

# Hydrogen Hubs

- *Building an Oregon Hydrogen Strategy*
- *Exceeding Renewable Energy Goals*
  - *Strengthening the Power Grid*

*The Northwest Hydrogen Alliance*

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## *II - Hydrogen Alliance Objectives*

1. Create a landmark Oregon Hydrogen Strategy.
2. Build the world's first Hydrogen Hubs.
  - Islands of 10-100 megawatt-sized load-centered power generation
  - Creating a market for high-value, urban-based power
  - Designed to meet high-priced peak energy demands
  - Renewable and non-polluting
  - Portable and dispatched within seconds
  - Distributed to ease dependence on distant, large-scale generation sources
  - Exceed health, safety and environmental requirements.
3. Help meet region's renewable portfolio demands.
4. Cut need for high-cost transmission and distribution construction.
5. Increase the energy capacity of wind generation.
6. Establish a new world-class industry centered in the Northwest.

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# *III - The Peak Power Challenge*

- Peak power demand is the dominant factor shaping the future of the power grid (Chart #1).
  - It drives the need for construction of new large-scale, at-distance power plants, transmission and distribution facilities.
- A peak energy challenge looms.
  - Exceptional regional population growth and demand for peak electricity;
  - Growing legal and environmental limits on carbon-based power generation and the on-peak flexibility of hydropower system;
  - Increasing penalties on carbon-based energy;
  - Serious problem of wind capacity system deficit as we build to 6,000 megawatts;
  - Intense environmental, site and capital pressures on distribution and transmission construction.
- Peak power prices will become increasingly volatile.
  - According to the most recent study, the region will depend almost entirely on non-firm energy sources, much of is as yet not yet under contract, to meet its 2012 *average energy* demand. Meeting peak demand faces increasing uncertainty. “The important thing for people to understand is what’s at risk are volatile prices,” according to Council Chair Tom Karier.
  - In early July peak power prices in the Northwest exceeded \$300 per megawatt hour. Throughout 2006-2007 Mid-C peak energy prices exceeded \$100 a megawatt hour for significant periods. During virtually all of the 2000-2001 energy crisis peak power costs ranged between \$100-\$1,000 per megawatt hour.
- An expanded regional Hydrogen Hub Network is designed specifically to address all these peak power challenges.

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## *IV - Other Power Challenges*

- **Resource Portfolio Standards.** Nearly half of all states, including OR, WA, and CA require that a significant portion of new load growth be met with renewable resources. Congress may adopt a federal RPS.
- **Tax Incentives.** Numerous tax incentives favor the development of renewable resources, particularly those located in OR.
- **Global warming concerns.** Leading policy makers consider shifting power production to non-carbon-emitting resources through a “cap and trade” system. This may increase wholesale power prices by \$5 to \$20 a megawatt hour or higher.
- **Increasing capital cost pressure.** The rapidly developing economies in India and China are putting upward price pressure on commodities and thereby large-scale power generation technologies.
- **Increase resource diversity.** The Northwest Planning Council’s Fifth Power Plan is based, among other things, on Modern Portfolio Theory (MPT) emphasizing importance of energy diversity by fuel type, location, size, and other characteristics. Portfolios that meet load growth at least risk and cost are said to be “on the efficient frontier.” Under this strategy, a “different” resource has value by lowering portfolio risk -- even if the resource is more costly than alternatives.
- Hydrogen Hub power will also meet each of these power challenges.

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## *V - Hydrogen Hub Pilot Objectives*

1. First practical demonstration of ammonia-hydrogen power generation.
  - Conversion of up to nine megawatts of existing diesel engines into renewable energy sources;
  - Purchase of an additional megawatt of from new, high-efficiency ammonia/hydrogen fueled ICE generators;
  - Goal of on-peak, capacity-rich, clean and renewable power generation at the source of load at market-based prices.
2. Demonstration “green” ammonia synthesis process.
  - Invest in new solid state ammonia synthesis process producing “green” ammonia fuel efficiently from both hydropower and wind power to fuel Hydrogen Hub generators.
3. Establish relationship with sponsor utilities.
  - Achieve practical, high-value integration of Hydrogen Hub generation to the power grid through key utilities in Oregon and region-wide;
4. Grow the Hydrogen Hub Network.
  - After a successful Hydrogen Hub Pilot demonstration, secure utility power sales contracts, expand the Alliance work force, and begin to deploy Hydrogen Hubs throughout the region and elsewhere.
  - Establish Alliance intellectual property and other rights to Hydrogen Hub technology and power generation.

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## *VI - Hydrogen Alliance Partners*

As a 501c(3) charity, the Northwest Hydrogen Alliance will have a working demonstration of a Hydrogen Hub within two years. The Alliance will partner with the the following groups to achieve this near-term objective:

- Federal, state and local government agencies;
- Utility sponsors;
- Utility Associations;
- Environmental organizations;
- Industries providing key technology to the project;
- Universities providing an independent assessment of the Hydrogen Hub's projected energy and environmental benefits;
- The general public and media through exceptional information outreach.

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## *VIII - Hydrogen Hubs: Measurable Results*

1. By year two, purchase up to 10 megawatts of cutting edge, high-compression ICE power generators and converted power generators -- both modified to run on hydrogen-rich ammonia. Generate 10 megawatts of power to match on-peak energy demand. Target purchase price: \$150,000 per megawatt.
2. By year two, manufacture up to 10 tons of “green” ammonia per day from off-peak wind and hydropower sources to power these generators. Target price for off-peak power: \$3.50 a megawatt hour.  
Achieve this by demonstrating a breakthrough, highly-efficient solid state ammonia synthesis process. Target price for green ammonia: \$350 per ton.
3. Within a year, secure a sponsor utility contract to purchase 10 megawatts of Hydrogen Hub power at high-value, on-peak, market-based prices. Monetize this contract to provide matching funds to help purchase land, equipment and staff for Hydrogen Hub operations.
4. Within a year, contract with universities and scientists to insure Hydrogen Hub power meets all energy reliability, cost and environmental goals through independent monitoring.
5. Within six months, establish a comprehensive public involvement and information plan surrounding Hydrogen Hub actions.

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## ***XI - Long-Term Hydrogen Strategy***

Following a successful demonstration of the world's first Hydrogen Hub for peak power generation, the Alliance will expand the long-term Oregon-based Hydrogen Strategy.

1. **Build out the Hydrogen Hub Network.** Beginning in 2009-2014, the Alliance will seek to build a minimum of 500 megawatts of Hydrogen Hubs at ten separate 50-megawatt locations throughout the region. Together these will form the world's first Hydrogen Hub Network. Depending on market response and manufacturing capability, the Network may be able to expand more rapidly, particularly throughout the Northwest, California and other high-cost, fast-growing regions of the American West.
2. **Secure Long-Term Financing.** Private sector financing will be secured for a significant expansion of the Hydrogen Hub Network by monetizing multi-year, take-or-pay power sales contracts by participating utilities;
3. **Invest in Emerging Technology.** The Alliance will receive revenues from Hydrogen Hub expansions. This will provide ongoing revenues for Alliance operations. It will also allow the Alliance to invest new revenues in purchasing increasingly efficient, and larger-sized generators running on green ammonia. We are particularly interested in investing in high compression internal combustion engines and high-efficiency combustion turbines in a scale at or above 10 megawatts and increasing manufacturing competition for these technologies.
4. **Expand of Green Ammonia Production.** Wind power and off-peak hydropower will expand green ammonia production from 2009-2014. Beyond that clean, CO2-sequestered coal and gas technologies can significantly expand availability of green ammonia fuel continent-wide to meeting demand for thousands of megawatts of Hydrogen Hub generation between 2014 and 2019.
5. **Develop Large-Scale Hydrogen Hub Network.** Hydrogen Hubs expand sufficiently beyond 2014 to provoke discussion of a ammonia pipeline in the western United States similar in size to that now operating in the Midwest. Hydrogen Hubs become potential fueling stations for the use of ammonia fuel in hydrogen vehicles with Hydrogen Network costs shared with the transportation industry.