far proven more insensitive to the current round of gasoline price increases. Without a drop off in demand, prices have remained persistently high. Research from the University of California, Davis explains the changes that have made it more difficult for individuals to decrease gasoline usage today versus the 1970s.[5] Changed land use patterns, such as suburbanization and longer commutes to work, limit individuals' ability to reduce mileage in times of high prices. In addition, the share of transit miles completed on public transit has decreased over the past 30 years. In the 1970s, new cars offered significant fuel savings over older cars. Today it is difficult to gain a meaningful improvement in mileage without downsizing to a smaller car or purchasing a relatively expensive hybrid, as overall mileage standards have been relatively stagnant. Even with oil price increases, gas expenses have become a smaller portion of an individual's total paycheck: from 6% of disposable income in

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[3] "The Investment Case for Natural Resources," City of London Investment Management Company Limited, March 2007.
[4] Ibid.
[5] Jonathan E. Hughes, Christopher R. Knittel, and Daniel Sperling, "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," University of California, Davis, 2007.

1980 to less than 4% today.[6] Persistent long-term high oil prices or significant supply shocks could change the elasticity of demand in a more meaningful manner. Nonetheless, in the short term, current trends indicate that a large decrease in fuel consumption is unlikely, absent some sort of major global recession (recognizing that demand remained steady during the two recent recessions) or unprecedented high prices (current prices, while high on a nominal basis, are still slightly below their inflation adjusted highs of the late 1970s).

The Energy Information Association (EIA) predicts that renewables will remain a relatively small piece of the world energy pie for the next couple decades based on assumptions that new regulations will not make a significant impact and that the growth of traditional fossil fuel usage will remain robust (Table G). For example, in transportation, current cellulosic ethanol technologies are still several years away from scaling to the mass market stage.

In contrast to the EIA's prediction of a continuation of the status quo, many venture capitalists investing in cleantech have more optimistic aspirations for renewables' share of the global energy pie. They are funding technologies that they hope will creatively disrupt the traditional energy supply chain, as happened with the internet and telecommunications in the 1990s. As Kleiner Perkins Caufield & Byers's John Doerr described, "The investments we're making are like those we made for the internet, they are based on technological and scientific innovation, they're driven by entrepreneurs, and they're distributed." In a similar fashion Vinod Khosla, head of Khosla Ventures, says, "Look at voice telephony, these days, it's basically free. Ten years ago, people told me that would never happen. AT&T believed that—and look what happened to them."[7] Clean Edge, a cleantech research and consulting group, estimates that the global market for biofuels, wind power, solar photovoltaics, and fuel cells will quadruple to $226.5 billion within a decade (15% compound annual growth rate [CAGR]). Of course, any ten-year estimate should be taken with a grain of salt and can vary significantly by source. Nonetheless, Clean Edge estimates the following market size growth for underlying subsectors from 2006 to 2016:

- Global Biofuels: 15% ten-year CAGR (from $20.5 billion in 2006 to an estimated $80.9 billion by 2016);
- Global Wind Power: 13% ten-year CAGR (from $17.9 billion in 2006 to an estimated $60.8 billion by 2016);
- Global Solar Photovoltaics: 16% ten-year CAGR (from $15.6 billion in 2006 to an estimated $69.3 billion by 2016); and
- Global Fuel Cells and Distributed Hydrogen: 27% ten-year CAGR (from $1.4 billion in 2006 to an estimated $15.6 billion by 2016).[8]

Currently it is unclear whose predictions about the growth potential of the renewable energy market are correct. But even if renewables simply maintain their share of the global energy pie, the large increase in the overall pie would still provide a large and increasingly investable market.

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[6] Peter Fritsch, "How Economy Could Survive Oil at $100 a Barrel," *The Wall Street Journal*, p. A1, September 20, 2007.

[7] "Fairfield v the valley," *The Economist*, May 31, 2007, p. 14.

[8] Joel Makower, Ron Pernick, and Clint Wilder, "Energy Trends 2007," Clean Edge Inc., March 2007, www.cleanedge.com.

Realizations

Strong global markets, an appetite for risk, and low borrowing costs have led to a favorable exit environment for cleantech investors to harvest gains in recent years. The recent credit dislocation does not appear to have affected the health of the energy IPO market thus far. There have been several high-profile cleantech IPOs in recent years (Table H). Cleantech IPOs raised $4.9 billion in 2006, gaining an average of 21% that year. Cleantech IPOs raised $2.6 billion in 2005 and gained an average of 32% from IPO price that year. European companies made up the majority of cleantech IPOs, at 55% of 2005 and 2006 value.[9] Whether these favorable exit trends will continue remains to be seen. The true test of these nascent investments will be their performance and the ability of their business models to survive when or if the IPO window has shut and corporations postpone acquisitions, and when or if market adoption is slower or sales and profits are slower than expected.

These high-growth companies tend to trade at high multiples, but unlike the internet stocks of years past, the market demands stronger profit margins. Mohr Davidow Ventures noted that unlike some of their technology portfolio companies, cleantech companies "need to have profits by their second quarter of being public." Because of the capital-intensive nature of many clean technologies, the profitability and cash flow requirements tend to be more stringent. A global solar company, Suntech Power, raised approximately $400 million in its December 2005 IPO (at $15 on December 14, 2005) and its shares have subsequently risen 350% (to $67.48 on November 26, 2007), compared with a 11% gain in the S&P 500 (from 1,272.74 on December 14, 2005, to 1,407.22 on November 26, 2007). Q-Cells, another solar company, raised approximately $325 million and its shares have gained 175%. (See Appendix D for descriptions of three cleantech companies.)

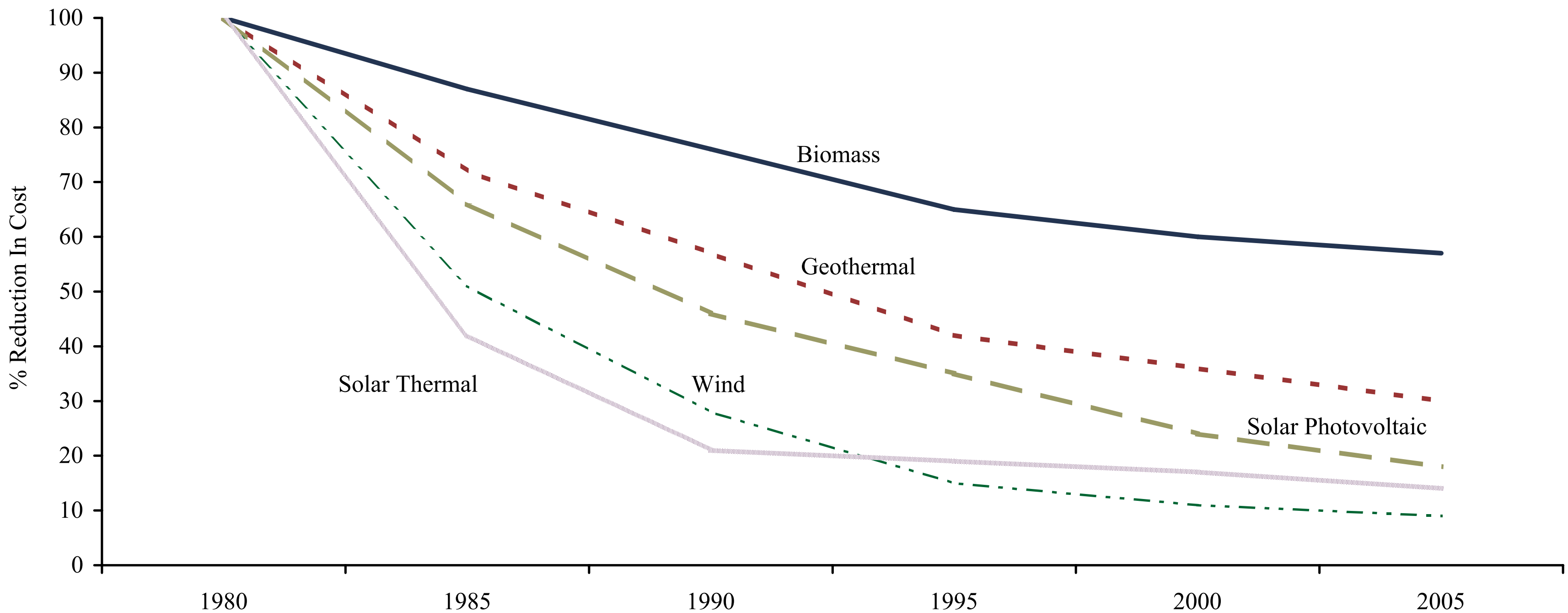
M&A is also a common exit. After General Electric turned its 2002 purchase of Enron Wind from a couple hundred million dollars per year business to several billion dollars, other conglomerates took heed. Danaher, Honeywell, ITT, Siemens, and European utility companies have been actively acquiring cleantech companies. Goldman Sachs turned its $150 million purchase and $800 million subsequent investment in Horizon Wind Energy into a $2.1 billion sale to Portuguese utility Energias de Portugal.[10] The creation of these successful exits and the presence of strategic buyers together with the continued development of competitive products and market adoption have encouraged further cleantech investment.

9 "'Clean Technology' Takes Off with $48 Billion in 2006 Funding, but Energy Tech Bubble Looms," Lux Research Press Release, April 30, 2007.
10 Monica Langley, "Why $70 Million Wasn't Enough," *The Wall Street Journal*, p. A8, August 18, 2007.

Table C

CLEAN TECHNOLOGY COSTS ARE DECLINING TOWARD GRID PARITY

January 1, 1980 – December 31, 2005



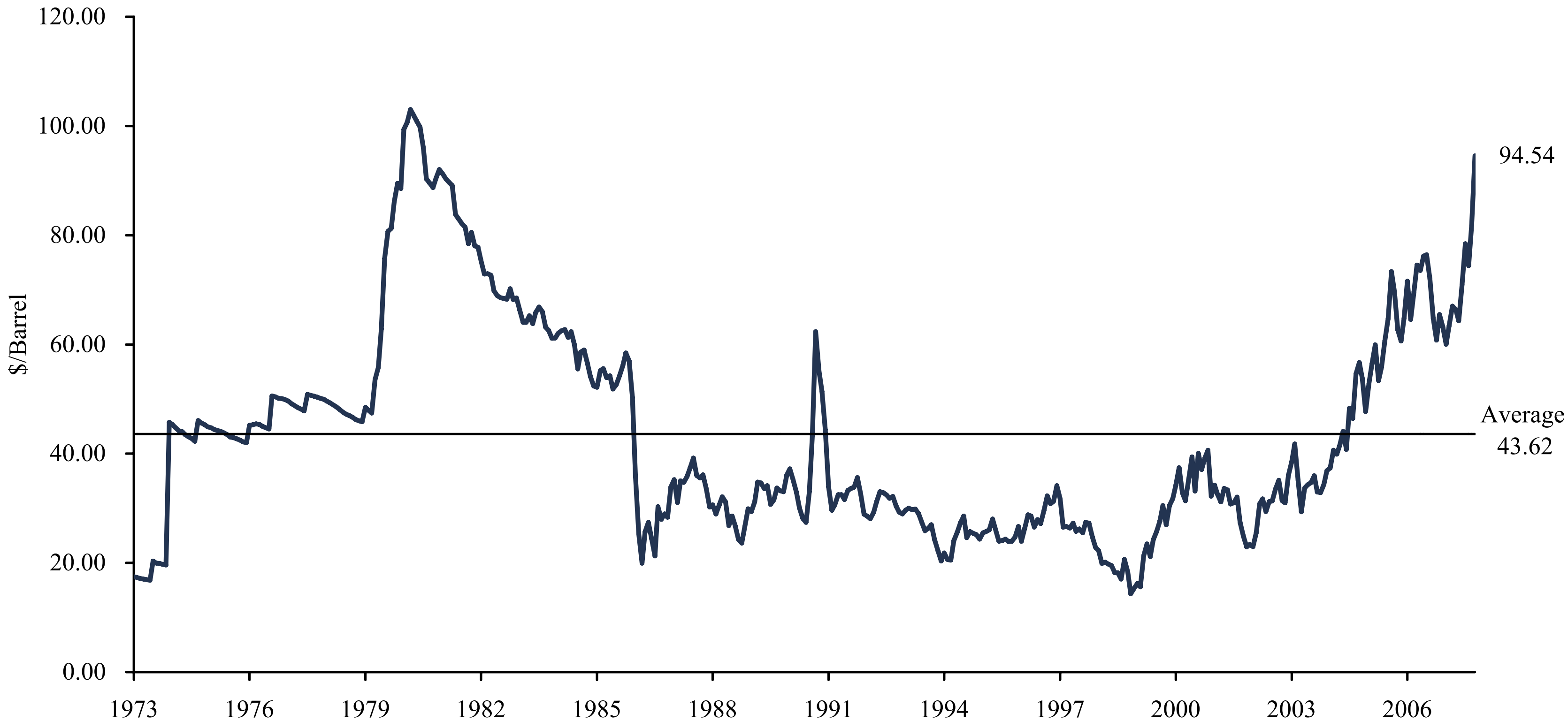
Source: NREL.

Notes: Energy prices differ significantly by market. Data reflect U.S. production costs, as many of the venture capital investments in cleantech are based in the United States.

Table D

HISTORICAL REAL OIL PRICES

January 31, 1973 – October 31, 2007
(Constant 2007 Dollar Basis)



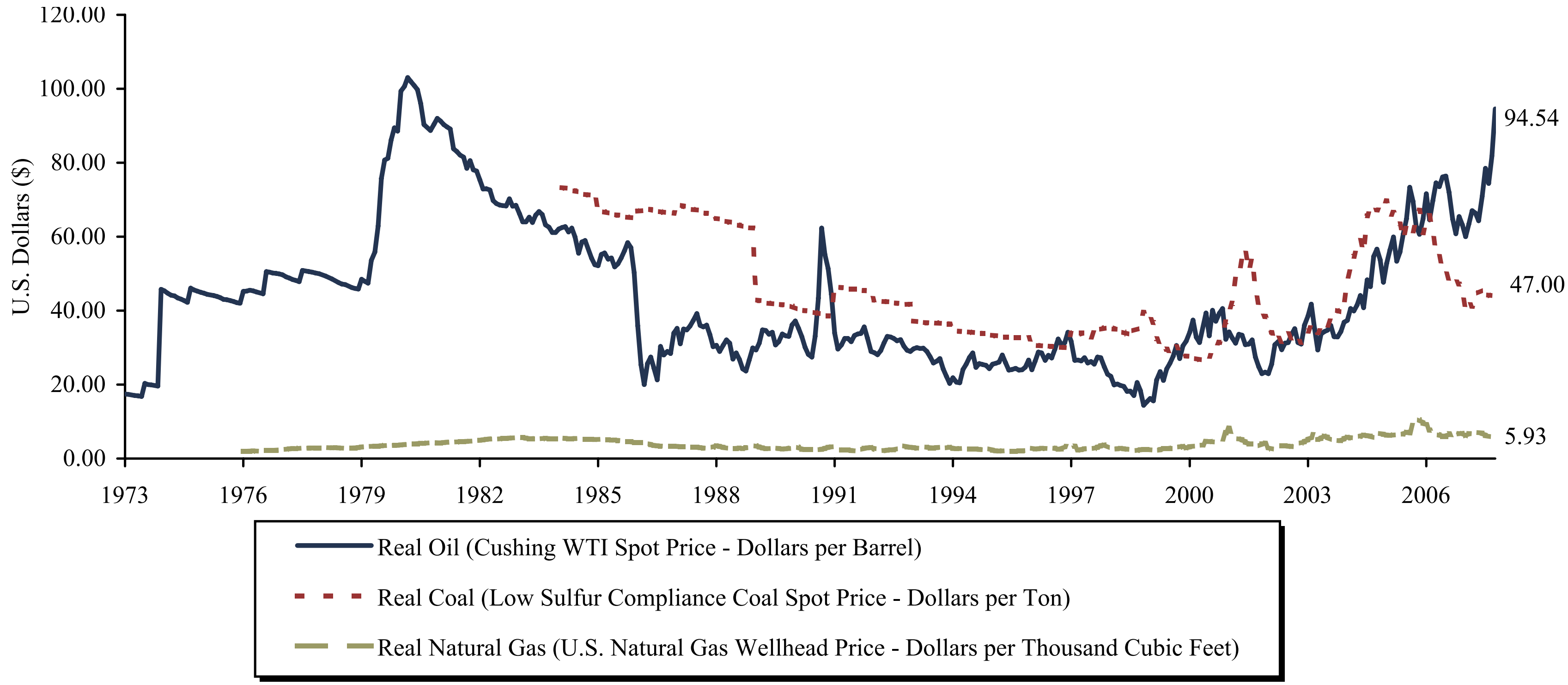
Sources: Calculated from data provided by the Oil & Gas Journal Energy Database, Thomson Datastream, U.S. Department of Labor - Bureau of Labor Statistics, and *The Wall Street Journal.*

Notes: The oil price is represented by the posted price for West Texas Intermediate for the period 1973–82 and the closing price for West Texas Intermediate for the period 1983 to the present. CPI-U data is as of October 31, 2007.

Table E

HISTORICAL REAL OIL, COAL AND NATURAL GAS PRICES

January 31, 1973 – October 31, 2007
(Constant 2007 Dollar Basis)



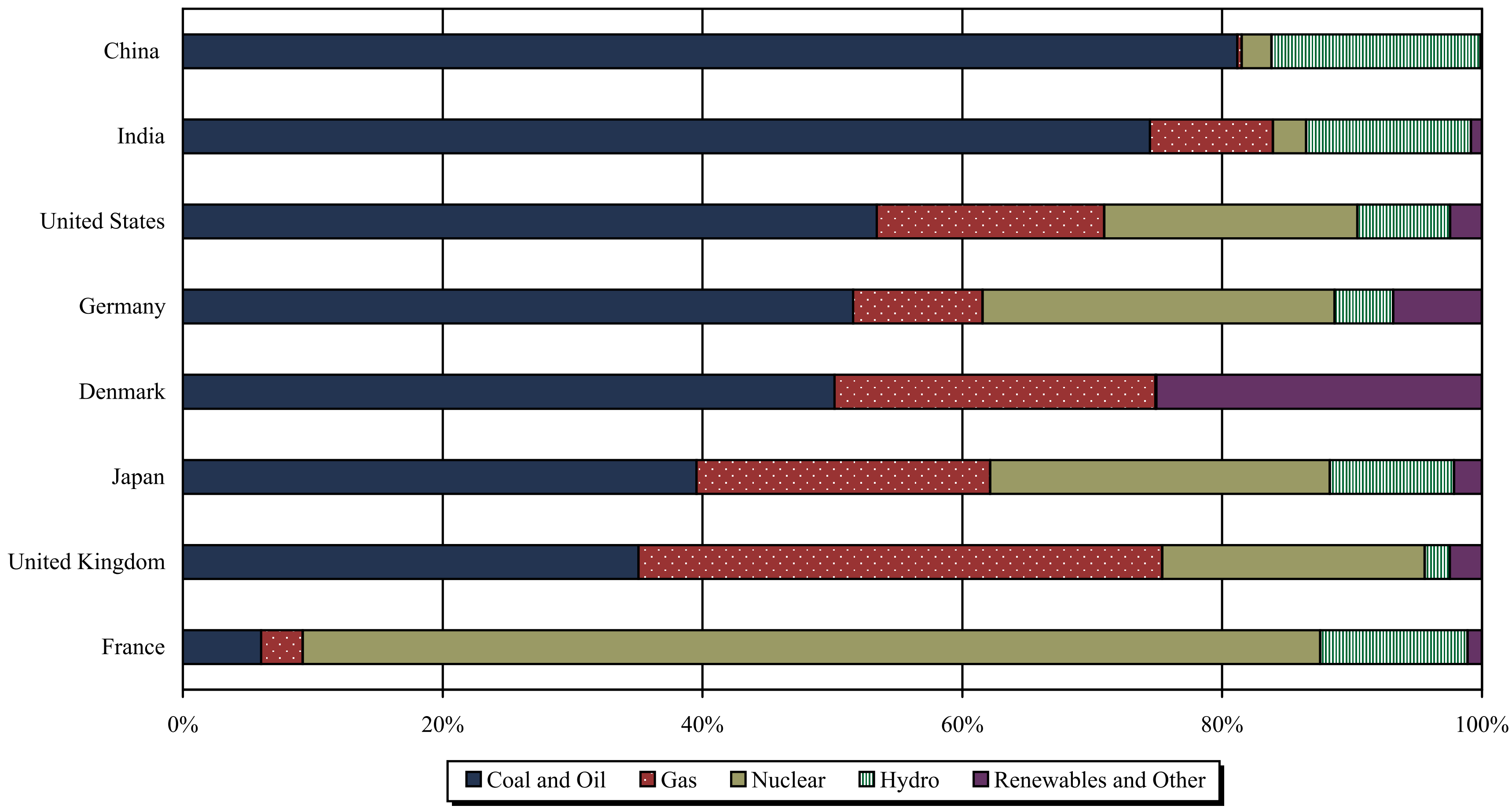
Sources: Bloomberg L.P., Oil & Gas Journal Energy Database, Energy Information Administration, Thomson Datastream, U.S. Department of Labor - Bureau of Labor Statistics, and *The Wall Street Journal.*

Notes: The oil price is represented by the posted price for West Texas Intermediate for the period 1973–82 and the closing price for West Texas Intermediate for the period 1983 to the present. CPI-U, coal, and oil data are as of October 31, 2007. Natural gas data are as of August 31, 2007.

Table F

ELECTRICITY PRODUCTION BY SOURCE

As of December 31, 2004

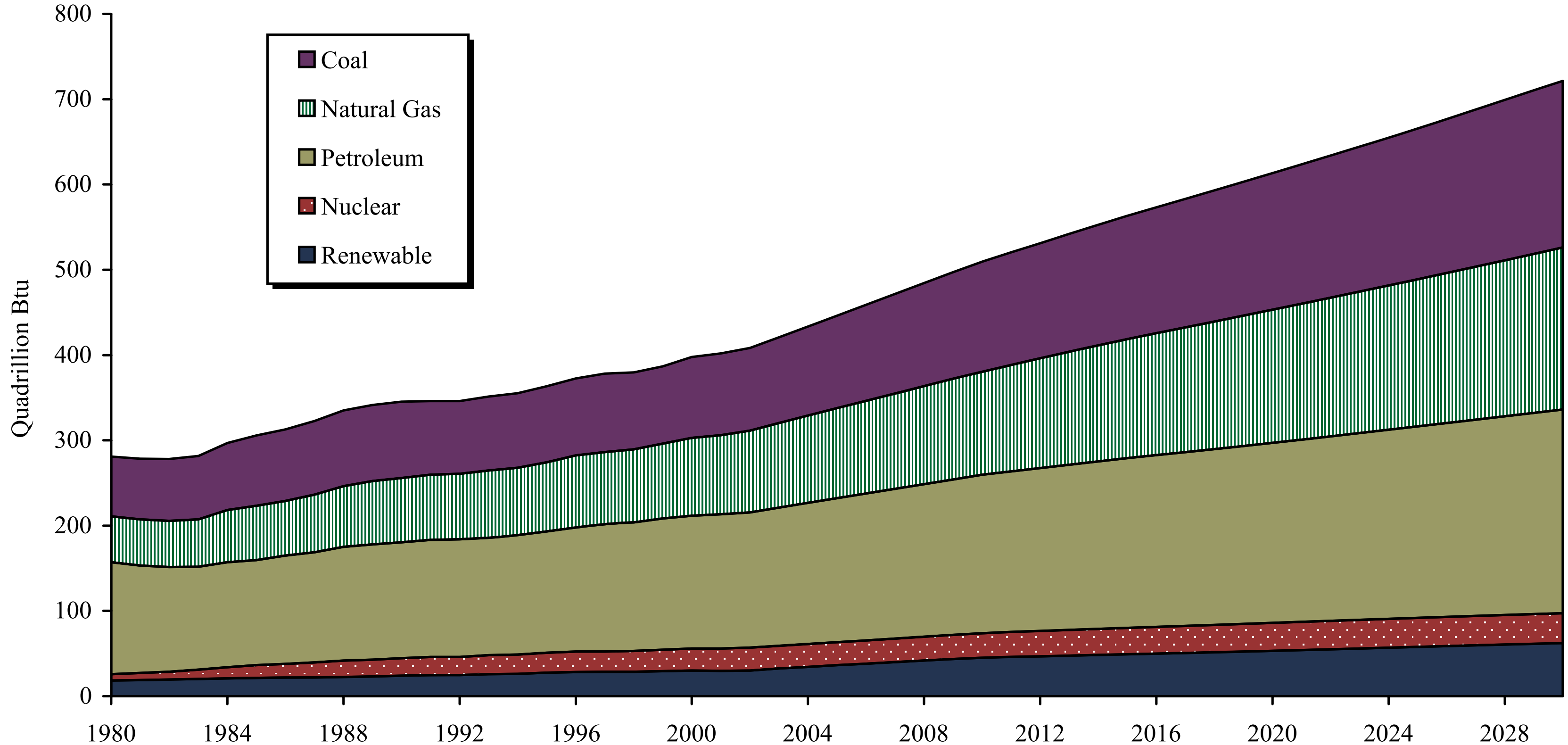


Source: International Energy Agency.

Table G

GLOBAL MARKETED ENERGY USE BY ENERGY TYPE

January 1, 1980 – December 31, 2030



Sources: BTM Consulting, Citigroup, EIA International Energy Outlook 2006, and NREL.

Note: Actual data are used for years 1980 to 2007 while estimates are used for 2008 to 2030.

Table H

SELECTED CLEANTECH INITIAL PUBLIC OFFERINGS

Name	Market Cap ($ Millions)	Revenue ($ Millions)	EBITDA ($ Millions)	EBITDA Margin	IPO Price ($)	IPO Date	Current Price ($)	% Change From IPO Price	Selected Pre-IPO Investors
Q-Cells	14,504.4	711.7	209.9	29.5%	45.7	Oct 05, 2005	132.1	189.1%	Apax, Ströher Finanzholding
Suntech Power	11,540.6	1,168.6	178.4	15.3%	15.0	Dec 14, 2005	77.2	414.5%	Actis, Goldman Sachs
LDK Solar	4,395.8	265.8	92.2	34.7%	27.0	Jun 01, 2007	42.0	55.7%	Xiaofeng Peng
Yingli Green Energy	3,722.7	417.7	51.5	12.3%	11.0	Jun 08, 2007	29.3	166.6%	Deutsche Bank, Inspiration
AECOM Technology	2,851.7	4,237.3	155.9	3.7%	20.0	May 11, 2007	29.0	45.0%	J.H. Whitney, U.S. Trust
JA Solar	2,545.1	89.2	18.4	20.6%	15.0	Feb 07, 2007	55.2	268.1%	Jinglong Group
Conergy	1,295.9	992.3	76.6	7.7%	72.2	Mar 17, 2005	37.9	-47.6%	
VeraSun Energy	1,193.4	682.4	100.4	14.7%	23.0	Jun 14, 2006	12.9	-44.1%	Bluestem, Donald Endres
ErSol Solar Energy	1,182.3	168.6	39.1	23.2%	50.6	Sep 30, 2005	110.6	118.4%	
Trina Solar	1,179.1	239.2	28.7	12.0%	18.5	Dec 19, 2006	47.3	155.6%	Divine Land, Topower
Solarfun Power	1,149.6	219.8	17.2	7.8%	12.5	Dec 20, 2006	24.0	91.6%	Citigroup
EnerNOC	916.8	47.0	-16.1	-34.2%	26.0	May 18, 2007	48.1	85.0%	Braemar, DFJ, Foundation
ReneSola	795.4	89.2	24.2	27.1%	1.5	Jun 13, 2006	8.0	430.3%	
Polypore International	737.2	516.8	141.8	27.4%	19.0	Jun 28, 2007	18.3	-3.7%	Warburg Pincus
US BioEnergy	673.5	384.0	70.0	18.2%	14.0	Dec 16, 2006	9.9	-29.2%	CHS Inc.
Clean Energy Fuels	646.0	114.8	-12.7	-11.1%	12.0	May 25, 2007	14.6	21.8%	Boone Pickens, Perseus
Comverge	569.4	41.5	-3.0	-7.2%	18.0	Apr 13, 2007	29.2	62.1%	Nth Power, Rockport
Aventine Renewable Energy	426.9	1,621.2	72.8	4.5%	43.0	Jun 29, 2006	10.2	-76.3%	Morgan Stanley
Canadian Solar	368.0	199.7	-10.0	-5.0%	15.0	Nov 09, 2006	18.3	22.0%	HSBC
VERBIO Vereinigte BioEnergie	363.4	412.7	58.4	14.1%	18.1	Oct 16, 2006	5.8	-68.2%	
Sunpower Group	59.0	50.2	6.6	13.2%	0.1	Mar 16, 2005	0.2	32.2%	
China Biodiesel International	26.2	12.7	5.2	40.6%	1.6	Jun 30, 2006	0.6	-63.2%	

Sources: Bloomberg L.P. and FactSet Research Systems.

Notes: Market capitalizations and current prices are as of December 6, 2007. Revenue data for Q-Cells, JA Solar, Conergy, ErSol Solar Energy, ReneSola, VERBIO Vereinigte BioEnergie, Sunpower Group, and China Biodiesel International are as of December 31, 2006. Revenue data for LDK Solar and US BioEnergy are as of June 30, 2006. Revenue data for Suntech Power, Yingli Green Energy, AECOM Technology, VeraSun Energy, Trina Solar, Solarfun Power, EnerNOC, Polypore International, Clean Energy Fuels, Comverge, Aventine Renewable Energy, and Canadian Solar are as of September 30, 2007. EBITDA data for Q-Cells, Yingli Green Energy, JA Solar, Conergy, ErSol Solar Energy, ReneSola, Comverge, VERBIO Vereinigte BioEnergie, Sunpower Group, and China Biodiesel International are as of December 31, 2006. EBITDA data for LDK Solar and US BioEnergy are as of June 30, 2007. EBITDA data for Suntech Power, AECOM Technology, VeraSun Energy, Trina Solar, Solarfun Power, EnerNOC, Polypore International, Clean Energy Fuels, Aventine Renewable Energy, and Canadian Solar are as of September 30, 2007.

Risks

While the market opportunities are clearly sizeable, and many investors and entrepreneurs have flocked to cleantech, investments in this area are not without risk. Will fossil fuel prices fall significantly due to supply/demand dynamics? Will regulations and subsidies change the outlook for cleantech in general or change the relative attractiveness of competing cleantech strategies? Will leading technologies today be leapfrogged by new technologies? Are there enough quality entrepreneurial companies available to accept the large and growing inflow of capital and deliver superior returns?

Sustainability of High Oil Prices

It is hard to ignore the fact that investment interest in cleantech has only reached significant levels during two periods: the 1970s and the past three years. Not coincidentally, these two periods represent the zenith of world energy prices. While the current round of interest in cleantech is not as intimately tied to energy prices as it was during the 1970s, the possibility remains of a rapid loss of interest in cleantech if energy prices were to return to 1990s lows. A sharp slowdown in the global economy could significantly dent energy demand. However, a rapid decline in energy prices appears unlikely for several reasons. Even if demand were to stabilize at current levels, there appears to be little additional new conventional supply coming into the market. New climate change regulations would make it more expensive to burn fossil fuels. Expectations of continued high transportation fuel and electricity costs have convinced energy intensive businesses like DuPont, Tesco, and Wal-Mart to use more renewable energy as a hedge against these increases. This move is also aided by the decline in the relative cost of renewable energy and by reliability improvements.

Changing Regulations

Cleantech companies are also subject to the fickle and conflicting whims of regulators who can withdraw subsidies as quickly as they grant them. Government subsidies can provide the training wheels for new energy technologies, but eventually these technologies need to be competitive on their own merit. Businesses whose profitability is dependent on government support are at the mercy of changing political winds. *The Economist* opines, "what one politician can mandate, another can terminate—and therein lies one of the biggest risks for clean energy." Consequently, it is incumbent upon investors to ascertain the degree to which an environmental investment's profitability is dependent upon a given or future regulatory regime, and to assess the probability that such a regime may change. (See Appendix E for more information on government regulations.)

Disruptive Technologies

Investors should also consider the risks to their portfolios of new disruptive technologies. The cleantech playing field is still wide open and without clear winners. Outcomes may be binary, with new technologies that are adopted having huge potential demand, but technologies that come in second place becoming obsolete. Apparent winners in this increasingly competitive, volatile sector will likely be leapfrogged repeatedly, as occurred with technology companies in the late 1990s.

The most vulnerable cleantech sectors appear to be first generation silicon-based solar and corn-based ethanol. Both sectors are funded heavily by government subsidies, are likely to be displaced by next generation technologies, and are subject to a number of other risks.

Silicon-Based Solar. One venture capitalist conjectured that there is an excess of capital in the solar photovoltaic market and that after the incentives go away, only the lowest cost players will survive, as happened with semiconductors in the 1980s. Because silicon is a scarce resource, the lowest cost providers over the long term are likely to be solar technologies that do not rely on silicon, but rather on cheaper materials. Second generation solar technologies, based on CIGS or other advanced materials, are considered likely to make obsolete first generation polysilicon solar once the technology is proven. With these new technologies gaining strength rapidly, investors are increasingly wary about investing large amounts of capital in first generation solar fixed assets. Note that oil prices have little direct impact on the solar industry's fundamentals because solar is not used for transportation, but for electricity, which is supplied primarily by coal and natural gas (although there is an indirect link because natural gas rises and falls with oil prices because of its use in the refining process).

Corn-Based Ethanol. Unlike renewable electricity sources that rely on free feedstocks, biofuels rely on feedstocks with volatile prices, which increases the risk of investing in them. Biofuels also rely on a specialized transportation and refining infrastructure that has yet to fully materialize. The recent boom in corn ethanol in the United States has largely been a result of government mandate and the glut of capital invested in corn-based ethanol has been based on billions of dollars of generous federal tax subsidies, which makes this biofuel vulnerable to subsidy changes or technological advances. Indeed, corn ethanol prices declined substantially in mid-2007 due to overproduction, and margins suffered due to increased transportation and corn costs.

In a similar fashion to next generation solar, second generation cellulosic ethanol is likely to make obsolete traditional ethanol based on food sources like corn or sugar (assuming regulations do not interfere and favor older technologies). Cellulosic ethanol is derived from plant waste and abundant, fast-growing weeds like switchgrass and miscanthus, which are orders of magnitude cheaper than food crops like corn and sugar. Mass production and commercialization is likely many years away, as the process to break down the plants' woody fibers is still being developed. Producing cellulosic ethanol still costs twice as much as making corn ethanol, according to the National Renewable Energy Lab. However, the Bush administration recently offered a $385 million subsidy to fund six cellulosic ethanol production facilities that should produce 130 million gallons of ethanol per year and an additional $375 million for biofuels research centers.

Cleantech Bubble?

The significant flow of capital into cleantech investments and the outsized valuations realized in recent years have left many wondering if we are in the middle of a cleantech bubble. Vinod Khosla, a venture investor deploying his capital after 18 years as a venture capitalist with Kleiner Perkins, recently discussed the potential implications of a cleantech bubble: "Cleantech companies will continue to innovate and grow independent of whether there is an investment bubble. In the 1830s, a bubble developed in the rail industry in the United Kingdom, but more railways were built in the ten years following the subsequent 'collapse' than during the bubble. Similarly, the dot com collapse has not stopped progress in the internet sector."[11] Daniel Gross, author of *Pop!: Why Bubbles Are Great for the Economy*, opined that without the failures of WorldCom and Global Crossing, we would never have had the fiber-optic cables that made Google possible. His book discusses how the boom/bust cycle of bubbles helps new industries get off the ground faster than they might otherwise, even if it means some investors get bruised in the process.

So where does this leave investors? Choosing managers and strategies carefully can enable an investor to avoid these pitfalls. Properly positioned as part of a well-diversified portfolio, cleantech venture investments offer the potential for outsized returns (as well as higher risk). In a world with very few undervalued investment opportunities, cleantech must be considered against other potentially overvalued sectors.

[11] Roger Franklin, "Cleantech Goes Mainstream," *Library House*, p. 20, April 17, 2007, www.libraryhouse.net.

Portfolio Diversification Impact

Cleantech investments can provide unique portfolio diversification as well as opportunities for outsized returns. This sector incorporates certain characteristics of private energy, infrastructure, and technology and biotech venture capital. These investments could hedge the risks of "clean energy" conversion or new carbon regulations on other parts of the portfolio, such as current investments directly and indirectly dependent on fossil fuels (e.g., airlines). These variables all combine to make cleantech a new and unique investment opportunity that could potentially provide lower correlation to and different risk characteristics than traditional investments.

Relationship to Venture Capital and Private Equity

In 2006, cleantech represented the third largest sector in U.S. venture capital as determined by invested capital, solidifying the sector's place after biotech and technology. Cleantech's use as a diversifier comes from the individual nature of the portfolio companies held by each manager, as well as their often highly concentrated portfolios. While publicly traded cleantech company stock prices exhibit moderate correlation to the price of oil, short-term movements in oil prices will have a far less dramatic affect on non-marketable cleantech investments. As in other non-marketable asset classes, individual cleantech fund returns will be based on the general partner's (GP) ability to purchase companies wisely, add value on the management side, and orchestrate a successful exit. This process is far more vulnerable to the health of the IPO and M&A markets, and the ability to invest and exit at attractive valuations, than it is to the short-term volatility of oil prices. The exit environment for cleantech companies will likely differ from that of information technology or biotech, allowing cleantech to act as an attractive diversifier within a venture capital and private equity portfolio if the return potential continues to develop.

Relationship to Oil Prices

While we cannot directly measure the long-term relationship between oil prices and cleantech returns, we can observe the short track record of the WilderHill Clean Energy Index (ECO) as a proxy for the global publicly traded cleantech industry. (See Appendix B for more information on cleantech indices.) The correlation between oil prices and this index over the past seven years is 0.47, somewhat surprisingly lower than oil's correlation to the Russell 3000® Index of 0.79 over the same period (Table I). It is counter-intuitive that the broad Russell 3000® Index would have a higher correlation to oil than primarily energy-focused cleantech companies. However, over the entire history of the ECO, oil supply has been tight relative to demand, so the strong global economic expansion that has lifted equity prices in general has also lifted oil prices. Over longer periods of time, we would expect the broad equity market to have a lower correlation to oil, and clean energy companies, a higher correlation. If oil prices continue to increase to a point that slows down economic growth, we would expect the broad equity market to come under pressure, while the cleantech sector would likely benefit.

Cleantech's vulnerability to oil's swings depends largely on the individual cleantech subsector. Sectors like ethanol are intimately tied to the price of oil, whereas water technologies or solar power are less dependent. Solar power tends to displace coal or natural gas-fired electricity, and is less correlated to oil.

Inflation Protection Attributes

While there is currently no reliable historical record for cleantech performance during periods of high inflation, the same factors that could drive inflation higher could also have a positive effect on areas of the cleantech sector. While other sectors could see reduced profitability due to increased raw material and energy costs (e.g., steel, copper, transportation costs), those pressures could lead to increased demand for products that help reduce the need for these raw materials. Cleantech companies are not immune to the ill-effects of increased input costs, however. Examples of this include higher corn prices for ethanol producers, increased silicon prices for the solar panel market, and increased metal material costs for wind turbines. In the case of corn prices, it is ironically the increased demand for ethanol that has pushed these prices up.

One oil alternative, traditional ethanol, is a less effective hedge against inflation from high energy prices because its inputs, notably corn or sugar, would be more likely to rise in concert with inflation. Oil prices usually cause ethanol prices to increase in lock-step, but the net margin is likely to remain the same or decrease if the underlying corn commodity price increases as well. Cellulosic ethanol would be less susceptible to commodity-based swings. Today the oil-driven transport sector is largely distinct from the coal and natural gas–driven electricity sector (natural gas–powered vehicles are a small minority of total transport vehicles). If plug-in hybrids gain significant market share, these distinctions could fade because electricity would start to power transportation for the first time in large scale.

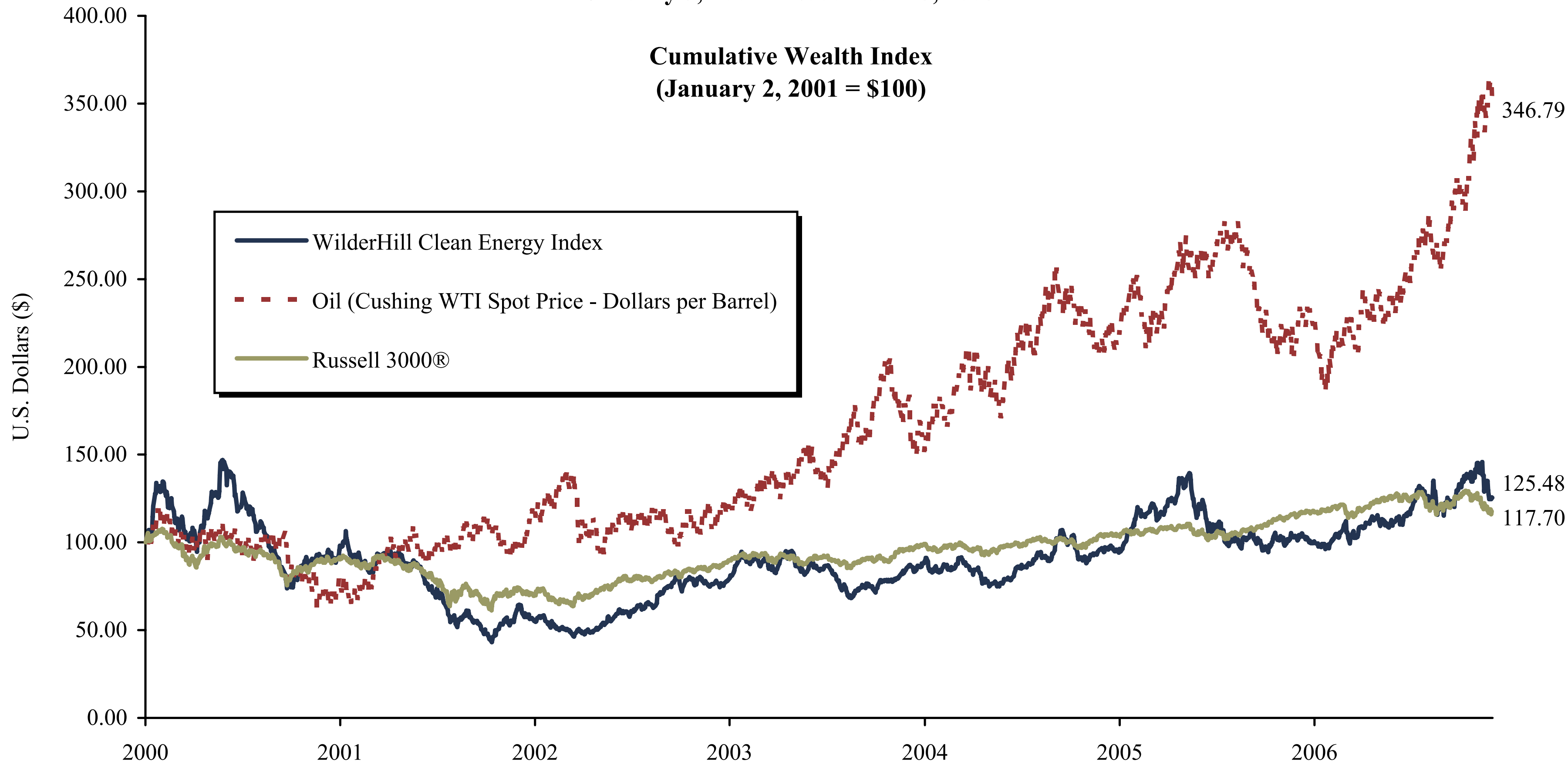
The U.S. electricity grid is largely decoupled from oil, relying primarily on natural gas and coal. As a result, renewable electricity provides more of a hedge to higher natural gas and coal prices than to higher oil prices. If electricity prices are rising due to coal or natural gas price increases (the majority of electricity comes from these commodities), wind or solar assets could serve as a hedge to the portfolio. Solar, geothermal, and wind power are currently more expensive than conventional alternatives, but this calculation does not include the valuable hedge they provide against future increases in fossil fuel prices. Renewable electricity tends to require a large upfront investment in solar panels or wind turbines, but into perpetuity the power inputs are free and not subject to commodity price fluctuations, lowering the total cost of ownership over time. In contrast, when a utility builds a natural gas or coal plant (or an investor funds it), it is wedded to fossil fuel prices for the life of the plant. If the utility were to lock in the cost of the inputs, it would require an expensive hedging contract with a financial intermediary.

Table I

CORRELATION OF CLEAN ENERGY INDEX, OIL PRICE AND RUSSELL 3000®

January 3, 2001 – November 27, 2007

Cumulative Wealth Index
(January 2, 2001 = $100)



Sources: Bloomberg L.P., Frank Russell Company, and Thomson Datastream.

Note: WilderHill includes 20% international ADRs as of November 15, 2007.

Implementation

The growing volume of capital flowing into cleantech may convince many investors to pursue these strategies, but implementation can be challenging. (See Appendix C for information on the cleantech investing initiative of two large pension funds.) Much of the $71 billion that went into global clean-energy investments in 2006 came from large company investment, while only $3.9 billion came from venture capital. However, as mentioned previously, cleantech is rapidly claiming a larger share of overall venture dollars. Due to the early-stage status of many potential investments in cleantech, there are more opportunities to invest in private cleantech companies compared to the smaller universe of pure-play, public cleantech companies. Direct and fund-of-funds non-marketable pure-play cleantech managers are available and growing in numbers, as is the cleantech exposure within generalist funds.

Private Equity/Venture Capital Approach

In investing in cleantech via a generalist or specialist private equity or venture capital manager it is important to look for the expertise and ability to source, evaluate, price, negotiate and add value to transactions, recruit talented management teams, manage through difficulties, and successfully exit investments. Also consider the level of validation of the manager's track record, the team, the organization, and alignment of interests. It remains unclear whether generalist funds with less cleantech industry expertise or newer dedicated cleantech managers will have stronger cleantech investing track records. According to venture capital firm Battery Ventures, in first quarter 2007, 52% of reported U.S. cleantech deals with disclosed investors were completed by generalists (sole or syndicated), 18% by cleantech specialist/strategic firms (sole or syndicated), and 30% by combined specialist and generalist syndicates.

In a nascent industry like cleantech, where large dispersion of returns is to be expected, investors require great confidence in the manager employed. As a result, it is more likely that an established manager will gain this confidence against a larger pool of emerging cleantech managers. Generalist managers can also time their cleantech investments relative to other sectors more opportunistically than pure-play managers can. However, many of the top-tier generalist firms are highly access constrained. In fact, in "hot" markets like the current one, even the better dedicated clean energy funds are access constrained. Investors may thus only be left with the fund-of-funds option.

Cleantech is currently in such a nascent stage of development that there is not yet a standard way to classify these investments on the portfolio level. Venture, buyouts, hard asset, and inflation-hedging categories all can make legitimate claims depending upon the particular manager's approach to cleantech investing. There is even a case to be made that cleantech is part of all asset classes. For example, in its early development, the Internet was a distinct business from mainstream business, but it eventually became a critical part of all business processes.

Many established venture and growth equity managers have expanded their investment mandate to invest in cleantech companies. Some of the investors with well-developed venture capital portfolios with whom we have worked have reached their desired cleantech exposure through their existing venture capital portfolio. Generalist venture capital and private equity funds—such as Advanced Technology Ventures, Battery Ventures, Carlyle/Riverstone, Charles River Venture, CMEA Ventures, Foundation Capital, Kleiner Perkins, Mohr Davidow Ventures, and Venrock—have broadened their universe of sectors to include cleantech. These managers have the flexibility to opportunistically invest in cleantech when they see good opportunities or avoid these investments if they do not find compelling projects. Diversified sector venture capitalists with a cleantech component have tended to focus on solar and biofuels because solar is similar to semiconductors and biofuels are "like the biotech industry without the FDA or clinical trials" (as one venture capitalist recently put it).

In addition, there are a growing number of cleantech funds, such as Braemar Energy Ventures; Clean Pacific Ventures; Climate Change Capital Limited; Expansion Capital Partners, LLC; Global Environment Fund; HgCapital Renewable Power Partners; Nth Power; NGEN Partners; Rockport Capital Partners; Sail Venture Partners; VantagePoint Ventures; and US Renewables Group, LLC. Most dedicated cleantech managers are emerging managers, with less than three funds, few realizations, and with GPs having worked together for a limited amount of time. Many cleantech funds invest alongside established generalist firms, allowing the generalist firms benefit from the pure-play fund's specific cleantech domain expertise. Cleantech managers may invest in the cleantech asset class broadly, or specialize in a sector, such as biofuels, solar, wind, or energy storage technology (batteries and superconductors).

Fund-of-Funds Approach

With the understanding that most pure-play cleantech funds are still in their infancy, investors may opt to take the fund-of-funds approach in an effort to spread risk across multiple managers. Macquarie Group, Parker Global Strategies, Piper Jaffray, and Robeco all have offerings. As with many direct managers, many fund-of-fund managers often are relatively new to cleantech. Funds-of-funds are appropriate for investors with smaller non-marketable portfolios who cannot meet direct fund minimums or who desire broader geographic and sector exposure to dedicated cleantech funds in order to reduce the manager-specific risk. Some traditional real assets/inflation-hedging funds-of-funds are also adding cleantech strategies to their traditional fossil fuel manager line-ups. The fund-of-fund's double fee structure adds an additional layer of costs to be considered. Investors may find the diversification of a cleantech fund-of-funds invested over several years in a broad range of sectors a welcome complement to direct plays, particularly where the universe of successful exits in cleantech is small but growing. Funds-of-funds may also be a source of co-investment or direct deal flow with desirable managers, and can provide an introduction to the strategy and underlying managers that may be used to build out a direct program.

Public Managers

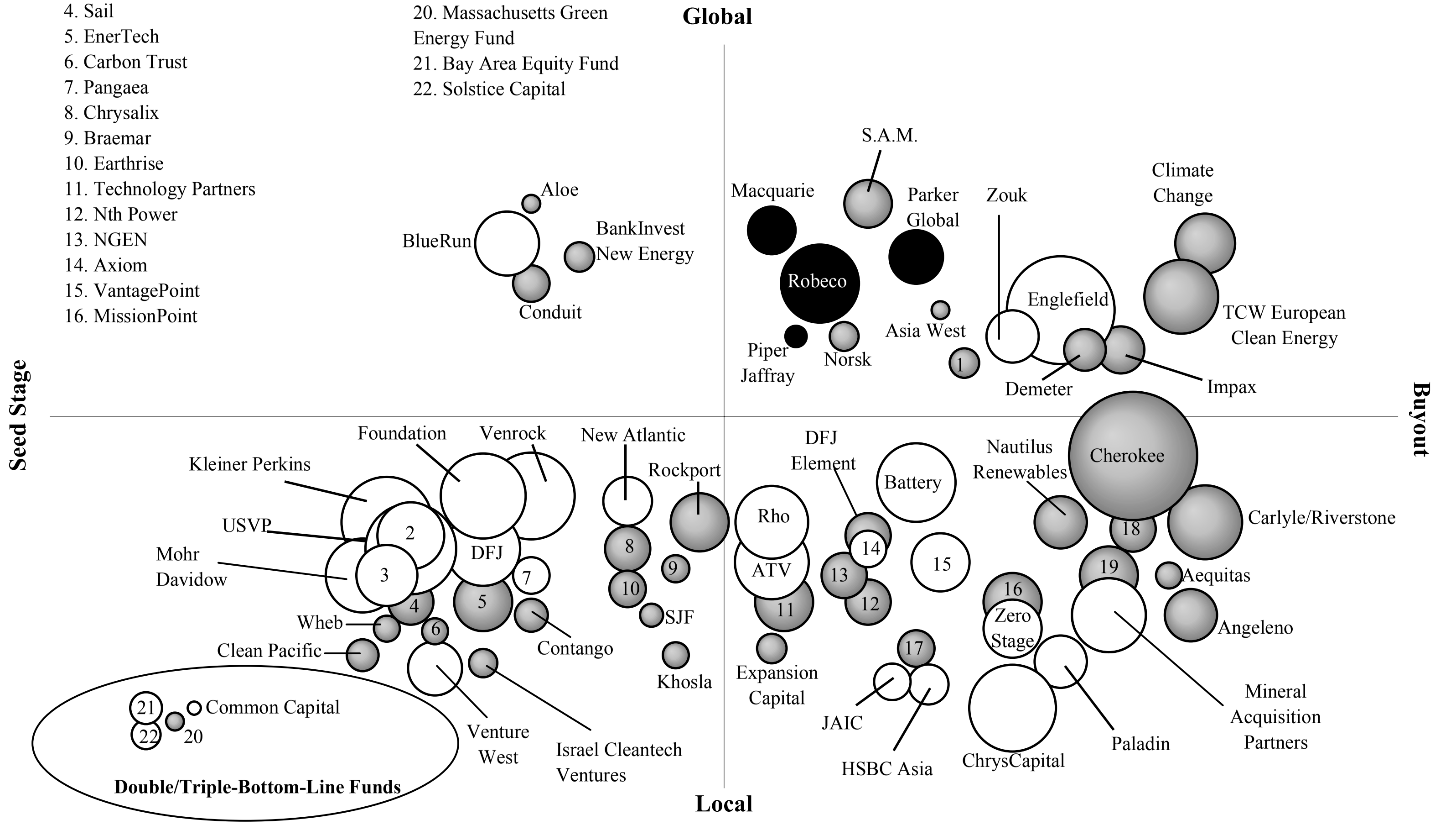
Investors with smaller non-marketable programs may not be able to achieve appropriate sector and vintage-year diversification on the private side and may instead consider public managers or cleantech indices (see Appendix B for index options). Pure-play cleantech investment opportunities are still more limited in the public markets and many of the most significant cleantech businesses are part of a larger, diversified conglomerate. Finding a cleantech public equity manager with a significant track record and relatively reasonable fees can be a challenge. However, there are some interesting cleantech long/short hedge funds available that can short overvalued cleantech sectors.

In summary, there are an increasing number of ways to gain exposure to cleantech, with different reasons and motivations for pursing each different strategy (Table J). An investor can approach the present opportunities based on his or her conviction, outlook, or access.

Table J

2007 CLEANTECH VENTURE CAPITAL AND PRIVATE EQUITY UNIVERSE

1. Environmental Technologies Fund
2. Benchmark
3. Charles River
4. Sail
5. EnerTech
6. Carbon Trust
7. Pangaea
8. Chrysalix
9. Braemar
10. Earthrise
11. Technology Partners
12. Nth Power
13. NGEN
14. Axiom
15. VantagePoint
16. MissionPoint
17. GEF
18. NGP
19. U.S. Renewables
20. Massachusetts Green Energy Fund
21. Bay Area Equity Fund
22. Solstice Capital



Sources: New Hampshire University and Worldwatch Institute.

Notes: The size of the "bubble" corresponds to the size of the most recent fund raised by that manager (i.e., the larger the fund, the larger the bubble and vice versa). Gray bubbles indicate a cleantech focus, white bubbles indicate a diversified investment strategy, including cleantech, and black bubbles indicate cleantech-focused fund-of-funds.

Conclusion

The long-term trends driving cleantech—including climate change, high energy prices, and regulatory changes—are clear, but are not without risks. Changes in government policies and subsidies, which have favored cleantech investments in recent years, will most likely have significant impact on certain cleantech sectors, especially those whose business models are not yet viable without these subsidies, such as corn-based ethanol. In addition, while supply/demand dynamics appear to be supportive of higher fossil fuel prices than have prevailed over the last several decades, a decline remains a risk for certain alternative energy companies. In particular, oil prices affect biofuels companies, and natural gas and coal prices affect solar and wind companies. GMO's Jeremy Grantham succinctly summarized the opportunity by opining that "Climate change and energy efficiency will be a giant investment area. And no doubt it will be full of interesting bubbles, of which, perhaps, boondoggle ethanol is the first of this new cycle."[12] High prices and scarcity drive entrepreneurs and businesses to find alternatives. There is a precedent for rapid disruptive change in the energy market, such as the conversion from whale oil to petroleum in the 1850s or from timber to coal in sixteenth century Britain. Investors can take advantage of these changes, while treading carefully to avoid bubbles. Implementation is not easy, but the entrepreneurial and fund management talent is rising quickly to meet the challenge.

[12] Jeremy Grantham, "Fed Up," October 2007 GMO Investor Letter.

APPENDIX A

GLOSSARY

Appendix A

GLOSSARY

Advanced Materials: "Advanced materials" is a broad label that is regularly applied to a number of nanotechnologies that are currently being utilized in technologically advanced cleantech operations. Examples of advanced materials include nanomaterials that absorb pollutants, solid-state lights that conserve energy, lightweight metals for more fuel efficient transportation, and nanosensor technologies that protect against contamination of water supplies.

Advanced materials are not an exclusive product of the cleantech industry, as they have a wide range of potential applications. However, due to the focus of many advanced materials on clean and energy-efficient operation, such new technologies are frequently appropriated and employed by cleantech industries.

Biodiesel: Biodiesel is a common, renewable form of biofuel that is used most prevalently in Europe. Biodiesel is produced using a method known as transesterification, in which algae, animal fats, and/or vegetable oils derived from certain crops (see table below for yield statistics) are processed to create a fuel similar in composition to diesel and only slightly less energy efficient.

Biodiesel
Fuel Yield Per Acre

Crops	Liters	Gallons
Oil palm	1923	508
Coconut	871	230
Rapeseed (canola)	386	102
Peanut	341	90
Sunflower	310	82
Soybean	212	56
Switchgrass	4353	1150
Hemp	3785	1000
Jatropha	765	202
Algae	18927	5000

Source: Worldwatch Institute.
Notes: Data on algae come from the University of New Hampshire. Data on hemp vary widely.

Biodiesel is biodegradable and nontoxic, and in typical use produces significantly less greenhouse gas (GHG) emissions than traditional, diesel fuel sources. While pure biodiesel can be used in any petroleum diesel engine, it is most commonly used in lower concentrations, as an additive to a diesel fuel source.

Although biodiesel is considered a clean alternative to diesel, its production and use has the potential to produce environmentally harmful side effects. Countries such as Indonesia and the Philippines have clear cut large quantities of tropical rainforest in order to create new land for crops that produce biodiesel-compatible vegetable oils. In addition, some environmentalists criticize any engines that use diesel, even in composite with biodiesel, as the fuel source traditionally produces 10 to 20 times more toxic particulates than gasoline.

Biofuels/Biomass Fuel: Biofuels, or biomass fuels, are any materials derived from plants or animals that are deliberately burnt as a source of fuel. Wood is the most common example, but the use of animal dung or crop residues as fuel is also widespread.

Biofuels can be produced from any short-term carbon cycle organic compound, meaning sources of carbon whose carbon cycle is considered renewable. While the combustion of biofuels does contribute to atmospheric carbon levels, it happens on a relatively short timescale, and the plant matter used as fuel can be constantly replaced through replanting, thereby removing carbon from the atmosphere. Therefore, biofuels are considered carbon neutral when their lifecycle has a net zero carbon emission. In contrast, while fossil fuels technically originate from ancient biomass, they are not considered biofuels, as they contain carbon that has been out of the carbon cycle for a significant period. Thus, the combustion of this carbon disturbs the equilibrium of carbon in the atmosphere.

As concerns over energy security and GHG emissions continue to increase, biofuels—such as ethanol from sugar cane or corn—and biogases—from anaerobic decomposition of waste—have become popular technologies. Biofuels can be produced from a variety of resources including animal waste, flaxseed, food scraps, jatropha, palm oil, rice husks, soybeans, and other biodegradable wastes.

Cap and Trade: A carbon emission trading scheme, also known as cap and trade, is a mechanism used to control pollution by providing economic incentives for individual entities to reduce the emission of pollutants. Under this plan, a central authority (usually a government agency) establishes a limit or cap on the amount of a pollutant that can be emitted. Individual entities (companies, groups, individuals) that emit a regulated pollutant are given credits, which represent the right to emit the pollutant up to a specific amount. The aggregate total number of credits distributed cannot exceed the cap, thereby limiting the total emissions of that pollutant to the cap level. Entities that pollute beyond their allowance must either buy credits from (or trade with) those that have credits to spare, or they must face heavy penalties. This system is intended to create a market for pollution whereby buyers are paying for pollution and therefore internalizing the cost of pollution, and sellers are being rewarded for reducing their emissions.

One advantage of a cap-and-trade system compared with other emission reduction strategies is that it gives entities (usually companies) flexibility in the manner in which they respond to regulations. A company can decide whether it is less costly to reduce their emissions or to buy carbon credits from entities that have reduced their emissions. However, some argue that a cap-and-trade system creates opportunities for cheating or special interest involvement. Yale economist William Nordhaus explains, "limiting emissions creates a scarcity where none previously existed and in essence prints money for those in control of the permits."[1] Additionally, a cap-and-trade scheme can lead to unpredictable fluctuations in energy prices, as the price of carbon credits is governed by supply and demand rather than a fixed price.

There are currently several trading systems in place to reduce GHG emissions, with the largest being the European Union Emission Trading Scheme, which is the largest multinational GHG emissions trading scheme in the world, with 27 member states. Established in January 2005, it was created in order to comply with the GHG emissions targets in the Kyoto Protocol. There are many other examples of emission trading systems at the state and national level. Additionally, cap-and-trade schemes have been used to limit emissions for other pollutants. Perhaps the most successful cap-and-trade scheme to date is the sulfur dioxide trading system established by the 1990 U.S. Clean Air Act, which was enacted in an attempt to reduce the prevalence of acid rain.

Carbon Dioxide (CO_2): Carbon dioxide is a gas that is naturally present in the earth's atmosphere and that contributes to the greenhouse effect. The burning of fossil fuels can contribute to increased levels of atmospheric carbon dioxide.

Carbon Sequestration: Carbon sequestration refers to processes that remove CO_2 from the atmosphere by generating carbon sinks. Technologies that aim to artificially capture and store carbon as well as enhance natural sequestration processes are currently being developed as a means of offsetting anthropogenic CO_2 contributions to the atmosphere.

Carbon Tax: A carbon tax, which places an excise tax on the producers of raw fossil fuels based on the relative carbon content of those fuels, is an instrument intended to internalize the social costs of pollution associated with the burning of fossil fuels. A carbon tax addresses a negative externality, which some economists favor because it taxes a "bad" as oppose to a "good" (such as income tax).

A carbon tax encourages polluters to clean up and entrepreneurs to find alternatives. Proponents of the system emphasize that it is less costly to administer than alternatives—such as a cap-and-trade system—as the tax can be collected through existing state and federal tax structures. Others emphasize that the nature of the system makes it less prone to manipulation by special interests, and that because it sets a price on pollution, it reduces volatility in energy prices.

However, opponents of the system argue that while the price of polluting is fixed, a carbon tax scheme does not guarantee pollution reduction, as polluters can simply internalize the new costs associated with their pollution. Therefore, while a carbon tax scheme is less costly to implement, it does not allow for emission reduction goals, making environmental policy harder to implement. Countries that have implemented a carbon tax system include Finland, the Netherlands, Norway, and Sweden.

[1] John Tierney, "Which Carbon Diet Works Better?," *New York Times*, May 26, 2007.

Cellulosic Ethanol: See "Ethanol."

Copper Indium Gallium Diselenide (CIGS): CIGS is a multi-layered, thin-film composite solar cell that is currently at the forefront of new solar technology development. CIGS cells are considered a positive alternative to traditional, silicon-based cells due to the fact they can be constructed from a thinner design and thus offer the benefit of reducing material costs during production. However, while CIGS cells require fewer materials to produce, their thin design requires them to convert solar energy to electric energy in a process that is considerably less efficient than that used in traditional solar cells.

A primary goal of CIGS research—which is gradually being realized—is to maintain the thin, cost-cutting structure of the design, while simultaneously developing ways to increase its energy-conversion efficiency to a level that is competitive with larger solar cells. Critics of CIGS solar cells point to the technology's reliance on indium, a relatively rare metallic element. In current designs, gallium, a much more common elemental material, is substituted for indium whenever possible.

Cleantech: We categorize cleantech into three main sectors: clean/alternative electricity, clean/alternative fuels, and other clean technologies.

Renewable clean/alternative electricity sources include geothermal power, hydropower (including tidal power), landfill gas, solar power, and wind power. Nonrenewable clean/alternative electricity sources include coal gasification plants and other clean coal technologies, natural gas, and nuclear power.

Clean/alternative fuel sources are renewable or emit fewer GHGs, including biodiesel, ethanol, and hydrogen.

Other clean technologies are varied, but can be split into two categories: clean industrial process technologies and environmentally preferable processes.

Clean industrial process technologies that help reduce natural resource usage and pollution generation include the following:

- Carbon sequestration technologies, which can be used to capture carbon and store it beneath the earth;
- Wastewater treatment and water purification;
- Hybrid and fuel cell–based automobiles;
- Organic foods;
- Products made with recycled content;
- Products that are biodegradable or otherwise recyclable;
- Products that are more energy efficient than comparable alternatives; and
- Advanced materials.

Environmentally preferable processes include, but are not limited to, the following:

- Designing energy-efficient buildings residential and business;
- Using fleets of natural gas–powered or high MPG trucks for transportation needs;
- Minimizing the use of toxic chemicals in manufacturing processes;
- Recycling wastewater, or otherwise reducing water usage;
- Using double-hulled tankers to transport oil to prevent spills;
- Avoiding resource extraction from environmentally sensitive areas; and
- Using renewable energy to power facilities.

The definition of cleantech is subject to much debate, as it encompasses a disparate group of industries and shares a significant overlap with non-environmental applications. We are aware that some of the technologies mentioned above are controversial, as they are known to have other environmental consequences that may offset their benefits.

Coal Gasification: Coal gasification is a process that manipulates coal at high temperatures and pressures in order to produce syngas, a mixture composed primarily of carbon monoxide and hydrogen. Using syngas as a fuel source has the potential to reduce GHG emissions, as the gas, which is comparable to natural gas, burns cleaner than coal in its solid state. Additionally, this process results in the separation of the CO_2 stream, which can then be sequestered geologically (see carbon sequestration), further reducing GHG emissions. Unfortunately, the process of coal gasification is energy intensive and relatively expensive when compared to traditional coal of processes.

Ethanol: Distilled ethanol is a liquid often used as a motor fuel or fuel additive that can replace petrol fuels in flex fuel engines, and as such is one of the most-researched alternatives to gasoline. Unlike petro fuels, ethanol produces very little pollution when burned. The most common method of ethanol production is through the fermentation of sugar, a process that is both efficient and cost effective. Ethanol can be made from a variety of other feedstocks, including bagasse, corn, miscanthus, molasses, sorghum, straw, sugar beet, sugar cane, and wheat, as well as many other types of cellulose waste. As a result, the production of ethanol requires large quantities of land to produce the feedstock materials.

Corn ethanol is the most common type of ethanol in the United States, but it is considered less efficient than other types of ethanol as only part of the plant can be fermented. Increases in the use of corn ethanol have been controversial, as they have instigated worldwide increases in the market price of corn.

Sugar cane is another common source of ethanol, and is often prefered to corn, as sugar cane ethanol is easier to extract and contains higher concentrations of sucrose (about 30% more than corn). Domestically produced sugar cane ethanol provides approximately 18% of Brazil's automotive fuel.

Ethanol

Fuel Yield Per Acre

Crops	**Liters**	**Gallons**
Sugar beet	2702	714
Sugarcane	2505	662
Cassava	1552	410
Sweet sorghum	1416	374
Corn	1340	354
Wheat	1049	277

Source: Worldwatch Institute.

Cellulosic ethanol (cellanol) is an emerging technology in which ethanol fuel is produced from lignocellulose, a structural material that constitutes much of the mass of plants. The chemical structure of cellulosic ethanol is identical to that of ethanol from other feedstock sources (corn, sugar cane, etc.), but has a significant advantage in that it can be made from a greater range of biomass sources, including waste products from urban and agricultural locations.

The production of cellulosic ethanol requires more processing than corn- or sugar cane–based ethanol. The two most common methods involve hydrolysis (also called the cellulolytic method) and gasification (also called the Fischer-Tropsch process), which produces a synthetic gas that can then be fermented.

The degree to which ethanol reduces GHG emissions depends on the energy used to produce and process the inputs of ethanol production. Cellulosic ethanol reduces GHG emissions by over 85% compared to reformulated gasoline. In contrast, corn ethanol, which requires natural gas to produce, reduces GHG emissions by 18% to 29% compared to gasoline.

First Generation Biofuels: This term refers to currently commercialized biofuels, including biodiesels, pure vegetable oils, and bioethanols (from sugar and starch crops). On average, first generation biofuels only reduce CO_2 emissions by roughly 50%, primarily because they require higher energy inputs to produce and process.

Fossil Fuels: Fossil fuels, also known as hydrocarbons, are sources of energy derived from the fossilized remains of ancient plant and animal life that have been exposed to heat and pressure in the Earth’s crust over hundreds of millions of years. Common types of fossil fuels include coal, oil, and natural gas. The term “fossil fuel” also includes other hydrocarbon-containing natural resources that are not entirely derived from biological sources (oil sands, oil shales, etc).

Fossil fuels are considered primary contributors to the greenhouse effect, as their combustion disturbs the equilibrium of atmospheric carbon by introducing carbon that has been out of the carbon cycle back into the atmosphere. This carbon cannot be replaced by soil at the same rate that it is introduced, and thus the carbon cycle is thrown into a state of disequilibrium.

Fuel Cell: A fuel cell is an electrochemical energy conversion device that produces electricity from an external source of fuel and oxidant. While hydrogen fuel cells use hydrogen as fuel and oxygen as oxidant, many different combinations of fuel and oxidant are possible. Because fuel cells are lightweight, have no moving parts, and do not make use of combustion, they are in theory a highly reliable form of energy production. In practice, however, fuel cell technology has not yet developed to a point that allows cells to generate energy in a cost-competitive manner.

Fuel cells are not batteries in that they do not store chemical energy within a closed system, but rather continuously consume fuel from an outside input and utilize it to generate energy. Unlike a battery, a fuel cell will not "go dead" so long as there is a steady flow of fuel into the cell.

There are still many problems associated with the use of fuel cells as a viable source of fuel, despite recent legislation by the United States allocating more than $1 billion to development of the technology. Current costs associated with the construction and maintenance of fuel cells remain prohibitively high, as do the unsubsidized costs of energy produced by the technology. There are also a number of concerns about the functionality of fuel cells, as most are only capable of producing energy when operated within a certain range of temperatures.

Geothermal: Geothermal technology uses geothermal heat from the earth's core to generate electricity or provide heating.

Geothermal power is generated through power plants, which use dry steam, flash, or binary technologies to capture geothermal energy. In these plants, condensed steam is captured and diverted to power turbines, which inject the remaining geothermal fluid back into the ground to pick up heat and transfer it to the surface.

Geothermal energy is a renewable energy source, as the hot water employed in the process is recycled and reused. The use of geothermal energy generates little, if any, GHG emissions, and the technology can provide power continually, as it is unaffected by changing weather conditions. However, the use of geothermal energy raises some concerns regarding land stability in the regions surrounding geothermal wells.

Global Warming Potential (GWP): GWP is a relative scale of measurement that evaluates how much a given mass of GHG is estimated to contribute to global warming. The GWP is a relative scale in that it compares the effect of the GHG under evaluation to the effect of an equal measure of CO_2 gas. Thus, as CO_2 is the basis of the scale, it always has a GWP of 1.

The GWP of any gas is based on several factors, most important being the heat-absorbing ability and the decay rate of the gas as compared to CO_2 (i.e., a gas with a high heat-absorbing ability and a low decay rate will have a higher GWP than a gas with a similar heat-absorbing ability and a high decay rate).

Different GWPs occur not only between different gases, but also between identical gases measured over different time periods. Some gases, such as methane, nitrous oxide, and certain chlorofluorocarbons, decay gradually over time, causing their GWP to decrease as the time horizon is extended. In contrast, some other gases, such as sulfur hexafluoride, escalate their effect the longer they are in the atmosphere, causing their GWPs to increase over time. (For example, the GWP of a quantity of sulfur hexafluoride over a period of 500 years is nearly twice the GWP of the same quantity of gas over 20 years.)

Greenhouse Gases (GHGs): Gases found naturally in the Earth's atmosphere, which absorb infrared radiation, including CO_2 and water vapor as well as trace amounts of chlorofluorocarbons, methane, nitrous oxide, and other gases. These gases allow sunlight to enter the atmosphere freely. When sunlight strikes the Earth's surface, some of it is reflected back toward space as infrared radiation (heat). GHGs absorb this infrared radiation and trap the heat in the atmosphere. Scientific consensus has concluded that an increase in atmospheric GHGs leads to increased atmospheric temperatures (global warming).

While all GHGs have a similar effect, the severity of this effect varies depending on the type and quantity of gas. Methane, for example, is a significantly less influential GHG than sulfur hexafluoride. The differences in potential effects of GHGs are evaluated as a measure of their respective GWP.

Hydrogen: Hydrogen, a colorless, odorless, and—at standard temperature and pressure—highly flammable gas, is the lightest of all chemical elements. It is also the most prevalent element in the universe, constituting roughly 75% of its elemental mass, although most of this mass consists of hydrogen in its atomic and plasma states. Elemental hydrogen gas, which is used in fuel cells and other clean sources of energy, is considerably less common on Earth, due to the high combustibility of the gas and its tendency to bond with other elements.

Hydrogen-based fuel products are considered extremely efficient due to the element's high energy-density-to-weight ratio, a characteristic that is utilized by the sun in the process of nuclear fusion. However, as technology has not yet developed to a level that permits the utilization of controlled fusion reactions to generate usable energy, hydrogen is primarily valued as a potential energy storage medium. It is in this context that hydrogen generates power in fuel cells.

Critics of hydrogen power cite the difficulties in production, storage, and distribution of the elemental gas, as well as the substantial expenses that would be required to overcome these difficulties.

Hydropower: Hydropower is a broad term used to refer to any number of techniques that capture and focus the energy of moving water. Some techniques, such as waterwheels and hydroelectric plants, are designed to harness the energy of rivers and other isolated bodies of water. Other techniques, such as tidal power plants and wave power plants, are designed to capture the latent energy of oceans.

Regardless of the technique used, hydropower is favored as a clean source of energy because it is sustainable, produces few pollutants, and is generally competitive in market price when compared to fossil fuels. Further, so long as the source of water is not diverted or destroyed, the process of generating energy is renewable and low impact.

Investor Network on Climate Risk (INCR): Working with institutional investors, INCR promotes understanding of the risks and opportunities posed by climate change. It organizes summits, conferences, and forums to educate pension fund managers and other investment professionals about climate risks to their portfolios. INCR supports and coordinates its members' engagement with their portfolio companies and with policymakers on climate risks and potential business opportunities, typically by means of shareholder resolutions. INCR has more than 50 members representing $3 trillion in assets.

Kyoto Protocol: The Kyoto Protocol is linked to the United Nations Framework Convention on Climate Change (UNFCCC) in which ratifying countries committed to reducing their GHG emissions and to a cap-and-trade system of emissions trading if they maintain or increase their GHG emissions. This treaty, adopted on December 11, 1997, at the Third Conference of Parties in Kyoto, entered into force on February 16, 2005. As of October 2007, the Kyoto Protocol covers more than 176 countries globally (making up 60% of global GHG emissions). The United States, Australia, and Kazakhstan are the only signatory nations that have not ratified the act.

The protocol offers three main mechanisms to achieve emission reduction targets. An emissions trading scheme allows Annex I (developed) countries to purchase carbon permits from and sell carbon permits to each other. The Clean Development Mechanism permits industrialized nations to finance projects that reduce emissions in developing countries and earn the financing nation credit toward its emissions reduction target. Similarly, a mechanism known as Joint Implementation allows industrialized nations to finance projects that increase efficiency and reduce emissions in the "transition economies" of central and eastern Europe.

The Kyoto Protocol also enables groups of Annex I countries to join together to create a cluster of countries with an overall emissions cap treated as a single entity for compliance purposes. The European Union is one such group and the European Union Emission Trading Scheme (EU ETS) was established as a carbon market within a global carbon market to comply with the protocol. Established in January 2005, the EU ETS is the largest multinational GHG emissions trading scheme in the world, with 27 member states.

There are many arguments for and against the effectiveness of Kyoto Protocol. Proponents of the protocol's effectiveness cite its market-based scheme of carbon credits trading, its inclusion of emerging countries, and the use of regulatory as opposed to voluntary compliance. Others cite its abundance of loopholes; the classification of China, India, and Brazil—three of the world's fastest growing (and polluting) economies—as Non–Annex I countries (i.e., not required to reduce their emissions); and the fact that the United States has not ratified the treaty as evidence of the protocol's limited effectiveness. International talks began in May 2007 to discuss a treaty to succeed the current one, which will expire in 2012.

Landfill Gas: Landfill gas is a by-product of landfills that has the potential to—and often does—leak into the atmosphere. If captured before escaping into the atmosphere, the gas can be used as a source of renewable energy for industry or to generate electricity for public consumption. Landfill gas contains approximately 50% methane, which is itself an excellent source of energy. When released into the atmosphere, methane produces more than 20 times the greenhouse effect of CO_2. However, when methane is combusted, it is converted into CO_2 and water, thereby reducing its greenhouse effect.

While combusting landfill gas does contribute GHGs to the atmosphere in the form of CO_2, its use efficiently offsets the use of other nonrenewable fuel sources by converting a by-product that would otherwise be released into the atmosphere in the form of more potent methane.

Methane (CH_4): Methane is the principal component of natural gas and is produced anerobically in the earth's crust through methanogenesis, a process in which microbes called methanogens produce methane in an environment devoid of oxygen. Methane is a potent GHG, with a greenhouse effect more than 20 times that of CO_2. However, burning one molecule of methane releases one molecule of CO_2 ($CH_4 + 2O_2 = CO_2 + 2H_2O$); therefore, the combustion of methane as a gas compared to its natural release reduces its greenhouse impact.

Technologies that relate to methane combustion include the use of natural gas, landfill gas methane, coal bed methane extraction, manure, and anerobically contained biodegradable materials. Each of these technologies has a variety of environmental and economic implications. In general, methane is considered an attractive fuel source, due both to its abundance and to the positive impact its combustion has on atmospheric levels of GHGs.

Natural Gas: Natural gas is the term applied to any number of highly combustible, gaseous fossil fuels that consist primarily of methane. As natural gases are, naturally, extracted from a variety of sources in the environment, including oil fields, natural gas fields, swamps, and marshes, the exact content of natural gas varies from source to source. While it consists primarily of methane, natural gas may also include significant quantities of ethane, butane, propane, CO_2, nitrogen, and other chemicals. These compounds are typically removed during the refinement process.

Natural gas is often considered a "clean" alternative to many traditional sources of energy, as it burns cleaner than fossil fuels and produces significantly less GHG. Natural gas can also be used to produce hydrogen, and is currently used in a compressed form to power compatible vehicles and homes.

Nonrenewable Energy: Nonrenewable energy refers to energy sources that rely on consumable materials that are not generated on a scale comparable to their consumption rates. These energy sources come out of the ground as solids, liquids, and gases and include energy derived from fossil fuels like coal, petroleum, and natural gas. Nuclear power is technically a nonrenewable energy source because it relies on finite sources of uranium. Timber may also be considered a nonrenewable energy source, but only when it is depleted at a faster rate than the rate at which trees can regenerate.

Nuclear Energy: The use of nuclear energy does not result in CO_2. Nuclear power is technically a nonrenewable energy source because it relies on finite sources of uranium, which is used to generate energy through a process known as nuclear fission. In this process, the nucleus of an atom of uranium is split, releasing smaller elements as well as large quantities of energy. If one ignores the radioactive by-products of the reaction, nuclear fission is an extremely efficient means of energy generation, producing millions of times the energy of that contained in a chemical fuel of the same mass.

Nuclear fission should not be confused with nuclear fusion, a reaction that involves the binding of multiple atomic particles in order to generate energy. The sun is an example of an engine that generates energy through nuclear fusion. Due to the extremely high quantities of energy required to fuse multiple atomic particles together, as well as the even greater energy released when fusion occurs, scientists have not yet determined a way of producing a reliable and controlled fusion reaction. It is hypothesized that should a method of controlling fusion reactions be discovered, the resulting technology could provide inexpensive energy to the entire world.

Oil Sands: Also referred to as bituminous sands or tar sands, oil sands consist of heavy crude oil mixed in water and sand (or clay). Oil sand deposits occur naturally in areas where lighter fractions of oil have been lost, leaving behind a heavy form of crude oil, which usually is partially biodegraded by bacteria.

Unlike conventional crude oil, which is extracted by drilling wells in formations where medium- or light-density oil flows from the pressures naturally generated by the reservoir, oil sand extraction requires large amounts of energy. Oil sands must either be strip-mined or made to flow using steam or solvents to reduce the viscosity of the heavy crude oil.

Despite being difficult (and therefore costly) to extract, oil sands are currently being mined in increasingly large quantities. The resulting oil is then refined into petroleum products or converted into synthetic oils. Significant oil sand deposits are present in the United States, Russia, and the Middle East, but the largest deposits are located in Canada and Venezuela (both of which are currently investing in oil sand technology and producing oil sand extracts).

Renewable Energy: Renewable energy is derived from natural processes that are constantly replenished and for all practical purposes cannot be depleted. Unlike nonrenewable resources (fossil fuels), renewable resources do not produce many GHGs or other pollutants, although their use is occasionally associated with other negative environmental effects (highly intensive land use, etc.).

Sources of renewable energy include geothermal power, hydropower, solar power, wind power, and power from biofuels derived from renewable resources. Renewable energy currently accounts for roughly 14% of the world's energy consumption, but the technical potential of renewable resources is large enough to cover many times that amount. Some renewable technologies, including geothermal and hydropower, are already economically competitive with fossil fuels, but many other technologies, such as solar power, still require subsidies in order to remain market competitive.

Renewable Portfolio Standard (RPS): An RPS refers to a regulatory policy requiring increased production of renewable electricity (and sometimes fuel) sources within its jurisdiction. RPS regulations require electricity providers to obtain a minimum percentage of their power from renewable energy sources by a certain date. Currently in the United States, the RPS policies in place vary from state to state, as no national policy exists in the United States for electricity.

RPSs rely almost exclusively on the private market for implementation, primarily because the regulation imposes a strict market standard that must be met. As a result, supporters claim that RPSs will drive competition and innovation to deliver renewable energy at the lowest cost, thereby allowing renewable energy to compete directly in the market with fossil fuels. Those opposed to RPSs claim that they raise consumer electricity prices and drive pricing inequalities across state lines.

As of August 2007, 26 U.S. states and the District of Columbia have enacted mandatory RPSs, accounting for more than half of electricity demand.

Second Generation Biofuels: Second generation biofuels convert low-value agricultural residues and crops into fuel, and therefore have the potential to reduce GHG emissions more than first generation biofuels. Second generation biofuel technology, which uses biomass-to-liquid technology, is still emerging and has not yet been commercialized. However, second generation biofuels are expected to enter the market in the next five to ten years. Second generation biofuel technologies currently under development include bioethanol (from lignocellulosic biomass), biohydrogen, bio-DME, biomethanol, and mixed alcohols.

Solar Power: Solar power is a renewable energy source that harnesses the energy of the sun to generate electricity, heat, and light. Other applications for solar power include the transportation and desalination of seawater. Solar electricity uses photovoltaic cells (solar cells), which use the photovoltaic effect of semiconductors to generate electricity directly from sunlight. Solar power development relies on advanced materials technology in making cost-effective semiconductors. Only through the development of cost-effective components can solar power eventually become a competitively priced source of power. Solar installations can be centralized and act like a power plant or more typically are installed on roofs at the point of use. Next generation solar technologies include CIGS thin cells.

Stern Report on Climate Change – "Climate Insurance": A 2006 report by Sir Nicholas Stern, former chief economist of the World Bank and head of the United Kingdom Government's Economic Services, found that the cost of reducing GHGs to avoid the worst effects of climate change would cost approximately 1% of global GDP per year (roughly $515 billion in 2006). However, without this insurance policy, he predicted that a business as usual scenario would result in the risks and costs of climate change equivalent to losing 5% of global GDP per year in perpetuity. Using a wider range of estimates, he estimated that the damage could rise to 20% of global GDP or more, equivalent to the World Wars or Great Depression of the early 20th Century. Much of this climate change insurance spending would be productivity enhancing. In comparison to the 1% cost proposed in the Stern report, 2.8% of global GDP went to military spending in 2006.[2] Stern also estimates the global market for low carbon energy products to be at least $500 billion per year by 2050, and "perhaps much more." If governments adopt this idea of climate change insurance broadly, it would further bolster the demand for low-carbon clean technologies.

Wind Power: Wind power is an increasingly popular technology that converts wind energy into electricity through wind turbines. Electricity is generated by converting the rotation of wind turbine blades into an electrical current through the use of an electrical generator.

Because wind energy is a renewable, plentiful, and widely distributed source of energy, it is an attractive replacement for fossil fuel–derived energy. The costs of this energy source are entirely front-loaded. Once the wind power facilities have been constructed, the only input, wind, is free over the life of the generation. Because wind power is intermittent, it is best used as part of a broader portfolio of energy generating assets. Wind power is a flexible power source that can be used with large-scale national electrical grids or with smaller regional grids. Wind energy can also be controversial, as it requires significant land areas to operate on a large scale. For this reason, there are concerns about the technology's potential impact on wildlife as well as its less than aesthetic appearance.

[2] According to the Center for Arms Control and Non-Proliferation, cited in "Insuring the Planet," Goldman Sachs Global Economics Weekly, July 18, 2007.

APPENDIX B

PUBLIC CLEANTECH INDICES

Appendix B

PUBLIC CLEANTECH INDICES

WilderHill Clean Energy Index (ECO)

Description

The WilderHill Clean Energy Index (ECO) is a modified equal dollar–weighted index made up of publicly traded companies whose businesses stand to benefit substantially from societal transition toward the use of cleaner energy and conservation. The index is rebalanced each March, June, September, and December. The index was created by and is a trademark of WilderShares, LLC.

Eligibility

1. For a stock to be included in the selection universe, the company must be identified as one that has a significant exposure to clean energy, or that contributes to the advancement of clean energy, or that is considered important to the development of clean energy. Companies in the ECO generally (1) work to further renewable energy efforts, doing so in ecologically and economically sensible ways; (2) help control pollutants, such as carbon dioxide, nitrogen oxides, sulfur dioxide, and particulates-avoiding carbon, or contaminants that harm oceans, land, air, or ecosystems structure; or (3) incorporate ideals of the precautionary principle or pollution prevention into their energy efforts. Companies in the ECO generally will not have their majority interests in the high-carbon fuels, such as oil and coal. Large companies with interests outside clean energy may be included if they are significant to this sector.

2. The market capitalization for most ECO stocks is typically in excess of $200 million. To account for those small but notable companies that are significant to the clean energy field, a minority of ECO stocks may have market capitalizations between $50 million and $200 million.

3. Typical stocks in the ECO should:

- Have a three-month average market capitalization of at least $50 million.
- Have a three-month average closing price above $1.00.
- Be listed on a major U.S. exchange such as the New York Stock Exchange (NYSE), the American Stock Exchange (AMEX), or Nasdaq. If they are a foreign company, they should have their ADR listed on one of these exchanges.
- Reach minimum average daily liquidity requirements for sufficient trade volume.

Index Sectors[1]

1. Renewable Energy Harvesting (36%)
2. Power Delivery & Construction (21%)
3. Cleaner Fuels (15%)
4. Energy Storage (13%)
5. Energy Conversion (9%)
6. Greener Utilities (6%)

Top Ten Holdings[2]

1. Echelon (4.30%)
2. Yingli Soar (4.27%)
3. Emcore (4.04%)
4. Ormat Technologies (3.48%)
5. Sunpower (3.44%)
6. JA Solar (3.38%)
7. Itron (3.24%)
8. Suntech Power (3.15%)
9. Cree (3.09%)
10. First Solar (3.06%)

WilderHill New Energy Global Innovation Index (NEX)

Description

The WilderHill New Energy Global Innovation Index (NEX) is a modified dollar-weighted index of publicly traded companies that are active in renewable and low-carbon energy, and that stand to benefit from responses to climate change and energy security concerns. The majority of index constituents are quoted outside the United States, and the index is rebalanced every March, June, September, and December. The index divisor was initially determined to yield a benchmark value of $100.00 at the close of trading December 30, 2002. The index was created by and is a trademark of WilderHill New Energy Finance.

Eligibility

For a stock to be included in the selection universe, the company must be identified as one that has a meaningful exposure to clean energy, either as a technology, equipment, service, or finance provider, such that profitable growth of the industry can be expected to have a positive impact on that company's

[1] Index sectors and weights are as of the October 1, 2007. www.wildershares.com.
[2] Index components and weights are as of September 17, 2007. www.wildershares.com.

performance. Generally, meaningful exposure is taken to mean that the company derives at least 10% of its market value from activities in clean energy, based upon the judgment of the index provider.

Eligible companies will typically have a three-month average market capitalization of at least $100 million. Market capitalization for a majority of index stocks is typically $250 million and above. To account for the notable but smaller companies sometimes significant to the clean energy field, a minority of index stocks may have market capitalizations between $100 million and $250 million. They will be listed on a major international or national exchange: the NYSE, AMEX, or Nasdaq in the United States; in Europe one of the major exchanges such as London, Paris (Euronext), Madrid, Frankfurt (Xetra), or Copenhagen; in Asia these may include, but not be limited to, the Australian Stock Exchange (ASX), Tokyo, Hong Kong, Shanghai, Shenzhen, Mumbai, or the National Stock Exchange of India. They will reach minimum average daily liquidity requirements for sufficient trade volume. A small number of index constituents may at any time not meet these criteria. Nuclear power is not considered clean energy for the purpose of this index. This is as much in recognition of the differing industry structure and drivers of the nuclear industry as it is ideological. A minor involvement in the nuclear industry will not, in itself, disqualify a company from inclusion.

Index Sectors[3]

1. Renewable - Wind (27.2%)
2. Renewable - Solar (22.9%)
3. Renewable - Biofuels, Biomass & Waste-to-Energy (12.0%)
4. Renewable - Other (11.3%)
5. Demand-Side Energy Saving (7.6%)
6. Services & Suppliers (6.8%)
7. Generation Efficiency & Smart Distribution (6.3%)
8. Hydrogen & Fuel Cells (3.7%)
9. Power Storage (2.4%)

Top Ten Holdings[4]

1. Acciona (2.5%)
2. Babcock & Brown Wind Partners (2.5%)
3. EDF Energies Nouvelles (2.5%)
4. Gamesa (2.5%)
5. Iberdrola (2.5%)
6. Nordex (2.5%)
7. Repower Systems (2.5%)
8. Scottish & Southern Energy (2.5%)
9. Theolia (2.5%)
10. Vestas Wind Systems (2.5%)

[3] Index sectors and weights are as of September 28, 2007.
[4] Index components and weights are as of September 28, 2007.

Geographic Distribution

- Europe, Middle East, and Africa – 48.3%
- Americas – 34.0%
- Asia and Oceania – 17.7%

Cleantech Index™ (CTIUS)

Description

The Cleantech Index™ United States (CTIUS) is an equal-weighted index of U.S. exchange-traded companies that are engaged in the cleantech industry. "Cleantech" is defined as any knowledge-based product or service that improves operational performance, productivity, or efficiency; while reducing costs, inputs, energy consumption, waste, or pollution. The CTIUS was established with a base value of $500.00 at the close on December 31, 1999. The index is rebalanced every March, June, September, and December. The index was created by and is a trademark of Cleantech Capital Indices LLC.

The index is calculated using an equal weighting methodology. In the event of a merger between two components, the share weight of the surviving entity may be adjusted to account for any shares issued in the acquisition. The index provider may substitute components or change the number of issues included in the index, based on changing conditions in the industry or in the event of certain types of corporate actions, including mergers, acquisitions, spin-offs, and reorganizations.

The companies listed on CTIUS have a combined market capitalization in excess of $290 billion and have at least 50% of their sales obtained from cleantech products and services. Calculations from backtesting of the CTIUS suggest that the past five and three years significantly outperformed the S&P 500 and Nasdaq indices.

The CTIUS is intended to provide investors with a vehicle to diversify into the emerging "cleantech" investment category while helping bring greater liquidity to publicly traded cleantech companies. The index encourages capital formation for privately held cleantech enterprises with strong IPO potential. The CTIUS is the premier investment vehicle developed for capturing the opportunities associated with the substantial increase in the economic value of clean technologies.

Eligibility

1. Listed on the NYSE, AMEX, or quoted on Nasdaq.
2. Three-month average market capitalization of at least $150 million.
3. Three-month average closing price of above $3.00.
4. Trade volume greater than 400,000 shares for each of the prior six months.

Index Construction

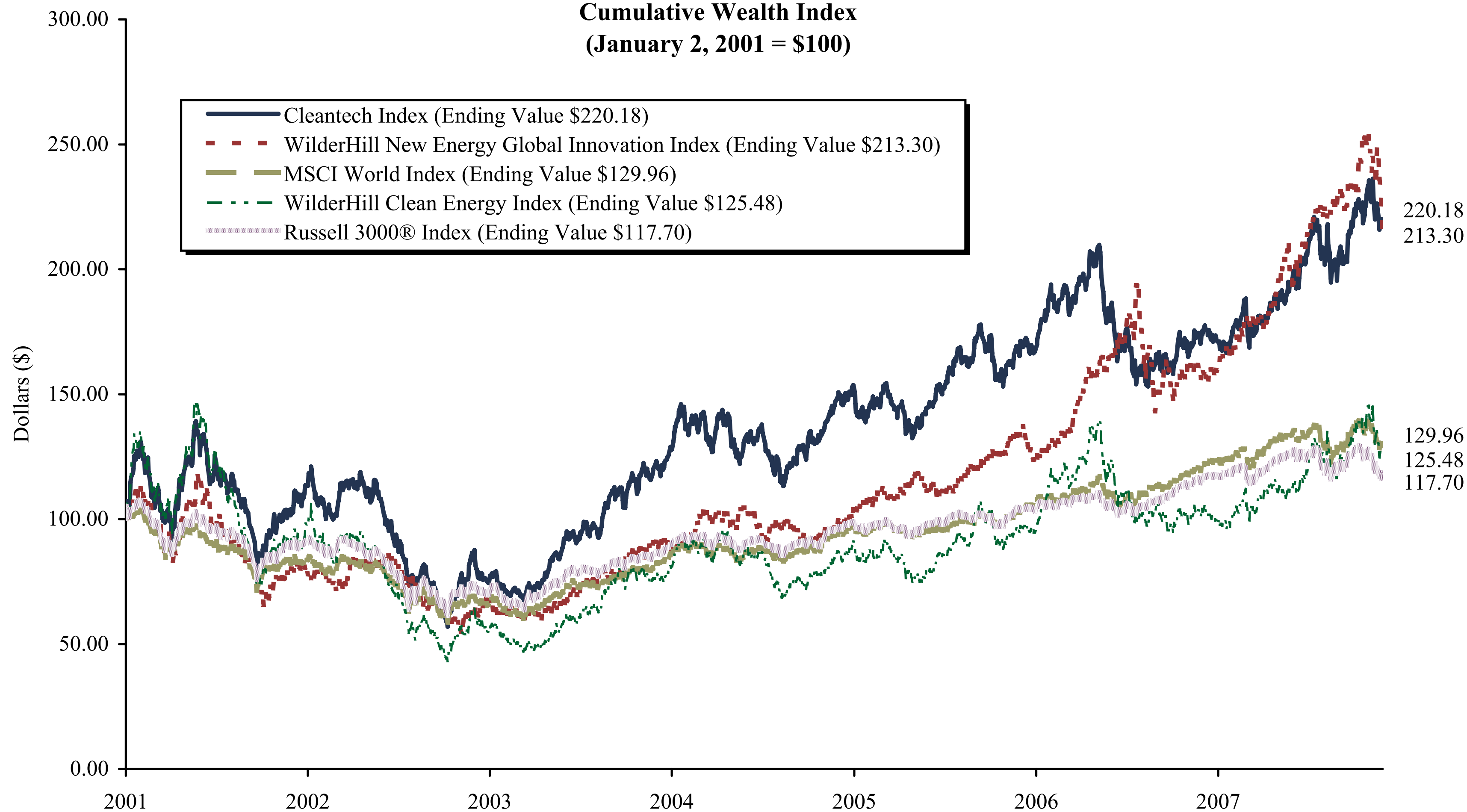
1. Advanced Electronics
2. Advanced Materials
3. Agriculture & Nutrition
4. Alternative Energy
5. Environmental & Waste Control
6. Filtration Technology
7. Flow Control Technology
8. Instrumentation & Process Control
9. Water Technologies

Exhibit B-1

CLEAN ENERGY INDICES

January 3, 2001 – November 27, 2007

Cumulative Wealth Index
(January 2, 2001 = $100)



Sources: Bloomberg L.P., Cleantech Group LLC, Frank Russell Company, MSCI Inc., Thomson Datastream, WilderHill New Energy Finance, LLC, and WilderShares, LLC. MSCI data provided "as is" without any express or implied warranties.

APPENDIX C

CALPERS/CALSTRS GREEN WAVE INITIATIVE

Appendix C

CALPERS/CALSTRS GREEN WAVE INITIATIVE

Two of the largest and highest-profile cleantech investors are the State of California's two large public pension funds—the California Public Employees' Retirement System (CalPERS) and the California State Teachers' Retirement System (CalSTRS)—through their Green Wave Initiative. This initiative has supported the creation of a number of new cleantech funds. The two pensions will invest $1.5 billion in cutting-edge technologies and environmentally responsible companies. The goal of the initiative is to improve long-term financial returns for pensioners and taxpayers through investments in the environmental technology sector, while also reducing the risks to the pension funds posed by corporate environmental liabilities.

The four prongs of this initiative are:

1. Environmental Accountability and Disclosure

CalPERS and CalSTRS request that corporations provide meaningful and consistent reporting of their environmental practices, risks, and potential liabilities. With a new environmental governance program, CalPERS and CalSTRS would encourage companies—using dialogue, shareholder resolutions, and other actions—to improve their environmental operations and reduce their environmental risks and liabilities.

In 2006, CalPERS was in the process of developing a strategy to encourage transportation, utilities, and oil and gas sector firms to disclose environmental data and meet minimum environmental standards. CalPERS is also a member of the Investor Network on Climate Risk, and has signed onto the Carbon Disclosure Project, which seeks to improve the transparency of business risks associated with climate change.[1]

2. Private Investment in Environmental Technologies

CalPERS and CalSTRS plan to invest a combined $500 million in private equity investments, venture capital, and project financing to develop "clean" technologies that can provide the pension funds with positive, long-term returns, and that can create jobs and economic growth in California in the years ahead.

CalPERS has established a $200 million target allocation to a diversified portfolio of private cleantech investments. As of October 2007, it has committed the full $200 million to the following venture capital and private equity firms: Carlyle Riverstone Renewable Energy, DFJ Element, Enertech Capital, NGEN, Paladin Private Equity, Rockport Capital, and VantagePoint CleanTech.

[1] See www.calpers.ca.gov for more information.

3. Stocks of Environmentally Responsible Companies

CalPERS and CalSTRS are investing a combined $1 billion of their stock portfolios into environmentally screened funds through leading active public equity investment managers with proven track records. Under this proposal, the performance of any manager selected must equal or exceed that of the funds' existing, active managers.

4. Real Estate Portfolios and Their Long-Term Value

CalPERS and CalSTRS have undertaken a comprehensive audit of their respective real estate investments to determine whether the investments are maximizing their opportunities to source clean energy, to be energy efficient, and to use green building standards and practices that reduce long-term costs and boost long-term value.

Focusing on its $5 billion core real estate portfolio, CalPERS is working with its real estate investment partners to encourage them to adopt ecologically preferable real estate building and management practices, including energy efficiency, water conservation, waste stream management, and indoor air quality. CalPERS seeks to reduce energy usage in its core real estate portfolio by 20% over the next five years. It also hopes to support investments that meet Leadership in Energy & Environmental Design (LEED)/Energy Star requirements.

APPENDIX D

CLEANTECH COMPANIES: THREE EXAMPLES

Appendix D

CLEANTECH COMPANIES: THREE EXAMPLES

Vestas

Name: Vestas Wind Systems A/S (Copenhagen Stock Exchange) (www.vestas.com)
Company Description: Vestas is a Denmark-based company active in the wind power industry. The company is engaged primarily in the development, manufacture, sale, marketing, and maintenance of wind power systems that use wind energy to generate electricity. Its product range includes land and offshore wind turbines capable of generating between 850 kilowatts (kw) and 3.0 megawatts (mw) as well as supervisory control and data acquisition products. Vestas Wind Systems A/S operates more than 30,000 wind turbines, which generate electricity in 63 countries on five continents.
Date Founded: 1979
Locations: Denmark as well as Australia, China, England, Germany, India, Italy, Norway, Spain, and Sweden
Pre-IPO Investor: Danish Government
Stock Price at IPO: 270 DKK (5/4/1998)
Present Stock Price: 516.4 DKK (12/06/2007)
Number of Shares Outstanding: 185.2mm (9/30/2007)
Market Cap: 95.0bn DKK (9/30/2007)
Customers: Maple Ridge Wind Farm, NY; Stateline Wind Project, WA/OR; Woodward Mountain, TX; and Blue Canyon, OK
Competitors: Abengoa S.A., Azure Dynamics, Domnick Hunter Group, Gamesa, General Electric, and Solarworld

Timeline of Notable Events:

1977: Vestas begins developing wind turbines in response to the oil crisis and growing environmental concerns.

1978: Vestas introduces the first three-blade turbine.

1986: After a change in legislation in the United States, Vestas collapses into bankruptcy.

1987: Vestas is reorganized as Vestas Wind Systems A/S, specialized in wind turbines.

1989: The company acquires Danish Wind Technology and establishes a subsidiary in Germany.

1998: Vestas goes public with a listing on the Copenhagen Stock Exchange.

2001: The company is chosen to supply turbines for the world's first major offshore wind farm at Horns Reef in the North Sea.

2003: Vestas delivers the Horns Reef platform.

2004: Vestas acquires Danish rival NEG Micon.

2005: Vestas receives its first large contract in China and announces plans to build a factory in Tianjin.

2006: The Vestas Group completes strategic repositioning in India.

2007: Vestas and Aalborg University set up comprehensive strategic research program.

Suntech

Name: Suntech Power Holdings Co., Ltd. (NYSE: STP) (www.suntech-power.com)
Company Description: Suntech is a solar energy company that designs, develops, manufactures, and markets a variety of photovoltaic cells and modules. It also provides photovoltaic system integration services in China. The company's products are used in a variety of applications in various markets for both on-grid electricity generation and off-grid use, such as standalone lighting for street lamps and garden lamps, as telecommunications relay stations, and as mobile phone networks worldwide, including in a number of European countries, such as Germany and Spain, as well as in China and the United States. Suntech sells its products outside of China primarily through distributors and in China primarily to module manufacturers and end users directly.
Date Founded: 2001
Locations: Wuxi Jiangsu Province, China; San Francisco, CA; and Middlesex, U.K.
Pre-IPO Investors: Actis China, Goldman Sachs (Asia), Million Power, and Win Mark
Stock Price at IPO: $15.00 (12/14/2005)
Present Stock Price: $77.18 (12/6/2007)
Number of Shares Outstanding: 149.5mm (9/30/2007)
Market Cap: $11.5bn (12/6/2007)
Customers: 2008 Olympic Stadium, Aterso, Conergy, IBC Solar, Ibesolar Energia, San Francisco Airport, and SolarWorld AG
Competitors: Kyocera Solar, Q-Cells, and Sharp

Timeline of Notable Events:

September 9, 2001: Suntech Power Co. Ltd is founded.

September 9, 2002: Suntech's first 10mw photovoltaic cell production line begins operation.

December 2002: Suntech signs R&D cooperation agreement with the photovoltaic research center at the University of New South Wales, Australia.

December 2003: New 15mw solar cell line begins operation.

August 2004: New 25mw cell line begins operation.

December 14, 2005: Suntech raises almost $400 million in its initial public offering on the New York Stock Exchange.

December 2005: Suntech's annualized photovoltaic production capacity reaches 150mw.

April 2006: Suntech is chosen to be the exclusive supplier of a 130kw solar system for Beijing's Bird's Nest Stadium, the main stadium for the 2008 Beijing Olympic Games.

July 29, 2006: Suntech secures significant silicon supply to support expansion through a ten-year contract with MEMC worth $6 billion.

August 10, 2006: Suntech announces establishment of Suntech America, Inc., to drive development of the market for solar products in North America.

October 23, 2006: Suntech announces establishment of Shenzhen Suntech to promote and develop solar power grid integration projects in China.

December 2006: Suntech's production capacity expands to 300mw, and it becomes the third largest silicon cell manufacturer in the world.

EnerNOC

Name: EnerNOC, Inc. (NASD: ENOC) (www.enernoc.com)
Company Description: EnerNOC, Inc. develops and provides demand response and energy management solutions to commercial, institutional, and industrial end users, as well as electric power grid operators and utilities in the United States. It uses a network operations center to remotely manage electricity consumption across a network of end-use customer sites and make electric capacity and energy available to grid operators and utilities on demand. The company's demand response capacity provides an alternative to building conventional supply-side resources, such as natural gas–fired peaking power plants, to meet infrequent periods of peak demand. It also offers meter data gathering and storage services for advanced meters; energy analytics and control services; energy procurement services; and emission tracking and trading support.
Date Founded: 2001
Locations: San Francisco, CA; Meridan, CT; Stamford, CT; Boston, MA; and New York, NY
Pre-IPO Investors: Braemar, DFJ, and Foundation
Stock Price at IPO: $26.00 (5/17/2007)
Present Stock Price: $47.06 (12/6/2007)

Number of Shares Outstanding: 19.1mm (11/13/2007)
Market Cap: $925.4mm (11/13/2007)
Customers: Commercial, institutional, and industrial customers, as well as electric power grid operators and utilities
Competitors: Comverge, ESCO Technologies, and Itron

Timeline of Notable Events:

August 23, 2003: Town of Fairfield and EnerNOC team up to re-energize Northeast. Town's participation in demand response event reduces load on power grid; aides recovery from blackout; town gets revenue from electricity grid operator.

January 25, 2005: EnerNOC secures additional round of funding. Foundation Capital was the lead investor in the round. First-round investors Draper Fisher Jurvetson, Braemar Energy Ventures, and DFJ New England also participated, bringing total investment in the company to over $10 million.

April 18, 2005: EnerNOC opens Manhattan office, adds 4mw to demand response portfolio.

June 15, 2005: EnerNOC acquires leading demand response provider Pinpoint Power.

July 31, 2005: Demand response relieves New York and New England grid emergencies.

March 7, 2006: EnerNOC introduces total energy management platform capable of saving customers up to 25% on energy costs.

May 24, 2006: EnerNOC solidifies leadership in demand response; surpasses 1,000mw of capacity under management with Celerity Energy acquisition.

December 4, 2006: The World Economic Forum selects EnerNOC as a Technology Pioneer of 2007.

March 2, 2007: EnerNOC awarded 40mw PG&E Contract.

May 24, 2007: EnerNOC closes on its initial public offering of 4,312,500 shares of common stock at a price of $26.00 per share.

September 17, 2007: EnerNOC acquires MDEnergy, LLC (MDE), an energy procurement service provider, for approximately $7.9 million.

APPENDIX E

OVERVIEW OF GOVERNMENT REGULATIONS

Appendix E

OVERVIEW OF GOVERNMENT REGULATIONS

Governments in the developed world, especially those subject to binding greenhouse gas reduction targets under the Kyoto Protocol, have been decarbonizing their electricity grids. For example, Spain is leading in solar power and Denmark has been a leader in wind power. The Danish government has encouraged Vestas Wind Systems to become the dominant wind turbine provider in the world (see Appendix D for more information). France for years has relied primarily on nuclear power. In contrast, China, India, and the United States have large reserves of coal, making it more difficult to diversify away from this cheap fuel. Nonetheless, the U.S. government has projects underway to use carbon sequestration in coal plants and wishes to share this technology with China and India. As the most carbon-intensive fuel source, coal presents an engineering challenge in a carbon-constrained world.

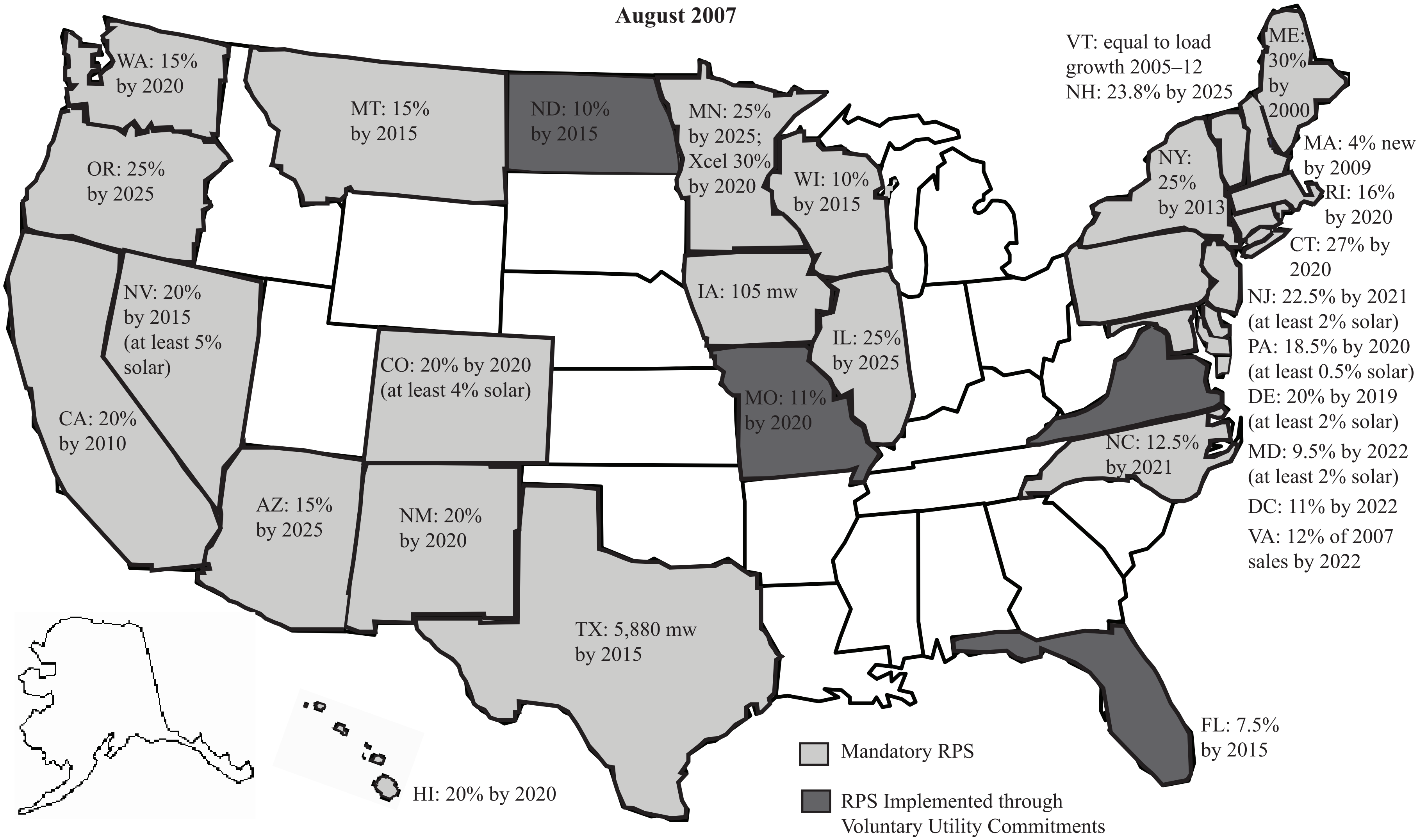
In addition, there are currently several trading systems in place to reduce greenhouse gas emissions, with the largest being the European Union Emission Trading Scheme. Established in January 2005, it was created in order to comply with the greenhouse gas emissions targets in the Kyoto Protocol. Countries subject to the Kyoto Protocol have a longer history of market-based incentives to reduce fossil fuel usage, and the regulation has spurred strong renewable energy industries in these countries. As a result, these countries have had a head start on developing renewable technologies. John Denniston of Kleiner Perkins noted that "Europe began investing in green solutions a decade ago… . America doesn't have a huge lead in greentech like we did for communications and IT." However, the United States, with its highly developed venture capital industry, is catching up quickly.

Absent a federal mandate, the current push for renewable electricity in the United States has largely come from states, as electricity is regulated at the state level and different states have different resources, such as strong wind speed, sunshine, hydropower, and coal. As of August 2007, 26 U.S. states and the District of Columbia, representing more than 50% of U.S. electricity demand, have established standards to require utilities to obtain a minimum level of renewable electricity, typically between 10% and 25% of total power (Exhibit E-1). In order to meet these goals, a significant amount of renewable electricity supply must be created in the next several years. These Renewable Portfolio Standards create a guaranteed market for producers of renewable electricity. Many rust-belt states, such as Pennsylvania, see cleantech as a promising new area for job creation. Some of these states also provide subsidies for transportation fuels, like ethanol and biodiesel. However, transportation subsidies have largely been at the federal level. The federal government's $0.51 per gallon credit for corn ethanol costs between $5.5 billion and $7.3 billion per year, according to the International Institute for Sustainable Development.

Exhibit E-1

STATES WITH RENEWABLE PORTFOLIO STANDARDS

August 2007



Source: Database of State Incentives for Renewables and Efficiency and Pew Center on Global Climate Change.

Notes: In June 2007, Florida Governor Charlie Crist drafted an executive order to require utilities in procure 20% of their electricity from renewable sources, subject to state approval. Minnesota, in addition to its statewide standard, also directed Xcel Energy, which generates about half the state's electricity, to produce 30% of its power from renewable sources by 2020.