PORTLAND PLAN

Energy

PORTLAND PLAN BACKGROUND REPORT
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City of Portland Bureau of
Planning and Sustainability
Sam Adams, Mayor | Susan Anderson, Director

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Energy

PROSPERITY AND BUSINESS SUCCESS

SUSTAINABILITY AND THE NATURAL ENVIRONMENT

DESIGN, PLANNING AND PUBLIC SPACES

NEIGHBORHOODS & HOUSING

TRANSPORTATION, TECHNOLOGY AND ACCESS

EDUCATION AND SKILL DEVELOPMENT

HUMAN HEALTH, FOOD AND PUBLIC SAFETY

QUALITY OF LIFE, CIVIC ENGAGEMENT AND EQUITY

ARTS, CULTURE AND INNOVATION

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TABLE OF CONTENTS

OVERVIEW

INTRODUCTION AND RESEARCH PURPOSE

Energy is fundamental to our economy and quality of life. Everything around us is dependent on energy - from transportation fuels to move people and goods, to electricity to power our buildings and manufacturing, to natural gas to heat our homes and water.

This report is designed to inform the Portland Plan process by providing energy-related background information useful in exploring potential policy choices. The report summarizes what is currently known about Portland's energy system, reviews current conditions and trends, and discusses the emerging issues of volatile oil prices and supplies and climate change. The primary focus of the report is a review of selected viable technology solutions to many energy challenges. This review relies on other background reports and the City of Portland's proposed Climate Action Plan to explore the broader energy implications of land use, urban form and transportation system planning decisions.

KEY FINDINGS

Energy prices have climbed at alarming rates in the past decade. From 2000 to 2007, electricity costs went up 75 percent, while prices for natural gas and transportation fuels went up 91 and 102 percent, respectively. Currently, Portlanders spend more than $1.6 billion a year on energy, with more than half those dollars going toward the purchase of transportation fuels. Nearly all of the energy used in Portland is imported from outside the state, much of which, comes from foreign sources. Contrary to popular belief, less than half of our electricity supply comes from hydropower. Instead, imported coal and natural gas supply the majority of the city's electricity. Because Oregon has almost no fossil fuel resources, dollars spent on these energy sources contribute little to the local economy. By redirecting energy dollars to pay for efficiency improvements and non-fossil fuel energy, businesses and residents will spend more money locally, thus expanding markets for locally produced products and services.

More broadly, climate change and peak oil present unparalleled challenges that will require us to think beyond the nearer term issue of climbing energy prices. Climate change and peak oil fundamentally threaten the foundation of Portland's quality of life - its food and water sources, power supplies, public safety and health, forests and local economies. Fortunately, the Portland region has a long history of seeking innovative solutions to community challenges. Climate change and peak oil present opportunities to respond in ways that will create more local jobs, improve personal health and enrich the quality of life for the community.

CHALLENGES AND OPPORTUNITIES

Buildings consume well over half of the total energy used in Portland. Addressing this challenge requires a two-pronged approach of improving the energy efficiency of buildings and diversifying the energy supply to those buildings, resulting in a more resilient energy system. Because buildings last for many decades (more than half of the building stock that will exist in 2050 already exists today), efforts to improve energy efficiency need to address both existing structures and new construction. Many efforts are under way to expand large utility-scale renewable energy sources, such as wind farms and large solar facilities. Additional opportunities exist to create district and neighborhood scale energy systems, such as onsite renewables, district energy and other distributed generation sources. In addition to diversifying the energy sources for our buildings, smaller scale and more local energy systems provide opportunities for efficiency gains by reducing transmission losses. This report summarizes a variety of viable solutions for addressing building-related energy challenges, including efficiency, green building, right-sizing, district energy, smart grid and onsite renewable resources (solar, wind, geothermal, biogas and biomass), as well as efficient technologies for onsite generation, such as micro-turbines and fuel cells.

The transportation of goods and people accounts for about 40 percent of the energy used in Portland. Land use planning and transportation funding decisions greatly influence transportation-related energy consumption. Addressing this challenge will require strategies that (1) reduce the number of miles that people and goods must travel using vehicles, (2) dramatically improve the fuel efficiency of those vehicles and (3) maximize the use of alternative and renewable transportation fuels. This report summarizes a variety of viable solutions for addressing transportation-related energy challenges, including transportation options, streetcars, alternative vehicles (electric, hybrid, plug-in hybrid and natural gas), electric vehicle charging infrastructure, fuel efficiency and renewable fuels.

RECOMMENDATIONS

- Further define the relationship of energy to other issue areas addressed in the Portland Plan, including economic development, affordable living, transportation, infrastructure, environment, urban form and other topics.
- Explore opportunities to address policy, code, legislative and financial barriers to onsite renewables and energy efficiency, including solar, district energy and building codes.
- Incorporate greenhouse gas emission considerations into key decision-making, policy and planning tools.
- Align key components of the Portland Plan to put Portland on a path to accomplish the goals and objectives of the City and County's proposed Climate Action Plan. The plan proposes an 80 percent reduction in greenhouse gas emissions by 2050.
- Pursue opportunities for coordination and regionalization of innovative approaches to energy-related challenges and issues.

CURRENT CONDITIONS AND TRENDS

Energy is the foundation of our economy, quality and way of life. Everything around us is dependent on energy either from manufacturing, transportation or the direct use of electricity in our buildings.

There are several key trends on both the supply and demand side related to energy. For example, prices for all sources of energy (natural gas, fuel oil, transportation fuels and electricity) have continued to climb. From 2000 to 2007[1] gasoline prices are up 102 percent, natural gas 91 percent and electricity 75 percent. As shown in the chart below, the residents and businesses of the City of Portland spent $1.6 billion on energy for transportation, electricity and natural gas in 2007.

[1] At the time of this report, 2008 energy use and cost data for Multnomah County were not yet available.

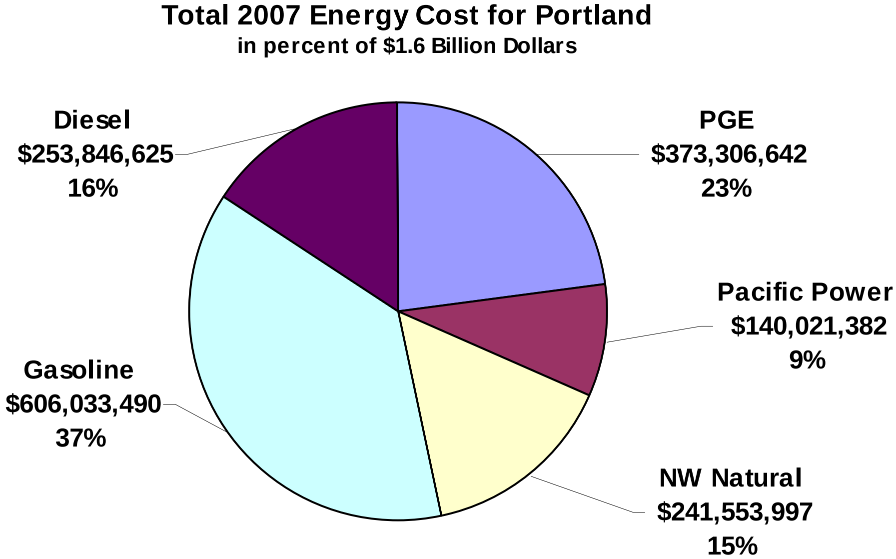

Figure 1: Total cost of energy used in Portland for 2007, including electricity, natural gas and transportation fuel, was $1.6 billion. More than 50 percent is spent directly on transportation fuel.

The U.S. as a whole is also experiencing an increasing dependence on foreign supplies of oil and natural gas. For example, much of our natural gas is imported from Canada where supply is beginning to decline. Another key trend relates to the limited capacity of electricity transmission systems, and the need to expand that capacity in order to accommodate new power plants and renewable energy production.

The following chart shows total energy use for the City of Portland from 2007 in a percent of Million British Thermal Units (MBTU), a standard unit of energy to compare different fuels sources. It is worth highlighting that only a relatively small share comes from renewable energy and renewable transportation fuels, 1 percent and 1.3 percent respectively.

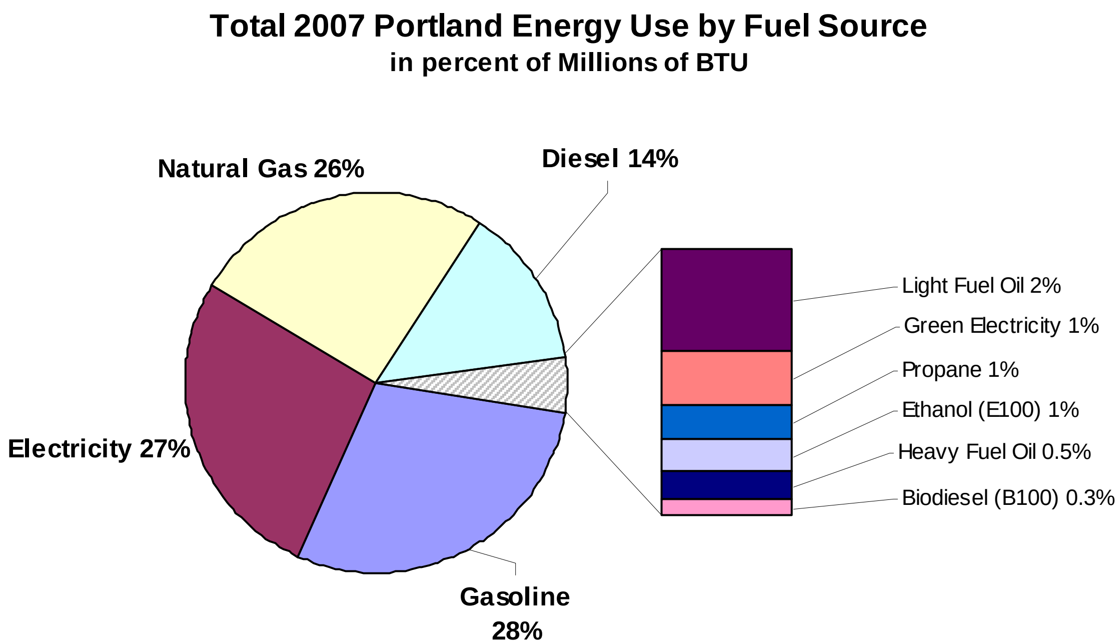

Figure 2: Sources of total energy used in City of Portland for 2007. Total energy used in the City from all fuel sources is equivalent to 105,077,140 Million British Thermal Units (MBTU).

The following chart shows total energy use by sector for Multnomah County in MBTU. According to the Oregon Public Utilities Commission, the average annual kilowatt hour (kWh) consumption of residential customers for Oregon investor-owned electric utilities as of 2006 was 11,395, a slight increase from 2002 when the average use was 11,289 kWh.

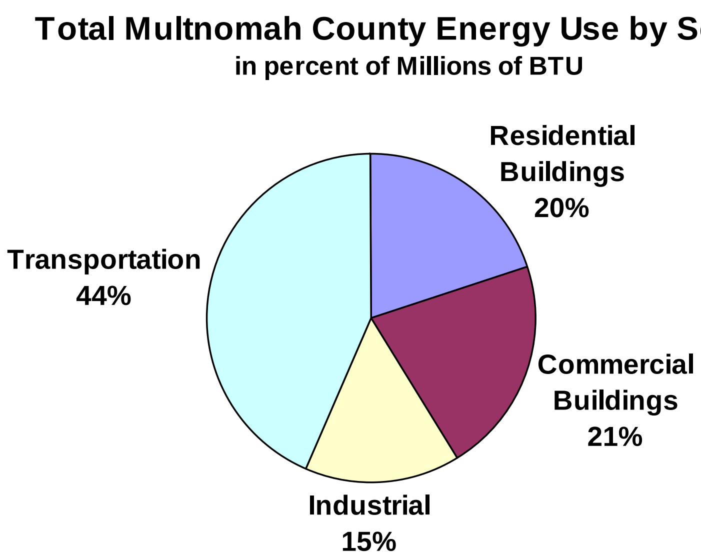

Figure 3: Total energy use by sector for Multnomah County in 2007 was 105,131,631 MBTU. According to the U.S. Census Bureau, the City of Portland makes up approximately 76 percent of Multnomah County by population and 86 percent by employment firms.

Figure 4, below, depicts the current sources of Portland's electricity supply, with Portland General Electric representing 72 percent and Pacific Power 28 percent of sales. Only 27 percent of our electricity comes from hydro (e.g., dams on the Columbia River), while the remainder largely comes from coal or natural gas. Figure 2, above, shows that about 90 percent of total energy use is derived from fossil fuels, given that 68 percent of the electricity is generated from natural gas and coal (see Figure 4).

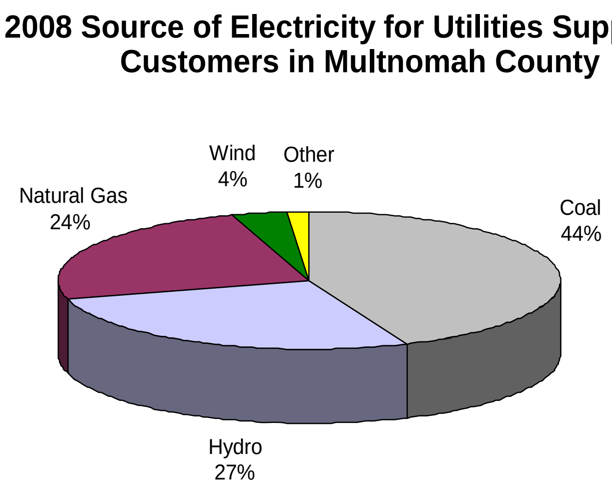

Figure 4: 2008 sources of Electricity for Multnomah County[2]. Coal plays a significant role in providing electricity to the Northwest. Year-to-year variability in hydropower supplies changes the mix each year, but coal and natural gas typically supply over half of all power to the Northwest, despite the extensive hydropower system. In Multnomah County, the power mix is even more dependent on coal, since Pacific Power, which provides about one-fourth of all electricity used in the county, relies on coal for about 70 percent of its energy.

Portland has a history of working aggressively on energy efficiency and renewables, going all the way back to the late 1970's. In the early 1990's, energy-related policies and programs also began focusing on global warming by expanding efforts into areas like land use planning, transportation, and energy supply. Portland adopted policies including the 1979 Energy Policy, 1990 Energy Policy, 1993 CO2 Reduction Strategy, 2001 Local Action Plan on Global Warming and 2007 Peak Oil Task Force Final Report.

Many of the most recent energy-related programs and policies are contained in the 2001 Local Action Plan on Global Warming. Update reports on Portland's progress toward implementing the Action Plan were issued in 2002 and 2005. The Bureau of Planning and Sustainability has drafted a new plan, titled City of Portland and Multnomah County Climate Action Plan 2009. The proposed plan sets the substantial goal of an 80 percent reduction in greenhouse gas emissions by 2050.

[2] Oregon Department of Energy for overall resource mix of each utility; Bureau of Planning and Sustainability for weighted average mix based on electricity supplied by Portland General Electric and Pacific Power to customers in Multnomah County.

In 2007 Oregon's Legislature adopted a Renewable Portfolio Standard which sets aggressive targets for Portland's two electric utilities, Portland General Electric and Pacific Power. The utilities are required to quickly increase the percentage of renewable energy provided– from roughly 4 percent today to 10 percent in 2012 and reaching 25 percent in 2025.

Many individual businesses and residents voluntarily choose to purchase renewable energy, which help offset the costs associated with meeting the renewable portfolio standards. Oregonians lead the nation with one of the highest percentage participation levels by residential customers for both utilities. In addition, Northwest Natural Gas was the first gas utility in the U.S. to offer carbon offsets to customers for their natural gas use.

Driven by both renewable portfolio standards and consumer demand, large-scale wind farms are rapidly developing along the east end of the Columbia River Gorge and in eastern Oregon. Photovoltaic installations driven by generous federal, state and Energy Trust of Oregon incentives are at record levels. The Oregon Department of Energy increased the Business Energy Tax Credit for renewables to 50 percent of project cost in 2008, creating an unprecedented incentive for businesses to install renewable energy systems.

EMERGING ISSUES AND CHALLENGES

PEAK OIL

Every day, businesses, government agencies and households around the world plan and make decisions based on the assumption that oil and natural gas will remain plentiful and affordable. In the past few years, powerful evidence has emerged that casts doubt on that assumption and suggests that global production of both oil and natural gas is likely to soon reach its historical peak. This phenomenon is referred to as "peak oil." Given both the continuous rise in global demand for these products and the fundamental role they play in all levels of social, economic and geopolitical activities, the consequences of such an event are enormous.

Predictions for the year oil production will peak range from the present day until 2040, with the most common estimates between 2010 and 2020. The International Energy Agency (IEA) nearly doubled their prediction of the global decline rate between 2007 and 2008. They are now predicting a 6.7% rate of decline in output from the world's existing oilfields. The Agency says the new number is based on the first major study of the world's 800 largest oil fields[3]. IEA chief economist Fatih Birol said for the first time in an interview that he expects a "plateau" in global oil supplies around 2020. In addition he said total oil production from non-OPEC countries will begin to decline within three or four years from now.

Despite the apparent breadth of current projections, even the most optimistic forecasts offer little time to adapt, given the very long lead times required to change such things as transportation and building infrastructure. In the report on peak oil commissioned by the U.S. Department of Energy, oil analyst Robert Hirsch said a 20 year mitigation program is needed before oil supplies peak, in order

[3] International Energy Agency, World Energy Outlook 2008. OECD/IEA 2008

to avoid global economic meltdown[4]. According to the IEA's new predictions there are far fewer than 20 years remaining.

Of all the impacts from rising oil prices, the clearest are those on transportation, which will experience profound pressure to shift toward more efficient modes of travel. For personal travel, this means transit, carpooling, walking, bicycling and highly efficient vehicles. Transportation of freight will become more costly and either decline or shift modes from air and truck to rail and boat, which are more efficient. Population may shift to city centers, and density and mixed-use buildings will increase.

Food is a critical resource, and the American food system has become highly dependent on fossil fuels. Food production and distribution accounts for 17 percent of U.S. energy consumption. Because of this, higher oil and natural gas prices are expected to lead to a decline in the amount and variety of food produced and available locally, even with Portland's proximity to the agricultural production of the Willamette Valley. Food prices will rise, further straining the ability of low-income households to put food on the table.

Like agriculture, the economy as a whole is expected to experience significant disruption and volatility. Impacts will vary widely by industry and firm. Portland has strengths in high technology and a relatively diversified transportation system. Portland also enjoys a strong and growing clean energy sector, which is likely to see increased demand. Nevertheless, many of Portland's industries are dependent on national and global markets, and business start-ups and failures are likely to increase as businesses try to adapt to a new economic paradigm.

The failure of traditional business models would increase unemployment, creating major economic and social issues. Vulnerable and marginalized populations are likely to grow and will be the first and hardest hit by rising oil prices, increasing dependence on social services. Increasing costs and decreasing incomes will reduce health coverage and further stress the health care system. Heating, maintenance, and monthly housing costs will consume a larger share of household budgets and push people toward lower-quality housing choices at the same time that auto transportation costs increase dramatically. First responders, especially police, are likely to be further taxed as social service agencies struggle to meet demand.

The Portland Peak Oil Task Force examined these impacts from peaking oil production and identified Portland's greatest vulnerabilities. The Task Force released a report in 2007 recommending a comprehensive package of actions, proposing strategies to initiate institutional change and to motivate action by households and businesses. The recommendations propose major changes for Portland, but the Task Force believed that implementing them would have a positive social and economic impact as local residents and businesses spend less on imported fuels and redirect dollars into the local economy. In response, Portland City Council passed resolution No. 36488 on March 7, 2007, establishing a goal to reduce oil and natural gas use in Portland by 50 percent in 25 years and to take related actions to implement recommendations of the Peak Oil Task Force.

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[4] Robert Hirsch, Roger Bezdek and Robert Wendling, Peaking of World Oil Production: Impacts, Mitigation, and Risk Management, prepared for the U.S. Department of Energy and published in February 2005.

CLIMATE CHANGE

Climate change is one of the defining challenges of the 21st century. As greenhouse gas emissions from human activities collect in the atmosphere, they destabilize the climate. The world's scientific community, having reached consensus on the basic science of climate change, indicates that in order to prevent potentially catastrophic change, humanity must dramatically reduce total greenhouse gas emissions, on the order of 85 percent by 2050. Figure 5, below, shows Multnomah County emission trends as a percent of 1990 levels, as compared to the United States.

Portland, Multnomah County and the entire Pacific Northwest will feel the impacts of global climate change broadly and deeply. Since 1900, the average temperature in the Pacific Northwest has increased by 1.5 degrees Fahrenheit. In the next century, the warming is expected to accelerate and increase at least three times as quickly.[5] In the last century, glaciers on Mt. Hood shrank by more than one-third.[6] However, melting ice on this iconic mountain is just one of the more visible impacts of climate change.

The Pacific Northwest will experience more warming in summer and nights will cool off less than they do today. Increased urbanization and population growth, with their related roads and rooftops, will exacerbate the urban heat island effect, increasing local temperatures even more. Winters will likely be wetter and summers drier. These changes, coupled with higher temperatures, will likely mean higher river flows in the spring, when water is already abundant, and lower flows in the summer, when surface water is badly needed for drinking, irrigation, hydropower, and salmon.

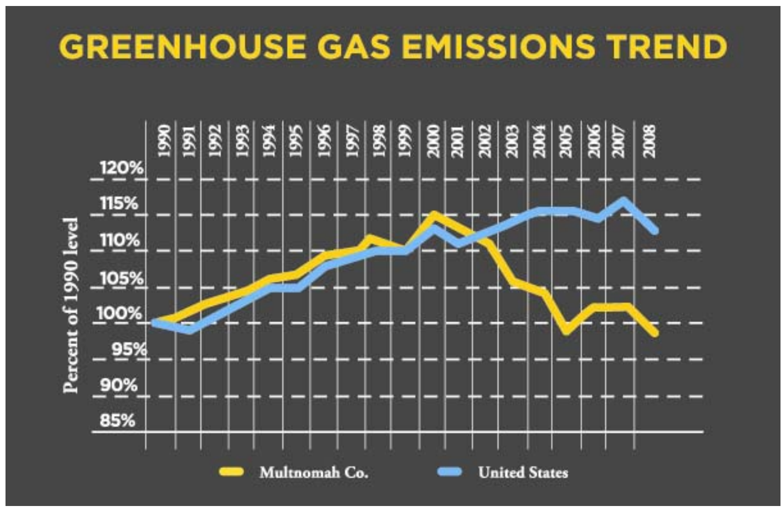

Figure 5: Greenhouse gas emissions trend for Multnomah County as compared to the United States, shown as a percent of 1990 levels.

The region's landscapes are at risk. Forests, a cornerstone of the economy and environment, are particularly vulnerable. Drought, fire, pests, and disease are likely to increase. Oregon's beaches are threatened by rising sea levels, stronger storms, and increased coastal flooding and erosion.

Climate change also poses a significant challenge to public health. Rising temperatures may be accompanied by increased incidents of diseases such as cholera and weather-related mortalities. Rising temperatures are a specific concern for seniors, who are particularly vulnerable to heat stroke—especially in this region, where most homes do not have air conditioning. The physical impacts of a changing climate are matched by social challenges and compounded by rising energy prices. Low-income and vulnerable citizens face disproportionate impacts of climate change, while

[5] University of Washington Climate Impacts Group, http://cses.washington.edu/cig/pnwc/cc.shtml.
[6] Jackson, K.M. and A.G. Fountain. "Spatial and morphological change on Eliot Glacier, Mount Hood , Oregon , U.S.A.." Annals of Glaciology, 46, 222-226.

having fewer resources to respond to these changes. Climate change and rising energy prices have the potential to exacerbate social inequities, and protecting and assisting vulnerable citizens needs to be a critical priority.

Additionally, large numbers of people will likely move from hotter, drier regions to cooler, wetter ones. “Climate refugees” will almost certainly have a major effect on population shifts in the 21st century. The Pacific Northwest, which likely will experience less drastic initial impacts of climate change than other regions of the country, may well experience population growth significantly above current expectations.

VIABLE ENERGY SOLUTIONS FOR THE BUILT ENVIRONMENT

The challenge of moving from a carbon-based economy to one based on sustainable resources is substantial, and it is clear that there is no “silver bullet” to replace the role of the fossil fuels. This creates a significant challenge but also enables us to be creative and develop a system that is flexible and more resilient than one dependent on the sole availability of one resource.

The proposed Climate Action Plan sets three objectives to meet by 2030 with regards to building energy use:

1. Reduce the total energy use of all buildings built before 2010 by 25 percent
2. Achieve net zero greenhouse gas emissions in all new buildings and homes
3. Produce 10 percent of the total energy used within Multnomah County from onsite-renewables and clean district energy systems.

Energy efficiency is the first step that needs to be systematically incorporated into everything in the built environment, from our buildings, appliances and vehicles to industrial processes.

ENERGY EFFICIENCY

Energy efficiency - getting the most from the energy we use to meet our needs in homes, businesses, and industry - can help mitigate the economic and social impacts of sharply rising costs and limited supplies, while simultaneously reducing greenhouse gas emissions that contribute to climate change. Whether heating, cooling or lighting our buildings, or manufacturing and transporting goods and materials, energy use can be reduced by improving our energy efficiency.

Evidence shows that most businesses can significantly reduce energy consumption through equipment maintenance and upgrades, smarter building systems and materials and energy-efficient technology. This is usually achieved using tried and tested technologies that are widely available from a range of suppliers. Energy-efficient designs in new homes and business can be achieved through thoughtful design of the building shell, the heating/cooling system, lights, plug-in equipment and the use of energy management controls. Commissioning the building so the systems operate as designed is a necessary action to ensure savings are captured. Periodic building tune-ups or retro-commissioning helps maintain energy savings over longer periods of time.

By reducing energy consumption, local businesses are better able to compete in the global economy, cost of living is lowered and dependence on fossil fuels is reduced. As a key target sector for Portland’s economic growth, energy efficiency and clean tech hold much promise for job growth.

Investment in energy efficiency is smart business and frequently returns 100 percent of the investment in just a few years through energy bill savings. It is common for energy improvements to have paybacks of 1 to 3 years at industrial facilities, 3 to 10 years for businesses and 5 to 20 years in homes.

A number of programs and resources exist in Portland to help the community reduce energy use and greenhouse gas emissions, including energy audits and cash incentive programs through Energy Trust of Oregon, the Oregon business and residential energy tax credit programs, and Federal energy tax credits. The Bureau of Planning and Sustainability is piloting a program called Clean Energy Works, which will help remove barriers associated with installing home energy efficiency measures. The pilot is a loan program, financing energy improvements for up to 500 homes. If the program is successful Portland intends to expand the opportunity to more than 100,000 homes with weatherization potential in the coming years.

Given that industry consumes 15 percent all energy used in Multnomah County, energy efficiency of industrial processes is critical. There are a variety of technology options for all types of industries, including high performance equipment, closed loop systems, heat recovery, and co-generation of electricity and heat. For example, YoCream in Northeast Portland upgraded its production equipment with variable frequency drive controls, high efficiency condensers, and a heat exchanger that recovers compressor waste heat to be used for space heating. Energy Trust estimates annual savings of 1,072,033 kilowatt hours and less than a 2-year payback on the investment after Energy Trust incentives and State Business Energy Tax Credits. The electricity savings from this one project are enough to power 90 single family homes per year.

HIGH PERFORMANCE GREEN BUILDING

Rising energy prices, climate change and a fragile job market pose serious threats to Portland's ability to thrive, both today and in the future. Buildings are responsible for nearly half of Portland's greenhouse gas emissions, and Portland residents and businesses now spend $750 million each year to heat, cool, and power our buildings. This figure has almost doubled over the past 10 years, largely due to increased energy costs, and will likely continue to rise sharply, further stretching tight household and business budgets.

Because buildings last for many decades, today's decisions will affect Portland for the next century or more. Each building represents an opportunity to strengthen Portland's future - or weaken it.

High performance green building presents one of the best solutions to improve environmental performance while strengthening the local economy and keeping buildings affordable in the long term. For more than a decade, the Portland development community has incorporated green building practices as part of a framework for improving energy and water efficiency, stormwater management, indoor air quality and materials selection. The resulting buildings are delivering financial savings to their occupants and owners while enhancing workplace productivity and personal health. However, green building is not yet standard practice in Portland. To reach important climate, energy and economic goals, new policies and actions must be implemented to accelerate the spread of high performance green building in new construction and renovation of existing stock.

Improving building energy efficiency helps maintain affordability in several ways:

- An investment in energy saving measures pays back in reduced utility bills for tenants and homeowners. For example, an Earth Advantage home is at least 15 percent more efficient than minimum state code, saving close to $400 annually in energy bills for a typical home.
- The added initial cost of new energy saving measures is partly offset by financial incentives from the Energy Trust of Oregon (ETO) and the Oregon Department of Energy (ODOE).
- Lower energy consumption reduces the impact on budgets from current and future rate increases. This allows more money to be available for other expenditures, keeping money circulating in the local economy, strengthening the business climate and adding local jobs.

High performance green building also reduces greenhouse gas emissions by increasing the energy efficiency of the building envelope, lighting and mechanical systems. Carbon dioxide, the primary greenhouse gas contributing to climate change, is emitted directly from buildings through natural gas and fuel oil combustion and indirectly through electricity use. Nearly half of community-wide carbon dioxide emissions result from electricity, natural gas and fuel oil consumption in buildings, including 20 percent from residential buildings and 24 percent from commercial buildings.

Given Portland’s existing residential and commercial building stock along with projected building trends through 2050 - based on the average growth of each building sector from 2000 through 2006 and an annual demolition rate of 0.5 percent - achieving Portland’s proposed 2050 climate protection goal will require a robust green building policy. A high performance green building policy will need to substantially reduce carbon dioxide emissions from both new and existing buildings in both the commercial and residential sectors.

In March 2007, Portland City Council adopted Resolution 36488 directing the Office of Sustainable Development to develop policy options to improve building environmental performance, including reducing oil and natural gas use and carbon dioxide emissions.

This resolution led to the proposed High Performance Green Building Policy, which includes the following proposals for advancing building energy performance in Portland:

1. **New commercial and multifamily construction:** The policy proposes a green building "feebate"—a market-based instrument that combines a fee for conventional construction, a waiver option for moderate green improvements and a reward for high performance green building projects.
2. **New single-family residential construction:** The policy proposes a performance target for a percentage of new homes that are built to green building standards. If the target is met, no new regulations will take effect; if the target is not met, policy options to increase the pace of market transformation will be reconsidered.
3. **Existing commercial buildings:** The policy proposes disclosure of building performance in the areas of energy usage, water usage and stormwater management. The policy also includes incentives to improve environmental performance. The building performance

measures would identify buildings that have the greatest potential to improve performance and could help prospective buyers and tenants make informed decisions.

4. **Existing single-family residential building:** Disclosure of building performance measures was also considered, but the stakeholder meetings highlighted the need to develop much better financing options for homeowners than are currently available. As a result, no requirements are proposed for existing homes at this time, and instead BPS is developing a large-scale fund to accelerate green building upgrades to existing buildings.

EFFICIENT HOUSING

Regardless of energy performance, larger buildings use inherently more energy, both in terms of the production of more building materials and increased space for lighting and heating, than their smaller counterparts.

The size of the average single family home has been increasing. According to data from the National Association of Home Builders, the size of the average U.S. single family home was 2,479 square feet for 2007, nearly 339 square feet more than the average from 1997.

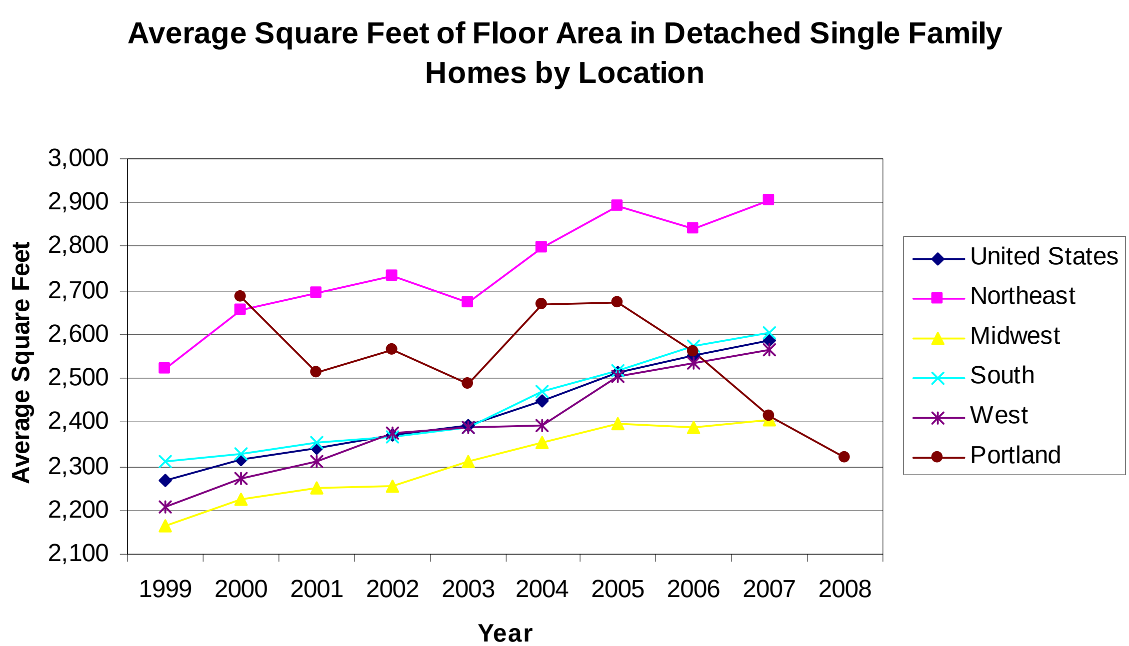

Figure 6: Average square feet of floor areas in detached single family homes by location, comparing Portland to averages for the U.S., Northeast, Midwest, South and West coast. The regional data are from the National Association of Home Builders based on home sales. The data for Portland are from the City of Portland Bureau of Development Services based on building permits.

Compare that increase to 1978, when the average home was only 1,750 square feet[7]. That is a 42 percent increase in the size of the average U.S. home over the last 30 years. In Portland, the size of the average single-family home has been decreasing over the last 3 years and is now at 2,320

[7] National Association of Home Builders, http://www.nahb.org/reference_list.aspx?sectionID=130

square feet, less than the U.S. average. The table above compares average square footage of detached single family homes for Portland versus other regions since 2000.

Shared wall units, both single family townhomes and multifamily units, are inherently more efficient than individual single family homes. The temperature difference between two spaces is the primary driver of heat flow and thus heat loss. When two heated units are next to each other, the amount of heat loss is minimized as compared to detached dwellings.

The physical size of households is of great concern in addressing climate change and energy challenges. The physical size of units and their proximity to other heated spaces also work to improve the efficiency of district energy systems, as the thermal energy can be shared with less infrastructure investment.

DISTRICT ENERGY

District energy systems are highly efficient heating and/or cooling systems that distribute thermal energy from a centrally located plant to a network of surrounding buildings in a “thermal grid”, allowing for greater energy conservation, reduction in heating/cooling costs, greenhouse gas emissions reductions and incorporation of alternative fuel technologies.

Some district energy systems also generate electricity as a by-product through the use of combined heat and power technologies (CHP). The waste heat from the CHP process is used as thermal energy in the district energy system, while the electricity output may be used on-site and/or distributed through a utility grid.

This is substantially different from electricity generated at a large-scale Utility power plant. Electrical generation from fossil fuels creates heat as a by-product, which is typically wasted since power plants are often located away from users of thermal energy. The transmission and distribution of electricity also experiences transmission losses, or voltage drop, the farther electricity has to travel from its generation. A district energy system with combined heat and power is more efficient as heat can be captured and used by nearby buildings and transmission losses can be reduced. Other efficiencies can be gained by economies of scale, as each building doesn’t need its own heating and cooling systems.

District energy has been used since ancient times in the form of distributed steam heat. Today a variety of fuel sources can be used in district energy systems. Modern systems are very common in northern Europe, where some countries, like Finland and Denmark, serve 50 percent of their total building area with district energy systems[8]. Sweden relies on a diverse mix of resources, including natural gas, biomass, biofuels and waste heat. There are over 6,000 systems in North America, primarily serving universities, medical facilities and some downtown urban centers. Examples of district energy systems that cross ownership boundaries in dense urban centers can be found in St. Paul and Vancouver, BC.

Downtown Portland had a privately owned district energy system that was built by Pacific Power & Light in 1910. The system included two steam plants that used hogged fuel (sawmill waste) to fuel boilers, producing combined heat and power- steam that was distributed as thermal energy underground to buildings and electricity for the grid.

[8] International Association for District Heating, District Cooling and Combined Heat & Power. Data from 2003.

The City of Portland has recently completed a Business and Technology Analysis for feasibility of a district energy system for the yet to be developed North Pearl District. The technical analysis reviewed a variety of technology options and fuel sources including industrial waste heat, sewer heat, Willamette river water, geothermal, brewery waste, natural gas, and biomass. The analysis demonstrated that a district heating and cooling system for the North Pearl District would be financially sound and would have immediate environmental benefits under a wide range of assumptions and technologies.

District energy systems typically require the involvement of local governments when the system crosses multiple properties or into the public right of way. Municipalities play a critical role in making district energy systems feasible, helping to create scale, accelerate development, access tools for financing and assistance with rate regulation and reducing revenue risk. There are a variety of ownership and operating models for a district energy system, and municipal ownership is not essential, although it can aid the development of a system. Municipal vision and policy leadership is required regardless of the ultimate ownership strategy for a district energy system. Recently some developers in Portland have attempted privately owned district energy systems and found the time required to secure ownership and right of way agreements cost prohibitive. More successful examples include:

Case Study: Brewery Blocks

Rather than a number of different cooling systems, Portland's Brewery Blocks complex is served by one central chiller plant. The chiller provides benefits on several levels. Larger chillers are by nature more efficient than smaller chillers. The system is also space-efficient, saving more mechanical room space than would be needed by multiple systems. The costs saved in maintenance are equally impressive, as it takes much less labor to service one chiller than it would for the numerous independent systems that would have otherwise been built. The Brewery Blocks' cooling system further saves energy by using efficient plant equipment such as variable-speed pump drives and cooling tower fans. This "smart" system operates strictly on demand and adjusts to use only as much energy and water as necessary. While the labor requirements of design and installation are more than conventional systems, the savings are projected to offset the extra cost within only a few years.

Case Study: South Waterfront

Interface Engineering designed the Central Utility Plant (CUP), intended to serve first the OHSU's Center for Health & Healing and then adjacent buildings in the South Waterfront District, as they come on line. The rationale for a CUP for this project included:

- Heat is generated at less than half the cost of a conventional boiler.
- Up to 80 percent of the waste heat can be captured in a useful form, if used nearby.
- Allows for synergy with the building's thermal mass and water storage systems.
- Lower carbon dioxide, nitrogen oxides and sulfur oxides emissions than from conventional coal or gas-fired power.
- Diversity of energy uses allows equipment downsizing, so that residential and commercial loads can be serviced with smaller systems, since they occur generally at complementary times of the day and week.
- Greater economic efficiency of centralized operations.

- System can grow over time in a modular way as more buildings are added to the district.

Interface Engineering examined several options for providing chilled water and power from the CUP. The company specified 1,000 tons of high efficiency, water-cooled centrifugal chillers, rated at 0.46 kW/ton, using reclaimed water from the building and pumped groundwater for cooling tower makeup water. The company also decided to look at alternative sources of on-site power production, such as micro-turbines and solar power.

The CUP is designed to convert waste heat from the turbine exhaust to hot water, and send it to stratified storage tanks in the garage below the building. The hot water use is prioritized first for pre-heating the hot water supply for the building. This hot water is used for all building heating needs by circulating through air handling units, fin-tube units, and room-level terminal re-heat units. It is also used to provide hot water demand for the building. If all of these needs are satisfied, then the free heat is stored in the first floor concrete radiant slab or the health-club swimming pool.

The CUP size and configuration were designed for future expansion, as the South Waterfront district grows. Hot water lines can be extended from the current Block 24 site to other adjacent institutional, residential and commercial buildings. As the district expands, additional micro-turbines can be installed to meet the needs of other projects for electricity and hot water.

SMART GRID

A smart grid delivers electricity from suppliers to consumers using digital technology to save energy, reduce cost and increase reliability. The concept of a smart grid is that of an electrical distribution system where decisions are made at various locations throughout the system, as opposed to the current system whereby decisions are solely made at the power plant and by the consumer. This is referred to as “situational awareness” and it will enable local electrical problems to be tracked and handled at the local level[9]. Upgrading the transmission and distribution grids will both optimize current operations and open up new markets for renewable energy production.

President Obama asked the United States Congress "to act without delay" to pass legislation that included doubling alternative energy production in the next three years and building a new electricity "smart grid."[10]

Although there are specific and proven smart grid technologies already in use, *smart grid* is an umbrella term for a group of related technologies, including demand side management; enabling grid connection of distributed generation power (with solar, small wind turbines, micro hydro, or even CHP); incorporating grid energy storage for distributed generation load balancing; and eliminating or containing failures such as widespread power grid “black-outs.”

To reduce demand during peak usage periods or when renewable energy sources are unavailable, utilities use communications and metering technologies. By tracking not only how much electricity is used, but when that electricity is used, prices of electricity can be increased during high demand periods, and decreased during low demand periods. This technique of demand side management is similar to the way cell phone companies bill for daytime versus night and weekend minutes.

[9] Bonneville Power Administration’s Pacific Northwest Smart Grid Demonstration Project Draft Summary.
[10] "Obama's Speech on the Economy". *New York Times*. 2009-01-09.

Most renewable energy sources are intermittent, depending on sun, wind and water flows to generate power. Thus for utility infrastructure to use significantly more intermittent renewable energy resources there must be a means of effectively reducing electrical demand by shedding loads, the act or process of disconnecting the electricity on certain power lines when the demand becomes greater than the supply.

Smart grid enables use of “smart appliances” and “intelligent equipment” in homes and businesses. The use of energy management control systems in high performance buildings enable consumers and Utilities to better manage energy use and reduce energy costs. Smart appliances can shut down to reduce loads during peak hours. Similarly, electric cars can be used with vehicle-to-grid technology that allows electric vehicles when plugged in to feed power back into the grid during peak periods. Smart chips have been developed that can interact with smart grid technology to facilitate this load balancing.

These technologies will reduce the amount of operating reserve that electric utilities have to keep on stand-by, as the load curve will be leveled, thus reducing electrical costs to everyone.

RENEWABLE FUEL SOURCES FOR ON-SITE GENERATION

Renewable energy generated on-site produces net reductions in pollution and greenhouse gas emissions and reduces dependence on traditional fossil fuels like coal, gasoline, diesel and natural gas. When electrical power is generated on-site the electricity can be fed directly into the electrical grid, which does not require the use of batteries for energy storage. In Oregon, “net metering” laws allow for small generators (under 2 megawatts) of onsite renewable electricity to reduce their electricity bill by sending surplus back onto the electrical distribution grid. When surplus electricity flows back onto the grid, the meter dial literally reverses direction, and the utility pays the customer for the surplus energy, thus reducing, or even eliminating, the customer’s electric bill. On-site generation also releases limited capacity on the utility electric grid and helps balance energy loads during peak hours of use.

There is little volatility to the availability of renewable resources. Investment in renewable resources and technologies won’t be defeated by cost volatility, supply depletion or political turmoil. As long as the sun shines and the wind blows, these resources are free to use. The constant temperature of the soil and water are consistent sources of thermal energy. Planting, harvesting and replanting creates a closed loop cycle with which to derive biofuels like ethanol and biodiesel. We can also harvest combustible biomass from parks in the urban environment. Energy can be obtained from human waste, solid waste, food waste and waste from industrial processes, virtually endlessly as long as lifestyles permit. Today’s technologies make utilization of these readily available fuels viable. Advancing technologies will only make use of renewable fuels more efficient and affordable.

Solar Power

Despite our rainy winters, Portland receives as much solar energy annually as the average U.S. city. Solar is Oregon’s most abundant renewable energy resource. More than 17,000 Oregon households have solar energy systems.

There are two kinds of solar energy systems for home use: solar water heating and solar electric, also known as photovoltaic (PV). A solar water heating system preheats the water that goes into the existing water heater, which reduces the amount of gas or electricity the water heater consumes. A solar electric system directly makes electricity, which means reduced purchase of electricity from the utility. If a system is producing more than consumed, the utility buys the power back.

In Portland, 429 solar systems were installed between 2003 and 2008, including 169 photovoltaic systems, 213 solar hot water heating systems and 47 pool heating systems. Total photovoltaic capacity is 1,913 kW, with annual estimated energy savings of 1,913,000 kWh annually or enough electricity to power 159 Oregon homes per year. Total estimated annual energy savings from solar hot water and pool measures is 1,581,500 kWh per year, or enough electricity to power 132 Oregon homes per year[11].

A typical installed solar water heating system costs $6,000-$9,000 before incentives. For a solar electric system, the average cost is $9,000 for each kilowatt (kW). Energy Trust of Oregon provides cash incentives to help Oregonians invest in solar energy systems. These incentives and tax credits can cover as much as half the cost. The costs vary depending on the system size, current market prices, and the ease of installation. Federal tax credits provide more cash back to homeowners installing solar electric systems. Commercial projects have access to Oregon's Business Energy Tax Credit for 50 percent of project cost, bringing the payback down to only a few years.

Solar is an investment that increases in value as energy costs rise. At today's gas and electric prices, a solar hot water system saves the average family $150 to $300 per year. Savings are typically higher for larger families. A 2 kW photovoltaic system can trim 15 percent or more off electric bills. In addition, value is added to the property that will be reflected in its resale price. Current sales data show that added resale value is about 20 times the annual cost savings of a system.

Heating water is one of the largest uses of energy in the home. Residential solar water heating systems can save 2,000 - 2,800 kilowatt-hours (kWh) (100 - 140 therms of gas) per year. That's 60 percent of the energy used to heat water in an average Oregon home. In the summer, the system may provide 100 percent of hot water demand. During the winter months, solar will still heat the water, but not to the temperature recommended for home use. Electricity production is directly proportional to solar electric system size. 1 kW of solar electric panels optimally oriented with minimal shade will produce approximately 1,000 kWh per year in Portland. A typical residential system of 3 kW will supply about 3,000 kWh annually, or a quarter of an average Oregon home's yearly electricity usage.

Not all buildings are properly situated for solar. Solar works best on south-facing roofs, though east or west oriented low-slope roofs may be suitable as well. Flat roofed warehouses and other commercial facilities are particularly well suited for solar. There are also pole mounted systems that can be installed where roof slope faces and angles limit solar production. There should be little or no shading from trees, buildings, chimneys or roof gables. Even a small amount of shading on a panel can significantly reduce the efficiency of the system.

Both solar electric and solar water heating systems use large panels that are typically mounted on the roof. Solar water heating panels, called collectors, are 4 feet x 10 feet. A typical system will have one or two collectors. Photovoltaic panels require 100 square feet for each kW installed. For

[11] Savings from solar hot water and pool measures is a mix of electricity (kWh) and natural gas (therm) savings. All therm savings have been converted to kWh for comparison.

solar water heating system, an additional 80 gallon storage tank will be installed near the existing water heater. Solar water heating systems can also be used in conjunction with a tankless, on-demand water heater.

The City of Portland is working to increase the number of solar systems on City owned facilities. Portland Parks and Recreation recently built the East Portland Community Center Aquatics addition, with the highest standard of sustainable design to attain a LEED Platinum rating. The project includes a third-party funded, 90-kW photovoltaic array. The system is designed to produce 99,000 kWh annually, meeting approximately 12% of the building's energy use, with additional savings from a solar hot water system for the showers. While the project was funded, installed and operated by a third party, the generated electricity is sold to the Bureau at or below the energy rates charged by PGE. After six years the City has the option to purchase the system at fair market value.

Wind Power

Wind power is the conversion of wind energy into a useful form, such as electricity, using wind turbines. Although wind produces only about 1.5 percent of worldwide electricity use,[12] it is growing rapidly, having doubled in the three years between 2005 and 2008. In several countries it has achieved relatively high levels of penetration, accounting for approximately 19 percent of electricity production in Denmark[13].

Small electric wind turbines for residential or small commercial use have been available for more than three decades. The current technology is highly reliable and converts wind energy into electricity efficiently. Wind turbines for residential applications typically range in electrical output capacity from 500 watts up to 10 kilowatts. These systems are mounted on towers. Tower heights are generally between 60 and 100 feet off the ground, preferably at least 30 feet above any obstructions within a 300 foot radius. The wind turbines have blades or rotors, up to about 20 feet in diameter.

In urban settings, like Portland, where there is access to utility power and the wind system generates more power than can be used on-site, the owner is able to sell the excess generation to the local utility under Oregon's "net-metering" law. The City of Portland's Sunderland Recycling Facility features a 10 kW wind turbine that generates enough power to serve the Sunderland office building, with excess power going to the grid.

Case Study: Building Integrated Wind Turbines (BIWT) - 12W Project

Gerding Edlen Development's (GED) 12W project is a mixed-use high-rise tower currently under construction in downtown Portland. The building is designed to be topped by four wind turbines with 18' blades spinning on 40' masts. The wind turbine array is anticipated to produce 1 percent of the building's electricity use.

[12] World Wind Energy Association (February 2009). "World Wind Energy Report 2008"
[13] "Danish Annual Energy Statistics", Danish Energy Authority. December 2006.

Despite the popularity of BIWT in concept, the complexity of the dynamics of wind resources and the lack of installed examples have slowed market penetration. The complexity of wind behavior in an urban environment is commonly underestimated. The design team to date has collaborated with Dr. Sander Mertens of DHV Engineering in the Netherlands to predict the wind speeds and distributions available at the project site. The team also collaborated with aeronautical experts from Aerovironment Inc. in a wind tunnel at Oregon State University to understand the local wind behavior at the rooftop and to determine effective turbine locations. With these feasibility studies in place, the team feels that the prospects are promising enough to proceed with the project. BIWT energy production will be monitored. The results will be gathered, processed, and shared with the public to further the general knowledge and experience of BIWT in the local environment and to supplement expertise of Portland’s clean tech industry.

Case Study: TriMet’s Green Line South Terminus

The Jackson South Terminus, designated by the City of Portland as a gateway to the city, will become an educational space with renewable energy sources that will be highly visible throughout the site.

The proposed design calls for piloting the use of 22 vertical helix wind turbines, manufactured in Portland, to be mounted on top of the light rail’s catenary poles, providing 275 watts of power. The project will also include 50 kilowatts from solar energy. The renewable energy will be fed directly into PGE's power grid, but will generate enough power to run LED site lighting and the buildings’ electrical systems. TriMet and Portland State University will monitor the energy output from the site’s alternative power sources and report on its performance.

Geothermal

Geothermal energy is generated from heat stored in the earth, or the collection of absorbed heat from underground. The most common type of geothermal system is a closed loop system that releases essentially no greenhouse gas emissions. Geothermal power is available continuously, 24 hours a day, unlike wind and solar. Geothermal resources range from the shallow ground to hot water and rock, depending on the availability of resources and how deep wells are drilled. Multnomah County does have minor low temperature geothermal resources recorded by the Oregon Department of Geology and Mineral Industries and the Geo Heat Center Database. In particular, the analysis for the North Pearl district energy system identified one such well located in downtown Portland at approximately 70 degrees Fahrenheit.

The most readily available geothermal application for Portland is ground source heat pumps. With a nearly constant underground temperature between 50 and 60° F, a ground source heat pump system consists of pipes buried in the shallow ground near a building, a heat exchanger, and ductwork into the building. In winter, heat from the relatively warmer ground goes through the heat exchanger into the building. In summer, hot air from the building is pulled through the heat exchanger into the relatively cooler ground. Heat removed during the summer can be used as energy to heat water. A direct exchange geothermal heat pump does not have a heat exchanger, and simply circulates the working fluid through pipes in the ground. Geothermal technology is fairly expensive and can be cost prohibitive for existing buildings but has proven to be a viable option for new construction in the Portland region.

Another type of geothermal system is a water source heat pump, which uses underground water as the energy source. In 1948 the first geothermal heat pump in the western hemisphere was installed in Portland's Equitable Building. The building is a National Historic Mechanical Engineering Landmark. Even in 1948 the building included heat recovery from exhaust air and heating of incoming air with waste cooling water reducing the heating/cooling load by one third. The heat source for the building was well water pumped from two wells, roughly 150 feet deep, one of 64½°F at 195 gpm, the other 62½°F at 450 gpm, and is disposed to a 57°F well 510 feet deep.

More recently in central east Portland, developer Kevin Cavenaugh drilled 300 feet below ground to reach an ice-age aquifer. His building, the Burnside Rocket, was designed to use just 50 percent of the energy of a typical commercial building by using water from the on-site well to heat or cool air. Air is cooled by water through a heat exchanger and then distributed through voids in the concrete floor slabs.

Biogas

Biogas is produced through anaerobic digestion of liquid wastes. Anaerobic digestion is when bacteria break down waste in the absence of oxygen. The process produces a methane and carbon dioxide rich biogas suitable for energy production. Other by-products include water and nutrient-rich solids that can be used as fertilizer.

Biogas can be produced at wastewater treatment facilities. The Oregon Department of Energy estimates that only about 60 percent of the biogas produced at wastewater treatment facilities is currently used for energy production.

Liquid food waste can also be used to produce biogas. Portland also has the highest concentration of brewpubs of any major city in the United States, and numerous dairy processing facilities. These facilities pay to dispose of liquid food waste that could potentially be used for biogas production.

Another form of biogas is landfill gas. Landfill gas is produced through the decomposition of solid waste in landfills. Because of the extremely high global warming potential of methane, collection of landfill gas is common. In the absence of a suitable use of this gas, it is simply burned or flared off.

Case Study: Waste Methane Used for Fuel and Power Generation

As part of the sewage treatment process at the Columbia Boulevard Wastewater Treatment Plant, a significant amount of waste methane is produced. In the past, this biogas was used to power an electrochemical fuel cell and, more recently, "micro-turbines" to generate electricity. In late 2008 the Columbia Boulevard wastewater treatment plant installed an internal combustion engine-generator-based combined heat and powers system.

The facility burns methane gas produced from the City's sewage waste to generate more than 12 million kilowatt hours of electricity, or about enough energy to power 1,000 Northwest homes, each year. The energy produced provides about half of the treatment plant's daily power demand, cutting its annual energy bills by about 40 percent.

In the treatment process, anaerobic digester tanks convert solid waste into 1 million cubic feet of biogas each day. The biogas is fed through a purification process and into the electric generators that work more like a car engine than a home furnace. Extra heat from the generators is then looped back into the digesters, further reducing the amount of energy used in the treatment process.

Before the co-generation facility started operating, most of the biogas produced during wastewater treatment was simply burned off. Now, the process produces the same amount of carbon dioxide emissions, but the facility produces energy from the waste gas, which results in an overall net reduction in greenhouse gas emissions.

Biomass

Biomass, as a renewable energy source, refers to combustible biological material used as fuel. In this context, biomass refers to plant matter grown to generate electricity or produced from debris such as dead trees, yard clippings, wood chips, municipal waste and animal matter. Although fossil fuels have their origin in ancient biomass, they are not considered biomass because they contain carbon that has been "out" of the carbon cycle for an extended period of time.

When biomass is combusted it produces similar emissions to fossil fuels and therefore has the same adverse effects on air quality and human health. Combustion of biomass releases carbon back into the atmosphere as carbon dioxide (CO_2). This happens over a relatively short timescale and plant matter used as a fuel can be constantly replaced with new plants to absorb CO_2. Therefore a reasonably stable level of atmospheric carbon may result from use of biomass as fuel.

Case Study: North Pearl District

The North Pearl District NEU Business Analysis included biomass as a feasible alternative as it provided the most significant opportunities for local resource supply and greenhouse gas emission reductions.

Local sources of solid biomass could include wood waste from local wood manufacturing industries; land clearing; demolition and construction activities; and trimmings from local parks and streets. There are several recycling facilities in Portland that separate out urban wood waste.

Oregon Department of Energy suggested there could be 250,000 bone dry tons/year of biomass from urban wood waste alone, although pulp and paper industries compete for some of this. There is also a refined form of biomass fuel called E-Coal being marketed in the Pacific Northwest as a potentially very clean-burning fuel. This fuel can be produced from a variety of feed stocks, including short duration crops cultivated on degraded land that cannot be used for food production. This fuel is being considered by Seattle Steam for use in its new biomass energy plant. Biomass boilers require some scale to be most cost effective. With a biomass boiler there is significant machinery required to process biomass feedstock. The analysis specifically did not recommend biomass boilers smaller than 10 MW thermal output.

TECHNOLOGIES FOR ON-SITE GENERATION

Micro-Turbines

Micro-turbines are compact turbine generators that deliver electricity on-site, or close to the point where it is needed. Owing to their market maturity, technological simplicity and relatively low cost, micro-turbines are fairly common for distributed generation and combined heat and power systems.

Some systems are air cooled, designed to operate without oil or coolants. They can substantially reduce energy costs and reduce pollution with their near-zero emissions.

Micro-turbines run on most commercial fuels, such as gasoline, natural gas, propane, diesel, and kerosene, as well as renewable fuels such as ethanol and biodiesel. Typical micro-turbine efficiencies are 25 to 35 percent. Combined heat and power cogeneration systems can achieve efficiencies of greater than 80 percent.

Exhaust heat can be used for water heating, space heating or air conditioning. This thermal energy can also be distributed for heating throughout a district energy system. There are a number of benefits to using micro-turbines to service buildings. Interface Engineering did an analysis for the South Waterfront CUP project and calculated that, by generating power on-site and using the waste heat efficiently, it could achieve about 78 percent efficiency of fuel conversion, as compared to 32 percent efficiency for typical electric power generation and transmission.

Fuel Cells

A fuel cell is an electrochemical conversion device. It works similarly to a battery by producing electricity from fuel (on the anode side) and an oxidant (on the cathode side), which react in the presence of an electrolyte. The reactants flow into the cell, and the reaction products flow out of it, while the electrolyte remains within it. Fuel cells can operate virtually continuously as long as the necessary flows are maintained. Fuel cells are different from batteries in that they consume reactant from an external source, which must be replenished, also called a thermodynamically open system. Conversely, batteries store electrical energy chemically and hence represent a thermodynamically closed system.

Many combinations of fuel and oxidant are possible. A hydrogen cell uses hydrogen as fuel and oxygen (usually from air) as oxidant. Other fuels include hydrocarbons and alcohols. Other oxidants include chlorine and chlorine dioxide. Fuel cells are not necessarily renewable, depending on the source of the fuel. Some systems use hydrogen that can be split from water molecules as fuel. Electrolysis is used to split water molecules into their constituent parts, and this can require a relatively large amount of energy. Some renewable systems use solar power or other renewable energy sources to split water to get hydrogen that can then be used in a fuel cell to generate even more energy. The fuel cell basically recombines hydrogen with oxygen, releasing energy and pure water. Hence, a sustainable system with water in and water out, as long as the electrolysis is fueled by renewable power.

A fuel cell system running on hydrogen can be compact and lightweight and have no major moving parts. Because fuel cells have no moving parts and do not involve combustion, in ideal conditions they can achieve up to 99.9 percent reliability[14].

Micro combined heat and power systems such as home fuel cells and cogeneration for office buildings and factories are mass produced. The stationary fuel cell application generates constant electric power (selling excess power back to the grid when it is not consumed), and at the same time produces hot air and water from the waste heat.

[14] "Fuel Cell Basics: Benefits". Fuel Cells 2000. http://www.fuelcells.org/basics/benefits.html.

Prior to the installation of newer micro-turbines, the City of Portland's Columbia Wastewater Treatment Plant had a 200 kW fuel cell that used renewable biogas from the facility's anaerobic digester as fuel. The digester biogas is a waste product of the sewage treatment process. The system produces continuous renewable power while at the same time solving the facility's need for a back-up supply source to protect the control center during grid power outages.

VIABLE ENERGY SOLUTIONS FOR TRANSPORTATION

Transportation is a major component of overall energy use and contributes nearly 40 percent of all greenhouse gas emissions. Electrification of transportation modes like light rail, streetcars and electric vehicles can reduce dependence on foreign fossil fuels, reducing greenhouse gas emissions. Use of renewable resources like wind, solar and biofuels reduces environmental impacts even further.

The proposed Climate Action Plan sets four 2030 objectives related to land use and mobility:

1. Create vibrant neighborhoods where 90 percent of Portland residents can easily walk or bicycle to meet all basic daily non-work needs and have safe pedestrian or bicycle access to transit.
2. Reduce per capita daily vehicle miles travelled (VMT) by 30 percent from 2008 levels.
3. Improve the efficiency of freight movement within and through the Portland metropolitan area.
4. Increase the average fuel efficiency of passenger vehicles to 40 miles per gallon and improve performance of the road system.
5. Reduce the lifecycle greenhouse gas emissions of transportation fuels by 20 percent.

Transportation will continue to play a key role in shaping Portland and will be instrumental in maintaining our quality of life, personal and freight mobility, the economy, and the environment. Planning for and building the transportation network in the future will largely determine the success of climate and energy reduction goals.

TRANSPORTATION OPTIONS

Each transportation option, or mode, has its own benefits, but all are necessary to achieve a comprehensive transportation system, including integration of light rail, streetcars and bus operations with bicycling and pedestrian infrastructure. The figure below shows Portland's current commute mode split.

Even for a city with such a large proportion of bicyclists and "choice" transit riders (people who take transit even though driving is an option), 66 percent of the population still drives alone[15]. The proposed Climate Protection Plan sets a 2030 target to reduce single occupancy vehicle trips to 25 percent of current commute mode spit.

[15] U.S. Census Bureau 2007 American Community Survey.

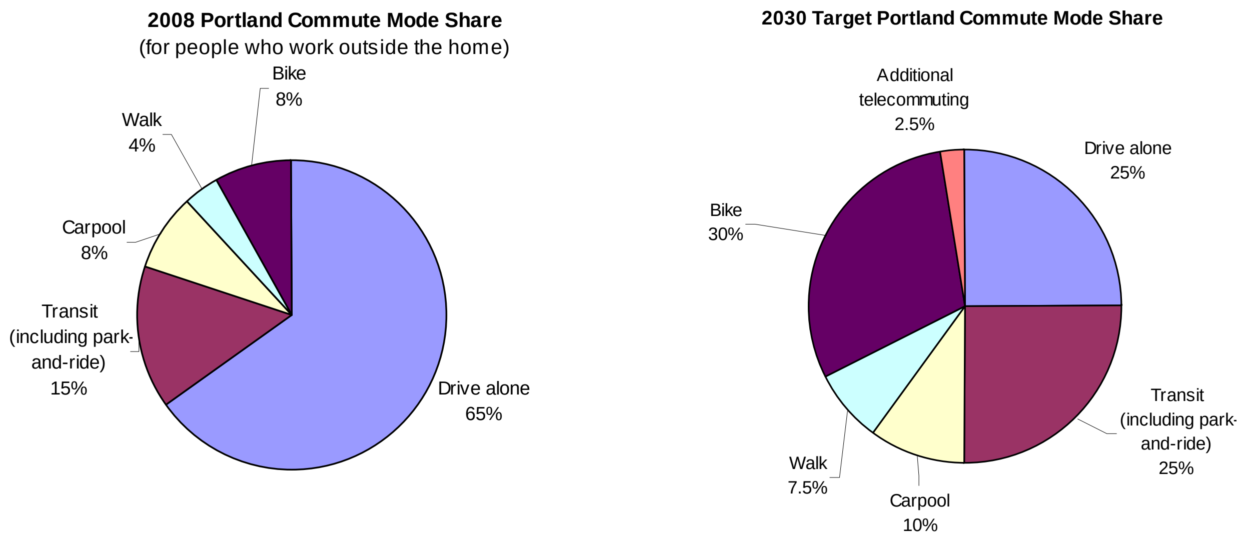

Figure 7: 2008 commute mode split for the City of Portland[16] compared to the Climate Protection Plan proposed 2030 target.

Reducing the number of automobile drivers can be accomplished through the use of more dense mixed use neighborhoods with a wealth of transportation options coupled with aggressive outreach and education efforts. Thus far, the City's investment in transportation options for mixed use neighborhoods is achieving the intended result. Data trends show that Portland residents travel 15 percent fewer miles in their cars, 20.3 VMT per capita, than the national average of 23.8 VMT per capita. Portland is one of a handful of cities where VMT per capita is decreasing.

As of 2008, Bicycle use in Portland showed a double-digit increase for the fourth straight year[17]. According to the U.S. Census Bureau, in 2007, Portland had the highest percentage of commuters traveling by bicycle in the nation. In 2008, over 16,700 cyclists crossed the Willamette River every day in Portland, up 15 percent from 2007. The number of daily cyclists crossing Willamette River bridges has doubled since 2002. TriMet reported a 46 percent increase in ridership between 1996 and 2006. Transit ridership numbers are on par with cities twice the size of Portland, and TriMet continues to attract a large number of people who ride by choice during peak and non-peak hours.

Polling data suggests that the opportunity to decrease the number of drivers who drive alone is substantial and that it can be reached with additional investments in infrastructure for transportation options, demand management, education and strategic investments in safety-related projects. For example, a huge latent demand exists for bicycling in Portland. Additional safety investments coupled with public outreach and education campaigns will help us realize this potential. In addition, visionPDX showed strong support for increasing the availability of transportation options for all residents in Portland.

The allocation and use of transportation options varies greatly across the city, however. Residents of outer East and Southwest Portland do not have the same levels of service or infrastructure for transit, walking, and biking as residents in inner Northeast, South, North, and Northwest Portland.

[16] City of Portland Auditor, Service Efforts and Accomplishments: 2007-08
[17] According to Portland Bureau of Transportation Willamette River bridge counts.

Consequently, a much higher percentage of trips are made in automobiles in outer East and Southwest Portland compared to closer in neighborhoods. Similarly, crash statistics show that some of Portland's most dangerous intersections are east of 82nd Ave. While carpooling is a viable option for those traveling longer distances, the percentage of residents carpooling has remained constant at around 10 percent for over a decade. This is likely due to the lack of investment in carpooling infrastructure (lanes or queue jumps), lack of large employment campuses and the relatively short trip distances.

STREETCARS

Portland developed around its historical streetcar network, which began with a horse-drawn line on 1st Avenue in 1872. The early streetcar lines served both as a mode of transportation and as an organizing tool for new development. They were constructed with the intent of drawing people to live in new, outlying neighborhoods. Between about 1890 and 1925, streetcar lines opened up at least 14 of Portland's historical neighborhoods for development. Over time, streetcar commercial districts evolved into the main streets that still exist in Portland's close-in neighborhoods. Streetcars were generally phased out between 1924 and 1958 in favor of private automobiles and buses for public transit.

The existing Westside streetcar line, completed in 2001, has demonstrated clear results to justify future expansions. Streetcars encourage denser development with a population that is less reliant on automobiles because destinations (e.g., home, work, and services) are closer and the streetcar, along with other transportation options are available.

According to Metro data, residents are almost twice as likely to walk, and are 45 percent more likely to use transit in mixed-use neighborhoods than in suburban neighborhoods. Analysis of the existing Portland streetcar experience indicates a savings of 60 million vehicle miles traveled per year due to added urban development, when compared to a similar suburban alternative[18].

It is estimated that the new development around Portland's existing streetcar system has resulted in a 60 percent reduction in greenhouse gas emissions, as compared to what emissions would be for a similar capacity of residential and business units developed in the suburbs[19]. This savings is realized through the reduction of motor-vehicle trips, consolidation and reuse of building materials, reduction in land consumption and less private and municipal infrastructure.

A significant opportunity to greatly influence land use patterns to help achieve the City's climate and energy goals exists with the completion and implementation of the Streetcar Master Plan. Not surprisingly, the proposed plan lays out streetcar routes throughout the city that reflect the historical streetcar routes. The proposed Climate Action Plan sets a goal of completing the Streetcar Master Plan and funding the next 3.3 miles of streetcar lines by 2012.

ALTERNATIVE VEHICLE TECHNOLOGIES

The electrification of transportation options - whether it's streetcars, light rail or single occupancy vehicles - shifts pollution away from vehicle tailpipes to power plants. From a human health perspective, shifting pollution away from densely populated areas is a significant advantage.

[18] URS and City of Portland Bureau of Transportation. "Why Streetcars? The Role of Streetcars in Portland".
[19] E.D. Hovee & Company, Memorandum on Carbon Footprint Benefits Modeling. February 2008

Centralizing the point source of vehicle emissions presents opportunities to both use renewable energy and capture and sequester carbon emissions. The following are some of the alternative vehicle technologies both on the market and in development.

Electric Vehicles (EV)

EVs run entirely on electricity, which can be charged at home or from charging stations on the go. In an EV, a battery is used to store the electricity that powers the motor. EV batteries must be replenished by plugging the vehicle into a power source, which charges it with electricity that comes from the power grid. Although electricity production may contribute to air pollution, EVs are considered zero-emission vehicles because their motors produce no exhaust or emissions.

There are currently no light-duty electric vehicles available from the major auto manufacturers, although Nissan has a plan to launch an EV pilot in Portland next year. Neighborhood electric vehicles (NEVs) are being manufactured by a variety of companies. These small vehicles are commonly used for neighborhood commuting and delivery and as golf carts. Their use is limited to areas with 35 mph speed limits or for off-road service on private property.

Hybrid Gas-Electric Vehicles (HEV)

HEVs combine the internal combustion engine (ICE) of a conventional vehicle with the battery and electric motor of an electric vehicle. The combination offers low emissions, with the power, range, and convenient fueling of conventional fuels. Unlike EVs, HEVs do not need to be plugged in. HEVs can use alternative fuels such as biodiesel or ethanol.

The flexibility and availability of HEVs from manufacturers like Toyota and Honda have made them very popular. The Toyota Prius is the top selling and most common HEV on the market. Portland has the highest per capita sales of HEV vehicles in the nation.

Plug-in Hybrid Electric Vehicles (PHEV)

A PHEV shares characteristics of conventional HEV and an EV, powered by both an ICE and batteries. What distinguishes PHEVs from a regular HEV is that PHEVs draw electricity from the grid, use the ICE as a secondary power source and have an all-electric range of at least 10 miles.

PHEVs are not yet in production. Kits are available to convert production model hybrid vehicles into PHEVs. Most PHEVs currently on the road in the United States are conversions of 2004 or later Toyota Prius models. Several auto manufacturers have announced their intention to bring production PHEV automobiles to the market in 2010, including Toyota, Nissan, General Motors, Ford, Volkswagen, Fisker Automotive and Aptera Motors.

A PHEV needs to be recharged daily by connecting to 110 volt household current. The vehicles are typically designed to handle a commuter-type range (20 to 60 miles) on their electric charge alone. Unlike other hybrids, they don’t need the ICE to get around town; it serves as a back-up to provide increased driving range.

After considering fuel and maintenance costs, a mass-produced PHEV should be more economical than either a conventional hybrid or a traditional gas powered vehicle. The estimated cost of electricity for a Prius PHEV is about $0.03[20] per mile compared to $0.07 per mile for gasoline based on California's electric utility rates[21].

On average, a PHEV driver is expected to achieve about a 15 percent reduction in net carbon dioxide (CO_2) emissions compared to the driver of a regular hybrid, based on the 2005 distribution of power sources feeding the U.S. electrical grid.[22] According to the California Cars Initiative, each kWh of battery power used will displace around 0.1 gallon of gasoline or diesel fuel. PHEVs also have the potential to be even more efficient than conventional hybrids, because limited use of the PHEV's ICE may allow the engine to operate closer to its maximum efficiency than conventional hybrids.[23]

Natural Gas Vehicles (NGV)

The interest in natural gas as an alternative transportation fuel stems mainly from its clean-burning qualities and the commercial availability of natural gas. Natural gas is readily available to consumers through existing utility infrastructure. However, it is important to note that natural gas is a non-renewable fossil fuel resource with supply and demand issues and greenhouse gas emissions.

Dedicated natural gas vehicles (NGVs) are designed to run only on natural gas; bi-fuel NGVs have two separate fueling systems that enable the vehicle to use either natural gas or a conventional fuel (gasoline or diesel). In general, dedicated NGVs demonstrate better performance and have lower emissions than bi-fuel vehicles because their engines are optimized to run on natural gas. In addition, the vehicle does not have to carry two types of fuel, thereby increasing cargo capacity and reducing weight.

Compared with vehicles fueled with conventional diesel and gasoline, NGVs can produce significantly lower amounts of harmful emissions. In addition, some natural gas vehicle owners report service lives of two to three years longer than gasoline or diesel vehicles and extended time between required maintenance.

Because of the gaseous nature of this fuel, it must be stored onboard a vehicle in either a compressed gaseous (compressed natural gas, CNG) or liquefied (liquefied natural gas, LNG) state. CNG and LNG are considered alternative fuels under the Energy Policy Act of 1992.

CNG must be stored onboard a vehicle in tanks at high pressure, up to 3,600 pounds per square inch. A CNG powered vehicle gets about the same fuel economy as a conventional gasoline vehicle. LNG must be produced by purifying and condensing the gas into liquid by cooling it to negative 260°F, a costly and energy intensive process. Because it must be kept at such cold temperatures, LNG is stored in double-wall, vacuum-insulated pressure vessels. LNG fuel systems typically are only used with heavy-duty vehicles.[24]

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[20] Cost dependent on electric range, battery type and electric utility rate. California Cars Initiative (April 20, 2006) "Fact Sheet: PHEV Conversions." Standard Prius gasoline cost is based on 50 mpg and $3.50 per gallon gas.

[21] According to the Energy Information Administration, as of May 2009, average California residential electricity rates were 41% higher than Oregon.

[22] Kliesch, J. and Langer, T. (September 2006) "Plug-In Hybrids: an Environmental and Economic Performance Outlook" American Council for an Energy-Efficient Economy

[23] Gonder, J. and Markel, T. (2007) "Energy Management Strategies for Plug-In Hybrid Electric Vehicles" (PDF) technical report NREL/CP-540-40970 presented at SAE World Congress, April 16–19, 2007, Detroit, Michigan

[24] U.S. Department of Energy; www.afdc.energy.gov/afdc/vehicles/natural_gas_what_is.html

ELECTRIC VEHICLE CHARGING INFRASTRUCTURE FOR EV AND PHEV

Access to charging infrastructure may present a challenge for people living in apartments and condominiums that do not have garages. Public charging stations offer a partial solution to this problem, but large-scale daytime use of rapid charging stations will increase electrical demand during peak hours. For electrical vehicles to be cost-effective and environmentally beneficial, they need to be charged overnight and use "smart chips" to pull power from the grid during off-peak hours.

Portland General Electric (PGE) recently installed its first PHEV charging station at its headquarters in downtown Portland and plans to install several more stations in the Portland metropolitan area. The City of Portland has also installed one station at SW 4th and Main outside the Portland Building. PGE is also seeking partnerships with automobile manufacturers such as Nissan to ensure that the charging stations work with existing and future electric vehicle technologies.

The State of Oregon is heading up a statewide effort to deploy electric car infrastructure in the coming year. Federal Stimulus funding for battery research has been granted to three Oregon businesses in Lebanon, Albany and Coburg. ETec, a subsidiary of ECOtality, Inc., is partnering with Nissan North America to deploy approximately 1,000 Nissan electric vehicles in Oregon and 2,500 charging stations will be installed at homes and businesses of those who choose to purchase the Nissan EVs and participate in the program. The deployment of vehicles and infrastructure will focus initially on the Portland-metro area and then expand to other areas in Oregon. Portland General Electric and the Oregon Department of Transportation are lead implementation partners.

FUEL EFFICIENCY

With the 2009 announcement of proposed uniform federal standards for both vehicle fuel efficiency and greenhouse gas standards, the pace of fleet-wide fuel-efficiency improvements in new vehicles appears likely to accelerate. Current federal standards require that the average fuel economy of new vehicles must be 35 miles per gallon by 2020; if implemented successfully, the new federal standards would achieve the same performance by 2016. It is essential to continue to improve fuel efficiency across all vehicle classes and with predictable improvements to reduce uncertainty in markets for emerging technologies; it is equally important for consumers to choose the most efficient vehicle that meets their needs.

One assumption underlying the analysis of changes needed to achieve an 80 percent reduction in local greenhouse gases by 2050 is that all new passenger vehicles will achieve at least 55 mpg by 2050. Portland intends to support progressive strengthening of federal fuel efficiency standards. The City will also work locally to identify and fund demand management projects and pilot congestion pricing programs to reduce emissions related to congestion and prioritize movement of freight and non-single-occupancy vehicles.

RENEWABLE TRANSPORTATION FUELS

Alternative fuels are materials or substances that can be used as a fuel, other than conventional fossil fuels. Some well-known alternative fuels include biodiesel, ethanol, hydrogen, methane, natural gas, and vegetable oil. Biodiesel and ethanol, also known as biofuels, have recently seen a surge in local production and demand.

Biodiesel is typically produced from soy and oilseed crops (e.g., canola and mustard) or used cooking oils and waste animal fats. Biodiesel runs in all diesel engines and can be blended in any proportion with petrodiesel. Biodiesel, typically a B20 blend, is currently available in many regions of the state, including Portland, Bend, Eugene, Corvallis, Hood River, McMinnville and Medford.

Ethanol is currently produced primarily from corn. In the near future, as commercialization of the technology develops, ethanol will also be produced from cellulose feedstocks such as wood waste, switch grass and agricultural residues. From 1992 to 2006, Portland's ethanol supply was blended with up to 10 percent gasoline during winter months to reduce carbon monoxide pollution. Several U.S. automakers sell flexible fuel vehicles capable of running on 85 percent ethanol (E85) at no added cost to buyers. However, public access to E85 stations is limited primarily to the Midwest. There are fewer than five retail stations selling E85 in the Portland area, with more on the way.

Biofuels are not a cure-all for transportation energy, but they are an important component in our toolbox of measures to reduce reliance on fossil fuels. Americans, per capita, consume more barrels of oil per year than any other country. With just 5 percent of the world's population, we consume nearly 25 percent of the global oil supply[25]. The U.S. fleet of approximately 210 million automobiles, SUVs, vans and pick-up trucks account for about two-thirds of our country's oil use (roughly 14 million barrels a day). At maximum production, the potential of biofuels to displace 25 to 30 percent of our current fossil fuel use is limited, at best[26].

Expanding the use of biofuels must be part of a larger, aggressive strategy to transition to a sustainable transportation model that focuses on reducing total energy use through a more compact community, increased vehicle mileage efficiency, fuel conservation and expanded utilization of alternative forms of transportation like walking, biking and transit, along with improved modes of shipping such as rail and barge. Portland has a long history of working on all aspects of this more sustainable transportation model, and promoting the use of regionally produced biofuels is a natural extension of those efforts.

In July of 2006, Portland became the first city in the U.S. to adopt a local Renewable Fuel Standard (RFS) for all motor vehicle fuels sold inside the city limits. The standard requires that all diesel fuel sold in the city contain a minimum of 5 percent biodiesel (B5) and that all gasoline contains a minimum of 10 percent ethanol (E10). In 2010, the minimum biodiesel requirement will increase to 10 percent (B10). Such innovative, results-oriented policies meet goals for job growth, greenhouse gas emission reduction and local environmental health.

Additionally, Portland prohibits the use of biodiesel produced from palm oil for compliance with this RFS and establishes desirable feedstock requirements once certain in-state production thresholds have been met. In 2007, Oregon's Legislature also adopted a RFS to be implemented statewide that includes requirements for the sale of 2 percent biodiesel blends (B2) and 10 percent ethanol blends (E10). Portland's RFS will remain in effect.

In an effort to maximize the City's own use of renewable fuels, City Council created a binding City policy formally requiring that all City-owned diesel vehicles use a minimum of 20 percent biodiesel (B20); gasoline vehicles must use a minimum of 10 percent ethanol (E10). Since 2006, the Portland Water Bureau has been using B99 in their fleet during summer months. CityFleet has installed an

[25] BP Statistical Review of World Energy, 2007
[26] U.S. Departments of Energy and Agriculture, Billion Ton Study

E85 tank for the City's approximately 80 flex-fuel vehicles. CityFleet now specifies flex-fueled vehicles in all new car purchases when that option is available. Portland also requires all residential garbage and recycling haulers to use a minimum B20 in their trucks that provide service inside the city's limits.

City Council has allocated financial resources to support economic development around clean energy, including biofuels. The City has offered a variety of grant and contracting opportunities to the private sector in an attempt to accelerate the development of the biofuels market as outlined in the priorities below:

- Increasing the number of gallons produced and sold in Portland, and secondarily in Oregon.
- Improving the ease, efficiency and cost effectiveness of storing, blending and distributing high blends of biofuels.
- Furthering the development of Oregon-grown feedstock supply chains and supporting the growth of farmer or cooperatively owned facilities and partnerships that enable farmers to share ownership throughout the value chain of their feedstock.

Currently, there are no reliable data on how much biodiesel is sold in the state, or by city and/or county. This is primarily a result of how the state currently tracks diesel fuel sales. As a result, it is difficult to estimate the exact impact the Renewable Fuels Standard and other policy and promotion efforts have had, or will have, on the local and regional biodiesel market. There is reason to believe, however, that at a minimum local trends mirror what we are seeing nationally. Data from the U.S. Department of Energy indicates that the number of ethanol and biodiesel production facilities and fueling stations has increased exponentially since 2003. Without Oregon, Washington and Portland's Renewable Fuel Standards, it is likely that growth in biofuels production would have remained solely a Midwest phenomenon.