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OCTOBER 2008

CARBON-FREE PROSPERITY 2025

How the Northwest Can Create Green Jobs, Deliver Energy Security, And Thrive in the Global Clean-Tech Marketplace

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How the Northwest Can Create Green Jobs, Deliver Energy Security, And Thrive in the Global Clean-Tech Marketplace

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Disclosure

Clean Edge or its principals have provided consulting services for or hold equity in the following companies mentioned in this report: Miasolé and Solaicx. Furthermore, the information contained in this report is not intended to be used as a guide to investing, and the authors make no guarantees that any investments based on the information contained herein will benefit you in specific applications, owing to the risk that is involved in investing of almost any kind.

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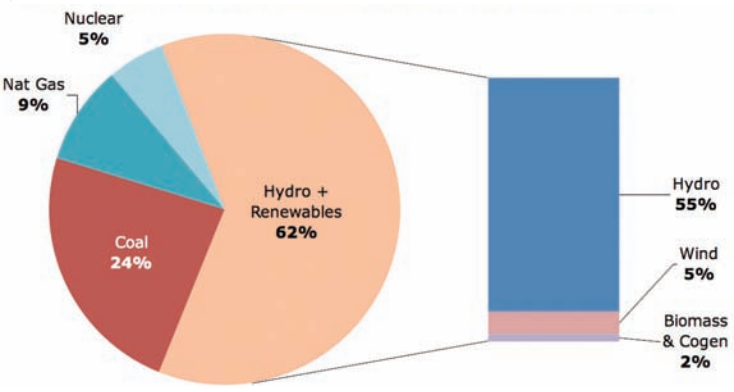
EXECUTIVE SUMMARY

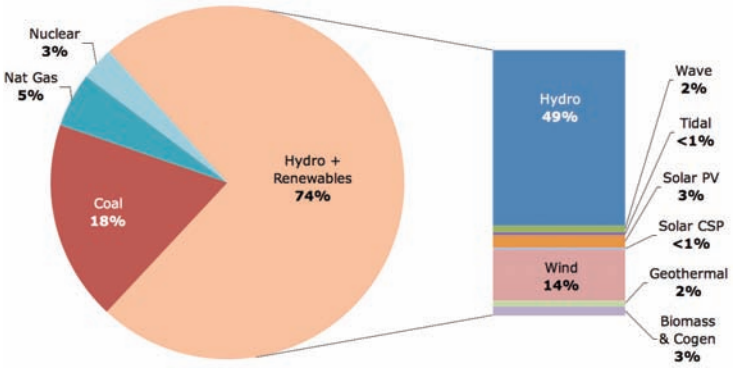
We stand at a unique crossroads in history: the transition from polluting, resource-constrained, fossil-based energy systems to those built on sustainable, renewable, resource-efficient systems. This historic and unprecedented shift, which is occurring within the electric utility market, the transportation sector, and the built environment, offers the promise of greatly reducing the Pacific Northwest's collective impact on the planet while helping to ensure the livelihoods and well-being of future generations. In a time of deep national economic uncertainty, it also offers one of the greatest opportunities for wealth- and job-creation in more than a generation.

In *Carbon-Free Prosperity 2025* we highlight how Oregon and Washington can create green jobs, deliver energy security, and thrive in the global clean-tech marketplace. In a fiercely competitive environment, the Northwest is already leading in a number of critical and emerging clean-energy segments. The region is home to one of the largest planned wind farms in the world; the largest planned U.S. solar crystalline photovoltaic (PV) manufacturing facility; the world's first silicon feedstock production facility completely dedicated to solar; and the largest global manufacturer of advanced meter reading (AMR) devices.

2008 - Supply, by Energy Type, for Major Utilities in Oregon and Washington



2025 - Supply, by Energy Type, for Major Utilities in Oregon and Washington



Oregon and Washington's major utilities currently get 62 percent of their electricity supply from hydro and renewables. According to our research, it's possible for the region to get more than 74 percent of its supply from hydro and renewables by 2025. Increasing efficiency and conservation targets by just 50 percent could help the region achieve 78 percent of its supply from hydro and renewables by 2025.

In this report, we outline:

- The region's key assets (strengths) and barriers (weaknesses)
- The top five clean-tech opportunities for the region, according to our interview and research findings
- A 10-point action plan for reaching carbon-free prosperity in Oregon and Washington
- How the region can be the first in the nation to achieve approximately 75 percent of its electricity supply from carbon-free sources (hydropower + renewables) by 2025
- How the region can create between 41,000 and 63,000 direct jobs by 2025 in just five clean-tech sectors

Assets, Barriers, and Opportunities

Oregon and Washington have a plethora of assets that support the region's drive to capture a dominant position in a number of low-carbon, clean-energy sectors. These include a prevalent green culture; supportive regional government policies; a significant natural resource base; and a strong base of manufacturing infrastructure and knowhow. The region also faces a number of not-so-insignificant barriers that must be overcome, including limited venture capital activity in the region; the lack of a 21st century grid to carry green electrons and accommodate energy intelligence initiatives; and the lack of a coordinated regional strategy.

But our research shows that Oregon and Washington can play a leadership role in a number of select clean-energy sectors. In talking with leaders throughout the region, we asked a number of probing questions to understand which opportunities they felt offered the region the best opportunity for mid-term growth (defined, for the purposes of this report, as between now and 2025) within the context of carbon-free prosperity. Which technologies already had a foothold in the region? In which technology sectors did the region have a unique competitive advantage? Which of these technologies would have the greatest impact on the reduction of carbon, not only within the region, but on the broader global playing field?

In a medium-growth scenario we could see more than 41,000 jobs in Washington and Oregon by 2025; in an accelerated-growth scenario more than 63,000 jobs.

Based on these interviews, five areas came out on top. Ranked in order of most times mentioned by our respondents, they are:

Solar PV Manufacturing

Green Building Design Services

Wind Power Development

Sustainable Bioenergy

Smart Grid Technologies

41,000 to 63,000 Jobs

These five sectors offer significant job growth opportunities for the region. According to our research, in a medium-growth scenario, we could see more than 41,000 jobs in Washington and Oregon by 2025 from these five sectors alone—and in an accelerated-growth scenario, more than 63,000 jobs in the region by 2025.

To put these numbers in perspective, northwest Oregon and southwest Washington's "Silicon Forest" high-tech cluster employed a similar number of employees at its peak a decade ago. It's also 2-3 times the total number of employees working worldwide at Internet giant Google. Our estimates are only focused on the five priority sectors targeted in this report. The potential for green job creation in the region is undoubtedly much broader and larger.

10-POINT ACTION PLAN AT-A-GLANCE

1. Put a price on carbon

2. Increase Washington RPS to 25% by 2025

3. Implement low carbon fuel standards

4. Pass aggressive green building codes

5. Foster regional cooperation

6. Ensure public funding for clean technology via public employees retirement system investments and through targeted clean-tech funds

7. Implement effective tax credits for renewables development

8. Deploy clean-tech workforce development programs

9. Establish government procurement policies for clean-tech products and services

10. Build out regional smart grids and 21st century transmission backbone

10-Point Action Plan

How can the Northwest leverage its assets and overcome its weaknesses to become a world-class center for clean energy and energy efficiency? Based on interviews with key stakeholders, and the collective research of Clean Edge, Inc. and Climate Solutions, we have come up with 10 key strategies.

Reaching carbon-free prosperity will not be easy, but as we point out in this report, creating a vibrant and expanding clean-tech industry is an environmental, geopolitical, and economic imperative. With the U.S. economy in perhaps its most perilous condition in decades, regions throughout the country are seeking new paths to quality job creation and sustainable prosperity. Against this backdrop, the Pacific Northwest has an enormous opportunity.

Compared to many other regions, Washington and Oregon are already in an enviable position. With assets that include abundant clean-energy resources, committed political leadership, progressive public policies, world-class quality of life, and a green-minded, technology-oriented populace, the region has an excellent foundation on which to build a thriving clean-tech economy. With a committed focus on the sectors of solar PV manufacturing, green building design services, wind power development, sustainable bioenergy, and smart grid technologies, we believe that the Northwest can dramatically reduce its carbon output while creating a prosperous 21st century regional economy and becoming an export leader. These efforts will create tens of thousands of skilled, high-paying, family-wage jobs across a diverse range of sectors.

Other regions as near as California and as far away as Massachusetts (indeed, as far-flung as Shanghai and Abu Dhabi) are moving aggressively to court the investors, entrepreneurs, and job seekers of the 21st century clean-tech economy. Building regional clean-tech clusters that steer toward a carbon-free future will be this century's most competitive playing field. If the Northwest wants to compete and thrive in this brave new world—and we firmly believe that it can—then the time to act is now.

INTRODUCTION

An economic, technological, and political transformation is underway that is changing the way we live, work, and play in the Pacific Northwest, across the nation, and around the world. Through the lens of dramatic carbon-reduction and resource-efficiency targets, we are witnessing an industrial transition that is rewriting the way we generate, store, manage, conserve, and consume energy. This historic and unprecedented shift, which is occurring within the electric utility market, the transportation sector, and the built environment, offers the promise of greatly reducing our region's collective impact on the planet while helping to ensure the livelihoods and well-being of future generations. In a time of deep national economic uncertainty, it also offers one of the greatest opportunities for wealth- and job-creation in more than a generation.

Indeed, clean energy is not only an attractive area for potential business investment and growth expansion, it has become a political and economic imperative. Those companies, communities, governments, and regions that embrace clean-energy technologies (everything from energy generation and transportation to energy efficiency and green buildings) stand to benefit immensely by creating new jobs; becoming centers of technological, business, and sustainability excellence; and leading the next wave of global innovation. Those that do not embrace this new wave, and continue to depend as much as they always have on carbon-intensive, increasingly costly and volatile fossil fuels, risk falling behind economically, socially, and environmentally. Pulitzer Prize-winning author Thomas L. Friedman, in his most recent book, *Hot, Flat, and Crowded,* explains: "the task of creating the tools, systems, energy sources, and ethics that will allow the planet to grow in cleaner, more sustainable ways is going to be the biggest challenge of our lifetime."

Welcome to the "brave new" low-carbon/post-carbon world.

Carbon Free Prosperity 2025 is based on interviews with more than 50 leading clean-energy and clean-tech stakeholders in Oregon and Washington. The report highlights how the region is already taking a leading role and well positioned in the emerging clean-tech marketplace—and recommends policy and industry actions to extend, expand, and accelerate that leadership. Specifically, it takes a close-up look at the region's greatest assets and barriers, assesses the five biggest near- to mid-term opportunities for clean-tech innovation in the region, and recommends a 10-Point Action Plan for reaching economic and environmental prosperity. Additional analysis on job creation impact is overlaid throughout the report.

Washington and Oregon: Leading the Way?

Clean energy, unlike many earlier technology revolutions, will not be birthed out of one place. No single region, for example, will dominate this revolution like Silicon Valley

did with the birth of the computer chip. Instead, it is emanating simultaneously out of dozens of nodes, from San Francisco and Austin to Tokyo, Japan and Freiburg, Germany. In order for the Northwest to compete and carve out a leadership role, the region must build on its past successes and focus carefully and selectively on new opportunities.

Fortunately, in a fiercely competitive environment, the Northwest is already leading in a number of critical and emerging clean-energy segments. While California garners big investments and China ramps up its manufacturing prowess, consider that the Northwest is home to:

- **One of the largest planned wind farms in the world.** The Shepherd's Flat Wind Farm, which would span Gilliam and Morrow counties in north-central Oregon, is proposed to have 303 wind turbines with a peak capacity of 909 megawatts (MW). While admittedly not as large as T. Boone Pickens' proposed 4,000 MW Texas wind farm complex (slated for completion in 2014), it would likely be the largest wind farm in the U.S., and potentially the largest in the world, if completed by its target date in 2012.
- **The largest planned U.S. solar crystalline photovoltaic (PV) manufacturing facility.** SolarWorld's 500 MW solar PV plant, which is currently ramping up production in Hillsboro, Oregon, would be the largest U.S. crystalline silicon PV facility when completed in 2011.
- **The world's first silicon feedstock production facility completely dedicated to solar,** owned and operated by REC Silicon, in Moses Lake, Washington.

We're Not Alone

Oregon and Washington may be leading in a number of critical ways, but other regions are aggressively pursuing the clean-tech opportunity. In the U.S. alone, dozens of cities, states, and regions large and small have set up initiatives to claim their piece of the clean-tech prize. Below is a sampling of some recent studies that outline how some of these regions are positioning themselves to participate in, if not dominate, various clean-tech sectors.

Title	Authors/Producers	Release Date
A Strong Clean Energy Cluster Can Bring $1 Billion in Incremental Investment to New England by 2012	New England Clean Energy Council; Topline Strategy Group	June, 2008
Energizing Michigan's Economy	Environment Michigan	February, 2007
Cleantech: A New Engine of Economic Growth for New York State	The New York City Investment Fund	January, 2007
Creating the California Cleantech Cluster: How Innovation and Investment Can Promote Job Growth and a Healthy Environment	NRDC; Environmental Entrepreneurs (E2)	September, 2004 (with updates since)
Harnessing San Francisco's Clean-Tech Future	Clean Edge; SF Dept. of Environment	October, 2004
Enriching Economy and Environment: Making Central Texas the Center for Clean Energy	Austin Clean Energy Initiative; IC2 Institute, University of Texas at Austin	November, 2002

- **Top ranking among cities with the most LEED-certified green buildings in the nation**, with Seattle and Portland consistently ranking in the top 3.

- **The number one global manufacturer of advanced meter readers (AMR),** Itron of Liberty Lake, Washington, now manufactures and sells more than eight million AMR units (meters and modules) annually via its worldwide operations.

It's a good start. But because of the immense amount of global and domestic competition in the broader clean-tech sector, it's critical that the region prioritize investments in carefully selected areas in which it is most likely to be a leader in global markets, leverage existing and emerging assets, and build out vibrant clusters of expertise. The "play to your strengths" strategy that often creates success for leading businesses and sports teams applies to clean-tech economic development as well. This report makes recommendations on where the Northwest should focus policy and industry efforts to best leverage the region's strengths.

In short, there's no time to lose. If the Northwest does not seize the opportunities of job creation and economic growth by targeting key clean-energy technology sectors, then it will lose out to other regions.

Within Reach: 75 Percent Carbon-Free Electricity by 2025

In contrast to most other regions, the Northwest finds itself in an enviable position. Thanks to the Columbia River watershed and federal and state power projects spanning multiple decades, Oregon's and Washington's major utilities currently get approximately 55 percent of their electricity from hydro resources (for direct use by customers in the region). That's followed by coal at 24 percent, natural gas at 9 percent, nuclear at 5 percent, and wind now at approximately 5 percent. Some utilities like Seattle City Light already get more than 90 percent of their electricity from carbon-free hydro, but that's balanced by others like Portland General Electric and Pacific Power, which both currently get less than 30 percent of their power from hydro.

Supply, by Energy Type, for Major Utilities in Oregon and Washington (2008)		
Source	Supply Contribution (MWa)	Supply Contribution (%)
Hydro	6707	55%
Coal	2900	24%
Nat Gas	1100	9%
Wind	662	5%
Nuclear	652	5%
Biomass & Cogeneration	206	2%
Total	12227	100%

Source: Clean Edge Inc., 2008

Combined, hydro and renewables (wind and biomass/cogeneration) currently represent an average 62 percent of the electricity mix of the major utilities. That contrasts dramatically with the national average of about 6 percent for hydro and around 3 percent for renewables. This rich hydro and renewables base offers Washington and Oregon the unique opportunity to reach ambitious low-carbon energy targets.

With current renewable portfolio standard (RPS) targets of 25 percent by 2025 in Oregon and 15 percent by 2020 in Washington, the region is within reach of obtaining a significant portion of its electricity from clean, carbon-free energy sources. As we highlight later in the report, if Washington were to increase its RPS to match that of Oregon, we believe the region could get nearly 75 percent of its electricity mix from non-nuclear carbon-free sources, comprising both hydro and new renewables (such as wind, solar, wave, and geothermal), by 2025. And if we increase planned targets for energy efficiency and conservation contributions in Washington and Oregon by 50 percent over this time period, the region's major utilities could get more than 78 percent of their electricity from hydro and renewables by 2025 (see 10-Point Action Plan and Appendix A for more details). This would be the most ambitious level of carbon-free, clean-energy targets anywhere in the nation, and would make Oregon and Washington world-class leaders in carbon-free electricity.

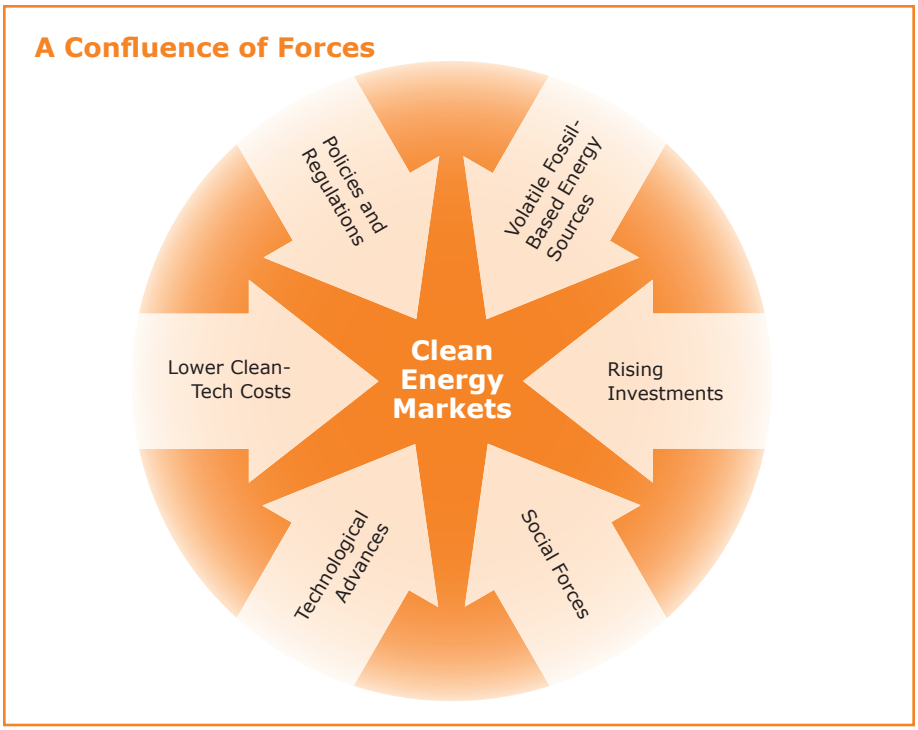
Supply, by Energy Type, for Major Utilities in Oregon and Washington (Base Case, Projected 2025)		
Source	Supply Contribution (MWa)	Supply Contribution (%)
Hydro	6767	49%
Coal	2550	18%
Wind	1952	14%
Nat Gas	688	5%
Solar PV	485	3%
Nuclear	413	3%
Biomass & Cogeneration	350	3%
Wave	250	2%
Geothermal	230	2%
Tidal	125	<1%
Concentrating Solar Power (CSP)	80	<1%
Total	13891	100%

Source: Clean Edge, Inc., 2008

A Confluence of Forces

There are a number of critical drivers behind the shift away from carbon-intensive energy sources and systems and towards the zero- or low-carbon options outlined in the region. These include:

- Emerging carbon and climate policies and regulations, including regional efforts such as the Western Climate Initiative



- Federal, state, and regional clean-energy funds, standards, tax incentives and other economic development initiatives
- Increasing cost volatility of fossil-based energy sources
- Advances in a range of clean-energy technologies, from solar, wind, and geothermal to energy efficiency, smart grid, and green buildings, that are making them increasingly cost-competitive
- Social forces that are demanding a shift from polluting, carbon-intensive, fossil-fuel based economy to a sustainable and efficient clean-energy economy
- Rising investments in clean energy by public and private markets, illustrated by venture investments in clean energy that have risen from one percent of total venture investments in 1999 to more than nine percent of total U.S. venture activity in 2007—$2.7 billion invested in clean energy, according to New Energy Finance, Clean Edge, and Nth Power research.

But for all the powerful forces aligning behind clean energy and energy efficiency, a host of obstacles remain. These include uncertainty around the long-term extension of the federal investment tax credit and production tax credit for renewables (at the time this report went to press the federal extension of the ITC and PTC had failed under at least eight separate votes by Congress); state coffers that at times will see contraction, instead of increases; and growing competition from regions within the U.S. and abroad.

Unique Time in History

In ways both large and small we find ourselves at a unique time in history:

- One in which both environmental and energy progress are integrally linked rather than oppositional.
- One in which clean-energy and carbon-reduction products and services offer the promise of regional economic competitiveness.
- One in which such diverse business, investment, and political luminaries as Al Gore, T. Boone Pickens, Andy Grove, and Arnold Schwarzenegger are calling for seemingly audacious goals to meet increasingly large portions of our energy needs from clean-energy generation and efficiency measures.

This report looks at the Northwest's unique opportunity to position itself as a leader in carbon-free and carbon-reduction technologies. Blessed with abundant renewable natural resources, a large and creative talent pool, and a global reputation as a green and sustainable leader, the region is better positioned than many of its global competitors to reap the benefits of a transition to clean energy and efficiency technologies.

Indeed, during the current economic slump, rises in nationwide unemployment, and financial turmoil, clean energy and energy efficiency technologies offer one of the few bright spots for economic and job growth. While many industries are contracting, clean energy and efficiency is expanding. According to our analysis, the five clean-tech sectors we've identified in this report currently employ roughly 11,000 people in Oregon and Washington. By 2025, we project this number could expand to more than 40,000 in a medium-growth scenario and more than 60,000 in an accelerated-growth scenario.

But as we point out throughout the report, Northwest clean-energy leadership is not a fait accompli. In fact, 8 years after Climate Solutions issued the first clarion call with its report *Accelerating the Clean Energy Revolution: How the Northwest Can Lead,* we find ourselves at a critical inflection point when numerous challenges face the region, including:

- The absence of a leading university technology incubator with the stature of an MIT or Stanford
- A regional technology investment climate that pales in comparison to centers such as Silicon Valley and Boston's Route 128 Corridor
- The small size of state public clean-energy support funds compared to other state leaders, particularly clean-tech mecca California
- An aging electric utility grid system challenged to carry increasing streams of electrons from distributed and variable energy sources such as wind farms,

wave installations, and solar roofs

- A comparatively small regional market served by relatively inexpensive hydroelectric power, compared to densely populated markets with high-power prices in other emerging clean-tech centers such as California and the Northeast.

But challenges, when carefully evaluated and addressed, can be transformed into opportunities. Northwest states, local governments, and universities can pioneer new

Report Methodology

For *Carbon-Free Prosperity 2025,* Clean Edge employed a comprehensive research methodology which included external interviews and primary and secondary research. The report is based on:

- Expert interviews — More than 50 interviewees representing a range of interests including industry, government, and finance
- Proprietary Clean Edge data — Market size, cost and pricing data, growth projections, and other key market data for a range of clean-energy sectors
- Online research of companies and utilities, third-party data, etc.

Interview participants included (affiliations listed represent those held at the time interviews were conducted):

Roger Woodworth
Avista

Marc Cummings
Battelle/Pacific Northwest National Labs

Andrew Haden
Bear Mountain Forest Products

Scott Lewis
Brightworks Northwest

Denis Hayes
Bullitt Foundation

Ted Bernhard
Cascadia Capital

Nik Blosser
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Vestas

Sharon Coleman
Vulcan

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Vulcan

William Brent
Weber Shandwick

forms of partnerships that synergistically mesh the region's many strengths. A region that gains understanding of its emerging clean-tech competitive edges can marshal public and private investments to greatest effect. An initiative to modernize the power grid can provide many launch-pad opportunities for emerging regional technology leaders that they can translate into global market success. And new energy systems that can succeed in challenging Northwest markets will quickly find substantial markets around the U.S. and overseas.

In order to transform these regional challenges into global opportunities, however, Washington and Oregon must act now to strategically build market strengths and secure competitive advantages within global clean-tech sectors. In the 10-Point Action Plan at end of this report, we highlight the key steps that the region must take to ensure economic success and build ecological sustainability in the new world of clean energy and carbon reduction.

NORTHWEST ASSETS AND BARRIERS

Oregon and Washington have a plethora of assets that support the region's drive to capture a dominant position in a number of low-carbon, clean-energy sectors. The region also faces a number of not-so-insignificant barriers that must be overcome. Our interviews uncovered six major regional assets/strengths and six major barriers/weaknesses. These were the items cited by the largest number of respondents in each category.

Strengths/Assets	Weaknesses/Barriers
Prevalent Green Culture and Regional Quality of Life	Limited Venture Capital Activity Compared to California and New England
Supportive Regional Government Policies for Renewables and Efficiency	Limited Scale and Business Engagement of Research Institutions Relative to Other Regions
Abundant, Cheap Electricity (Attracts Manufacturing)	Abundant, Cheap Electricity (Makes it Harder for Efficiency and Renewables to Compete)
Significant Natural Resource Base (Wind, Solar, Waves, Biomass)	Limited Size of Managerial Talent Base
Strong Manufacturing Base and Knowhow	Lack of 21st century Grid Infrastructure to Carry Green Electrons
Massive Export Market Opportunities	Lack of Regional Strategy

Combined, these strengths and weaknesses offer an up-close, inside view of a region at a crossroads. While the Northwest has an early lead in some clean-energy and energy-efficiency sectors, it also has much it needs to do to exploit future opportunities and guarantee a thriving place in the sustainability and clean-tech movement. Interviewee respondents were clear in their assessment: "this is both a good news, bad news story." Yes, there's a lot to be positive and upbeat about, but there's also a lot of hard work that remains.

Below we take a closer look at each of the strengths and weaknesses of the region. It's important to note that the following is simply a snapshot in time. The assets and barriers of any region are constantly in flux. That said, the following provides a unique view into a region, and provides an assessment of its clean-energy opportunities and challenges.

Top Regional Assets (Strengths)

PREVALENT GREEN CULTURE AND REGIONAL QUALITY OF LIFE

Oregon and Washington have both earned reputations for their "green ethos" and sustainability leadership. Oregon, with Portland as its crown jewel, was mentioned by many of our respondents for its global leadership in sustainable urban planning, architecture, mass transit, progressive politics, and other aspects of sustainability. Some pointed to the city as the nation's, and perhaps the world's, sustainability lab.

Oregon's and Washington's populations exude everything green. Seattle and Portland both rank in the nation's top five or better in green buildings, hybrid car ownership per capita, use of bicycles for commuting, and other green stats. This commitment

to everything sustainable, from the regional food movement to clean energy, also consistently places the region on the top lists of places to live in the U.S. To be sure, not everything is always rosy—even in the Rose City—but during the recent housing meltdown experienced through much of the U.S., housing prices have remained comparatively stable in Washington and Oregon. All this translates not only into a political and social culture that's strongly supportive of clean energy growth and carbon reduction. It's also a critical factor in attracting the type of 21st century creative, technical, and entrepreneurial talent that will fill the jobs of the region's low-carbon economy.

SUPPORTIVE REGIONAL GOVERNMENT POLICIES FOR RENEWABLES AND EFFICIENCY

Most of our respondents cited the statewide RPS mandates of Oregon and Washington, and Oregon's Business Energy Tax Credit (BETC), as key policies moving clean energy forward. We see this particularly in the recent explosive growth of solar PV manufacturing in Oregon. City policies such as Portland's renewable fuels standards and Seattle's and Portland's green building requirements for public buildings are also among the nation's most progressive, and political leaders like Seattle Mayor Greg Nickels, Oregon Governor Ted Kulongoski, and Washington Governor Christine Gregoire have earned "green leadership" kudos throughout the region and beyond. And one third of the region's residents live in cities that have committed to Kyoto Protocol carbon reduction targets by joining the Cities for Climate Protection program. There's still plenty of room for improvement, particularly in state policy in Washington, and we discuss specific recommendations in our 10-Point Action Plan later in this report. But today's policies are clearly a strong regional asset.

ABUNDANT, CHEAP ELECTRICITY (ATTRACTS MANUFACTURING)

For more than seven decades, the Northwest has enjoyed abundant, low-cost, low-carbon electricity thanks to its rivers and dams [the Bonneville Power Administration (BPA) even once commissioned folk singer Woody Guthrie to write songs celebrating the Columbia River's hydro resource]. Low electric rates are great incentive to build manufacturing plants here, and easily-dispatchable hydro is also the best baseload power to pair with variable clean energy sources like solar and wind. "Dams make good storage," said one expert. (On the flip side, cheap power is also seen by some as a liability because it makes it harder for renewables to compete on price; we discuss this below in the Barriers section.) However, rates are rising dramatically for natural gas and coal in the region, as they are nationwide, so this current advantage doesn't necessarily apply long-term in areas served by investor-owned utilities that don't have a majority of hydro in their energy mix.

SIGNIFICANT NATURAL RESOURCE BASE (HYDRO, WIND, SOLAR, WAVES, BIOMASS, GEOTHERMAL)

The Northwest boasts an abundant and diverse supply of clean energy resources. In addi-

tion to 'King Hydro', Washington and Oregon generate electricity from sun, wind, biomass, and geothermal resources, with wave power also potentially abundant. Such diversity led one interviewee to call the region the "Saudi Arabia" of renewable resources.

STRONG MANUFACTURING BASE AND KNOWHOW

For many decades, the region's economy has featured a solid manufacturing base. Boeing, Paccar, Oregon Iron Works, the semiconductor foundries of Intel and other chipmakers, and hundreds of other large and small manufacturers give the Northwest a rich supply of industrial production and management expertise. To be sure, not all of those jobs translate easily to clean tech. But there is a wide range of synergies that can be tapped in the manufacture of solar PV cells and modules, smart grid devices, green building materials, and many other components of the clean energy economy.

The Northwest's long history of ties to California and East Asia give the region an inside track.

MASSIVE EXPORT MARKET OPPORTUNITIES

The Northwest's long history of cultural and economic ties to California and East Asia, particularly Japan and China, give the region an inside track to export its products and intellectual capital into two of the largest and fastest-growing clean tech markets in the world. It's an enviable position that the region would do well to exploit as it grows its clean-tech sectors.

Top Regional Barriers (Weaknesses)

LIMITED VENTURE CAPITAL ACTIVITY COMPARED TO CALIFORNIA AND NEW ENGLAND

Never considered a world-class financial capital, the Northwest lacks the robust venture capital infrastructure that's fueling the clean-tech boom in places like Silicon Valley and the Boston/Cambridge area. Washington and Oregon have made considerable progress in this area, but simply can't match up to those regions in VC dollars, muscle, or influence.

LIMITED SCALE AND BUSINESS ENGAGEMENT OF RESEARCH INSTITUTIONS RELATIVE TO OTHER REGIONS

This is a critical weaknesses cited by a significant number of our interviewees. Although the major universities of both Washington and Oregon were praised for excellence in many specific areas, they were also faulted for less-than-robust ties to the business community for the commercialization of R&D advances. "We need an MIT," one respondent said, echoing the sentiments of many others.

ABUNDANT CHEAP ELECTRICITY (MAKES IT HARDER FOR EFFICIENCY AND RENEWABLES TO COMPETE)

This is the flip side of low electric rates as a competitive advantage to lure manufacturing to the region. "Grid parity," where the costs of renewables decline and become competitive against the rising cost of conventional energy sources (such as coal and

nuclear), is often cited as the Holy Grail for renewable energy technologies to reach adequate scale. But it's a tougher goal for wind, solar, and other renewables to meet when the average kilowatt-hour rates on the grid are both low and relatively stable, thanks to the region's robust hydro resource. This is one key reason why the region's best solar PV opportunity is in manufacturing rather than widescale deployment, and it presents a cost challenge for wind farm developers as well. But low-cost power is not a consistent barrier throughout the region, as some utilities like Pacific Power have significant percentages of price-volatile natural gas and coal in their generation mix.

LIMITED SIZE OF MANAGERIAL TALENT BASE

Given the fierce competition with other regions for the executive skills to manage burgeoning clean-tech companies, the Northwest's relative lack of major corporate headquarters results in a limited talent pool to tap. Not that there isn't plenty of managerial talent at Boeing (with headquarters recently moved to Chicago), Nike, Microsoft, Weyerhaeuser, Starbucks, Amazon.com, and other Northwest companies—but the region has a small number of Fortune 500 headquarters relative to other regions (especially Oregon, which is home to only two Fortune 500 companies). And in addition to the lack of an influential research university cited above, the region also currently lacks a top-25-rated business school.

LACK OF 21ST CENTURY GRID INFRASTRUCTURE TO CARRY GREEN ELECTRONS

This barrier presents both a challenge and an opportunity. As we will detail in the Smart Grid Technologies opportunity section below, the region's current grid is not capable of absorbing and transmitting the requisite megawatts of wind, solar, and other clean energy sources for Oregon and Washington to meet their respective RPS targets. But in expanding and upgrading the grid to be the backbone of a robust, 21st century clean energy delivery system, the Northwest can stake out a national and world leadership position in smart grid technology development and production.

LACK OF REGIONAL STRATEGY

Whether for political or competitive reasons or both, Washington and Oregon have not come together to form a cohesive strategy, either for public policy direction or business development, to map out the region's clean-tech future. As noted above, the Northwest boasts an impressive range of assets to build on as it moves toward the goal of carbon-free prosperity—with many pieces of strong political and business leadership in place. But without a comprehensive clean-tech strategy for the region, strong assets and good intentions are destined to result in piecemeal, uncoordinated efforts that fall short of the region's ambitious goals.

Recent Clean-Tech and Sustainability Initiatives at Northwest Colleges and Universities

College/University	Activity	Details
Columbia Gorge Community College	Associate of Applied Science Degree in Renewable Energy Technology	Graduates work in jobs related to hydro-generation, wind-generation, and automated manufacturing
Oregon Institute of Technology	Bachelor of Science Degree in Renewable Energy Engineering	The nation's first undergraduate program in renewable energy
Oregon State University	Northwest Marine Renewable Energy Center	The center will work with partners to advance wave energy technology
Portland State University	Miller Foundation—$25 Million Grant	The university's largest-ever gift will be used to strengthen research and education in sustainability
Seattle University	Algae-based biodiesel research	In a project for startup company Bioalgene, mechanical engineering students designed a photobioreactor to produce biodiesel from algae
University of Washington	Bioresource-Based Energy for Sustainable Societies	Ph.D. level program focused on energy research
Washington State University	Bioproducts, Sciences and Engineering Laboratory	WSU/PNNL partnership to conduct bio-based product R&D
Partners: OSU, UO, OIT and PSU	Oregon BEST Center (Building Environment and Sustainable Technologies)	Facilitates R&D and establishes partnerships to transition research success into business opportunity

While the Northwest was faulted for not having an MIT or Stanford, some respondents did point out some of the positive clean-tech developments at top academic institutions in the region. Above is a sampling of some notable recent developments and collaborations.

Clean-Tech Investing: Capturing our Share

One of the biggest issues outlined in our research was the seeming dearth of venture capital activity for clean-energy and clean-tech concerns in the two states. While clean-energy investing flourishes, reaching more than $2.7 billion, or nine percent of total venture activity in the U.S. in 2007 (up from less than one percent in 1999), the Northwest is being left behind. According to research firm New Energy Finance, Oregon and Washington companies together accounted for around four percent of the total $2.7 billion in venture activity in the U.S. compared to more than 50 percent for California and 14 percent for Massachusetts. While Oregon and Washington were both in the top-ten states to garner venture capital investments, they still trail far behind the top-tier VC leaders. One of the issues is that the big venture funds are mostly concentrated in places like Silicon Valley and the Boston Corridor. But another reason might be that fewer public-sector dollars are flowing into clean-tech investing. As we highlight in the 10-Point Action Plan, a concerted effort to invest more public dollars could go a long way in giving markets the confidence that the region is serious about delivering the necessary financial backing to clean tech.

Top Ten States for Clean-Energy Investments, Venture Capital, 2007 ($ Millions)	
California	$1,393.37
Massachusetts	$377.58
New York	$130.60
Pennsylvania	$114.55
Georgia	$86.70
Colorado	$70.62
Oregon	$64.65
Washington State	$47.11
Maryland	$46.01
New Hampshire	$44.49

Source: New Energy Finance, 2008

THE BIG 5 OPPORTUNITIES

In talking with leaders throughout the region, we asked a number of probing questions to understand which opportunities they felt offered the region the best opportunity for mid-term opportunity (defined, for the purposes of this report, as between now and 2025), within the context of carbon-free prosperity. Which technologies already had a foothold in the region? In which technology sectors did the region have a unique competitive advantage? Which of these technologies would have the greatest impact on the reduction of carbon, not only within the region, but on the broader global playing field?

Based on our research, five areas came out on top. Ranked in order of most times mentioned by our interviewees, they are:

Solar PV Manufacturing

Green Building Design Services

Wind Power Development

Sustainable Bioenergy

Smart Grid Technologies

Each of these technology sectors is covered in depth in the following pages, with:

- An overview of the opportunity
- Highlight of the Northwest's unique strengths in that sector
- An overview of barriers and challenges
- A look at the job creation impact of these sectors on the regional economy
- An inside look at some of the key companies and players shaping the opportunity.

Three Runners-Up

While the technology sectors we selected were the clear winners in our survey approach, three other sectors were near-finalists or runners-up: **wave power**; **geothermal**; and **advanced, clean vehicle manufacturing**. While these technologies did not make it into our top tier, they nonetheless offer significant opportunities for the region.

Wave power, for example, is projected to bring on at least 500 MW of new generation capacity by 2025, according to the Oregon Wave Energy Trust. We project that wave

power could represent 2 percent of total energy supply of the major utilities in the region by 2025. Wave energy, however, faces some challenges. The timeline for wave power commercialization is a decade or two away; many people liken the state of today's wave power industry to that of wind power two to three decades ago. In addition, unlike our solar PV manufacturing opportunity, we do not see a large-scale opportunity for the manufacturing, and export of wave turbines. Because of the size and weight of wave turbines, most experts expect that turbines will be built near their point of use. While this is promising for jobs related to development of local resources, it means less potential for major manufacturing export opportunities. Certainly, the region can be a leader in this burgeoning arena, and it should consider pursuing it wholeheartedly, but wave power didn't get ranked as highly as our top five picks.

Geothermal power, likewise, offers significant potential as another good renewable energy source to meet Oregon's and Washington's RPS targets—particularly for its ability to provide baseload power. The Northwest is already seeing interesting players such as AltaRock and the inclusion of a growing but limited amount of geothermal in the power plans of utilities such as Snohomish County PUD. In August 2008, AltaRock, which has its technology development office in Seattle, took an important step towards developing its advanced geothermal technology. The company closed $26 million in second round funding from A-list financiers Khosla Ventures, Kleiner Perkins Caufield & Byers, Google.org, Advanced Technology Ventures, and Vulcan Capital. Other geothermal players, such as Bend, Oregon-based Vulcan Power, have ambitious plans to develop geothermal sites in Oregon. While these are promising developments, nothing in our respondent surveys or research showed the emergence of a large cluster for geothermal technology in Oregon and Washington. That said, we believe it's worth pursuing regional geothermal deployment and development. With Google and others putting significant capital and marketing might behind next-generation geothermal, it could be an important emerging area for the region.

Finally, clean transportation systems, comprising everything from electric scooters to all-electric cars to light rail, are emerging with increased activity in the region, with companies like Brammo, EcoSpeed, Commuter Cars, and Green Lite Motors Corporation starting to make their mark. We are also seeing established old-line players such as Boeing developing fuel-efficient airplanes (the Dreamliner), Paccar planning to adopt hybrid technologies for medium-duty trucks, and Oregon Ironworks working to supply modern streetcar systems to cities across North America. The emergence of a clean-transport systems cluster offers bright opportunities for the region. Like our other two runners-up, while this sector didn't make our final cut, the mid- to long-term opportunities for clean transportation shouldn't be overlooked.

Moving Forward

The following Big 5 opportunities will not necessarily come as a surprise to industry players and even casual onlookers of the clean-tech marketplace. But perhaps this

lack of surprise, the quintessential "aha" moment, isn't such a bad thing. It's always nice to find the needle in the haystack, or the often elusive "silver bullet." But our list, if it seems "reasoned and appropriate," is simply a reflection of the fact that the region is already gaining a significant presence in these five areas—and that there's an increasing level of consensus around the best areas of opportunity.

But we've also taken things that might seem obvious, and drilled down a layer or added a twist—i.e., the opportunity isn't just green buildings, it's the value-added solutions and design services that lay at the foundation of the green building movement. In biofuels, we point beyond the standard corn-based ethanol to "sustainable" bioenergy, primarily from the feedstocks of wood, agricultural, and municipal waste streams.

Job Creation Engine

As we show in the following pages, each of the sectors offers significant job growth opportunities for the region. We go into more depth within each of the individual sections (defining types of jobs, what's counted and what's not counted, our projection basis, etc.). But according to our research, in a medium-growth scenario, we could see more than 40,000 jobs in Washington and Oregon by 2025 from these five sectors alone—and in an accelerated-growth scenario, more than 60,000 jobs by 2025 in the region.

To put this number in perspective, northwest Oregon and southwest Washington's "Silicon Forest" high-tech cluster employed a similar number of employees at its peak a decade ago. It's also 2-3 times the total number of employees working worldwide at search-engine and Internet giant Google. It's important to remember that our objective wasn't to tally all of the "green jobs" or "clean tech" jobs in the region, but the specific direct jobs created by our selected sectors. Our estimates are only focused on the five priority sectors targeted in this report. The potential for green job creation in the region is undoubtedly much broader and larger.

MEDIUM GROWTH JOBS ESTIMATES

Year	Solar PV Manufacturing	Wind Power Development	Green Building Design Services	Bioenergy	Smart-Grid	TOTALS
Current	800	2,217	3,826	3,207	1,280	11,330
2010	1,863	3,043	4,284	3,224	1,491	13,905
2015	3,677	2,650	6,899	4,100	1,715	19,041
2020	9,260	3,408	10,137	5,688	2,209	30,703
2025	14,182	4,507	12,937	6,946	2,669	41,241

ACCELERATED GROWTH JOBS ESTIMATES

Year	Solar PV Manufacturing	Wind Power Development	Green Building Design Services	Bioenergy	Smart-Grid	TOTALS
Current	800	2,217	3,826	3,207	1,280	11,330
2010	1,912	3,749	4,284	4,030	1,935	15,910
2015	4,643	3,861	7,719	6,151	2,781	25,155
2020	13,080	4,541	12,432	8,533	4,478	43,064
2025	22,560	6,083	16,834	10,419	7,212	63,107

OPPORTUNITY #1: SOLAR PHOTOVOLTAIC (PV) MANUFACTURING

The worldwide solar PV industry is growing rapidly and attracting significant investment capital. Over the past four years alone, solar PV installations expanded nearly fivefold globally, from 600 MW installed in 2003 to nearly 3,000 MW installed in 2007. According to Clean Edge research, the global market for solar PV (modules and installations) is now worth more than $20.3 billion and is expected to grow nearly four-fold to $74 billion by 2017.

Against this backdrop of yearly double-digit growth, the industry's expansion has actually been hampered by a shortage of silicon supply, keeping modules scarce and prices high. But the industry climate has begun to change—and we expect prices to continue their traditional declines as silicon and module supply increases. Crystalline silicon feedstock manufacturers, for example, have been ramping up their production

Solar PV Manufacturing jobs: By The Numbers

Solar PV manufacturing currently represents roughly 800 jobs in Washington and Oregon at companies such as REC Silicon, SolarWorld, and Solaicx. We see that number expanding to nearly 2000 by 2010. By 2025, we project the total number of jobs to expand to between 14,182 and 22,560.

SOLAR PV MANUFACTURING TOTAL JOBS ESTIMATES

Year	Medium Growth	Accelerated Growth
Current	800	800
2010	1,863	1,912
2015	3,677	4,643
2020	9,260	13,080
2025	14,182	22,560

Solar PV Manufacturing Economic Modeling Notes

Our projections for solar PV manufacturing jobs are based on proprietary Clean Edge data, including installed PV market size, cost and pricing data, growth projections, and other key market data which closely follows the forecasts released in our annual Clean Energy Trends reports. We then assessed global demand for Northwest-produced solar PV products (i.e. our potential global market share) and conducted an in-depth analysis of US-based demand to cross reference our numbers. Globally, we assume solar PV reaches just under 50 gigawatts (GW) of annual installations by 2025 in our Medium Growth Case, and 90GW in our Accelerated Case (compared with around 3 GW of total global installations in 2007). By 2025, we estimate the Northwest could garner up to 14.5% of global market production output (7.1 GW) in our Medium Growth Case, and 12.5% (11.3 GW) in our Accelerated Growth Case (a lower market share, but based on a much larger global market). In order to come up with our jobs calculations, we assumed an average of 3.5 jobs per MW of solar PV manufactured, declining over time to 2 jobs per MW by 2025. These numbers are based on accepted industry standards and in-depth Clean Edge research on current and projected manufacturing/jobs ratio statistics.

capabilities significantly to meet the needs of the solar manufacturing industry, and major investment in both silicon and non-silicon PV technologies is bringing economies of scale into full force. We're poised to see PV prices coming down rapidly, the first step to solar becoming ubiquitous in the U.S. and around the globe.

But what does this rapid scale-up mean for the Pacific Northwest?

In a region that has been hit hard by the dot-com bust, increased outsourcing, and reduced timber activity, the Pacific Northwest is competing on a global field with such locales as Singapore, Japan, Germany, California, and China to capture as much of the solar PV manufacturing supply chain as possible. While the notion of the often gray and rainy Northwest as a solar leader may seem incongruous, the region's inexpensive hydro power, silicon production expertise, and access to a global market for finished modules make it attractive for the manufacturing of solar cells. PV manufacturing has surfaced as one of the most promising economic opportunities in the region. The question now is whether the Northwest can continue attracting top-tier next-generation companies and prove itself to be a manufacturing powerhouse that can compete globally.

Those interviewed for this report agree almost unanimously that the region is well-positioned to realize a significant portion of the global solar PV manufacturing market. "Oregon is the only place besides Japan where the entire computer value chain exists," said one interviewee. Solar utilizes "the same technology base, same employee knowhow, and high volume manufacturing. We're going to see a cluster of the whole value chain... building off of technology expertise that already exists."

The Northwest could see as much as 2,000 MW production output and approximately 4,000 jobs in PV manufacturing by 2015, with an estimated 14,000-22,000 jobs by 2025. The high-tech cluster around Portland and southwest Washington, dubbed the "Silicon Forest" because of its semiconductor chip production prowess which peaked in the late 20th century, is now providing the foundation for one of the next major regional economic engines of this century.

Capturing the Whole Supply Chain

The region's manufacturing assets of cheap and reliable electricity (more than half currently coming from hydro), skilled labor force (a solid supply of high-tech production talent), and great financial incentives like Oregon's Business Energy Tax Credit (BETC), fit the "wish lists" for many companies and are making the vision of vertically integrated solar industry here a reality. There are about 50 producers of solar PV cells globally, of which the top five—Q-Cells, Sharp, Suntech Power, Kyocera, and First Solar—have almost 40 percent of the market. We expect to see consolidation in the industry

Solar PV Manufacturing Job Titles

Below is a list of some of the types of jobs being created in the emerging area of solar PV manufacturing.

- Crop & Slab Engineer
- Crystal Growing Engineer
- Laser Operations Technician
- Logistics Manager
- Module Manufacturing Engineer
- Production Planner/Scheduler
- Quality Insurance Manager
- Silicon Crystal Growers
- Wire Technology Engineer

in coming years, which will provide both an opportunity and a challenge to the Northwest. Bolstered by existing players like REC Silicon, the arrival of new entrants like Germany-based SolarWorld, and new announcements from companies such as Intel spin-off SpectraWatt, the Northwest could account for a significant share of the global PV production market by 2025.

Silicon Refining

Near the banks of Moses Lake in central Washington, REC Silicon's PV plant owns bragging rights as the first fully dedicated polysilicon plant in the world. REC Silicon has been ramping up the facility's capabilities significantly, more than doubling capacity over the past five years. When the planned expansion is finished, REC Silicon's Moses Lake and Butte, Montana facilities will have a combined production capacity of more than 12,000 metric tons (MT) of polysilicon each year. In five short years, thanks to ambitious RPS targets for West Coast states and the global growth of the solar PV market, REC is at the heart of a regional PV manufacturing epicenter.

Peak Sun Silicon, which claims that its fluidized-bed reactor process can generate silicon wafers using 80 percent less energy than conventional silicon wafer processing, is the most recent silicon processing company to join the regional PV fray. The company is targeting production of 50 MT of polysilicon by first quarter 2009, and 10,000 MT by 2013, at its Millersburg, Oregon plant. Combined, these two companies could produce enough feedstock for 2 gigawatts (GW) worth of crystalline modules by 2013. That would provide the bedrock to a self-reinforcing Northwest cluster of vertically integrated solar PV manufacturing that over the past year has added Sanyo, Solaicx, SolarWorld, and SpectraWatt to its ranks.

Ingots, Wafers, Cells, Modules

Converting a former semiconductor manufacturing plant to a 500 MW solar PV production facility in Hillsboro, Oregon, the German company SolarWorld is a showcase example of the region's opportunity for companies to capture the entire PV value chain. The company currently has the capability to transform silicon into a single crystal ingot, the building block of solar panels, at its Vancouver Washington facility and the new Hillsboro plant. The ingots are then cut into wafers and strung together to make electricity-conducting cells. While the company currently sends the cells down to California to be made into completed modules, the Hillsboro site will eventually expand to include module production. The proximity of the supply chain provides major operational efficiencies in a sector that has already enjoyed sizeable margins over the past three years. The company seeks to ramp up to full production by 2011.

First generation solar modules have an efficiency (the amount of sunlight actually converted to electrons) of 16-18 percent. If crystalline solar is going to scale up aggressively, that efficiency will have to increase while significantly reducing cost. In

Solar PV Manufacturing Opportunities

Below are some near-term and mid-term opportunities for solar PV manufacturing in Washington and Oregon.

Near-Term (0-5 years)

Silicon Feedstock Processing

Ingot and Wafer Manufacturing

Crystalline PV Cell and Module Manufacturing

Mid-Term (6-10 years)

Thin-Film Solar PV Manufacturing (CIGS, Nano, etc.)

Building Integrated PV Modules

the race to develop advanced processes that will result in next-generation advanced crystalline and non-silicon-based technologies, Solaicx is an example of how the region can have a major impact. Flush with $45 million in venture investment, the San Francisco Bay Area-based firm opened a manufacturing plant in North Portland in November 2007. The company has developed its own advanced crystal growing techniques that the company claims are five times more productive than traditional ingots. The wire saws used by the company are its own design and can cut wafers 300 to 150 microns thick—much thinner than first-generation wafers, significantly reducing silicon use and excess waste. The company's 48 MW capacity plant currently houses eight growers and close to 100 workers, but has its eyes set on 160 MW capacity by the middle of 2009—with room to support up to 300 MW.

In traditional PV, with every doubling of manufacturing output, finished modules have roughly seen an 18 percent cost reduction. So it was no surprise when Intel—the company that gave us 'Moore's Law' for the rapid cost reduction of the microchip—announced it was spinning out its' Hillsboro, Oregon-based subsidiary SpectraWatt, as a separate company with the goal of applying the same principles to the cost of solar. The company will manufacture and supply photovoltaic cells to solar module makers and has raised a combined $50 million led by Intel's own global investment arm, Intel Capital, among others. SpectraWatt said it will break ground on its "advanced technology development facility" in the second half of 2008 with shipments expected by 2009. The company has reportedly already secured enough silicon supply to make 60 MW annually for the first phase of its operations. According to Jesse Pichel, solar analyst at Piper Jaffray & Co., the company is targeting one GW of production by 2012, but SpectraWatt has said it may look out of state for a second facility depending on the financial incentives available at that time.

The region also boasts a leading manufacturer of solar inverters, PV Powered in Bend, Oregon, which is covered separately in the section on Smart Grid technologies. This is further indication of the opportunities to create a vertically integrated industry that includes all the components needed for PV production and installation.

Industry Changes and Challenges Ahead

NEXT-GENERATION SOLAR

Currently 90 percent of global PV manufacturers specialize in crystalline, but next-generation solar technologies—thin-film, advanced crystalline, and concentrating PV—are attracting healthy venture investments and scaling up rapidly. Another area of

growth has been concentrating solar power (CSP) which uses lenses to heat a medium (usually water) to turn a turbine to generate utility-scale power. These emerging opportunities present a big challenge, and possibly a big risk, for the Northwest. "What Oregon has done very well so far is traditional crystalline technologies. But the tide is shifting towards new technologies such as thin-film—and how Oregon positions itself or doesn't position itself will determine if it can get the thin-film players as well," said one interviewee.

Currently, XsunX is the only thin-film company that has broken ground in the Northwest, with a 35 MW facility in Wood Village, Oregon. Not far away in southeast Washington, McDonnell Douglas spin-off Infinia, which manufactures Stirling energy systems for space and military applications, has set its sights on CSP. In spring 2008, as a validation of the company's new focus, Infinia raised $57 million from investors that included Vinod Khosla and Paul Allen. The infusion will fund the manufacturing of its new concentrating solar system, which it claims is 25-30 percent more efficient than traditional silicon PV systems. According to news reports, Infinia will produce 250,000 3kW units each year for markets in the American Southwest, Portugal and Spain requiring an estimated 200 new employees, four times its current workforce.

In stark contrast, however, California is home to a growing fleet of startup thin-film PV manufacturing companies, such as Miasolé, Nanosolar, and OptiSolar and CSP leaders such as Ausra, BrightSource, and GreenVolts, that are competing to bring the cost of solar down to grid parity. First Solar in Arizona is leading the nation in the race to deliver low-cost thin-film solar solutions, and currently has a market capitalization of more than $18 billion. This thin-film competition from players outside of the Northwest poses challenges to the region. In the opinion of one interviewee, "technology development is something California does best".

But Northwest solar industry proponents should not despair. As the Infinia example clearly shows, the region has solar companies working to leverage existing skills, expertise, and track records of innovation in new areas. Equally important, the region is still well-positioned to attract outside players with its low-cost energy, high-tech infrastructure, incentive programs, and other assets.

Reminiscent of Silicon Valley in its early days, rumors are abuzz in Silicon Forest about the numerous new solar companies eyeing the region, with cloak-and-dagger code names like Project Ark, Project Harvester, and Project Tahoe. And while Sanyo's name was leaked to the press in July (and confirmed just days before this report went to press), we would not be surprised to see multiple plants moving to the Northwest over the next few years, including some that are leaders in next-generation technologies.

Select Solar PV Manufacturing Companies in Washington and Oregon

The following represent some of the key companies and organizations involved in solar PV manufacturing in the Pacific Northwest. Click names to visit company's web site.

CLOSING THE GAP

As we note above, solar companies have been attracted to the Northwest for a myriad of reasons. But perhaps the strongest incentive has come from the Oregon Business Energy Tax Credit (BETC). State officials predict that in 2008, Oregon will reach $1.4 billion in committed capital for solar manufacturing in the region. A big part of the pull is the BETC, which provides a tax credit of 50 percent for a solar manufacturing plant up to a maximum of $20 million. Just four companies – SolarWorld, Peak Sun Silicon, Solaicx and PV Powered – have received approval for a combined $46 million in tax credits from this one subsidy alone.

While such incentives might become increasingly difficult during a time of economic uncertainty and tightening state budgets, the BETC has proven a very effective tool in attracting big solar players to Oregon. We expect that the state's commitment to the program, perhaps with small tweaks to guarantee the appropriate level of incentives, will continue to attract emerging and established solar names to the region.

FORECAST: BRIGHT SKIES WITH OCCASIONAL CLOUDS

Several recent reports have warned of the risk of too much PV supply on the global market, which when combined with the looming expiration of the federal PTC/ITC (See the 10-Point Action Plan section for details) could cause the PV market to contract at a critical time. Most interviewees expect the PTC/ITC to be extended next year at the latest, and Clean Edge sees any stall in the market as temporary at worst. As we move toward 2025, solar PV's solid fundamentals include its role as a peak power hedge for utilities; its avoidance of transmission construction; its dramatically decreasing costs; and the increasing and volatile costs of competing generation sources such as coal, natural gas, and nuclear power. In fact, the dramatic increase in PV supply will cause further drops in the price of solar—the final step needed for solar to hit grid-parity and enable solar to be cost competitive in a host of markets around the U.S. and the globe.

The Northwest is proving that despite being covered by dark clouds for much of the year, the region can still look to the sun as a major driver of new business opportunities, job creation, and economic vitality. The region can and should continue to pursue opportunities to install solar locally to meet RPS requirements and build out its renewable supplies. (It's worth noting that the global leader in solar power generation, Germany, has a worse solar profile than Western Oregon or Washington, and east of the Cascades the Northwest boasts solar potential comparable with Florida). But the real opportunity for the region, we believe, lies in expanding its strength in manufacturing. In the end, re-aligning Silicon Forest's focus to solar ensures that the region will stay on the leading edge of the global challenge to maximize the social and economic benefits of clean energy.

OPPORTUNITY #2: GREEN BUILDING DESIGN SERVICES

Along with the Pacific Northwest's natural beauty from the San Juan Islands to Crater Lake, its urban bike paths, and its salmon streams, green buildings rank among the most visible physical manifestations of the region's green ethos. The green building sector of Portland and Seattle in particular, already world-renowned for pioneering leadership in eco-conscious design, architecture, and construction, is a key pillar of any regional effort in carbon reduction and green job creation.

Green building, the second-most cited clean-tech sector noted in our interviews behind solar PV manufacturing, presents the Northwest with a "triple threat" opportunity for leadership and competitive advantage. By growing their commitment to carbon-reduction technologies and processes in the built environment, Washington and Oregon can:

- Leverage their existing green building leadership. Even with recent competition from cities like New York, Chicago, and Pittsburgh, the Northwest's Portland and Seattle consistently rank near the top among U.S. cities in Leadership in Energy and Environmental Design (LEED) certifications from the U.S. Green Building Council. Depending on the measure, the two cities (as well as Washington and Oregon statewide) are in the top five, and often the top three, in LEED-certified projects, LEED-registered projects under construction, and total LEED-certified

Green Building Design Services Jobs

Year	Medium Growth	Accelerated Growth
Current	3,826	3,826
2010	4,284	4,284
2015	6,899	7,719
2020	10,137	12,432
2025	12,937	16,834

Green Building Design Services Economic Modeling Notes

Our look into green building design services began with a thorough definition of where design ends and construction begins. For this report, we focused exclusively on those jobs "pre-construction." As a proxy, we analyzed the number of LEED accredited professionals (LEED APs) in "design" categories, and based on a survey with industry players, we concluded that for every LEED AP, there is another green building job that is not LEED certified. We used this one-for-one multiplier to estimate total current "design services" jobs, cross checked with other methodologies, and measured them against various growth scenarios. Our Medium Growth case assumes relatively flat growth in the near term due to poor macro-economic conditions in the building sector, then 8-10% growth in jobs from 2010 through 2015, and long-term normalized growth of 5% (representing a CAGR of 7.4% over the period). Our Acceleration Case assumes similar flat growth in the near term due to poor macro-economic conditions, but an 8-13% growth in jobs from 2010 through 2015 and a 6% long-term growth rate (representing a CAGR of 9.1% over the period).

square footage, both overall and per-capita. There is also notable green building activity and showcase LEED work in other parts of the region. Projects include a 44-unit LEED Gold affordable housing facility in Pasco, Washington; the nation's first LEED Gold hospital in Newberg, Oregon; and the Spokane Convention Center—the third convention facility in the U.S. to earn LEED certification (the Oregon Convention Center in Portland was the second).

- Create jobs and reduce carbon locally, with new LEED construction and the often less-touted market of retrofits.
- Take green building to its next level and lead in reinventing the built environment. The Northwest can seize a leadership opportunity in greening entire communities, designing zero-energy and net-energy positive buildings that go beyond LEED Platinum standards, and rethinking the relationship between the built and natural environments.

The region's key focus should be the continued growth and development of the sector we call Green Building Design Services. Although there is some potential in the manufacturing of green building materials, the region's true strength lies in the intellectual capital of the region's thousands of architects, consulting engineers, project and construction managers, energy and water efficiency experts, and other 'green' professionals. "Among architects, engineers, and designers, there's a very strong green building culture here," said one interviewee. We use a broad definition of design services well beyond traditional architecture and aesthetics. The design services opportunity includes project conception, energy and water systems design, plans for materials sourcing, transport, and reuse/recycling—essentially, new ways of thinking about the built environment and its use of resources.

Green Building Design Services Job Titles

Below is a list of some of the types of jobs being created in the emerging area of Green Building Design Services.

Building Energy Analyst

Design Simulation Professional

Energy Engineer/Building Scientist

Energy Modeler

Green Building Analyst

Green Commissioning Mechanical Engineer

Home Energy and Green Rating Professional

LEED AP

LEED Certification Coordinator

Sustainable Building Engineer

That expertise not only creates green buildings in the Northwest, but as we will discuss later in this section, is 'exportable' across the U.S. and overseas. Whether it's a Portland designer sending CAD schematics to green developers in Atlanta or a Seattle-based LEED architect consulting on site for a new green resort in rural China, design professionals working and living in the Northwest are making their mark far and wide. We project that jobs in the green building design sector can grow from an estimated 3,826 today to 12,937 in 2025 in a medium-growth scenario and 16,834 in an accelerated-growth scenario.

A Strong Legacy

Since the Viridian Place office complex in Lake Oswego, Oregon earned one of the world's first LEED certifications in 2001, green building has been a key part of Northwest culture. In fact, one could easily argue that the region's green building ethos even

predated the LEED label and standards, with Portland's urban growth boundary and other early sustainability measures setting the Northwest on its path to today's green reputation—and several Northwest architecture and development firms already active in the field in the 1990s. Former Oregon Department of Energy director Christine Ervin was the USGBC's first president and CEO from 1999 to 2004, with both the LEED standard and the national Greenbuild conference launched during her tenure. Today, high-profile green building projects in Portland, Seattle, and elsewhere are cited as world-class examples of green design and execution, with the firms responsible for them developing reputations to match.

An impressive and growing roster of green-focused architecture, engineering, and development firms give the Northwest a solid case to make as a world-class cluster of green design. Such firms include Gerding Edlen Development, Interface Engineering, Brightworks, and Sakura Urban Concepts in Portland, and McKinstry, Mithun, and eco-minded developer Vulcan Real Estate in Seattle. Global environmental engineering giant CH2M Hill, founded in Corvallis 62 years ago by Oregon State alumni, now calls Colorado home but maintains a strong presence and workforce (700 employees) in Portland alone. Green projects in the region with national and global renown include the Brewery Blocks, Oregon Health and Science University's Center for Health and Healing, and The Casey Tower (the nation's first LEED Platinum high-rise condominiums) in Portland; and City Hall, the Alcyone apartments, and the Seattle Center's Fisher Pavilion in Seattle. The Emerald City also boasts the nation's largest concentration of LEED-accredited professionals (LEED APs), with nearly 1,200.

Public policy has played a critical role in growing the region's green building sector. Seattle was the first city in the nation to mandate that all new public buildings meet LEED standards, and from 2001 to 2005 the city helped jump-start the sector by offering up to $2 million in reimbursements per project for water efficiency, natural drainage, and LEED design and consulting expenses. Portland was close behind Seattle with a city-building LEED requirement in 2001, and in 2005 added further mandates for city projects such as the recycling of 75 percent of construction and demolition waste, and energy and water savings 30 percent beyond state and federal standards. The Energy Trust of Oregon, with an annual budget of more than $100 million, has been instrumental in promoting energy efficiency upgrades in buildings throughout the state.

But building codes in both cities, and throughout Washington and Oregon, have not always kept pace with the region's green building momentum and have acted as a hindrance; graywater recycling, for example, is illegal in some parts of Seattle. In our 10-Point Action Plan later in this report (see page 56), we urge both states to pass building codes that incorporate 21st century energy and water efficiency

Green Building Design Services Opportunities

Near-Term (0-5 years)
Green Building Design
Energy Efficiency Upgrades and other Green Retrofits
Smart Grid Interconnection

Mid-Term (6-10 years)
Living/Regenerative Buildings (zero energy or better)
Energy District Planning and Development
Green Neighborhoods
Distributed Infrastructure ('off-grid' energy, water treatment, waste processing)

capabilities. Another need: a separate, streamlined process for green building permitting and approval. There needs to be "a special, sustainable or LEED focused design board as opposed to the standard one," said one expert. "We need to slice through that bureaucracy." In a positive step earlier this year, Oregon's state building codes division created a separate green building services section. The unit has already worked with the plumbing industry to update building codes for the use of graywater and rainwater.

The Next Frontier: Design Services

The Northwest can't retain its leadership in green building by resting on past laurels or even on completing current projects in the construction pipeline. Green building is ramping up aggressively across the nation and world, from midtown Manhattan to Grand Rapids, Michigan to the United Arab Emirates. Washington and Oregon can maintain leadership and job creation momentum with a focus on design services: the intellectual capital needed to design, finance and construct major green projects. This includes functions in all phases of green design services, including green architecture; energy, HVAC and water systems engineering; and landscape design and planning. It also includes materials selection, sourcing, transport, and recycling; construction project management; finance; LEED certification process expertise, and integrated project development.

This recognition of a competitive advantage for Northwest green building leaders is already starting to happen. Gerding Edlen, the region's most prominent and prolific LEED developer, launched consulting practice Gerding Edlen Sustainable Solutions in June 2008. "After years of getting the question 'how do you do it?,' it struck us that we were missing out on an opportunity," said cofounder Mark Edlen. "We're not just a development company; we're an integrated solutions provider." As another example, SERA Architects in Portland maintains an extensive and widely-consulted green materials database.

Seattle-based McKinstry, a mechanical/engineering design services stalwart for nearly half a century, has built a national reputation (and an employee base of 650, much of it union jobs) on providing energy usage expertise to a wide range of projects. "McKinstry has morphed into essentially an energy efficiency company," said one expert. "More and more companies, providing services to the built environment, will have to do that. There are thousands of companies that can and must become energy efficiency companies—whether you're a homebuilder, electrical engineer, mechanical engineer, general contractor, Home Depot or Wal-Mart."

Services from companies like these are a sign of things to come as more Northwest green building firms, whether through a formal consulting business unit or not, bring their expertise to projects both within and outside of the region. Two recent examples: CH2M Hill is program manager for the construction of Masdar City in Abu Dhabi, the world's largest sustainable city project, and Brightworks, manager of 85 commercial LEED projects in 10 states, is helping develop a model green community in the rebuilding of tornado-leveled Greensburg, Kansas.

The opportunities to work on these and many other exciting projects worldwide will help continue to attract top creative talent to the green design firms of Portland and Seattle. And the Northwest's green culture and high quality of life, from stunning natural beauty and dynamic urban centers, to great local culture, food, beer, and wine, will continue to entice professionals to work here, perhaps more than in any other industry sector.

"Looking at the big picture, [green building design services] is the biggest potential opportunity of my generation," said one expert. "It could rival Silicon Valley. As a region, if we can continue to be innovative, and export this expertise, the knowledge base opportunity is just huge."

The industry is also proactive in training the next generation of talent. The Emerging Green Builders program of the local USGBC chapter, the Cascadia Region Green Building Council (comprising Oregon, Washington, and British Columbia), features regular presentations in Seattle and Portland to those just breaking into the business from leading Northwest green architects like Mithun and ZGF.

Untapped Opportunity: Retrofits

Most green building attention and headlines focus on new construction, but the Northwest has a significant opportunity for carbon reduction and job creation in energy efficiency improvements and other upgrades of existing structures. This is the focus of the relatively new "LEED for Existing Buildings: Operations and Maintenance" category, green retrofits that can often deliver more bang for the buck than new construction, returning significant energy-reduction benefits for a smaller investment than starting from the ground up. In the residential market, Portland-based nonprofit Earth Advantage (with licensees in Ashland and Eugene) works with remodelers as well as new home builders to promote energy-efficient design and other sustainable features.

Some interviewees noted that much of Washington and Oregon's building stock is relatively new (compared to the Northeast and Midwest, say), and easier to upgrade. Simple weatherization of homes, particularly in low-income neighborhoods, is a win-win that creates community jobs and reduces energy bills. "The penetration of weatherization among low-income residences is only about 15 percent," said one interviewee. "We already have a pretty good delivery system and the jobs don't require a lot of extra training." McKinsey & Co.'s landmark 2007 study on the economics of carbon reduction highlighted building retrofits, including improved lighting, HVAC, and building control systems, as a prime area of "negative costs" that ultimately save more dollars than they cost.

Beyond LEED: Zero Impact or Better

The LEED standards, although effective and widely recognized, have come under increasing scrutiny from progressive architects who feel they don't go far enough. Even LEED Platinum buildings, they argue, are considerable energy users and carbon

emitters. The Northwest has started to lay the groundwork for the next steps in green design: "living buildings" that generate (100 percent renewably) more energy than they use, deliver filtered water back to the local ecosystem, and produce other quantifiable environmental benefits. "It's a holistic, systemic approach, as opposed to installing this or that gadget," said one interviewee. "The more buildings that can meet their own needs, the better off the grid and the environment will be."

Cascadia GBC's Living Building Challenge, launched in 2006, calls on designers, architects, and developers to produce such structures. Buildings must meet strict criteria in categories of appropriate site selection, energy, water, materials, indoor quality, and beauty and inspiration. No buildings have yet earned a Living Building designation, although seven projects were named winners of Cascadia's 2007 Living Building competition for coming the closest. Three were in the Northwest: OHSU's Center for Health and Healing in Portland, the Kenton Living Building residential project in Portland, and the Seminar II learning facility on the Evergreen State College campus in Olympia, Washington.

Living Buildings are a key landmark in pushing the limits of what's possible in archi-

Select Green Building Design Services Companies in Washington and Oregon

The following represent some of the key companies and organizations involved in green building design services in the Pacific Northwest. Click names to visit company's web site.

Seattle Area
- Ankrom Moisan Associated Architects
- Glumac
- Group Mackenzie
- McKinstry
- Mithun
- Vulcan Real Estate
- Zimmer Gunsul Frasca Architects

Portland Area
- Ankrom Moisan Associated Architects
- Brightworks
- CH2M Hill
- Callison
- Earth Advantage
- Gerding Edlen
- Glumac
- Green Building Services
- Group Mackenzie
- Interface Engineering
- Sakura Urban Concepts
- SERA Architects
- Zimmer Gunsul Frasca Architects

Living Buildings are a key landmark in pushing the limits of what's possible in architecture and construction.

tecture and construction, rethinking the conventional relationship between buildings, their use of resources, and their environs. The Northwest can and should be front and center in that effort in areas that range from district energy planning to the USGBC's new LEED for Neighborhood Development standards to buildings as energy generators for the grid.

By growing and exporting the appropriate intellectual capital, implementing progressive building code reforms and green building incentives, and leading by example in its own construction projects, the Northwest can be a world-class leader in the next generation of green building design.

OPPORTUNITY #3: WIND POWER DEVELOPMENT

Along with solar, wind is the fastest-growing source of clean energy worldwide, and it now contributes a significant portion of new generation capacity. Cumulative global installations have passed 100 gigawatts (GW)—with the U.S. accounting for approximately 20 percent of that total. In 2007, approximately 30 percent of total new electricity generating capacity installed in the U.S. came from wind. In early 2008, the U.S. Department of Energy released a study that showed the U.S., with an aggressive but achievable plan, could generate 20 percent of its total electricity from wind by 2030. Worldwide, Clean Edge expects wind industry revenue to nearly triple in the next decade, from $30.1 billion in 2007 to $83.4 billion in 2017.

The Pacific Northwest is already a major player in that global market. While the region may not have the fanfare and publicity of T. Boone Pickens, or the wind resource of the Midwestern plains, it holds its own in wind-related intellectual capital, comparatively strong existing transmission resources, geography, and the benefit of being one of the first regions to embrace wind farms as a significant power resource. As a result, the Northwest has developed a solid cluster of operations and management centers for several of the world's largest wind industry players.

Wind Power Development Jobs

Year	Medium Growth	Accelerated Growth
Current	2,217	2,217
2010	3,043	3,749
2015	2,650	3,861
2020	3,408	4,541
2025	4,507	6,083

Wind Power Development Economic Modeling Notes

To quantify the potential for jobs within the Northwest's wind cluster, we looked at three primary categories of jobs: a) construction, b) O&M, and c) regional headquarters jobs (to capture employment at Iberdrola, Vestas, and other regional headquarters jobs that aren't captured by the "in-the-field" categories). We then developed metrics for jobs-per-MW for the "in-the-field" jobs, and concluded that construction produces approximately 2 jobs/MW, while operations and maintenance (O&M) produces approximately 0.20 jobs/MW. Note that construction numbers can fluctuate year to year according to the wind construction boom and bust cycle, and our numbers currently assume the PTC will be extended and the current boom will continue at an elevated level through at least 2010. We estimated total current "regional HQ" jobs based on primary and secondary research, and concluded there are approximately 800 jobs in the Northwest today (i.e. regional HQ only, not including construction and O&M). Finally, we developed regional deployment figures for the region based on a 25% RPS for OR and WA [see recommended action items in our 10-Point Action Plan], and also factored in wind projects intended to be producers of "exported" electricity to California and elsewhere. In our Medium Growth Case, nameplate capacity reaches approximately 9.8GW by 2025, while our Accelerated Growth case reaches total nameplate capacity of just under 14GW by 2025.

With more than 2,600 MW of wind capacity currently installed or under construction, wind power is a critical component of the Northwest's low-carbon energy mix, with the potential to contribute a significant percentage of our 75 percent target for clean electricity generation by 2025. Combined with a growing wind development community, the right policy incentives, investment in infrastructure, and workforce development, we expect the trend can continue and flourish, making wind power development a key sector for job growth and economic vitality. We project that jobs in the wind sector in the Northwest can grow from an estimated 2,217 today to 4,507 in 2025 in a medium-growth scenario and 6,083 in an accelerated-growth scenario.

A Wind Energy Laboratory

Currently ranked 5th and 7th respectively, in total US wind installations, Washington and Oregon have been wind-power test-beds for the nation. Strategies for successfully integrating a massive scale-up of wind into our regional energy portfolio can benefit the national market, and serve as a model for other parts of the country. That's why many of the nation's top wind brains are working here—at premier wind development companies such as Iberdrola Renewables (formerly PPM), EnXco, Ridgeline Energy, and Horizon Wind, and leading turbine manufacturers such as Vestas and Suzlon.

Wind Power Development Opportunities

Near-Term (0-5 years)

Wind Farm Construction and Generation

Wind Farm Design and Planning

Transmission Expansion and Upgrades

Mid-Term (6-10 years)

Offshore Wind Development

Smart-Grid Integration

But contrary to what some in the region believe or hope, our research indicates that wind industry manufacturing, particularly for wind turbines themselves, is not likely to be a regional strength. This was most recently evidenced by Vestas, despite having its North American headquarters in Portland, opting to build its turbine manufacturing plant in Colorado. Here, the Northwest's geographic remoteness from much of the country is a factor; transportation proximity to the Midwest plains, where hundreds of GW of wind could be installed over the next 20 years, is a priority for turbine manufacturers.

Northwest Wind Drivers

Wind development companies have moved to the Northwest to take advantage of the region's solid wind resources, transmission infrastructure, policy/financial incentives, comparatively cheap real estate, and increasingly to feed California's large market demand for clean energy.

WINDSURFERS AND WIND TURBINES

It is not uncommon for people to see 100-foot wind turbine blades transported around the Northwest on truck beds en route to the Columbia River Gorge that separates Oregon and Washington. Although neither state ranks among the top 20 in the U.S. for total wind resource potential, according to a Pacific Northwest National Laboratory study, the wind-surfing mecca of the Gorge is definitely a gusty place. At 300 MW, Stateline is currently the largest operating wind farm in the region—and at the time it was proposed in 2001, it

was the largest single wind energy development in the world. Built and operated by FPL Energy, the country's largest wind developer, the farm now supplies electricity across the state of Washington to Seattle City Light, the Bonneville Power Administration and Avista. Since land-based wind systems require average wind speeds of 6 meters/second (13 mph) at a height of 50 meters above ground, wind turbines are going to continue to add to the backdrop of the scenic River Gorge for the foreseeable future.

AGGRESSIVE RPS TARGETS (INCLUDING CALIFORNIA'S) AND FINANCIAL INCENTIVES

Regional investment in wind power could reach as much as $700 million in 2008 and $3.8 billion in 2013, according to BCC Research. Wind power, as the single largest non-hydro renewable resource, currently represents approximately 5 percent of Oregon and Washington's generation mix for major utilities. As the most easily deployable, cost-competitive, and scalable renewable resource, wind will likely be the main generation driver (and just behind conservation and efficiency in the ranking of energy resources) that would enable the region to achieve a combined 25 percent RPS target for its major utilities.

Wind Power Development Job Titles

Below is a list of some of the types of jobs being created in the emerging area of Wind Power Development.

Wind Field Technician
Wind Plant Monitoring Technician
Wind Data Analyst
Site Supervisor
Senior Risk Management Analyst
Senior Buyer
Wind Energy Forecasting and Resource Assessment
Site Prospector
Wind Plant Administrator
Senior Property Agent

In our medium-growth scenario, by 2025 wind could provide 14 percent of the region's major utility supply with approximately 10 GW installed. This would represent more than half of Oregon and Washington's RPS requirement, while still having remaining capacity to export out of state. In an accelerated scenario, the region could hit 14 GW of wind installed, exporting more than 50 percent of the energy generated to other regions. The latter target is ambitious, and would require significant expansion of the region's transmission capacity. But the rising costs of fossil fuel-based electricity combined with other states' growing demand for clean energy makes this goal potentially achievable.

As we are already seeing, California's growing demand for electricity and its aggressive RPS target of 33 percent by 2020 will continue to be a major driver of wind development in the Northwest. Three recently announced Oregon-to-California power purchase deals emphasize this point. The newly-approved 909 MW Caithness Shepherd's Flat wind farm in Central Oregon will be sending electrons 1,000 miles south to Southern California Edison for the next 20 years. On a smaller scale, Los Angeles Department of Water and Power is buying 100 percent of the electricity generated from a 72 MW farm in Gilliam and Morrow Counties, and Pacific Gas & Electric will buy 90 MW from Iberdrola Renewables subsidiary Klondike Wind Power III's wind farm in Sherman County. California utilities are scrambling to meet their existing RPS targets and wind is one of the fastest ways to get there.

WIND PROVIDES A HEDGE AGAINST FOSSIL FUELS

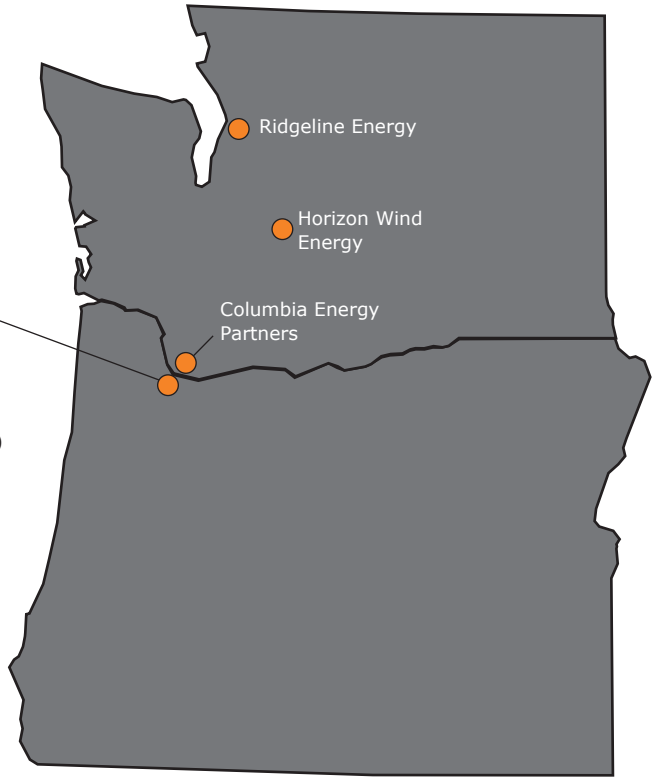
As a price on carbon develops in the next few years as either part of a regional or national system, wind provides an important hedge against costly fossil fuels. This point has not been lost on utilities that understand the impact on their operations—not to mention customer rates—of a continued increase in the cost of fossil fuels combined with a cap and trade or carbon tax regime. In Oregon and Washington, utilities are procuring wind power through power purchase agreements in addition to developing the resource in-house and owning the project themselves. The Northwest boasts a key feature that helps assuage utilities' fears about the intermittent nature of wind power: the country's most extensive network of hydroelectric dams. Dams provide the flexibility required for balancing generation; in simple terms, holding water back or letting it flow. As one interviewee said, "the Northwest has a great set of batteries."

Regional Workforce Training Resources

Unlike many other clean tech sectors, the wind industry already has a fairly solid

Select Wind Power Companies in Washington and Oregon

The following represent some of the key companies and organizations involved in Wind Development in the Pacific Northwest. Click names to visit company's web site.



Portland Area

- EnXco
- Horizon Wind Energy
- Iberdrola Renewables (formerly PPM)
- REpower Systems USA
- RES (Renewable Energy Systems)
- Suzlon Energy
- Vestas

education/training base in the region; Central Washington University, Lane Community College, and Columbia Gorge Community College, among other institutions, all offer wind-related programs. Success in landing wind technician jobs for graduates of the Columbia Gorge program has inspired The Dalles-based college, with a second campus in Hood River, to set its sights on tripling the size of the program in the next three years. These programs are extending the benefits of wind for rural communities beyond simply leasing land for wind turbines. To be sure, there will need to be more coordination, funding, and support for training/workforce development at the state and federal levels to meet the demand for high-quality technicians, operators, and wind energy analysts. But with the right investments and policies in place, the locally trained graduates will continue to extend the region's expertise in wind power management and production.

Challenges

PTC/ITC

Like solar, wind development is highly dependent on the federal tax credits. Although many of our interviewees were confident that Congress would pass the soon-to-expire Production and Investment Tax Credits (PTC/ITC) for at least another year, the threat alone is damaging. Wind is the most cost-competitive renewable resource but needs the tax incentive in order to compete with other sources of electricity in the region. In a carbon-constrained scenario—where coal and natural gas are subject to a price on carbon—wind will be more likely to compete on economics alone. But until then, deployment in the region could slow without the extension of the PTC/ITC.

STORAGE, TRANSMISSION INFRASTRUCTURE AND CURRENT GRID AVAILABILITY

A key challenge for most renewables—the need to provide baseload capacity and increase storage capability—becomes more critical as wind scales up. As a foreshadowing of things to come, a 'sudden thaw' of ice from the Hood River Valley in mid-2008 caused an unexpectedly large amount of water to flow down the Columbia River's series of dams. Since the region was simultaneously experiencing strong winds, it meant that wind power had to be throttled back—and a significant amount of potential wind-generated energy went to waste. In the future, with a combination of storage capability and an upgraded transmission infrastructure, that excess power could be used later or sold to other markets.

Utilities are attempting to solve the storage conundrum. Xcel Energy in Colorado is testing a sulfur battery system with the potential of up to 7 hours of storage—a major balance to wind's intermittency. Advances on this front could be a major game-changer for wind developers in the Northwest and elsewhere.

Transmission is a key challenge for the region. The vast majority of electricity demand comes from the central and western parts of the region, but the majority of the clean-

energy generation sources, including wind, are in the less-populated east. Interviewees said that once the region hits a 6,000 MW target of wind power capacity—potentially within the next 5-7 years—there will need to be significant improvement to the transmission grid to accommodate any additional growth. “Transmission is absolutely critical—no matter what resource gets built,” said one industry expert.

Financing is one of the central challenges to solving transmission issues in Oregon and Washington. One of the region’s key coordinating bodies, The Northwest Power Conservation Council, convened a Wind Integration Group in 2007 that brought together the region’s major utility and wind players. Among the group’s 15 recommendations was to overhaul the current system of financing for new generation projects. “The financing model must address the Catch-22 confronting many wind project developers,” said the group’s report. “They cannot [finance] a new transmission line unless they have security in the form of a power purchase agreement; yet they typically cannot secure a power purchase agreement without a long-term transmission service agreement.”

Clearly, all of these issues are not falling on deaf ears. The solutions to these challenges are not beyond the ability of the individuals, organizations, and companies that have created this robust and growing Northwest cluster. It is now mostly a matter of timing. The faster these solutions come online, the sooner the full economic opportunity wind provides can be realized in Oregon and Washington.

OPPORTUNITY #4: SUSTAINABLE BIOENERGY

No clean technology sector faces more current global controversy than biofuels. The diversion of food crops like corn and soybeans as energy feedstocks has impacted global commodity supplies and prices, and even non-food energy crops like switchgrass have raised land-use issues. In recent months, this has brought ethanol and biodiesel under unprecedented scrutiny as cleaner alternatives to petroleum. Some U.S. politicians have sought scale-backs of mandated government renewable fuel standards (RFS), something that the European Union did earlier this year; the Republican Party's 2008 campaign platform calls for an end to the RFS mandate altogether.

But we believe that the biofuels market, even though it has hit some recent potholes and speed bumps, is poised for continued significant expansion, especially for biofuels based on new "non-food" feedstocks. In fact, growing pressures on global petroleum supplies are accelerating the drive toward liquid fuel alternatives. Oil now accounts for over 95 percent of global vehicle fuels, so this drive will only intensify as China, India, and other nations become more affluent and motorized. It is vital that sustainable biofuels options be vigorously pushed forward, or less sustainable biofuels and carbon-intensive unconventional fossil sources such as tar sands and coal-to-liquids could be widely developed. Energy supply and security considerations will likely trump all others as liquid fuel supplies become increasingly stressed, so it is crucial to bring solutions on line that also meet environmental goals.

The national RFS signed by President Bush in 2007 calls for U.S. biofuel production to increase from 6.5 billion gallons in 2007 to 36 billion gallons by 2022. And equally

Sustainable Bioenergy Jobs

Year	Medium Growth	Accelerated Growth
Current	3,207	3,207
2010	3,224	4,030
2015	4,100	6,151
2020	5,688	8,533
2025	6,946	10,419

Sustainable Bioenergy Economic Modeling Notes

In order to come up with our bioenergy job calculations, we divided bioenergy into two subsectors: a) biofuels and b) biomass. For biomass, we looked at current production levels in Washington and Oregon, grew them according to annual growth figures extrapolated from our RPS exercise (again, assuming 25% in both OR and WA), and applied them to a jobs/MW factor of 6 jobs per MW. Our Medium Growth Case assumes production of just under 1GW by 2025, while our Accelerated Growth Case assumes production reaches 1.4GW by 2025. For biofuels, we assumed an RFS of 10% by 2025 in our Medium Growth case, reaching 550MGP (million gallons of production) by 2025. Our Accelerated Growth Case assumes a CAGR of 11.2% over the period (vs. 8.6% in our Medium Growth Case), reaching 825MGP, or a 15% RFS. Using similar methodology to our biomass figures, we used 2.5 jobs/MGP trending downwards to 2.2/MGP by 2025.

striking, starting in 2009, the RFS includes an escalating mandate for fuel from cellulosic feedstocks, with the requirement reaching 16 billion gallons, or 45 percent of U.S. production, by 2022. (Cellulosic feedstocks refer to non-food plants, i.e. not corn or soybeans, agricultural waste such as wheat straw, wood waste, and non-ag feedstocks such as municipal waste.) Globally, with expanding demand in Europe, Asia, Brazil, and other places, Clean Edge projects the worldwide ethanol and biodiesel markets to grow from $25.4 billion in 2007 to $81.1 billion in 2017.

Against this backdrop, the Pacific Northwest has a significant opportunity for global leadership in truly sustainable bioenergy. By that we mean bio-based sources for fuel, heat, and electricity, primarily from the waste streams of forestry, agriculture, and municipalities. This opportunity capitalizes on the region's world-class natural resources and traditional industries of logging and farming, combined with new technologies and intellectual capital in areas such as sustainable forestry, enzyme development, refinery design and engineering, and biochemical and thermal conversion techniques.

The resources for sustainable feedstocks are here; the opportunity lies in developing and growing the intellectual resources to make sustainable bioenergy a true regional clean technology industry. It's a next-generation industry with the potential for job creation, carbon reduction, and the export of related intellectual capital beyond the region nationally and globally. We project that with the right policy incentives as outlined in the 10-Point Action Plan section of this report, the Northwest's sustainable bioenergy can grow from an estimated 3,207 jobs today to 6,946 in 2025 in a medium-growth scenario and 10,419 in an accelerated-growth scenario.

Sustainable bioenergy carries the added benefit of bringing the new energy economy to the often economically sluggish farming and logging areas of the region, helping bridge the economic and political divide between urban and rural areas cited by many of our report's interviewees. "We can't have an urban vs. rural culture war around the environment," said one interviewee.

Like most clean-tech opportunities, this is an urgent one, with other regions also looking to wrest the current bioenergy crown away from the Midwest as the world moves from corn and soybeans to cellulosic feedstocks in the coming years. Colorado-based cellulosic ethanol pioneer Range Fuels, for example, has chosen the pine forests of Georgia for a 100 million gallon-per-year cellulosic refinery. The Northwest has no time to lose in pursuing sustainable bioenergy leadership.

Sustainable Bioenergy Job Titles

Below is a list of some of the types of jobs being created in the emerging area of Sustainable Bioenergy.

Plant Engineer
Biodiesel Process Engineer
Engineer—Biomass Systems Integration
Assistant Plant Operator
Station Attendant
Maintenance Mechanic
Production Operator
Operating Engineer
Plant Technician
Laboratory Technician

A Solid Start

The Northwest has developed a strong biofuels base in recent years. Pacific Ethanol (with a 40 million gallon-per-

year ethanol plant in Boardman, Oregon) and Portland-based SeQuential Biofuels have been solid players in the industry, and Seattle's Imperium Renewables, although facing financial and management stumbles in recent months, has done pioneering work in commercial-scale biodiesel production. Policy mandates—such as Portland's first-in-the nation requirement that all fuel sold in the city include a biofuel component (10 percent for gasoline, 5 percent for diesel) and strong statewide Renewable Fuel Standards—have helped establish a strong local market in Oregon and Washington. But it's the next generation of bioenergy feedstocks, specifically waste streams that offer the region the best opportunity for meaningful carbon reduction and the creation of regional cluster expertise. The potential for world leadership in the use of non-food feedstocks for bioenergy, filling a critical need in the coming decades, makes this opportunity an exciting one.

Sustainable Bioenergy Opportunities

Near-Term (0-5 years)

Wood waste to fuel, energy, and cogeneration

Custom-grown trees (e.g. poplar) to fuel

Municipal waste conversion

Crop waste (e.g. wheat straw, grass seed straw) to fuel

Paper pulp to fuel

Mid-Term (6-10 years)

Aviation biofuels

Biogas (natural gas) from cow manure, at scale

Another potential biofuels niche, aviation fuel, can capitalize on one of the region's traditional leadership industries. Boeing is already working with a number of worldwide airlines in testing biofuel alternatives to petroleum-derived kerosene to power jets. So far, Northwest-based suppliers of alternative jet fuels, like American Clean Coal Fuels of Portland and Baard Energy of Vancouver, Washington, have focused on synthetic aviation fuels derived from coal—a process that would likely increase rather than decrease the carbon intensity of aviation fuels. But it's an area worth watching as Boeing works with world aviation leaders like Virgin Atlantic founder Sir Richard Branson on the next generation of aviation fuels, including those from sources such as wood waste, prairie grass, jatropha and algae. Boeing has taken the lead in forming the Algal Biomass Organization, a trade association working on creation of biofuels from algae, which is holding the 2008 Algae Biomass Summit conference in Seattle in October 2008.

Timber: A Range of Feedstocks

The Northwest's best-known source of biomass is the region's traditionally dominant commercial activity for more than 150 years, the timber industry. Forests cover 47 percent of all acreage in Washington and Oregon, and forest thinnings and lumber mill shavings, among other wastes along the timber processing chain, create a huge volume of wood residue with the potential for conversion to biofuels and bioenergy products like wood pellets. Many R&D efforts are underway to study and develop appropriate conversion technologies, notably the Catchlight Energy LLC joint venture between Weyerhaeuser and Chevron, with employees in both Federal Way, Washington, and San Ramon, California. In theory, Oregon alone creates enough waste wood, fiber, and pulp production annually to produce 700 million gallons of ethanol, according to the Oregon Science and Technology Partnership. That's enough to displace a significant

chunk of its annual 1.5 billion gallons of gasoline consumption.

Timber waste has been historically used as an energy source for industrial processes, both through direct combustion in "hogged fuel" (an unprocessed mix of bark pieces and wood fiber) boilers and through combustion of pulping residues such as black and red liquors. Increasingly, many industries are turning to cogeneration as a way to get sell low carbon power to utilities anxious to meet state-mandated renewable power standards. The Northwest's largest renewable biomass energy project is at the Simpson Tacoma Kraft mill in Tacoma, where a 55 MW cogeneration facility powered by the mill's wood waste and recovery furnaces plans to begin supplying power Iberdrola Renewables in August 2009.

Significant challenges, however, face the use of wood residues as a feedstock for liquid biofuels. Wood is high in lignin, which is generally harder for most enzymes to break down into biofuels than the cellulose of "softer" feedstocks like switchgrass and miscanthus. Then there are the logistical, and often carbon-intensive, challenges of hauling trimmings from remote forest areas to biorefineries located near cities or transportation hubs. But the biggest hurdle may be financial. To date, the wood waste-to-bioenergy proposition simply hasn't made economic sense in most cases. Where it is feasible to collect and transport the trimmings, most suppliers get a much better price for using wood waste in materials rather than conversion to fuel or energy.

The economic formula changes, however, in the niche of growing specialized trees specifically as cellulosic feedstocks. One company, GreenWood Resources in Portland, operates a Forest Stewardship Council-certified 17,000-acre poplar farm near Boardman, Oregon, for this purpose, GreenWood aims to supply woody biomass feedstock to Pacific Ethanol and smaller producers like ZeaChem, a California company building a 1.5 million gallon-per-year cellulosic biorefinery at the nearby Port of Morrow. The partially DOE-funded Pacific Ethanol plant in Boardman, the Northwest's largest cellulosic ethanol demonstration facility, will produce fuel from wood, wheat straw, and corn stover. GreenWood, with other tree farms in Canada, China, and Chile, is also bringing its trees-to-biofuels expertise to international markets.

Another potential wood-related bioenergy opportunity is the use of paper industry pulp mills as "biorefineries" to convert wood wastes and pulping byproducts into biofuels and fuel sources for heat and electric generation. This nascent area carries potential as both a sizable source of regional bioenergy production and the chance to create new green jobs in reviving the infrastructure of a depressed industry.

Pulp mills already get some 60 percent of their power from the firing of wood residues and pulp waste known as "liquors," so exporting energy products beyond the mill is not a huge leap—if the economics are right. This opportunity is still in the R&D stage; the pulp industry has identified at least a dozen thermochemical, gasification, gas-to-liquid and other technology pathways from pulp to energy, but no winners have yet emerged. The American Forest and Paper Association published a summer 2008 study

detailing some of these processes, and presented findings at an international bioenergy and bioproducts conference held in Portland in August.

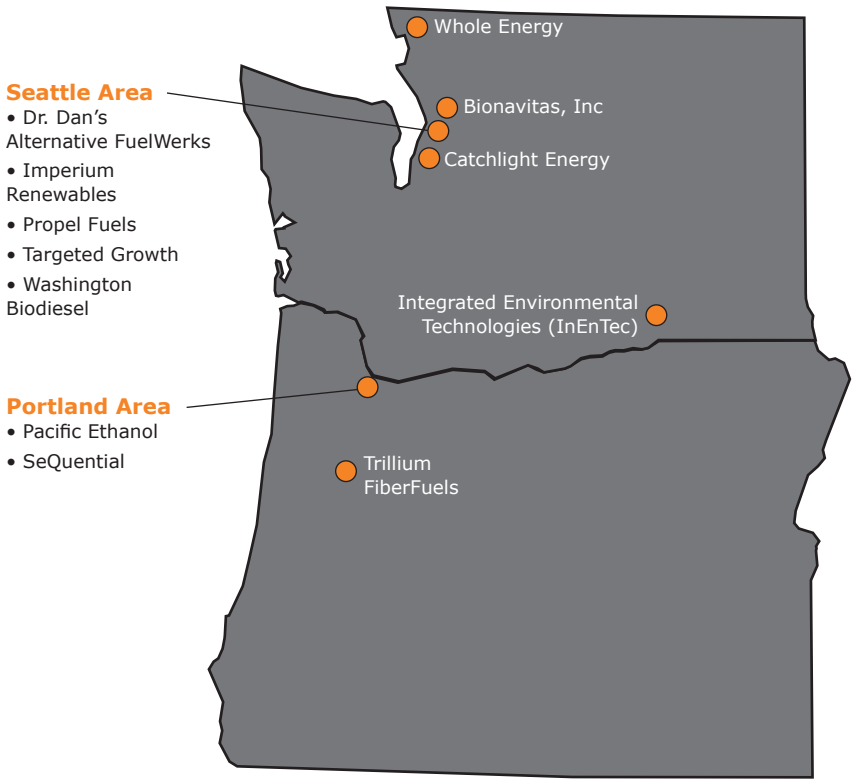
A closely related niche may involve combining pulp-to-biofuels and the use of agricultural waste feedstocks with paper recycling. New Leaf Paper, the world's largest producer of recycled paper, is considering using a shuttered mill on the Columbia River near Wallula, Washington, to convert wheat straw into both paper and cellulosic ethanol—its first foray into biofuels.

Municipal Waste-to-Energy

Compared to forests, the Northwest's municipal waste streams solve the feedstocks-from-long-distances problem and in fact have the opposite effect, reducing the current carbon emissions from transporting cities' trash to remote landfill sites. Most municipal trash is hauled great distances from the region's population centers along I-5 to huge landfills east of the Cascades, notably the Roosevelt Landfill in Klickitat County, Washington (home to garbage from 34 of Washington's 39 counties) and the Columbia

Select Sustainable Bioenergy Companies in Washington and Oregon

The following represent some of the key companies and organizations involved in Sustainable Bioenergy in the Pacific Northwest. Click names to visit company's web site.



Ridge Landfill near Arlington, Oregon, 130 miles from the Portland metro area.

The organic waste content of Oregon and Washington's municipal waste represents fully 70 percent of the region's entire biomass resource, according to Pacific Northwest National Laboratory's 2008 report, Biofuels in Oregon and Washington: A Business Case Analysis of Opportunities and Challenges. "In order to get past 10 percent bio content for the region's fuel supply, you're not going to get there on wheat straw or wood waste," says one of the report's authors. "You need a bigger biomass resource base, and that's the opportunity. Municipal waste isn't what people first think of as a renewable resource, but several million tons of it every year goes to Roosevelt and goes into a big hole."

Although the technologies to process the organic components of municipal waste into bioenergy are still nascent, leadership in the Northwest is already emerging. Integrated Environmental Technologies LLC (InEnTec) in Richland, Washington and Bend, Oregon, is commercializing a waste-to-ethanol process based on hazardous/radioactive waste processing technology developed at PNNL. The technology is being used in the nation's first planned commercial-scale municipal waste-to-biofuels project, the Sierra BioFuels plant being built near Reno, Nevada, with a projected opening in 2010. The project aims to convert 90,000 tons of garbage per year into 10.5 million gallons of ethanol, and InEnTec says it's talking with several municipalities in the Northwest about comparable projects.

Agriculture Feedstocks and Market Realities

Unlike farmers in the Midwest, where the already-dominant food crops of corn and soybeans became (with much federal assistance) a ready market for the biofuels industry, Northwest agriculture faces a different challenge and opportunity. The region's biggest food and feed crops of wheat, hay, and alfalfa aren't feasible feedstocks for ethanol or biodiesel. So farmers essentially face an economic choice of what can fetch a higher market price: wheat, say, or an emerging type of crop for use as a cellulosic or oilseed feedstock. To date, the answer has nearly always been wheat, mainly because cellulosic and oilseed fuels markets will remain low-volume until the requisite enzymes and refining processes work out their respective technological kinks.

Therein lies a regional opportunity for research-focused enterprises such as Trillium FiberFuels in Corvallis, Oregon and Seattle-based Targeted Growth Inc. Perfecting (and lowering the costs of) cellulosic and oilseed refining is an area where Northwest startups, in partnership with researchers at PNNL or state universities, can establish leadership and then transfer expertise to other regions. Targeted Growth is a key example of the emerging Northwest life sciences sector branching into energy, applying scientific understanding of cell growth developed in the biomedical field to emerging biofuels oilseed feedstocks such as camelina.

Using agricultural waste streams for biofuels presents a very attractive carbon reduction proposition. A great deal of the straw residues from Oregon and Washington wheat,

cereal grain, and grass seed production are generally burned or left to decompose, resulting in significant CO2 emissions. In theory, collecting straw and transporting it to refineries for processing into petroleum-displacing biofuels could have a major payoff in carbon reduction.

But here again, the economics are tricky. The PNNL report concluded that the costs of collection, storage, and transport reduce the cost-effective portion of the region's straw waste to less than a million tons per year (out of a total resource of 10 to 12 million tons). Any residue collection system must also take into account the need to leave a portion of biomass in the fields to preserve soil fertility.

Another major agricultural waste stream, in more than one sense of the word, is cow manure. NW Natural, the region's largest natural gas supplier, is working to expand the nascent technology of biogas—natural gas captured in methane biodigesters. The potential is big—Oregon's dairy cows alone produce nearly 15 million pounds of manure a day. NW Natural was the first natural gas company to offer customers an offset program, analogous to electric utilities' green power options. Home and business natural gas customers who sign up for NW Natural's Smart Energy program choose to pay a small premium to help fund biogas development. It's another niche that helps bring clean energy jobs and revenue to rural agricultural areas. California will also credit biogas fed into natural gas lines around the West for meeting its renewable electricity standard.

In sum, Oregon and Washington have a significant opportunity to lead in the development of technologies, processes, and expertise for converting waste streams into 21st century cellulosic and oilseed bioenergy. Although the region likely won't be a major grower of energy crops, its leadership in the conversion of agricultural, forest and municipal waste to biofuels and biogas could become a major force as the world turns away from food crops to produce energy. The Northwest's existing concentration of expertise, leading companies and installed industrial base in the forest products area provides opportunities for adaptive leadership. With the type of policy incentives and leadership outlined in this report, we believe that the region could become a world-class center of expertise for creating the next generation of sustainable bioenergy.

OPPORTUNITY #5: SMART GRID TECHNOLOGIES

Smart grid technologies, in many ways, hold the key to most of the Pacific Northwest's top clean-tech opportunities. Moving forward toward 2025, the regional growth of the wind, solar, and green building sectors will all rely to some extent on grid modernization. So the development of smart grid technologies is both a ripe opportunity and something of an imperative for Oregon and Washington.

The growth in emerging generation technologies such as solar PV and wind power, coupled with green buildings and energy efficiency—plus the demands of our always-on digital economy—require the build-out of an improved, 21st-century grid. This significant shift from the "old ways of doing business" offers significant opportunities to innovative Northwest companies that can provide next-generation energy intelligence. This burgeoning field spans everything from software and smart meters to energy management systems and demand response—the control of customers' electricity demand based on changes in costs or levels of energy supply.

Smart Grid Technologies Jobs

Smart Grid Technology Companies currently represent around 1,300 jobs in Washington and Oregon, with the bulk coming from the two largest players in the region, Itron and Schweitzer Engineering Laboratories, Inc. While we don't see as many jobs coming out of the Smart Grid Sector as Solar PV Manufacturing, for example, we could see the emergence of a number of growing players with a combined regional employment base of between approximately 3,000 and 7,000 by 2025

Year	Medium Growth	Accelerated Growth
Current	1,280	1,280
2010	1,491	1,935
2015	1,715	2,781
2020	2,209	4,478
2025	2,669	7,212

Smart Grid Technologies Economic Modeling Notes

Similar to our methodology in solar PV manufacturing, we developed our jobs figures for smart grid technologies by looking at global industry figures and using primary research to come up with an ongoing global market share for PNW-based smart grid companies. Our Medium Growth Case assumes the industry grows at a lower overall growth rate (10% CAGR), and that the Northwest garners a slightly lower market share (8% initially trending to 3% long-term). Our Accelerated Growth Case assumes an overall growth reaching a CAGR of 13%, with the Northwest's market share trending from 8% initially to 5% long term. Globally, the numbers estimate total PNW smart grid-related revenues growing from $3.2B today to $6.7B by 2025 in our Medium Growth Case and to $18B in our Accelerated Growth Case. The significant difference between our Medium Growth Case and Accelerated Growth Case is primarily due to the region being able to capture, in our Accelerated scenario, a much larger percentage of the total global market for smart grid and advanced 21st century grid technologies. Finally, we researched current industry revenues per employee (both regionally and nationally) to arrive at our assumed jobs metric of 5 jobs/$1M Revenue, which we then applied to our regional revenue figures calculated per our above methodology to arrive at our final jobs figures.

Fortunately, as with the other four opportunities detailed in this report, the smart grid builds on existing technology and intellectual capital strengths already present in Washington and Oregon. The simplest definition of what the smart grid means—applying information technology for the more intelligent and efficient delivery of electricity—taps into the region's traditional IT leadership and workforce skills from Intel, Microsoft, and many other players.

In early 2008, Microsoft joined the Bonneville Power Administration (BPA), Pacific Northwest National Laboratory, Hewlett-Packard, Itron, Washington State University, and some 60 other companies and organizations as a member of the GridWise Alliance, a Washington, D.C.-based organization promoting a more reliable and intelligent grid. Intel (through its VC arm Intel Capital) has invested in Grid Net, a provider of network management system software which licenses its solution to customers such as GE Energy. High-tech participation is critical, as the smart grid incorporates Internet-based concepts such as redundancy, distributed networks, and the two-way flow of information and electrons. That clearly creates business opportunities for the Northwest's sizable tech-savvy workforce.

Smart Grid Technologies Opportunities

Below are some near-term and mid-term opportunities for Smart Grid Technologies in Washington and Oregon.

Near-Term Opportunities (0-5 years)

Smart Meters

Digital Sensors

Demand-Side Management

Energy Efficiency Software

Mid-Term Opportunities (6-10 years)

Electric and Plug-In Hybrid Vehicles Integration (V2Grid)

Management of Grid Interface with Living Buildings and Green Neighborhoods

Energy District Planning

Both BPA and PNNL have been leaders in researching, developing, testing, and deploying a range of smart grid concepts and technologies. BPA's wide area management system (WAMS) substation sensors network, providing updates on the Bonneville grid 30 times per second, has been a model for similar projects in the West and Northeast. The University of Washington and Washington State University have two of just 15 power engineering graduate programs in the U.S. And smart grid-related technology companies of various sizes—among them Itron in smart meters, Verdiem in demand-side management systems, PV Powered in solar inverters, Schweitzer Engineering Laboratories in utility systems controls, Serveron (now a unit of BPL Global) in transformer monitors, Alerton in building intelligence, and V2Green in vehicle-to-grid integration, have made the Northwest a significant force in the energy-management and smart grid sector.

Athena Institute, which evaluated the smart grid market for an earlier Climate Solutions report, identified 225 "smart energy" companies in the region in 2002, comprising $2 billion worth of a then $15 billion global industry. More recently, Itron alone posted revenue of $1.46 billion in 2007 and employs more than 8,500 people worldwide. Research firm Global Smart Energy, headquartered in Redmond, Washington, now estimates the global market for smart grid technologies at approximately $40 billion for 2007.

"Energy efficiency, smart grid, and demand response may not be as glamorous as solar or wave power," said one expert interviewed for this report. Nevertheless, they involve clear opportunities to save significant amounts of energy, and create jobs, in a sector

where Northwest companies have already demonstrated leadership.

Leadership Lost?

But the Northwest, say several of this report's interviewees, has ceded much of its early smart grid leadership to other regions. A 2005 Climate Solutions report, Powering Up the Smart Grid, called for an ambitious Northwest Smart Energy Initiative that would bring together state and local policy makers and regulators, utilities, research labs, and companies to jump-start and coordinate smart grid efforts; it has not happened, at least not in this region. Instead, the United States' largest test of a smart grid deployment began this year under the auspices of Minneapolis-based utility Xcel Energy in Boulder, Colorado, not the Northwest. Many of the fastest-growing U.S. players in the sector, such as Comverge, EnerNOC (both with recent initial public offerings), and GridPoint, are based elsewhere. "Either the Northwest has fallen behind on smart grid," said one interviewee, "or other areas have caught up."

Smart Grid Technologies Job Titles

Below is a list of some of the types of jobs being created in the emerging area of Smart Grid Technologies.

AMI (Advanced Metering Infrastructures) Hardware Product Manager

Electronic Test Technician

Energy Systems Controls Engineer

Field Service Engineering Technician

Manufacturing Supervisor

Power Electronics Engineer

Program Manager

Senior Software Engineer

Test Automation Engineer

Utility Program Manager

While we see the big opportunity in the region as growing the business and workforces of the companies that make the software, meters, and other "intelligence" features of the smart grid, local utility involvement is also critical, as we point out in the 10-Point Action Plan later in this report. But utilities, in the Northwest and around the nation, aren't known for their risk-taking and innovation. "Utilities really stink at R&D," said one interviewee. "Companies that make shoes spend more on it than [utilities] do." According to a number of respondents, the region also has no policy or incentive or support for organized large investment by utilities in areas like the smart grid, further dampening the potential for regional smart-grid deployment.

A Multi-Location Opportunity

Perhaps more than some of the other clean-tech opportunities, smart grid technologies can create employment clusters in a wide swath of areas across the Northwest. As with solar, bioenergy and other clean-tech sectors, smart grid leadership doesn't need to come from the region's largest urban centers of Seattle and Portland. PNNL in the Tri-Cities area of central Washington, Itron in the Spokane suburb of Liberty Lake, PV Powered in the Oregon, high desert city of Bend, and Schweitzer Engineering Laboratories in Pullman, Washington, among other examples, are bringing quality technical jobs to some of the more remote parts of the Northwest.

The Challenge and Opportunity of Electric Vehicle Integration

If (as we expect) battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) proliferate in the coming years, their use will present new challenges and opportunities to the electric grid. On the demand side, most plug-ins are charged at off-peak times like overnight, changing utilities' conventional load planning formulas and practices. And in

even more of a change for grid operators, plug-in batteries can essentially function as thousands of mobile electricity storage devices, available to deliver electrons back to the grid when the vehicles are parked—a scenario known as vehicle-to-grid (V2G).

In this emerging smart grid niche, the Northwest has a good chance to play a leading role. For one thing, several cities, including Seattle, Portland, and Bend, are among the national leaders in hybrid vehicles per capita. "A high percentage of our population wants to buy hybrids," said one respondent. "I think we will be a leader in the use of PHEVs and V2G even though we won't make the hybrids here. Someone is going to lead that in the world, and it could be us."

Early leadership is already here in the form of Seattle-based V2Green, founded in 2006 by three IT veterans, two with Microsoft on their resumes. V2Green creates what it calls "smart charging" software that can sync up a plug-in vehicle's electron flow, either charging up or giving back, with patterns in the utility's demand cycles. V2Green is in pilot tests with Seattle City Light, Xcel Energy, and Austin Energy, the municipal utility of the Texas state capital that's home to Plug-in Partners, the national non-profit promoting PHEVs.

It is still early days in this emerging technology, but there's great potential to tap the region's IT expertise. V2Green's acquisition by Arlington, Virginia-based GridPoint, announced just two weeks before the publication of this report, puts a significant stamp of approval on the V2G niche from one of the fastest-growing and best-funded players in the smart-grid sector. According to GridPoint officials, the company plans to keep V2Green's vehicle-utility integration team based in Seattle.

Several of our report interviewees noted that transportation electrification, if it can be done at significant scale, can make a considerable dent in Northwest carbon emissions. Thanks to hydro power, as we've noted, Oregon and Washington already have a lower-carbon electricity supply than most areas of the U.S.—meaning that a greater percentage of CO2 emissions, about 40 percent—comes from fossil fuels burned in transportation. Converting a portion of the vehicle fleet to BEVs and PHEVs running on electricity would not only reduce gasoline and diesel use, it would power those vehicles with "cleaner electrons" than in parts of the country whose vehicles are plugging into a grid primarily fueled by coal.

But the V2G niche, and the entire smart grid opportunity, comes with a major caveat for all high-tech players and particularly Microsoft. It is critical for the future build-out of the smart grid that its technologies, whether developed in the Northwest or elsewhere, be based on open, easily replicable standards. "I would like to see the PUC get the industry together, sit down, and develop a set of common, open [smart grid] standards," said one expert. "We don't want to see people building closed, proprietary systems—they need to be built on open architecture and open source."

A Mountain Worth Climbing

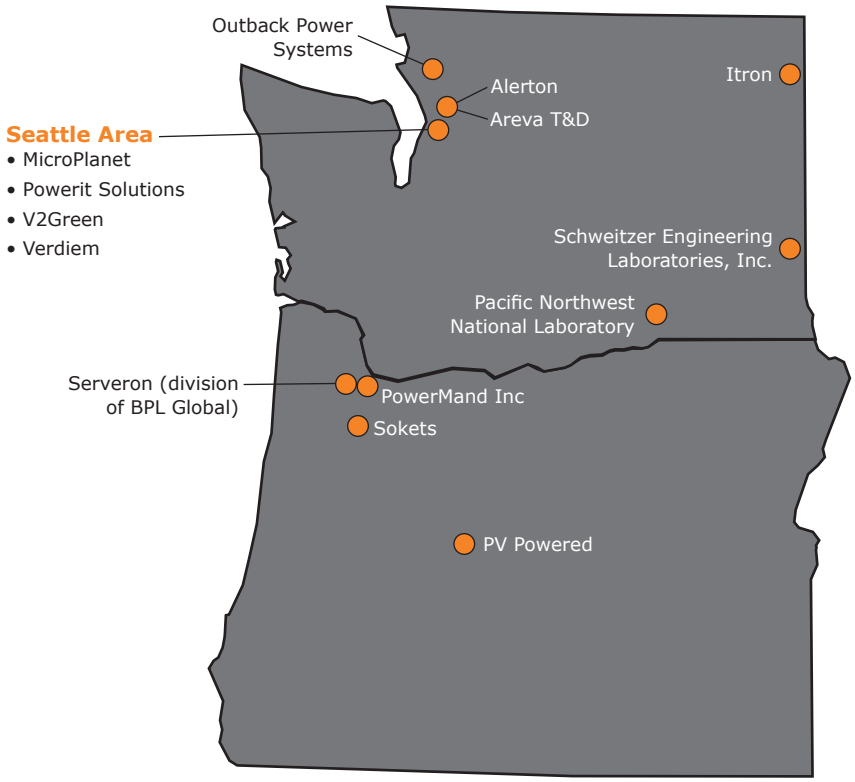
The multi-faceted nature of the smart grid presents both a challenge and an opportunity.

Because the sector comprises so many different technologies and players—from a BPA engineer planning a major network upgrade to a startup's software expert tweaking a tiny digital sensor—coordination of an integrated effort is a huge undertaking.

The Northwest has most of the right pieces in place across the public and private sectors, but to date has not been able to pull it all together. The same could be said for other regions—but many are moving forward. Xcel Energy in Boulder may have received the most attention, but Duke Energy in Indiana and other areas, and utilities in France and Italy, are piloting significant smart-meter deployments and many other smart grid initiatives. There is also a huge opportunity to build smart grids from the ground up, rather than retooling existing infrastructure, in fast-growing economies like China and India. If Washington and Oregon can lead the nation (if not the world) in proving the leading-edge concepts and building the technologies of the 21st century grid—and coordinate and harness that grid's myriad components—the region can create a robust regional industry that delivers key smart grid products locally and around the world.

Select Smart Grid Technologies Companies in Washington and Oregon

The following represent some of the key companies and organizations involved in Smart Grid Technologies in the Pacific Northwest. Click names to visit company's web site.



STRATEGY AND RECOMMENDATIONS: 10-POINT ACTION PLAN

How can Oregon and Washington leverage their assets and overcome their weaknesses to become a world-class center for clean energy and energy efficiency? The following, based on the collective research of Clean Edge, Inc. and Climate Solutions, and our interviews with experts in the field, are ten key strategies.

1. Put a Price on Carbon

Over the past few years, the idea of putting a price on carbon in the U.S. has become an increasing inevitability, instead of an uncertain question mark. But what will it look like, how will it work, and what's the best carbon-price strategy for the Northwest?

Among our respondents, there was considerable debate about the best method for achieving a price on carbon in the region, but hands-down, our interviewees felt that putting a price on carbon was one of the most critical steps in moving the region (and nation) toward robust, effective climate-change initiatives.

While the majority felt that participation in the Western Climate Initiative (WCI), and the implementation of a regional cap-and-trade system, were the best routes to putting a price on carbon, others felt that a carbon tax was a more elegant and effective solution. It's worth noting that just across the Washington border, British Columbia implemented North America's first carbon tax in February 2008. Similarly, while a majority of respondents felt that a regional effort was the right place to start, others thought that pushing and advocating for a national system/approach, would be more impactful.

We believe that the best approach for Oregon and Washington is threefold:

- Join and implement a carbon cap-and-trade policy via the WCI. The WCI currently offers Oregon and Washington their best chance to impact regional and national carbon policy. Regional leadership on carbon pricing will be

10-POINT ACTION PLAN AT-A-GLANCE

1. Put a price on carbon

2. Increase Washington RPS to 25% by 2025

3. Implement low carbon fuel standards

4. Pass aggressive green building codes

5. Foster regional cooperation

6. Ensure public funding for clean technology via public employees retirement system investments and through targeted clean-tech funds

7. Implement effective tax credits for renewables development

8. Deploy clean-tech workforce development programs

9. Establish government procurement policies for clean-tech products and services

10. Build out regional smart grids and 21st century transmission backbone

the best route to create clear markets that drive investments in low-carbon technologies.

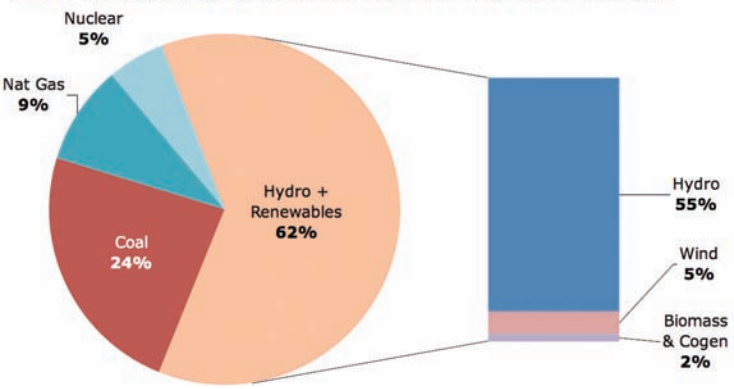
- Set up state-level commissions to review the value of carbon tax schemes. Consider how a regional carbon tax might be implemented in the region alongside a cap-and-trade system.

- Remain active at the federal policy level so that the Governor's offices, members of Congress, and other Northwest leaders are pushing for federal carbon regulation that will enable the entire country to implement effective and impactful carbon policies.

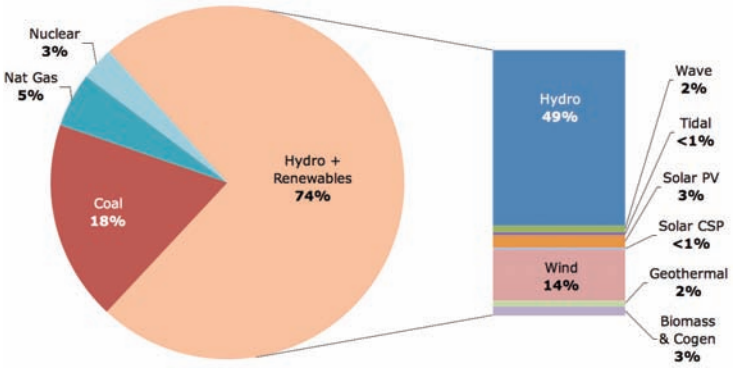
2. Increase Washington RPS to 25 Percent by 2025

Renewable portfolio standards, which require that a specified percentage of a state's electricity come from renewables by a targeted date, have proven to be one of the most effective clean-energy policies of our time. More than two dozen states now have RPS requirements.

2008 - Supply, by Energy Type, for Major Utilities in Oregon and Washington



2025 - Supply, by Energy Type, for Major Utilities in Oregon and Washington



By 2025, we project that non-nuclear carbon-free energy sources (hydro and renewables) will represent 74 percent of the energy mix of the major utilities in Oregon and Washington (25 percent renewables and 49 percent hydro). If efficiency and conservation efforts are increased by 50 percent between now and 2025, we estimate that renewables and hydro could represent up to 78 percent of the fuel mix used by major regional utilities. Either scenario would make the Northwest a global leader in carbon-free energy.

We recommend that Washington increase its RPS from 15 percent by 2020 to 25 percent by 2025, bringing it into alignment with Oregon's target. While the current Washington target is to be commended, it falls short of its two fellow Pacific Coast states (in addition to Oregon's more aggressive target, California's target is 20 percent renewables by 2010, with a goal to raise that to 33 percent by 2020). It is critical that the legislatures in both states reject attempts to dilute this important policy tool.

Our RPS projections in the Tables below show that, if Oregon and Washington both had 25 percent by 2025 mandates, the region could meet all projected new electricity demand with renewable energy and energy efficiency and conservation measures. There would be no need to add any new coal, natural gas or nuclear power to the mix (in fact, the region could reduce its need for these three energy sources). In 2008, the region's major utilities already

meet 62 percent of their energy mix from hydro and renewables. By 2025, we see that mix increasing to 74 percent or potentially even higher. We expect that the Northwest would be the national leader in non-nuclear, carbon-free electricity generation at that time.

3. Implement a sustainable, low carbon fuel standard in both states.

Current controversies over biofuels underscore the point that not all biofuels are created equal. If the full lifecycle of production is not taken into account, biofuels such as corn-based ethanol may actually emit more greenhouse gases than petroleum—when energy in the refining process is derived from coal, for example. Low carbon fuel standards require that alternative fuels used to meet the standard are genuine greenhouse gas reducers. California has enacted the first standard, which requires that the carbon intensity of the state's vehicle fuel supply be reduced 10 percent by 2020. The state is now conducting lifecycle studies of various fuels to determine the climate pollution reduction value of each. A number of other states are considering standards including Oregon and Washington. Both state's climate action plans call for low carbon fuel standards—and we call on them to follow in California's footsteps, by implementing similarly aggressive carbon reduction requirements that assess each biofuel type's lifecycle carbon footprint, not just tailpipe emissions.

These standards differ from Renewable Fuel Standards in that they do not require addition of certain fuel types; instead they set a performance goal for carbon reduction. So a range of fuels could be employed to power the region's vehicles, including advanced biofuels, electricity, and natural gas. For the Northwest, low carbon fuel standards could play an especially important role in unleashing the sustainable bioenergy and plug-in hybrid vehicle sectors. The Northwest possesses significant cellulosic resources from farms, forests, and waste streams, and cellulosic biofuels offer far greater greenhouse gas cuts that traditional corn ethanol or soybean-derived biodiesel.

4. Pass aggressive green building codes.

We call on both Oregon and Washington to meet the Architecture 2030 Challenge for reducing carbon emissions from the building sector by 50 percent by 2010 and 100 percent by 2030. High level endorsers of the Architecture 2030 challenge include the American Institute of Architects, U.S. Conference of Mayors, and U.S. Green Building Council.

Buildings represent approximately half the carbon emissions in the U.S., so meeting the 2030 challenge is critical to reducing global greenhouse gas emissions. Meeting these goals will require bringing building codes into alignment with the targets of the 2030 challenge.

The region is off to a good start. Seattle enacted the first green building ordinance in the nation in 2000, Washington enacted the first state law requiring green building standards in public buildings, and Oregon and Portland have also been deploying

leading edge codes. Oregon's state building codes division created a separate green building services section in 2008 to help streamline green building permitting processes and modernize codes. But we must do more. By meeting the 2030 Challenge, and realigning its building codes, the Northwest can lead the nation in the effort to dramatically reduce the carbon footprints of the built environment—and further boost the growth and competitiveness of the regional green building design and construction sector. Firms skilled in designing and building to leading-edge codes can translate that experience to other jurisdictions in the U.S. and overseas—a key reason why the Northwest sector is a global green design leader.

5. Foster regional cooperation among governments, academic and research institutions, businesses, and NGOs.

As we noted in the Assets and Barriers section, one of the region's weaknesses is the lack of a coordinated effort among key players in Oregon and Washington. A lot of clean-tech activity is happening, but it doesn't form a cohesive whole.

We recommend the following actions to ensure that the region is able to capture the full clean-energy opportunity:

- Build new links of communication and cooperation among companies and between industry and government. Sometimes the key is to build self-awareness among cluster participants themselves, to get them talking with one another.
- Have the governors of both states convene industry leaders in cluster leadership councils and organizations to discuss common challenges and opportunities, and identify the best policy and regulatory actions for state and local governments to take.
- Convene regional summit conferences that bring together clean-tech sectors to identify synergies and common opportunities.
- Develop joint regional branding, market building and trade strategies to promote Northwest clean tech worldwide. Oregon and Washington governors could lead a trade mission of leading companies to Asia –as Governor Arnold Schwarzenegger has done for California.
- Most important, bring together the region's academic institutions to build out clean-energy expertise. While some industry clusters develop out of one great academic institution (think MIT in Boston and Stanford in Silicon Valley), other clusters can be born out of a regional network of universities cooperating and sharing capabilities and knowledge.

Oregon has taken an important step, forming the Oregon Built Environment & Sustainable Technologies Center (BEST), which brings together partners from Oregon State

University, Portland State University, the University of Oregon, and Oregon Institute of Technology. This virtual network of higher education institutions is centered around clean-tech R&D. We encourage Washington to form its own virtual network among the University of Washington, Washington State University, and other higher education institutions. Such networks can find synergies under the clean-tech umbrella of each school's traditional research strengths, such as UW in nanosciences, WSU in bioenergy and power engineering, OSU in forest resources and wave power, and UO in solar. Then the region's leaders need to explore ways to link the two statewide networks together, and to coordinate with Pacific Northwest National Laboratory, a U.S. Department of Energy research and development center, in key areas including smart grids, hybrid vehicles and bioenergy.

6. Ensure public funding for clean technology via Oregon's and Washington's Public Employees' Retirement Systems (PERS) investments and through targeted clean-tech funds.

A number of states have led the way in clean-tech investing by putting the power of their pension funds and other government funds behind clean-energy investing. The largest and best-known example is California's Green Wave Initiative, launched in 2004, which initially called on the state's pension funds to invest up to $1.5 billion in clean-tech companies and projects, both public and private. To date, both CalSTRS and CalPERS have gained approval from their Boards to invest up to nearly $1 billion in such types of investments.

The impact on California's clean-tech industry has been notable, with solar, biofuels and many other clean-tech players garnering needed investment funding. Some clean-tech entrepreneurs now consider California state to be more committed to long-term policies that encourage clean-tech business and industries as a result of these investments. The treasurers of Washington and Oregon should consider launching regional "green wave" initiatives of their own that take advantage of the region's unique assets and renewable sources. As we pointed out earlier in the report, one of the biggest challenges facing the region is lack of financial capital to back regional clean-energy and efficiency start-ups. Guaranteeing that the state's pension funds are active investors in companies and technologies that help alleviate global warming, reduce emissions, and build regional emerging growth industries not only directly infuses capital into the clean-tech sector, it would also go a long way in attracting third-party investments. As California discovered when considering the Green Wave Initiative, clean-tech sectors have abundant investment-grade opportunities that fully meet risk prudency rules under which pension funds must and should operate.

In addition to state pension funds, there are other possible models of public funding for clean-tech companies and projects. Directed funds, such as the Massachusetts Technology Collaborative and the Connecticut Clean Energy Fund, have helped support successful industry clusters in those states. Energy Trust of Oregon might be in a

position to replicate this type of model in Oregon. The city of Portland is considering an annual multi-million dollar clean-energy retrofit fund that would finance energy efficiency upgrades in buildings, with a projected 5 to 6 percent return on investment over 20 to 25 years.

Another intriguing possibility is a clean-tech investment fund of the Bonneville Power Administration, as an extension of its federal mandate to provide inexpensive and reliable power to the region. Such a fund, focused on efficiency technologies and renewable generation, could be a significant contributor to the Northwest's clean-energy future.

7. Implement effective tax credits for renewables development.

The PV manufacturing industry, along with the rest of the clean-energy sector, faces tax-credit challenges at the federal level. Namely, at the time of this report's publication, Congress in 2008 had failed eight consecutive times to extend the production and investment tax credits (PTC/ITC) for the solar, wind, geothermal and other clean energy industries. Several interviewees put it very bluntly: "No PTC/ITC, no solar".

We encourage state policy makers, and the state's representatives in Washington D.C., to help turn this around. Indeed, Sen. Maria Cantwell (D-WA) has been an outspoken proponent for the extension of the PTC and ITC, and coauthored the Clean Energy Stimulus Act of 2008 with Sen. John Ensign (R-NV).

A Navigant Consulting study estimates that more than 100,000 solar and wind jobs are in jeopardy in the U.S. if the federal tax credit isn't extended. That would be a shame in a time of mounting job losses and rising unemployment. We expect that members of Congress understand the need to provide long-term incentives to clean-energy growth industries, and suspect that the issue will be resolved by the next Congress, if not sooner.

At the regional level, Oregon has been a trailblazer in establishing one of the most innovative energy tax credits in the nation—attracting a range of companies, including solar PV manufacturers, in the process. The Business Energy Tax Credit (BETC) currently provides a tax credit of 50 percent for a solar manufacturing plant up to U.S. $20 million.

We call on Washington to catch up. While not as flexible without an income tax, parallel possibilities might exist through the state's business & occupation tax. We urge that Washington legislators and other interested parties look at how the state might join Oregon in providing incentives that will attract more companies, create jobs, and add to the payroll coffers.

8. Deploy workforce development programs to train the next-wave of clean-tech employees.

A region's ability to supply and attract people with the needed skills, talents and knowledge to staff clean-tech companies is critical to establishing a strong competitive

edge in the field. The Northwest has formidable quality of life and "green ethos" advantages, as detailed in the Assets section above, but our education system is not keeping up. This report's respondents strongly urged, besides a general increase in investment in all Northwest public education, much more comprehensive Green Jobs/ Clean Energy workforce training based on analysis of cluster needs.

The good news is that this process is underway, but public officials in both states need to ensure it remains a priority. Washington's Climate Action and Green Jobs Bill, signed into law by Gov. Christine Gregoire in March 2008, has initiated that market analysis in the Evergreen State. It is the first state Green Jobs bill in the nation, with the goal of tripling the number of green jobs in the state by 2020 and providing pathways to family wage jobs in the clean energy economy for those most in need of new employment opportunities. We urge the legislature to authorize significant funding next year, particularly at the community college level.

Community colleges have proven to be one of the most effective venues for green jobs training programs, and Oregon provides a successful case in point in the wind industry. Several institutions, in particular Columbia Gorge Community College in the wind resource-rich gorge area, run popular programs training students in turbine installation, maintenance, operations, and other in-demand skills.

Both states should consider that kind of sector-focused effort for other clean-tech areas. One note of urgency: energy in general and utilities in particular face the challenge of an aging workforce. The next generation of workers needs to be trained in the up-to-date technologies of energy efficiency, the smart grid, and other key sectors.

9. Establish government procurement policies that feed the expansion of regional clean-tech industries.

One of the best ways to build robust regional markets for green products and services is for state and local governments to lead in their procurement decisions. This not only sets a positive "we walk the walk" tone for clean tech, it establishes instant local market demand for green building technologies, cleaner fuels and vehicles, and other products and services that governments buy on a regular basis. Oregon already requires that new and renovated public buildings exceed the state energy efficiency code by at least 20 percent, and spend 1.5 percent of the construction budget on solar technology. Oregon has also committed to get 100 percent of the electricity for its state operations from renewable sources by 2010. Washington has committed to run public fleets on 20 percent biodiesel starting in 2009.

We call on both states to ensure that:

- Public buildings run on renewable energy to the greatest extent possible.
- Energy efficiency goals for public buildings meet or exceed the Architecture

2030 goals as outlined in Action #4 above.

- Public fleet procurement prioritizes purchases of hybrids, plug-in hybrids and biofuel-powered vehicles where practically and economically feasible.

10. Provide incentives and policies for public and private utilities to build out regional smart grids and a robust 21st century transmission backbone.

As noted in the five top clean-tech opportunities section of this report, the smart grid is in many ways the linchpin of the Northwest's clean energy opportunities. The wind, solar, and green building sectors all rely to some extent on grid modernization for their long-term growth. But a smart grid build-out won't happen without policy action.

Several of our respondents cited policy and regulatory barriers to leadership by Northwest utilities in development and deployment of leading-edge smart grid technologies. Investor-owned utilities need financial incentives to invest in technologies, particularly new and relatively untested ones. The best regulatory course to encourage new investments in smart grid and efficiency technologies is decoupling—the separation of a utility's revenue stream from the amount of power it sells. Oregon regulators have a precedent in decoupling gas rates from Northwest Natural, a gradual process that began in 2002.

Breaking the link between energy throughput and utility profits via decoupling, while at the same time giving utilities the ability to rate-base their technology investments, are critical steps to incentivize the build out of smart grids in the Northwest. And they will, in turn, create important regional demand for the smart grid technologies and services being created by the innovators and entrepreneurs of Washington and Oregon.

In addition, the region must provide other financial incentives and regulatory support to enable the build out of new transmission capacity to carry green electrons to consumers. Recently, the state of Texas' Public Utility Commission approved the expenditure of $4.9 billion to build new transmission lines to move more than 18,000 megawatts of wind generation from gusty West Texas to the state's large cities. While we don't expect the price tag in Washington and Oregon to reach such Texas-sized proportions, utilities in the region need to be given the ability to invest in such critical 21st century grid infrastructure.

CONCLUSION: AN URGENT IMPERATIVE

Now more than ever, a vibrant and expanding clean-tech industry is an environmental, geopolitical, and economic imperative. With the U.S. economy in its most perilous condition in decades, regions throughout the country are seeking new paths to quality job creation and sustainable prosperity. Concurrently, the challenge of reducing carbon emissions and cutting demand for polluting, often foreign-sourced fossil-based energy sources grows more urgent every day.

The challenge of reducing carbon emissions and cutting demand for polluting, often foreign-sourced fossil-based energy sources grows more urgent every day.

Against this backdrop that spans global and local issues, the Pacific Northwest has an enormous opportunity. The aim of carbon-free, renewable-energy sources producing some 75 percent of the region's electricity by 2025 is not a pipe-dream vision, but an achievable goal.

Compared to many other regions, Washington and Oregon are already in an enviable position. With assets that include abundant clean-energy resources, committed political leadership, progressive public policies, world-class quality of life, and a green-minded, technology-oriented populace, the region has an excellent foundation on which to build a thriving clean-tech economy. With a committed focus on the sectors of solar PV manufacturing, green building design services, wind power development, sustainable bioenergy, and smart grid technologies, we believe that the Northwest can dramatically reduce its carbon output while creating a prosperous 21st century regional economy and becoming an export leader. These efforts will create tens of thousands of skilled jobs across a diverse range of sectors and will provide Northwest companies with a competitive edge.

The goal is achievable—but challenging. Washington and Oregon face a range of hurdles, including limited venture capital activity relative to some other regions, the lack of a cohesive regional clean-tech strategy, an outmoded 20th century electric grid, and universities that, despite outstanding research excellence in some areas, don't match other regions in the critical nexus of R&D and business commercialization. Overcoming these and other barriers will require redoubled commitments by the Northwest's business, regulatory, academic, and especially government leaders to enact the measures outlined in our 10-Point Action Plan. Initiatives such as regional carbon regulations, a multi-faceted public funding effort, and a comprehensive workforce development program will be needed if the region is to fulfill its clean-tech potential.

As we have discussed in this report, other regions as near as California and as far away as Massachusetts (indeed, as far-flung as Shanghai and Abu Dhabi) are moving aggressively to court the investors, entrepreneurs, and job seekers of the 21st century clean-tech economy. Building regional clean-tech clusters that steer toward a carbon-free future will be this century's most competitive playing field. If the Northwest wants to compete and thrive in this brave new world—and we firmly believe that it can—then the time to act is now.

APPENDIX A: RPS OVERVIEW AND WORKSHEETS

25 Percent by 2025—Oregon and Washington Renewable Portfolio Standards (Two Scenarios)

As part of the research for *Carbon Free Prosperity 2025,* we put together two scenarios of what electricity supply might look like for the region based on 25 percent by 2025 RPS targets for both Oregon's and Washington's major utilities. Combined with projected hydro contributions and conservation efforts, our research shows that the region's major utilities can get to 74 percent (Base Case Scenario) and to 78 percent (Increased Efficiency Scenario) non-nuclear, carbon-free electricity supply by 2025. As we point out in our 10-Point Action Plan, reaching such targets will require that Washington increase its RPS from 15 percent by 2020 to 25 percent by 2025 (matching Oregon's existing RPS target).

In doing our research, we relied upon data and information from the Northwest Power and Conservation Council (NWPCC)—a regional utility coordinating body that tracks installations, allocation of energy among utilities, and provides crucial guidance on the role that renewables and conservation can play in meeting individual state RPS requirements. The NWPCC has led regional working groups on the most pressing and sophisticated issues surrounding transmission, efficiency, and integration of renewables, and is one of the region's key assets and contributors to what makes the Pacific Northwest one of the country's foremost energy laboratories.

The following two scenarios are based on information provided by the NWPCC and discussions with their staff; estimates of projected installations provided by renewables industry experts; and Clean Edge projections. These are simply two of a number of different scenarios that could enable Oregon and Washington to meet RPS targets of 25 percent by 2025 for both states; and it does not reflect an endorsement by the NWPCC.

Every five years, the NWPCC reviews its regional power plan which lays out load estimates and a non-binding set of resource development targets. Under the most recent Power Plan (the 5th Power Plan), Oregon and Washington have targets to achieve savings of approximately 2,700 average megawatts (MWa) due to demand response and energy efficiency measures, dramatically decreasing load growth. We based our Base Case Scenario on those targets. In 2009, the NWPCC will publish their 6th Power Plan for the region. While we expect to see increased targets for demand response and energy efficiency, our Increased Efficiency Scenario may be even more aggressive than the targets in that new plan. That said, with improvements outlined in the smart-grid and other sections of this report, we consider the Increased Efficiency Scenario an ambitious but achievable goal.

Projections for meeting a regional 25 percent RPS under the 5th Power Plan load estimates (Base Case)

In this scenario, the region achieves a 25 percent RPS with hydro and renewables combined accounting for 74 percent of total supply for major utilities in Oregon and Washington. By 2025, wind is the largest contributor in the renewables category, accounting for 14 percent of total major utility supply. This equates to 6,101 MW of nameplate wind (total installed capacity); with solar PV and biomass/cogeneration each contributing approximately 3 percent of total major utility supply representing 2,853 MW and 438 MW (nameplate capacity) respectively. The large difference between the nameplate capacities is reflected by solar's significantly lower efficiency factor. Combined, wave, tidal, solar CSP and geothermal represent roughly 5 percent of total supply by 2025.

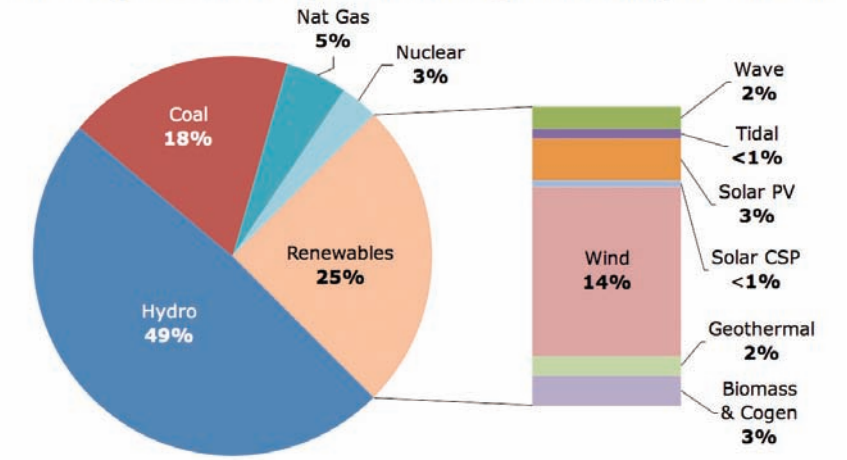
According to our projections, hydro does not see much change in output between 2008 and 2025. While some of the most environmentally destructive dams may be breached in the future, and others may undergo efficiency improvements, for the most part, the Northwest's hydro resource, we believe, will remain static. One legitimate concern, that we were unable to quantify, is the impact that global warming might have on hydro resources in the time frame we were looking at.

Between 2008 and 2025, in the Base Case Scenario, there is no need to bring on any new natural gas, coal, or nuclear resources. In fact, in the base-case scenario, they are reduced by 38 percent, 12 percent, and 37 percent respectively. However, other factors such as availability of hydro, dispatchability issues with a range of renewables, and the emergence of distributed storage capabilities could impact our projections in either direction.

Projected Sources of Electricity Supply for Major Utilities in Oregon and Washington (Nameplate MW)—Base Case

	2008	2010	2015	2020	2025
Hydro	13,414	13,406	13,483	13,392	13,533
Wind	2,069	2,356	3,219	4,844	6,101
Coal	4,143	4,143	3,929	3,643	3,643
PV	3	35	412	1,588	2,853
Nat Gas	1,375	1,330	1,205	1,000	861
Wave	-	2	162	459	676
Nuclear	815	813	810	686	517
Biomass & Cogeneration	258	258	313	375	438
Tidal	-	-	95	270	338
Geothermal	-	22	89	189	256
CSP	-	-	91	242	242
Total	22,075	22,365	23,806	26,689	29,456

2025 - Projected Supply for Major Utilities in Oregon and Washington - Base Case



Renewables + Hydro = 74%

Projected Sources of Electricity Supply for Major Utilities in Oregon and Washington (MWa)—Base Case

	2008	2010	2015	2020	2025
Hydro	6,707	6,703	6,742	6,696	6,767
Coal	2,900	2,900	2,750	2,550	2,550
Wind	662	754	1,030	1,550	1,952
Nat Gas	1,100	1,064	964	800	688
PV	0	6	70	270	485
Nuclear	652	651	648	549	413
Biomass & Cogeneration	206	206	250	300	350
Wave	-	1	60	170	250
Geothermal	-	20	80	170	230
Tidal	-	-	35	100	125
CSP	-	-	30	80	80
Total	12,227	12,304	12,659	13,235	13,891

Projections for meeting a regional 25 percent RPS under an increased efficiency and conservation scenario

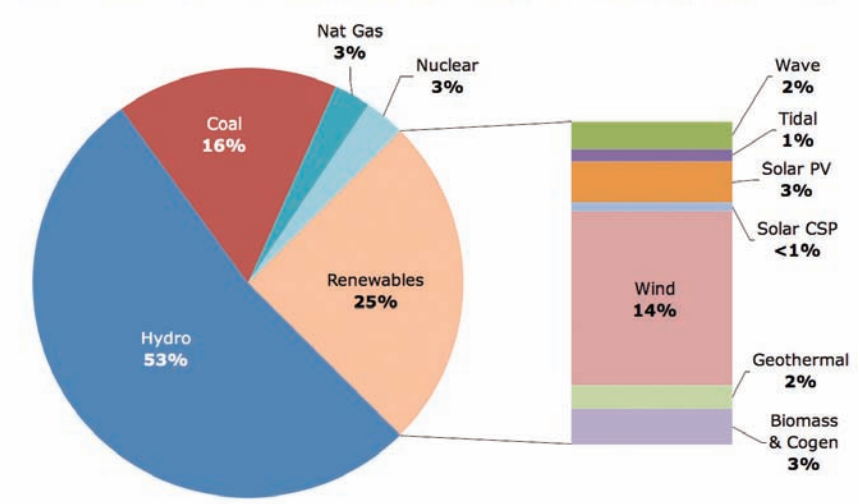
In this scenario, because of the impact of a 50 percent increase in conservation and efficiency targets over our Base Case Scenario, hydro and renewables reach a combined 78 percent of total supply for the major utilities in Oregon and Washington.

By 2025 the benefits of increased efficiency are immediately apparent. While wind still makes the largest contribution among renewables at 14 percent of major utility supply, it can achieve this percentage with less wind capacity contributions. Similarly, all of the

other renewables contribute the same percentage of supply as the Base Case, but require less total capacity. But more importantly, in the increased efficiency scenario, the need for fossil-based energy sources is significantly reduced. Compared to the Base Case Scenario in year 2025, hydro's percentage of supply reduces from 53 to 49 percent. Coal and natural gas see similar reductions from 18 to 16 percent and 5 to 3 percent respectively.

As noted above, this scenario could be impacted by a range of variables that are not yet known. In addition, long-term clarity on the region's plans for efficiency and conservation are critical for resource planning processes. Our hope with the Base Case and Increased Efficiency scenarios is to paint a picture of what the region's energy future might look like in meeting RPS requirements.

2025 - Projected Supply for Major Utilities in Oregon and Washington - Increased Efficiency Scenario



Renewables + Hydro = 78%

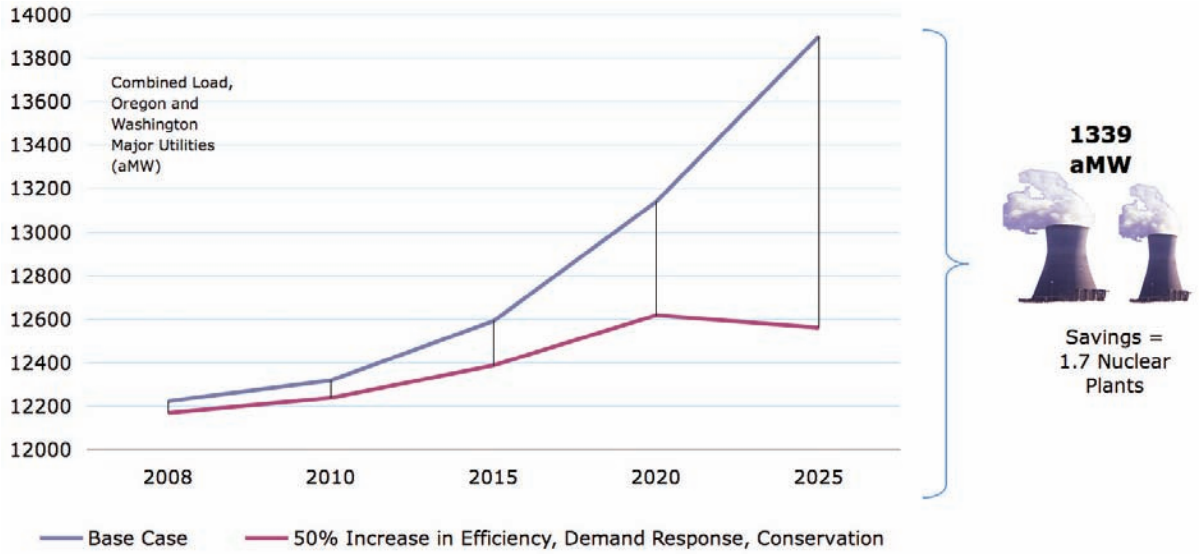
Projected Sources of Electricity Supply for Major Utilities in Oregon and Washington (Nameplate MW) - Increased Efficiency Scenario

	2008	2010	2015	2020	2025
Hydro	13,414	13,406	13,483	13,392	13,333
Wind	2,069	2,356	2,750	4,313	4,981
Coal	4,143	4,143	3,929	3,571	2,986
PV	3	35	412	1,206	2,324
Wave	-	2	149	216	743
Nat Gas	1,375	1,330	1,163	838	475
Nuclear	815	813	785	661	454
Biomass & Cogeneration	258	258	313	313	438
Tidal	-	-	95	176	338
CSP	-	-	30	242	273
Geothermal	-	22	89	156	256
Total	22,075	22,365	23,196	25,083	26,600

Projected Sources of Electricity Supply for Major Utilities in Oregon and Washington (MWa) - Increased Efficiency Scenario

	2008	2010	2015	2020	2025
Hydro	6,707	6,703	6,742	6,696	6,667
Coal	2,900	2,900	2,750	2,500	2,090
Wind	662	754	880	1,380	1,720
PV	0	6	70	205	395
Nat Gas	1,100	1,064	930	670	380
Nuclear	652	651	628	529	363
Biomass & Cogeneration	206	206	250	250	350
Wave	-	1	55	80	275
Geothermal	-	20	80	140	230
Tidal	-	-	35	65	125
CSP	-	-	10	80	90
Total	12,227	12,304	12,429	12,595	12,685

Comparing Projected OR/WA Load for Major Utilities - 50% Increased Efficiency Scenario, 2008-2025



The Importance of Demand Reduction

Under the Increased Efficiency Scenario, the result would be an additional 1,339 MWa savings compared to the Base Case Scenario. This savings represents the same amount of generation provided by 1.7 nuclear plants or 2.4 coal plants.

The most important impact that increased efficiency, demand response, and conservation measures have on utilities' ability to meet RPS targets is that they enable utilities to significantly scale back their fossil-based supplies, and also reduce the total amount of renewables needed to meet load requirements. The easiest way to think about the impact of demand reduction is that with a smaller pie, fewer renewables would need to come online to reach 25 percent. More importantly, fossil fuels and nuclear would be drastically reduced, as we show in our Increased Efficiency Scenario. As the NWPCC, efficiency experts, and others love to point out (correctly), the negawatt is the least expensive source of electricity.

NOTES:

- The tables represent the amount each source contributes to meeting estimated demand among major utilities in Oregon and Washington—not the total generation of that source in both states. For example, we project that there will actually be 10 to 14 GW of wind installed between the two states by 2025, but in our Base Case Scenario, only 1,952 MWa (6,101 MW Nameplate) would actually be used in Oregon and Washington. As we stated in the narrative of the report, we believe California's fast-growing demand for energy will make a major contribution to the number of installations in the Pacific Northwest.

- Major utilities in Oregon are those subject to the 25 percent by 2025 RPS requirement; also known as Group 1 utilities. Major utilities in Washington are those subject to the current 15 percent by 2020 RPS requirement.

- In the report, and above, we talk about both average megawatt (MWa) and nameplate capacity. As background, utilities primarily think in terms of average megawatts. For example, wind installations totaling 6,101 MW (nameplate capacity) is equal to 1,952 MWa (actual output of the wind farms). In other words, 6,101 MW (nameplate capacity) x .32 (capacity factor) = 1,952 MWa.

- The tables do not necessarily represent sources of electricity that are geographically located within the boundaries of Oregon and Washington. For example, a significant amount of the electricity coming from coal will be imported from Idaho. Similarly, Oregon and Washington utilities may only see half of the power coming from CSP plants physically located in Oregon and Washington, and buy the remaining electrons from the deserts of Nevada.

- The decreases shown among fossil fuels and nuclear does not necessarily mean that these plants will actually experience a net reduction in production. It just means that they will contribute less to Oregon and Washington supply. In other words, power from such plants may just be shipped elsewhere.

- We did not account for massive integration of electric nor plug-in hybrid electric vehicles (especially a scenario in which they are acting as storage devices for the grid). This analysis was outside the scope of our RPS exercise.

ABOUT CLEAN EDGE AND CLIMATE SOLUTIONS

Clean Edge, Inc., with offices in the San Francisco Bay Area and Portland, Ore., is a leading research and publishing firm that helps companies, investors, and policy makers understand and profit from clean technologies. Founded in 2000 by environmental and high-tech business pioneers Ron Pernick and Joel Makower, Clean Edge and its network of partners and affiliates offer unparalleled intelligence and insight into the clean-tech sector. Among its many activities, the company publishes the annual Clean Energy Trends report, produces the annual Clean-Tech Investor Summit (along with IBF), and maintains a number of stock indexes, including the NASDAQ® Clean Edge® U.S. Liquid Series (CELS) index, which track U.S.-listed clean-energy companies. To keep abreast of the latest clean-tech news, access industry reports, learn more about our annual summit and stock indexes, or sign up for our e-newsletter, visit www.cleanedge.com, email us at info@cleanedge.com, or call 503-493-8681.

Climate Solutions is a not-for-profit organization whose mission is to accelerate practical and profitable solutions to global warming by galvanizing leadership, growing investment and bridging divides in the Pacific Northwest. Since its inception in 1998, Climate Solutions has been the foremost champion of Northwest climate and clean energy leadership that generates economic opportunities for Northwest businesses and workers. Working with a broad array of partners from business, rural, government, and the public-interest community, Climate Solutions helps to advance a new sustainable prosperity in the Northwest that accelerates the technologies, policies, and enterprises that can deliver climate solutions to the world. Climate Solutions has offices in Seattle, Olympia, Portland and Missoula. To learn more, visit www.climatesolutions.org.