A Climate Solutions Special Report
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Accelerating the Clean Energy Revolution:

How the Northwest Can Lead

by Patrick Mazza

Cost of power from large, advanced wind turbines is dramatically dropping.

SUMMARY

A clean energy revolution is breaking out. Solar energy, the world's second fastest growing energy source, is positioned to reach mass scale in coming years. Wind power, at number one, is posting growth rates in the same stratosphere as internet and cell phone companies. Fuel cells, moving to commercialization faster than expected, will be widespread in cars and buildings by the end of the decade.

This clean energy revolution is coming just in time. It holds the opportunity to rapidly phase out fossil fuels, by far the major source of human greenhouse gas emissions that are already warming the climate. The recent spate of record hot years has spurred the heads of the top climate monitoring organizations in the United States and Britain to break with any past scientific reticence and

continued

clearly state that human activities are warming the globe.

This paper represents a full-scale revision of one we issued in 1998, How the Northwest Can Lead a Clean Energy Revolution. *It details the global status of solar, wind and fuel cell industries. (Biomass and geothermal also have significant clean energy potential, but for the most part are beyond the scope of this paper.) The convergence of the information technology and clean energy revolutions is examined. Actions to build clean energy markets are detailed. The Pacific Northwest's present and potential contributions to the clean energy revolution are a key focus.*

CLEAN ENERGY TECHNOLOGIES

Solar Photovoltaic - A $2 billion industry growing 20-25% annually crossed a threshold in 1999, a gigawatt, one billion watts, of solar cells manufactured in the industry's first 27 years. At the current rate — 1999 sales were 160 megawatts (MW) — it will take around 4 to reach the second gigawatt. Solar PV prices are expected to dramatically drop over the coming decade, creating a market for several gigawatts annually.

Wind Turbines - Wind power, expanding on average 30% annually since 1994, grew even faster in 1999. The year began with about 10,000 MW worldwide and ended with 13,400. Wholesale costs down 80% over the past decade, wind is closing in on the cheapest fossil sources. It could become the cheapest by 2010.

Fuel Cells - Generating electricity from the reaction of hydrogen and oxygen, the fuel cell is the leading contender to take the place of internal combustion engines in cars, and will also become common in buildings. Over the coming 4 years several companies will market home and business systems, and fuel cell vehicles will reach Ford, Daimler-Chrysler and Nissan showrooms.

The Energy Web - The old centralized "mainframe" model of one utility pumping out juice to many customers is being supplanted by a distributed "internet" model of many micropower plants. It relies on information technologies to link the plants in a smart network. Those technologies also are a vital internal element of micropower units. At the same time, the demand of computers for super-reliable power is propelling the growth of distributed generation, while computer controls are significantly increasing energy efficiency.

BUILDING MARKETS

The U.S. led the way in solar and wind during the 1980s, but Europe and Japan have pulled into the lead. Governments there have aggressively supported their infant clean energy industries. The 5 top solar photovoltaic companies are under Japanese or European ownership. Germany is the largest wind energy producer while Denmark is the top wind turbine maker.

But American states are now becoming hotbeds of clean energy innovation, implementing new tools to build up renewables. Systems Benefit Charges (SBC), small power line tolls, will raise $1.7 billion for renewables. Renewables Portfolio Standards (RPS) mandate development of 3,800 MW of clean energy. States are making bulk clean energy purchases and supporting citizens who invest in clean energy. Thirty states let utility customers with micropower units sell back to the grid. States, cities and innovative entrepreneurs are engaged in a wide range of efforts to build green power markets.

The largest potential clean energy markets are in developing nations, where 2 billion people live without electrical service. Because extending power grids is vastly expensive, solar is already the least expensive power source in many areas. At the same time, the developing world is expected to become the largest greenhouse gas source by 2020. A grand global opportunity exists to leapfrog developing nations directly to clean energy sources, improving their quality of life while cutting emissions and building global clean energy markets.

THE NORTHWEST'S ROLE

The Northwest has potential to play a leading role in the clean energy revolution if it marshals its already considerable resources.

Some of the world's top clean energy companies make their home in the Northwest including key fuel cell innovators and leading firms in solar energy and electronic regulation of clean energy devices. The Northwest is also a leader in information technology and advanced materials — Both play a crucial role in clean energy development.

The region has public sector energy innovators including Bonneville Power Administration and Pacific Northwest National Laboratory. A public energy policy leadership tradition has given the Northwest a legacy of world-class expertise. It also boasts a high quality of life, technically skilled workforce, major pool of technology-oriented venture capital and trade connections with developing nations.

A Northwest clean energy strategy, outlined at the end of the paper, can be founded on a strategic alliance of Oregon and Washington to build regional clean energy industries, and on rounding out clean energy policy packages in each state. This includes setting renewable energy development targets in both states and creating a clean energy fund in Washington, as Oregon did in 1999. The Northwest has the assets to become a world clean energy pacesetter. With visionary leadership and creative partnerships, the prize is well within reach. ■

Accelerating the Clean Energy Revolution:

How the Northwest Can Lead

MAIN REPORT

For the infant clean energy industry, these are heady times. Spending most of its years in uphill struggle, it has now climbed to the take-off point. Wind and solar are the world's fastest growing energy sources, their costs rapidly curving down toward competitiveness with fossil fuels. Fuel cells which provide clean electricity for buildings and new generation vehicles are nearing the market.

With the right mix of public and private initiatives, clean energy could ramp-up rapidly. Shell Oil planners see renewables potentially cost-competitive with fossil fuels by 2020 and producing more than half the planet's energy by 2050.

"I believe there will be a complete revolution in energy technology, which will enable us to turn around global warming," President Clinton recently said. "I just hope it happens in time to avoid melting the polar ice cap, or some other disastrous thing."

Time is of the essence. Presidential science advisor John Holdren notes power plants on the drawing boards now will still be in operation in 2050. "We are running out of time for a smooth transition to a sustainable energy future."

The 1990s were the warmest decade in at least 1,000 years — 1998 was the hottest of those years. Now 1999 is going down in the books as the second warmest year on land, and the past winter in the U.S. had the record highest average temperature. The growing evidence spurred the heads of the top climate monitoring organizations in the United States and Britain to break with any past scientific reticence to clearly connect global warming with human activities.

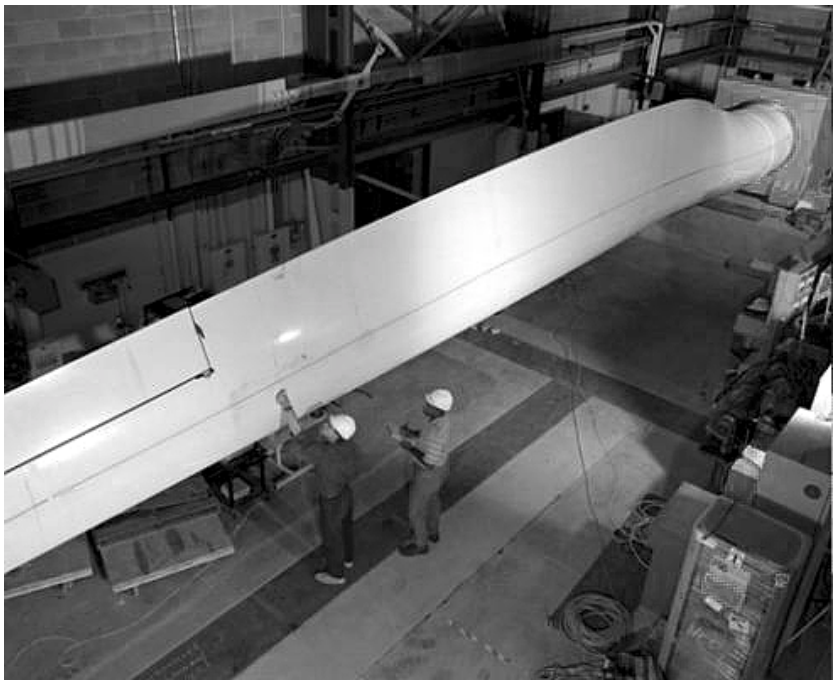
"Our climate is now changing rapidly...Our new data and understanding now point to a critical situation we face," said U.S. National Oceanic and Atmospheric Administration chief James Baker and U.K. Meteorological Office head Peter Ewins in December 1999. "Ignoring climate change will surely be the most costly of all possible choices, for us and our children."

"We're now coming clean and saying we believe the evidence is almost incontrovertible, that man has an effect and therefore we need to act accordingly," Ewins added.

While climate scientists have been moving toward that conclusion for some time, a similar finding by the World Economic Forum came as a shock. Hundreds of the world's very top business and political leaders meeting at the group's annual meeting in Davos, Switzerland in January 2000 selected climate change as the world's most challenging problem.

A study by a group of 11 scientists carried in *Nature* in October 1998 underscores that averting catastrophe from global warming will be no small task. They concluded that holding greenhouse culprit carbon dioxide (CO_2) to its current concentration in the atmosphere will require production of 10 terrawatts of non-

A wind turbine blade undergoes a test at the National Renewable Energy Lab's Northwest Technical Center. Some modern turbine blades are wider than a 747 wingspan.
(erected windmill shown on cover)



"Our climate is now changing rapidly...Our new data and understanding now point to a critical situation we face."

JAMES BAKER, HEAD, NOAA,

PETER EWINS, HEAD, U.K. METEROLOGICAL OFFICE

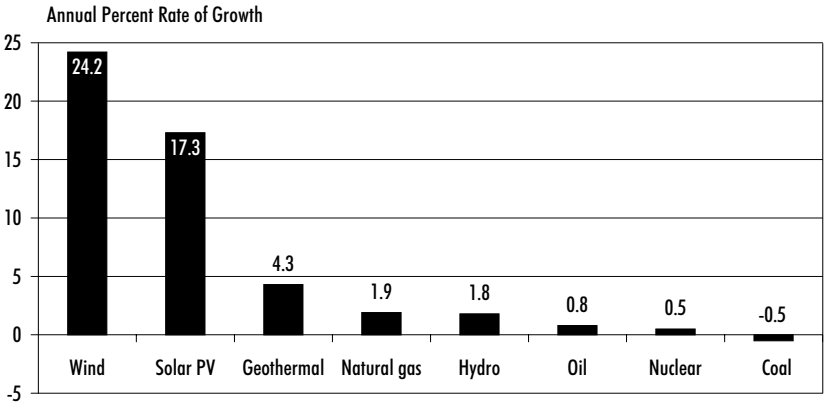
fossil-fuel energy — equal to two-thirds of current primary global energy production — by 2018. If producing that much carbon-free energy takes until 2035, CO_2 will double from today's already climate-disrupting level.

Added Martin Hoffert and his fellow scientists, "...market inefficiencies may preclude timely development of such technologies at the required scale...The past century, accelerated development from wartime and postwar research produced commercial aviation, radar, computer chips, lasers and the internet, among other things." The need to stabilize the climate could require a crash program "pursued with the urgency of the Manhattan Project or the Apollo space program."

Though the task is imposing, the clean energy revolution is coming along just in time, promising genuine climate solutions as well as phenomenal economic opportunities. Energy generated with clean sources such as sun, wind and hydrogen at millions of points, all linked by information technology that manages both power production and consumption for peak efficiency — This is the picture of an emerging Energy Web that parallels the internet and is in many ways tied to it. It represents the most significant energy transformation since Edison set up the first power plant over a century ago.

We are at the portal of a clean energy revolution. Whether it takes off fast enough to re-stabilize the climate is an issue of global urgency, with long-term, irreversible implications. Required are gutsy entrepreneurs, visionary business leaders, and public leadership, not only at the federal level, but also from enlightened states and cities moving to protect the planet and seize a significant economic opportunity at the same time.

Global Trends in Energy Use, 1990-1999
Source: Worldwatch Institute



Fast growing solar power crosses billion-watt threshold

Solar energy crossed an important symbolic threshold in 1999 when the worldwide total of solar photovoltaic (PV) cells surged past a gigawatt, 1 billion watts.

The solar PV industry took 27 years to hit its first gigawatt. It will almost certainly take 4 or less to reach its second. In 1999 global PV sales were 160 MW, 20% over the previous year, Strategies Unlimited estimates. (One megawatt powers around 1,000 average U.S. homes.) Solar power continues as the world's second fastest growing energy source (after wind), a position it held through the 1990s.

"The total solar power market is estimated to be approximately $2 billion, growing at 20-25% per year," notes the investment firm of Robertson Stephens.

Solar power's progenitor is Einstein who discovered sunlight releases a stream of electrons when it hits some materials. Based on Einstein's insight Bell Labs, inventor of the transistor which forms computer chips, also developed its near relative, the silicon-based PV cell. It underwent its first workout in the 1960s space program but was too costly for just about anything else. Born as a commercial industry in 1972, PV electricity cost $500/watt. But by 1999, wholesale prices were down to $3.50/watt.

That translates into $8/watt by the time retail solar panels are on the roof pumping juice, around $24,000 for a system capable of meeting all non-heating electrical needs of an average U.S. house — Not cheap, but public programs from Germany to the U.S. and Japan are supporting early adopters. In remote locations that require reliable power PV is already the low-cost alternative.

PV is expected to become markedly cheaper over the coming decade. Learning curves and economies of scale, which have had such spectacular effects on computer chips, work as well with solar cells. U.S. Department of

Energy studies show PV costs drop 18% each time the amount of PV worldwide doubles. Allied Business Intelligence projects wholesale costs of $1/watt by 2010. Prominent solar analyst Paul Maycock agrees, "It's perfectly likely to occur." When PV hits that magic $1 mark, "Demand will rise to several gigawatts per year," says Allied Senior Analyst Michael Kujawa.

Just how rapidly prices decline depends on how fast production is ramped up. With construction of a 100-MW plant, economies of scale will bring wholesale PV down to $1.25/watt, Maycock says. A study done for Greenpeace by KPMG, one of the world's leading accounting firms, projects that a 500-MW plant would drop the wholesale price to 90¢/watt. That brings the retail cost into the $2-$2.50/watt area, an important threshold. When PV prices reach $2, everyone will be installing panels "and won't ask why," Colorado-based PV advocate James R. Udall says.

KPMG estimates that building the big plant, along with an installation to supply raw silicon, would cost $660 million, less than 1% of annual global expenditures on oil exploration. "It comes down to a classic chicken and egg problem," KPMG says. "As long as demand is small, production of solar energy will remain small-scale and expensive, and as long as production is small-scale and expensive, the price will remain high and the demand small: Catch 22. It is clear someone will have to bite the bullet and act."

Silicon, which represents 40-60% of the cost of a solar panel, remains an impasse. The solar industry has lived off the scraps of computer chip makers. But, notes energy consultant Chris Robertson, "The PV industry cannot grow on that scenario. There just isn't enough material. So it needs a dedicated source of supply."

Robertson, who has worked with Portland's world-class cluster of microchip companies on reducing energy use, points to a new process capable of economically supplying both computer and solar industries called Green Silicon. San Diego-based Schumacher Technology has developed a method to make industrial-grade silicon that reduces energy consumption by 80%. PV cells now must operate several years before they make up for the energy required in their manufacture, Green Silicon tightens the energy payback time to just 1 year, developer John Schumacher says.

Ultimately, silicon use could be cut by 100-fold as thin film solar cells come to market. Thin film can be coated on building materials. But thin film does not have the efficiency or proven resiliency and durability of standard solar cells, which are expected to remain the prevailing type for some time.

Trends point to a solar industry reaching mass scale in coming years. A climate under assault from fossil fuel emissions demands this happen sooner rather than later. A combination of supportive public policies and visionary entrepreneurship can move solar forward quickly enough to make a significant contribution toward settling the climate.

Energy generated with clean sources such as sun, wind and hydrogen at millions of points, all linked by information technology... This is the picture of an emerging Energy Web that parallels the internet...

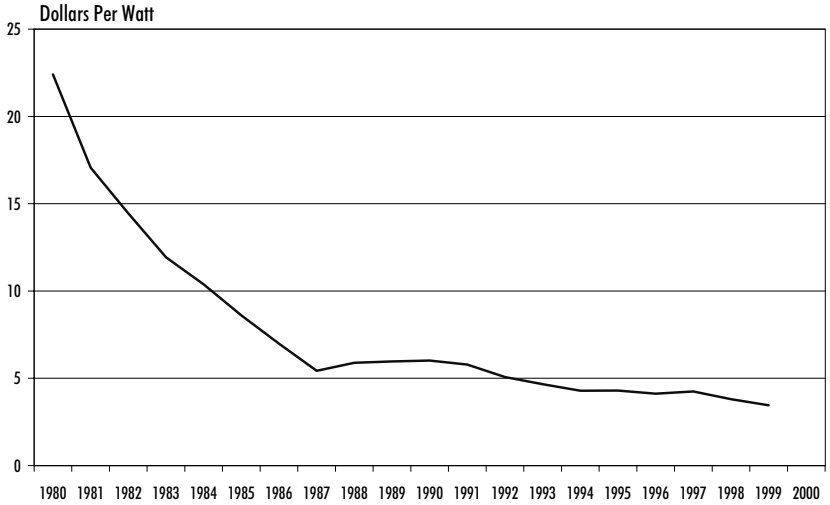
Solar industry thriving under Northwest's gray skies

Some of the world's leading solar firms are growing under the Northwest's cloudy skies.

The Northwest is already a kind of Silicon Valley in the industry, says Bill Yerkes, who founded and later sold a company that is one of the world's largest PV producers.

That company, Siemens Solar, makes its world center for silicon processing at

World Price for Photovoltaic Modules, 1980-1999
Source: Paul Maycock; Graph courtesy of Worldwatch Institute



Learning curves and economies of scale, which have had such spectacular effects on computer chips, work as well with solar cells.

Vancouver, Wash. Siemens grows silicon ingots from which all its PV cells are made, about 25 MW worth in 1999. Resembling 5-foot-long silver sausages, the ingots are shipped to Siemens' main plant in Camarillo, Calif., where they are sliced into solar cells. The Vancouver plant, which has 60 employees, drew significant investments from Siemens in 1998-99 to keep up with growing demand.

Siemens was drawn to the Portland area by cheap power rates, which have also contributed to the area's emergence as one of the world's leading computer chip makers. This suggests the area would make an ideal location for the large-scale PV plant in the KPMG study.

Another piece of the solar business is putting together solar panels with supporting equipment to create systems capable of serving users from residential to commercial. The second largest solar systems integrator in North America is based in Lacey, Wash. Applied Power Corporation, by 1998 the fastest growing distributor of PV in the U.S., broadened its capabilities by acquiring several other solar firms.

Solar Electric Specialties of Willits, Calif., makes solar components. Ascension Technologies, based in Massachusetts and Colorado, is strong in research and development. Alternative Energy Engineering of Redway, Calif. is one of the world's largest PV distributors. The acquisitions "rounded out our range of services," says Applied spokesperson Susannah Sulsar.

Applied itself was bought by Idaho Power in 1996, creating the first U.S. equity partnership between a utility and PV distribution company. The utility was the first in the U.S. to offer PV systems to service territory residents who live off the grid. Much of Applied's business is in the developing world, where its projects include solar power for off-grid villages.

Most solar panels require an inverter, which converts direct current into usable alternating current and regulates power flow. Trace Engineering of Arlington, Wash. is the world's top inverter manufacturer, with about 90% of the U.S. market and 50% worldwide. Its sales are growing 35% annually, and it has 300 employees. PV represents only one piece of the market. Fuel cells, microturbines, microhydro and many wind turbines require inverters. Trace was recently bought by GFI Energy Ventures, a Los Angeles based fund investing in companies that stand to benefit from changes in the electrical industry.

With fast-growing companies such as Trace, Applied and Siemens operating in the Northwest, the regional solar PV industry's future looks sunny.

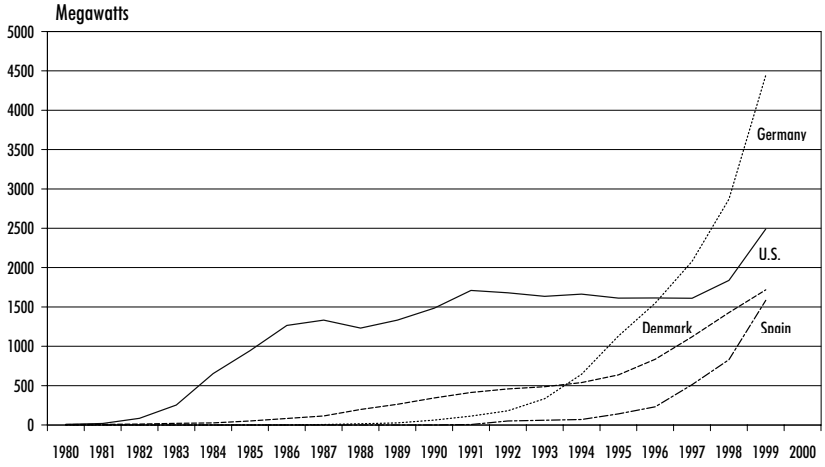
Wind power's surprising growth: Cool breeze for an overheating climate

One of the world's chief energy sources before the fossil fuel era, wind is returning to a starring role in the 21st century. A wind energy boom, with growth rates soaring in the same stratosphere as internet and cell phone industries, is one of today's great untold stories.

Wind power, expanding on average 30% annually since 1994, grew even faster in 1999. The American Wind Energy Association says a year that began with about 10,000 MW worldwide ended with 13,400. The U.S. added 732 MW in places as diverse as Oregon, Wyoming, Minnesota and Iowa, diversifying from California where it has been centered in this country.

Denmark now generates 10% of its electricity from the wind, the Spanish state of Navarra

Wind generating capacity in the United States, Germany, Denmark, and Spain, 1980-99
Source: Gipe and Associates; Graph courtesy Worldwatch Institute



20% and the German state of Schleswig-Holstein 11%. Germany, the world's third largest economy, relies on windpower for 1% of its electricity. Even at the center of the oil patch, Texas sustained the third-fastest wind growth rate in the U.S. in 1999, and has undertaken one of the world's largest windpower expansions. Texas aims to develop 2,000 MW of renewable energy by 2009, the overwhelming majority from wind.

Says British Wind Energy Association head Nick Goodall, "...wind has progressed from what some still imagine to be the world of bearded, tree-hugging enthusiasts to a mainstream energy source popular around the world."

Not only are concerns about climate and environment driving wind growth — Sheer economics are weighing in. Wholesale costs down 80% over the past decade to 4-6¢/kilowatt hour (kWh), wind is closing in on the cheapest fossil sources. The California Energy Commission puts the wholesale cost of gas-fired electricity at 4.2¢/kWh and coal at 5.2¢. Fossil costs are not expected to decline much, and natural gas might rise substantially. But wind could drop as low as 2.5¢/kWh by 2010, even without the 1.8¢/kWh federal tax credit that is now offered, the U.S. Department of Energy projects. Today that tax credit puts wind in the race — With it a 107-MW Minnesota wind farm came on line in 1999 at 3¢/kWh.

A technological revolution is spurring wind's growth. Tough fiberglass blades make turbines stronger while advanced electronic controls enable them to use wind more effectively. A 1981 turbine might have produced 25 kilowatts (kW). Today's far juicier machines run around 750 kW, and next generation turbines with blades wider than a 747 wingspan will generate a megawatt plus.

Wind faces one significant environmental concern, mortality of migratory birds. That can be addressed by making sure wind farms are not sited on flyways.

The American Wind Energy Association projects at least 48,000 new wind megawatts will be added in the next 10 years, increasing world wind capacity nearly 5-fold. The Wind Energy Council estimates that $150-400 billion will be invested in new windpower worldwide between 1996-2020. A federal initiative announced by U.S. Energy Secretary Bill Richardson in 1999 aims at generating 5% of U.S. electricity, 80,000 MW, from wind by 2020.

Given proper encouragement, wind can exceed current projections and provide 10% of world electricity by 2020, a recent report from Greenpeace and the European Wind Energy Association says. It will take a 1999-2020 investment of $720 billion — Not small but not overwhelming in the context of $10 trillion in energy investments expected over that timeframe. The yield by 2020 would be wind capacity exceeding today's total European electrical generation, 1.7 million people employed in the global wind industry, and 11 billion fewer tons of CO_2. That amounts to canceling 4 years of current greenhouse gas accumulations.

The report says that fully reaching wind's potential will require firm targets for wind growth, elimination of vast subsidies still granted to fossil fuel, and policies to promote clean energy purchases.

For an overheating climate, wind power comes as a cooling breeze. To what degree will depend on the level of commitment to wind growth made in the next few years by businesses and governments around the world.

A wind energy boom, with growth rates soaring in the same stratosphere as internet and cell phone industries, is one of today's great untold stories.

Northwest wind power growing but hitting turbulence

When Washington state gains its first wind energy farm in 2001, it will represent the first mass deployment of an innovative new wind turbine designed and built by a Bellevue, Wash. company.

Since the mid-'90s, the Wind Turbine Company has been working on the first wind generator designed from scratch since the 1980s, WTC President Larry Miles says. Most of today's machines have 3 blades sitting in front of the tower, but the new turbine sites 2 blades downwind. That makes for a lighter and more flexible generator that delivers more juice for the buck.

Ironically, even as Bellevue, Wash.-based Wind Turbine Company gains its first big Northwest market, California could steal the company away.

"When you put blades in front of the tower, the wind tries to push them back toward the tower, which requires a very stiff tower and blades," Miles explains. Reversing the arrangement changes wind dynamics enough to allow around 40% weight savings, translating into 20% materials cost savings. Towers can rise higher letting machines capture more wind.

The advantages caught the attention of Energy Northwest, the old Washington Public Power Supply System primarily known for a largely failed nuclear construction program that caused the worst municipal bond default in history. The utility is changing more than its name — It has committed to develop 100 MW of new renewable energy by 2006. Most is expected to come from wind. In the first phase, a 10-15-MW wind farm, WTC will supply 20-30 of its 500 kW machines. They will be assembled in the Seattle area. The wind farm site, somewhere in Eastern Washington, remains to be finalized.

"We need a responsible mix," Energy Northwest Project Development Manager Dan Porter says. "Wind power won't be all the answer for the Northwest but it should be part of the portfolio."

Ironically, even as WTC gains its first big market in the Northwest, a far larger market could steal the company away. A move to California is "under serious consideration," Miles says. The company has contracts with the California Energy Commission, involved in one of the world's largest clean energy programs. "They don't want to be sending their checks out of state."

It's not just the money "but also the amount of interest in wind in California," Miles says. "If we were a dot-com or a biotech company we would probably get more attention up here. But we are not quite in the right niche in Washington state. It's amazing with the size of the global electrical industry."

Wind has had a turbulent history in the Northwest. Boeing was involved at an early point but pulled out. More recently, Advanced Wind Turbines, working on a design similar to WTC's, closed down here.

The Northwest can boast 2 world-class wind consulting firms. Global Energy Concepts of Kirkland, Wash. offers the full spectrum of consulting services needed to develop wind farms. GEC and its 16 employees work on projects across the U.S. and around the world, from China and India to Mexico and Brazil. Springtyme L.L.C., based in Sequim, Wash., is operated by Bob Lynette, a leading wind consultant since the 1980s. Lynette recently worked on a village wind project in Nepal.

Wind development is starting to pick up in the Northwest. In 1998 Oregon's first wind farm opened on Vansycle Ridge near Pendleton. It pumps 25 MW during peak winds and 8 MW averaged over the year. With 38 turbines manufactured by California-based Vestas-American Wind Technology, the $35 million installation was built under contract to Portland General Electric.

On Earth Day 1999, Wyoming's first wind plant opened on Foote Creek Rim. Owned by PacifiCorp and Eugene Water and Electric Board, which together invested $62 million, the wind farm ships a substantial amount of its production to the Bonneville Power Administration (BPA). With 69 Mitsubishi-built turbines, Foote Creek generates 41 MW at peak and averages 18 MW, consistently closer to top capacity than almost any other wind farm in the U.S.

More wind development is in the works. As part of the 1999 deal which allowed Scottish Power to take over PacifiCorp, the new owner agreed to build 50 MW of new renewables, much likely to be wind. BPA is also committed to develop at least 25 MW of new wind energy.

The Northwest certainly has vast potential, Renewable Northwest Project figures show. Montana, a Saudi Arabia of the breeze, could reliably supply 116,000 MW, 15% of U.S. electrical demand. Oregon with 4,900 trusty megawatts and Idaho with 8,300 could meet all their own power needs. Washington's 3,700 MW are enough to run 3 million homes.

Cost for that power would range from 4-6¢/kWh, notes Renewable Northwest Project. With the standard Northwest wholesale power running 2.5-3¢/kWh, wind still faces hurdles. But when wind becomes fully competitive in a

decade or so turbines are bound to shoot up all over the region and world. Whether they bear nameplates of Northwest companies crucially depends on the level of support regional institutions show today.

Fuel cells: Good chemistry for the climate

Invented in 1839 before the internal combustion engine, the fuel cell is the leading contender to take its place in 21st century cars, and will also become a mainstay of a new decentralized electrical network.

Fuel cells resemble both a battery and an engine. Like batteries, they provide electricity from chemical reactions without combustion or moving parts. But they never need recharging because like an engine they run off a fuel source.

The fuel source is hydrogen, most abundant element in the universe. Combining with oxygen, the reaction pumps out electricity, heat and pure water. Most fuel cells use fossil fuels, breaking hydrogen from carbon. They release some climate-altering greenhouse gases, but less than if the fuel is burned. A March 2000 study by David Suzuki Foundation and the Pembina Institute for Appropriate Development shows that fuel cells cut natural gas emissions 70%, but reduce gasoline emissions only 20%. Ultimately fuel cells will be powered by greenhouse-emission-free pure hydrogen, which a Ford-U.S. Energy Department study showed can actually be stored more safely than gasoline. A company called Energy Conversion Devices is working on an even safer solid-form hydrogen.

Fuel cells can be scaled from postage-stamp size to utility power plant. Several companies plan to market home systems around the size of a major appliance. Today a couple of hundred 200-kW fuel cells are part of the power supply at institutional sites ranging from a New York City police station to Vandenberg Air Force Base. Tomorrow they will be everywhere. Fuel cells "are on the leading edge of a tidal wave of change that promises to scale down electric generators and distribute them as broadly as the home computer," notes BPA head Judi Johansen.

Mass production economies are expected to dramatically drop prices in a few years. Leaving out the vehicle market, sales are expected to grow 25-fold from 1999's $40 million to over $10 billion by 2010, Allied Business Intelligence projects. Says David Walker, president of fuel cell maker DCH Technology, "...what was once far off, is now a market reality."

GE's Plug Power will begin selling home cells in 2001 in New Jersey for $7,500-$10,000, and aims to bring that below $4,000 by 2003. At that price, about the same as a heat pump, electricity would be 7-8¢/kWh, very competitive with grid power in many regions. GE plans to market business-scale systems by 2002. In January investors suddenly aware of fuel cell prospects tripled Plug Power's stock to $79 in one day.

Auto industry developments are also moving at a frenzied pace. Recently considered too expensive and heavy for vehicles, fuel cell technology has been making unanticipated breakthroughs.

"I believe fuel cells will be a significant part of our industry in the not-too-distant future," Ford Motor Chair William Clay Ford Jr. says.

Within 4-5 years, fuel cell vehicles will reach Ford, Daimler-Chrysler and Nissan showrooms. Companies hope to sell at only a 10% premium over conventional cars. Daimler will premier an $18,000 fuel cell version of its Mercedes A in 2004, aims to sell 100,000 fuel cell vehicles by 2005, and projects that 25% of the 2020 global auto market will be fuel cell-

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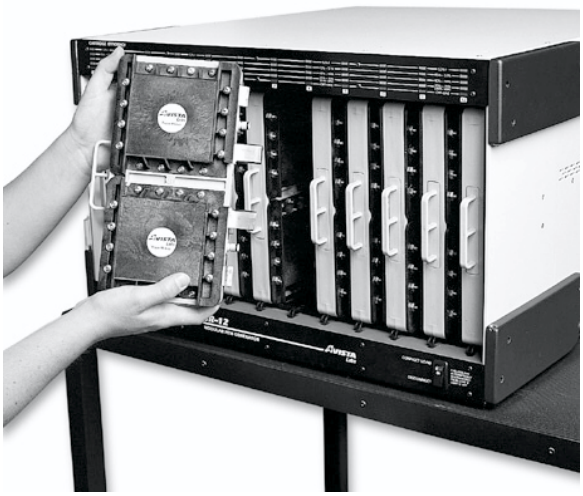
WILLIAM CLAY FORD JR.



Avista Labs of Spokane in 2000 is test marketing a fuel cell for home use. The device is arrayed in modular units which can be replaced even while it is still running.

Fuel cells "are on the leading edge of a tidal wave of change that promises to scale down electric generators and distribute them as broadly as the home computer..."

JUDY JOHANSEN, BONNEVILLE POWER ADMINISTRATION CHIEF

powered. General Motors, working with Toyota on fuel cell engines, plans to include them in 10% of cars it sells in 2010. Volkswagen, BMW, even Southern States Power, have fuel cell vehicles in the works.

Fuel cells will realize their full potential as a technology for fighting global warming when they are fed not with fossil fuel but by pure hydrogen. The National Renewable Energy Lab recently patented a technique to produce hydrogen from algae. The gas could also be supplied by large-scale renewable power installations generating electricity that cracks hydrogen from water. Iceland is already exploring the potential. An Icelandic consortium in 1999 signed a deal with Daimler and Shell aimed at developing the world's first fossil-fuel-free hydrogen economy, with fuel cells at the center.

Coming over the next few years to the next generation of cars and the new distributed electricity network, the good chemistry of fuel cells is certain to draw positive reactions all around.

Pacific Northwest a global fuel cell epicenter

In the global ascent of fuel cells to become a major 21st century energy source, some of the most significant drivers are Pacific Northwest companies and institutions.

When Daimler-Chrysler and Ford begin selling fuel cell cars, the engine will be the product of a Vancouver, B.C.-area company, Ballard Power Systems. One of the world's leading fuel cell developers, Ballard in 1998 joined with Daimler and Ford in an $800 million global partnership.

Ballard fuel cells already run 3 city buses each in Chicago and B.C. This January Ballard unveiled the production model car fuel cell, 50% smaller and 50% more powerful than previous incarnations. The 800-employee firm also announced it will build a $300-400 million North American plant. On those announcements, Ballard stock soared 25%. The company is also working with Coleman on 1-to-25-kW fuel cells for portable generating applications. Ballard is also moving into power plants for buildings. By 2003 it aims to market a 250-kW unit capable of powering whole neighborhoods.

Ballard is a prime example of how public investment can drive regional clean energy industries into the lead. The British Columbia provincial government over the past few years has devoted $30 million to Ballard and overall fuel cell development. That laid the groundwork for the recent announcement of Canadian federal investment in a Vancouver-based fuel cell research center.

Public support on the U.S. side is coming from BPA, which is sponsoring the first residential-scale fuel cell demonstration project by an electrical utility anywhere. By July 2000, BPA and several utility partners will install 10 3-kW fuel cells in homes unconnected to power lines or in need of backup power. If results are satisfactory, they will install another 100 by 2002. The hand-crafted units are now $50,000 apiece, but costs will steeply plummet with mass production. Johansen has issued a challenge to regional utilities to offer micropower at 5¢/kWh over the next 5 years, making it competitive with grid-delivered power.

Fuel source for the original 10 units is methanol, which is mostly derived from natural gas. But further units could use a variety of fuels including ethanol which can be made from farm crops. While ethanol releases CO_2, emissions will effectively be zero since growing new feedstock will soak up CO_2.

Breakthroughs by a Bend, Ore. company help make the Bonneville fuel cell initiative possible. Northwest Energy Systems has devel-

2nd Generation Fuel Cell Transit Buses in Chicago
Source: Ballard Power Systems

oped a fuel processor to extract hydrogen, which drives fuel cells, from fossil and biomass fuels. It is small and economical enough to run home-scale units. The company stands to make $3.5 million if all 110 units are installed.

Also in the fuel processor game is Pacific Northwest National Laboratory, which recently drew an *R&D Magazine* R&D 100 Award for developing an ultra-compact processor to be used in vehicles.

Yet another utility-connected company is jumping into fuel cells. Spokane-based Avista Labs, part of the old Washington Water Power, will begin delivering residential fuel cells by the end of May 2000. At least 200 of the 720-watt air-conditioner-size fuel cells will be customer tested over the next 2 years in preparation for a 2-kW device to be marketed in 3-4 years. The January announcement that Bill Gates has bought 5% of Avista is one sign of growing interest in fuel cells by high tech investors.

Avista has come up with a unique design which solves a critical fuel cell problem. Fuel cells can be damaged by impure fuel, necessitating shutdown and repair of the entire unit. Avista's fuel cell eliminates that need with modular design. The cell is composed of a dozen videotape-size elements that can be individually removed and replaced even as the unit is operating.

In Portland one of the nation's first 3 fuel cells powered by wastewater gas has operated at the Columbia treatment plant since July 1999. The 200-kW unit helps power the facility and is fueled by the plant's major byproduct, methane, which if allowed to escape is a highly powerful greenhouse gas. While its electricity is about one-third more expensive than grid power, the unit provides reliable current during outages, obviously crucial for sewage treatment. After a test phase, the city may install more fuel cells at the plant.

Fuel cells are coming on quickly to take a major place in the clean energy revolution, thanks in significant part to the drive and innovation of visionary Northwest companies and public agencies.

The clean energy web — high tech's next revolution

The basic shape of the electrical grid has changed little since the late 1800s when Thomas Edison built the first central generating station. But dramatic changes are coming as the distributed intelligence revolution embodied in the internet spreads to electrical power, offering a major opportunity to turn around what is now the nation's leading industrial source of climate-disrupting greenhouse gases.

"We are on the verge of a significant transformation in the electric industry that will 50 years from now look as important as Edison's invention," says Terry Esvelt, BPA vice president for energy efficiency.

Bonneville is planning for an "Energy Web" which replaces the old "mainframe" model of one utility pumping out juice to many customers with an "internet" model where many energy producers and consumers are linked in a smart network. While BPA is known for huge power dams, Judi Johansen says the agency has every incentive to involve itself in the new model.

"A technological revolution is breaking out in the electric utility industry," Johansen says. "It promises to turn the business upside down, making reliable, low-cost generators available to virtually every consumer. Utilities will either help make it happen or risk being swept aside."

Distributed generation by fuel cells, solar panels, microturbines and other micropower devices is the foundation of the Energy Web. Many of the new micropower technologies eliminate or drastically reduce air pollution. Since electrical utilities are now the largest industrial air polluter in the U.S., the Energy Web could profoundly improve both human health and the odds of averting catastrophic global warming.

Just as important to the new energy revolution as micropower plants are the very technologies at the heart of distributed intelligence — microprocessors and telecommunications. They are "the glue that holds the Energy Web together," Esvelt says.

By themselves, small-scale generators can only provide power on-site, Esvelt explains. "The Energy Web works when they start

The January announcement that Bill Gates has bought 5% of Avista is one sign of growing interest in fuel cells by high tech investors.

The internet is an integral element of the Energy Web.

talking to each other." Through telecommunications, micropower plants can receive price signals in real time, particularly important for larger commercial and institutional users. During hours when electricity is cheap the user can pull from the grid while its micropower unit is shut down or recharging batteries. The unit powers the building during peak periods when grid electricity is costly, and might ship juice back to the grid. "By being connected you have a tremendous opportunity to make money or save money," Esvelt notes.

The garage at home or the office could even become a power plant. While parked, fuel cell cars could generate electricity used on site or the grid.

The internet is an integral element of the Energy Web. Notes Hugh Holman, senior equity analyst with the investment firm of Robertson Stephens, "We count 50-odd companies building energy businesses on an internet platform." Among those are around a dozen websites where buyers and sellers can trade power on line. Marketers of environmentally friendly Green Power are using the web as well.

"There are now people worldwide who broker power millisecond by millisecond," notes Mark Anderson of Strategic News Service. "You can buy power in all flavors and colors. It's a complete revolution."

Fuel cells capable of supplying home and business electrical needs will soon become common. This unit was assembled by Northwest Power Systems, a Bend, Ore. company.

The more complex energy market demands more information and enhanced abilities to manage it. Holman inventories 34 companies writing business management software specifically for utilities and other energy providers.

Distributed intelligence which links micropower plants is also built into the plants themselves in the form of inverters which regulate power flow. "Modern inverters use microcontrollers, miniature computers programmed with software, which provides intelligence so systems can act appropriately according to conditions," Trace Engineering President Bill Roppenecker notes.

Inverters make possible "net metering" schemes now in effect in 30 states, which let customers use excess power to spin meters backward. The inverter senses when the micropower station is generating a surplus and so should sell power to the grid. It recognizes when the grid is blacked out and stops outward current so linemen won't be harmed. Regulated by these indispensable devices, solar panels, fuel cells and other micropower plants are no less software-driven than computers.

Many wind turbines, which can be arrayed in installations from small to utility-scale, also rely on inverters. In addition, some turbines are guided by intelligent drives that adjust for wind speed and direction in order to generate maximum wattage. Power production reports are telecommunicated moment by moment to wind farm managers.

Even as information technology makes micropower plants smarter and links them together in a network, the information economy's absolute need for reliable electricity is driving the move to distributed energy sources.

Solar PV panels are the power source of choice for the wireless phone industry's many remote towers and stations. Strategies Unlimited says industrial customers represent one-quarter of the PV market — Of that telecommunications absorbs 80%.

Cell phones, laptops and digital appliances, now limited by battery life, will in a few years be powered by miniature fuel cells. Motorola is testing a model. The Alliance of Angels, a Seattle high-tech venture capital group, is also investing in the field.

The most significant information technology industry push for micropower is coming from computer-dependent businesses which can lose millions from even momentary spikes or outages. Computers are built to withstand blackouts no longer than .008 seconds.

"Bits demand unusually clean, stable, reliable electrons," notes the *Huber Mills Power Report*. While the grid provides 99.9% reliability, *Huber Mills* explains, "Reliability demands start at six nines for the telecom and dot-com world — 99.9999%. Practically speaking, the traditional power grid will never be able to provide much better than three, perhaps four nines...information-quality power is becoming a sine qua non of the information economy, and thus one of the greatest business opportunities of our time."

"To accommodate this great energy shift," *Huber Mills* says, "much of the sprawling infrastructure of the U.S. power grid will have to be rebuilt." The information technology economy, spreading through all sectors, requires "a constellation of new sources of electric power," connected by a relative of the microchip, the power chip, that can reliably, seamlessly switch from source to source. A more stable power network is in prospect. Peak loads and prices "will be flattened by back-up generation systems whose owners start wheeling their excess power back on the grid."

Most on-site generators are diesel, while natural-gas-fired microturbines are emerging. But the more climate-friendly alternative of fuel cells is starting to make inroads. First National Bank of Omaha, the seventh largest credit card processor in the U.S., in 1999 installed a fuel cell power system at its new Omaha processing center. It came from Connecticut-based Sure Power, which builds such systems for the high nines market.

"For data centers, internet hubs, telecom centers, high tech manufacturing and a lot of different types of facilities where high reliability is very important, fuel cells are robustly cost effective," Chris Robertson notes.

That is because some electricity is far more valuable than plain vanilla grid power. Three nines power might market for 10¢/kWh. Information-intensive businesses typically invest $1,000 for the same quantity of six nines. To protect against spikes and provide reliable backup generation, U.S. businesses annually spend $4 billion. The market for premium, information-quality electricity is growing at double digit rates, *Huber Mills* says.

Not only is the distributed intelligence revolution driving creation of the distributed energy network — It is also yielding dramatic leaps in energy efficiency.

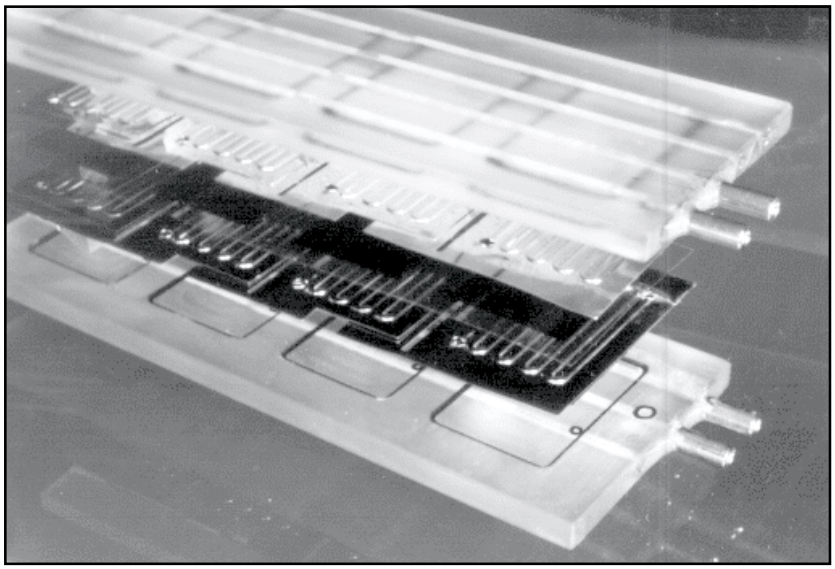
The Business Roundtable in a 1999 assessment of technology's role in responding to climate change concerns noted, "The 'digital revolution' likely will bring pervasive and deep changes in how energy is used and managed in every sector. Not only are machines, motors, lights and equipment in general afforded 'intelligence,' but entire processes from design to fabrication, delivery and operation are improved by the rapidly emerging capabilities of the microprocessor and telecommunications."

"Innovations which cut heat-trapping carbon dioxide emissions by saving energy put electronic technologies at the forefront in protecting the global climate in ways unforeseen just a few years ago," says a World Resources Institute report.

Commonplace technologies such as lighting and motors, still the top energy consumers, are undergoing electronic transformation which has already produced major efficiency improvements. The process is far from played out. Fluorescent lights with controls that adjust to various lighting conditions, computer-controlled speed drives on motors, microprocessors that can cut boiler energy use 25%, all tied in

The most significant information technology industry push for micropower is coming from computer-dependent businesses which can lose millions from even momentary spikes or outages.

Micro-fuel cell developed by Fraunise ISE for use in applications such as cellular phones



"Innovations which cut heat-trapping carbon dioxide emissions by saving energy put electronic technologies at the forefront in protecting the global climate in ways unforeseen just a few years ago."

WORLD RESOURCES INSTITUTE

digital energy management systems that monitor and control entire buildings, spell remarkable efficiency improvements. Texas A&M researchers have demonstrated building control systems that cut energy use 25% and pay for themselves in 18 months. An advanced system at Xerox's research center which switches on heating, cooling and office equipment only when a person approaches cut energy use 45%.

The internet connects with building energy management at a number of points. Large businesses are increasingly hiring Energy Service Companies, ESCOs, to handle all energy needs. ESCOs typically provide clients with up-front financing for efficiency improvements, and recoup the investment through a portion of the resulting energy savings. With that incentive, ESCOs are starting to link building control systems via the net so they can monitor and operate them from a central location.

At the residential level, Puget Sound Energy in December 1999 announced one of the nation's first tests of a technology that uses the net to adjust heating levels. In 200 Kent, Wash. homes the utility employs the net to turn down smart thermostats up to 6 degrees during daytime peak demand. If customers want the heat they can log on to the net, either from home or a remote location, to override the command. The utility is interested in reducing the need for costly peaking facilities. Some savings could be reflected in customers' bills.

"Early trials of remote controlled home energy management systems suggest the savings in energy bills could be as high as 10%," energy analyst Joseph Romm notes.

The test is tied to deployment of another smart technology, digital meters that instead of being read once a month report real time electrical use data by radio every few minutes. Such real-time information is a crucial component of the Energy Web, Esvelt says. By the end of 2001, 95% of Puget's customers will have smart meters. Customers will be able to monitor their usage from a password-protected location on the web, information they can use to control energy use.

The spread of information-crunching power throughout the economy is both driving and making possible the widespread distribution of electrical-generating power. At the same time, distributed intelligence is transforming how energy is used in every area of life. The microchip is the keystone technology in the shift to a super-efficient economy powered by distributed energy sources. If this transformation is deliberately steered toward climate-friendly, carbon-free energy, computing power can become the most important clean energy source of all.

Europe, Japan seize clean energy lead

Mac Moore as business development director for British Petroleum's solar division recently said, "My feeling is that we are at the point in time where the personal computer was in the late '70s. Over the next 10 years, if things go well, there's going to be a revolutionary change in the way that we obtain power."

For the United States, whose prosperity is so much tied to technological leadership, that trend raises major concerns. It has ceded its place at the head of clean energy industries to Europe and Japan.

A recent Renewable Energy Policy Project report noted, "U.S. policymakers have chosen to reject strategies designed to commercialize renewable energy in favor of continued reliance on fossil fuels, especially oil . . . Europeans have now seized the lead in deploying [renewable energy technologies]" and Japan has "systematically laid the groundwork for a possible wide scale deployment of renewable energy."

"The U.S. has played a huge role in the development of efficiency technologies and renewable applications. But right now European and Japanese companies are making most of the new investments," Climate Institute President John Topping says. "The renewable energy industry is potentially as significant as the electronics and computer industry. If major U.S. energy companies step aside on this, they are going to play a largely diminished role in the future."

It is as if it were 1979 and most computer companies were under foreign ownership. Three of the top 5 PV producers are Japanese, and the other 2, while American-managed, are

European-owned. Only one U.S.-owned PV firm makes the top 10.

Much of the situation tracks to public priorities. Japan set a national goal to install PV on 70,000 roofs. In 1997 its public support program for solar became the world's largest. In 2000, the Japanese Ministry of International Trade and Industry plans to spend around $200 million on the program plus another $300 million to develop PV technology. In response, major Japanese corporations have scaled up solar production, and are innovating new solar systems built into roof tiles. Kyocera, Sharp and Sanyo rank among the top 5 PV makers, and Japan ranks first in PV production.

"As with other, earlier, business revolutions," solar advocate Jeremy Leggett notes, "the Japanese government is wisely using targeted and time-limited subsidy to help speed the commercial take-off point, and position Japanese companies at the head of the grid when the market race begins in earnest."

Germany in 1999 announced an even larger effort, aimed at putting PV on 100,000 roofs. By offering interest-free loans, the government effectively cut the price of PV installation by 37%. The U.S. has a more ambitious goal, the Million Solar Roofs program started in 1997. But annual funding is around $72 million, far lower than in Japan or Germany.

As with solar, so with wind, where the U.S. was once the world's leading producer of wind turbines and energy. Now Denmark has seized top spot among turbine builders — 50% of turbines operating are of Danish origin. Meanwhile, Germany has become the world's largest wind electricity generator. In each case, leadership is a product of concerted public efforts to build up infant wind industries. Ambitious efforts to develop wind power blanket Europe. Several Spanish provinces are spurring local turbine manufacturing. Britain and the Netherlands also have active programs.

Such initiatives are in line with the historic development of the energy industry.

"Today's energy systems did not arise just through the hidden hand of market forces, though markets have played an important role," the American Council for an Energy-Efficient Economy and 4 other energy policy groups noted in a 1997 report. "They are as much a product of strategic visions, wherein private investments melded with government incentives and policies to create the complex networks and industries that dominate the energy scene."

Helping infant industries overcome early hurdles is the place for intelligently designed public policies. Many now huge industries grew from the foundation laid by public investment and guaranteed government markets. A public hand-up was necessary for transcontinental railroads in the 19th century and aerospace, electronics, computers and advanced telecommunications in the 20th. Communications satellites and internet had their start as public projects.

"In the 1960s, integrated circuits were far too expensive for general uses that could benefit the public," notes Denis Hayes, Energy Foundation chair and head of solar energy research in the Carter Administration. "Massive government purchases, mostly by the Defense Department and NASA, led to design innovations and efficiencies of mass production. If the government had not purchased huge quantities of computer chips before they were cheap enough for commercial applications, the technology might have never become cost-effective. The same strategy could work for solar cells."

Making public initiatives particularly crucial is the need for rapid replacement of fossil energy to stabilize the climate. Disruption of the world's weather patterns deserves as vigorous a public response as any other serious national and international security threat.

One crucial point about support programs for solar and wind in Europe — Much of the initiative has been bottom up. Policies were tried out first by cities and provinces before being implemented at the national scale. U.S. states and cities are playing a similar and increasingly important role here.

"The renewable energy industry is potentially as significant as the electronics and computer industry. If major U.S. energy companies step aside on this, they are going to play a largely diminished role in the future."

JOHN TOPPING
CLIMATE INSTITUTE

Seven ways states are exerting clean energy leadership

American states, the laboratories of democracy, are now becoming hotbeds of clean energy innovation. Many are seeking to build their own clean energy "Silicon Valley."

American states, the laboratories of democracy, are now becoming hotbeds of clean energy innovation. Many, seeking to build their own clean energy "Silicon Valley," are innovating a toolbox of policies to spur on the industry.

The utility restructuring process spreading through the states over the past several years "seems to have brought new attention to renewable energy policy," Lawrence Berkeley National Laboratory energy analyst Ryan Wiser says. With the direction of federal energy policy uncertain, "...state policies have become all the more important for renewable energy developers and advocates."

Here are 7 tools states are employing with best examples of their application:

1) Support clean energy investment with a small charge on electricity shipped through the power grid.

Known as a Systems Benefits Charge (SBC), this is the equivalent of a toll booth on power lines. Twelve states including Oregon, Illinois, Massachusetts, Rhode Island and Montana have SBCs that will channel $1.7 billion to new renewables development over the next 10 years. California has the largest share. Its 1998-2002 renewables fund is $540 million, on a par with clean energy programs by national governments.

2) Require that utilities supply a certain percentage of clean energy.

Under these Renewable Portfolio Standards 8 states have mandated adding 3,800 MW of renewables by 2010. (The standards will also support 3,600 MW of existing renewables.) The biggest so far was passed by the Texas Legislature in 1999. It calls for development of 2,000 MW of clean energy in 10 years. As a result Texas is expected to become a globally significant center of wind energy development.

3) Put a charge on power plant greenhouse gas emissions to support clean energy development.

Oregon in 1997 passed the first mandatory measure in the U.S. to control CO_2. Builders of all new gas-fired power plants are required to reduce emissions 17% below the cleanest performance available under current technology. Plant owners can comply through investing in carbon-reducing measures such as clean energy development. They can set up their own carbon mitigation program or pay a fee to a nonprofit called the Oregon Climate Trust which makes carbon offsetting investments. Though small, with around $4 million in fees expected over coming years, the effort gives Oregon the first electricity in the nation to carry a portion of its greenhouse costs.

4) Make high visibility government clean energy purchases.

Government represents one of the biggest energy markets. State and local governments can organize bulk purchases to build renewable and efficiency technologies. Some of the best examples are in vehicle fleets. California is purchasing a number of clean and reduced emissions vehicles including 70 fuel cell powered cars and buses. Nebraska aims to power 25% of its Transportation Service Bureau fleet with alternative fuels by 2000.

5) Provide clean energy tax breaks.

Tax incentives are regarded as some of the most effective tools to boost new energy technologies. One of the oldest programs is one of the best. Though many energy tax incentives adopted in the wake of the '70s oil shocks are gone, Oregon retains the longest standing energy efficiency and renewable resource incentives in the Northern Hemisphere. Oregon offers a tax credit — a straight-up write-off against taxes owed — of up to $1,500 for residential solar installations and alternative-fuel vehicles. Oregon businesses can write off 35% of renewable and efficiency investments over 5 years.

6) Support clean energy buyers with cash and credit.

Sunlight and wind are free, but installations to capture their energy are more expensive than conventional energy equipment so up-front costs are higher. To balance the equation, 16 states including Oregon offer low-interest loan programs for renewables. In terms of cash

support, California is leading the way in the U.S., covering up to half the cost of installing PV systems.

7) **Credit small-scale clean power producers when they feed juice back into the grid.**

This is net metering, which lets customers runs their utility meters backwards. Net metering is now the law in 30 states. The Washington state statute is one of the best because credit for power generation can be carried on the books for up to a year. Summer solar energy generation can offset bills in winter when sunlight is limited. Under most state laws excess power is credited against bills only the month it was generated.

While national-level policies will play a crucial role in transforming the energy system, states offer essential proving grounds. In the clean energy revolution, the laboratories of democracy are leading the way.

Markets opening up to green power.

From California to Pennsylvania, marketers of clean, green power are signing up customers and building new clean energy plants. It is a 2-year-old business tied to utility restructuring, which is opening monopoly service areas to retail competition.

In 1998 California was first to open its market. The subsequent effort to recruit green power customers "provided more information about renewables to Californians in one year than they received in the previous 20," says Joe Costello of Center for Energy Efficiency and Renewable Technologies. At least 100,000 customers there have signed up for clean power service, notes Rachel Shimshak of the Renewables Northwest Project.

Perhaps the most exciting new customers are California cities and counties. Around 30 cities and 9 counties are purchasing green power. Santa Monica made history in February 1999 when it became the first city in the world to move to 100% green energy for its municipal facilities. It is purchasing 5 MW of geothermal energy. The $140,000 added costs are well worth it, City Councilmember Paul Rosenstein says. "The sooner government agencies make these kinds of commitments to green power, the sooner a market is created to lower costs, benefiting all consumers."

In November 1999 Oakland followed suit and decided to run its city government totally on clean energy. Oakland will buy 9 MW.

All the new green customers have made a market for facilities such as California's first utility-scale PV plant, a 132-kW array in Hopland that opened in September 1999.

The power is sold by Green Mountain, the most successful of the new green power marketers. Though Green Mountain projected it would only gain 2-6% of California customers who chose new power providers in the first 5 years, it picked up 25% after only one. Green Mountain is installing new windmills to supply customers for a renewables package that includes 25% wind.

Pennsylvania followed California in 1999 as the second state to open its markets. By July, 1 in 8 eligible customers had opted out on their old utility supplier. Green Mountain took 70,000 out of 384,000 residential customers who shifted by November. Pennsylvania became Green Mountain's first state government customer. The Department of General

Santa Monica made history in February 1999 when it became the first city in the world to move to 100% green energy for its municipal facilities.

The nation's first solar hydrogen-fuel cell system is located at the Telonicher Marine Lab in Trinidad, Calif. Power from solar panels breaks water into hydrogen and oxygen. Hydrogen feeds a fuel cell which generates electricity when it re-combines with oxygen. Hydrogen from renewable sources could feed millions of fuel cells powering vehicles and buildings.

New green power customers in California and Pennsylvania are driving development of new solar and wind power plants.

Services will buy 5% green power in 2000 for facilities ranging from the State Capitol to Penn State University.

As in California, a new customer base is driving clean energy development. "Green Mountain has built the largest solar energy facility in Pennsylvania, and we are about to break ground on the largest wind farm in the eastern U.S.," notes lead investor Sam Wyly, whose family invested $100 million in Green Mountain after successfully building Sterling Software.

Restructuring is not without issues. Utilities have been employing the process to write off troubled assets such as nuclear power plants. Public interest groups have been working hard to make sure the public benefits from the deal, gaining commitments for energy efficiency, renewable energy and low-income assistance. Retail choice also leads many customers to select the cheapest power, which is often the dirtiest. And some "green" offerings have included power from questionable sources such as big power dams. Nonetheless, the shift from monopoly, combined with affirmative public policies to build up clean energy, holds significant positive potential.

A model Green marketing effort undertaken prior to restructuring is a wind subscription plan offered by Public Service of Colorado and vigorously promoted by grassroots groups. Customers can buy blocks of wind power in increments of $2.50. Around 16,000 have subscribed, including New Belgium Brewery of Fort Collins. It will purchase the full production of one wind turbine at a Wyoming wind farm to make its Fat Tire Beer.

Another voluntary effort in the Northwest centers on the Bonneville Environmental Foundation. Under the program, utilities that agree to have green power products certified as environmentally preferable by a panel of environmental groups pay a small portion of revenues to the foundation. It invests in renewable energy development, such as an Ashland, Ore. effort that represents one of the Northwest's largest solar support programs so far.

The city and its municipal utility are leading a program to place 25-30 kW of PV panels at the post office, city council chambers, Southern Oregon State College and the town's famed Shakespeare Festival. The city is financing the above-market cost of the power with contributions from partners such as Bonneville and a voluntary green pricing program in which Ashland utility customers buy blocks of PV capacity for $4. That is just the first phase. In the second, customers who install their own PV systems will receive direct cash support expected to be around 25¢/kWh, also paid by the green pricing program. As of early March 2000 the popular program had signed up 240 customers, enough to support the first phase and commence the second (though the latter will not start up immediately).

"Informed consumers can use the power of their everyday purchases as a force for positive environmental change," notes Wyly. "When people are empowered and educated to factor the environment into their everyday choices, we will reverse climate change and air pollution."

Clean electrification of developing world a global opportunity

Two billion people in the developing world are without electrical service, while dirty energy sources force many others there to live under some of the most polluted skies in the world.

"The energy problem in developing nations is staggering," says Jim Sullivan, U.S. Agency for International Development (USAID) associate international administrator.

They are hard pressed to come up with the $60-100 billion of investment per year needed to keep pace with growing electrical demand. The unserved must wait many years for the electrical grid to reach them, if ever. Meanwhile, the most rapidly growing source of greenhouse gases is developing nations. By 2020 their emissions will surpass those of the industrial world.

"The developing world will, as things stand, mostly use coal to deliver future supplies," solar advocate Jeremy Leggett notes. "If they do this, there is enough fossil fuel below ground to create ruinous global overheating and climatic catastrophe."

That most developing nations are not bound to greenhouse gas reductions under the Kyoto climate treaty is a major obstacle to its ratification by the U.S. Senate. At the same time, rich nations are responsible for the overwhelming portion of human-caused greenhouse gases now in the atmosphere, and will continue even after 2020 to emit substantially more greenhouse gases per person.

Currently, notes presidential science advisor John Holdren, "The richest 15% of population accounts for more than half of emissions, and spreads damage across the world."

Developing nations are more vulnerable to climate disruption than the industrial world, because they are more reliant on natural systems, have fewer resources to respond to disasters, and tend to be on the tropical storm track. Since late 1998, India, Mexico, Vietnam, Honduras, Venezuela and Mozambique have experienced devastating floods that at least foreshadow the greenhouse world. Global warming is truly the world's greatest environmental justice issue.

Within these multiple and interrelated crises exists a grand global opportunity to promote development, slow down global warming and reduce the costs of clean energy sources. The key is to enable the developing world to leapfrog over the model of large power stations that still prevails in the industrial world, to jump them directly to a decentralized system based on many micropower plants.

A parallel already exists in telecommunications, where a number of developing nations are going right to wireless. China, notes BPA's Esvelt, has more cell phones than any other country. "They decided they didn't need to put up the wires and poles. Distributed generation will enable developing countries to leapfrog the whole investment in infrastructure."

"The old concept of monolithic infrastructure is too costly and time consuming to install," says Bill Roppenecker. "Distributed power generation from solar is a quicker and more cost-effective solution."

PV also replaces fuel, particularly costly to transport to remote regions. USAID case studies in which PV replaced diesel for livestock water pumping showed PV costs lower after 2 years at one Mexican ranch and 6 years at another.

PV is already the cheapest power provider in much of the planet's sunny south. Southern California Edison studies have shown a developing world market for PV too big to be quantified.

Nonetheless, barriers are substantial. Upfront costs can be higher compared with current sources such as diesel. Financing that would let people spread costs over several years is hard to find. A marketing infrastructure including local solar businesses and credit sources must be constructed. Awareness is also lacking.

"Many people don't know they have a renewable option," says Andre Verani, international program coordinator for Enersol, a solar company that works in the developing world. Needed is "vision espoused by political leaders."

"The U.S. should be playing a leadership role," Holdren says. "We are not doing it in an adequate way."

The demands of global equity and the urgent need to stabilize the climate call for a dramatic increase in assistance by industrial nations for clean electrification of the developing world. This would also have significant economic benefits for all countries. The richer nations would find new export markets, while the growing PV market would yield economies of scale that bring down prices.

"There must be a global effort to accelerate the growth of this vital market," Leggett says.

If this grand opportunity is seized, it will be one of the 21st century's great win-wins. It will yield improved lives for people around the world, and vastly improve the odds for restabilizing the climate, which would be vanishingly small without full participation by the billions of the developing world.

The developing world could leapfrog over the model of large power stations to a decentralized system based on many micropower plants.

The Northwest's clean energy advantages

An industry now in its infancy is rapidly emerging to take its place as one of the new century's most important. The time of opportunity for the Pacific Northwest is now.

"The clean energy industry will be large; it will have global significance and, in economic terms, it will be a prize worth having."

RENEWABLE ENERGY POLICY PROJECT

"The Northwest owes much of its economic success to capturing an early edge in high tech," Washington Governor Gary Locke notes. "We have a tremendous opportunity to reap the rewards of leading the next technology revolution — clean energy."

"Renewable energy advocates envision (Washington) state becoming a Silicon Valley of the renewable energy industry," the *Seattle Post-Intelligencer* reports. "The state is well on its way to preeminence in the field, which promises to be a growing one."

A 1998 study released by the Washington Department of Community, Trade and Economic Development found the state's clean energy industry already generates annual sales of nearly $1 billion, equal to the wholesale value of the state's apple crop, and employs 4,000 people.

The clean energy industry, notes the Renewable Energy Policy Project, "will be large; it will have global significance and, in economic terms, it will be a prize worth having . . . a vibrant, burgeoning prize that will contribute to the local economy, improve local quality of life, and form a core for sound, continuing local development."

In the race for this prize the Northwest has a number of assets which place it firmly in the running.

Great companies — Applied Power Corporation, Siemens Solar, Ballard Power Systems, Avista Labs, Northwest Power Systems, Trace Engineering and Wind Turbine Company are all significant contributors to the clean energy revolution. As the industry grows, several could credibly become a "Microsoft," a firm which generates spin-off ventures and helps shape a world-class technology cluster.

Workers installing solar cell roofing.

Technology center — One of the world's core technology regions, the Northwest is home to top global players in computer software and chips, aerospace and advanced materials. This offers abundant possibilities for crossfertilization. Electronics, software and advanced materials are crucial to clean energy development and the emerging micropower network. The region also is home to a major federal energy research establishment, Pacific Northwest National Laboratory in Richland, Wash. That holds great potential for clean energy industry development, notes Susannah Malarkey, executive director of Technology Alliance of Washington. "When you look at technology clusters, places which have a concentration of world-class firms in a particular industry, the common element is a major research institution," Malarkey notes.

Trade orientation — The Northwest is one of the most international-trade-centered regions in the U.S. And the greatest current potential for clean energy is in the developing nations, particularly Asian nations such as China with which the Northwest already has strong relationships. Of the top 15 exporting states in the US, Oregon is in the lead for the portion of exports going to Asia, 64%. Washington comes in second at 55%. That connection is one of the major reasons Trace is located in Washington. "Some of the biggest markets are in the far east, where there are gigantic prospective investments in infrastructure," Trace's Bill Roppenecker says.

Capital availability — Growing strong high tech companies requires technology-savvy venture capital. The Northwest in general and Puget Sound in particular has one of the nation's leading pools of just such investment dollars. PriceWaterhouseCoopers says Seattle is the second-fastest growing venture capital center in the U.S. and will move into first in 2000. "Having plenty of locally available venture capital — which Seattle now has — is a huge advantage when growing technology companies," Malarkey says. "Venture capitalists and angels like to invest in local companies with high growth potential that utilize technologies they understand. Investors who

understand clean energy technology can serve as lead investors and educate the rest of the investor community about the advantages of these investments."

Skilled workforce — Roppenecker moved from upstate New York in the mid-'90s. "One thing that amazed me was the general technical competence of almost everyone you run into. It's distinctly different than the Northeast." That is a hugely attractive factor for renewables producers. Notes Siemens Solar Communications Manager Clay Aldrich, "A lot of people who have experience in semiconductor processing go right into our pipeline. A lot of physics and chemistry go into the growth of a silicon ingot. It takes a lot of skill. The higher the quality of product we produce, the more profitable we will be."

Quality of life — Global Energy Concepts of Kirkland, Wash. consults on wind energy projects around the world. For its home base, "There's not a specific location that would make more sense than any other," GEC President Karen Conover notes. So why has the company located in the Northwest? "It's a nice place to live." With clean energy, much as the rest of the region's high-tech industries, high quality of life is crucial to attracting leading edge firms and finding and retaining the best workers.

Energy expertise — In the wake of the early 1980s WPPSS nuclear fiasco, the Northwest instituted least-cost power planning. It was a revolution for a utility industry always focused on building new power plants — Draw new power from the cheapest sources available, including renewables and energy efficiency. This made the Northwest a global leader in these fields. Energy expertise is a regional export. "We have a concentration of talent that I don't think is matched anywhere else," Northwest energy analyst K.C. Golden says.

Innovative utilities — Utilities such as Seattle City Light, Emerald Public Utility District, Eugene Water and Electric Board and Avista continue to mount vigorous energy conservation and renewables development programs, even after many utilities around the U.S. have scaled their efforts back. Seattle City Light, a part owner of the Centralia, Wash. coal-fired power plant before its recent sale, will plow money back into clean energy, planning to invest $2 million in renewables annually. BPA in February 2000 announced plans to develop 150 MW of new renewables by 2006 to meet demand created through green marketing programs mounted by itself and other regional utilities.

The Northwest has the assets to become a world clean energy pacesetter. With visionary leadership and creative partnerships, the prize is well within reach.

"We have a tremendous opportunity to reap the rewards of leading the next technology revolution — clean energy."

WASHINGTON GOVERNOR GARY LOCKE

A Northwest strategy for clean energy leadership

The Northwest already thinks regionally about energy through such institutions as the Northwest Power Planning Council and BPA. An integrated regional strategy to build clean energy industries is the logical next step.

A strategic alliance between Oregon and Washington is a good place to start. By giving clean energy emphasis in economic development efforts and rounding out their clean energy policy packages, the 2 states can together find their place in the sun of a dawning new industry.

ECONOMIC DEVELOPMENT — While the 2 states have in the past competed for economic development, cooperation on clean energy makes more sense. The 2 state governments should convene a working group of policymakers and business leaders to identify ways the region can build clean energy industries on existing strengths, such as its leading edge companies, Pacific Rim connections, Portland-Vancouver's silicon-processing complex, Puget Sound's software and information industries, and the Tri-Cities' research prowess.

FULL POLICY PACKAGE — Both Washington and Oregon now have enacted the key policy of net metering. But significant gaps exist in other areas:

Renewable Portfolio Standard — Neither state now has an RPS. Both need one. Since utilities

make the choice of how to meet the standard, this will particularly favor the low-cost alternative of wind energy. State and local governments should also set their own internal standards to buy some or all of their energy from clean sources.

Systems Benefit Charge — Oregon in 1999 enacted a 3% SBC that will provide $87 million for clean energy development this decade. Washington needs its own SBC and renewables fund. To level the playing field with much larger funds such as California's, the 2 states can leverage their clout by making joint investments in clean energy development. The funds can also provide low-cost loans, tax credits and direct cash support to buyers of clean energy equipment, and support high-visibility clean energy purchases by cities and states. Sacramento requires a level of local production to participate in its solar support program. The Northwest can do the same.

Carbon Offsets — Washington should consider implementing a version of Oregon's pioneering program requiring that developers of new natural gas-fired power plants pay to offset a portion of carbon emissions. Leaders in both states should also begin a conversation about carbon taxes on all fossil fuel burning. No doubt this is a political hard sell, and implementation will ultimately require a broad consensus and public understanding of the benefits. Carbon taxes will be more politically palatable if revenues are used to cut unpopular levies on property and sales, and invest in climate-saving measures that also produce jobs.

"Throughout economic history, the greatest financial rewards have been reaped by those who identify potentially lucrative discontinuities and exploit them," Worldwatch Institute energy analyst Christopher Flavin notes. "It remains to be seen what company will be the Microsoft of a new energy system — or where it will be based."

In energy, this is truly a time of discontinuity, a sharp break from the past that will transform the energy landscape in rapid order. The Northwest has all the assets needed to seize the opportunity. If we do so, it will generate significant economic gain. More importantly it will give the children of today and tomorrow better odds for full and healthy lives. For our own sake and that of future generations, we must rise to the opportunity and help lead the way to an age of clean energy that steadies a troubled climate. This is, after all, the best reward we could have.

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