



Infrastructure Crisis, Sustainable Solutions:

Rethinking Our Infrastructure Investment Strategies 



the evergreen
state college

Center for Sustainable
Infrastructure

Affordable Resilient Sustainable Integrated

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Table of Contents

Introduction	3	Integrate Smart Systems.....	28
Infrastructure Crossroads, a New Paradigm		Partner With Nature and Enhance the Community....	28
Emerging	4	Value Capacity and Expertise	28
Change Drivers	5	Implementing the Principles	28
The Infrastructure Deficit	5	Policy Tools for State Leadership	29
Technology and Markets.....	5	Washington and Oregon Policy Approaches	29
Climate Change	6	Overarching Policy Themes	31
The Need for Infrastructure Resilience	6	Physical Design	32
What Does the Future of Sustainable		Financing.....	33
Infrastructure Look Like?	8	Project Analysis.....	35
Integrated Solutions	8	Five Big Goals for 2040	36
Closing loops, recovering resources.....	8	Ace the state infrastructure report cards; lead the nation in innovative projects.....	36
Digging up the streets.....	8	Convert 95% of all types of energy use to renewables; fully deploy efficiency to cut demand 60%	36
Nature delivers the goods (and services)	9	Wring out water waste by 60%; integrate across water-wastewater-stormwater silos	37
Water-smart energy systems, energy-smart water systems	10	Upgrade 75% of neighborhoods to “Very Walkable”; connect cities with high speed transit.....	38
The future of cars: less petroleum, more electricity.....	11	Ensure 90% of products are managed by producers after use, and most ‘waste’ material is recovered by local industry	39
Smart-talking infrastructure	11	Building the Sustainable Infrastructure	
Aligning our economic development and infrastructure strategies.....	12	Movement in the Northwest	40
Innovations Within the Sectors:	13	Convene Innovators.....	40
Energy.....	13	Best Practices Clearinghouse	40
Transportation.....	15	Professional Development and Consulting for Decision-makers	40
Water	18	Grow a Sustainable Infrastructure Emphasis at Evergreen and Partner with Other Academic Institutions.....	41
Waste	21	Communications to Re-imagine Infrastructure	41
Key Challenges	24	Create the Policy Environment to Support Sustainable Infrastructure	42
Ten Guiding Principles for Innovation	27	Next Steps	43
Go for the Triple Crown: Fiscally Sound, Resilient, and Sustainable	27	Acknowledgments	44
Consider Broader Alternatives.....	27	Sponsors	48
Encourage Silo-Busting.....	27		
Build a Better Business Case	27		
Educate, Engage, and Inspire.....	27		
Build Community Prosperity	27		
Choose for a Changing World	28		

Introduction

During the first half of 2014, the Center for Sustainable Infrastructure formally interviewed 70 of the Pacific Northwest's top infrastructure innovators and thought leaders.¹ Distilling the prevailing themes and key insights, the purpose of this report is to provide inspiration and guidance to the region's current and future infrastructure leaders, policymakers, and change agents.

The Center exists to advance a new sustainable infrastructure paradigm and practice in the Pacific Northwest and beyond, and to help Washington and Oregon to become nationally-recognized innovators in sustainable infrastructure solutions. The Center envisions a future for the region where sustainable, resilient, and affordable infrastructure systems provide vital services accessible to all, supporting healthy, prosperous, beautiful, and cohesive communities.

To achieve that future, many billions of dollars in needed infrastructure investment in the region must shift from conventional approaches toward innovative new policies, programs, and projects. A shift of this magnitude will be not be easy. A wide range of professions have a role to play, from the leaders of infrastructure agencies and utilities, to community planners and elected officials, builders and design teams, engineers and technology firms, financiers and

lenders, advocates and regulators. Our hope is this report will prove useful to them as they help Northwest communities transform how they think about, plan for, and invest in their infrastructure assets.

To this end, this report will:

- Explain some of the forces compelling decision-makers to rethink our infrastructure investment strategies, and show why our goal for future investment should be to optimize for long-term affordability, resilience and sustainability at the same time.
- Paint the picture of innovative, integrated infrastructure strategies emerging to reshape the energy, transportation, wastewater, stormwater, water supply, and waste sectors.
- Highlight a number of real-world examples from Northwest communities of innovative projects and programs.
- Frame some of the key challenges in making the shift.
- Articulate 10 guiding principles to grow the sustainable infrastructure toolkit of our planners and decision-makers.
- Compare the state infrastructure policy frameworks of Washington and Oregon and highlight statewide strategic goals suggested by the thought leaders.
- Offer "5 Big Goals for 2040" to begin shaping a vision that looks 25 years out.
- Distill the top roles and services to build sustainable infrastructure capacity in the region that thought leaders recommended for the Center and its allies, and flag some next steps going forward.

¹ The full list of thought leaders and innovators who generously gave of their time to participate in these interviews is included in the Acknowledgements section at the back of this report.



➔ Infrastructure Crossroads, a New Paradigm Emerging

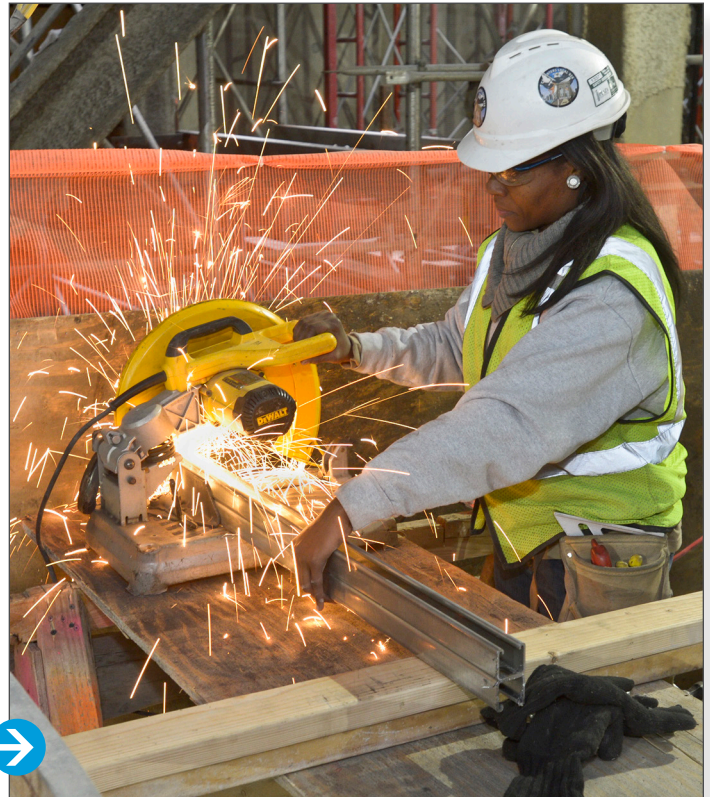
Our choices when investing in infrastructure have vast consequences for our economy, environment, and commitment to equity. Energy, transportation, water, and waste systems represent some of the greatest public works investments we as a society undertake. But propelled by urgent financial, environmental, and social drivers that force change, we must rethink in the coming decade how we invest in these vital circulatory systems of society.

Enormous amounts of capital must be secured and invested to refurbish and modernize our infrastructure systems in the next decades. Globally, McKinsey and Company estimates that \$57 trillion in infrastructure investment will be required in the next 17 years just to keep up with GDP growth, not factoring in the need for climate resilience and carbon reductions.¹ Along the Pacific Coast, the need is estimated at well over \$1 trillion in the next 30 years.²

These infrastructure spending decisions are intimately tied to long-term human well-being and sustainability: much of humanity's heat-trapping and ocean acidifying emissions, for example, result from the way these infrastructure systems are designed and the personal, commercial, and industrial activities they support.

But in many cases, the funding is not currently in place to meet the need – especially where aging systems largely built out several decades ago are serving demand that has grown – leaving an ‘infrastructure deficit’ with important implications for our economy. A 2011 American Society of Civil Engineers (ASCE) study, for example, calculated that the costs of fixing deteriorating drinking water and wastewater treatment infrastructure in the U.S. – assuming standard, business-as-usual approaches – will exceed identified funding sources by \$84 billion by 2020. The substandard infrastructure resulting from this funding gap, they estimate, will trigger \$206 billion in increased costs for businesses and households, which in turn would jeopardize up to 700,000 jobs.³

Given the gap between need and available resources, infrastructure managers and engineers are doing an extraordinary, if unsung, job keeping aging systems operating reliably. But the public may be largely unaware of the growing urgency of this infrastructure deficit.



Work on the Fulton Center in Lower Manhattan in 2013. Photo: Patrick Cashin. (By Metropolitan Transportation Authority of the State of New York. "FultonSt_4039" uploaded by tm. Licensed under creativecommons.org/licenses/by/2.0)

Recognition is growing among infrastructure professionals, however, that innovative and creative new approaches are needed to inspire smarter investment and foster public support. “We’re making decisions today that we’ll live with for 50 years. We can’t keep doing things the way we always have,” says Peter Binney, 2011 winner of the ASCE President’s Medal. Indeed, the entire built environment that we share was shaped to a significant extent by the infrastructure choices made by previous generations. Infrastructure represents not only shared long-term investment, but a crucial intergenerational legacy. Now we are faced with fundamental decisions about how we want the built environment to look and function for the next generation, and our immediate infrastructure choices will enable or frustrate that vision.

In the emerging new infrastructure practice, rigorous analysis of alternative strategies early on, in the ‘pre-design’ phase, is the key to identifying investments that leverage new technologies and techniques to deliver the best return for the community. Combined with public education and transparency, evaluating a broader set of innovative options and a broader set of costs and benefits can help convince the public to support, and pay for, new investment in our infrastructure systems.

1 McKinsey Global Institute, Infrastructure Productivity: How to save \$1 trillion a year, January 2013: http://www.mckinsey.com/insights/engineering_construction/infrastructure_productivity.

2 West Coast Infrastructure Exchange – CH2MHILL Report Summary, Nov 14, 2013: http://westcoastx.com/assets/documents/WCX_CH2MHill-summary.pdf.

3 ASCE, Failure to Act: The economic impact of current investment trends in water and wastewater infrastructure, 2011: http://www.asce.org/uploadedfiles/infrastructure/failure_to_act/asce%20water%20report%20final.pdf.



Infrastructure Crossroads, a New Paradigm Emerging

The outlines of a new sustainable infrastructure paradigm are emerging, though there is no widely accepted definition today of the term sustainable infrastructure. For purposes of this report, sustainable infrastructure systems are:

- **Environmentally sound and resilient:** They achieve radically improved environmental performance and greater resilience to future disruption risks.
- **Integrated:** They connect across the silos now isolating different systems to deliver better, more efficient services.
- **Affordable:** They demonstrate a strong business case for investment decisions, commit the resources necessary for proper maintenance, and enjoy reliable, equitable revenue streams from users and beneficiaries.
- **Rich in co-benefits:** They offer a portfolio of important co-benefits of real value to the community for the economy, public health, social equity, the environment, and more.
- **Beneficial to the local economy:** They support economic and community development by stimulating local investment, growing local capacity in the building industries and trades, and helping promote more broadly-shared prosperity.

Change Drivers

The Infrastructure Deficit ~

The gap between available resources and the funds required to keep our infrastructure systems in working order poses an increasingly serious challenge for many infrastructure managers. The 'infrastructure deficit' has two faces. For one, capital funding is lagging to replace and restore aging facilities, and to accommodate growth. Traditional federal funding sources are shrinking, and many infrastructure agencies are not setting aside enough funds to replace aging facilities. Second, budgets for operating and maintaining infrastructure are under serious strain as systems age and costs escalate.

Many infrastructure systems rely on revenue sources that are inadequate to meet ongoing capital, as well as operations and maintenance (O&M), needs. Much of the funding for road infrastructure, for example, comes from declining gas tax revenues. The American Society of Civil Engineers' 2013 Report Card for America's Infrastructure assessed the state of the nation's infrastructure, delivering an overall grade of D+ (D is 'Poor' and C is 'Mediocre'). Washington and Oregon fare only marginally better, with a C and C-grade, respectively. While ASCE estimates \$3.6 trillion is needed nationally by 2020 to raise the grade to B, only about \$2 trillion in funding sources are currently in place.⁴

4 ASCE, "2013 Report Card for America's Infrastructure," <http://www.infrastructurereportcard.org/>.

Most infrastructure agencies aren't funding depreciation of their capital assets, which would require them to set aside resources to replace aging systems, says Stan Finkelstein, Chair of Washington State's Public Works Board. At the same time, many O&M budgets are not properly scaled to maintain infrastructure that is both aging and stretches into relatively low-density, expensive-to-serve suburbs.

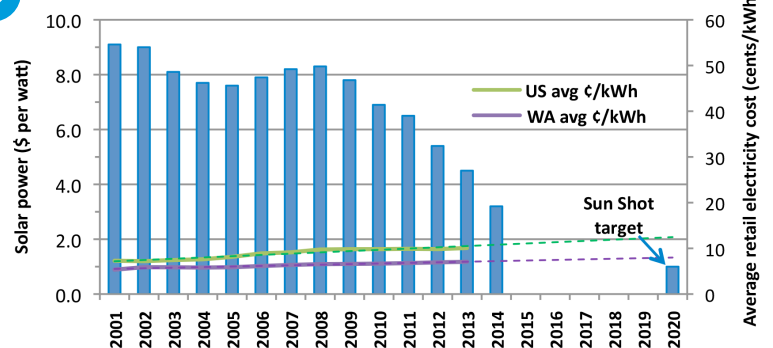
Sustainable infrastructure, on the other hand, "is both financial and ecological – it minimizes life cycle costs, as well as ecological impacts," says Chris Taylor, Executive Director of the West Coast Infrastructure Exchange. To get there, though, will require a fundamental reset in how we plan, budget and procure infrastructure projects.

Technology and Markets ~

Two other major change drivers, technology and markets, are conspiring, most starkly in the electricity sector, to drive us toward just such a fundamental reset. With stunning growth and economies-of-scale driving costs down, solar photovoltaics (PV), for example, are becoming an economically attractive option for residents and businesses in many regions



Average Costs of US Installed Solar Power and Retail Electricity



Costs for solar power have dropped steadily since 2008. With rapid global growth, the industry is on track to meet the US Dept of Energy's "SunShot" target of \$1/watt (before incentives) by 2020, or 6 cents per kWh, a rate broadly cost-competitive with non-renewable energy. Sources: National Renewable Energy Lab, Energy Information Agency.

of the U.S. and the world.⁵ As a result, two-thirds of solar PV installations worldwide were installed in just the 2.5 year stretch beginning January 2011, with another near-doubling forecast for the 2.5 years that follow, according to GTM Research.⁶ This rapid growth is fueling further economies-of-scale and plunging costs.

5 Morgan Stanley Research North America, Clean Tech, Utilities and Autos. "Batteries + Distributed Gen. May Be Negative for Utilities," March 4, 2014.

6 Stephen Lacey, greentechsolar, "Chart: 2-3rds of Global Solar PV Has Been Installed in the last 2.5 Years," August 13, 2013, Greentechmedia.com.



Infrastructure Crossroads, a New Paradigm Emerging

At the same time, automakers are racing to scale up production and drive down costs of battery technology to enable electric vehicles to compete with conventional cars.⁷ In addition to revolutionizing how we power our vehicles, low-cost batteries could also capture a home and business market that, in tandem with solar PV, would offer millions of customers the option to save money by either minimizing use of the electric grid or actually unhooking from their power company.⁸

Meanwhile, advanced electronics, wireless communications, and new GIS tools offer transformative potential for infrastructure planners and operators. "Our public works infrastructure will make up much of the Internet of Things," says Liz Kelly of CH2M Hill.

"Consider the changes we have experienced with smart phones in the past decade and imagine similar efficiency gains with infrastructure operations."

Climate Change ~

Climate change is also emerging as a powerful driver for rethinking infrastructure – both our reliance on carbon-based fuels and the vulnerabilities of our critical infrastructure to extreme weather. Climate change, for example, is complicating infrastructure planning. "Cities typically design and size storm drain systems to handle the 10 year storm," says Bobby Cochran of the Willamette Partnership, "but with a changing climate, we don't know what a 10 year storm is anymore." The trend toward more extreme weather, "keeps infrastructure managers up at night," says Rich Hoey, Public Works Director for the City of Olympia.

Although political rivalry and controversy continue to paralyze national action by the U.S. Congress, the consensus for action along the Pacific Coast has been quite robust and sustained. Already the Pacific Coast Collaborative (PCC) of the three West Coast governors and British Columbia's premier has pledged cooperation on climate solutions: "By working collaboratively to shape policy and facilitate aggressive action on climate change, the Pacific coastal region will lead the world in reducing greenhouse gas emissions, and reduc-

ing risks of creating impacts beyond our ability to respond and adapt."⁹ The PCC has spun off a new organization, the West Coast Infrastructure Exchange, to draw new investment into climate-smart infrastructure.¹⁰

The Need for Infrastructure Resilience ~

Infrastructure systems are vulnerable to a variety of natural and human hazards, from extreme weather events and earthquakes to terrorist attack and large-scale accidents. And when they happen, public attention can focus, powerfully if episodically, on infrastructure vulnerabilities and on the need for more resilient systems. Resilient systems are less 'brittle,' less vulnerable to catastrophic failure, than standard systems, and recover to

restore service more quickly in the event of disruption.

The U.S. Department of Homeland Security's National Infrastructure Advisory Council says, "The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."¹¹

"To get smart about this resiliency planning, we need to factor in – before we commit large amounts of money into infrastructure investments – future disaster scenarios and figure out how the facilities will be protected and the systems recovered," says Eric Holdeman, Director of

the Center for Regional Disaster Resilience. "You need to look at all your systems and their interdependencies and identify which ones, if they go down, could knock you out of business."

Planning for resilient systems is not a mandate to overspend. "We can't afford the economic and environmental costs of overbuilding our infrastructure," points out Hoey. "Our models of future demand that drive infrastructure planning need to adapt to changing demographics and technology," which in many cases are bending demand curves away from continuous growth toward greater efficiency and conservation.

"We can't afford the economic and environmental costs of overbuilding our infrastructure. Our models of future demand that drive infrastructure planning need to adapt to changing demographics and technology."

Rich Hoey, Director
City of Olympia Public Works

7 Anton Wahlman, The Street, "Tesla and the New Frontier in Electric Car Competition," December 23, 2013, thestreet.com.

8 Morgan Stanley Research North America, *ibid*.

9 Pacific Coast Collaborative, www.pacificcoastcollaborative.org.

10 West Coast Infrastructure Exchange, www.westcoastx.com.

11 National Infrastructure Advisory Council, Critical Infrastructure Resilience Final Report and Recommendations, September 8, 2009.



Infrastructure Crossroads, a New Paradigm Emerging

Sustainable infrastructure aims to combine affordability and resilience with excellent environmental performance. Key environmental performance metrics include:

- Maximum capture of the efficiency resource and locally-plentiful renewable resources.
- Clean sources and efficient use of water, energy, and materials.
- Little or no greenhouse gas emissions.
- Little or no release of toxic compounds and other pollutants.
- Enhanced and restored natural systems.

Sustainable infrastructure could help build the public support and trust necessary to marshal the resources to address our growing infrastructure deficit. By considering broader alternatives, and applying new economic analysis tools and rigor, decision-makers can demonstrate to the public that they are making smart investments with a strong business case. Sustainable systems can show impressive efficiencies, lower lifecycle costs, and offer a range of compelling co-benefits for the community. These co-benefits can have real economic value across other sectors, improving results from public health programs, reducing costs for environmental compliance, and fostering job opportunities accessible to lower-income residents, for example.



The Floodplains by Design effort is integrating the use of natural infrastructure as a means to achieve multiple outcomes for flood protection and fish habitat. Photo by Marlin Greene/One Earth Images.



City of Olympia Public Works – Innovating for a Midsize Community

Olympia, Washington is innovating on many fronts. The City's Public Works Department is institutionalizing the Envision™ sustainable infrastructure rating system and recently trained 60 staff members – engineers, operations supervisors, planners, and inspectors. Rich Hoey, Olympia's Director of Public Works, likes "the way Envision gets our staff and public to really think about upfront and long-term costs. It will be very valuable as we do our capital facilities planning 6 years, 20 years and even 50 years out." Staff meets at least twice a year in Performance Roundtables to explore opportunities to integrate across sector lines.

The City is committed to 'low-impact development' centered on distributed stormwater management strategies, and is increasingly working to adopt integrated water resource approaches. Its new Wastewater Plan calls on Public Works to apply the Envision system.

The City has completed millions of dollars' worth of energy efficiency projects on its buildings and is converting all its street lights to LED which, when completed in early 2015, will save over \$230,000 a year on the power bill and still more on maintenance costs.

The City recently brought 6 electric vehicles into its fleet and is adding the conduit and facilities to support more. Hoey describes EV's as "a perfect application for city fleets," and says, "In 10 years with the technology evolution of batteries and the like, things will look very different. We want to be positioned as early adopters, and take advantage of resources available for early adopters." The City is also aiming to build vibrant urban corridors with density, mixed use, and people living close to work and transit, aiming for an every 15 minutes Level of Service for transit along major corridors, along with good bike and pedestrian connections to those transit stops.

The mission of the City's Waste ReSources Utility is to lead and inspire the community toward a waste-free future, and a key mandate for its staff is to create opportunities to eliminate waste. And the City walks its talk in its operations: Olympia is a regional pioneer of every-other-week garbage, organics and recycling collection, as well as one-side-of-the-street collection, which dramatically reduces miles driven and fuel consumed by its hauling trucks.

➔ What Does the Future of Sustainable Infrastructure Look Like?

The future of sustainable infrastructure will increasingly blur boundaries between our energy, transportation, water, and waste systems to implement complementary strategies that benefit more than one system. But today, for the most part, our communities' infrastructure systems are developed and managed separately, by separate utilities and agencies. Among our most important, and difficult, challenges will be reforming these institutions and their funding mechanisms to enable and incentivize integrated, whole-system solutions that benefit our communities the most.

This section begins with several examples of such integrated, silo-bridging solutions. It then circles back to look at the shape and form that innovation is taking in each of the infrastructure sectors – energy, transportation, water, and waste.

Integrated Solutions

Integrated solutions benefit more than one infrastructure system and, at the same time, deliver a generous range of other economic, social and environmental benefits. Integrated solutions take many forms. "We have a generational imperative to reimagine our infrastructure systems," says Nan McKay, former Chair of the Puget Sound Action Team. "We've got to break through institutional silos and find innovative solutions that connect systems for the greatest community-wide benefit for the long term."

Innovators are beginning to do just that, pioneering new solutions that integrate across traditional silos. *Here are several early examples of these types of integrated innovations:*

Closing loops, recovering resources ~

Steve Moddemeyer, Principal with CollinsWoerman and leading advocate for closed loop infrastructure systems, says, "In nature nothing goes to waste. Instead waste becomes the feedstock for other systems." He describes closing loops in urban systems as "identifying productive reuse of waste products at the smallest scale reasonable."

Moddemeyer led a detailed study evaluating integrated infrastructure opportunities for the redevelopment of the Yesler Terrace neighborhood in downtown Seattle. The designs aim for sustainability and resilience at the district scale, and were required to "meet or beat the levels of service of business-as-usual, at the same or lower costs."

The system recommendations were specifically tailored to address the size, phasing, and needs of Yesler Terrace. Winning systems centered on onsite wastewater treatment, water reuse, energy efficiency, and a district energy thermal loop system for heating and cooling, a system powered by water warmed by the sun and with heat pulled from a city sewer line. In the study, these systems would enable the new neighborhood to reduce its draw on City water supplies by 45% and to send 70% less wastewater to the County treatment plant, at a net savings of \$300,000 a year. Over 90% of the neighborhood's heating and cooling energy would be supplied by onsite renewable energy, tamping down costly peaks in energy demand by 40%.¹



Our communities are heavily invested in many infrastructure systems but for the most part they are managed separately and are uncoordinated. Courtesy of CollinsWoerman.

Digging up the streets ~

Moddemeyer points out that roughly 30% of a typical city is covered by streets and sidewalks, so the public owns, via the street right-of-way, much of the community's most valuable urban real estate. Beneath those public streets lie an assortment of critical infrastructure pipes – for sewer, water, wastewater, stormwater, natural gas, and sometimes electricity and telecommunications cable. If a single business controlled several systems concentrated on its real estate, it would be unthinkable bad management not to closely coordinate maintenance activities across business lines.

Yet the infrastructure upon and under the public's wealth of high value real estate is managed by separate utilities and agencies, each with their own mandates, budgets, planning,

¹ Steve Moddemeyer, CollinsWoerman, Yesler Terrace Sustainable District Study: Final Draft, Revised December 12, 2010.



What Does the Future of Sustainable Infrastructure Look Like?

and work cultures, making close coordination the exception rather than the rule. Some cities are beginning to coordinate among utilities and agencies to dig up streets less often and to get more done when a street is opened up. For example, Seattle's Planning Analysis Coordination Tool (PACT) was designed to facilitate tracking of utility projects in public right-of-ways to identify opportunities to save money and reduce disruption,² a similar approach to efforts in New York and Chicago.³

Nature delivers the goods (and services) ~

According to the World Resources Institute, over the next 15 years, \$10 trillion will be invested globally in water infrastructure alone.⁴ 'Natural infrastructure,' an interconnected network of natural areas, open spaces, and constructed features such as green roofs, green streets, bioswales, and constructed wetlands, planted in rich water-retaining composted soil, is poised to make a major contribution.

Natural infrastructure can reliably augment the functions of conventional engineered systems ("gray infrastructure"), often at much lower cost by shrinking the need for water filtration plants, reservoirs, chillers, and dikes and levees.⁵ "Restoring natural processes in coordination with built infrastructure," says Callie Ridolfi, President of Ridolfi Inc., an engineering firm specializing in sustainable practices, "can improve performance, enhance adaptive capacity and resilience, and create cost-effective infrastructure solutions." The World Resources Institute studied six U.S. cities which saved 60% on their water infrastructure investment using natural infrastructure strategies. In addition, these systems increased the longevity of conventional systems.⁶

"Restoring natural processes in coordination with built infrastructure can improve performance, enhance adaptive capacity and resilience, and create cost-effective infrastructure solutions."

Callie Ridolfi, President of Ridolfi Inc.

While investments in natural infrastructure can save money on water infrastructure, rebuilding natural systems simultaneously spreads benefits throughout the community. Important community co-benefits of natural infrastructure extend from stormwater and flood management to protection of clean water supplies, local climate control and energy savings, biocarbon capture, cleaner air, improved habitat for a variety of native species, and enhanced beauty and comfort in urban communities.

The co-benefits of investing in nature are not merely nice add-ons but integral to Oregon Metro's \$15 million Nature in Neighborhoods Capital Grants program, managed by Mary Rose Navarro. "If this grant program simply focused

on urban nature, we would be failing to capitalize on the opportunity to fully invest in our communities," says Navarro. "Projects need to be thoughtfully and creatively conceived to achieve multiple benefits such as economic development, local job creation, workforce development, and community cohesiveness."

Economists are beginning to recognize and measure the economic value of the goods and services that water and land systems provide. These 'natural capital assets' provide clean water, clean

air, fish and wildlife habitat, pollination, recreation, public health and more. In 2013, the Tacoma-based non-profit Earth Economics, a global leader in calculating the economic benefits provided by natural assets, released a comprehensive economic valuation of natural ecosystems in Clallam County, Washington, finding economic benefits to the local and regional economy of at least \$18 billion every year.⁷ An assessment of Oregon's McKenzie River watershed, found economic benefits for the regional economy ranging from \$248 million to \$2.4 billion per year.⁸ While it is challenging to monetize this widely distributed value, "It makes good economic sense to pay attention to this suite of benefits that nature provides," says David Batker, Executive Director of Earth Economics.

² Seattle Department of Transportation, www.seattle.gov/transportation/pactutility.htm.

³ Matt Flegenheimer, New York Times, City Aims for Teamwork to End Dig-Pave-Dig Cycle on Roads, October 17, 2011; Stephen Goldsmith, Governing, "Chicago's Better Way to Dig Up Streets," November 20, 2013. www.governing.com.

⁴ World Resources Institute, "Natural Infrastructure for Water," www.wri.org/our-work/project/natural-infrastructure-water.

⁵ Todd Gartner, World Resources Institute, "A Critical Moment to Harness Green Infrastructure – Not Concrete – to Secure Clean Water," January 10, 2013; www.wri.org.

⁶ World Resources Institute, "Natural Infrastructure for Water."

⁷ Nature's Value in Clallam County, Earth Economics, November 2013; www.earthconomics.org.

⁸ Nature's Value in the McKenzie Watershed, Earth Economics, May 2012; www.earthconomics.org.



What Does the Future of Sustainable Infrastructure Look Like?

Water-smart energy systems, energy-smart water systems ~

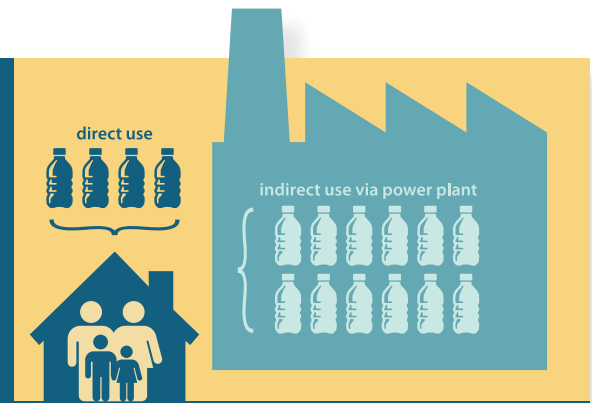
Saving energy saves water, as does switching from fossil fuels to renewable energy sources. Nuclear, coal, and gas (especially deep shale gas) energy facilities require enormous amounts of water – 48% of all U.S. water withdrawals in 2000, according to USGS⁹ – while wind and solar PV require very little water. A typical coal plant, for example, can require seven times more water in its lifetime than the annual consumption of the entire city of Paris, according to Michael Liebreich, CEO of Bloomberg New Energy Finance.¹⁰ Reliance on huge supplies of cool water is a significant risk factor for these power plants, as well as the Northwest's hydropower facilities, into the future, especially as climate change impacts hydrologic patterns. Already, in 36 states surveyed by the GAO, water managers anticipate water shortages in the next 10 years even under "normal conditions."¹¹

Meanwhile, the shift toward electric cars and better car-free transportation options will help reduce the load of pollutants entering stormwater systems, streams and other water bodies from contaminants linked to internal combustion vehicles,

Average daily water use by U.S. family of four

Assuming its home is powered by a coal-fired or nuclear power plant that takes freshwater for once-through cooling, an average family of four directly uses 400 gallons of freshwater per day, while indirectly using 600 to 1,800 gallons through power plant water withdrawals.

 = 100 gallons



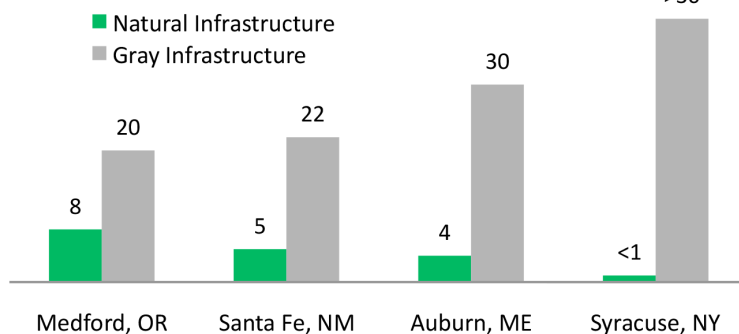
Courtesy of Union of Concerned Scientists.

such as motor oil, that are picked up by rain that runs off roads and parking lots.¹²

Saving water, in turn, saves energy. Drinking water and wastewater systems alone consume an estimate 3-4% of all energy in the U.S., resulting in 45 million tons of greenhouse gas emissions, according to the US EPA.¹³ A recent study by the Pacific Institute of the potential for water-use efficiency in drought-stricken California found solutions harnessing existing, cost-effective technologies in four areas – urban, agriculture, water recycling, and stormwater capture – can save roughly a third of current statewide demand.¹⁴



Costs for Natural vs Built Solutions to Protect Water Supply (\$ millions)



Communities can save substantial money by investing in natural systems to protect the quality of drinking water, according to World Resources Institute case studies. Source: World Resources Institute: http://www.wri.org/sites/default/files/wri13_report_4c_naturalinfrastructure_v2.pdf.

⁹ "The Wind-Water Nexus," Wind Powering America Fact Sheet Series, U.S. Department of Energy, Energy Efficiency and Renewable Energy; <http://www.nrel.gov/docs/fy06osti/37790.pdf>.

¹⁰ Michael Liebreich, "Water May Top Up the Case for Renewables," VIP Briefing, Bloomberg New Energy Finance, September 27, 2012; www.bnef.com.

¹¹ "The Wind-Water Nexus," *ibid*.

Water systems consume a lot of energy, but can also be tapped for energy. For example, wherever water flows downhill through pipes there is potential energy, and new mini-turbine technology, such as that pioneered by Portland-based Lucid Energy, could make it profitable for water utilities to tap it. Wastewater utilities are increasingly harnessing methane generated at their treatment plants, as well as deriving value by transforming the carbon and nutrient-rich solids that are left over after the treatment process into a marketable, biologically-rich soil amendment. Forward-looking communities are also pulling out heat embedded in the wastewater flowing through sewer pipes to meet hot water and space heating needs.

A recent feasibility study prepared for the Washington Department of Corrections found sewer heat recovery technology could save \$250,000 a year in diesel fuel costs at the Clallam Bay Corrections facility,

¹² "Electric and Hydrogen Fuels and Vehicles," California Air Resources Board; www.arb.ca.gov.

¹³ "Energy Efficiency in Water and Wastewater Facilities," U.S. Environmental Protection Agency, State and Local Climate and Energy Program, 2013.

¹⁴ "A Sustainable Water Future for California," Pacific Institute; <http://pacinst.org/wp-content/uploads/sites/21/2014/06/ca-water-future.pdf>.



What Does the Future of Sustainable Infrastructure Look Like?

enough to pay back the capital and installation costs in less than four years.¹⁵

The future of cars: less petroleum, more electricity ~

In the coming decade, we may see the beginnings of a dramatic shift from petroleum-fueled internal combustion cars toward electric. Elon Musk, founder of PayPal, Space X, and Tesla Motors, told investors in August that he's confident electric vehicles (EVs) will match or beat the price of comparable petroleum-powered cars within 10 years. Tesla is teaming with Panasonic to build a 'gigafactory' near Reno, Nevada to produce batteries on a scale not yet seen. Current Tesla batteries cost \$250 per kilowatt hour (kWh) of storage; for EVs to have a clear price advantage, those costs must drop to \$100/kWh. Musk told investors he'd be 'disappointed' if Tesla batteries didn't hit that target within 10 years. "It's heading to a place of no contest with gasoline," said Musk.¹⁶

The health and environmental benefits of a shift to electric vehicles could be wide-ranging.¹⁷ In areas where dirty coal power is the primary source of electricity, the benefits will be less. The Northwest grid is already cleaner than most regions of the country, and as the power grid gets cleaner, the benefits will grow.¹⁸

A major transition to EVs will depend not only on cost parity, but also on how EVs overcome their current disadvantage in range and refueling convenience. Already, Tesla's Model S sedan goes 300 miles on a full charge, comparable to many cars on today's roads. Recharge speed and availability of charging stations may be the key infrastructure challenge the EV industry must solve to go mainstream. Road infrastructure, which now depends primarily on the gas tax, will also need to be rethought, a challenge already coming to the fore as fuel efficient vehicles and reductions in driving rates are curbing gas tax revenues.

Smart-talking infrastructure ~

"We can't optimize with an abacus and a hand calculator," points out Jesse Berst, Chairman of the Kirkland, Washington-based Smart Cities Council. Smart infrastructure "talks and it listens," he says. "It talks to tell you how it is – it tells you if the streets are congested. It tells you if the

building on fire is occupied, how much water's being used. It listens, in that it accepts remote commands – you can save having to send crews out on multiple trips to deal with issues that can be handled remotely."

Smart infrastructure systems use feedback loops of data captured from sensors to inform decision-making and improve performance and efficiency. Smart systems can monitor, measure, analyze, communicate, and act on this stream of information.¹⁹ Europe is leading the world in the race to develop the world's smartest cities, Berst notes. European cities are uncovering new ways to deploy low-cost digital capabilities to conserve resources and save money in delivering quality city services. For example, in Barcelona sensors attached to trash cans now alert workers when they need to be emptied. Irrigation systems built into Barcelona's parks monitor soil moisture and turn on sprinklers only when water is needed – which the city expects will cut its water bill 25% and save \$60 million a year.²⁰



Solar-powered trash compactors at University of Washington text when they're full, reducing costs for unnecessary pickups. Photo by Sandra Hines.

We all accept smart phones now, and increasingly smart cars. Why not smart cities? Berst says it is crucial to have a "vision for what the city or region wants to be when it grows up, and to put technology in service of those goals." Think, he says, in terms of integrated strategies, so the city's communications network can serve the power utilities, as well as the water, fire, police, and emergency services. Not only will shared, integrated communications networks save money, but they can get back online quicker in a crisis: "When

15 www.sewageheatrecovery.com/; International Wastewater Systems, Feasibility Study Report, Project: Clallam Bay Corrections Center, Clallam County (WA). Submitted: September 22, 2014.

16 Julie Pyper, E&E Reporter, "Tesla chief predicts price parity with gasoline-powered cars within 10 years," *Climatewire*, August 14, 2014.

17 State of Charge, Union of Concerned Scientists, June 2012; www.ucsusa.org; Kevin Bullis, "Are Electric Vehicles Better for the Environment Than Gas-powered Ones?," *MIT Technology Review*, July 12, 2013.

18 A Roadmap to Climate Friendly Cars: 2013, Research Report by Climate Central, August 8, 2013; www.climatecentral.org.

19 Smart infrastructure: the future, The Royal Academy of Engineering, January 2012.

20 Mark Scott, "Old World, New Tech," *New York Times*, April 21, 2014.



What Does the Future of Sustainable Infrastructure Look Like?

Hurricane Sandy blew through, a lot of cities had to repair and stand up 12-15 separate communications networks.”

Aligning our economic development and infrastructure strategies ~

Infrastructure spending and investment is widely and correctly recognized as a cornerstone of our economy. In 2012, according to a Brookings study,²¹ over 14 million U.S. workers were employed in infrastructure jobs, accounting for 11% of national employment. Perhaps surprisingly, a large majority – 77% – of these workers focus on operating infrastructure, compared to construction (15%), design (6%), and governance (2%).

Infrastructure jobs provide pathways out of poverty because barriers to entry tend to be low – only 12% of infrastructure workers have a bachelor’s degree or higher, for example. These jobs offer better wages compared to other occupations, paying over 30% more to workers at lower ends of the income scale, according to the Brookings study. The study finds that job opportunities should continue to be plentiful: Infrastructure employment is projected to grow 9% in the next decade, while nearly one-quarter of the existing infrastructure workforce will need to be replaced due to retirements or other employment shifts.

Investing in modernizing our infrastructure is an opportunity to broaden access to economic prosperity in our communities. Cylvia Hayes, Oregon’s First Lady and CEO of 3Estrategies, recalls: “One young man whose family had struggled with poverty his entire life asked me a great question: ‘How can there be people out of work when there is so much work that needs to be done?’” Investing in sustainable infrastructure, Hayes says, “opens up opportunities for more people to make a living doing work society needs done, helping vulnerable people and nature.”

Leveraging infrastructure investment to create pathways out of poverty for local people can reduce income inequality and effectively boost the community’s economy for everyone. Strong evidence has accumulated in recent years to suggest that reducing income inequality, and achieving greater racial and economic inclusion, correlates with stronger and more sustained economic growth.²²

How we prioritize and focus our infrastructure investments can have a tremendous impact on the long-term economic vitality of our communities. Forward-looking communities will align their infrastructure modernization strategies with the community’s strategic goals for the economy and development. “A 10-year infrastructure strategic plan should be

integrated with agency plans for service delivery, the regional economy, community development and population patterns, and the livability and economic goals of local governments,” says infrastructure finance expert Karen Williams. “This kind of planning answers the questions, ‘are we doing the right project?’ and ‘are we doing the project right?’”



Workers ensuring frames for solar panels have a good foundation.
(By Oregon Department of Transportation. “Footings” uploaded by Smallman12q. Licensed under creativecommons.org/licenses/by/2.0)

To maximize local economic benefits, when it is time to build the right infrastructure project, Williams suggests the lead agency set employment- and wealth-building performance requirements to optimize local contractors, suppliers, labor, and workforce training, as well as energy efficient and sustainable design.

²¹ Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs, Brookings, May 8, 2014.

²² Minnesota’s Tomorrow: Equity is the Superior Growth Model, PolicyLink, 2014.



What Does the Future of Sustainable Infrastructure Look Like?

Innovations Within the Sectors:

Integrated solutions that connect traditionally separate utilities, agencies and systems are a key aspect of building a sustainable infrastructure future. But within each of the sectors, there is significant dynamism, and market forces, policy imperatives, and innovations are spurring positive change.

→ ENERGY

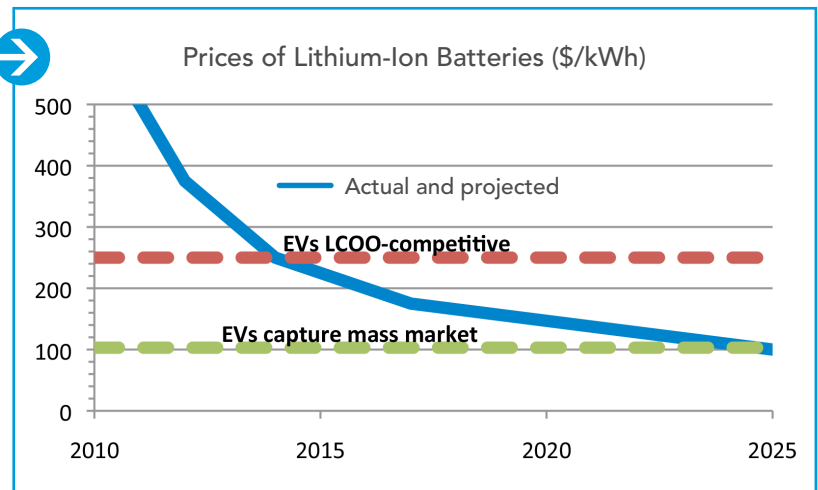
There's a revolution coming to the electricity industry that has utilities across the country worried and, along with the regulators and advocates, starting to grapple with the fact that the utility business model of the past century may not be viable in the future.

One indicator of this coming revolution is that Silicon Valley sees business opportunity and is joining the fray in a serious way. Distributed energy resources and smart grid tools are right in the sweet spot for technology entrepreneurs and investors. Eric Strid, founder and CEO for over two decades at Oregon's Cascade Microtech, attended the May 2014 World Innovation Forum. He found, "Driven entrepreneurs and their teams are willing to 'eat glass' as necessary to achieve their missions. Many of these people come from IT or semiconductors and expect exponential jumps in cost-performance." Our infrastructure strategies should anticipate that technology entrepreneurs will transform many aspects of the energy marketplace in surprising ways.

Elon Musk's gigafactory, for example, is part of Tesla's plan to roll out the first affordable, mass-scale electric vehicles within a decade. But gigafactories successfully producing batteries at or below \$125/kWh can also capture a huge market in the home and commercial power sector. "Improvements in batteries and distributed generation could partly or completely eliminate some customers' usage of the power grid," reports a Morgan Stanley brief in March. "We see the greatest potential for such disruption in the West, Southwest, and mid-Atlantic."²³

Morgan Stanley analyzed the implications for utilities state-by-state from the combination of rapidly declining prices for solar PV and batteries which could enable many customers to supply all their electricity needs, storing enough power in batteries to carry through times of low solar production. In California, for example, the analysts foresee under plausible assumptions that a typical residential customer can choose to pay their utility 26 cents a kilowatt hour (kWh) in 2020, or will have the choice to opt for a solar-battery package to unhook from the grid at 10-12 cents per kWh. Their base scenario

projects a U.S. residential and commercial solar market of 240 gigawatts, fully 15% of current demand in these sectors. With somewhat more favorable policies, their bullish scenario projects 415 gigawatts.



As the electric vehicle (EV) market expands, battery costs have begun falling, and now are near a price that makes the 'lifetime cost of ownership' (LCOO) of EVs competitive with gas-powered cars. At \$100/kWh, many analysts believe EVs will dominate the new car sales market. Data from Tesla, Navigant, McKinsey, Sandia, Bloomberg New Energy Finance, Rocky Mountain Institute.

Utilities facing potential loss of 15% or more of their customer base will be forced to raise rates on remaining customers to cover costs for past infrastructure investments. Higher rates would inspire more customers to opt for the off-grid solar-battery path, propelling still higher rates for remaining customers. This is known as the 'utility death spiral,' and it is gaining increasing attention.

On the other hand, the electricity sector is poised to take over a significant portion of the transportation sector from petroleum fuels in the next 10-20 years as electric vehicles go mainstream. While threats abound, utility executives can regard this as a major market opportunity, and an opportunity to wear the environmental white hat by proactively facilitating the transition and ensuring it is fueled with clean power sources.

Indeed, our electric utilities need not go the way of the phone booth. "Distributed energy technologies can actually add value back to the grid," says Tom Starrs, Vice President for Market Strategy and Policy at SunPower Corporation. "Utilities today are thinking of these technologies as part of the problem; soon they'll be seen as part of the solution, helping improve reliability, security, safety and efficiency of the grid."

In fact, advanced technologies are enabling a more interactive, responsive 'smart grid,' able to 'talk to' and integrate

23 Morgan Stanley Research North America, Clean Tech, Utilities and Autos. "Batteries + Distributed Gen. May Be Negative for Utilities," March 4, 2014.



What Does the Future of Sustainable Infrastructure Look Like?

thousands of distributed energy resources. These distributed resources include small-scale power systems, batteries, and other energy storage devices, and 'demand response' contracts in which residents and businesses agree to shift a flexible portion of their power needs from times of peak demand to other times when the grid has plenty of electricity available. "Microgrids" are emerging as localized networks of distributed resources and smart grid management tools that nest within the larger power grid, but can detach and operate independently when disruptions hit the larger grid.

Wind power has already gone mainstream, supplying a rapidly growing share of bulk power to the larger grid. Buoyed by steadily declining costs and its ability to come online in smaller increments, yearly additions of new wind resources grew from less than 4,000 megawatts in 2000 to almost 40,000 megawatts a year on average for the past 5 years.²⁴ About 4% of total electricity produced in the U.S. came from wind last year, but the National Renewable Energy Laboratory estimated a nearly 40% share in 2050 for its Renewable Energy Futures Study.²⁵ China's new Wind Base program, meanwhile, is building seven wind mega-complexes of 10 to 38 gigawatts generating capacity each, a scale unprecedented globally; in total bringing power generating capacity online equivalent at full force to 130 large coal or nuclear power plants.²⁶

Compared to wind and solar, other renewable energy technologies are still early on the economy-of-scale, price-decline curve. Promising technologies include geothermal electric, heat pumps, sewer heat recovery and district energy, biogas, and sustainable biofuels, ocean tidal and wave energy, and fuel cells for buildings and large vehicles.

While conventional sources of the fossil fuel known as natural gas are in decline within the U.S., hydraulic fracturing technology has enabled dramatic increases in domestic production from shale rock, supplying well over 30% of U.S. gas production today. Natural gas is generally considered an attractive substitute for coal energy because it burns significantly cleaner and with lower emissions of carbon dioxide, can come online in smaller increments, and can help integrate into the power grid the variability in production from wind and solar power.

But the overall benefits and costs of 'fracked' gas are not yet clear. In addition to ongoing concerns such as chemical contamination of water from fracking, calculating the lifecycle climate impact of natural gas is difficult and very sensitive to methane leaks. In fact, Cornell researchers calculate a higher

greenhouse gas emission profile for shale gas than for coal or oil,²⁷ but there is no scientific consensus on the issue that has yet emerged. The Global Commission on the Economy and Climate recommends regulating shale gas production to prevent methane leaks, putting a price on greenhouse gas emissions, and supporting other low-carbon energy technologies so that their deployment is not slowed down when gas prices are low.²⁸



Pullman: The Northwest's First Smart Grid Community

The City of Pullman, home to Washington State University (WSU), is becoming the Pacific Northwest's first smart grid community. Smart grid systems use remote control and automation to send real-time data about energy usage to both the utility and the consumer. Two-way digital communication technology allows the utility—in this case Avista, an investor-owned utility based out of Spokane—to adjust thousands of individual devices on the grid from a central location. According to the Northwest Power and Conservation Council, as the share of electricity from new renewables such as wind and distributed solar continues to grow, smart grid systems can improve the reliability and flexibility of our regional power system.

The Pullman project is part of the Pacific Northwest Smart Grid Demonstration Project, the nation's largest such project, a partnership of the Bonneville Power Administration, 11 utilities, two Washington universities, and other technology partners. Approximately 13,000 electric and 5,000 gas meters in Pullman have been upgraded to smart meters. In 2013, a project to deploy smart voltage controls achieved energy savings of 2.5% across the entire Pullman Smart Grid. As a result of its participation in the Pullman smart grid project, WSU is expected to save approximately \$150,000 in energy costs each year. "Because it takes a significant amount of energy to run a campus the size of WSU, we can adjust how much energy our utility has to supply to WSU by modifying the energy levels in the schools' buildings and facilities," said Avista's Heather Rosentrater, Director of Engineering and Systems Operations. Sources: Avista Utilities; WSU.

24 Global Wind Energy Council, "Global Annual Installed Wind Capacity 1996-2013," www.gwec.net.

25 Renewable Energy Futures Study, Volume 1, National Renewable Energy Laboratory, 2012; www.nrel.gov.

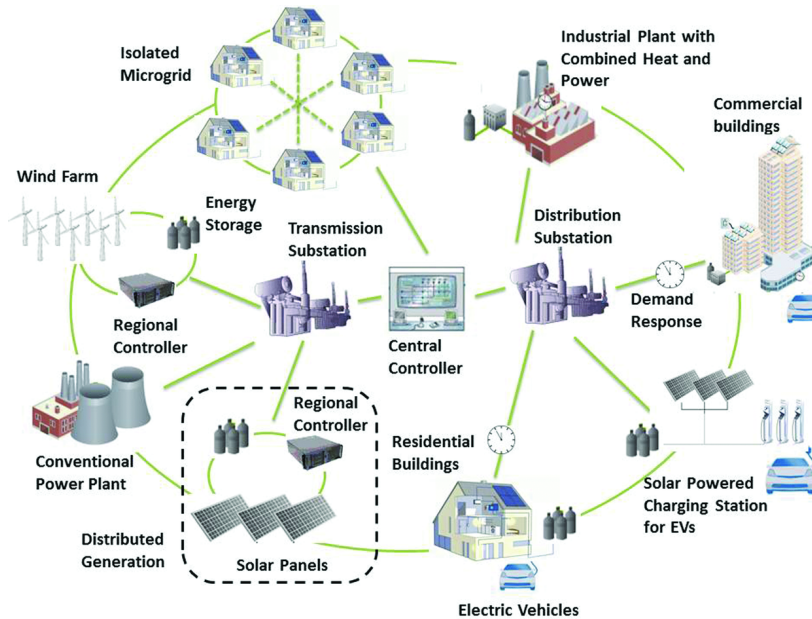
26 Earth Policy Institute, www.earth-policy.org/books/wote/wotech9.

27 R.W. Howarth, "A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas," *Energy Science & Engineering*. 2(2): 47-60, 2014.

28 Better Growth, Better Climate, Global Commission on the Economy and Climate, September 2014.



What Does the Future of Sustainable Infrastructure Look Like?



Our electric grid is evolving from a relatively simple system delivering power from large central power plants, to an internet of energy that manages, controls, conditions, buys, sells, and stores power in a dynamic marketplace involving millions of participants.

Courtesy of Georgia Tech Climate and Energy Policy Laboratory: <http://www.cepl.gatech.edu/drupal/node/43>.



Energy efficiency, on the other hand, is the revered old silverback of sustainable energy infrastructure, and a remarkable success story. For 30 years the Northwest has been at the forefront of the energy efficiency revolution.

According to Angus Duncan, CEO of the Bonneville Environmental Foundation, "Energy efficiency today is the region's second largest electricity resource, after hydro. The efficiency we've captured over the last 30 years is now double the amount we generate annually from the largest hydroelectric dam in America – Grand Coulee, on the Columbia River in Washington – and at one-third the cost of power from a new fossil-fuel power plant." What's more, says Duncan, we can expect another three Grand Coulee's worth of efficiency savings in the next 20 years.

The efficiency resource is not only a cheaper way to satisfy new energy demand than building new power plants, once installed it is also pollution-free. Further, according to Duncan, efficiency reduces the amount of power that must be moved across the region's transmission infrastructure, conserving valuable capacity on the electric grid. And it reduces daily and seasonal peaks in demand, which are the most expensive increments of power to supply. Finally, because the efficiency resource once installed has no centralized facilities, it is resilient, with little vulnerability to disruption by natural or human hazards.

Globally, investment in energy efficiency in 2012 reached \$375 billion, according to HSBC, the London-based global banking and financial services company, as much as was

invested in producing electricity from fossil fuels and 50% more than was invested in renewable energy sources. Now, efficiency may be poised for even more accelerated growth with tech giants including Apple, Google, and Samsung moving aggressively to provide 'smart home' tools that enable customers to conveniently save energy by controlling power use in appliances and devices. Investment bank Citigroup describes this as "the early rumblings of a potentially epic battle between the tech giants and the conventional energy producers."²⁹

→ TRANSPORTATION

The sustainable infrastructure path emerging for the transportation sphere includes two distinct tracks: 1) the shift to new vehicle technologies and ownership patterns; and 2) greater accessibility and convenience of car-free options to get around.

In both, emerging technologies will contribute to transportation transformation, but markets are only just emerging to drive significant change in the years ahead. Public decisions will continue to be pivotal to transportation, both directly in steering capital investments toward a more balanced, less auto-centered infrastructure, and indirectly in shaping urban land development policies. These decisions can accelerate transformation along both tracks of sustainable transportation. First, by directing new transportation

²⁹ Giles Parkinson, "Why Solar May Not Be Biggest Threat to Energy Utilities," *RenewEconomy*, August 12, 2014; reneweconomy.com.



What Does the Future of Sustainable Infrastructure Look Like?

spending to support clean vehicles, smart technologies, and 'complete streets' that are friendly to people and car-free transportation options. Second, by channeling growth into underutilized urban land (failing malls, parking lots, brown-fields, suburban arterials) to build mixed-use, mixed-income walkable and transit-oriented neighborhoods.

Market competition is driving the race to lead in mainstreaming electric cars, with incumbents BMW, Mercedes, GM, Ford, Toyota, Honda, Nissan, Renault and Kia competing with newcomer Tesla.³⁰ The key barriers these companies are working to solve include getting to a 'full-tank' driving range comparable to today's cars, and to enable customers to recharge quickly and conveniently.

Already, smart technologies are beginning to transform our relationship to cars, with big implications for the future of our transportation infrastructure. Although it may seem futuristic now, some thought leaders see self-driving cars becoming widely available in the next 10 years. With 360 degree sensors, self-driving cars should be able to safely drive much closer together, enabling far more cars to fill existing road space. This in turn could free up highway lanes for high-speed public transit, freight, and other priorities. "Estimates are these self-driving cars can quintuple our highway capacity – a massive efficiency gain for our road infrastructure," says Daniel Malarkey, former Deputy Director of Washington State's Department of Commerce.

Car-on-demand and car-sharing services, fully leveraging smart phone technology, will help more people to forgo owning their own car and more families to own just one car where today they own two. "If you can get around with one less car, it's like getting a raise!," enthuses Dan Kaempff, Principal Transportation Planner at Oregon Metro. "The typical family might spend 20% of their household income on transportation – lower income people might spend closer to 30%."

Car sharing clubs, which enable members to rent cars by the hour, are growing rapidly, from 1.3 million members in 2010 to 3.3 million in 2013. Frost & Sullivan projects 26 million members by 2020, with every car in a car sharing club reducing the number of cars on our streets by seven to nine. Members typically save about \$3,000 a year over car ownership, making this a particularly attractive option for tech-savvy young people. Major automakers are beginning to adapt by repositioning themselves into "service providers offering integrated mobility solutions." Daimler, for example, expects to generate over \$130 million from its mobility services in 2014 and is aiming for 10 times that by 2020.³¹

30 "How Tesla Fares Against Upcoming Electric Cars," iStockAnalyst, November 19, 2013; www.istockanalyst.com.

31 Sarwant Singh, "Future of Personal Mobility – Life With or Without Ownership of Cars," *Forbes*, April 23, 2014.



Mosaic: Adapting Least-Cost Planning from the Energy Sector to Transportation Planning

"Least-Cost Planning" is a tool, pioneered in the Northwest, which has transformed energy planning and investment, resulting in energy efficiency becoming a keystone resource for cost-effectively meeting growing energy demand. Now, Oregon's Department of Transportation (ODOT) is leading the way in developing a new tool, Mosaic, to apply Least Cost Planning principles to transportation planning and investment.

According to ODOT, Least-Cost Planning is designed to nest within Oregon's existing transportation planning processes, and enable transportation planners and decision-makers to evaluate the social, environmental, and economic costs and benefits of transportation investments. Investments in the range of alternatives to driving alone will be compared side-by-side with traditional investments in expanding road space for cars.

The tool helps identify the mix of transportation investments that provide the best value for the money, given increasingly limited resources. Transportation planners will still survey needs, come up with potential solutions, evaluate them, and make recommendations. The tool simply improves the process by enhancing the evaluation step, making trade-offs among bundles more explicit by monetizing results, where possible, and providing a method to compare monetized and non-monetized results.

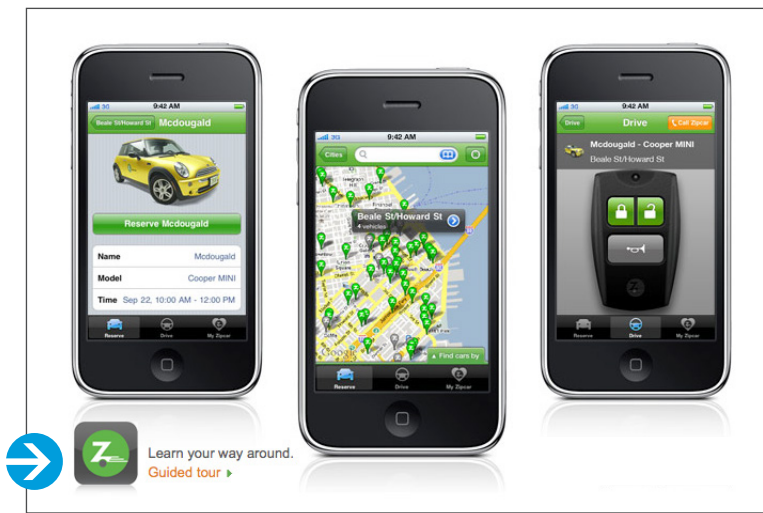
Mosaic's guiding principles include:

- Mosaic will seek the most cost-effective solutions considering the goals to be achieved over the long term, not necessarily the least expensive solution in terms of up-front costs.
- Use of Mosaic will result in information that can be considered and compared in a decision process, not result in one specific solution.
- Mosaic will be consistent with related ODOT efforts, such as those to address greenhouse gas reduction goals, link planning and environmental compliance strategies, and implement practical design.
- Mosaic will not be a static product. ODOT will continue to update and amend the methodology as more is learned and tools and techniques are improved over time.

Source: Oregon Department of Transportation.



What Does the Future of Sustainable Infrastructure Look Like?



ZipCar's recent car-sharing application for smart phones. Courtesy of ZipCar.

Similarly, emerging smart apps put real-time information on car-free transportation options at the fingertips of people who'd like to know the quickest, most convenient ways to get from here to there right now. This capability is in its infancy with potential for rapid advancement. Chris Watchie, one of Oregon's top experts on transportation options, says, "Public agencies need to make the relevant data open source – real-time transit data, as well as bike lane, walkability and roll-ability factors – so that apps can be developed to enable people to tap their smart phones to make transportation choices, at any moment for any place, based on cost, convenience, timing, and safety."

In general, sustainable transportation infrastructure will provide people several convenient transportation choices to get where they need to go – multiple modes are viable. That means bus or rail service is frequent and extensive. Walking, biking, wheelchairs, and other active transportation options are safe and enjoyable, integrated with nature, and accessible to all income levels. At a regional scale, too, we will ensure fast and efficient networks for public transit, as well as for freight.

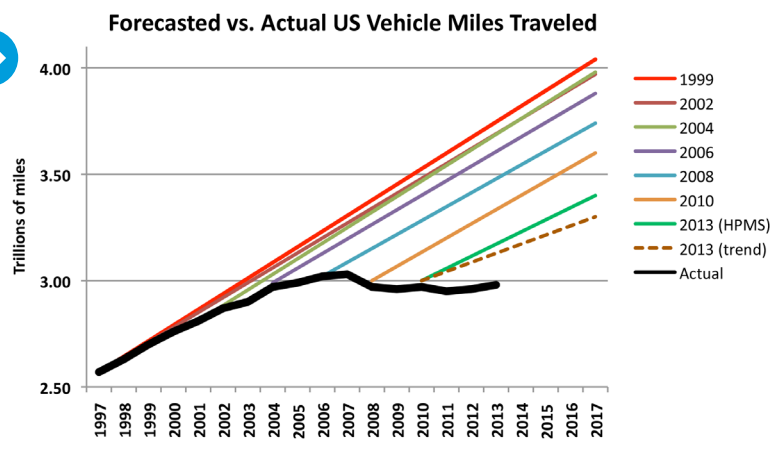
Nevertheless, "most of our transportation spending today is still going into giant road expansions," according to Alan Durning, Executive Director of Sightline Institute. "It's an expensive engineering approach based on outdated models of ever-increasing numbers of cars driving ever-increasing distances."

"The very thing that will allow the transportation system to work reasonably well for cars is, ironically, to reduce the amount of cars on the road by making the alternatives viable," says Gordon Price, former Vancouver BC city councilor and leading proponent of redesigning our communities for

people rather than cars. "People didn't see the shift coming in terms of vehicle miles peaking and beginning to decline starting around 2004. There's a generational shift going on."

A key challenge for transportation infrastructure agencies is that land development policies for several decades have favored sprawling, low-density patterns that lock a high percentage of the population into driving for most trips. Transportation infrastructure spending has gone hand-in-hand, disproportionately serving personal vehicles over all other modes.

Shifting to development policies that concentrate housing, retail, and commercial activity around transit hubs powerfully supports cost-effective infrastructure systems of all sorts, not least of which is 'multi-modal' transportation infrastructure. When more residents, jobs, shops, services, and parks are in close proximity and clustered near transit hubs, walking, biking and transit are viable and convenient choices for many more trips. In turn, the more people utilizing car-free infrastructure, the more cost-effective are investments in that infrastructure. Puget Sound Regional Council is developing Corridor Action Strategies to maximize the value derived from \$25 billion in voter-approved regional rapid transit investment by locating housing, jobs, and services close to transit.³² The Portland region's MAX light rail system now boasts over 50 miles of track and 85 stations, around which over \$10 billion of real estate development has been located.³³



Transportation engineers have repeatedly forecast continually increasing auto travel in spite of a decade of evidence that driving miles have leveled off. This graph compares US Dept of Transportation forecasts (straight colored lines) with actual miles driven nationally (thick black line). Courtesy of State Smart Transportation Initiative, www.ssti.us.

³² "About Growing Transit Communities," Puget Sound Regional Council; www.psrc.org.

³³ John Karras, "How Your City Can Succeed in Transit-Oriented Development," March 14, 2014, urbanscale.com.



What Does the Future of Sustainable Infrastructure Look Like?

Much of our sprawling suburban landscape, developed since World War II, though, was designed to accommodate cars – at the expense of people outside of their cars. Over time, these areas can be redeveloped. “The key is to strategically allocate new growth to fill in the paved parking lot areas and underutilized strip zones with new mixed use density along arterials,” says Patrick Condon, a professor of landscape

architecture at the University of British Columbia. “And then refashion the arterials from ‘car sewers’ to become more civic space where streets now engineered only for auto movement are redesigned more for the human body – walking, transit, and biking.” Condon says that in Oregon and elsewhere, developers are increasingly beginning to look at these areas as underutilized strip zones that can be densified and transformed. “The arterial corridors can, in the long run, be bus and streetcar corridors – but you have to take a long-term approach.”



How Public Health Benefits From Sustainable Infrastructure

Spending on health care is a major segment of our national economy, representing about 17% of the U.S. Gross Domestic Product as of 2012, according to the Harvard School of Public Health, much of which is spent “for conditions that could be prevented or better managed with public health interventions.” The many billions we will spend on public infrastructure in the next decade can help benefit public health and reduce health care costs.

Obesity, for example, is an epidemic in America, adding an estimated \$147 billion in medical costs in 2008. About 34% of adults are considered obese and at greater risk of diabetes, heart disease, stroke, and certain types of cancer, according to the Centers for Disease Control. The obesity rate in children and adolescents has tripled in a generation to 17%.

One key prescription to address obesity is to increase daily physical activity, which has a wide range of additional health benefits. According to the Washington State Department of Health, “Scientific evidence shows that physical activity at moderate intensity keeps you healthy.” Transportation investments can help build communities that are safe, comfortable and attractive for biking, walking and other forms of active transportation and recreation. Water utility investments in natural infrastructure and outdoor green spaces will further promote an active, healthier population.

The public health benefits of sustainable infrastructure are very extensive. In addition to supporting physically active lifestyles, for example, our infrastructure choices can reduce air pollution and asthma, death and injury from vehicles, and toxic runoff into waterways and fish. Because of these many connections, it makes sense to increase coordination and collaboration between our infrastructure and public health sectors.

Sources: Harvard School of Public Health; U.S. Centers for Disease Control; Willamette Partnerships; Washington State Department of Health.

Dan Kaempff, Principal Transportation Planner at Oregon Metro, agrees that retrofitting our suburbs is one key to sustainable infrastructure innovation. “We may be building some roads there, but it will move toward street grids,” he says. “We also need to look at shrinking some of our roads – we’ve overbuilt them and the result is higher speeds and people getting killed. We need to narrow or remove travel lanes and make them ‘complete streets,’” which enable safe access for all users of all ages and abilities, from pedestrians to bicyclists, motorists and transit riders.³⁴

While safe and walkable streets for people are essential, freight mobility must also be integrated into multi-modal transportation infrastructure and land use policies. “Moving freight to market is really an integral component of the economic lifeblood of our communities,” points out Scott Woerman, Director of Client Services at Landau Associates. “We can’t take our eye off that ball.” Goods are often transported long distances and may move by ship, airplane, truck, and train but, as with many forms of infrastructure, each of these modes are typically planned, funded, and operated separately. Meanwhile, getting freight to retail markets often involves moving trucks through urban areas where a variety of users are concentrated on valuable street space. Innovative approaches to foster sustainable freight mobility include regional coordination to ensure smooth and efficient connection between modes, real-time information sharing across the distribution chain, congestion management, and coordination of different freight modes for lower impact on road surfaces, the environment, and shared streetways.³⁵

→ WATER

The sustainable infrastructure path emerging for water systems broadens the investment strategy well beyond the traditional pipes, pumps, filtration, and treatment facilities to improve financial and environmental performance of the overall system. These investment strategies range from conservation and pollution prevention, to transforming waste

34 “What Are Complete Streets?”, Smart Growth America; www.smartgrowthamerica.org.

35 The Innovative DOT, Focus Area 6: Providing Efficient, Safe Freight Access, Smart Growth America; http://www.smartgrowthamerica.org/documents/the-innovative-dot-2_focus-area-6.pdf.



What Does the Future of Sustainable Infrastructure Look Like?

into valuable resources, integrating neighborhood-scale technologies, harnessing smart technologies, and expanding green infrastructure assets.

As in the power sector, utilities that manage water infrastructures are investing in cost-effective strategies that result in less 'product' in their pipes, be it for water supply, wastewater, or stormwater. For example, Northwest agencies have invested significantly in low-flow toilets, showerheads, and front-loading washing machines which have cost-effectively reduced both water consumption and wastewater generation – as well as the energy consumed to deliver and filter the water.

Sustainable water infrastructure investments also help protect waters from contamination and reduce the sources of toxics that can enter our waters. "We can't afford to engineer our way out of pollution challenges with 'end of pipe' solutions," says Rich Hoey, Olympia's Public Works Director. "We have to 'go upstream' to remove the sources of pollution from drinking water, wastewater and stormwater." Reducing toxins and contaminants entering water systems can pay off in lower costs to clean up the water and reduced risk of violating clean water regulations. Wastewater utilities, for example, have made great progress working with industry and commercial businesses to reduce toxics entering their system.

Wastewater utilities, in particular, have a special opportunity to become resource recovery utilities, because our wastewater is rich in valuable energy and biological resources. Innovative utilities are developing the ability to not only clean up waste water, but to recycle it for irrigation, industrial use, recharging groundwater, and other appropriate uses. They are also harvesting energy and creating rich soils, even accepting other organic wastes in the community that are complementary. Biodigester technologies, steadily growing more affordable and efficient, convert organic wastes into energy and rich soil amendments. Compost-amended soils have strong water-holding capacity, so these composts can, in turn, be used to good effect in green stormwater infrastructure projects.³⁶

'Biosolids' – the treated material that comes out of a biodigester at a sewage treatment plant – suffers from a perception problem in that people understandably fear that it is contaminated. But Pam Elardo, Director of King County's Wastewater Treatment Division, points out that, "After the biosolids run through the digester, it is no longer poop – it is really the skeletons of the micro-organisms that digest the material!" These micro-organisms generate fertile soils rich in micro-nutrients. "We study our biosolids extensively," notes Elardo, "and they typically test better than steer



Albany-Millersburg's Talking Gardens Project

The Talking Gardens Project cools treated wastewater before it enters the Willamette River. Wastewater discharges to the river had led to declines in coldwater fish such as salmon and trout, which prompted Oregon regulators to mandate new discharge limits for public and private entities on temperature and pollutants.

The cities of Albany and Millersburg partnered with a major metals manufacturer, ATI Wah Chang, which was required to relocate its point of discharge, to build a combined wastewater treatment wetland.

The project is naturally aerating treated wastewater to reduce pollutant levels, including the removal of 2,000 pounds per day of nitrogen and 40 pounds per day of phosphorous. At the same time, the project promotes wildlife habitat in a former industrial area, creating a new natural attraction for Albany-area visitors and a living laboratory that brings wetland science to life for K-12 and university students.

The project is a net win for the climate as well. The wetland vegetation, covering over 30 acres, along with one acre of riparian forest and five acres of oak savanna, removes tons of carbon dioxide from the atmosphere annually and stores the carbon in soil, sediments, and plants for many decades. Waterfalls designed into the Talking Gardens also help curb the production of methane, a significant greenhouse gas that can be generated by wetlands as organic matter breaks down in the absence of oxygen.

Source: *Natural Infrastructure: A Climate-Smart Solution*, *Climate Solutions*, www.climatesolutions.org.

manure, which has a lot of pharmaceuticals and other contaminants, though people tend to perceive manure as organic and clean."

The Association of Oregon Clean Water Agencies is convinced that the state's wastewater utilities can become energy independent – eliminating purchased electricity through energy efficiency, use of digester gas, and renewable energy sources like solar and gravity-based hydro.³⁷ In addition, according to Joshua Proudfoot, Principal at Good Company, "they have the potential to grow poplars and make that the hub of an integrated, symbiotic natural materials industrial complex."

³⁶ *Natural Infrastructure: A Climate-Smart Solution*, *Climate Solutions*, August 2013.

³⁷ Oregon Association of Clean Water Agencies, www.orawa.org.



What Does the Future of Sustainable Infrastructure Look Like?

Proudfoot says Clean Water Services, based in Hillsboro, is at the forefront. “They are doing joint ventures with fertilizer companies, for example, and exploring making ethanol in partnership with a soda company using expired soda,” he says. “They are breaking down every wastewater source that could drive them to have to expand capacity and looking for ways to convert it into a marginal revenue stream. It’s really about striking the right business opportunity with the right partner.”

As with energy microgrids, neighborhood scale water systems – including rainwater harvest, wastewater micro-processors with water recycling, and the range of green stormwater facilities – can nest advantageously within the larger system, while saving money, enhancing resilience, and conserving valuable capacity within the larger system. “Ideally, those distributed strategies are managed in coordination with the centralized utility, so the benefits of each model are magnified,” argues Paul Fleming, Manager of the Climate Resilience Group at Seattle Public Utilities. “There needs to be a clear line of sight into the ongoing maintenance of these new systems to ensure their operability 10 years into the future and beyond. If we get a lot of nested distributed systems designed and managed independent of the central system, with no coordination of planning for O&M, a lot of investments will end up degrading with time and going down the drain.”

Most water infrastructure systems today are largely ‘dumb,’ relying on gravity, human labor, and mechanical systems. Smart technologies utilizing automated and remote instrumentation, controls, feedback and communications have begun to integrate with traditional systems and are poised for further advances. These technologies will enable valuable efficiencies, rapid response to changing conditions, remote control and adjustment of systems, and more sophisticated system planning.³⁸

There are over 16,000 wastewater systems in the U.S. But it is important to note that the majority are small, poorly capitalized, and less able to adopt best practices and innovation than the well-resourced larger systems, according to Chris Taylor of the West Coast Infrastructure Exchange. “To get these innovations more widely adopted,” he says, “we need a way to get smaller systems to regionalize or collaborate in some other way to achieve scale.”

For all the water-based infrastructures, investing in open space and natural systems, and building nature-mimicking green infrastructure facilities can, in many cases, deliver better results cheaper than relying too heavily on spending on pipes, pumps, and traditional treatment.



The Squaxin Island Tribe: Sustainable Infrastructure Reflects Shared Values and Traditions

“We envision a culturally and economically strong community of self-governing, resilient people united by shared values and traditions.”

— Squaxin Island Tribe Vision Statement

Northwest Tribes own, operate and invest in sustainable infrastructure systems in a variety of ways that reflect essential tribal values. For example, as the People of the Water, sustainability of natural and cultural resources, community, and self-governance are at the heart of the Squaxin Island Tribe’s governmental and economic development programs.

The Tribe designed its Natural and Cultural Resources building to the Platinum standard of the LEED green building rating system, and installed a solar hot water system at its community swimming pool. The Tribe has weatherized 31% of homes, and implemented thermal shell improvements for 18 homes and 6 duplexes. It constructed two 6-plexes on a reclaimed drain field, certified to Built Green® and Energy Star standards and built to Stewardship Partners’ “Salmon Safe” standards for low-impact development. The Tribe treats its wastewater to stringent Class A standards with a membrane bioreactor, using this cleaned up water for irrigation for Salish Cliffs Golf Club, the world’s first salmon-safe golf course.

The Tribe’s natural resources protection and restoration programs include land conservation, clam enhancement, salmon ID tracking, water quality sampling, and stream restoration projects, as well as co-management of fishery and hunting resources. In its business operations, the Tribe has completed efficient motor upgrades for their casino’s HVAC systems, and converted businesses to high-efficiency LED indoor and outdoor lighting.

Its transit system served over 23,000 passengers in 2013 with regularly scheduled and dial-a-ride services, and serves as a hub linking Mason County, Thurston County, Grays Harbor County, and Tribal transit systems. The Tribe located Elder’s Housing a very short walking distance to the Tribal Health Clinic and essential Tribal government offices. A 2009 Tribal Council resolution tasks Squaxin Community Development with the ongoing implementation of sustainability measures in infrastructure and the built environment.

³⁸ Smart infrastructure: the future, The Royal Academy of Engineering, January 2012.



What Does the Future of Sustainable Infrastructure Look Like?

Managers of water-based systems are increasingly seeing green infrastructure strategies as an integral component of their investment strategy for the future. In King County, for example, Elardo says that “some of our biggest infrastructure investments by 2030 (approaching \$1 billion) will be to address basins with combined sewer-stormwater overflow problems in the most innovative, resilient, sustainable way we can, including green infrastructure strategies.”

The City of Spokane faced a daunting price tag to comply with Clean Water Act regulatory requirements to prevent untreated stormwater and sewage from flowing into the Spokane River during storm events. Nearly 55 million gallons a year of combined sewage and stormwater, and a billion gallons of untreated stormwater, enters the Spokane River. The standard response, building a bigger water treatment system, would cost \$450 million. Instead Spokane developed an Integrated Clean Water Plan with major investments in green infrastructure. The Plan commits the City to deliver a cleaner river faster, but at a significantly lower cost of about \$310 million.³⁹

Levees and dikes built to control river systems are another water-related infrastructure system that many communities are taking a fresh look at, finding that pulling back the confinements and restoring natural floodplain functions can deliver overall benefits in some cases. Yakima County in central Washington and its partners, for example, are undertaking a variety of levee setbacks, habitat improvements, and infrastructure modifications to restore and enhance the Yakima River floodplain.⁴⁰

King County manages almost 500 levees on its rivers and is actively looking for beneficial opportunities to move levees back and free up the floodplain. On the Green River, for example, a major flood could cause more than two billion dollars in damage. According to Mark Isaacson, Director of the county’s Water and Land Resources Division, bolstering the levee systems in place could cost \$300-400 million over the next 20 years, so the county is exploring alternative ways to spend that money that restore floodplain function and protect property, while creating new recreational facilities and natural habitat.

While investing in natural infrastructure and green facilities can deliver better infrastructure results more affordably, the co-benefits are a more beautiful and better place to live. The City of Portland’s South Waterfront is a former industrial zone now redeveloping on a large-scale with high-rise towers complemented by parks and green spaces. Michael



Seattle’s restoration of Thornton Creek emphasized natural stormwater solutions as well as beautification. Courtesy of Thornton Place.

Armstrong, the city’s Policy, Research and Innovation Manager, describes those green assets as, “Infrastructure masquerading as a pleasant park!”

→ WASTE

The purpose of our waste management infrastructure originally, and still today to a great extent, is to handle and dispose of the stuff that we throw away. But the sustainable infrastructure path is about moving beyond waste toward a future where, in the words of Oregon’s 2050 Vision, “The products and materials we use, wherever they are extracted from or produced, are made in a manner that supports human health, well-being, and healthy, resilient communities and environments.”

This expansive view of waste management, or as some people prefer to call it, materials management, requires us to consider the full ‘life cycle’ of the materials flowing through our economy and ending up as ‘waste.’ Washington’s Beyond Waste Plan envisions that we can “transition to a society where waste is viewed as inefficient, and where most wastes and toxic substances have been eliminated.”

Oregon’s 2050 Vision further looks to a future with:

- “Products and materials (wherever they are extracted or produced) that minimize:
 - Release of toxins, greenhouse gases, and other pollutants.
 - Use of energy and water.
 - Extraction of non-renewable resources.
 - Harmful disturbance of land and natural ecosystems.
- Products and materials which, when they are no longer usable or wanted, are recovered for their next highest and best use.”

39 Integrated Clean Water Plan – Draft; CH2MHill, March 2014; www.spokanewastewater.org.

40 Gap to Gap Floodplain Restoration and Enhancement Plan – Technical Memorandum, Anchor QEA, Prepared for Yakima County, WA, January 2014.



What Does the Future of Sustainable Infrastructure Look Like?

Life-cycle analysis, or environmental footprinting, measures the environmental impacts of products and materials through the entire chain of extraction, manufacture, transport, and disposal. This is a discipline in early development – it's getting better all the time but still has a long way to go. Washington and Oregon are collaborating to consider barriers and opportunities to advance product footprinting by businesses located in and selling products into the Pacific Northwest. With time, our materials policies and strategies will be informed by better and better footprinting information.

In many ways, the West Coast is leading the way nationally with innovative efforts in waste reduction, recycling and composting. Entrepreneurs in the region are springing up to support the 'beyond waste' vision. For example, a Redmond, Washington-based company founded by former Microsoft executives, WISErg, has developed a promising technology for urban food waste. The Harvester is an appliance-sized unit for grocery stores and commercial kitchens which converts food discards into organic fertilizer, and whose smart technology also helps stores better track and reduce waste. Liberty Bottleworks in Yakima, Washington, is a green chemistry success story whose 42 employees produce a safe, very well-vetted sports bottle made of recycled and recyclable aluminum.

But as pioneers of new practices, the region is working through challenging problems. For example, regional waste management officials frequently face a lack of sustainable local markets for recyclables and compost facilities that are challenged by odor and contaminant issues.

Priorities for the next 5-10 years in the waste-materials sector, according to Janine Bogar, an environmental planner at Washington's Department of Ecology's Waste 2 Resources Program, should include:

- Establishing effective and efficient waste reduction efforts and systems to reuse materials, such as refilling bottles and re-refining motor oil.
- Supporting local markets for recyclable materials, including metals, plastics, glass and paper.

- Developing better systems and technologies for converting organic wastes from urban areas and the agriculture sector into soil amendments, energy, and other valuable co-products.
- Promoting 'green chemistry' to facilitate safer chemical alternatives for products that include hazardous compounds, which are far more ubiquitous in consumer products than most people realize.

British Columbia is leading the region in adopting an innovative policy structure, called product stewardship, which requires manufacturers to collect their products after their useful life for recycling or safe disposal. Because the companies, rather than the public, bear the cost of collecting, processing, recycling, or disposing, they have an economic

incentive to design their products with end-of-life in mind, maximizing ease of recycling and reuse, and minimizing waste and toxicity. BC now has twenty different product categories under a product stewardship structure, while Washington and Oregon each have just two so far.

Interestingly, the paint industry supports product stewardship policies that enable a producer financed, designed and managed post-consumer recovery system that ensures recycling or safe disposal of paints. Oregon, California, and six other states have adopted the policies. However, in Washington adoption has been derailed by opposition from waste haulers, among

others. Like privately-owned electric utilities, waste haulers make money based on volume, so policies to reduce waste can be perceived as undermining profits, a key policy design challenge for their regulators. "In the future, the companies we regulate shouldn't still be thinking of themselves as garbage haulers, but rather waste services companies," says Dave Danner, Chair of the Washington Utilities and Transportation Commission.

In fact, public solid waste utilities are just as dependent on trash volumes for operating revenues as the private haulers. "The core problem is we're dependent on waste to fund our environmental mission. At best, that's ironic," points out Pat McLaughlin, Director of King County Solid Waste Division. "But because of our success, we will be operating on half the

"In the future, the companies we regulate shouldn't still be thinking of themselves as garbage haulers, but rather waste services companies."

Dave Danner,
Chair of the Washington Utilities
and Transportation Commission



What Does the Future of Sustainable Infrastructure Look Like?

waste volumes that we'd predicted. So we've got a drop in tonnage – the only funding mechanism we have. We have a really ambitious recycling goal but currently don't have the roadmap in place to achieve it. So we're in the early stage of re-envisioning the business model and redefining what our line of business is – the full suite of our products and services."

What about the fraction of materials that are not recoverable at any given point in time? Should that continue to be landfilled or should we instead direct that material toward facilities that can extract energy? According to Marc Daudon, Founder and Senior Principal at Cascadia Consulting, "We should pretty easily be able to increase our recovery to 80% of what we throw away. Instead of landfilling the other 20%, can we recover energy?"

David Allaway at Oregon's Department of Environmental Quality agrees that extracting energy from wastes is probably better than landfilling, but warns that, "There is the serious problem that an energy recovery facility, once built, needs to be fed a certain steady volume in order to pay for amortized construction costs." Once a community is

committed to supplying a certain amount of waste to such a facility, "this can create a de facto cap on the amount of the material-stream a community will tackle via waste reduction and recycling," warns Allaway.

Joshua Proudfoot points out that extracting energy from a variable mix of wastes is not as efficient or effective than pulling energy from a single waste stream. "Typical mixed material waste-to-energy plants don't have a great energy return on energy investment because they are generalists, and they require energy input to maintain the proper burn conditions as materials vary," notes Proudfoot. "Energy recovery technologies designed for very specific waste streams can optimize value."

Bill Dunbar, Policy Advisor with U.S. EPA Region 10, says the place to start is with organic wastes that are currently generating methane, a powerful greenhouse gas pollutant, at our landfills, sewage processing plants, farms and lumber mills. "We need to get governments in the mindset that this is valuable stuff that we toss," he says. "We could be turning that into valuable energy, benefiting rural and urban areas alike."

The place to start is with organic wastes that are currently generating methane, a powerful greenhouse gas pollutant, at our landfills, sewage processing plants, farms and lumber mills. We could be turning that into valuable energy, benefiting rural and urban areas alike. – Bill Dunbar



→ Key Challenges

We clearly have abundant opportunities to change how we spend and invest in our infrastructure to develop smarter, more affordable, sustainable, and resilient systems. So why is sustainable infrastructure still the exception rather than the rule?

The thought leaders interviewed for this report identified many reasons that the status quo is tenacious. One example is the typical approach to awarding infrastructure construction contracts to the lowest bidder. “If your job as a contractor is to respond with the lowest bid for construction, you’re not incentivized to care about minimizing operating expenses over the 30-year lifespan,” says Chris Taylor of the West Coast Infrastructure Exchange. “This can work well for many types of projects. But not necessarily for large, complex and innovative projects, because all cost overruns are borne by the public under traditional procurement, which can end up being much more expensive than an approach in which a private partner absorbs the performance risk and long-term operational costs.”

Infrastructure finance expert Karen Williams of Carroll Community Investments, LLC adds, “Traditional procurement leaves the vast bulk of the risk with the public owner, even though the owner is not in primary control of design, construction, and long-term performance risks.” Williams notes that these risks discourage innovation: “Agencies usually avoid innovation in favor of long-proven methodologies, even if the innovative solution might result in a better performing product,” says Williams.

“Risk aversion tends to increase as you go up the ladder of management,” says Rich Hoey, Public Works Director for the City of Olympia. “There’s fear of things failing and blowing up and leaders looking bad.” Indeed, Noah Siegel, Policy Advisor at Oregon Metro, points out, “if you expend the political capital to do something bold, there is risk. If it becomes a high profile failure, then you’re dead in the water – you won’t be able to do anything else.”

Several thought leaders suggested that the civil engineering culture, in particular, favors standard over innovative approaches. “I’m a licensed civil engineer and we get taught to build BIG things,” says CH2M Hill’s Liz Kelly. “If we go into government, if things go wrong it gets on the front page, so there’s an incentive to actually overbuild, build for redundancy, build it plenty big to handle any future scenarios. And there’s a lack of incentives for developing systems approaches.” Daniel Malarkey, former Deputy Director of the Washington Department of Commerce, suggests the tendency to overbuild comes not just from the engineers: “Politicians and contractors have an ‘Edifice Complex’ that drives them to build big mega-projects and chronically under-cost the project. There is a lot of good academic work to show that mega-projects consistently come in over budget.”

→ Tribe and Farmers Partner to Bridge Waste and Energy Silos in Rural Washington

In Monroe, Washington, Qualco Energy—a public-private partnership between the Tulalip Tribe, Northwest Chinook Recovery, and the Sno/Sky Agricultural Alliance—turns manure and food waste into electricity, methane, and fiber compost. The partnership represents a convergence of important stakeholder interests: dairy waste is a leading source of the fecal coliform that pollutes salmon streams, in which tribes have a 50% stake by Treaty. Developed in 2008, the Qualco digester was financed by a \$3 million federal renewable energy loan, a grant from the U.S. Department of Agriculture, donations by its partner organizations, and the donation of a state-owned dairy farm from the Washington State Legislature. It is currently operating with a positive cash flow, with revenue coming from the sale of electricity to Puget Sound Energy via Snohomish Public Utility District, Renewable Energy Credits, and tipping fees from non-dairy waste sources.

Qualco has maximized the efficiency of its biogas production processes to the extent that it actually exceeds its 450 kilowatt generator capacity, with enough methane potential to generate 1.2 megawatts of electricity. Qualco is currently partnering with researchers at Washington State University to develop alternatives to flaring off its excess biogas, including installing a second 750 kW generator and investing in technology to produce renewable natural gas for vehicle use.

Sources: Puget Sound Starts Here, “Working Together: The Qualco Biodigester.”

Highway funding came in for particular criticism from thought leaders for lacking strategic rationale. “There is no transparent process, no accountability for how Washington State’s \$10 billion transportation budget is expended,” argues Shefali Ranganathan of Transportation Choices Coalition.

The basic business model by which our utilities and infrastructure agencies are funded may pose a fundamental barrier to innovation. “For most of our infrastructure systems, the revenues to invest in and operate the system are tied to sales volumes – whether its gasoline, electricity, water, or garbage,” says Jules Bailey, Multnomah County Commissioner. That means infrastructure agencies that are highly effective at promoting conservation and sustainability reduce their



Key Challenges

volumes and risk starving the system of revenues it needs to operate. “This creates a profound disincentive to fully investing in affordable and sustainable infrastructure solutions,” says Bailey. “As policymakers and regulators, we absolutely have to crack this nut.”

While some thought leaders cited civil engineers’ ‘in-the-box’ thinking as a key challenge, others noted that a looming wave of retirements threaten to drain critical knowledge from our infrastructure agencies. “There is a huge amount of institutional history and knowledge being lost and we don’t have the people to replace them,” says Josh Bratt of Morgan Stanley, an expert in the region’s electric industry. “We can’t pull them in from other parts of the country because every utility everywhere is losing their power engineers and the schools are not graduating enough of them.”

Most thought leaders cited institutional silos as a key challenge. “Conventionally, we design infrastructure within its silo, rather than looking for opportunities to optimize between systems,” says Aaron Berg. Water utilities, for example, might not consider tapping their pipe infrastructure for gravity-fed energy generation, even though this will slow the water’s flow downhill which, at certain times of year, is valuable for the utility. Another example: shifting to electric vehicles. “The transportation and electric industries tend not to talk to each other,” says Angus Duncan.

Simply communicating across silos can be challenging. “People coming from different fields and perspectives can speak almost a different language,” says Ecotrust’s Brent Davies. Funding channels for infrastructure can discourage integration as well. “The funding programs are pigeon-holed, which stifles innovation,” points out Chris Watchie. Divided responsibilities can mean it is no one’s job to develop integrated strategies to optimize the whole system. As the Bullitt Foundation’s Steve Whitney points out, “You’ll have a watershed with 14 jurisdictions and 25 taxing districts. It makes it really, really hard to do anything at scale.”

Another reason it is difficult to comprehensively rethink our infrastructure systems is “the diminishing capacity of government to finance infrastructure, and to be the primary driver establishing vision and direction to do big bold projects,” says Tony Usibelli, Director of the Washington State Energy Office. Oregon Metro’s Noah Siegel says, “The polling data today suggests everyone really wants to just fill the pot-holes and maintain what we have, rather than do bold new investment.”

While we have spent dramatically less on infrastructure over the past 20 years, underfunding the earliest phase – the pre-design phase to decide which projects are the right ones – can be especially short-sighted, according to Chris Taylor of the West Coast Infrastructure Exchange. “We are drastically underfunding the planning (pre-design phase) of infrastruc-

ture. We need to spend 1-5% to plan to ensure the 95% is spent really well,” he says. “In my wind industry career I had teams of experts and millions in the budget to plan, model, permit and design projects that we knew we could deliver on.”



Spokane and Portland: Bridging the Water and Transportation Silos

In mapping a strategy to meet its regulatory obligation to clean up the Spokane River, the City of Spokane has designed a plan that breaks down silos that separate transportation, wastewater and stormwater planning. The plan will not only deliver better results faster for cleaning up the river at a savings of about one-third over the standard response of bigger capture-and-treat infrastructure. By connecting planning for multimodal, walkable streets with planning for streetside green stormwater infrastructure and for the pipes underneath, the City is able to achieve efficiencies and multiple benefits when working on a given street segment.

Similarly, the City of Portland combined its’ sewer, stormwater, and transportation strategies in the Division Streetscape Project, jointly funded and managed by the Bureau of Environmental Services and the Bureau of Transportation. Launched in May 2013 at a \$12 million total cost, this project represents a total redesign and reconstruction of Division Street, featuring new curb extensions for bus landing, new crosswalks and streetlights, improved signalization, new on-street parking, 55 green street bioswales, planting of 124 street trees, replacement of over 4,900 feet of sewer pipe, and installation of public art. By combining forces, the project not only achieves efficiencies and cost savings. It gives the neighborhood an attractive main street with increased access to transit, improved safety and access for pedestrians, bicyclists, and transit users, better traffic operations through the corridor, and improved air and water quality.

Sources: Spokane Integrated Clean Water Plan – Draft CH2MHill, March 2014; Portland Bureau of Environmental Services.

Meanwhile, O&M budget constraints are causing infrastructure managers to put off vital maintenance work, but, “Deferred maintenance ends up costing two to four times more, depending on the type of infrastructure asset, than doing maintenance when it is needed,” according to Taylor.



Key Challenges

Many thought leaders also suggested that another key challenge is that the tools for assessing the economics and for paying for our infrastructure systems are inadequate. For example, “Our current economic indicators don’t measure the impact of infrastructure investment on community cohesiveness and equity,” says Mary Rose Navarro of Oregon Metro.

energy efficiency and renewable energy in states with strong climate policy such as California and Massachusetts.”

Similarly, the health benefits of sustainable infrastructure choices, such as cleaner air and water, are not adequately weighed by our economic assessment tools, nor are the benefits of healthy natural systems. Valuing the benefits of natural assets correctly is essential to enable financing to flow toward protecting and enhancing these systems. As Earth Economics’ David Batker points out: “We need to change accounting rules so that green infrastructure’s value is fully recognized on the bottom line of the balance sheet. Right now its value as an asset is counted as zero.”



A construction worker installs solar panels at the Marine Corps Air Ground Combat Center in Twentynine Palms, California.

Current tools also do not reflect the full range of environmental costs and benefits of our infrastructure choices. The lack of a price on carbon emissions is a leading example of an ‘external cost’ that is not reflected on the economic balance sheet today. “Strong climate policy, including putting a cap and price on carbon emissions, accelerates innovation on the ground by sending the right market signals to level the playing field with the fossil fuel industry,” says Eileen V. Quigley, Director of Strategic Innovation at Climate Solutions. “Just look at the groundbreaking innovations in



King County’s Equity Impact Review Toolkit

King County’s equity and social justice program was initiated in the early 2000’s to address disproportionate incarceration and disparate health outcomes among low-income communities and communities of color in King County, Washington. The Equity and Social Justice Initiative was broadened by County Executive Ron Sims in 2008 into a comprehensive approach to advance equitable outcomes and opportunities in every facet of county governance.

In 2010, the Initiative was institutionalized with adoption of the Equity and Social Justice Ordinance, which established definitions for 14 determinants of equity and identified the specific approaches needed to implement the county’s vision for a “fair and just” system of governance. Among the determinants of equity that refer specifically to infrastructure are “healthy built and natural environment” and “transportation that provides everyone with safe, efficient, affordable, convenient, and reliable mobility options.”

The Equity Impact Review tool and process was developed to provide a structured approach to understanding how various policy, project, or operational alternatives may affect populations of concern. The tool, modeled in part on Health Impact Assessments, helps identify the ‘pathway of impact’ (which may be benefits or burdens) to various populations. Capital program managers use the tool to consider how project sequencing and prioritizing may impact equity determinants, and, for capital projects, to reveal how siting and design alternatives vary in their impact on equity for populations of concern.



Ten Guiding Principles for Innovation

Distilling the prevailing themes and key insights from the thought leader interviews, the Center for Sustainable Infrastructure here offers infrastructure agency leaders, elected officials, and community planners the following 10 guiding principles for sustainable infrastructure innovation.

Go for the Triple Crown: Fiscally Sound, Resilient, and Sustainable

There are growing constituencies for infrastructure change. Some are focused most urgently on how we can finance a ballooning 'infrastructure deficit' and deal with increasing costs for operations; others on making our systems quicker to recover in natural disasters and emergencies; and still others on the crucial environmental performance of infrastructure systems. The good news is that there are a rich array of opportunities and new infrastructure strategies that offer strong and simultaneous affordability, resilience, and sustainability benefits.

Consider Broader Alternatives

Smart investors seriously consider alternatives as part of their due diligence. Before committing real money to business-as-usual infrastructure projects and programs, smart public infrastructure decision-makers consider it a wise investment to draw on the best innovations out there to thoroughly compare a portfolio of options that provide the most benefits for the cost – including cost-effective investments in reducing demand.

Encourage Silo-Busting

Virtually all our communities are heavily invested in multiple infrastructures – everything from streets and bridges, to electricity, natural gas and heating services, water supply, sewers and stormwater, and waste collection, recycling and disposal. Very often planning and investment for these systems are departmentalized, and as departments grow they often grow compartmentalized, too, which can lead to missed opportunities for multiple benefits and increased overall value. When we consider these systems as parts of a larger interacting whole, valuable synergies emerge where, for example, waste from one system can become a resource for another.

Build a Better Business Case

Once infrastructure planners narrow the project or program options to the top few, it's crucial to weigh the full benefits and costs, and to do it on a life-cycle basis – meaning for not only construction but also operation and maintenance over time. But benefits and costs should not be limited to the department charged with managing one particular infrastructure system. Smart investments will save money, manage risk, and accrue benefits to other departments, and serve broader community goals. Considering capital and operating budgets simultaneously is key. The full range of benefits, costs and risks – to the department, to government as a whole, and also to the broader community – all need to be carefully evaluated and documented with well-designed business cases to compare investment options one against the other.

Educate, Engage, and Inspire

Infrastructure systems are the most costly and enduring capital assets any community joins together to invest in. With legacy systems often aging and under stress, and with serious constraints on the public purse, citizen support for needed infrastructure investment is increasingly crucial. Earning that support requires effective communication and public engagement, which in turn must rest firmly upon a compelling vision of where we are going, why it's so important, and why the strategy is smarter and more cost-effective than the standard way of doing business.

Build Community Prosperity

Infrastructure spending is paid by and benefits the whole community. It is widely recognized as a job generator and important to local business and economic vitality. Evaluating the community's strategies for infrastructure in light of its economic development goals can reveal opportunities and strategies to in-source infrastructure jobs and lift up segments of the community too often left out. Higher education can build the critical pipeline of local talent by designing technical training and advanced degree programs that build skills important to sustainable infrastructure.



Ten Guiding Principles for Innovation

Choose for a Changing World

Infrastructure decision-makers must increasingly be future-casters. Capital projects this year will often be paid for over many years and in operation even longer. It's vital to make sure we are building infrastructure systems well-adapted to our changing world – from technology revolutions to major environmental stresses, from shifting living patterns to changing lifestyles and demographics as one generation ages and the next one grows up.

Integrate Smart Systems

Today people carry devices in their pockets packing information, communications, and monitoring capabilities unimaginable a generation ago. Advanced technologies are transforming many industries, but for our infrastructure systems unrealized opportunities abound. Infrastructure managers, tapping private sector expertise, can harness low-cost monitoring and real-time management technologies to improve service and achieve cost-saving efficiencies.

Partner With Nature and Enhance the Community

A community's most beloved places are often where natural features and beautiful structures are richly present. Increasingly, water, wastewater, and stormwater utilities find that investing in natural systems can provide increased functionality and save money compared to relying solely on traditional hard infrastructure approaches. And when conventional infrastructure investments do make the most sense, investing in beautiful design can turn an 'ugly' industrial-looking facility into a valued community asset.

Value Capacity and Expertise

Successful infrastructure innovation that delivers long-term cost savings and a host of better outcomes requires sophistication and deep expertise. Centers of expertise can help ensure local agencies don't reinvent the wheel and access the best data, tools, policies, and case studies from the broader marketplace. New procurement strategies may also be key: Rather than staging the typical 'low-bid war' to hire the cheapest contractor, new approaches can incentivize private sector innovation and sustainability, reduce risk of cost overruns borne by the public, and reward quality performance over time. Within organizations, translating a new vision into the day-to-day priorities of staff may require revamping job descriptions, performance metrics, and training.

Implementing the Principles

Two ideas emerged from the thought leader interviews for implementing these principles in a comprehensive way:

For community leaders, develop a 10 year Sustainable Infrastructure Strategic Plan for the community that encompasses the various infrastructure systems. Because infrastructure is central to the future of a community's economy, fiscal health, sustainable land development and quality of life, creation of an infrastructure strategic plan can provide a central focus aligning both implementation efforts and the various other local plans. It can also provide a platform for the agencies and utilities managing different infrastructure systems, both local and regional, to harmonize their plans with the community's goals and aspirations.

For infrastructure managers, adopt the disciplined practices of Sustainable Asset Management. Traditional asset management tools uncover investments that control the total cost of ownership over the lifecycle of the system's infrastructure assets. Sustainable Asset Management adds two crucial elements to the discipline: integrated strategies that reveal solutions benefiting more than one infrastructure system, and 'Triple Bottom Line' metrics that measure not only financial factors, but also important social and environmental considerations.

➔ Policy Tools for State Leadership¹

Both Washington and Oregon have a rich recent history of public policy attention to infrastructure, including studies directed by the legislature, by executive agencies, and by stakeholders, as well as coordination initiatives, and an executive order. There are important similarities and differences in the two states' approaches. Within this context, the thought leader interviews surfaced a valuable set of fundamental policy ideas, which could inform an overarching framework for future infrastructure development in both states, a need identified in many recent studies.

¹ The state policy tools section was composed for CSI by Craig Partridge, retired Director of Policy and Government Relations for Washington Department of Natural Resources, based on Center for Sustainable Infrastructure research and content of thought leader interviews.

Washington, Oregon Policy Approaches

In Washington State, the second half of the decade of the 2000s saw a series of infrastructure studies concerned primarily with project funding in a time of increasing need and decreasing public financial capacity. These studies included the following:

- Two Office of Financial Management studies, in 2005 (the "Berk Report") and 2009.
- 2005 and 2006 policy briefs by the Washington Research Council.
- A study by the Joint Legislative Audit and Review Committee in 2006.
- A 2007 report focusing on counties by the state Department of Community, Trade, and Economic Development (CTED; now Commerce).
- An Association of Washington Cities study in 2008.
- A 2008 Growth Management Act-related study by CTED.
- Two other local government-focused studies by the Association of Realtors (2006) and the Puget Sound Regional Council (2009).

➔ Sustainable Asset Management

Across the U.S., decades of capital investment have bestowed a rich legacy of infrastructure facilities within and connecting our communities. These facilities represent valuable assets and in recent years the practice of "Asset Management" has begun to take hold in the infrastructure field. The U.S. Environmental Protection Agency defines infrastructure asset management as "*managing infrastructure capital assets to minimize the total cost of owning and operating them while delivering the desired service levels*" over the course of the assets' lifecycle.

With **Asset Management (AM)**, infrastructure managers conduct rigorous analysis to gain a full picture of their system, prioritize investment, and make fiscally sound decisions for the long term. Steps include:

- Inventory the current condition of all the working parts system-wide.
- Determine the level of service expected by the customer base or required by regulators.
- Understand which assets could fail, the likelihood, and the costs and consequences of failure.
- Evaluate the life cycle costs of alternative strategy to rehabilitate, repair or replace aging assets.
- Determine how to pay for the life cycle costs of the resulting strategies.

Sources: "Sustainable Asset Management" brief, Steve Moddemeyer, Principal, Collins Woerman, September 2014; US EPA; Seattle Public Utilities.

Sustainable Asset Management builds on AM's proven success to add two valuable steps:

1. Explore and analyze *integrated strategies* that span infrastructure silos to optimize benefits collectively, in addition to penciling out within the specific silo.
2. Expand metrics used to evaluate life cycle costs, to encompass not only financial factors, but also important social and environmental metrics.

One striking example of the benefits of Sustainable AM is the Cedar River Watershed Bridge Replacement Program. The Cedar River Watershed provides the primary source of clean drinking water for 1.4 million residents of the greater Seattle area. The Watershed was crisscrossed by over 600 miles of roads and bridges, some of which had fallen into disrepair, with an estimated replacement cost of \$700,000 per bridge. By examining broader alternatives and applying social, environmental, and financial metrics, Seattle's Asset Management Committee determined that some roads could be decommissioned, and some bridges removed or replaced with less expensive materials. The result: \$8 million in savings over the City's 11-year Watershed Bridge Replacement projections, as well as tremendous benefits for habitat conservation from the decommissioning of over one-third of the watershed's roads and bridges.



Policy Tools for State Leadership

The Puget Sound Regional Council report contains an excellent summary of all these studies. In general, these studies:

1) identify an increasing gap between local infrastructure investment need and the local, state, and federal financial resources available; 2) point out that local governments shoulder 75% of the funding burden for local infrastructure, and vary dramatically in their capabilities to raise funds; 3) document the wide variety of state grant and loan programs spread among many agencies and the absence of overarching state-level strategic goals and prioritization mechanisms with which to target state resources; 4) document increasing reliance on loans, and bonds backed by a range of revenues, from local utility rates to the state general fund, along with decreasing grant programs; and 5) highlight the distinctive challenges faced by growing cities, and by small towns and rural areas with modest resources.

Among the many recommendations in these studies are the following:

- Calls for restored funding under more flexible rules.
- More consolidation of state programs under more unified and efficient direction.
- Authority for new local user-based revenue sources, such as tolls and impact fees.
- New local planning requirements, including more explicit demand management.
- Regional coordination.
- Ear-marking for future operation and maintenance expenses.
- Improved monitoring and information systems.
- Attracting private investment capital in longer-term contracts, including expanded private roles in design, finance, construction, operation, and maintenance.

Since 2009, Washington State infrastructure policy deliberations have been more sector-specific, with creation of a statewide energy plan and state transportation strategy. The recession hammered infrastructure funding programs, and then considerable effort was focused on securing and administering federal Recovery Act funding for job-creating infrastructure projects. CTED was renamed the Department of Commerce in 2009 and reorganized to consolidate some infrastructure programs. In 2011, a legislative infrastructure financing task force met briefly, focused on possible creation of a state investment bank. Most recently, Washington legislative budget writers have been laboring under State Supreme Court direction to come up with far greater funding to support constitutional obligations to fund education, which has already affected other funding priorities.

The State of Oregon also has an active recent history of public policy attention to infrastructure. Unlike Washington,



Cool New Tool:

'Envision' Sustainable Infrastructure

A new rating system called Envision™ is designed to serve a similar role for the infrastructure world as the LEED system has for green buildings. The LEED green building rating system was launched in 1998 and helped transform how thousands of buildings are designed and constructed in the U.S. and increasingly globally.

Envision is a tool for evaluating and rating all types and sizes of infrastructure projects holistically, to assess the community, environmental, and economic impacts and benefits over the project's lifecycle. It can be used by infrastructure owners, builders, and design teams, as well as by community groups, regulators and policymakers. Envision aims to support better decision-making in the conception and design of infrastructure projects to include broader community priorities and support collaboration between the project team and the community. The approach helps the project team and the community to discuss together and answer the questions: 'Are we doing the right project?', and, 'Are we doing the project right?'

Envision™ Sustainability Professionals are trained in the use of the rating system and are certified by its parent organization, the Institute for Sustainable Infrastructure. These credentialed professionals serve as a key part of any team developing a project to be rated by Envision, helping guide the team to achieve higher levels of sustainability, document achievements, and submit the project to be rated and recognized.

Source: Institute for Sustainable Infrastructure: www.sustainableinfrastructure.org/rating/.

Oregon has taken a more active and focused statewide and regional approach in the past few years. For example, Oregon took the lead in convening a 2011 meeting of California, Oregon, Washington, and British Columbia, leading to the 2012 establishment of the West Coast Infrastructure Exchange, which began under the auspices of the Oregon State Treasurer (and has since become an independent organization). The purpose of the Exchange is to create innovative new methods to finance and facilitate development of the infrastructure needed to improve economic competitiveness, support jobs, and enhance quality of life, by relying on private sector expertise and increasing accountability.



Policy Tools for State Leadership

In 2013, Oregon and Washington, along with Idaho, also responded to an invitation by the Secretary of the Interior to form the Pacific Northwest Regional Infrastructure Team, to advance infrastructure projects that spur job growth, further energy independence, and manage climate change risk, by better aligning state and federal siting and permitting processes.

Oregon Governor John Kitzhaber in 2012 issued an Executive Order laying the groundwork for greater state integration of infrastructure programs and more robust public-private investment in infrastructure projects. The Executive Order identified the need for an intentional plan of investment or common standards for return on investment, and established steps to facilitate more integrated planning and financial processes. The goal is to create sustainable asset management over the life-cycle of investments by projecting sustainable financial returns.

In response to 2013 Oregon legislative direction, a task force was created and completed a December, 2013 report to the Oregon Legislature. The report recommended administrative consolidation and creation of a centralized “center of expertise,” in part to help attract private investment capital and risk-sharing for larger infrastructure projects or aggregations of projects. This administrative mechanism is modeled on Partnerships BC, a provincially-owned company created in 2002, which has garnered over \$17 billion in public and private investment funds for the successful completion of a wide range of over 40 infrastructure projects. In 2014, Oregon’s legislature adopted HB 4111, which establishes a public infrastructure commission, requires screening of all projects with over \$50 million in state funding, among other things.

Overarching Policy Themes

A core conclusion of infrastructure initiatives in both Washington and Oregon has been that multiple infrastructure plans and investments need to address more unified, overarching state goals and prioritization mechanisms, in order to create more value for the dollars spent. Better value can be realized, according to proponents, through efficiencies, aligning functional outcomes, and ensuring greater sustainability for infrastructure systems, human communities and the natural environment. Accordingly, Oregon and Washington thought leaders recommended a number of key policy ideas that can serve as those overarching state policy themes.



Performance-Based Infrastructure

Performance-Based Infrastructure (PBI) can bring positive outcomes for projects of relatively large scale, where the complexity of design and delivery offers opportunities for innovation. PBI is a public-private partnership model in which the public sector agency invites the private sector to offer solutions to a problem or set of problems in the form of Design-Build-Finance-Maintain proposals that look at cost-benefit over the lifespan of the investments. The proposer is accountable for the cost of operating the infrastructure over the long haul, so they are incentivized to design for efficiency and durability. The reason to invite private sector proposals is not only to tap private funding resources and bring innovation, but also to transfer risk of cost overruns and poor performance from the public onto the private sector. Partnerships British Columbia is a global leader in PBI.

According to Portland-based PBI expert Karen Williams, “Finding the right projects that will really generate benefits via this model takes careful analysis. So the best practice is a Center of Expertise like Partnerships BC helping all the jurisdictions to apply best practices. Our report to the Legislature recommends how to do this for Oregon.”

Partnerships BC is charged with helping the Province navigate the world of public-private partnerships, to make sure deals are structured properly so the public gets the best return on its investment in infrastructure. So far, according to the *Governing Magazine*, “it appears to be doing just that, racking up a record number of projects that are finished on schedule and at significant savings to taxpayers.” Partnerships BC supports the Province’s climate action plan to reduce greenhouse gas emissions and improve energy efficiency in public sector buildings by structuring and implementing partnership solutions which serve the public’s economic and environmental interest.

Partnerships BC provides a full spectrum of services ranging from business planning and procurement management to advisory services during the design, construction and operations phases. Partnerships BC is also helping the West Coast Infrastructure Exchange (WCX) develop its infrastructure development strategies, with Oregon leading the way. WCX thinks about how it can impact climate change, improve water sustainability, energy efficiency and how it can use the PBI approach to do all that.

Sources: Partnerships BC: www.partnershipsbcc.ca; Report to the 78th Legislative Assembly of Oregon, *The Oregon Innovation in Infrastructure Task Force*, December 30, 2013.



Policy Tools for State Leadership

Physical Design

Integrate Infrastructure Across Sectors ~

Most interviewees recognize, as did the various Washington and Oregon studies cited above, the potential efficiencies and increased benefits to be gained from integrating across infrastructure categories, where technically feasible. Policy innovations could relate to flexibility in the use of currently dedicated funding now limited to specific infrastructure types, requirements for consideration of more integrated alternative designs in planning, and analytical requirements that would reveal the advantages of integrated designs. Interviewees recognized, however, that integration can increase project complexity, the diversity of stakeholder objectives, and the risk of public fatigue. Therefore, at a minimum, state policy support is critical.

infrastructure systems, and cost reductions. One example offered is the recently built Bullitt Center in Seattle, a “living building” designed to generate its own energy and handle its own waste water on site. In these recommended future scenarios, current infrastructure providers may take on new roles emphasizing system coordination, and integration and support services for distributed systems. Also, in a time of less centralization of utility services, some interviewees still point out the continuing potential value for centralized administration in the areas of integrating across infrastructure categories, ensuring efficiency from common sets of practices and standards, gaining information technology benefits of system-wide monitoring and control, and aggregating similar projects to attract greater investment, especially private sector and foundation investment.

Incorporate Natural Infrastructure ~

Many interviewees endorse a policy of investing in restoring natural system functions to augment infrastructure systems where technically feasible and economically efficient. Adopting such practices supplies additional co-benefits, such as species habitat, biodiversity, and community amenities, while reducing the net costs of providing infrastructure services over time. Low impact development practices at the site and neighborhood scale, such as permeable surfaces, rain gardens, etc., are well-established examples. Another often-cited major project example was the decision by Clean Water Services in the Tualatin Valley to fund streamside tree-planting by upstream landowners to create cooling shade, thereby avoiding or delaying the need for expensive chillers at a water treatment plant.

Promote Compact Development ~

Some interviewees believe that state growth management and urban land development policy can do more to ensure that growth is promoting high densities of mixed-use development that is much more cost-effective to serve with infrastructure of all types than low-density development. Compact development can also provide the foundation

for good multi-modal transportation access by residents to places of employment, commerce, entertainment, and amenities. Crucial to success, existing neighborhood residents’ misgivings about higher densities need to be seriously addressed. Thought leaders emphasized community education and engagement based on a compelling vision, combined with substantial investment in neighborhood ‘livability infrastructure’ (parks, public art, etc.) and development policies that strongly encourage redevelopment of heavily-paved, currently under-utilized locations.



The Bullitt Center in Seattle, Washington: North America's most ambitious green building. Benjamin Benschneider Photography.

Develop New Business Models to Realize the Benefits of Distributed Systems ~

Many interviewees promoted the advantages of emerging trends toward decentralization of infrastructure services, such as distributed on-site energy production or on-site waste and wastewater treatment. Advantages cited included greater flexibility and resiliency, contributions to “right sizing” of



Policy Tools for State Leadership

Improve Infrastructure Security ~

Several interviewees stressed that infrastructure security should be seen as an emerging public policy priority, both from the standpoint of global and domestic political conflict and terrorism, and from that of climate change-induced natural disasters such as fire, drought, landslides, and flooding. A truly pervasive emphasis on security could transform current views of sustainability, financial risk, community planning, optimal project size and redundancy, and other core features of infrastructure system planning and design. Various examples arising from Hurricane Sandy illustrate this concern. Designing for resilient systems and rapid recovery at a local scale, mimicking natural systems, may be a compelling new model.

Financing

Attract Private Investment ~

Mirroring the primary focus of recent infrastructure financing studies and discussion in both Washington and Oregon, many interviewees pointed to opportunities to address the infrastructure funding gap and the reduction in available public funds by attracting investment from private sector entities. Rather than being passive bond investors or bidding on construction contracts, this thinking envisions more involved private roles. These roles include appropriate risk-sharing and public-private partnerships leading to contracts to assign private partners some combination of design, finance, operations, and maintenance responsibilities, in addition to construction. The public sector would retain ownership of infrastructure and control over public benefit outcomes, but performance contracting could help stimulate innovative ideas from private partners. State "Centers of Expertise" form the core repository of technical expertise for this innovative financing approach. Partnerships BC is currently the best-developed example of this financing concept. U.S. constitutional, legal, and institutional circumstances will need careful consideration in expanding this model to Washington and Oregon.

Fix the Disincentive to Use Less ~

Currently, revenues to pay for road, water, electricity, and waste infrastructures depend heavily on rates or taxes paid by customers based on sales volume. The more resources consumed or waste produced, the more revenue is generated to pay for the capital and O&M costs of infrastructure services, an approach that has worked reasonably well in the past. The shift toward sustainable infrastructure investments, however, that actively encourage conservation, distributed systems, and alternative technologies can shrink sales of gasoline, water, and power, and reduce solid waste tipping fees. This creates an institutional disincentive for infrastructure agencies to fully invest in sustainable systems.



Grow Smart to Control the Cost of Infrastructure

Oregon and Washington both have policy frameworks that aim to rein in sprawling land development, yet the spread of low-density development continues to take a toll on local government budgets for vital services and infrastructure.

Local governments in the U.S. raise and spend about \$1.6 trillion dollars annually, and about a third of that, \$525 billion, is heavily affected by local development patterns. The first national comparison of the costs to local governments to build the infrastructure and provide services to sprawling versus more compact developments found upfront costs are nearly 40% greater to serve sprawl, and another 10% more every year to deliver ongoing services. Meanwhile, compact development generates ten times the tax revenue per acre for local governments than sprawl.

A study by 1000 Friends of Oregon pointed to an enormous infrastructure deficit in Oregon communities aggravated by sprawl that could be mitigated by shifting to 'quality growth.' Key findings included:

- \$10 billion in unfunded infrastructure maintenance through 2035 in the Portland Metro area, even without new growth, a burden on every resident estimated at \$6,000.
- 69% of Oregon cities expect property taxes to fall short of the cost of providing essential services.
- To meet the current maintenance and construction needs, cities need \$187 million in new annual revenue.

The 1000 Friends study points out that current Oregon law does not require cities to consider the full lifecycle costs of infrastructure when making growth decisions. It recommends that Oregon communities employ a tool known as Fiscal Impact Analysis to assess the full lifetime infrastructure costs incurred by different styles of development "to understand the true obligations its growth decisions will create for future residents."

Sources: Building Better Budgets: A National Examination of the Fiscal Benefits of Smart Growth Development, Smart Growth America; More Extensive is More Expensive: How Sprawl Infrastructure Bankrupts Oregon Communities, and What We Can Do About It, 1000 Friends of Oregon, January 2013.



Policy Tools for State Leadership

Tools pioneered in the electricity sector, such as least-cost planning and 'decoupling' of utility revenue from sales volume, could help inform design of new revenue systems in other sectors tied to a greater extent to services provided rather than volume of throughput.

Front-Load Life-Cycle Costs ~

Several interviewees suggested that current problems of funding deficiencies for ongoing infrastructure operation and maintenance (O&M) costs could be alleviated if those future costs could be better reflected in initial project financing. For example, bringing in private partners up front through a contract that includes ongoing O&M costs to incentivize smarter designs that cost less over time. One mechanism could be a dedicated funding set-aside from the initial project investment or from ongoing revenue streams. The trade-off could be higher initial capital costs and debt service obligations for taxpayers or ratepayers in the service areas. Besides finding ways to factor in life-cycle costs up front, interviewees also point out that future costs to be considered should include an even broader array of costs and risks, as well as benefits, such as from integration of multiple infrastructure services.

Reform Low-Bid Procurement ~

To build life-cycle costs into project financing, public procurement rules must evolve from simple low-bid requirements. Instead, rules should encourage broader statements of project scope and more flexible criteria that can reward proposals that envision a more active role for the private partner in ongoing system management.

Price Carbon ~

Several interviewees stressed that one key to both financial and environmental innovations is a price on carbon emissions. This, say proponents, would drive market forces to incentivize a smaller carbon footprint throughout the infrastructure sector, and possibly unleash new sources of investment. A carbon price can come from several policy actions, such as a cap-and-trade system, a carbon tax, and low-carbon policies directed at specific sectors like transportation (low carbon fuels standard) or energy (coal phase-out). In these sectors particularly, a price on carbon is likely to significantly alter the structure of demand for infrastructure, opening doors for innovations like distributed energy production and transit-oriented development. Interviewees recognize the broad political support needed at the state and national level for these policy enactments. A carbon price may also open the door toward much-needed new revenue for infrastructure, to augment diminished revenue sources such as the gas tax.

Upgrade Bond Rating Methods to Recognize Natural Assets ~

Currently, ratings for the municipal bonds typically used to finance local infrastructure projects make no allowance for the value of healthy natural systems to mitigate risks, for example, to public water supplies from drought, or land-



High Point: Redeveloping for Low-Income Housing and a Healthy Environment

High Point is a Seattle Housing Authority (SHA) neighborhood that is being redeveloped to include both affordable and market-rate housing using low-impact, sustainable design in a dense urban setting that benefits the environment while promoting healthy living. The redevelopment is the result of the close cooperation between planners, residents and other community stakeholders focused on quality design, a healthy environment and an engaged community.

High Point is one of three SHA communities originally built to house defense workers during World War II. To date, 639 of the original 716 worn-out units have been replaced, both on-site and off-site, with housing affordable to people whose income falls below 30% of the area's median income. Over 400 of these units are on-site in the High Point neighborhood, integrated with market rate housing into an overall plan for 1,700 units across 120 acres. High Point has a number of services that benefit residents and the surrounding neighborhood, including a public library, medical and dental clinic, and extensive parks and open space. High Point's Neighborhood Center is home to a jobs connection program, a teen center, youth tutoring and advancement, and a family center.

New construction at High Point includes 60 Breathe Easy Homes, which are built to help decrease the risk factors that cause asthma among low-income children. High Point's walkable streets are narrow, with wide planting strips, and short blocks – a site design that supports physical activity, social interaction, and less dependence on cars. Efficient, sustainable design reduces utility bills for residents. In partnership with Seattle Public Utilities, an innovative natural drainage system is being used to manage stormwater on site, improve water quality, protect salmon habitat and allow the built environment to mimic natural drainage qualities.

Source: Seattle Housing Authority.



Policy Tools for State Leadership

slides due to changing rainfall patterns or land development. For example, Seattle Public Utilities (SPU) purchased most of the Upper Cedar River Watershed over a century ago to protect the city's source of clean water. To build a filtration plant today that provides the same level of service as the protected watershed would cost SPU an estimated \$200 million.¹ Because valuable natural assets, like the Cedar River Watershed, are not recognizable on a utility's balance sheet, bond financing that may be readily available for constructed facilities cannot be accessed for activities to protect and enhance such natural assets.

Project Analysis

Incorporate More Holistic Analysis ~

Most interviewees also recommend various forms of improved analysis in the development of infrastructure planning. Key analytical steps include drawing a broader boundary around relevant costs and benefits, such as accounting for total capital, O&M, and risk costs over the lifespan of system investments (life-cycle analysis). They also include considering environmental and equity outcomes (triple-bottom-line analysis), taking a broad "portfolio" perspective on integrated infrastructure systems when prioritizing projects (asset management), and inclusion of non-monetary but quantified effects of projects. While these methods can add great value, care must be taken to build

these analytical steps preferentially into the earliest stages of planning when greatest flexibility still exists.

Recognize and Pursue Multiple Benefits ~

Most interviewees also emphasized that optimal infrastructure solutions will deliver a variety of local benefits that accrue to the community but not directly to the balance sheet of the infrastructure agencies investing in their system. Recommended strategies center on policy incentives to design infrastructure projects and programs that deliver multiple benefits, and utilization of project analysis tools that ensure a broad range of community costs and benefits are estimated and considered.

Interviewees also made several other recommendations for strategic considerations that intersect public infrastructure policy. These included:

- Acknowledging and explicitly budgeting for some degree of failure tolerance when piloting cutting-edge new approaches and innovations.
- Redesigning institutional details to transform current infrastructure management organizations into implementers of innovative policy direction.
- Finding a balance between achievable incremental steps and deeply analyzed, ambitious, larger scale projects and programs.
- Committing support for higher education programs to produce the next generation of sustainability-minded engineers and professionals.

¹ Jason Twill, David Batker, Stuart Cowan, Theddi Wright Chappell, The Economics of Change, Earth Economics, October 2011.



→ Five Big Goals for 2040

Infrastructure investments across our transportation, energy, water and waste systems add up to a generational legacy. Many projects are designed to last for 25 years or more. The many billions of dollars in capital investments we make each year between now and 2040 will, added together, almost completely renew our infrastructure systems and thereby reshape our built environment. Thinking forward 25 years, we have an opportunity to fully reimagine these systems to be sustainable, resilient, and affordable. To get there, we need to begin developing a vision for how the systems will work in 2040, and then ensure our investments each year are beneficial in the near-term and move us toward our vision.

Drawing inspiration from the interviews with thought leaders and innovators, the Center for Sustainable Infrastructure offers these Five Big Goals as a conversation starter for a sustainable infrastructure vision for Oregon and Washington in 2040:

- 1** Both states achieve 'A' grades on the 2040 ASCE infrastructure report card, and together boast a majority of the 100 U.S. projects ranked highest by the Envision™ rating system.

To achieve an 'A' grade in 2040 from the American Society of Civil Engineers' Report Card on America's Infrastructure, Oregon and Washington will have succeeded in 'paying off' our infrastructure funding deficits to put in place state-of-the-art, resilient systems. The capacity of these systems will

be scaled to serve efficient and distributed demand, and revenues will be adequate to maintain systems in top condition, into the future. The ASCE grading system will need to evolve to better reflect new sustainable infrastructure principles, such as the value of integration across silos, dramatically improving environmental performance, and managing systems to deliver multiple benefits to the community.

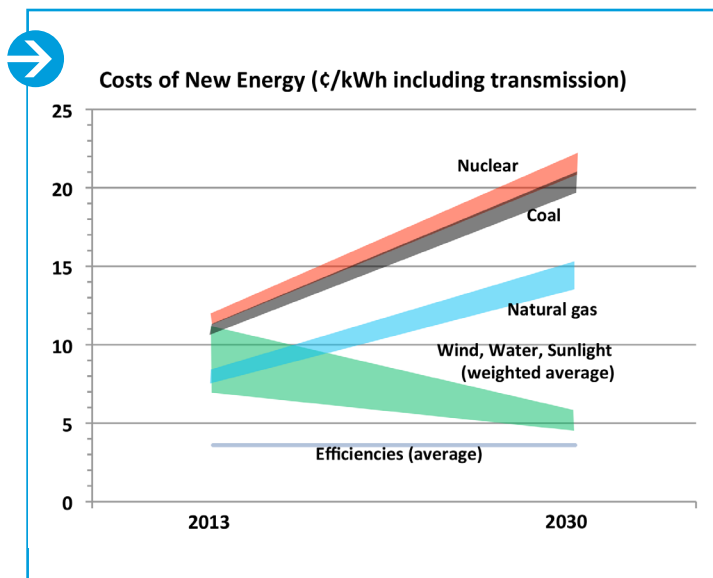
The Envision rating system is explicitly designed to advance the field of sustainable infrastructure. To secure a majority of the projects on Envision's top 100 list, Oregon and Washington will clearly have established the Pacific Northwest as the nation's leading center of innovation. Our region will have done more than any other to define the state-of-the-art for sustainable infrastructure and put in place the necessary policies, funding systems, centers of expertise, and talent development programs for sustained success.

- 2** Renewable energy meets 95% of demand for all energy uses, efficiency gains reduce total energy demand per person by 60%, and sustainable solutions for heavy transportation have been adopted.

Looking out to 2040, the potential for renewable energy to supply the region's power needs is tremendous. Nationwide, a major study, the Renewable Electricity Futures Study, led by the National Renewable Energy Lab, concluded: "Renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the country."

More recently, researchers at Stanford University proposed an energy plan for Washington state¹ that shows renewable sources of energy – from wind, water, and sunlight – can more than supply 100% of the power needed statewide in 2050 for electricity, heat, cooling, industry, and even for transportation. Since ongoing fuel costs for wind, water, and sun energy resources are essentially zero, these sources help stabilize energy prices. Fossil fuels, by contrast, carry serious risk of price escalation due to market forces and further regulation to protect public health and climate.

The Stanford plan assumes all power needs in 2050 convert to electricity, or to hydrogen fuel cells for long-distance transportation needs (shipping, air, trucking), splitting hydrogen from water molecules using electrolysis powered



Costs for the portfolio of renewable energy in the 100% renewable energy plan for Washington state from researchers at Stanford, compared to rising costs projected for nuclear, coal, and gas based on the rate of increase in electricity prices 2000-2012. Sources: Jacobson, et al. <http://web.stanford.edu/group/efmh/jacobson/Articles/I/WashStateWWS.pdf>; Northwest Power and Conservation Council.

¹ Mark Z. Jacobson, corresponding author (jacobson@stanford.edu), A 100% Wind, Water, and Sunlight (WWS) All-Sector Energy Plan for Washington State, July 14, 2014.



Five Big Goals for 2040

by renewable energy. Because electricity is a more efficient application of energy than burning fuel for heat and electric motors, the researchers calculate that the all-electric plan will reduce energy demand in 2050 by 35%.

Interestingly, the energy efficiency resource is a very minor slice of the Stanford plan to meet 2050 demand. While our region has done much to 'build' the efficiency resource into its energy infrastructure, a large resource remains untapped. Total U.S. energy demand by 2050 can be reduced 40-60% below projections, according to an American Council for an Energy Efficient Economy study, at a net cost savings of \$400 billion per year, equivalent to \$2,600/year for every household on average.²

And technological innovations continue to advance the energy efficiency state-of-the-art. For example, just one technology advancement – sensors to customize ventilation to the needs of the actual people in a particular room or zone – could cut overall energy demand 18% in an average large office building, a remarkable gain for a single measure, according to Pacific Northwest National Lab modeling.³

While the Stanford plan foresees hydrogen fuel cells powering heavy transportation, some analysts believe storing and distributing hydrogen is not technologically or economically feasible for use by heavy transportation. The Northwest has been a leader in the challenging effort to develop biofuels that can meet rigorous sustainability standards and achieve commercial viability. Boeing, in particular, is working with the non-profit Climate Solutions and a range of other Northwest partners to find optimal sustainable pathways to power airplanes and other heavy transportation vehicles.⁴

3 Efficiency gains reduce water withdrawals by 60% and more than 75% of the population is served by integrated water-wastewater-stormwater utilities.

The potential for cost-effective savings in water demand in our cities and towns is great. A recent study by the Pacific Institute found that available cost-effective urban water efficiency measures can reduce demand in California's cities and towns by nearly 60%. Increasing recycling of water cleaned up at treatment plants and capturing stormwater for later use can make an additional, but smaller, contribution.⁵

2 The Long-Term Energy Efficiency Potential: What the Evidence Suggests, American Council for an Energy Efficient Economy, January 11, 2012. www.aceee.org.

3 Pacific Northwest National Laboratory press release, "Stop hyperventilating, say energy efficiency researchers," June 18, 2013. www.pnnl.gov.

4 "Sustainable Aviation Fuels Northwest," Climate Solutions, www.climatesolutions.org.

5 "A Sustainable Water Future for California," Pacific Institute.



Irrigation Innovation: Great for Farmers and Fish

Irrigation canals are a water-based infrastructure critical to the agricultural economy. Farmers need water to grow crops. To get it to their farm, farmers must maintain a water delivery system to transport water from a river or lake. Since these systems travel through rugged terrain for miles, farmers have spent decades working on screening technologies to keep fish, sticks, and leaves from entering pipes and canals, clogging systems, and obstructing the flow of water. While maintaining these systems is costly for farmers, it has proven to be a large problem, too, for fish.

In search of a way to reduce expenses, protect fish, and keep irrigation canals free of debris, the farmers of the Farmers Irrigation District in Hood River, Ore. spent ten years developing the Farmers Screen. This ingenious invention places the screen horizontally, parallel to the stream flow, rather than the prevailing method which forces water through a vertical screen. Water moves over the Farmers Screen surface at a relatively high velocity, and flows downward through the screen at lower velocity. Fish and debris are swept by higher velocity water over the screen and back to the stream, and the water dropping through the screen is fed into the irrigation canal free of fish and debris.

Clogged screens are a perennial headache and major expense for farm irrigators. Leveraging the current's velocity to sweep debris off the screen and back into the stream, the Farmers Screen is basically self-cleaning, resulting in valuable economic benefits: O&M costs drop dramatically, and reliability increases for water delivery during critical times for crops. Reliability increases, too, for farmers tapping irrigation canals to produce clean, low-impact energy, virtually eliminating down time and increasing power production.

In field installations and through rigorous testing, the Farmers Screen proved so effective that the Farmers Irrigation District patented the technology. But it chose a novel route to bring this technology to market, forming a social enterprise nonprofit called the Farmers Conservation Alliance, and charging it to invest sales revenue into other solutions that benefit both fish and farms.

Source: *Farmers Conservation Alliance*, www.farmersscreen.org.



Five Big Goals for 2040

However, the greatest water saving gains are likely to be made in agriculture. In Washington, agriculture uses nearly 60% of water⁶ and in Oregon just over 80%, with another nearly 10% used by aquaculture. A report by Oregon Environmental Council⁷ finds the potential for water-use efficiency in the agriculture sector has barely been tapped. Their top recommendations include:

- Make conservation a central priority in water resource planning and place a greater emphasis on water saving opportunities in the agriculture sector.
- Make existing incentives more effective by coordinating disparate energy and water conservation programs and targeting outreach efforts on stream reaches that can benefit most.
- Increase funding for water conservation and resource management.
- Build knowledge and capacity in local organizations that are best equipped to support farmers in their area to tap into the right water conservation technologies, practices and incentives for their operations.

Meanwhile, across Oregon and Washington water, stormwater, and wastewater are currently managed largely as separate systems, often controlled by separate utilities. But it doesn't have to be so, and in many ways it makes more sense to design all water-based systems together.

For example, investing in healthy watersheds and natural infrastructure can benefit all three services. Managing most stormwater through open space and natural infrastructure systems, which promote water retention and infiltration in soils, reduces the load on wastewater treatment systems that combine sewage and stormwater. Wastewater treatment, in turn, can supply clean recycled water for irrigation and industry, as well as rich, water-retaining soils for natural infrastructure projects. Where water in pipes is propelled downhill by gravity, it can be tapped for energy, as can human sewage in pipes and at treatment plants, helping offset

energy needed for pumps and processing. Integrated, small-scale systems can be optimized for specific neighborhood needs and natural features, nesting into a larger, coordinated watershed system.

Developing a vision and plan for the future of water-based systems, specifically tailored to each watershed, is key. Every watershed is unique. One size does not fit all. A watershed plan for water systems must work with the specific local climate, soils, drainage patterns, water bodies, ecosystems, and human activities and development patterns.

- 4** *75% of the population at each income level live in neighborhoods that achieve a Walk Score rating of "Very Walkable", and our interstate highway corridors have diversified to supply high speed, convenient, amenity-rich, and affordable public transit.*

Walk Score uses patented algorithms to measure the walkability of any address, producing a score based on walking distance to the range of amenities and services people need to access.



New York City's street redesigns have improved both human safety and retail business. Photo by Jim Henderson/Wikis Take Manhattan project.

6 Estimated Water Use in Washington, 2005, Scientific Investigations Report 2009-5128, U.S. Department of the Interior, U.S. Geological Survey.

7 Making Water Work: Strategies for Advancing Water Conservation in Oregon Agriculture: Executive Summary, Oregon Environmental Council, January 2012. www.oeconline.org.

Achieving the target of 75% of the people in Washington and Oregon living in Very Walkable or better neighborhoods means we will have succeeded in redeveloping thousands of acres of parking lots, failing malls, abandoned lots, brown-



Five Big Goals for 2040

fields and suburban arterials in our cities and towns. In the process, terribly underutilized real estate will be converted into high-productivity, high-value acreage, drawing billions in private investment. Tens of thousands more residents will live in walkable, transit-friendly, mixed-used neighborhoods. Green space, pocket parks, public plazas and art, and other quality-of-life amenities will make these attractive places to live. Transportation spending that in current budgets goes predominantly to accommodating cars will have diversified to create 'complete streets.'

Special attention and policy strategies will be required to ensure people at lower income levels are not pushed out by the forces of gentrification, but instead our neighborhoods accommodate a rich mix of people of varying income levels, ages and backgrounds. Many residents will find they need one less car, saving on costs that AAA now pegs at over \$9,000 a year on average.⁸ If some of this savings is put toward home ownership instead, Todd Litman of the Victoria Transportation Policy Institute points out, people can shift a significant chunk of income from a wealth-depleting asset (the depreciating car) into a wealth-building asset (the value-retaining home). And for every kind of infrastructure, it costs less and is more efficient to serve these compact developments than today's more sprawling development patterns.

Connecting many of our population centers, our interstate highway corridors are tremendously valuable public right-of-ways that are friendly to high speed transportation. Today, these transportation corridors are dedicated primarily to personal vehicles and trucks for freight, but by 2040 these corridors can be repositioned to accommodate high-speed public transit, be it rail, bus, or another form yet to be invented.

Evidence is growing that younger Americans prioritize automobile ownership far less as a reflection of their identity than previous generations, and are more likely to invest discretionary income on personal technology devices.⁹ To respond to this fundamental demographic change, our regional transportation strategies need to shift gears. By 2040, Oregon and Washington interstate corridors could provide travelers an attractive public transit option – fast, convenient, and friendly for information surfers and workers alike. This shift would not only provide an affordable, energy-efficient and low-polluting transportation option, but it would actually benefit drivers and freight transportation significantly by freeing up space on our often-crowded highways.

Interstate highway corridors could be an attractive place to site a system of bullet trains, helping overcome the expense and difficulties of securing dedicated and continuous right-of-way. Bullet trains may be the fastest and most enjoyable public transit option. However, buses traveling in dedicated high-speed lanes would require far less capital investment and have fewer barriers to overcome. The region should begin now to examine options and develop its strategy to reposition highway corridors to accommodate high speed public transit by 2040.

5 90% of products are the producers' responsibility after their useful life, enabling the majority of discarded materials to be reused or recovered for high-value use by local industry.

The importance of our waste and materials strategies for sustainability is often underestimated. For example, standard accounting for each state's greenhouse gas emissions adds up sources within the state. Waste landfills and incinerators account for about 1-2% of a state's emissions by this method. But a 'consumption-based greenhouse gas inventory' developed by Oregon's Department of Environmental Quality estimates the emissions everywhere in the world associated with satisfying consumption by Oregonians. Using this approach, the share of Oregon's CO₂ emissions associated with Oregonians' material consumption is far greater – about 42%. It is these materials that eventually become waste.

Currently in Oregon, 48% of discarded materials are recovered for other uses, with paper, metal, and glass above 65%, plastics at about 15% and food, carpet and textiles below 10%.¹⁰ Washington claims a somewhat higher 57% recovery rate as of 2011, compared to just 25% in 1999. However, total waste generated in the state nearly doubled during that time – so the amount of waste discarded actually increased in spite of the improved rate of recovery. Also of concern is the fact that much of the material that is recovered in Oregon and Washington is exported overseas or funneled to low value uses.

Transitioning materials from waste, exports, and low-value uses to higher value uses by local industry could be a significant job creator. A 2009 survey of national literature, found channeling a ton of material into the reuse and recycling sectors creates almost 10 times the jobs of a ton of material disposed, at higher than average wages.¹¹

8 American Automobile Association press release, "Costs of Owning and Operating a Vehicle in U.S. Increases Nearly Two Percent According to AAA's 2013 'Your Driving Costs' Study," April 16, 2013. newsroom.aaa.com.

9 Darren Ross, "Millenials Don't Care About Owning Cars, and Car Makers Can't Figure Out Why," Fast Company, March 26, 2014.

10 "Materials Management in Oregon: 2050 Vision and Framework for Action," Oregon Department of Environmental Quality, Adopted by the Environmental Quality Commission December 6, 2012. www.deq.state.or.us.

11 Recycling and Economic Development: A Review of Existing Literature on Job Creation, Capital Investment, and Tax Revenues, King County Linkup, prepared by Cascadia Consulting Group, April 2009.

Building the Sustainable Infrastructure Movement in the Northwest

The purpose of the Center for Sustainable Infrastructure is to advance a new sustainable infrastructure paradigm and practice in the Pacific Northwest and beyond, and to help Washington and Oregon to become nationally recognized innovators in sustainable, resilient, smart, and integrated infrastructure systems.

Founded in December 2013, the Center's first order of business was to interview sustainable infrastructure thought leaders and innovators to, in part, ground the Center's strategic direction in the insights of the practitioners. Thought leaders were asked: *"What services or functions would you suggest the Center take on that would be of most value to the 'sustainable infrastructure movement' in the region?"*

For the region to emerge as a national leader in sustainable infrastructure innovation, of course, will require many organizations – public agencies, non-profits, universities and technical colleges, and companies – to embrace a shared vision of regional leadership and take on key parts of the work. While the interview question asked about services and functions the Center can take on, the set of ideas that emerged represents a kind of portfolio of priorities that will require the participation and leadership of many organizations.

Key ideas suggested by the thought leaders include:

Convene Innovators

The infrastructure status quo is tenacious; innovators and advocates will need to collaborate to make progress. Cultivate and support an interdisciplinary professional community of infrastructure innovators in Oregon and Washington. Host networking events and forums with structured discussions that enable key actors to work through shared challenges.

"Convenings are really important. Start with a strawman of some sort and convene people around key questions. It's about building a community knowledge base, and building a common agreement on the direction we want to go." – Patrick Mazza

"I think: Why does this stuff not happen? Someone needs to drive it! So the convening function is really important – but you have to earn that. So the Center, based in Washington, would need partnership in Oregon."
– Andrea Durbin

"Serve as a backbone organization for sustainable infrastructure in the region. The Center can convene collaborative processes. When doing that, it's very important

working with really busy people to frame the conversation around topics that are big enough to be attractive to multiple organizations to engage and get behind, but small enough to have productive, high-value focus on real-world important levers that they are grappling with."

– Fletcher Beaudoin

Best Practices Clearinghouse

Would-be innovators within the infrastructure professions – public, private, and civic – need access to tools to help them effectively champion new approaches. Develop toolkits for infrastructure planners and decision-makers, and conduct timely and targeted best practices and case study research in response to identified needs of infrastructure agency partners.

"These fields are really new and rapidly evolving.

Academic literature is coming out quickly. New pilots are being tried around the country. There is no obvious place where the state of the knowledge on sustainable infrastructure is being aggregated, synthesized, and reported out." – Steve Whitney

"Develop the case studies that help rebut the status quo view that innovative solutions are too expensive – making the business case is super important!" – Eileen Quigley

"We need to develop the standards and templates to make innovation less risky and more successful. We also need to equip public sector decision makers with the skills and confidence to try different approaches that have worked in other places." – Chris Taylor

"Look at projects that have been operating for a while and evaluate if they really work as anticipated. You get a lot of really superficial case studies in the energy field, often built on a few hours of looking into it or a one-day field trip. The Center can go into more depth and look at the infrastructure performance over a longer period of time – five years later, how well has performance matched expectations, what else have we learned?" – Tony Usibelli

Professional Development and Consulting for Decision-makers

Tap the knowledge of the region's top sustainable infrastructure innovators to develop training materials and programs for infrastructure professionals, and develop a service to



Building the Sustainable Infrastructure Movement in the Northwest

help public decision-maker clients redesign how they plan, manage, and invest in infrastructure.

"There is a need to inspire and teach more regional innovators. There are not necessarily very many of them out there right now." – Janine Bogar

"Local governments are both frontline players in sustainable infrastructure and under-resourced to do it effectively. Figuring out ways to help them would be really valuable." – Rob Knapp

"Wouldn't it be great for you to be able to come into a community and do a holistic analysis of the infrastructure? Establish a consultancy that can develop an action plan to bring your infrastructure up to a sustainable level." – Chris Watchie

"Help City Councils to plan infrastructure facilities in an integrated, coordinated way." – Paul Fleming

Grow a Sustainable Infrastructure Emphasis at Evergreen and Partner with Other Academic Institutions

In many infrastructure fields a wave of retirements threatens to drain critical understanding of the systems; a new generation of professionals needs to be cultivated and inspired. Provide a new special emphasis area in sustainable infrastructure that enriches Evergreen's MPA and MES programs and serves interested students. Harness the benefits of student research projects. Develop mutually beneficial relationships with other colleges based on complementary strengths and compatible approaches. Feed the relationships with joint projects involving students, faculty, and staff.

"At a time when huge investments in infrastructure are critical and when we need to find ways to moderate our environmental footprint, the work of the center is of particular importance. The opportunity it will provide for students to become involved in such groundbreaking research is truly exciting." – Michael Zimmerman, Evergreen Provost and Vice-President for Academic Affairs

"Cross-discipline training is valuable – across public administration, law, finance, engineering, hard sciences, urban studies. The application of the engineering and hard sciences talent will be leveraged by some sort of cross-discipline collaboration." – Josh Bratt



Building the Talent Pipeline for 21st Century Infrastructure

Many of our utilities and infrastructure agencies are grappling with a serious loss of talent and institutional knowledge due to a looming wave of workforce retirements. The loss of engineers is especially challenging as the complex systems they manage are changing with new technology, environmental and reliability demands.

An initiative in Oregon is designed to develop the next generation of engineers for the electricity sector with the critical skills sets needed to create and operate the infrastructure for 21st century power. The Oregon Power Engineering Education Project (OPEEP) is a collaboration among the Oregon Institute of Technology, Oregon State University, and Portland State University.

OPEEP aims to provide power engineering students with the type of practical, real world experience that can make them career-ready. OPEEP will align course offerings across institutions and recruit top power engineering faculty. It will also develop project-centered coursework and internships, and establish three top-flight power engineering Project Centers that provide students with space, tools and equipment for projects, and that serve as hubs linking the university and power industry.

The program comes from work done by Oregon Engineering, Science, and Technology Research Alliance (OESTRA) which identified the serious workforce shortage in the power sector. Dr. Bob Bass, a faculty member in the PSU Engineering Department developed the OPEEP concept with Laura McKinney, Executive Director of The Engineering and Technology Industry Council (ETIC), and author of "Renaissance," a policy document designed to transform the way Oregon invests in talent.

Source: OESTRA.

Communications to Re-imagine Infrastructure

With many of our infrastructure systems aging and under stress, and with serious constraints on the public purse, public support for needed investment is essential. Build persuasive and tested messages and frames for public leaders that help them effectively educate their public to understand holistic, integrated infrastructure approaches, and to



Building the Sustainable Infrastructure Movement in the Northwest

embrace the imperative to invest in innovative sustainable, resilient infrastructure policies and practices.

"A key role for the Center revolves around the West Coast Infrastructure Exchange's work to create best practices standards for infrastructure projects. The Center could encourage other jurisdictions to adopt these standards and become part of this market. Given that legislators are still very focused on jobs and economic development, they'll be receptive to our message that here's something else we can do to get more projects moving forward and in the pipeline." – Margi Hoffmann

"We need more infrastructure funding and I don't see anyone focused on helping local officials figure out what sells with their constituents. I don't know who's out there doing the analysis to create the right set of economic/quality of life messages. That's cross cutting – how you sell a water project or a transit project will have similarities." – Chris Taylor

"Tell the story and highlight the opportunities. Most people who think about infrastructure think of it as stimulus and job creation – that's really helpful to frame it that way. Show where it is working!" – Sylvia Hayes

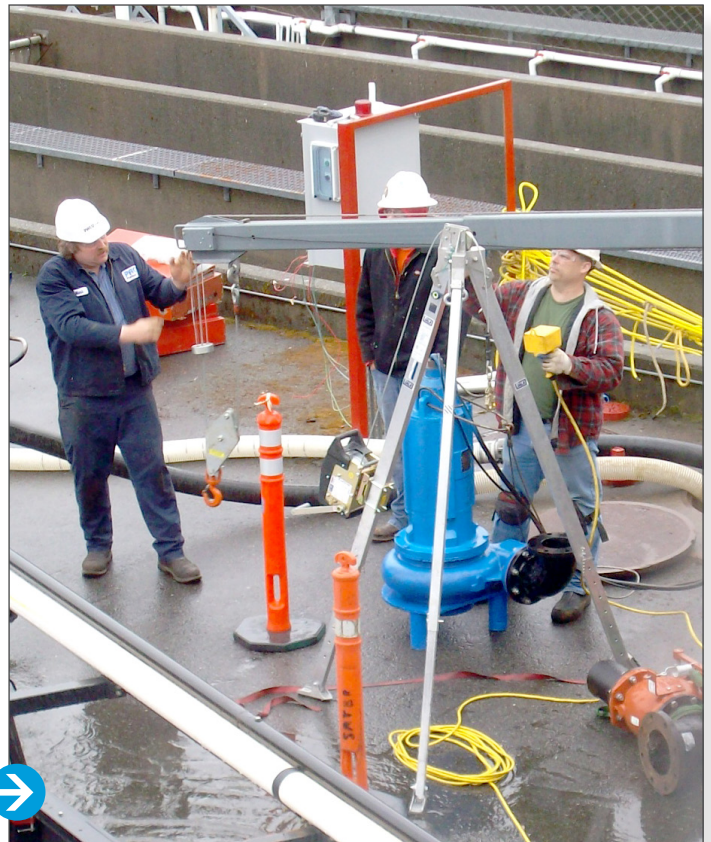
"Bring attention to integrated sustainable infrastructure and connect the dots. Tee up the conversation as an unrealized opportunity to boost the economy, create jobs, and benefit the long-term viability of our states." – Andrea Durbin

Create the Policy Environment to Support Sustainable Infrastructure

If we're to modernize our infrastructure, policies will need to be revamped to support sustainable, resilient, and affordable systems. Develop a shared vision that is compelling enough to overcome a fractured policy process. Assemble the best policy examples being implemented by other state and local governments and help policymakers target the specific steps to effectively advance the vision.

"We've got some great examples of sustainable infrastructure, so now we need that compelling, implementable policy vision that would move sustainable infrastructure from an innovation to simply normal." – Bobby Cochran

"Develop the toolkit of policy best practices. Not only introduce them to the policymakers, but publicize them so the public begins to see there are new, smarter, better ways to do this." – Jesse Berst



Aging pumps replaced at Makah National Fish Hatchery in order to increase efficiency and decrease energy use. (Photo by Marsha McGee/U.S. Fish and Wildlife Service. "Pacific Region's" is licensed under creativecommons.org/licenses/by/2.0)

"Get sustainable infrastructure strategies and metrics built into our state's lean management and environmental programs, such as Governor Inslee's Results Washington program." – David Bakter

"I could see teams of graduate students assigned to look at the history of each issue in the state – what's the history of bills that have passed or didn't pass, who were the folks lined up on each side over time? That gives you the context to sit down and write a really good argument for that specific sector – here's where we've been and here's where we need to be. I'd want another group of graduate students to investigate the very best things being done in other regions and other countries." – Nan McKay

Next Steps

Infrastructure investments, across our transportation, energy, water and waste systems, add up to a generational legacy. But urgent financial, social and environmental drivers are forcing us to rethink how we plan, design, and invest many billions of dollars in these vital systems in the years ahead.

This report, the first from the new Center for Sustainable Infrastructure at The Evergreen State College, is intended to help fuel a conversation about the urgent need for new and smarter approaches to address our critical infrastructure challenges in the Northwest. A major focus for the Center going forward will be on communicating this urgency, the opportunities to realize much greater financial, social, and environmental return from our infrastructure investments, and the strategies that can get us there.

In the coming months, too, the Center will convene advisors and allies to consider new programs, projects, and partner-

ships to build capacity in the region to innovate and lead. The Center itself will aim to add value to the overall ecosystem of organizations rather than duplicate in areas where others can be more effective. Among the roles the Center will consider are:

- Developing and sharing practical tools for infrastructure decision makers.
- Convening leaders and innovators to collaborate to address key challenges.
- Galvanizing support for a compelling long-range vision for regional leadership, and for rethinking the infrastructure finance and policy in the region.
- Creation of new professional development training programs and strategic consulting services.

You can help by sharing this report with professionals and leaders in the field; posting about it in newsletters and social media; and inviting presentations from the Center at your next conference or forum. You are in the best position to think creatively about how you can best contribute to helping this region become a national leader in sustainable infrastructure innovation. You can support the Center with a financial gift by clicking the 'Donate' button at evergreen.edu/csi, and if you'd like to get involved in the work of the Center, please get in touch via the 'Contact' button on the same page.





Acknowledgments

Pacific Northwest Infrastructure Innovators and Thought Leaders

During the first half of 2014, the Center for Sustainable Infrastructure formally interviewed the following Pacific Northwest infrastructure innovators and thought leaders who were extraordinarily generous with both their time and ideas. This report is based largely on their insights, though the author maintains responsibility for the report's content, and all its errors and shortcomings. () Also part of the Executive Review Team.*

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Jesse Berst, Chairman, Smart Cities Council

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Deborah Curran, Hakai Professor in Environmental Law
and Sustainability, University of Victoria

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Seattle Public Utilities

Bruce Flory, Principal Economist, Seattle Public Utilities

Nathan Gibson, Vice President, Business Development,
Skanska USA

Cylvia Hayes, CEO of 3Estrategies, First Lady of Oregon*



Acknowledgments

Pacific Northwest Infrastructure Innovators and Thought Leaders (continued)

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Whistler Centre for Sustainability

Rich Hoey, Director, City of Olympia Public Works*

Margi Hoffmann, Energy Policy Advisor,
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Christian Watchie, Director, Trans-Watch

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Acknowledgments

Executive Review Team

A special thank you to the Executive Review Team, which provided invaluable feedback on a draft of this report. In addition to those marked in Acknowledgments (), reviewers included:*

Noah Enelow, Economist, Ecotrust

Kevin Francis, Director, Graduate Program on the Environment, The Evergreen State College

Cathy Kellon, Water and Watersheds Program Director, Ecotrust

Cheryl Simrell King, Director, Masters of Public Administration Program, The Evergreen State College

Bruce Lund, Managing Director, Washington Public Works Board

Micah McCarty, President's Liaison to Tribal Governments, The Evergreen State College

Scott Merriman, Director of Policy and Legislative Relations, Office of the Washington State Treasurer

Mary Rose Navarro, Natural Areas Grants Coordinator, Metro Regional Government (Oregon)

Neelima Shah, Program Officer, Bullitt Foundation

Callie Ridolfi, President, Ridolfi Inc.

Jill Sterrett, Sterrett Consulting, LLC

Jonathan Trutt, Program Manager, West Coast Infrastructure Exchange

Special Assistance

Nikkole Hughes and Maria Thomas, graduate students with Evergreen's Master of Public Administration program, provided the project with vital research, policy analysis, and conceptual framing during their internships with the Center in the first quarter of 2014.

Eric Strid contributed important research and graphics assistance.

Special thanks also to The Evergreen State College's Amanda Walker, Michael Zimmerman, Todd Sprague, Nani Paape, and Meryl Lipman.

Report design and layout by Anza Evans Design Services.



Acknowledgments

I am deeply indebted to the many innovators, thought leaders, and experts who took valuable time from their busy schedules to patiently coach me on the intricacies and challenges of rethinking our infrastructure investment strategies.

Thanks, also, to the research team, to the support staff and leadership at Evergreen, and to the co-sponsors and financial supporters of the Center.

This work would simply not have been possible without your contribution.

– Rhys Roth

Sponsors

This report was made possible by vital financial support for the Center for Sustainable Infrastructure, provided through The Evergreen State College Foundation, from the Bullitt Foundation, David and Leigh Bangs, Arlene Levy, the Laird Norton Family Foundation, Rogers Weed, Stephanie Solien and Frank Greer, and Steve Sundquist.

In addition, the following people responded generously to a special call to help sponsor this project: Eric Strid, Rob Cole, Peter Baum, Betsy Clapp, David Cosman, Libby Dunkin, Jean MacGregor, Brian Arbogast, Tim Gates, Nan McKay, Brett Redfearn, Heidi Wills, and Craig Partridge.

Finally, this report was also made possible by these co-sponsoring agencies and companies:

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