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Idaho National Laboratory
Battelle Energy Alliance
Department of Energy

# Energy and Water-Globally and Locally

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# Demand for Electricity and Water is Outpacing Supply

# Global Population 2,000 Years Ago

# Global Population 1,000 Years Ago

# Global Population 1800

# Global Population 1927

# Global Population 1960

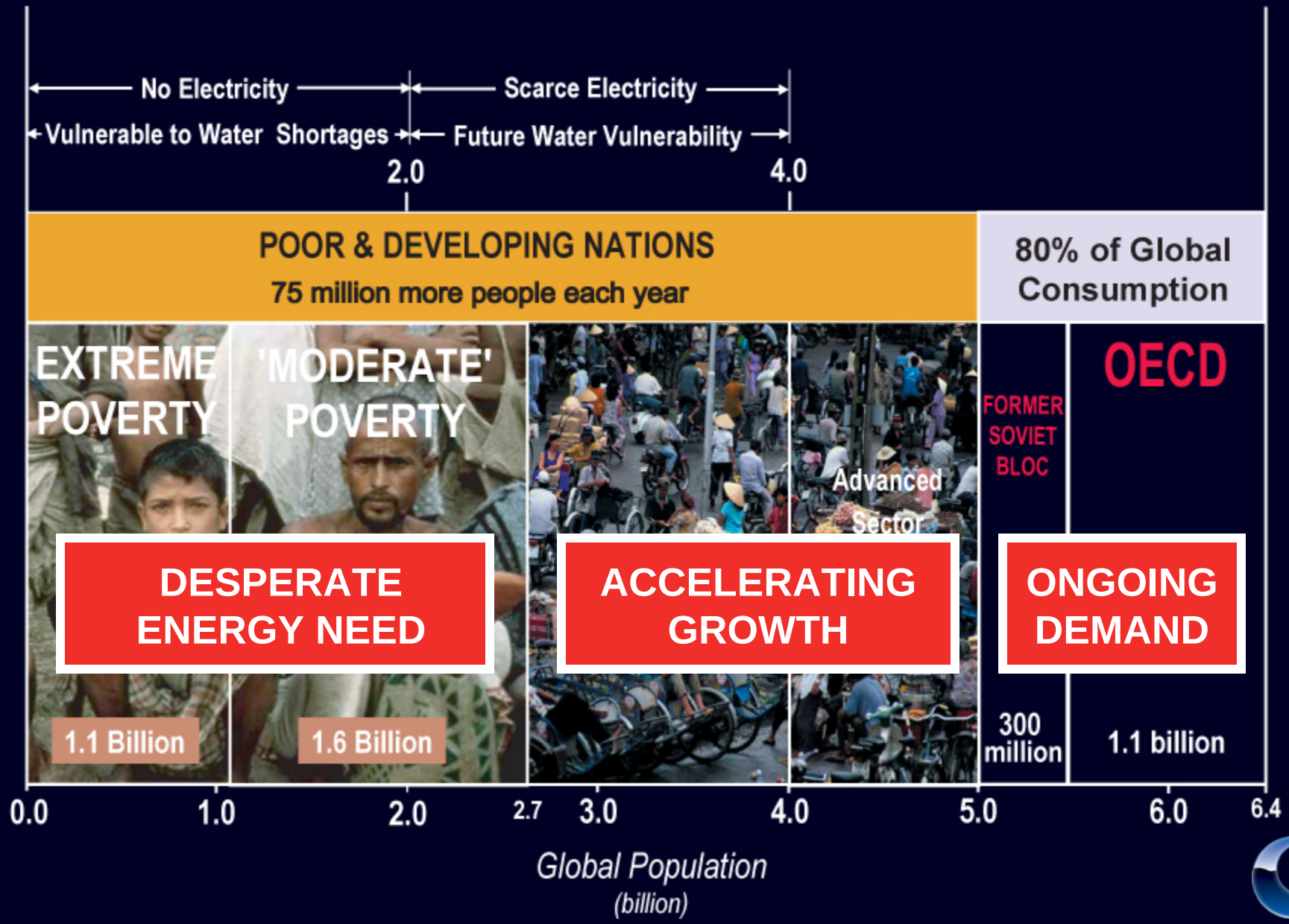
# Global Population 1974

# Global Population 1987

# Global Population 1999

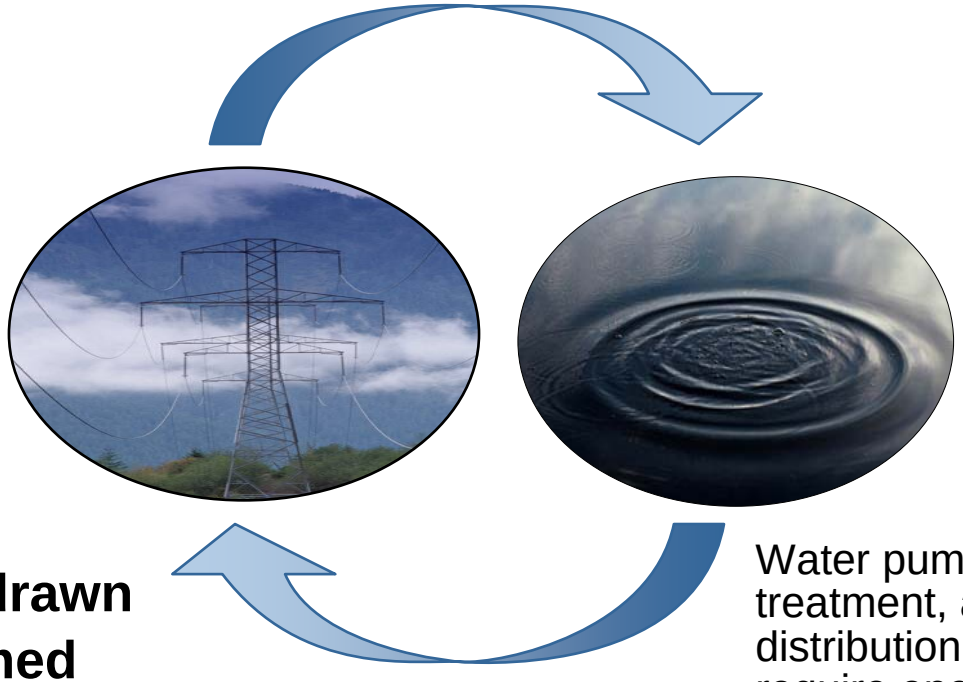
# Global Population 2050

# A World of Extremes



# Energy and Water are Inextricably Linked

Energy production and generation require water – thermal electric power generation is the second largest user of water in the United States



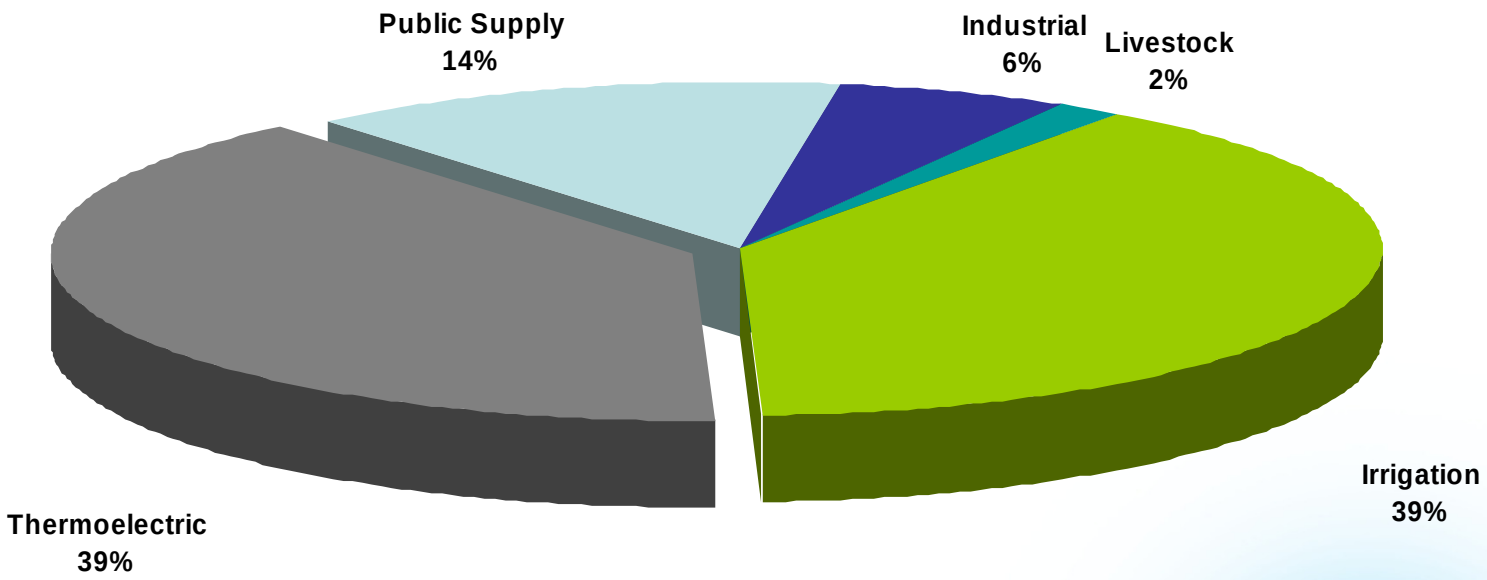
Water pumping, treatment, and distribution require energy – 80% of the cost of treating, processing and pumping water is for energy

- **Power Plants**
  - **132,000 Mgal/day withdrawn**
  - **3,000 Mgal/day consumed**
- **Irrigation**
  - **134,000 Mgal/day withdrawn**
  - **81,399 Mgal/day consumed**

Source: "Estimated Use of Water in the United States in 1995," USGS Circular 1200, 1998

# As Much Freshwater Is Used For Producing Electricity As For Irrigation

## Estimated Freshwater Withdrawals by Sector, 2000




Source: USGS Circular 1268, March, 2004

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# Figures on Energy-Water in the United States

- In the United States 2 gallons of water are evaporated for every kilowatt-hour of electricity produced by hydroelectric and thermoelectric stations
- We use as much water turning on the lights and running our appliances as is used directly in taking showers, drinking water and watering lawns
- In 2000, agriculture and thermoelectric production used equal withdrawals of freshwater
- Electricity production requires 136 billion gallons of freshwater per day accounting for 40% of the total withdrawals
- The U.S. used 123 billion kWh to supply water and treat wastewater just under 4% of the total electricity sales

# By 2020 our growing population will require 393,000 megawatts of NEW generating capacity

- This requires 1,300 to 1,900 new power plants – more than one built each week
- Water will become a critical issue for the power industry
- Population grows, energy demands increase, and freshwater supplies remain constant, which means less water
- Population shifts without regard to water (25% growth in intermountain west, 2% growth in Northeast)
- Growing population consumes more food, with the two largest water users- energy and agricultural producers, further complicates the problem

# Critical Water Challenges

**Idaho Denies Water Rights Request for Power Plants**

- *U.S. Water News Online, August 2002*

**New Mexico Utility Plans to Increase Power, Use No More Water**

- *Albuquerque (NM) Journal, June 2003*

## Water in the U.S. is already allocated for energy, agriculture, and other needs

- Ensure that limited water supplies do not hinder development of future energy supplies
- Minimize water-related energy needs
- Protect interdependent activities (transport, recreation, etc.) from water used for energy

# Water in West is Linked Climatically

- Rivers and groundwater fed by snowmelt
- Timing of snow fall and amount of snow pack impact availability for:
  - Irrigation
  - Power production

# Water and energy security: What's up in Idaho?

**"Solving Idaho's water crunch: Will it work? A bad deal for Idaho's taxpayers" (4/05)** *Water rights, fallowing fields*

> The reason values for the Bell Rapids irrigated farmlands are so low is because it can cost as much as $200/acre per year for the electricity to pump the water more than 600 ft. vertically from the Snake River to the fields…. (editorial, J. Marvel)

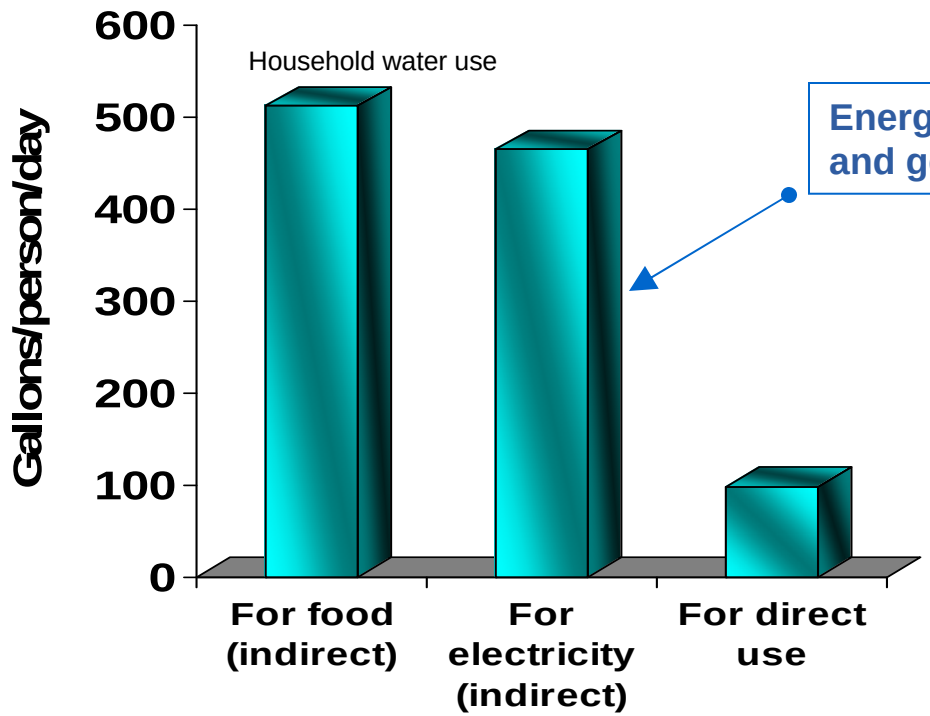
**"Idaho Power jumps into water conflict" (2/05)** *Surface/groundwater*

> "It is clear that extensive groundwater pumping has contributed significantly to the declines," in the river, which hurts Idaho Power's ability to generate power, attorney Jim Tucker said in his letter… (Times-News)

**"Officials rehash salmon plan" (6/05)** *Environment vs. power*

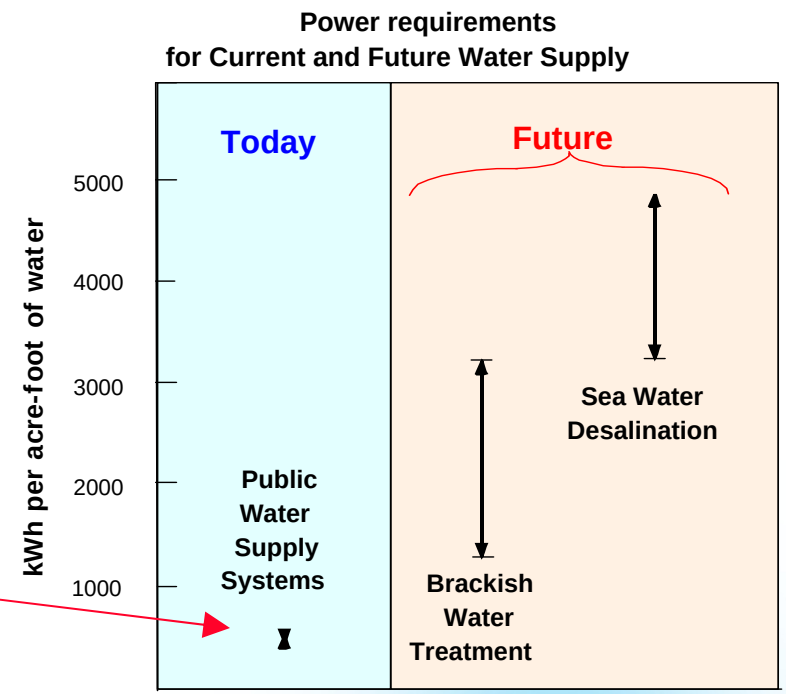
> Federal agencies and the governors of Idaho, Washington, Oregon and Montana are trying to forge a salmon-protection plan that would meet a federal judge's approval and preserve cheap Northwest hydro power…The federal dams tied up in the lawsuit provide nearly half of the electricity that powers the nearly $400 billion economies of the four states.

# Energy and Water Issues are Interrelated and complex




**Energy requires water for production and generation**

Water requires energy for pumping, treating and delivery and will need more in future




## So what are our energy choices?

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# Domestic and Imported Oil

- Facts and Figures:
  - **U.S. consumes ~21 million barrels of oil per day (25% of the worldwide daily total)**
  - **In 1970 we imported 28% of our transportation fuels, today we import ~68%**
  - **Oil provides 40-43% of all energy use worldwide - transportation consumes 70% of that**
- Pros:
  - **Relatively cheap; widespread; highly portable; markets well-established; enables worldwide commerce through its use in transportation sector**
- Cons:
  - **Most remaining supplies controlled by governments through state-owned oil companies; limited supplies remain at current worldwide pricing; U.S. must rely on foreign sources for a majority of our oil needs; high $CO_2$ production—contributes significantly to global warming**
- What is Needed:
  - **New extraction technologies to recover more oil**

***Bottom line:*** *Because of our strong reliance, oil will remain an crucial part of any future energy portfolio. But submitting our economic future to a commodity over which we have so little price and supply control is, at best, deeply risky. Economic reliance on oil imposes morally difficult and costly foreign policy scenarios, threatens our national security, and heightens global warming.*

# Biofuels

- Facts and Figures:
  - **If all possible arable acres of land in the U.S. (~427 million acres) grew corn strictly for ethanol production, at current yields ethanol would satisfy only 12% of transportation fuel demand**
  - **Ethanol currently represents just over 2% of gasoline sold**
  - **Studies indicate full-scale cellulosic ethanol could be produced for 60 cents per gallon**
- Pros:
  - **Domestic production; burn cleaner than fossil fuels; biodiesel can utilize current distribution systems and run in current diesel motors**
- Cons:
  - **Possible compromise of food supplies; no high-volume distribution system for ethanol; ethanol requires "flex fuel" engines**
- What is Needed**:**
  - **Breakthroughs in production of cellulosic ethanol**
  - **Incentives are needed to properly value biofuels**

***Bottom line:*** *Despite some limitations, biofuels offer a domestic source of liquid transportation fuels, and are therefore an important component of any future transportation fuel portfolio. However, production needs to be optimized to create the greatest amount of biofuel possible per acre of feedstock.*

# Wind

- Facts and Figures:
  - **Wind produced 0.44% of U.S. electricity in 2005**
  - **Wind farms currently produce power at a cost of 6-9 cents per kWh**
  - **2/3 of worldwide wind production capacity is located in Europe**
- Pros:
  - **Environmentally friendly and sustainable; low cost projections**
- Cons:
  - **Areas of greatest generation are not well-aligned with load centers creating a need for infrastructure enhancements; can be inconsistent; harm to migratory birds; visibility**
- What is Needed:
  - **Storage methods need to be developed to increase reliability of wind**
  - **Multi-billion dollar infrastructure projects needed**
  - **Government incentives needed to properly value wind as a means of avoiding fossil fuel usage**

***Bottom line:*** *Committing to wind power on a large scale would require expensive power distribution infrastructure enhancements, and most likely a means to store wind power so that it is a more consistent source. Smaller-scale implementations could be designed to provide intermittent power locally, but would provide much less impact on the national energy portfolio.*

# Solar

- Facts and Figures:
  - **Solar power produced 0.01% of the U.S. electricity supply in 2005**
  - **Photovoltaic solar installations currently produce power at a cost of 26-35 cents per kilowatt hour**
  - **Utility-scale Concentrated Solar Power installations produce power at a cost of 9-12 cents per kilowatt hour**
- Pros:
  - **Abundant source of energy; environmentally friendly; fairly stable; the times of day with the greatest solar potential coincide with "peak loads"; proven technology with favorable economics**
- Cons:
  - **Panels still expensive; additional electricity transmission infrastructure is lacking, utility-scale solar installations are feasible only in certain areas of the country**
- What is Needed:
  - **Enhancements to traditional solar panel design**
  - **More federal tax credits to incentivize usage**

***Bottom line:*** *Solar power holds the potential for both incremental gains as a power source for individual home owners as well as utility-scale concentrated solar power installations. Location and equipment costs remain primary concerns. Breakthroughs in solar cell design (particularly in materials) could pave the way for cost competitive solar installations across the country.*

# Coal

- Facts and Figures:
  - **Coal power produced 49.7% of the U.S. electricity supply in 2005**
  - **A plant brought online in 2015, using today's technology is expected to produce power for about 5.31 cents per kWh**
  - **The U.S. has demonstrated coal reserves of approximately 496 billion tons of coal (more than any other country in the world)**
  - **Consumption of coal worldwide is expected to increase 71% between 2004 and 2030**

- Pros:
  - **Abundant reserves; cheap and stable cost; well-known technology**
- Cons:
  - **Environmentally unfriendly; coal fired plant technology doesn't allow for shut downs; cleaner burning coal and carbon sequestration technology are expensive**

- What is Needed:
  - **Further research on methods to burn coal more cleanly**
  - **More research needs to be done to determine the feasibility and location of carbon sequestration**
  - **At the present time, utility companies have no incentive to sequester carbon or install-burning coal equipment**

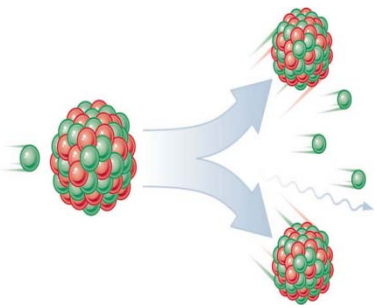
***Bottom line:*** *Because coal is abundant in the U.S., relatively easy and inexpensive to extract, and not laden with foreign policy and national security issues, it will no doubt be an important part of a future energy portfolio for the U.S. However, there is justifiably strong public support for ensuring that the environmental effects of coal use are minimized, creating the need for cleaner burning coal technologies as well as carbon sequestration.*

# Natural Gas

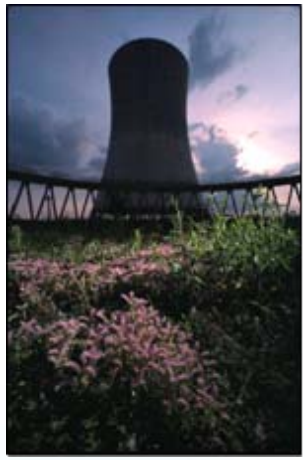
- Facts and Figures:
  - **Natural gas power produced 19.1% of the U.S. electricity supply in 2005, and contributed to 13.5% of electricity generation carbon dioxide emissions**
  - **A plant brought online in 2015, using today's technology without carbon capture, is expected to produce power for about 5.25 cents per kilowatt hour**
- Pros:
  - **Reasonable supplies domestically; burns cleaner than coal; distribution infrastructure and markets are well-established**
- Cons:
  - **Prices can be volatile; not a sustainable, renewable energy source; although relatively clean, still emits greenhouse gases**
- What is Needed:
  - **Incentives and technology breakthroughs needed**
  - **Infrastructure needs**

***Bottom line:*** *Natural gas will remain a cleaner power generation alternative to coal in the near-term, and the availability of domestic supplies will make it an important part of a future national energy portfolio. However, the volatile price of natural gas has economic consequences, and greenhouse gas emissions as well as the threat of supply disruption will remain areas of concern.*

# Nuclear



- Facts and Figures:
  - **Nuclear power produced 19.3% of the U.S. electricity supply in 2005, and 70% of the carbon free supply**
  - **A plant brought online in 2015 is expected to produce power for about 5.91 cents per kilowatt hour**
  - **Known uranium reserves would only supply worldwide energy needs for 5-25 years using current technologies**
- Pros:
  - **Environmentally friendly; stable cost**
- Cons:
  - **Long permit and construction waits; uranium is a finite resource; radiation exposure threat; legacy waste issues**
- What is Needed:
  - **Technology developments to extend usability of nuclear fuel**
  - **Monetary incentives to acknowledge nuclear's environmental friendliness**



***Bottom line:*** *Although some risk remains, the safety of new nuclear installations is much greater than in the past when public perception turned against nuclear power after several highly public failures. Nuclear installations are not a short-term solution, as conception to power generation takes 10-15 years due to a cumbersome federal permitting process. The significant issues such as uranium waste, uranium supply, and power plant life spans need to be adequately addressed.*

# Conservation & Alternative Energy Sources Cannot Meet the Demands

- **Renewable/sustainable energy sources supply only 2% of U.S. electricity**
- **Conservation and diverse energy technologies could potentially save 33% of current energy consumption if implemented over 10 years. This is slightly greater than current U.S. oil imports**
- Conservation and use of renewables can help but cannot meet global energy demands:
  - Solar: **high land use demands, not cost-effective in all areas of the world**
  - Wind: **high maintenance, high land use demands, harmful to migratory fowl, not effective everywhere**
  - Biofuels: **requires fossil fuel input, displaces a food source**
  - Hydro: **limited remaining siting locations, impeding spawning routes of fish**

# The Crucial Premise for Action

Humankind cannot conceivably achieve a global clean-energy revolution without a huge expansion of nuclear power

- **To generate electricity**
- **To produce battery power and possibly hydrogen for tomorrow's vehicles**
- **To desalinate seawater in response to the world's rapidly emerging fresh-water needs**

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# A Balanced Energy Portfolio is Needed for Our Future

***<u>ALL</u> concentrated and large-scale forms of energy generation have costs, risks, and environmental impacts***

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