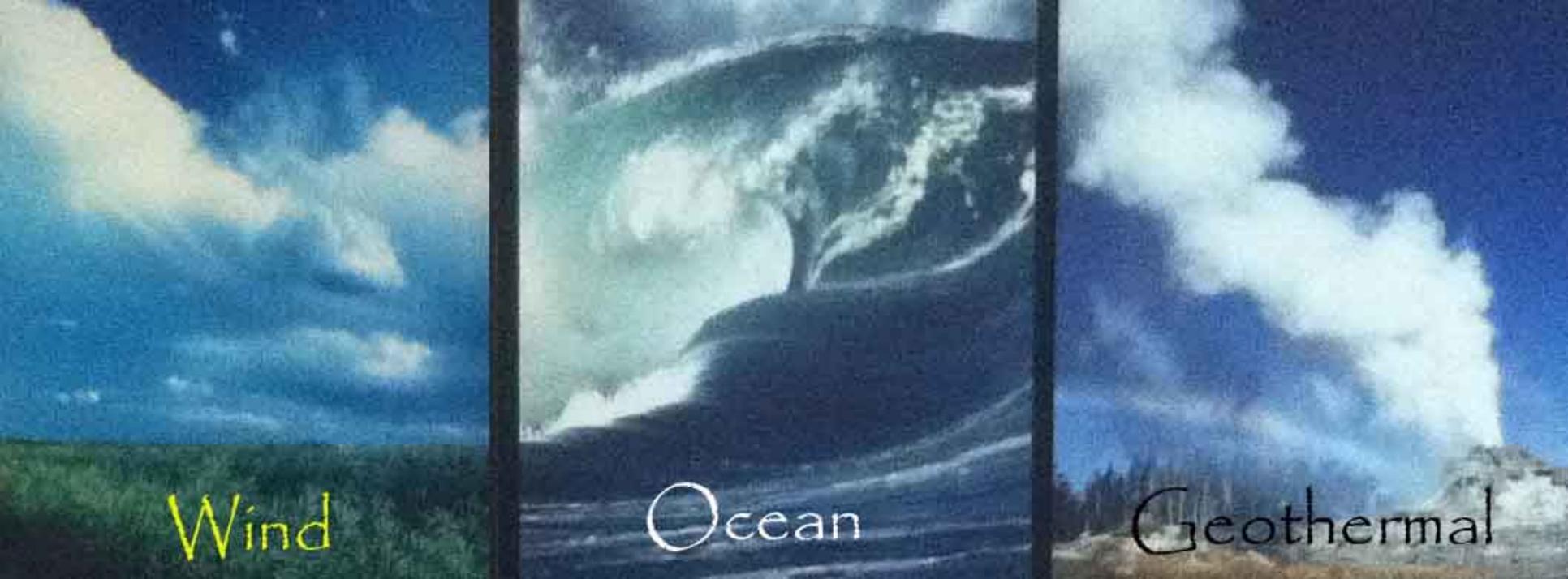


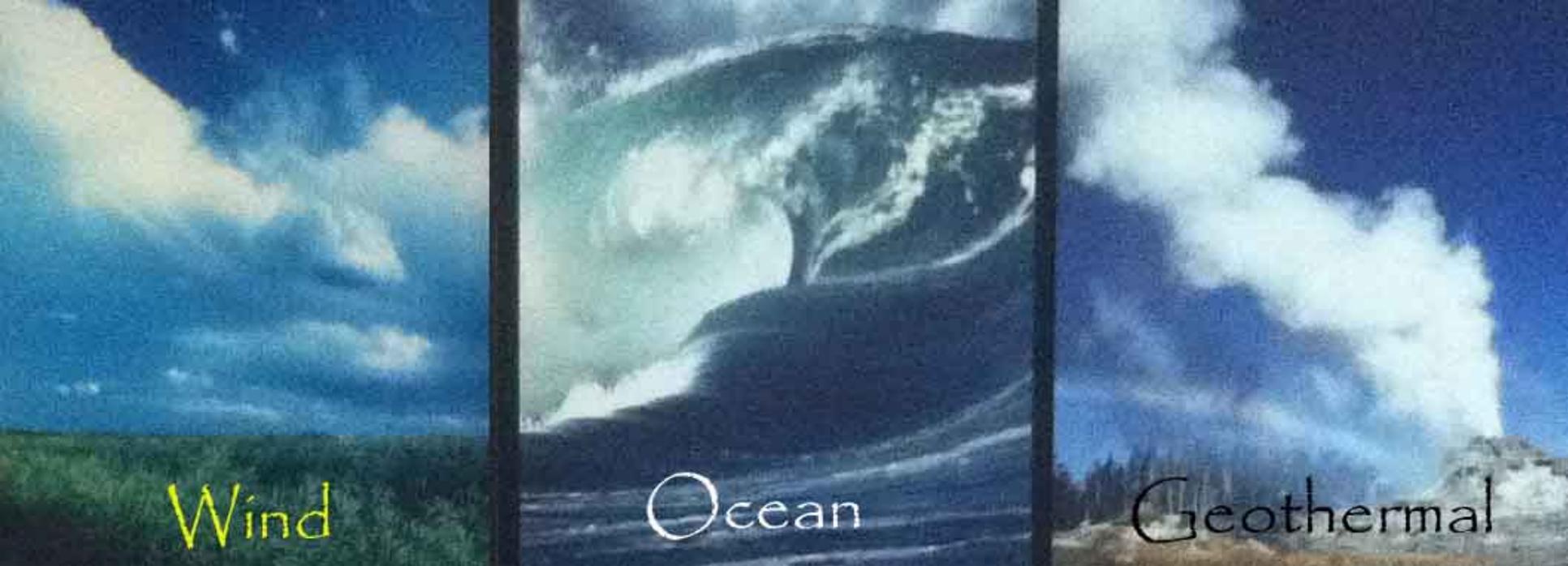
Alternative Energy Applications for Wind, Ocean, and Geothermal

Developed for the 2012 SEET Workshop
October 17, 2012



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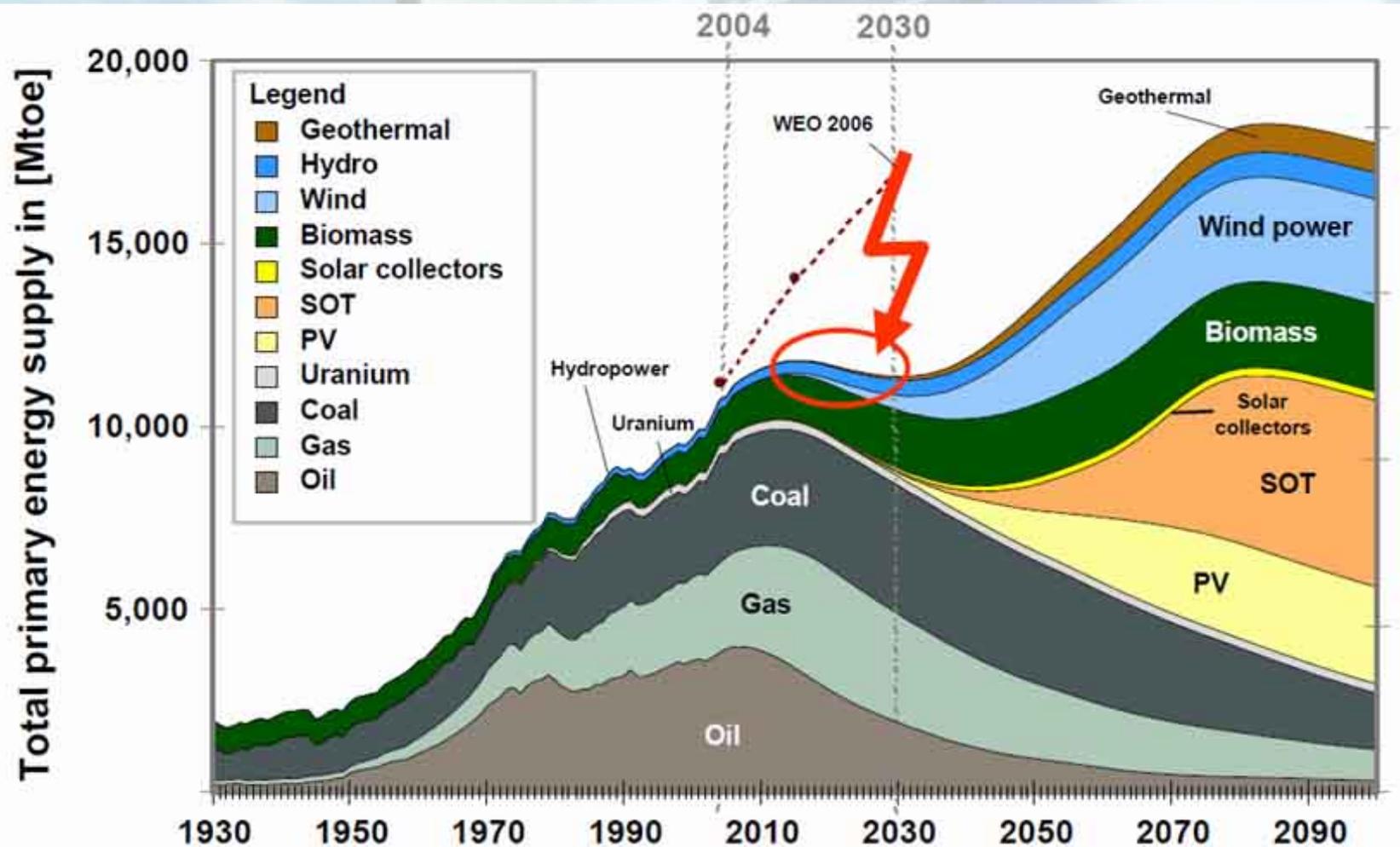
Presentation Outline

- Why renewables are important
- Wind
- Ocean
- Geothermal

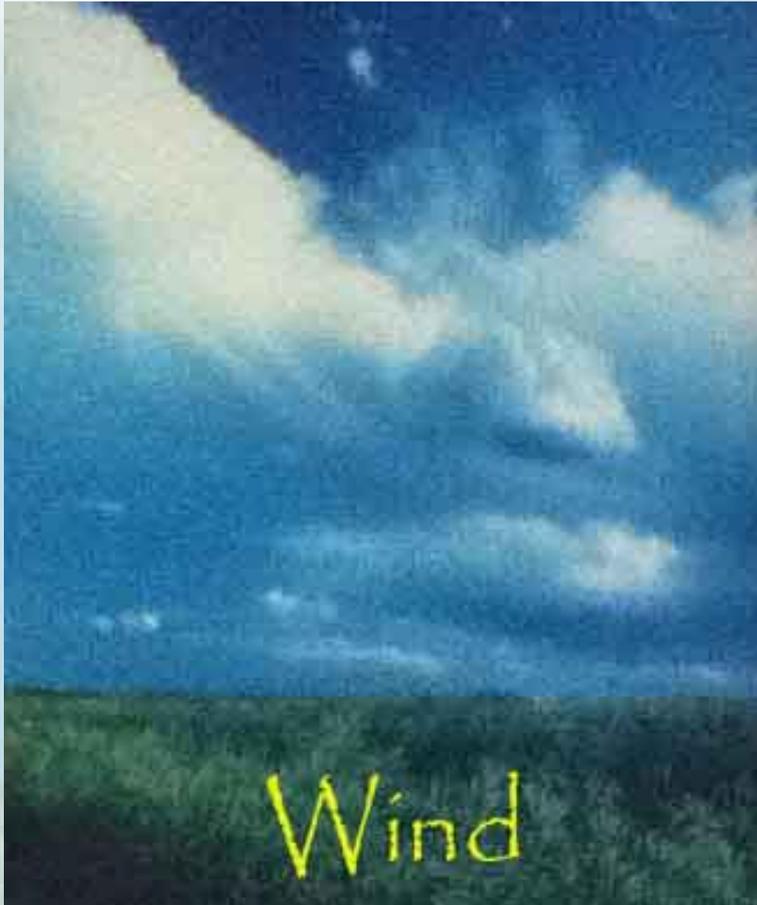
Current and Future Energy Challenges—Why Renewables?

- Sheer quantity of use
 - Population growth
 - Overconsumption
- Problems with fossil fuels
 - Finite resource
 - CO₂  Climate Change
 - SO₂  Acid Rain
 - NO_x  Ozone
 - PM_{2.5/10}  Respiratory Health

Current and Future Energy Challenges: Why Renewables? (cont.)



Wind Energy



- Introduction
- History–past, present, future
- Wind energy basics
- Applications

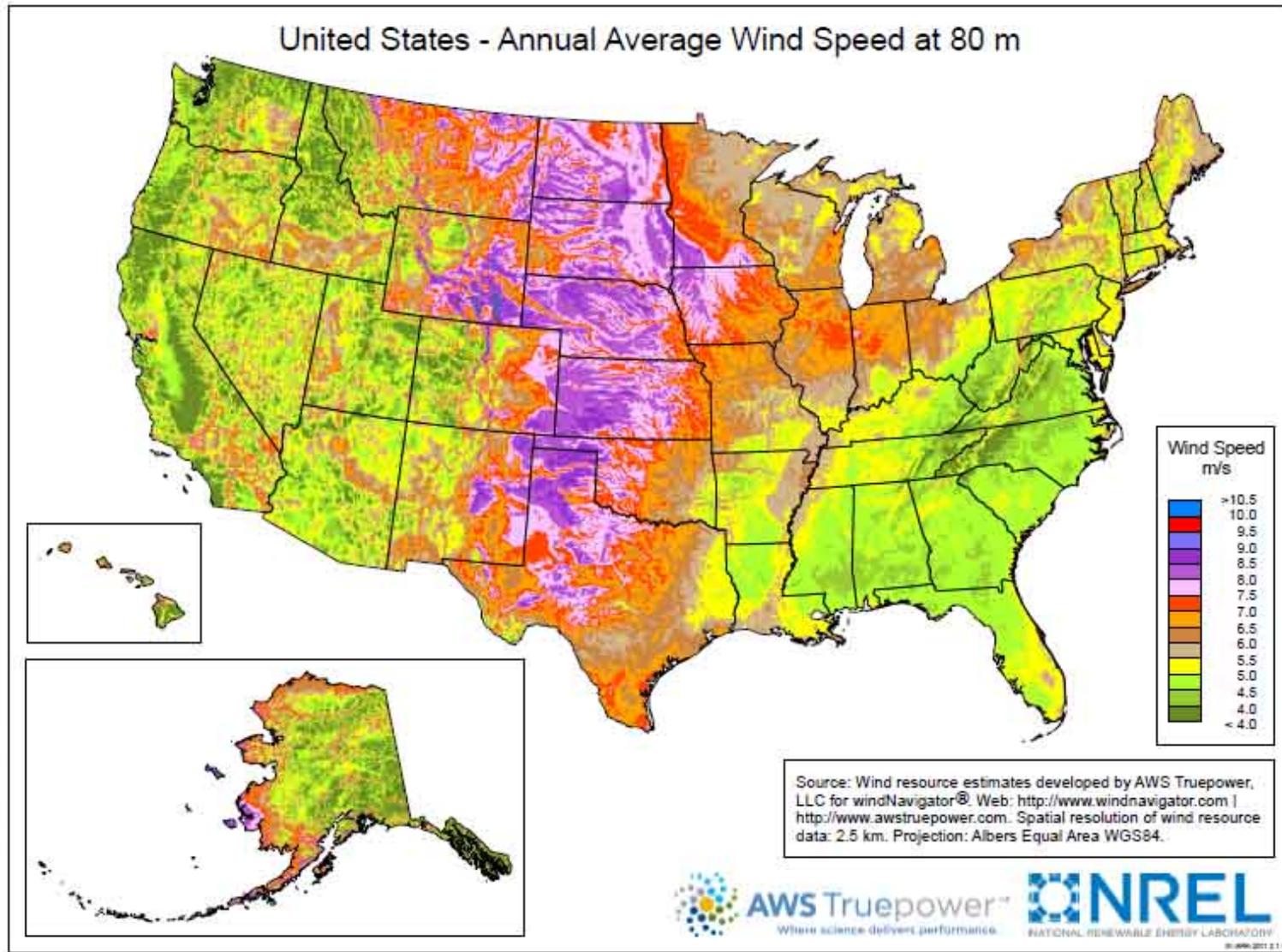
History of Wind Energy

- Egyptian sailboats
- Chinese and Persian simple water pumpers and grist mills
- Explorers brought back to Europe
- Denmark developed first wind turbines in late 19th century
- New technologies are expanding into the future

Wind Energy Basics

- Wind turbines convert the kinetic energy in the wind into mechanical power.
- This mechanical power can be used for some specific tasks (such as grinding grain or pumping water).
- A generator can also convert this mechanical power into electricity.

Wind Energy—U.S. Resources



Applications of Wind Energy

- Utility-scale power generation
- Residential-scale power systems
- Dehumidification of the atmosphere for creation of potable water
- Desalination of brackish aquifers and sea water

Utility-Scale Power Generation



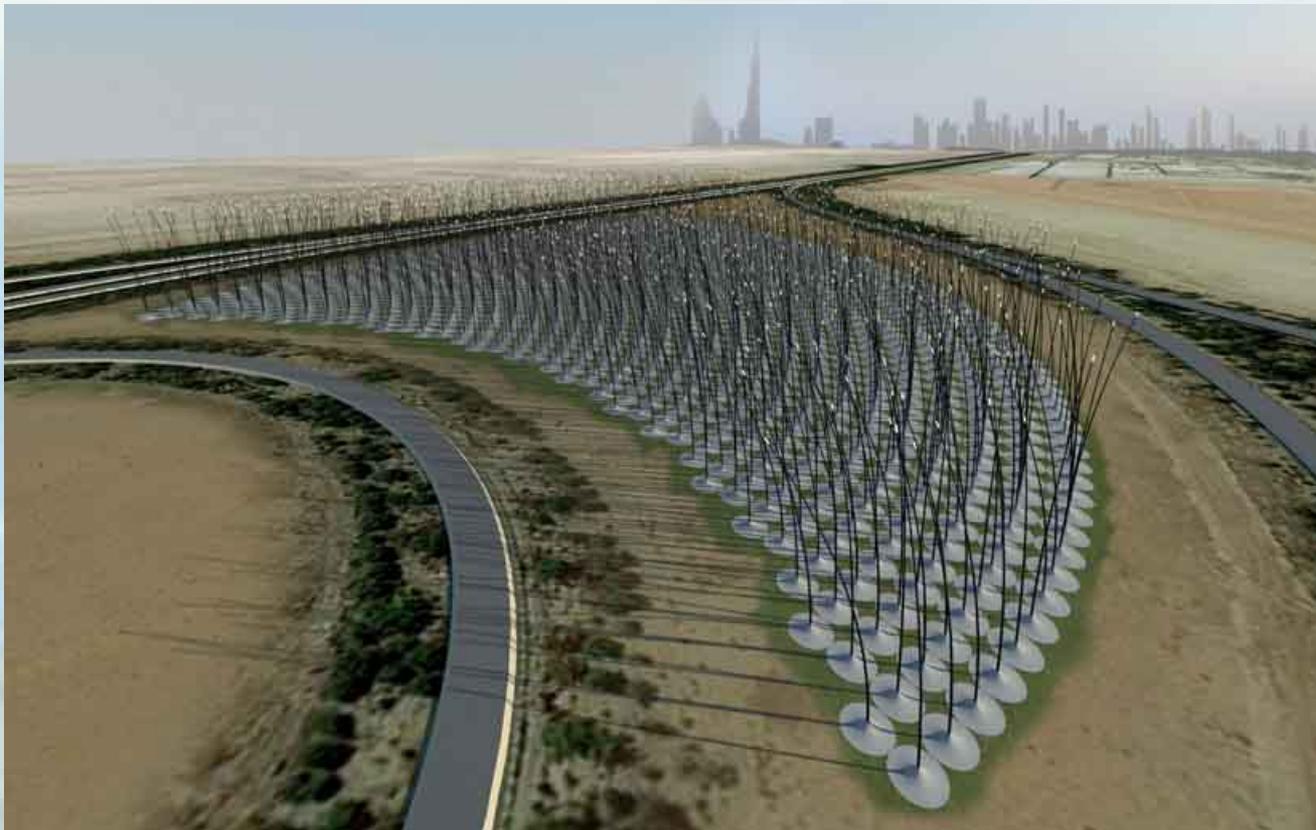
Horizontal Axis Wind Turbine with Gearbox



Direct Drive Horizontal Axis Wind Turbine

New Developments in Utility-Scale Power Generation

- "Windstalk" project



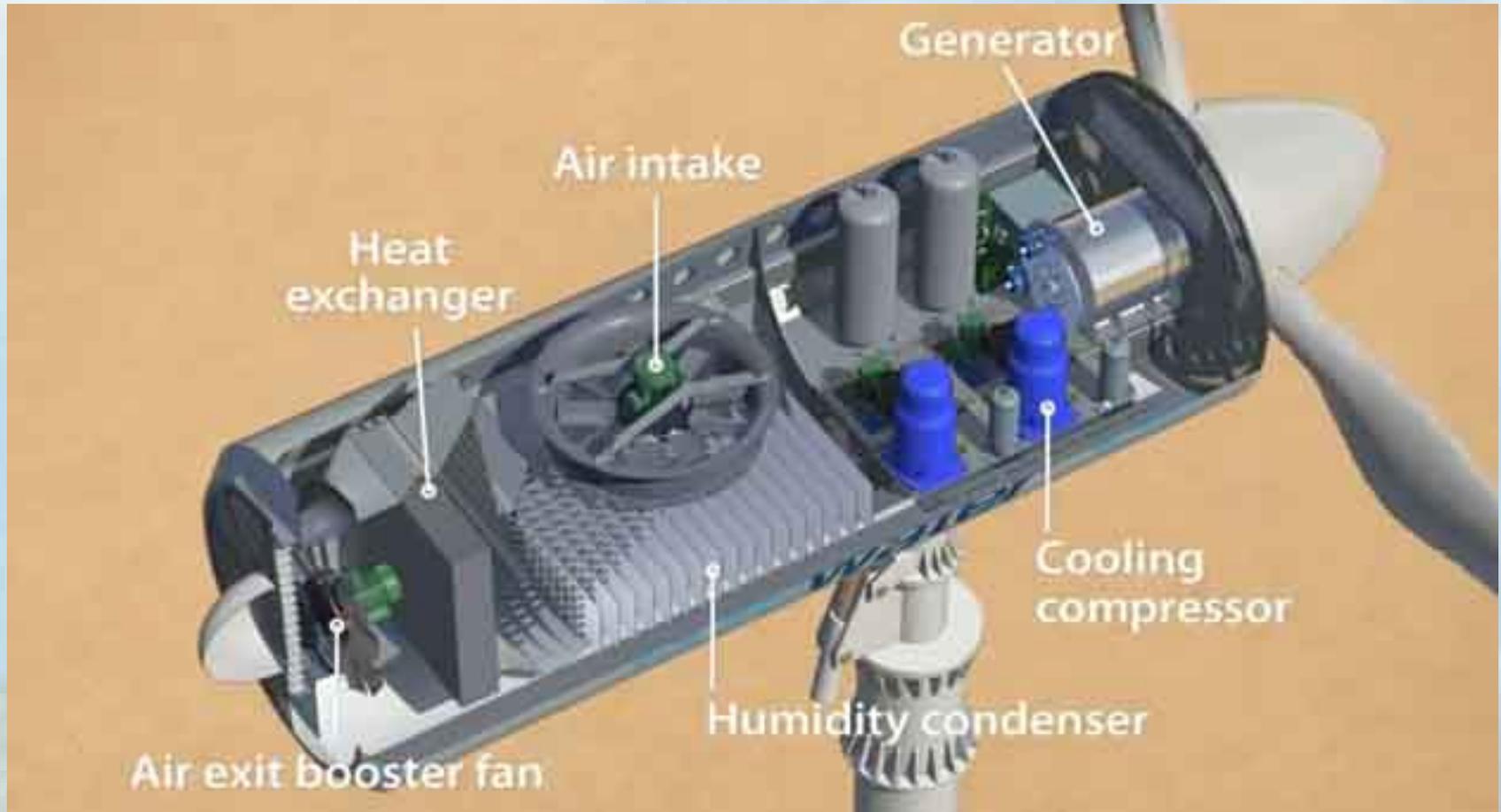
Pros and Cons of Utility-Scale Power Generation

- Pros
 - Wind has no fuel cost.
 - Wind farms have no carbon emissions.
 - Wind farms allow communities to have independent power.
- Cons
 - Intermittent source
 - High upfront cost
 - Grid stability can be affected.

Residential-Scale Power Systems



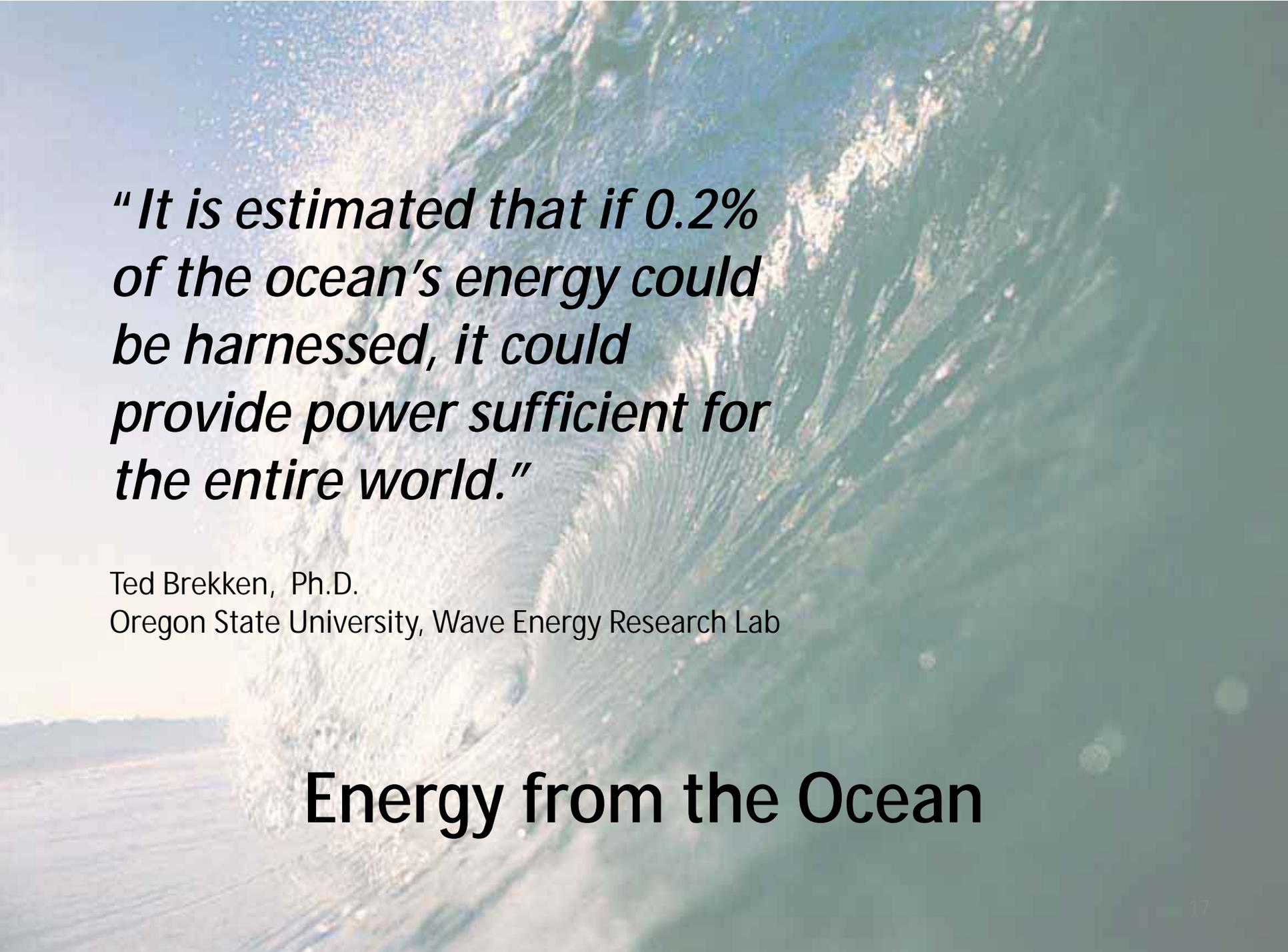
Dehumidifier for Potable Water



Desalination of Brackish Aquifers and Seawater

For every 100,000 gallons intake, production is about 70–80,000 gallons of freshwater with aquifers and 50,000 gallons of freshwater with seawater.



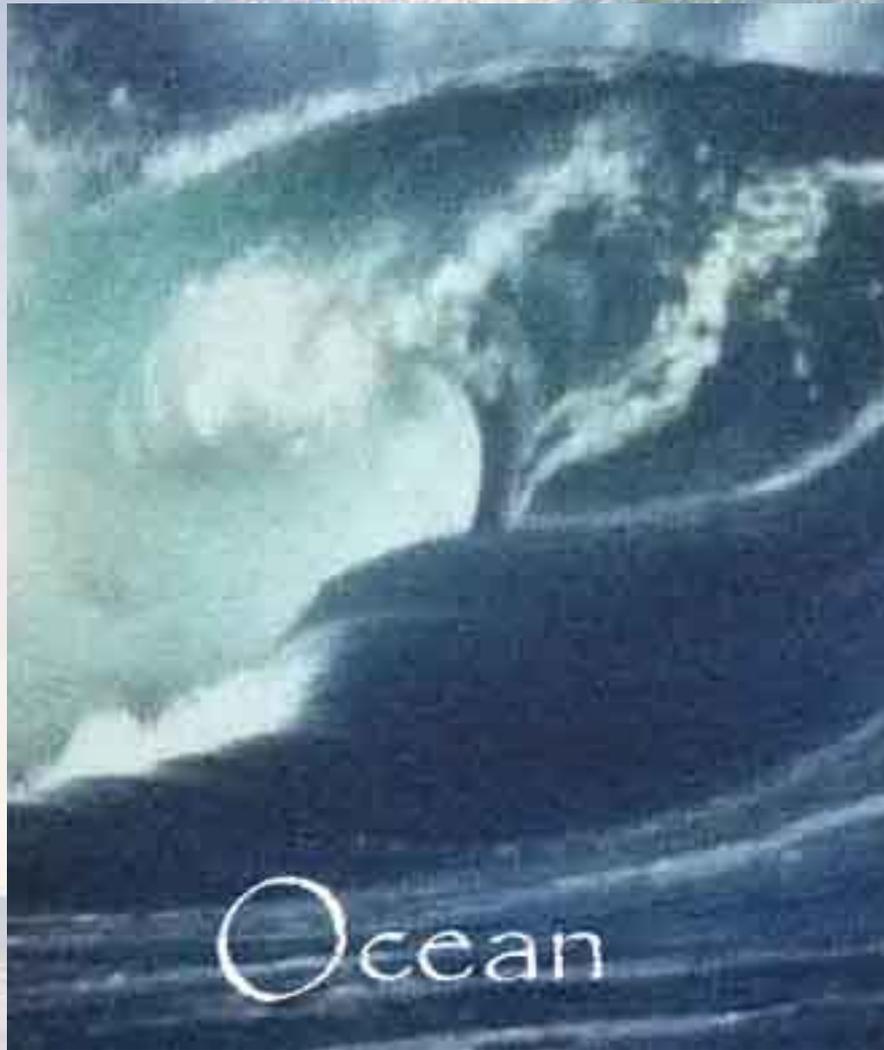
An aerial photograph of a large ocean wave, showing the white foam of the crest and the deep blue-green water of the trough. The wave is moving from the top right towards the bottom left of the frame.

"It is estimated that if 0.2% of the ocean's energy could be harnessed, it could provide power sufficient for the entire world."

Ted Brekken, Ph.D.

Oregon State University, Wave Energy Research Lab

Energy from the Ocean



Introduction

Tidal Energy



Ocean Thermal Energy Conversion (OTEC)

OTEC

and the State of Hawaii . . .

OTEC can satisfy all present and future residential, industrial, and commercial power, as well as domestic water needs in the State of Hawaii.

With the development of electric vehicles, OTEC could also provide the electricity required to support land transportation.

-  Envision two to three floating OTEC plants (50 MW/16 MGD** to 100 MW/32 MGD**) tailored to the islands of Hawaii, Kauai and Maui . . .
 -  Seven to ten large floating OTEC plants deployed around the island of Oahu can meet all present and future power and water needs.
 -  A smaller plant could meet all water and power requirements in Molokai. In the case of Lanai, it would be more cost effective to supply power from Maui via a submarine power cable.
- Environmental pollution would be minimal and the State would only have to import aviation fuels.
- Presently, 30% of the energy consumed is for aviation—therefore, by implementing OTEC, petroleum imports could be reduced by approximately 70%.

** MGD = Million Gallons of Water per day; e.g., 16 MGD is enough for 100,000 residents.

ISLAND	DE FACTO POPULATION (1990)	INSTALLED CAPACITY (1990)
HAWAII	135,000	130 MW
KAUAI	68,000	160 MW
LANAI	2,500	5 MW
MAUI	130,000	140 MW
MOLOKAI	8,000	5 MW
OAHU	910,000	1,200 MW

Hawaii map section: Copyright Raven Maps & Images, 1988

OTEC—How It Works

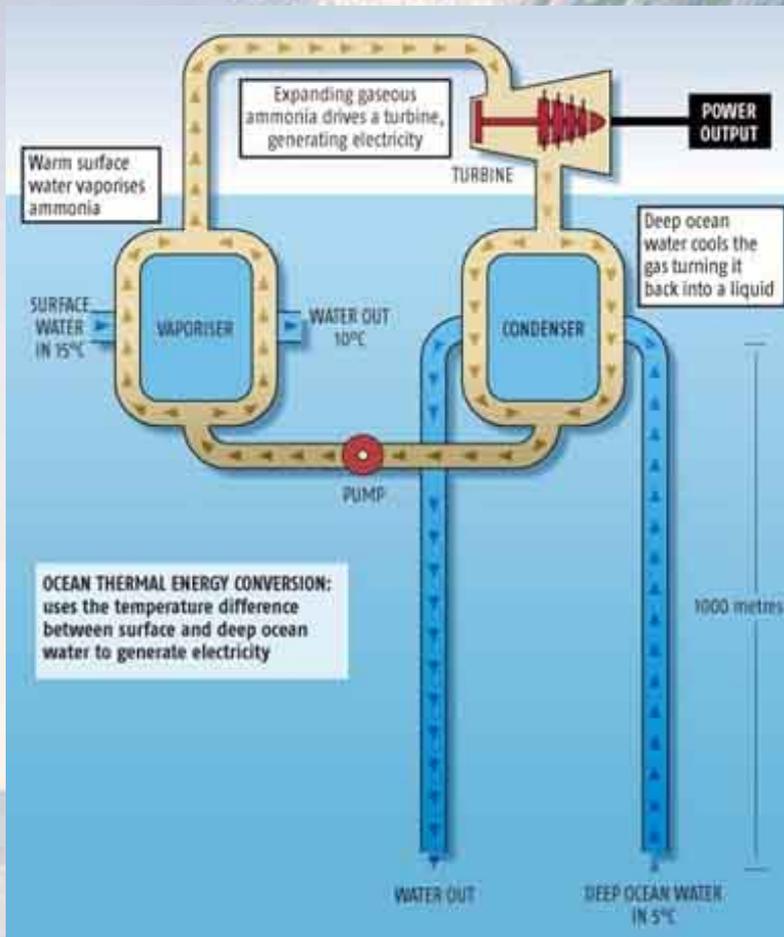


Diagram illustrating the conversion of ammonia from a liquid to a gas and back again, using temperature differential

Source: *New Scientist*

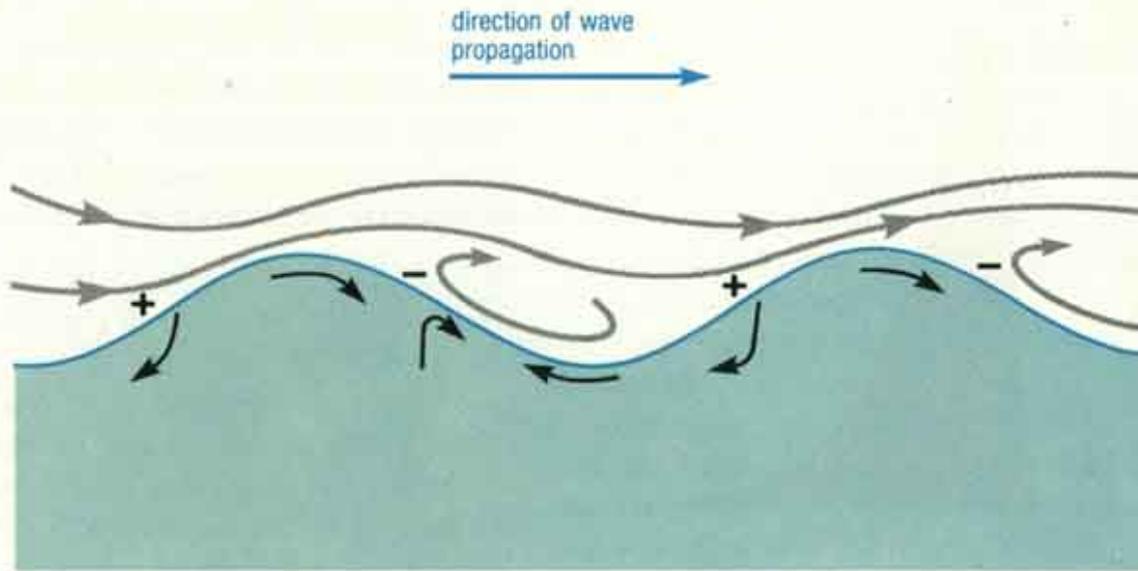


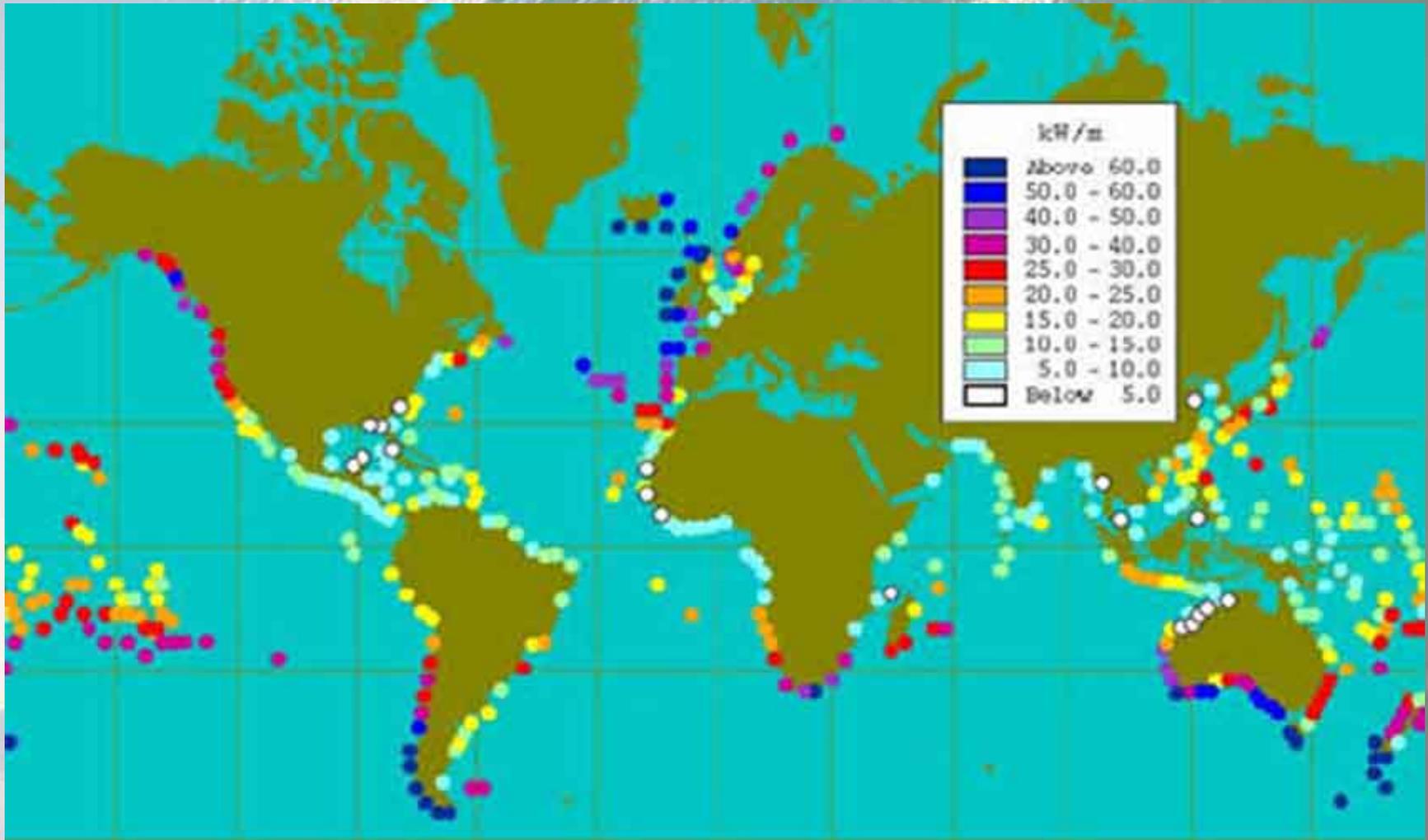
Figure 1.3 Jeffreys' 'sheltering' model of wave generation. Curved lines indicate air flow; short, straight arrows show water movement, which will be explained more fully in Section 1.2.1. The rear face of the wave against which the wind blows experiences a higher pressure than the front face, which is sheltered from the force of the wind. Air eddies are formed in front of each wave, leading to differences in air pressure. The excesses and deficiencies of pressure are shown by plus and minus signs respectively. The pressure difference pushes the wave along.

Wave Generation

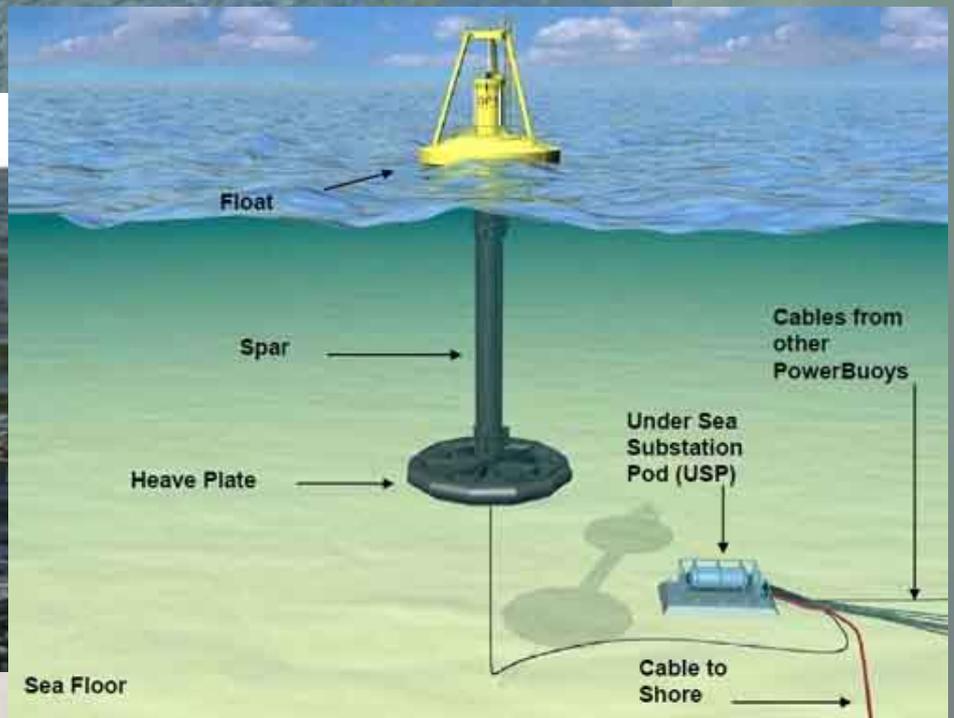
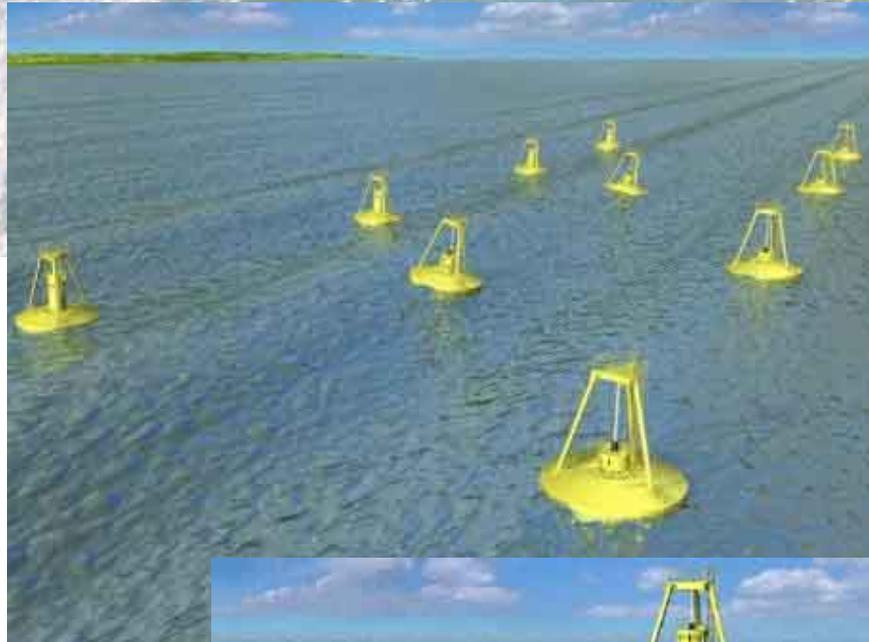
Wave Energy

- Ocean waves are predictable.
- Ocean waves are continuous.
- Wave energy technologies have a low viewshed impact.
- Approximately 60% of the world's population lives within 50 miles of a coastline.

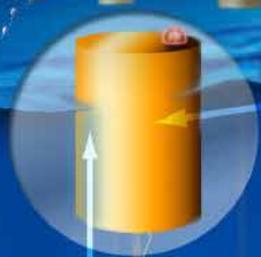
Wave Power Density



Source: *Global Energy Network Institute*



Oregon State University Conceptual Wave Park



100 ft

100 ft

Magnetic Shaft
*anchored to
sea floor*

Electric Coil
*secured to
heaving buoy*

12 ft

Permanent Magnet
Linear Generator Buoy

Oregon State University Wave Park

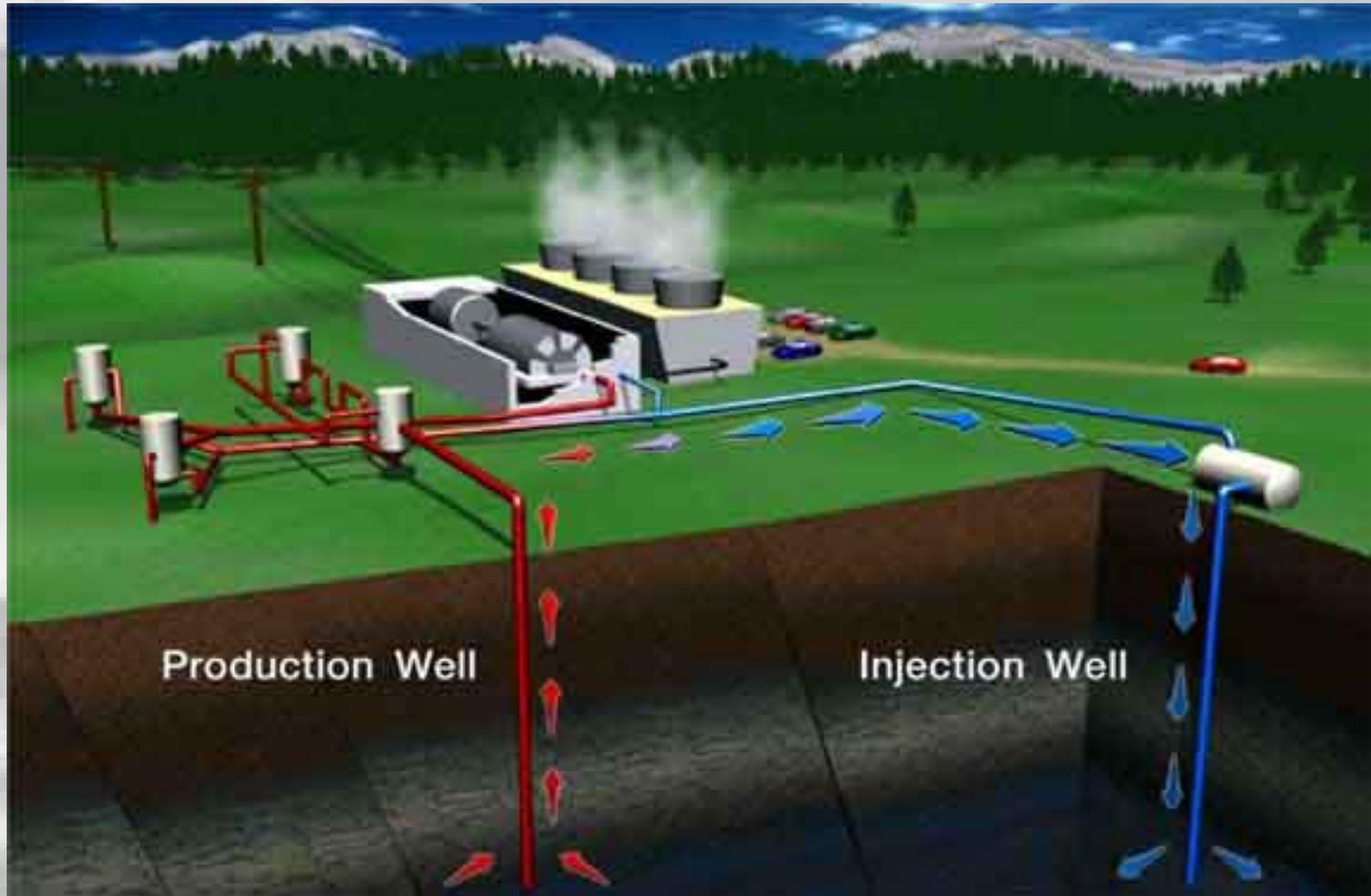


<http://www.kezi.com/researchers-try-to-capture-wave-energy/>



Introduction

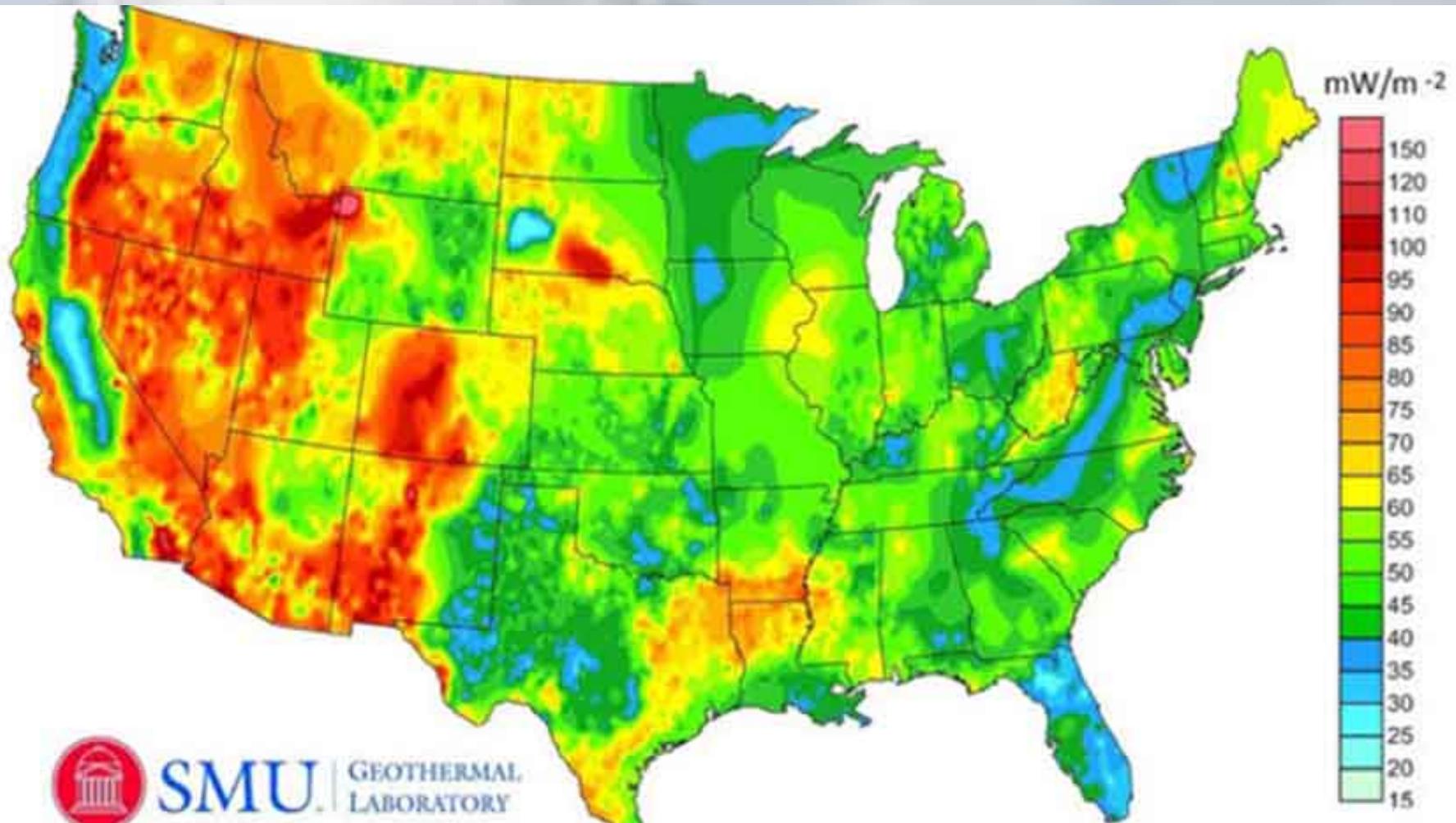
Geothermal Energy



Geothermal Power

- **Principle:** Heat in earth's core can be tapped for human use. Near-surface access to this heat is a potential energy source.
- Only large-scale renewable energy source that does not depend on sun
- US current: 2,500 MW of electricity
 - Equivalent to three large nuclear power plants

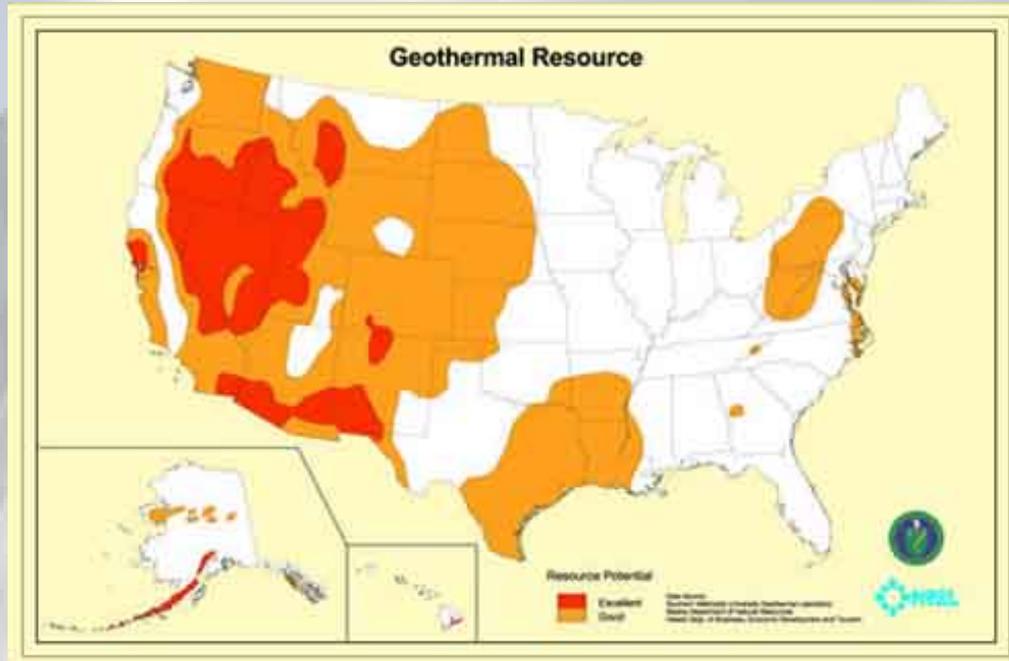
New Google-Funded Geothermal Potential Map



Geothermal Resources

- Natural hydrothermal reservoir
 - Spontaneously produces hydrothermal fluid
 - Hot water or water/steam mixture: “liquid dominated”
 - High quality steam (saturated?): “vapor dominated”
- Geopressurized
 - Reservoir of pressurized hot water that does not generate hydrothermal fluid at surface
 -
- “Hot dry rock”
 - Rocks at ca. 200°C+, but have no fluid
 - Drill and inject water to generate fluid at surface
- Magma
 - Molten rocks (650°C+) at accessible depths
 - Harvesting heat is a real problem (i.e., we don't know how).

Enhanced Geothermal Systems (EGS)



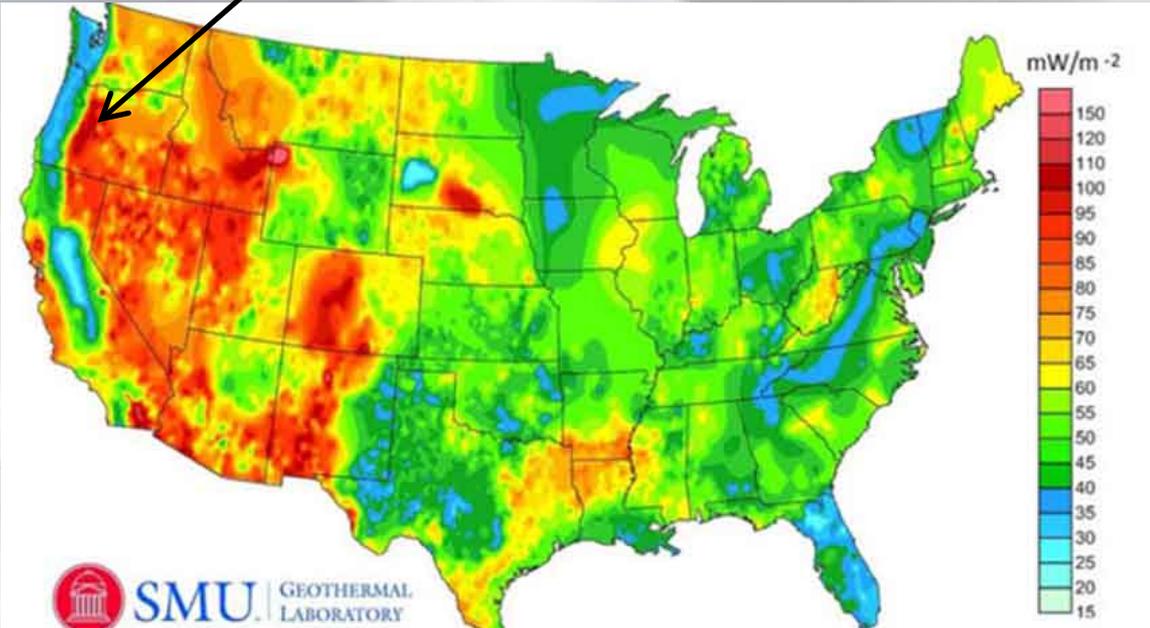
Enhanced geothermal systems (EGS) could supply up to 10% of the country's electricity needs within 50 years at prices competitive with fossil fuel-fired generation.

TABLE 13.1 Geothermal resource estimates (adapted from Tester et al. 2005)

Resource	United States (1000 quad)	World (1000 quad)
Hydrothermal	10	130
Geopressurized	170	540
Magma	1,000	5,000
Hot, dry rock	30,000	105,000

EGS (cont.)

Newberry Crater



Newberry EGS
 Enhanced Geothermal Systems
 DEMONSTRATION

A Demonstration of EGS Technology
 The National Science Foundation and University of Oregon
 Department of Energy, Program on Renewable Energy
 Geothermal Technology Program
 awarded a grant of \$10 million to fund the development of EGS in
 the central Oregon. The project is led by the University of Oregon,
 University of Tennessee, and the University of California.

Project Location - Central Oregon, USA
 The project is located in the central Oregon region of the
 United States, in the vicinity of the Newberry Crater.

Demonstration Phases

- Phase I** - Feasibility study, public outreach, and regulatory review.
- Phase II** - Site characterization, including geophysical and hydrogeological studies.
- Phase III** - Construction and commissioning of the EGS system.

Goals of the Demonstration

- Develop a 25 MW EGS system.
- Generate clean, renewable energy.
- Reduce greenhouse gas emissions.
- Improve energy security.
- Develop a model for EGS systems.

Contract Awards

URS
 Project Manager
 www.newberryegs.com
 503.325.1234

For more information
 visit our website or contact us at
 www.newberryegs.com
 or call 503.325.1234

MISSION

The mission of the Newberry EGS project is to demonstrate the feasibility of EGS technology in the central Oregon region of the United States. The project is a joint effort between the University of Oregon, the University of Tennessee, and the University of California.

EGS (cont.)



<http://www.youtube.com/embed/Oscqx08zBXQ>

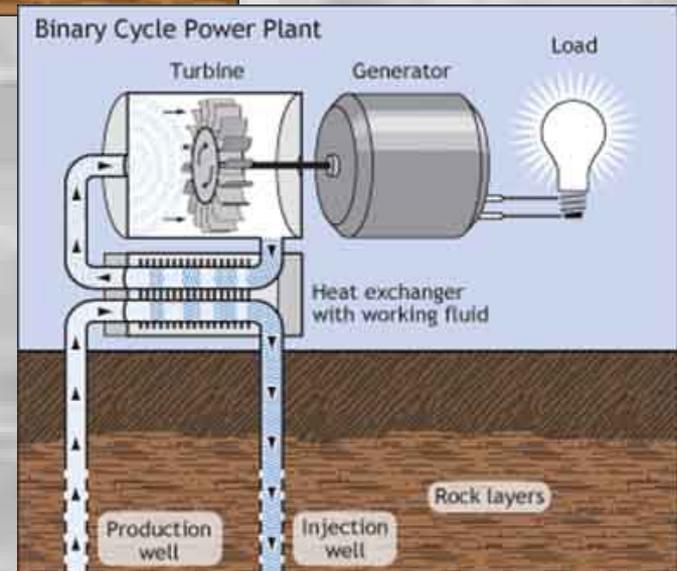
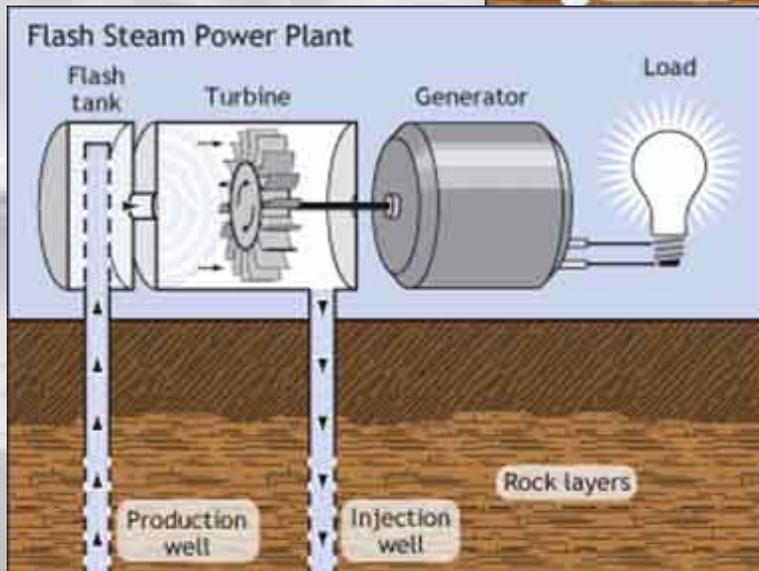
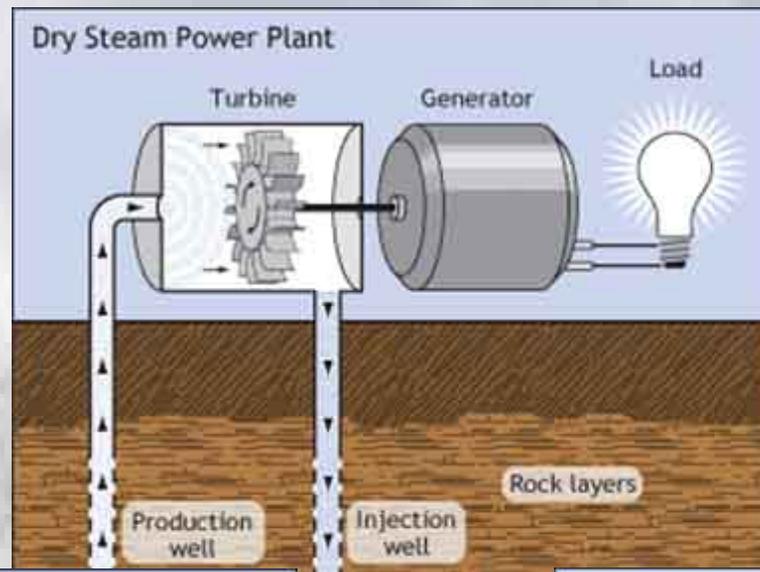
Main Challenges of EGS

- 40% of costs from exploration and development
- Tough to find drilling rigs (already in use with oil/gas industry)
- Potential seismic disruption
 - Basal, Switzerland problem
 - Increased avalanche hazards a possibility
- Water requirements
 - 24M gal. of ground water for Newberry project
 - Altarock says it's available.
 - Opposition groups are concerned about impact on underground aquifer.

Is EGS Fracking?

- **NO!** EGS uses hydraulic shearing process, not hydraulic fracturing (fracking) process.
- ~1,500 psi pressures for shearing, relative to ~10,000 psi pressures for fracking (to extract oil and natural gas)
- Fracking uses chemical soup; EGS does not.

Approaches to Geothermal



Google: Renewable Energy

- Google invested \$6.25M in Altarock Energy in 2008 and \$850M in renewable energy in past couple of years.
- \$21.4M Department of Energy grant also helping fund the project



For more information on the SEET Energy Webinar Series, please contact ATEEC at:
mdocherty@eicc.edu.

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<http://ateec.org/energy>.