

# ***ALTERNATIVE ENERGY***

Beyond Petroleum and Coal



Clean Renewable Energy

<http://geothermal.marin.org/GEOPresentation/sld121.htm>

# ***Alternative Energy Sources***

- Solar
- Biomass
- Rivers, winds and tides
- Geothermal
- Other fossil fuels
- Advancing Technologies
  - Electric sportscar
  - <http://www.teslamotors.com/>

# ***Solar***

- Direct uses
  - Space heating
  - Water heating
- Converted to electricity

# *Four Solar Systems*



- Passive heating
- Active heating
- Photovoltaic
- Water heating

# ***Passive Space Heating***

- Let the Sun shine in
  1. Heats air inside building
  2. Heat up massive structure
    - Stone, brick, concrete
    - Returns heat to air when Sun isn't shining
- Sun-facing windows

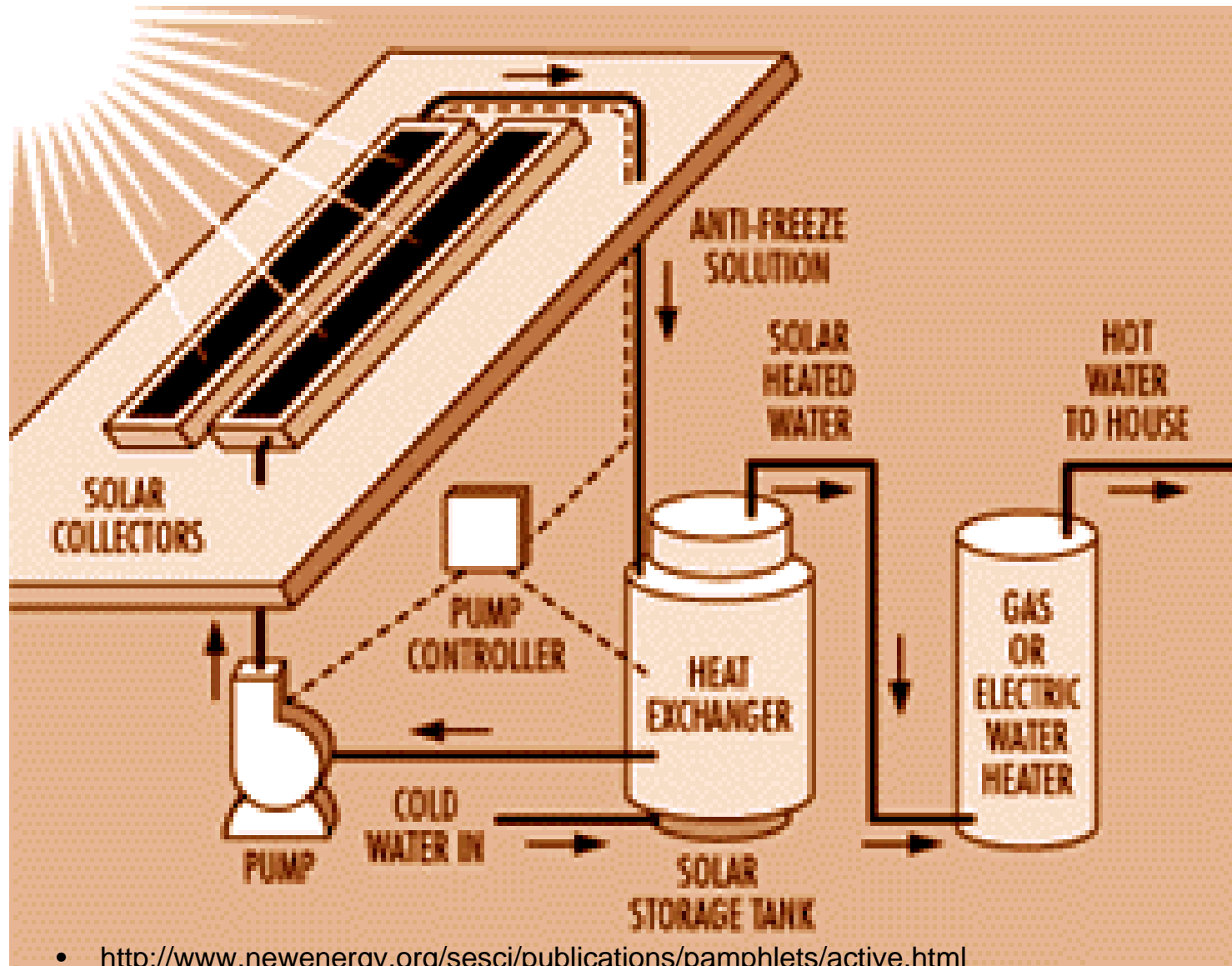


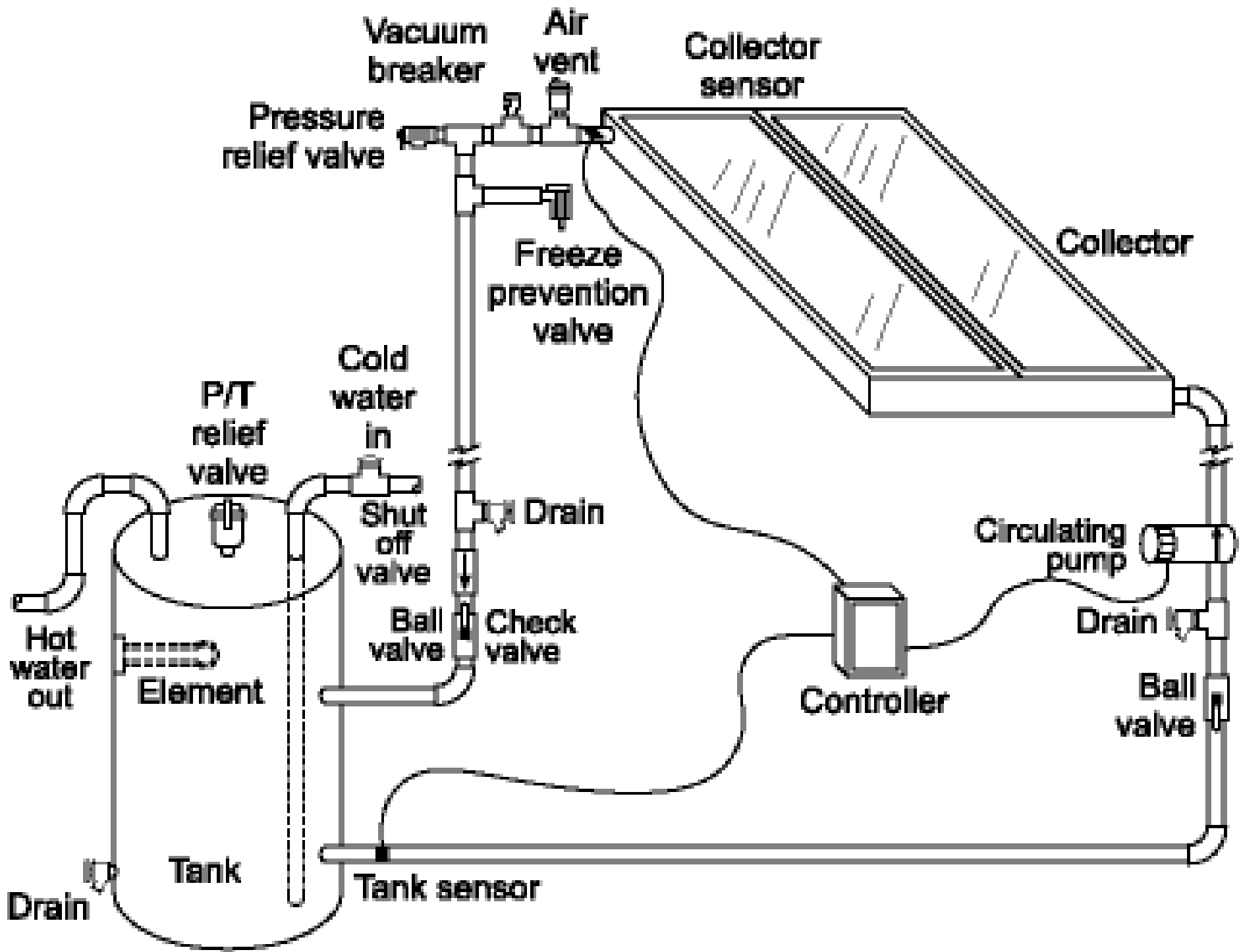
- <http://www.earthship.com/staticpages/index.php?page=sale&osCsid=e2e983564ec7a5b9921a71236bed60c8>
- Building for passive Sun heating
- Photovoltaic and Water heating also incorporated
- Note operable skylight for cooling



- <http://www.newenergy.org/sesci/publications/pamphlets/active.html>

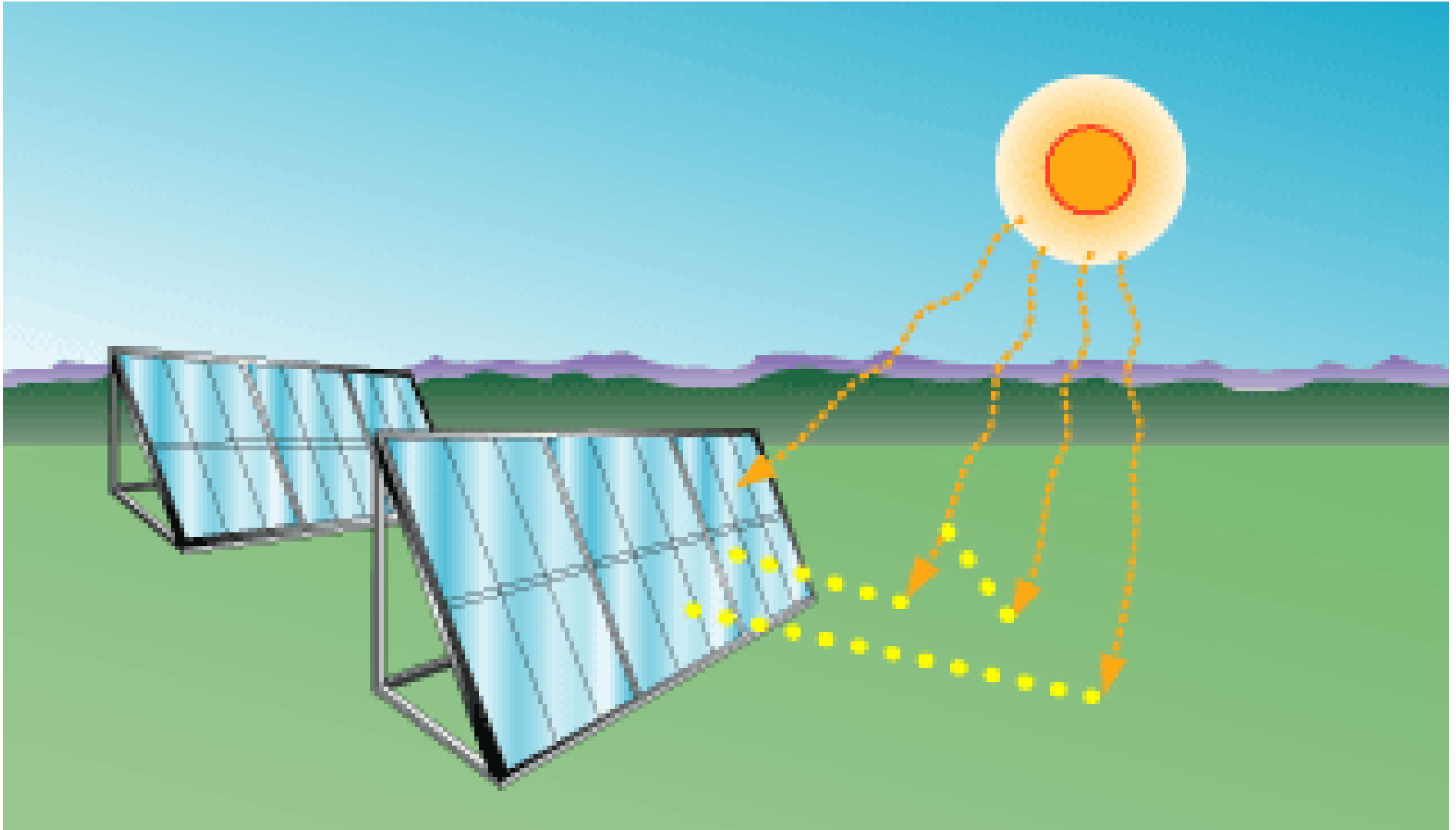
# *Solar Water Heating System heat-exchange*



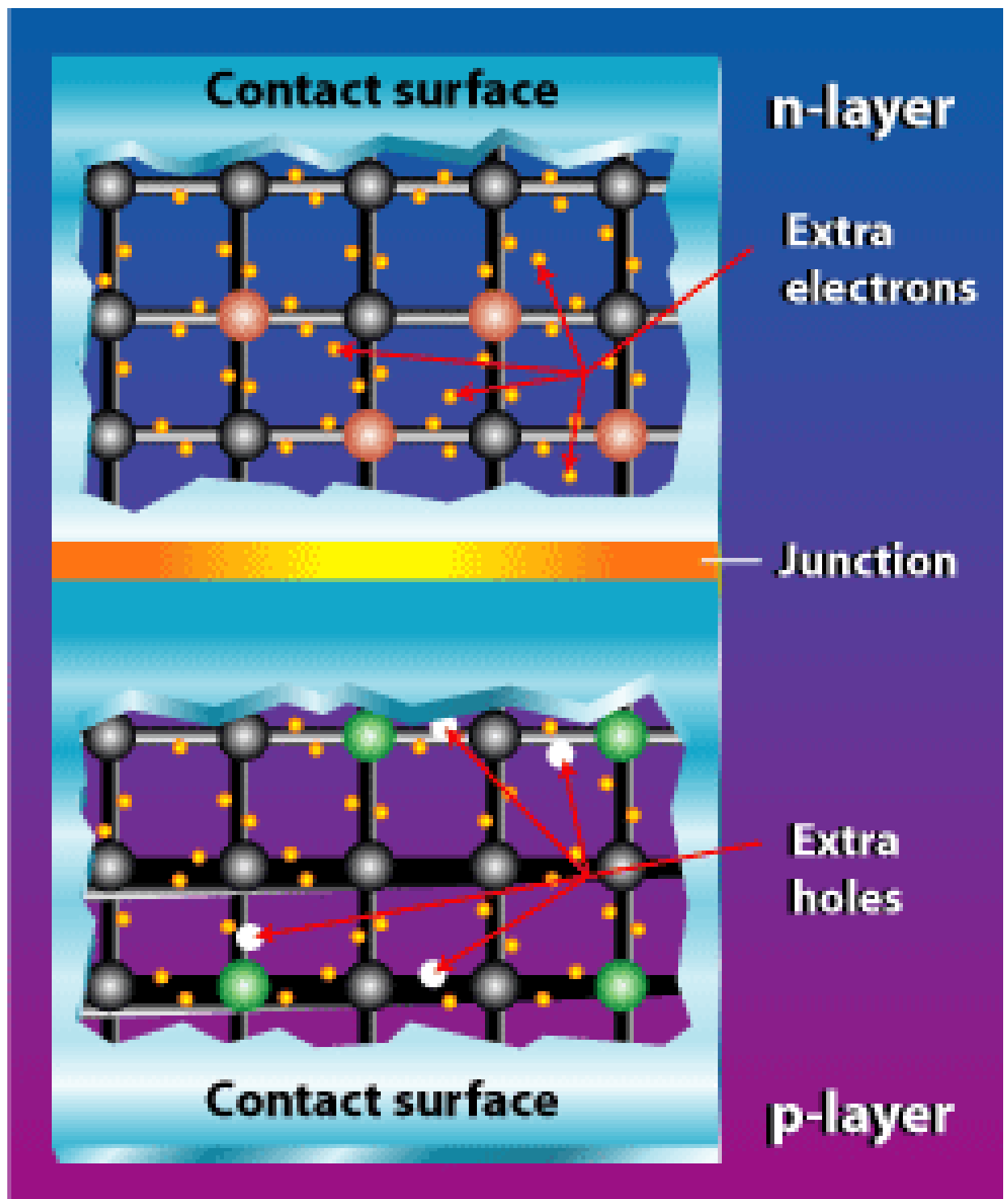


- <http://www.fsec.ucf.edu/solar/apps/sdhw/en5.htm#Circulation>

# ***Sun shines directly and is reflected onto PV panels***



# How PV Panels Work



# ***Photovoltaic Electricity***

- Photons from Sun excite electrons in atoms
- Induces current flow
- Produces direct current electricity
- About 100 watts/m<sup>2</sup>

# ***Disadvantages to Solar***

- Not much solar gain in some areas
  - Cloudy areas
  - Low sun angle
  - only works in the day, too
- Photovoltaic electricity is not very efficient
- Cost of the balance of the systems
  - Batteries
  - Panel racks and trackers
  - Inverter to get AC power

# ***Biomass***

- Direct burning of plant material
- Oil harvested from seeds
- Plant material converted to
  - Alcohol: methanol and ethanol
  - Converted to methane

# ***Drawbacks of Biomass***

- Lack of arable land where fuel is needed
- About 3% efficient

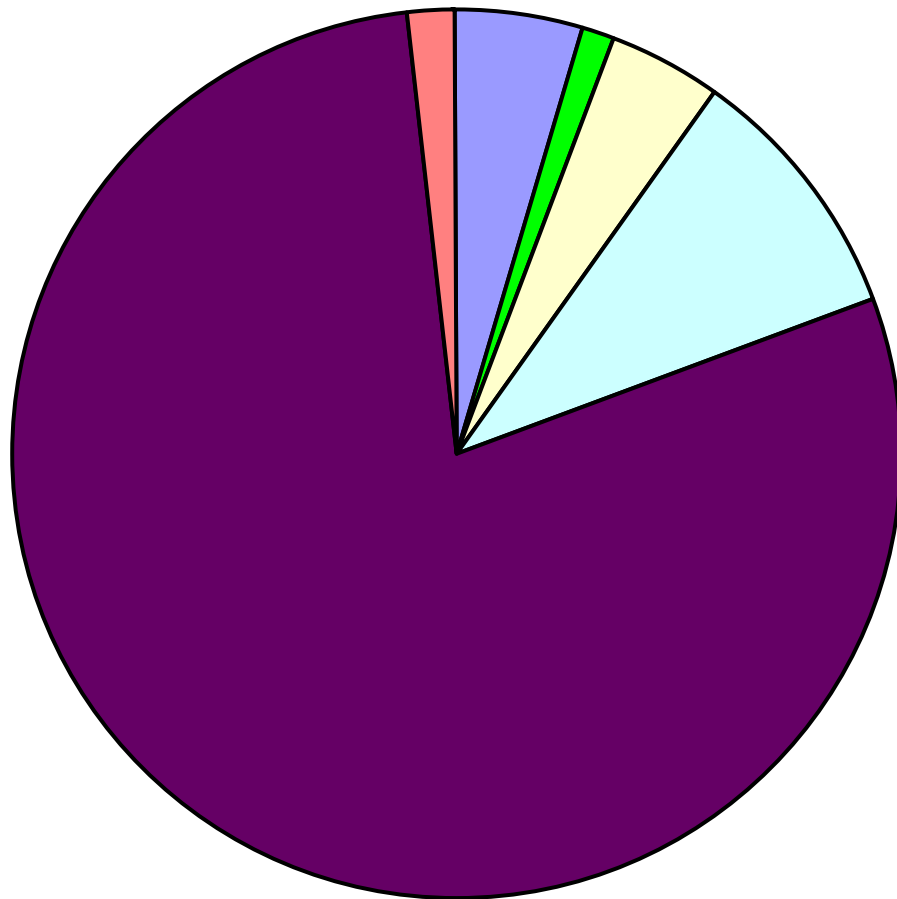
## Advantages

- Utilize waste plant material
- Reduce dependence on fossil fuels
  - Corn syrup fails this test: tractor fuel for seeding and harvest
  - carbon-release of production offsets any reduction in carbon footprint of corn-syrup-derived ethanol

# ***Water Power***

- Hydroelectric Generation
- 9% of U.S. electricity is from hydroelectric generators (Oregon about 50%)
- Need to dam rivers where precipitation is reliable

# 1990 Electrical Generation



Coal



Petroleum



Natural Gas



Nuclear

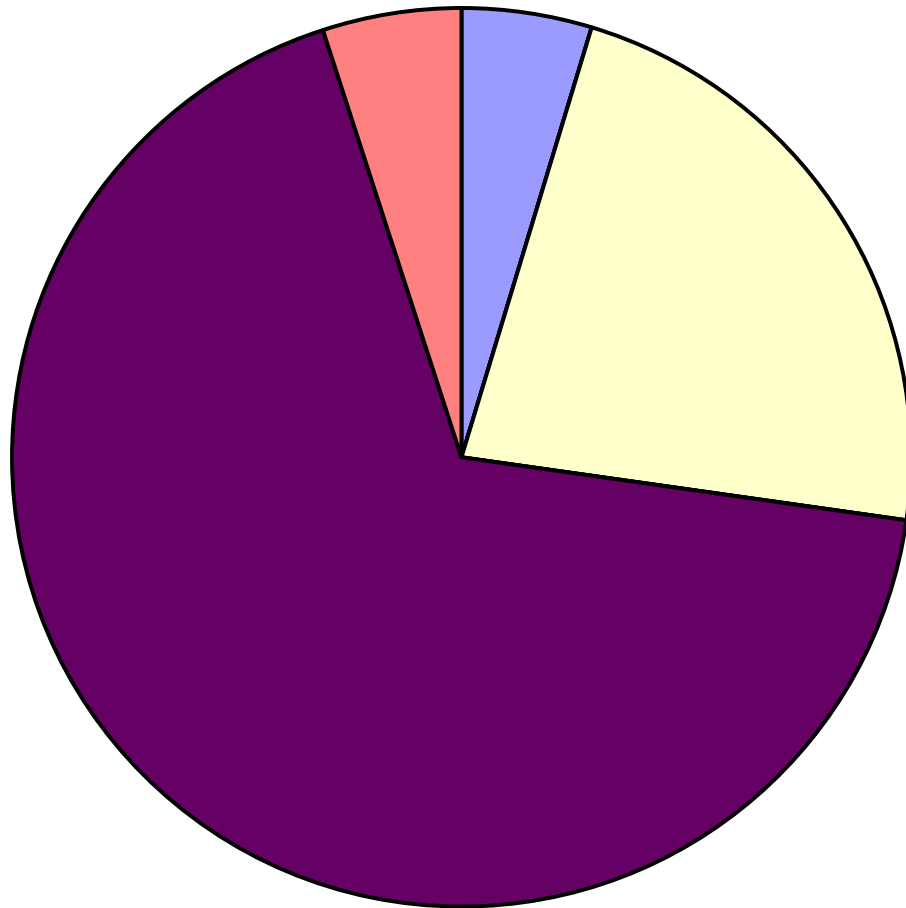


Hydroelectric



Other Renewables

# 2006 Electrical Generation



Coal



Petroleum



Natural Gas



Nuclear



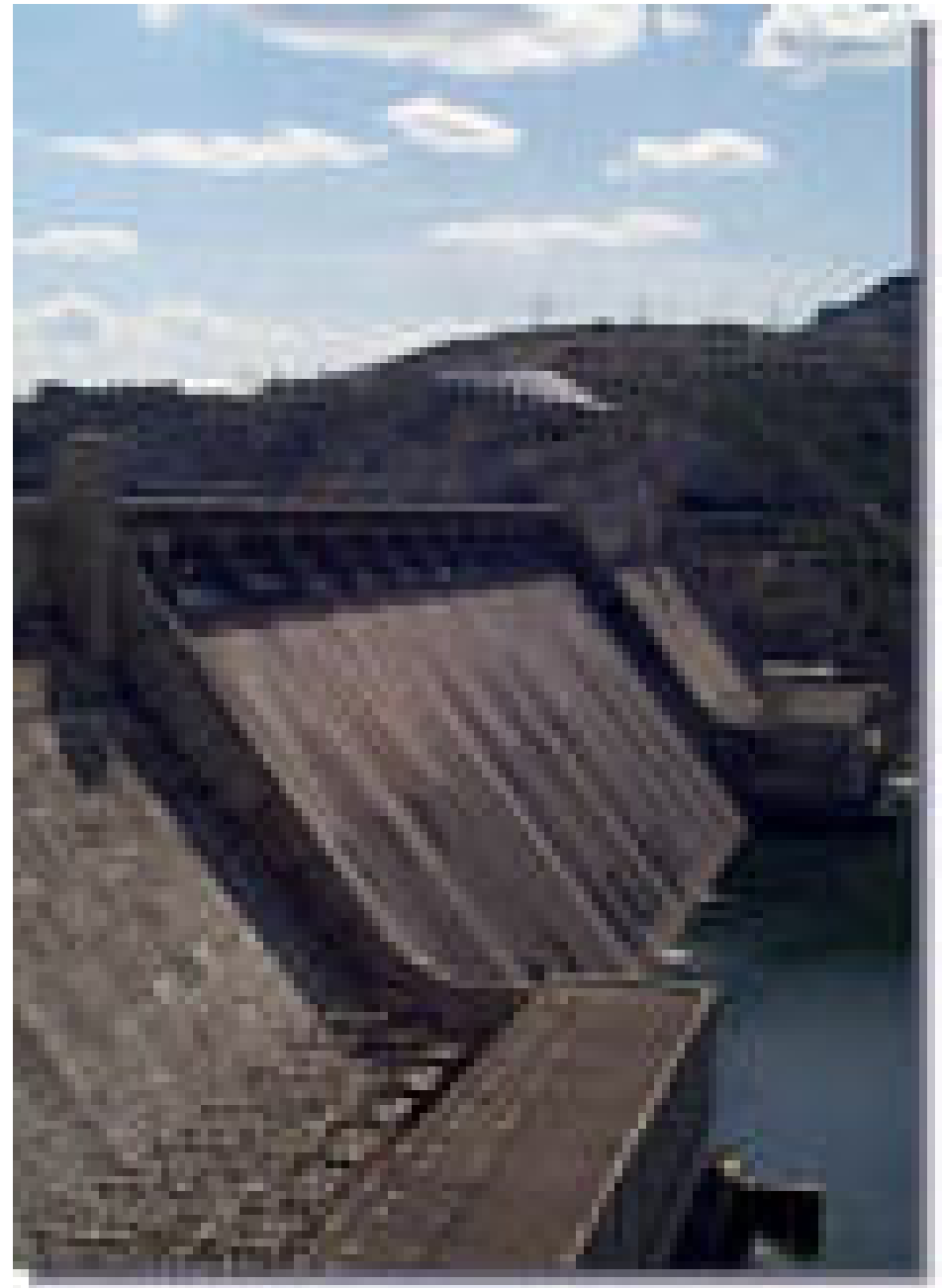
Hydroelectric



Other Renewables

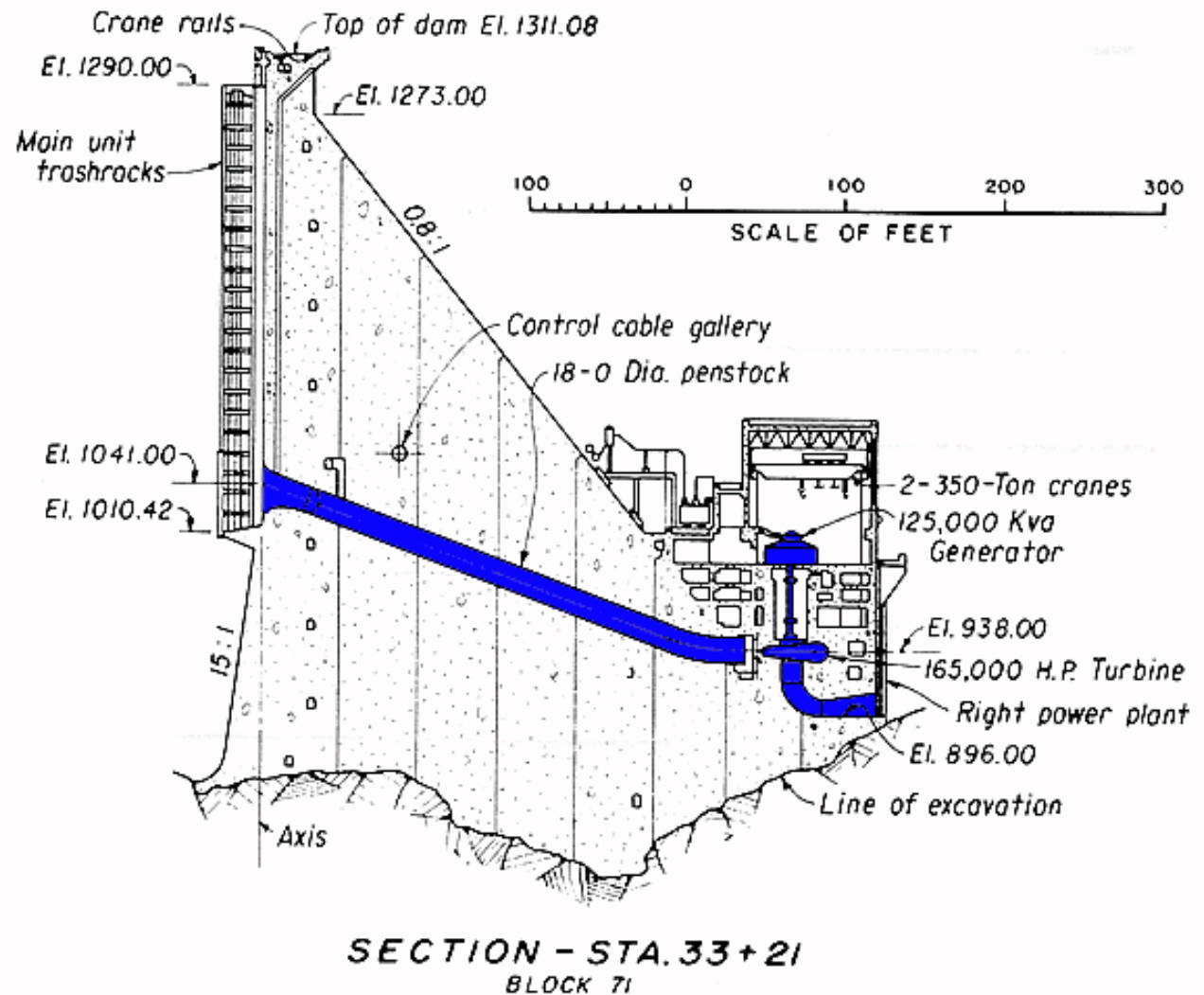
# ***Grand Coulee Dam***

- North America's largest concrete structure
- Located on the Columbia River in Central Washington



# Grand Coulee Dam

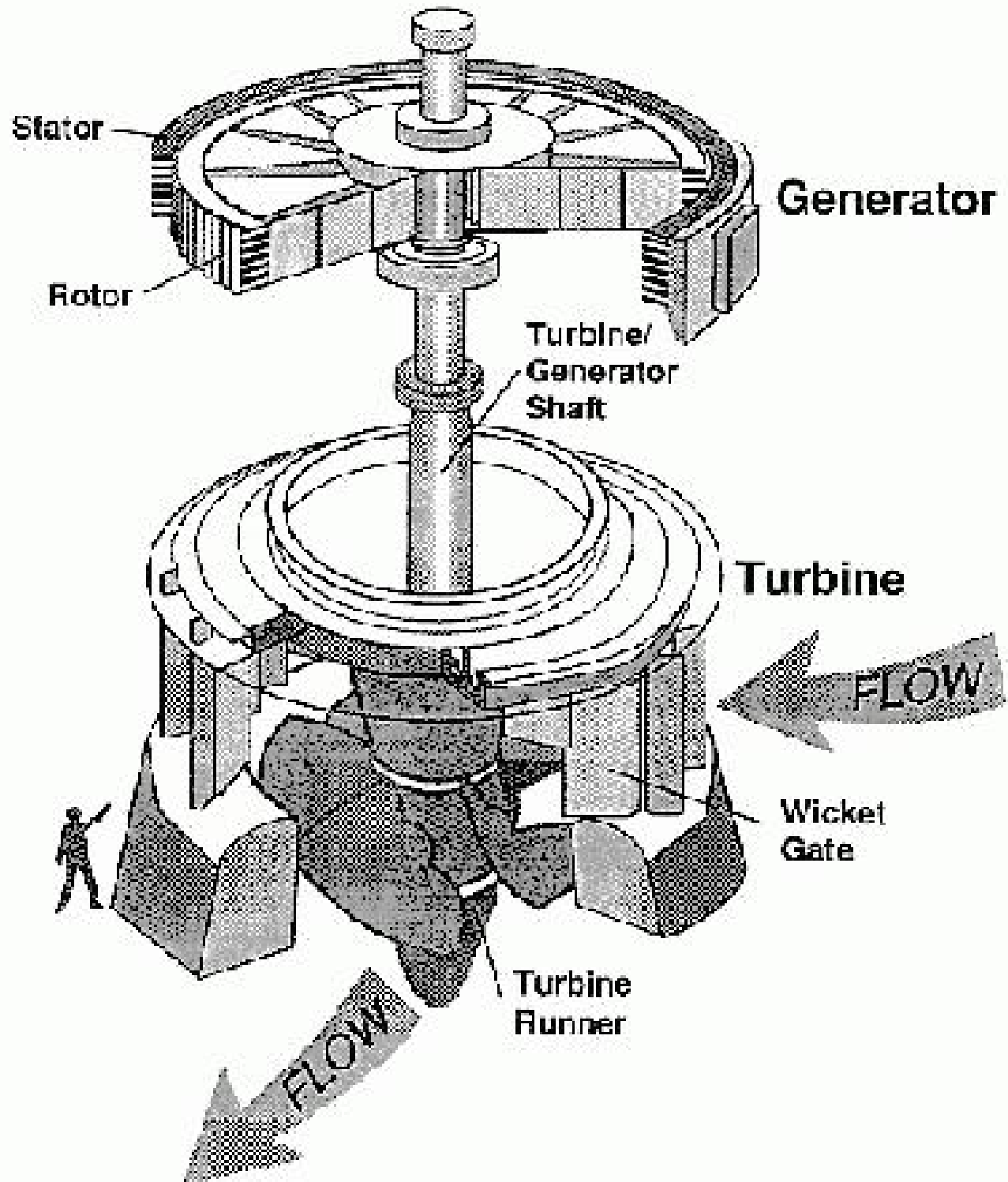
- 3<sup>rd</sup> largest producer of electricity in the world
- Irrigation water and flood protection



- <http://users.owt.com/chubbard/gcdam/html/hydro.html>

# *Water Power*

Cut away view of  
a water-driven  
electrical  
generator

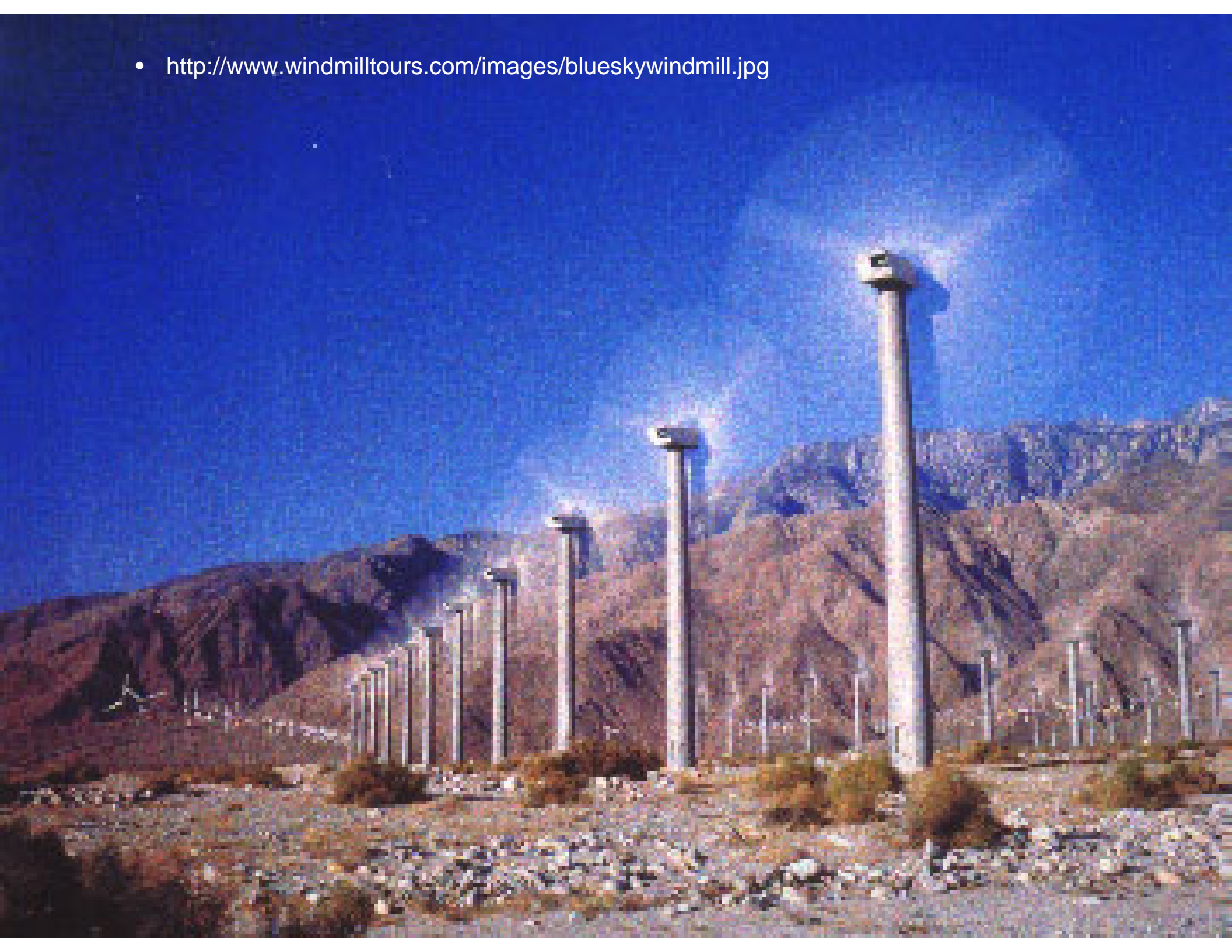


# *Wind Power*

- 10 Kw generator
  - ~\$50,000 cost
  - 30% tax CREDIT
  - Grid-inter-tie
    - To send power to the utility company
    - Credits toward energy you use other months
- <http://www.bergey.com/>



- <http://www.windmilltours.com/images/blueskywindmill.jpg>



# ***Present Utilization of Wind***

- Denmark 20% of its electricity
- Germany almost 7% of its electric power  
U. S. could easily generate 10% by wind
- California, intermountain west, and  
Minnesota at present
- Oregon capacity is ~7% of its use

# *Tides*

- “Lunar Power”
- Tides come in and go out twice daily

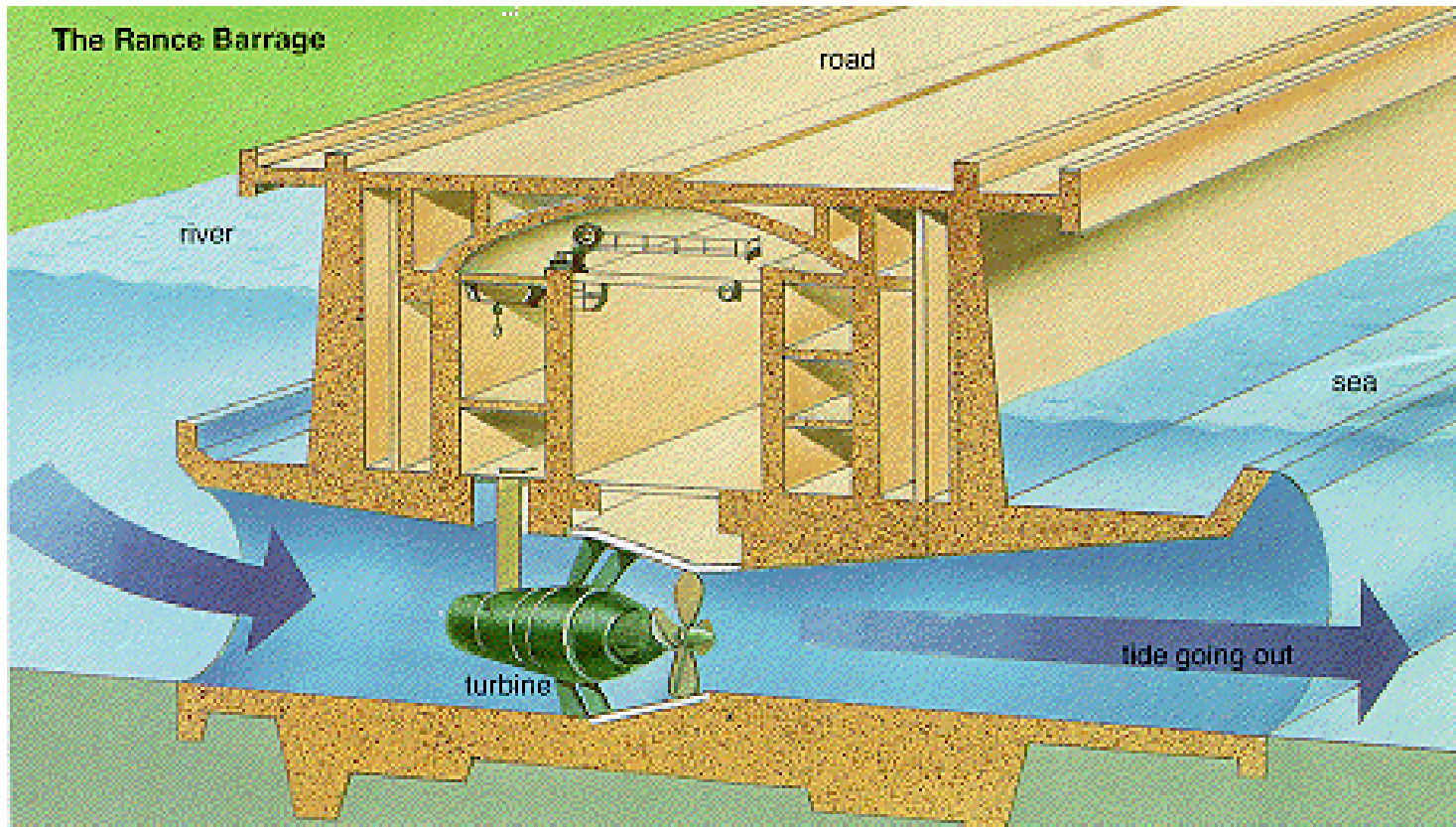
# *Tides*

- Need area with reasonable tidal range
- Presently utilized by damming tidal estuaries where water naturally backs up
- Largest at St. Malo, France 240 MW

# ***La Rance, France***



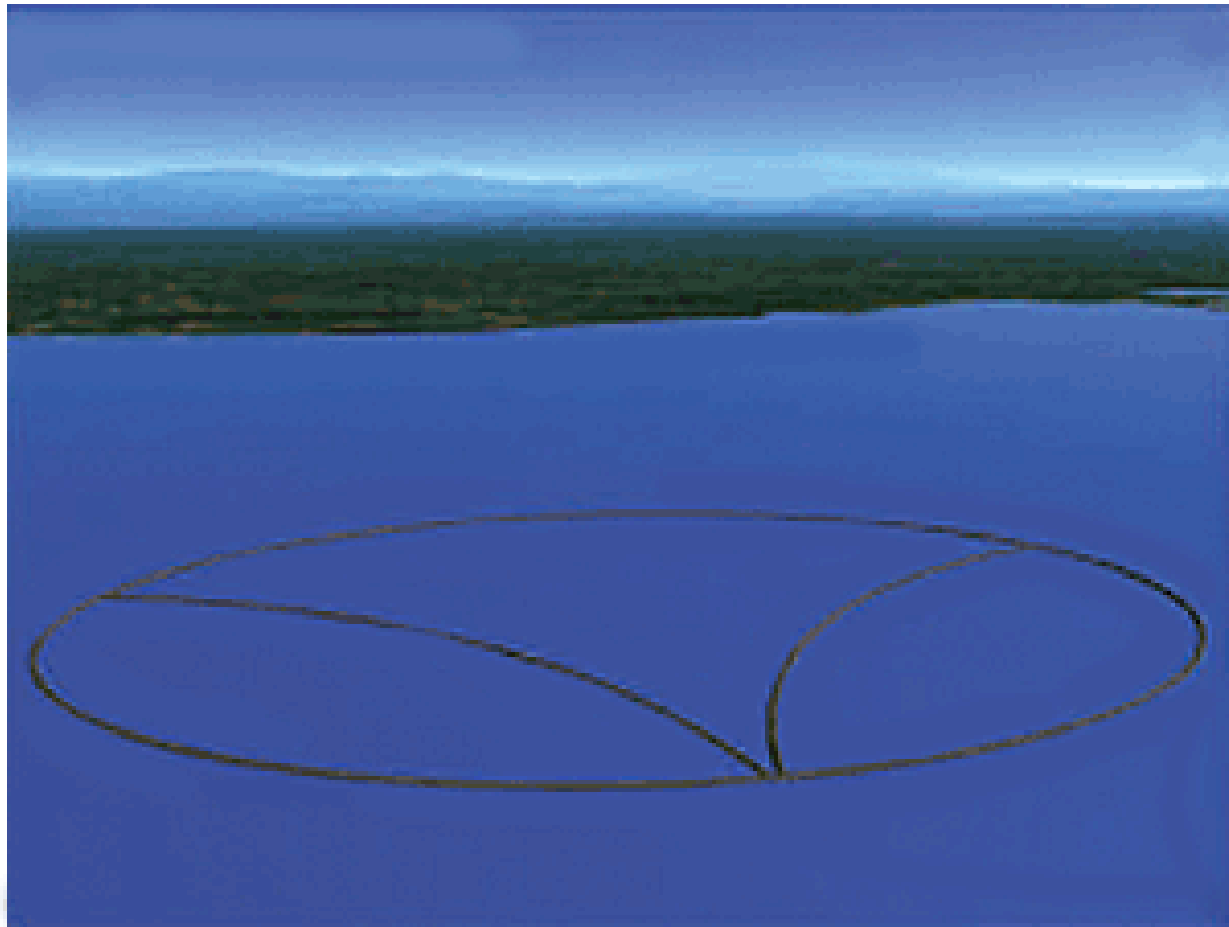
# ***LaRance Tidal Barrage***



# ***Disadvantages of Tidal Barrage***

- Prevents migration of anadromous fish
- Inhibits navigation
- Damages natural and scenic coastlines

# ***Tidal Lagoon***

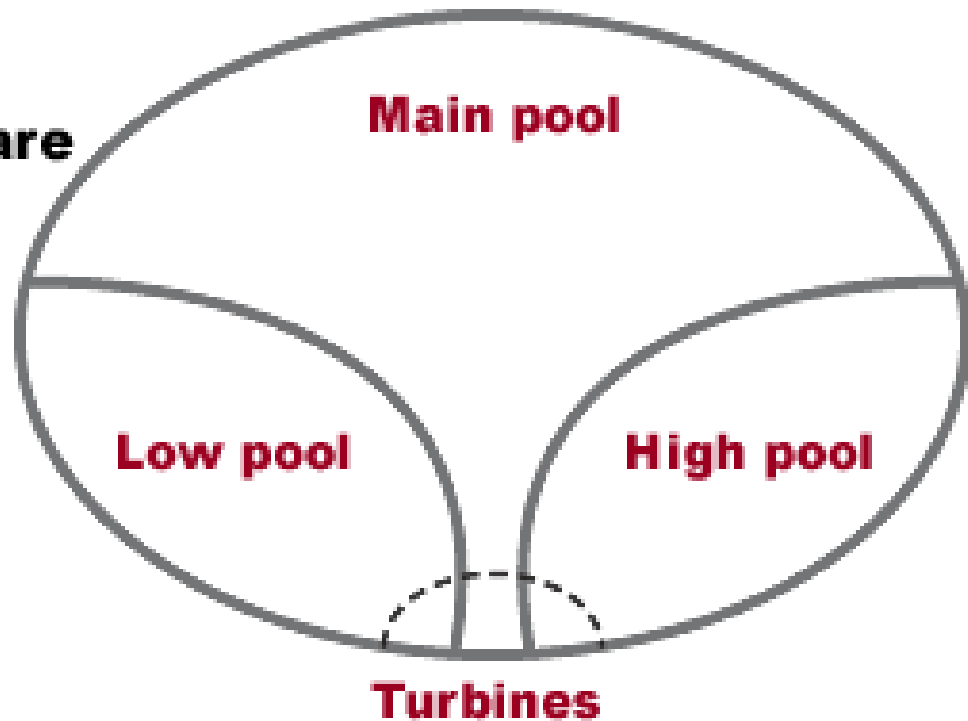


**Artist's impression of a tidal lagoon 2 kilometers offshore.**

- <http://www.forbes.com/global/2003/0721/042chart.html>

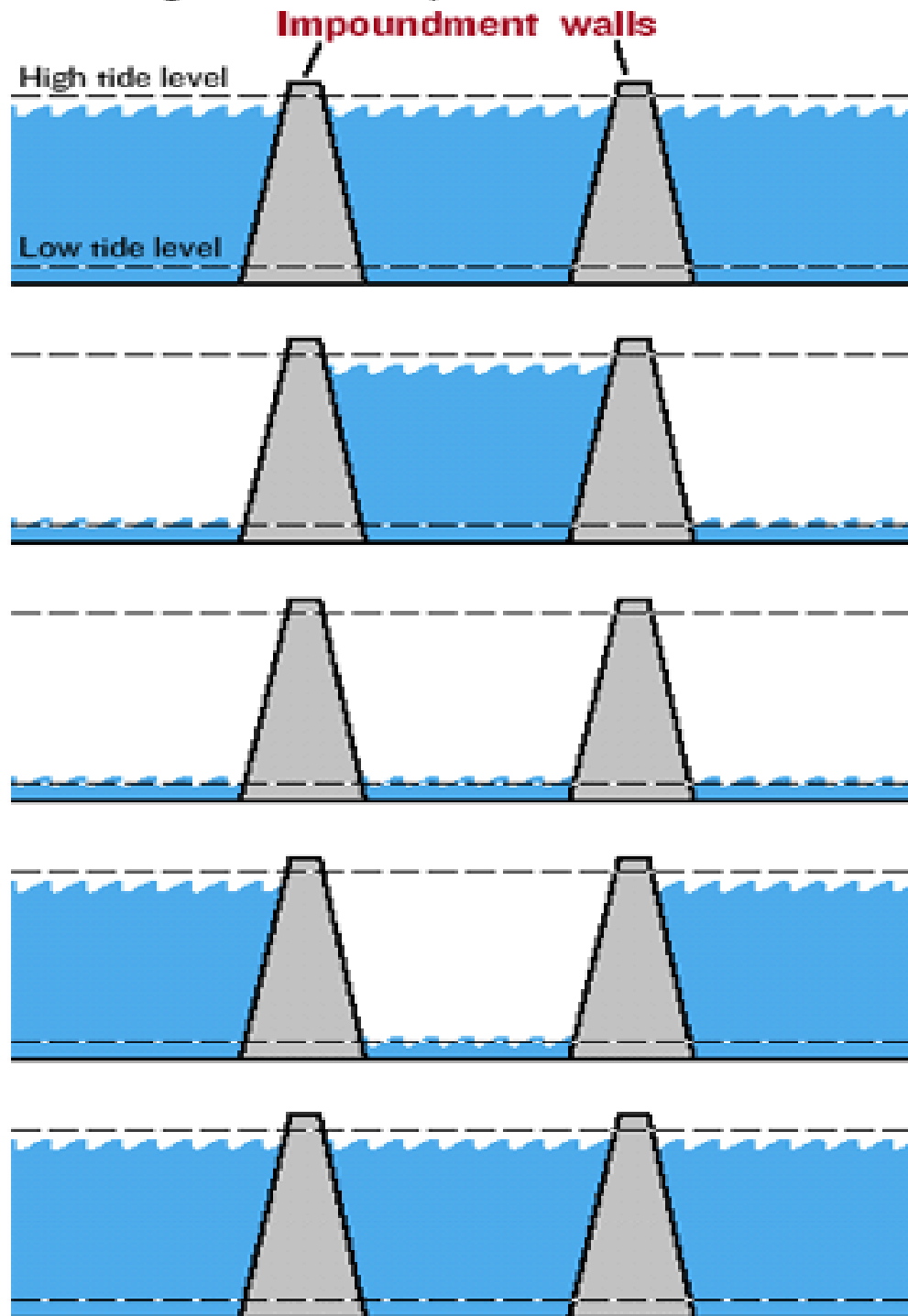
# *Tidal Lagoon*

**The lagoon is divided into three cells that are filled and emptied in sequence, thereby producing a more continuous output of electricity. Water goes in and out through the turbines.**



- <http://www.forbes.com/global/2003/0721/042chart.html>

# Power-generation cycle



**Starting point:  
High tide,  
impoundment full.**



**Tide goes down,  
creating "head."**



**Power generation.**



**Low tide,  
impoundment empty.**



**Tide goes up  
creating "head."**

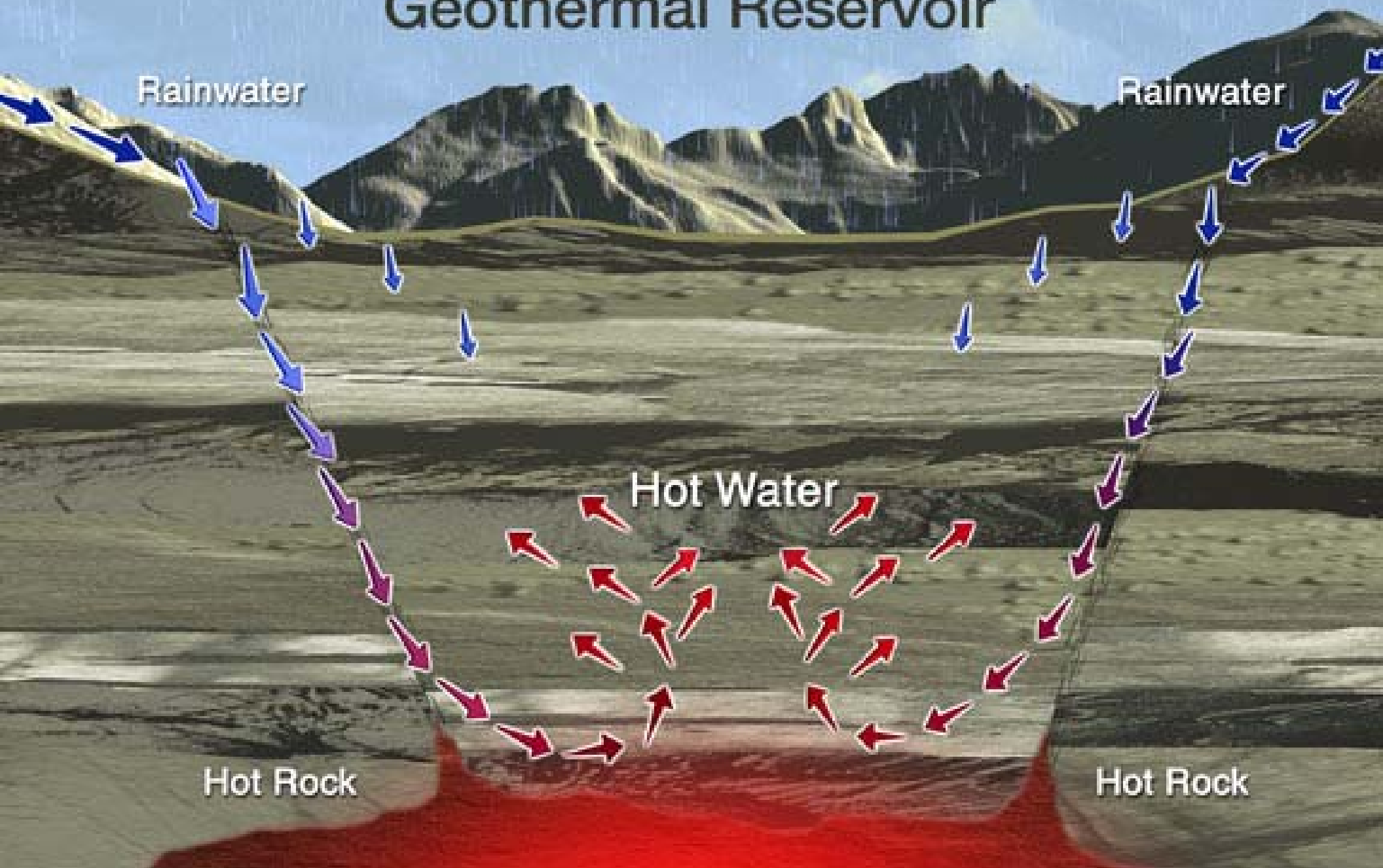


**Power generation.**



**Return to starting  
point.**

# Geothermal Reservoir



# ***Geothermal***

- Direct use for heating
  - Warm and hot sources of heat can be utilized for heat
- Generation of electricity
  - Requires hot source
- Water and hot-dry rock for both uses

# Geothermal

STEAM

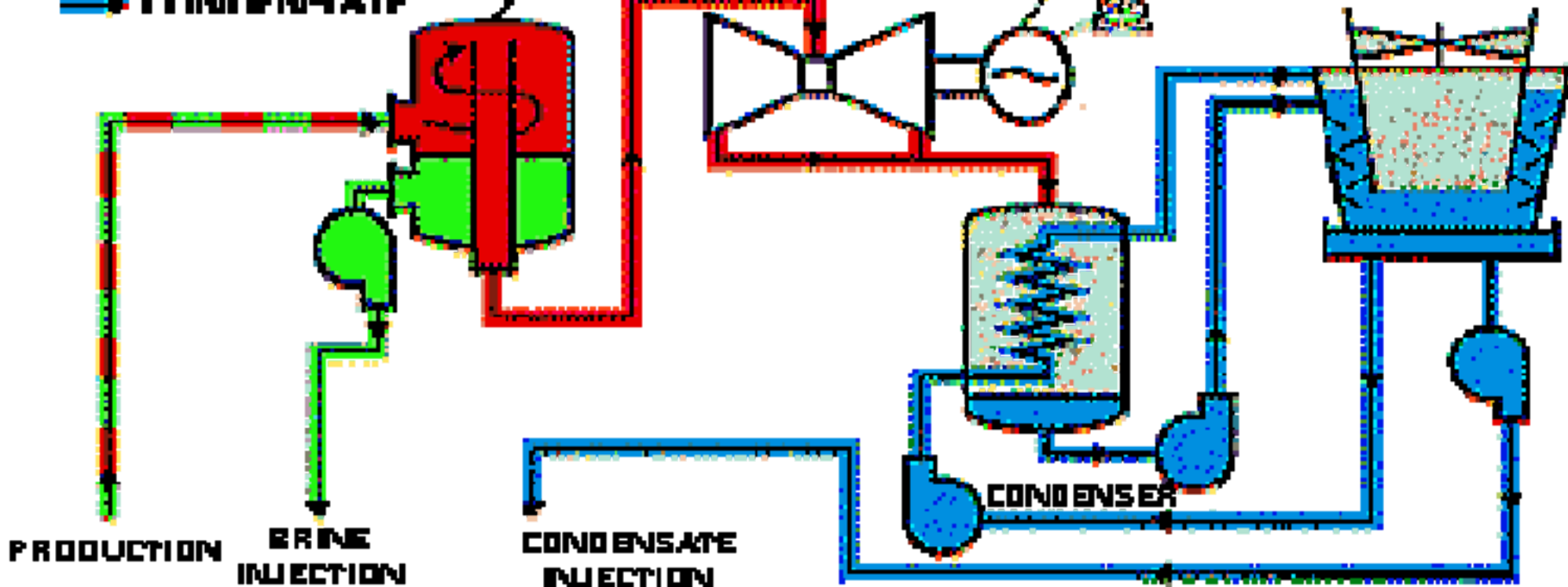
BRINE

CONDENSATE

SEPARATOR

TURBINE GENERATOR

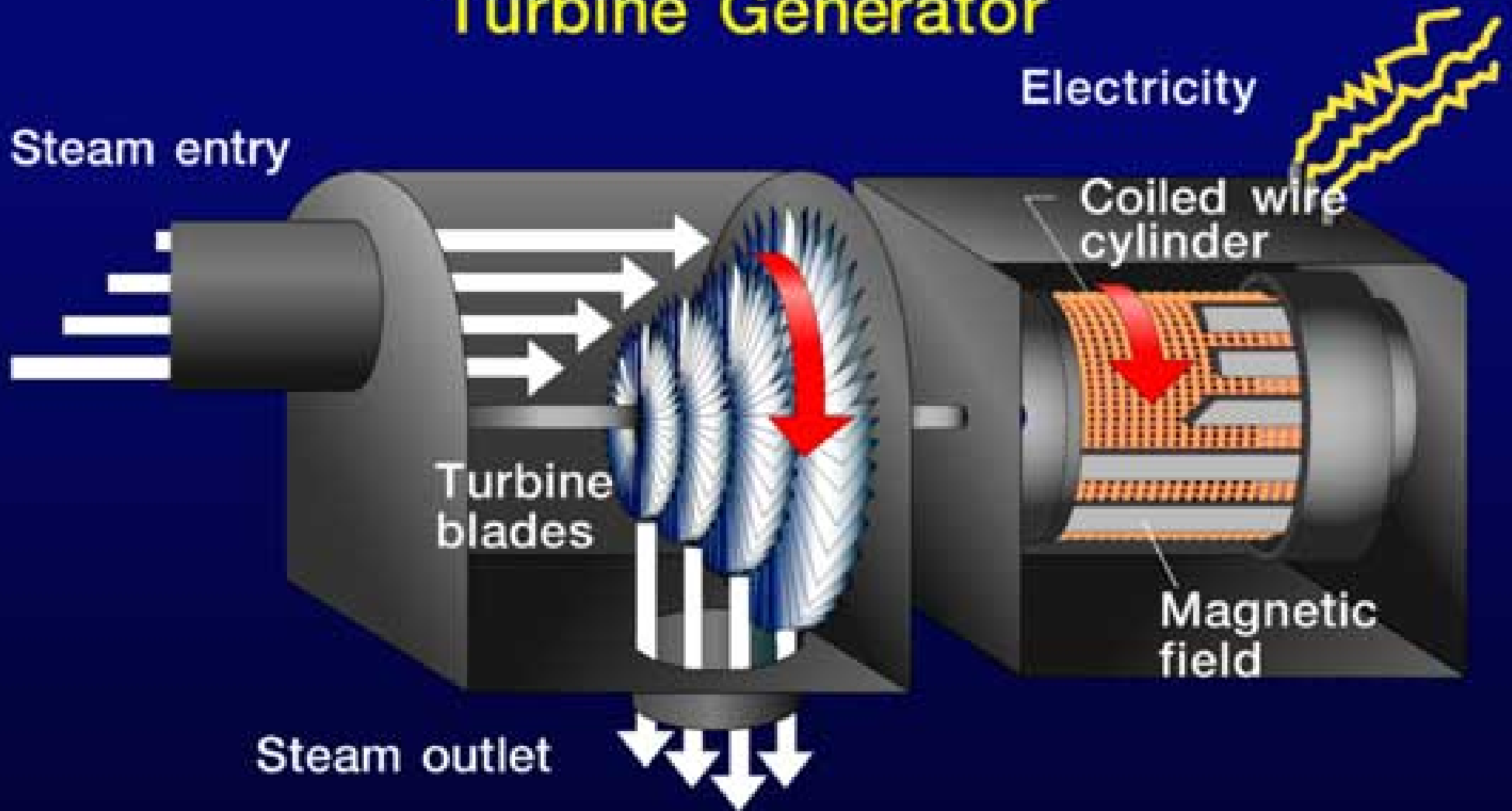
COOLING TOWER



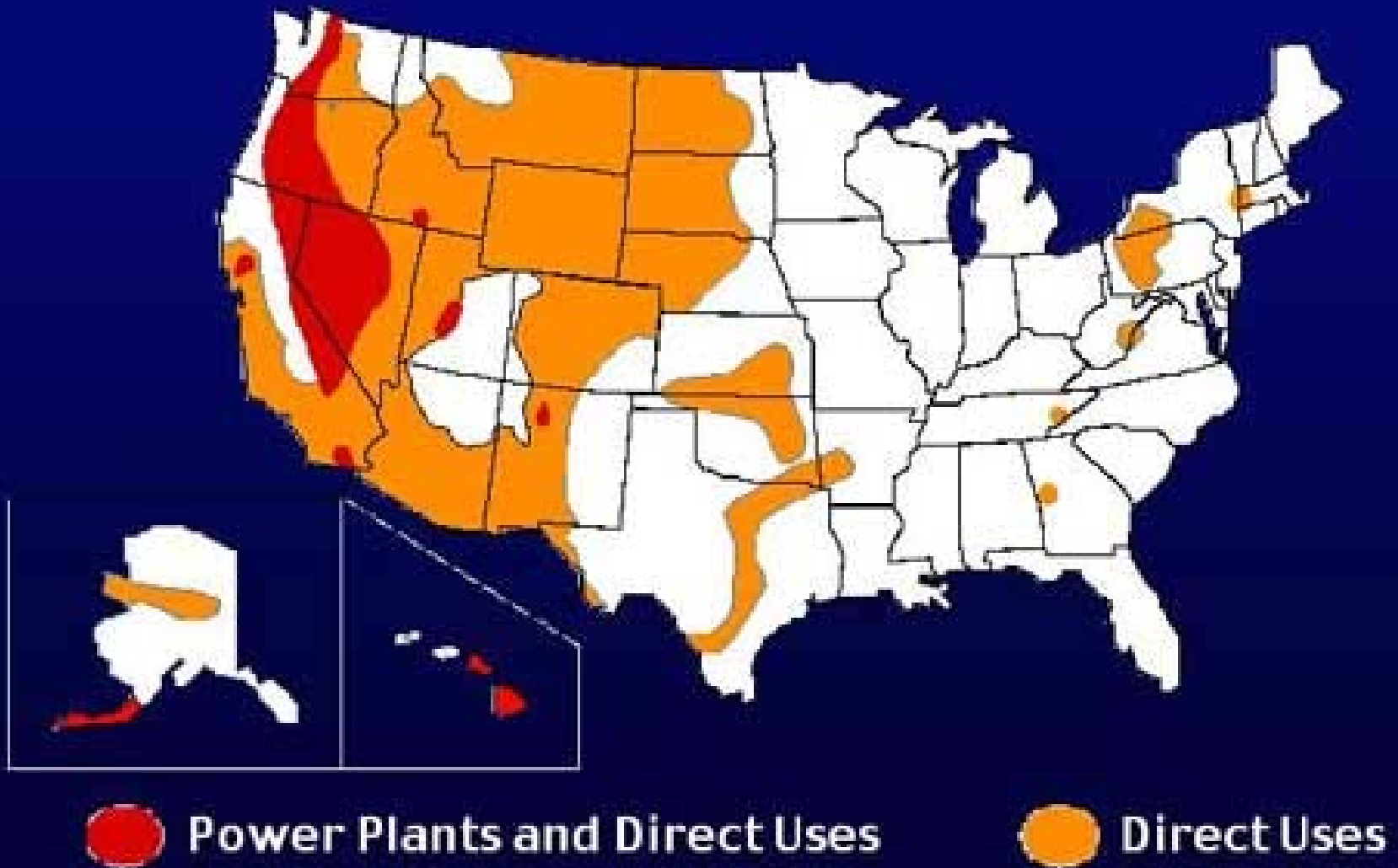
## Single-Flash Cycle

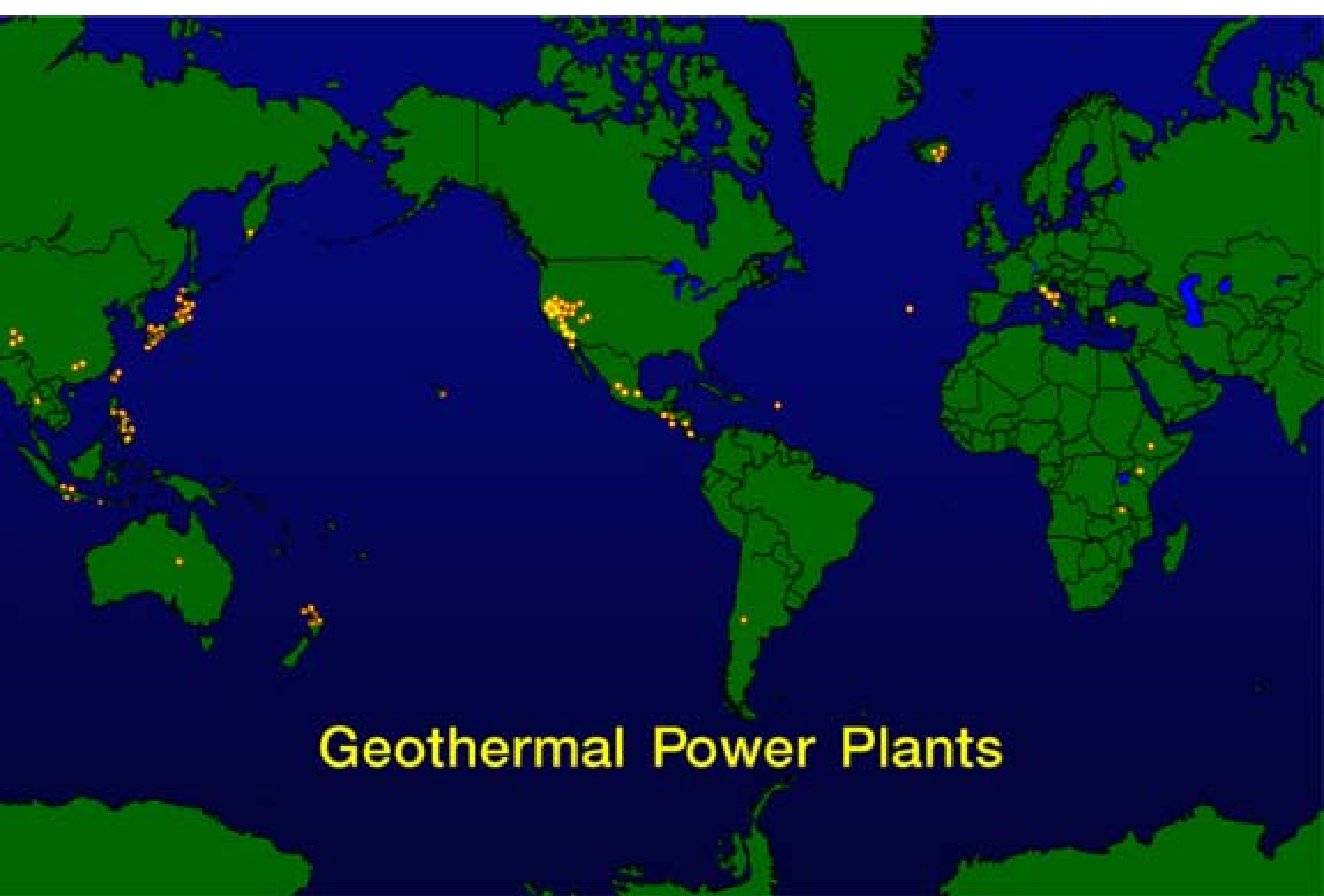
<http://www.unocal.com/geopower/power.htm>

# Turbine Generator



# U.S. Geothermal Potential





# Geothermal Power Plants

# Geysers Dry Steam Geothermal Plant



Largest plant  
In the world

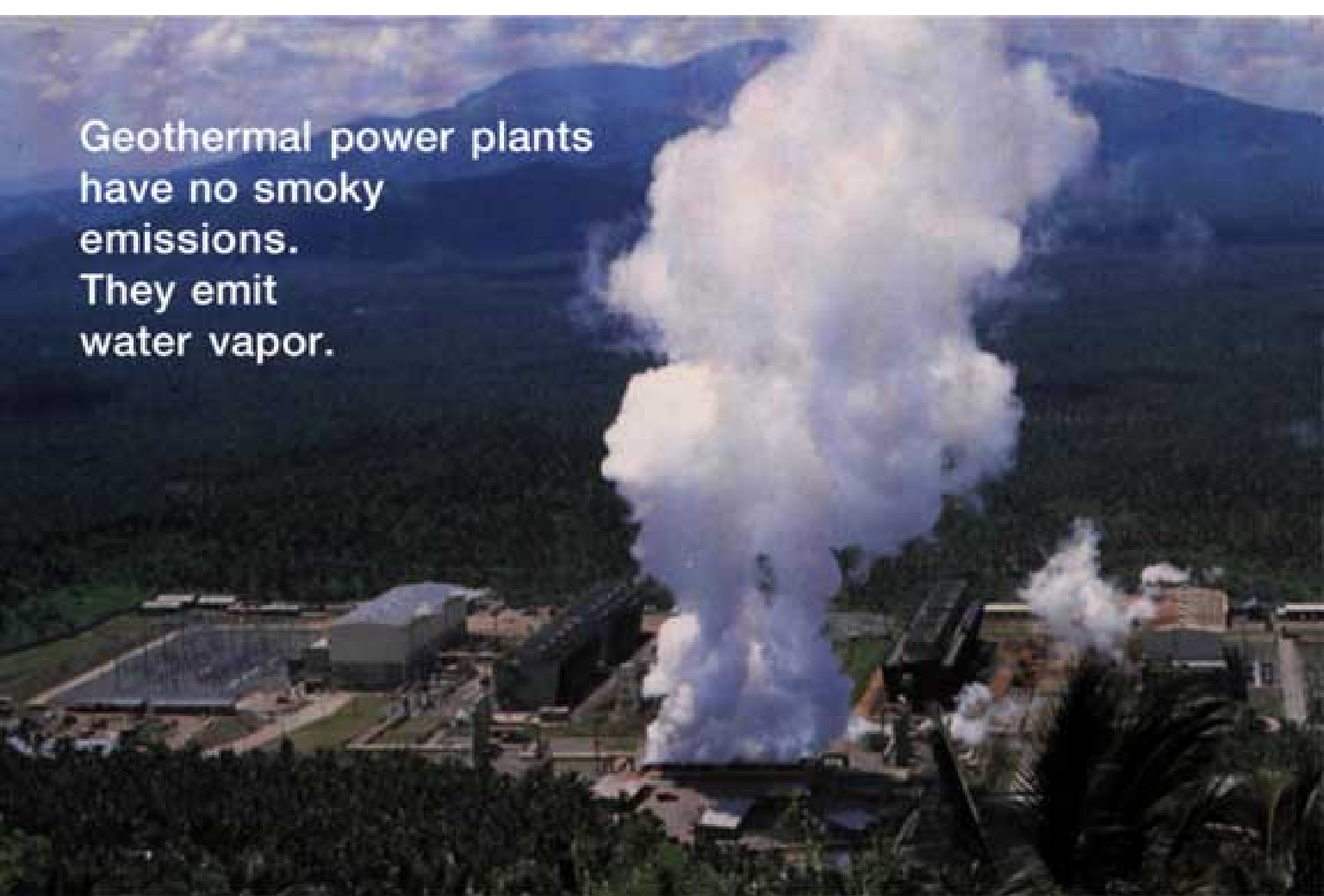
Produces  
2000 megawatts  
From 14 units

- <http://www.ldeo.columbia.edu/users/menke/ENERGY/GEOTHERM/img16.html>

# ***Geothermal***

- California about 10%
  - ‘The Geysers’ geothermal field
- Hawaii’s Big Island 25%
- The Philippines 27%

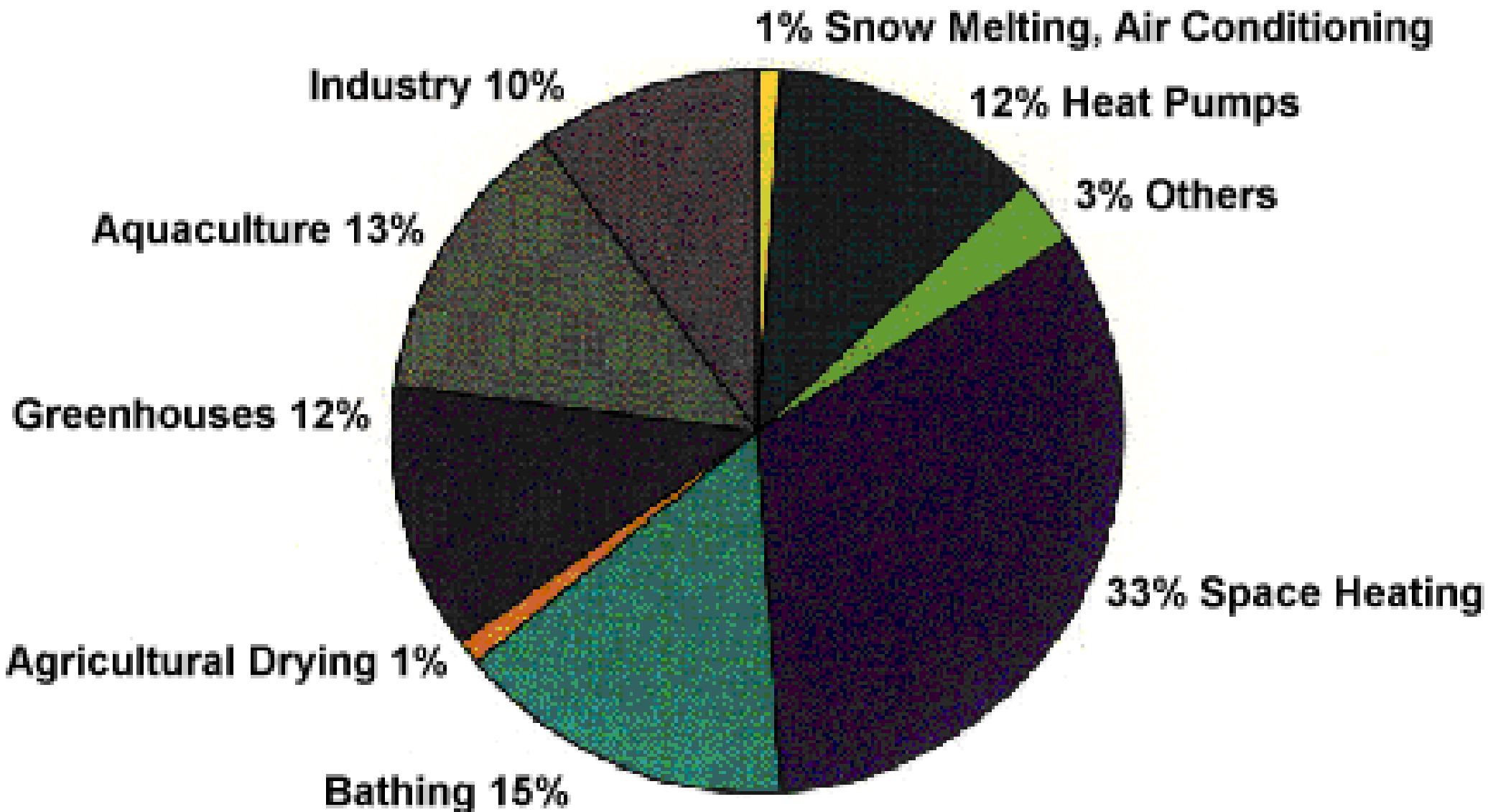
Geothermal power plants  
have no smoky  
emissions.  
They emit  
water vapor.



# ***Geothermal***

- Advantages
  - No pollution
  - No CO<sub>2</sub> added to atmosphere
- Disadvantages
  - Water is corrosive
  - Steam is depleted from hot reservoirs

# Direct-Heat Uses



*World's First* **COMMERCIAL  
FOOD DEHYDRATION PLANT**

TO BE OPERATED WITH GEOTHERMAL ENERGY

SCHEDULED FOR OPERATION SEPT. 1978

FINANCING BY  
NEVADA NATIONAL BANK  
WELLS FARGO. N.A.

LOAN GUARANTEED BY  
U.S. DEPARTMENT of ENERGY

OWNERS & DEVELOPERS  
GEOTHERMAL  
FOOD PROCESSORS, INC.

Brady Hot Springs, northern Nevada, dries onions for Burger King

<http://geothermal.marin.org/GEOpresentation/sld087.htm>



Reykjavik Using Fossil Fuels

## Reykjavik in the 1930s

<http://geothermal.marin.org/GEOpresentation/sld094.htm>



## Reykjavik Using Geothermal

Reykjavik today

<http://geothermal.marin.org/GEOpresentation/sld095.htm>





<http://www.worldbank.org/html/fpd/energy/geothermal/>



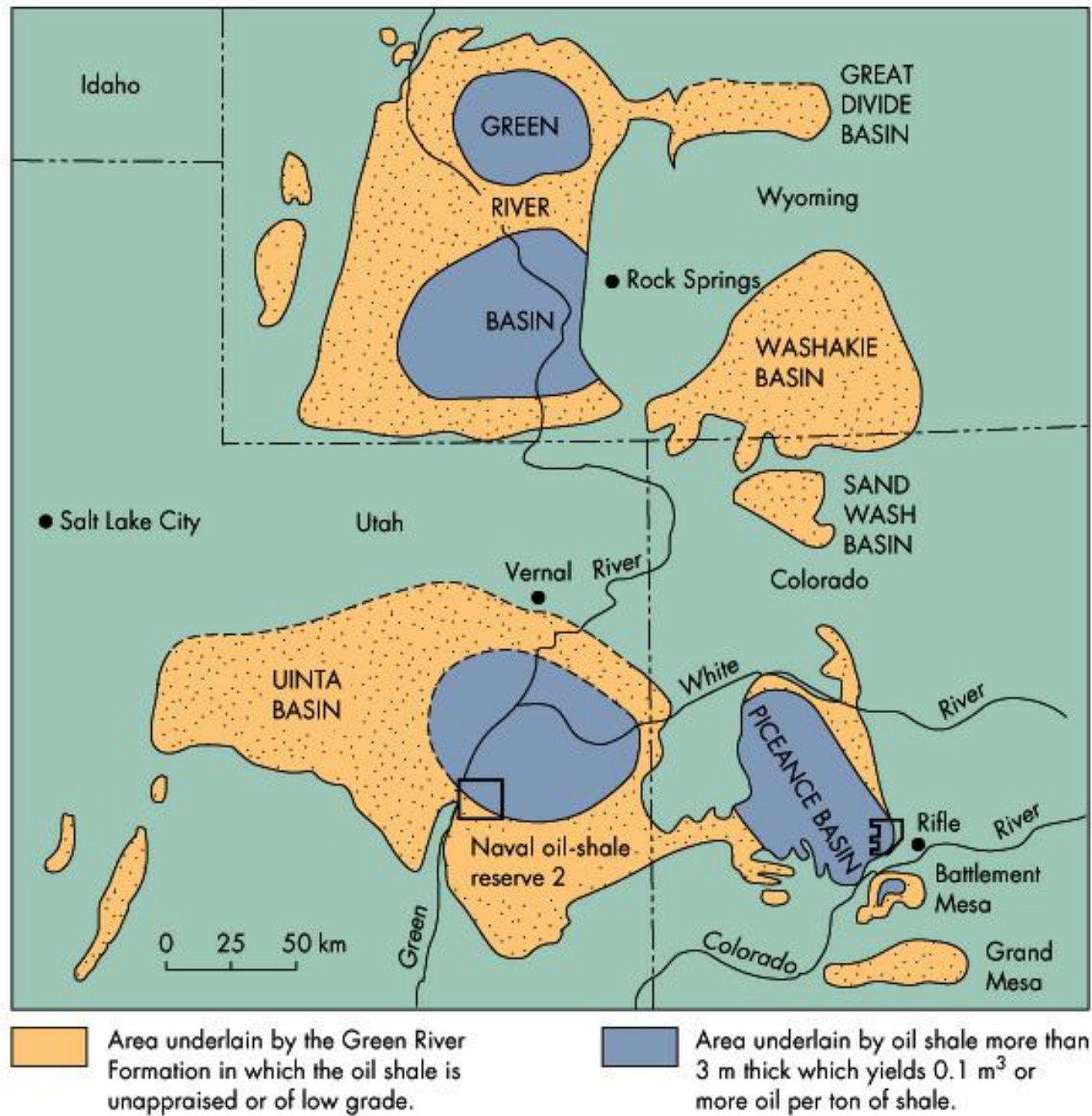
<http://geothermal.marin.org/GEOpresentation/sld082.htm>

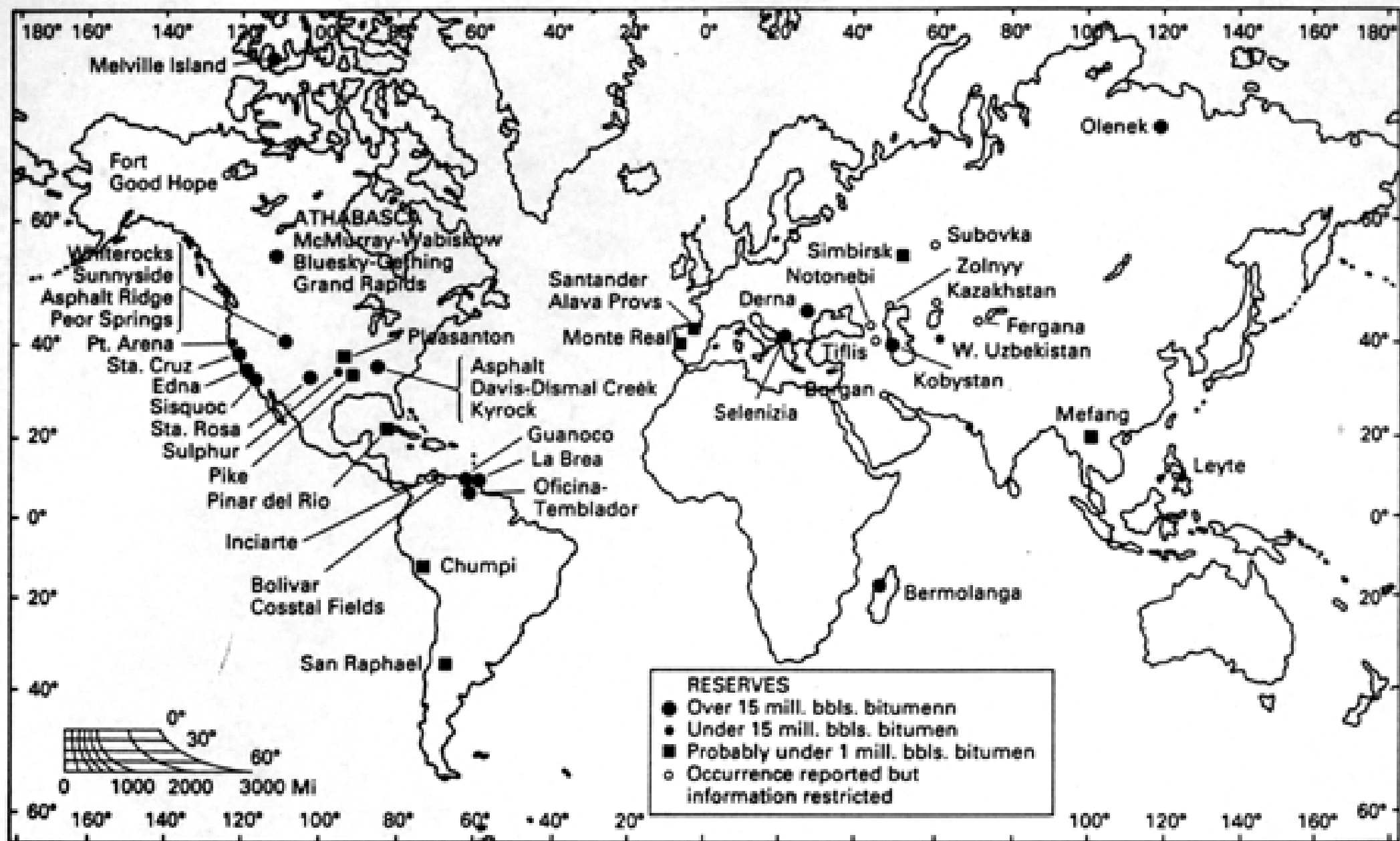


# ***Oil Shale***



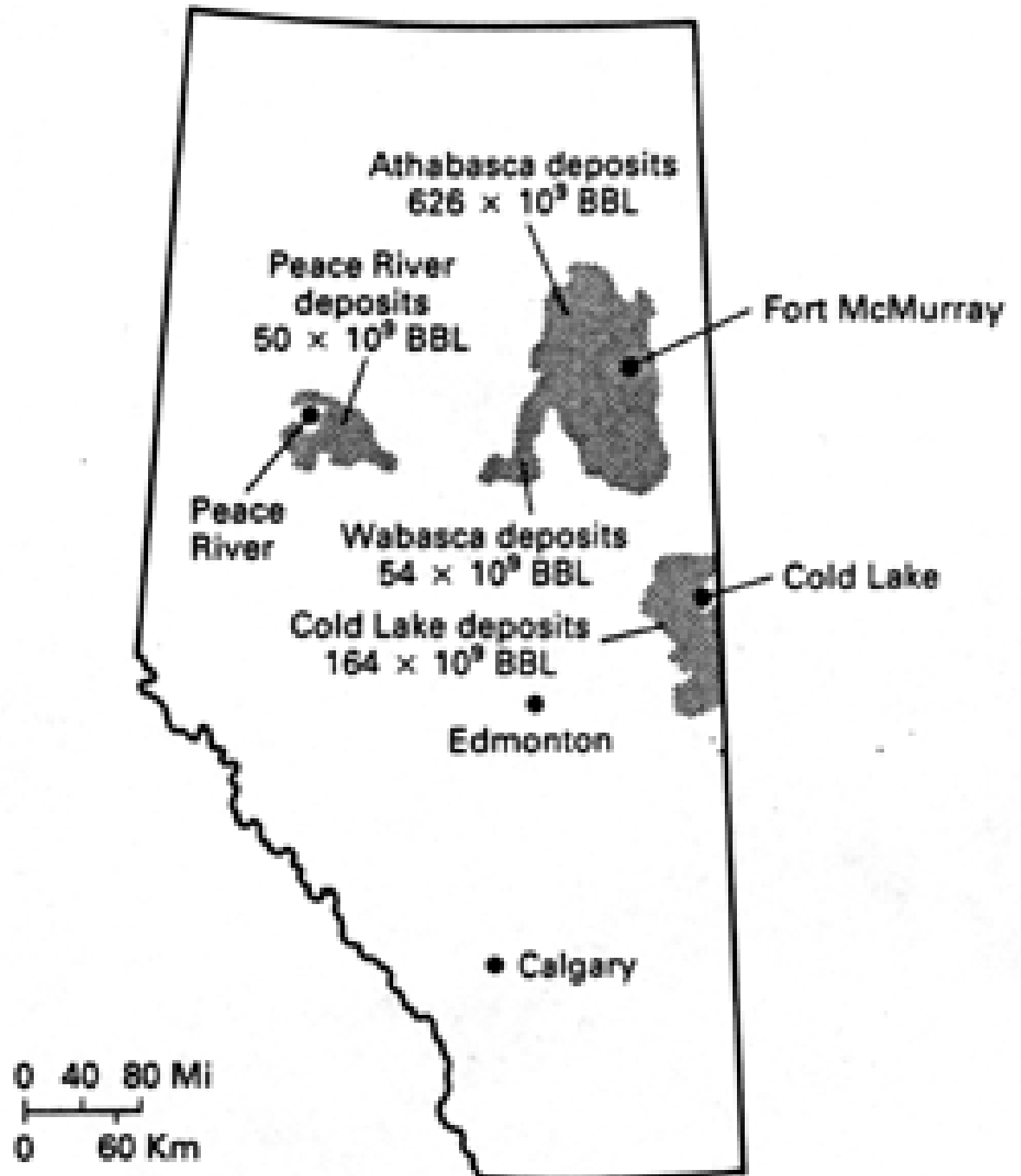
# Green River Oil Shale





<http://www.ideo.columbia.edu/edu/dees/U4735/projections/pitman/5.55.tarsand.gif>

# *Athabasca Tar Sands*



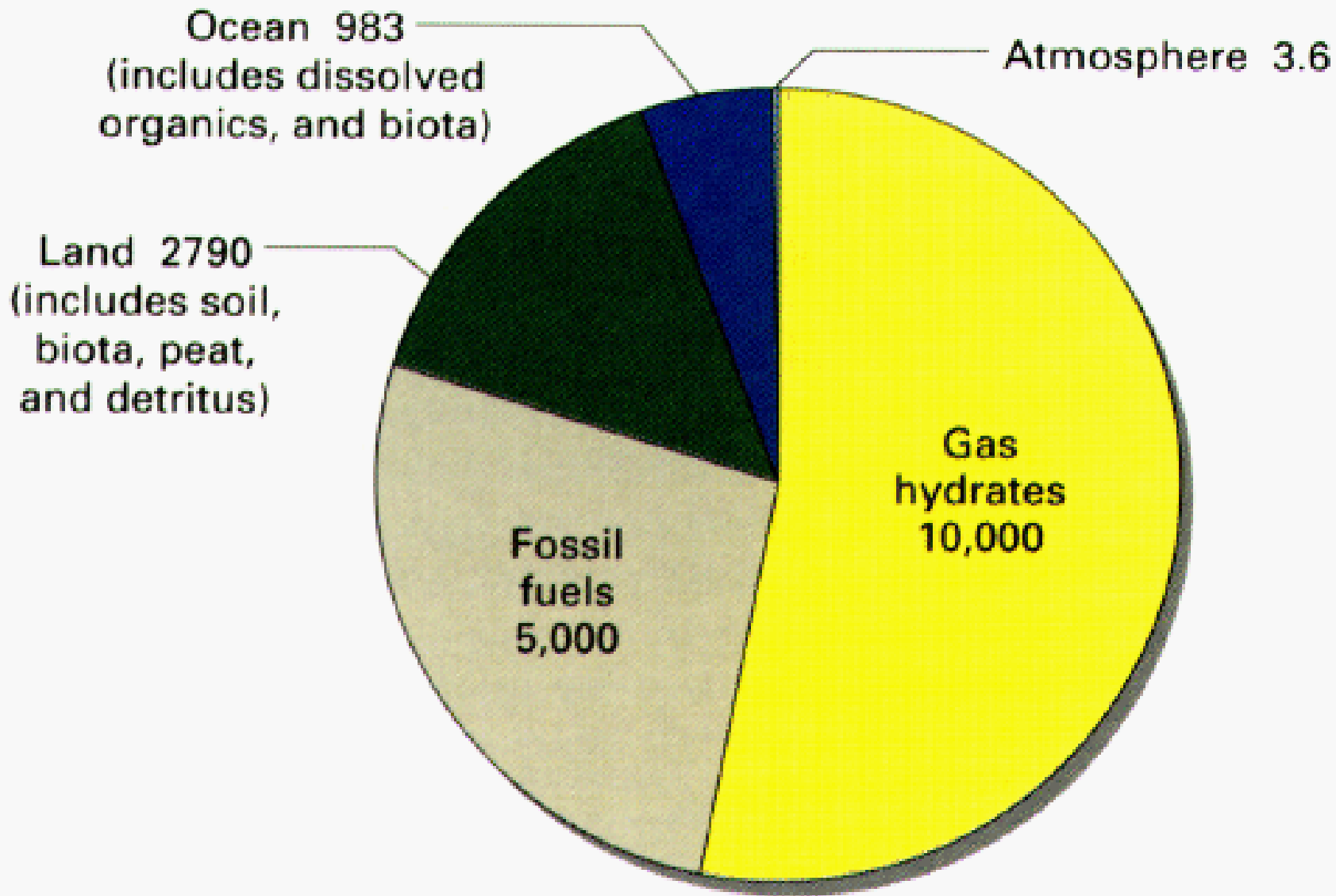
<http://www.ideo.columbia.edu/edu/dees/U4735/projections/pitman/5.55.tarsand.gif> (b)



[http://www.protectowire.com/images/applications/profiles/electric-shovels/tar\\_sands\\_lg.jpg](http://www.protectowire.com/images/applications/profiles/electric-shovels/tar_sands_lg.jpg)

# ***Methane Hydrate***

- Natural ices of methane and water
- Formed in permafrost and below 300 meters in ocean sediments
- Probably 100 times cubic feet of methane hydrate compared to natural gas in US
- Thaws to over 150 times its volume of methane



*Distribution of organic carbon in Earth reservoirs (excluding dispersed carbon in rocks and sediments, which equals nearly 1,000 times this total amount). Numbers in gigatons ( $10^{15}$  tons) of carbon.*

# ***Coal Gasification***

- Convert coal to methane
  - $C + 2 H_2 \rightarrow CH_4$
- Use coal to make hydrogen
  - $C + H_2O \rightarrow CO + H_2$
- Convert coal to methanol alcohol
- All these are fuels that can be utilized today

# ***Coal Gasification***

- Removed most pollutants in coal
- More easily transported than solid coal
- More efficient than burning coal
- Can contain or eliminate CO<sub>2</sub>
- Very promising technology

# *Hydrogen*

- More energy than any other fuel
  - $2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O} + 572 \text{ kJ heat energy}$
- WATER is the reaction product—clean!
- Can be distributed in presently existing pipelines
- But isn't hydrogen DANGEROUS??

# *Hindenburg explosion*



- <http://www.altavista.com/web/results?itag=wrx&q=Geysers+Geothermal+Plant&kgs=1&kls=0>

# ***Hydrogen safety facts***

- Escapes easier than natural gas
- Smaller molecules dissipate more readily
- Lighter than air so doesn't form pools of invisible explosive gas
- Natural gas is explosive too

# *Hydrogen Technology*

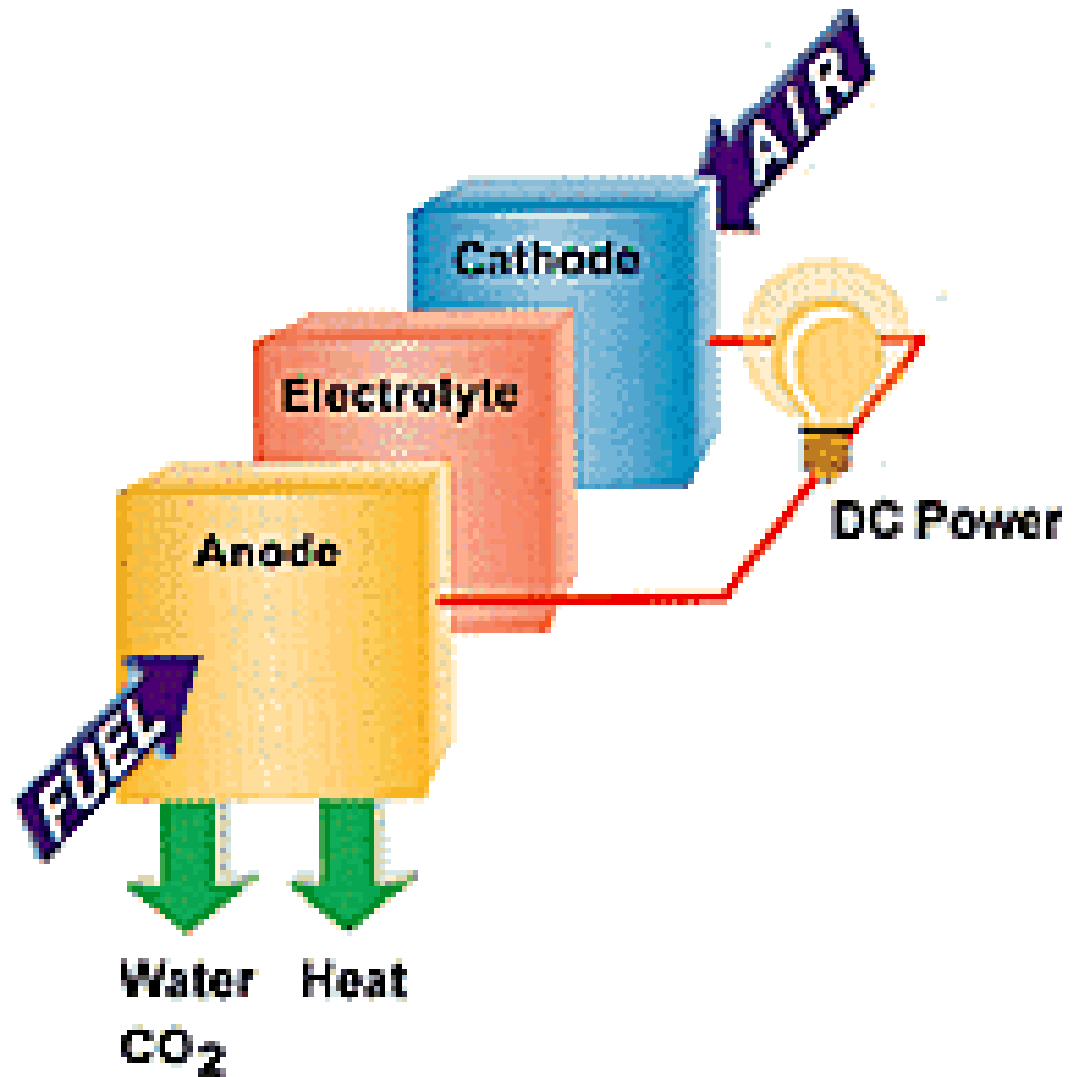


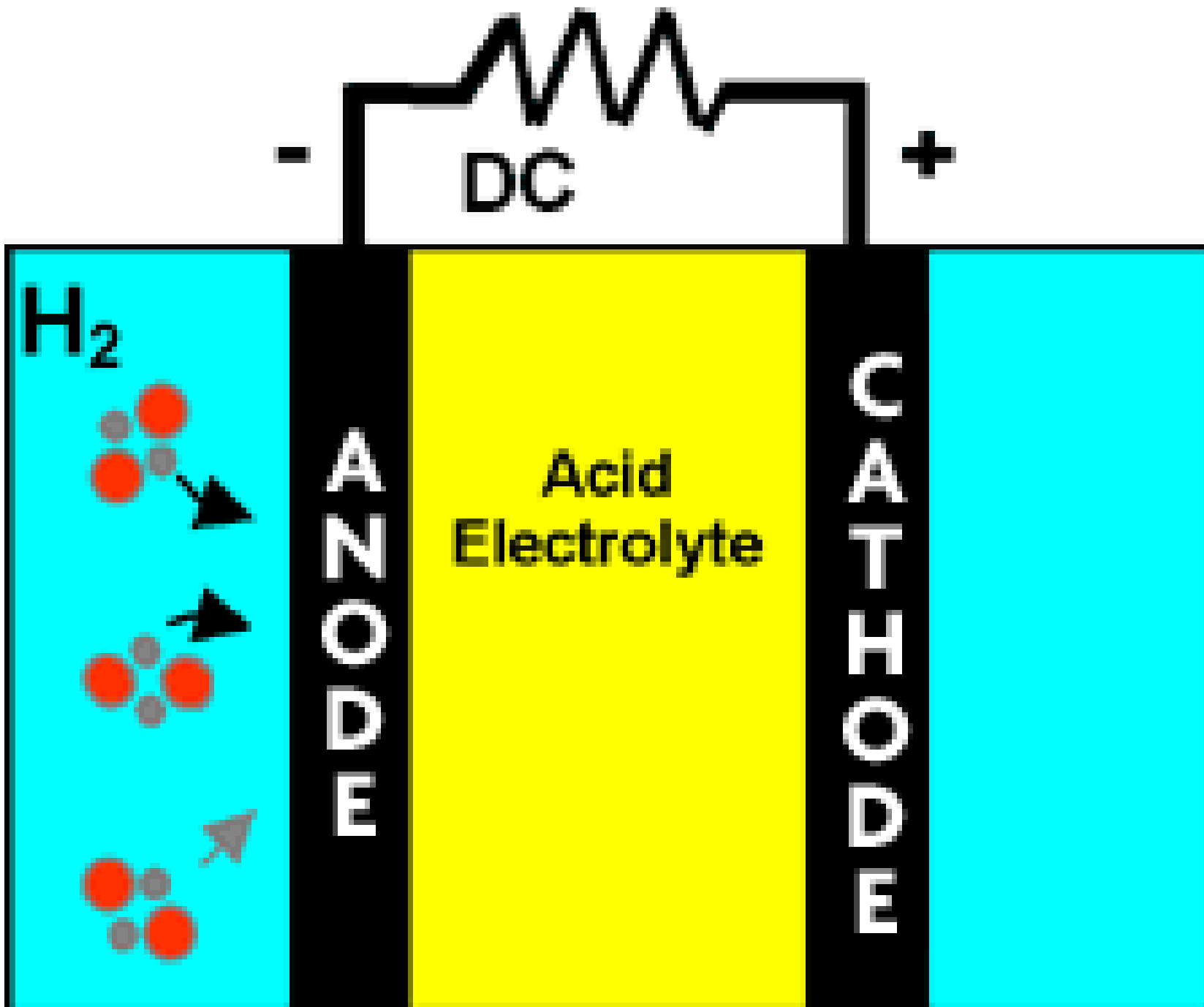
<http://www.bmwusa.com/Standard/Content/Uniquely/FutureTechnologies/Hydrogen.aspx>

# *Fuel Cells*

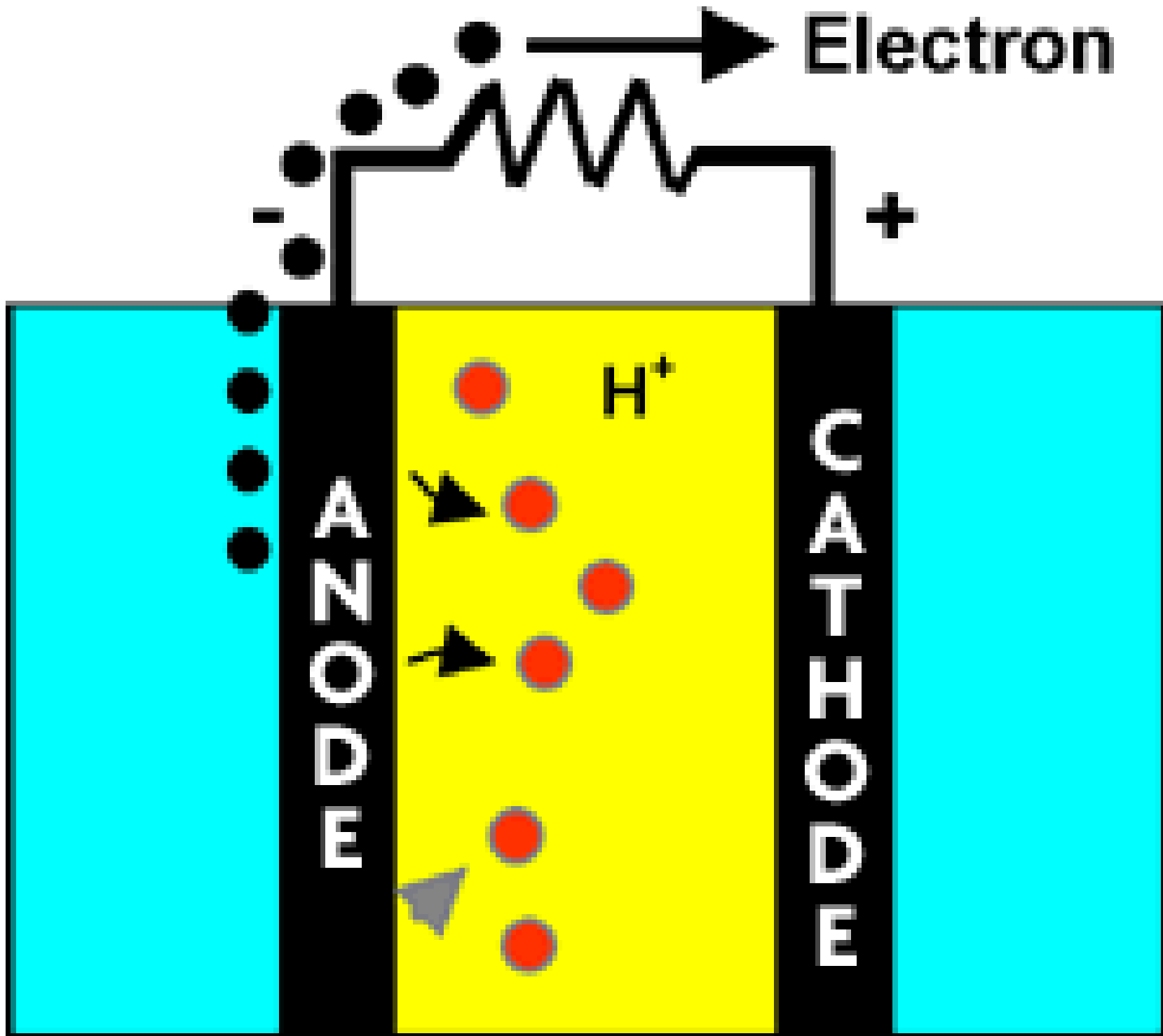
Release  
electrons in  
reaction of  
hydrogen and  
oxygen

Does not release  
carbon dioxide

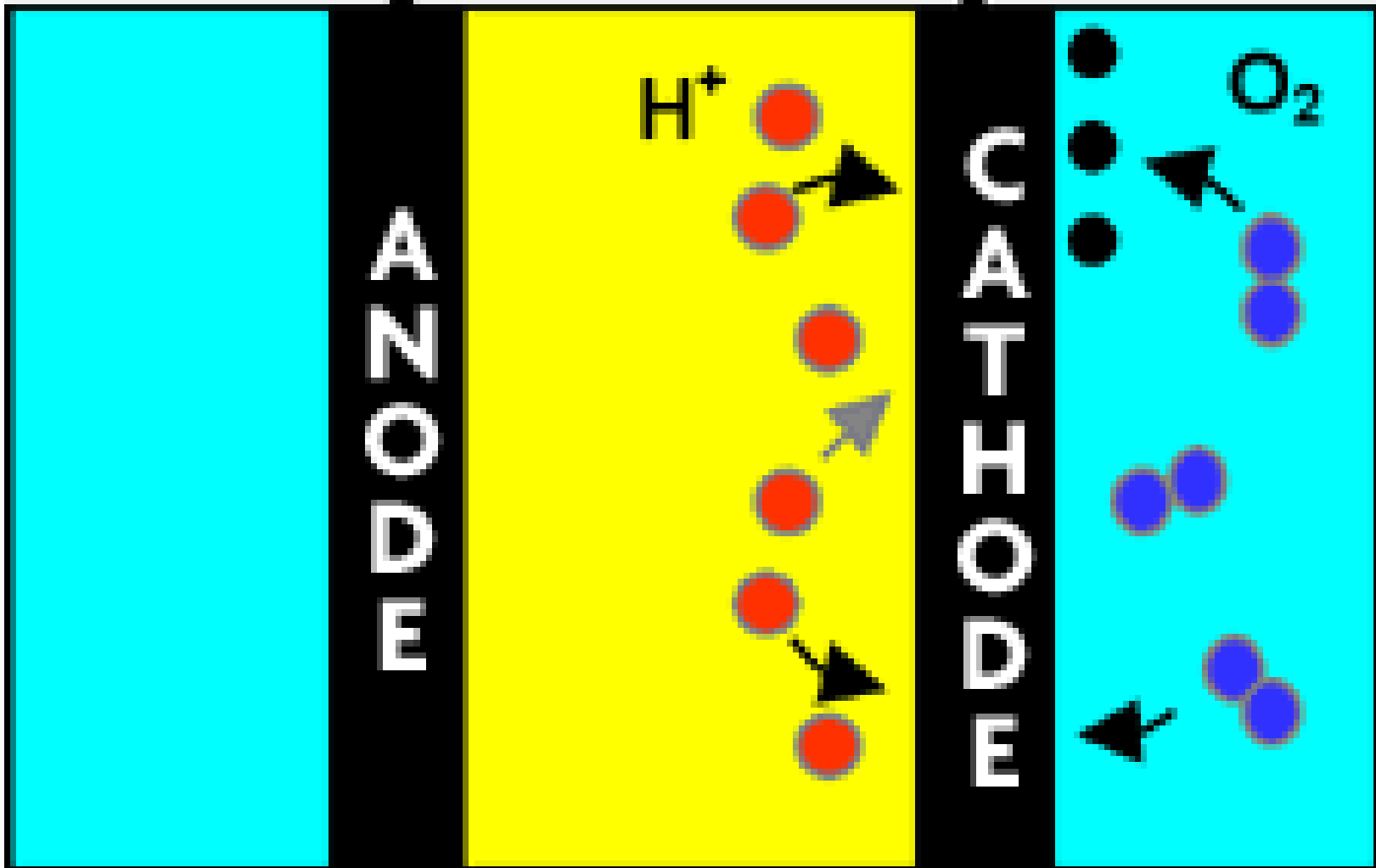




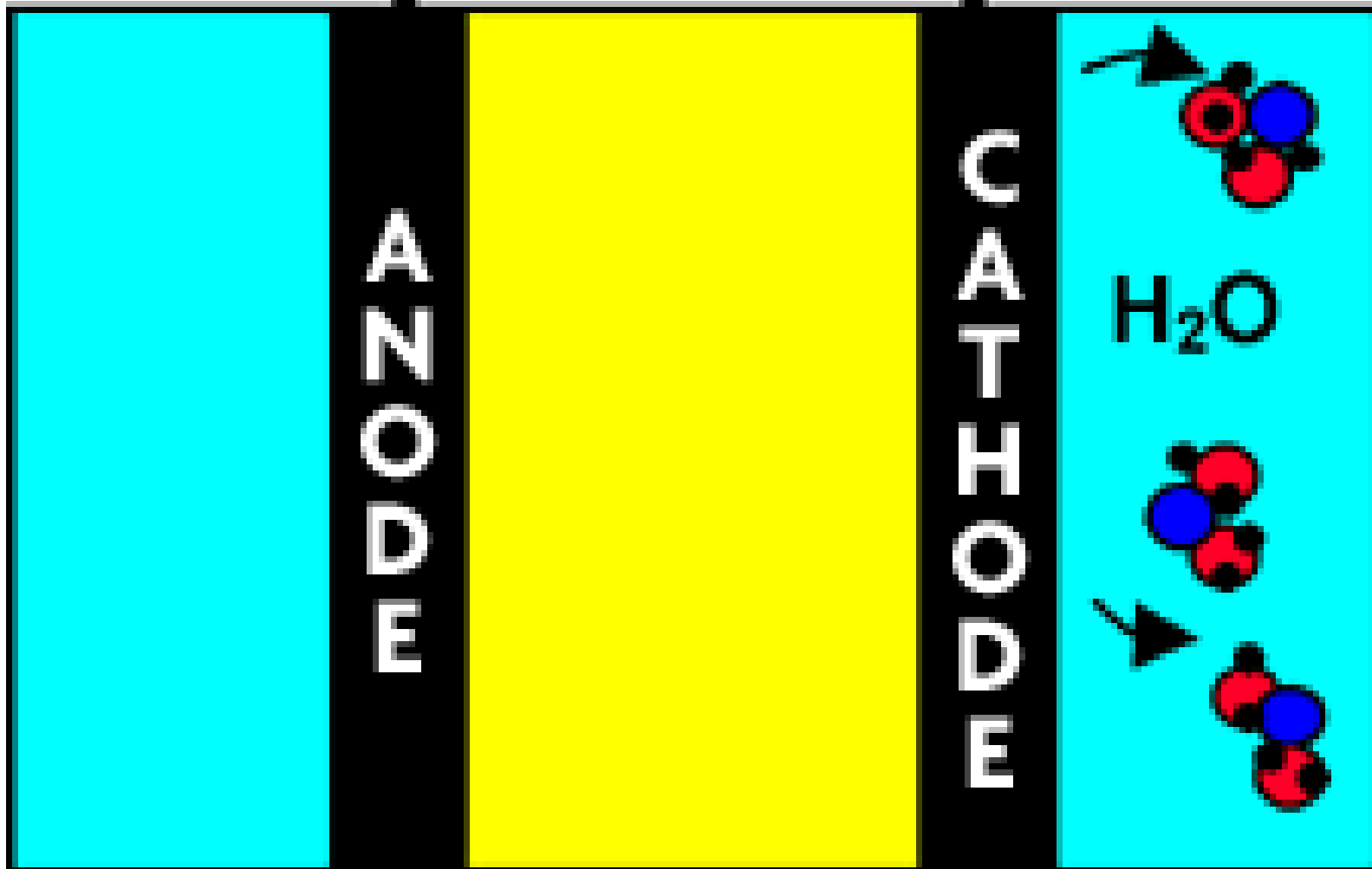
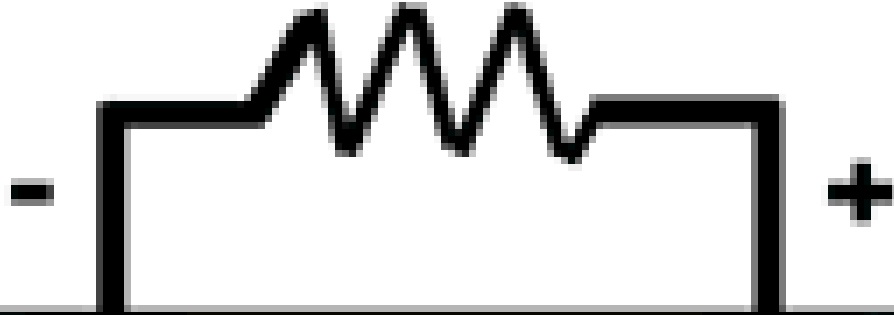
- <http://www.worldpress.org/europe/0123iceland.htm>



Electron



Electron



# *Fuel Cell Vehicles*

- General Motors

