

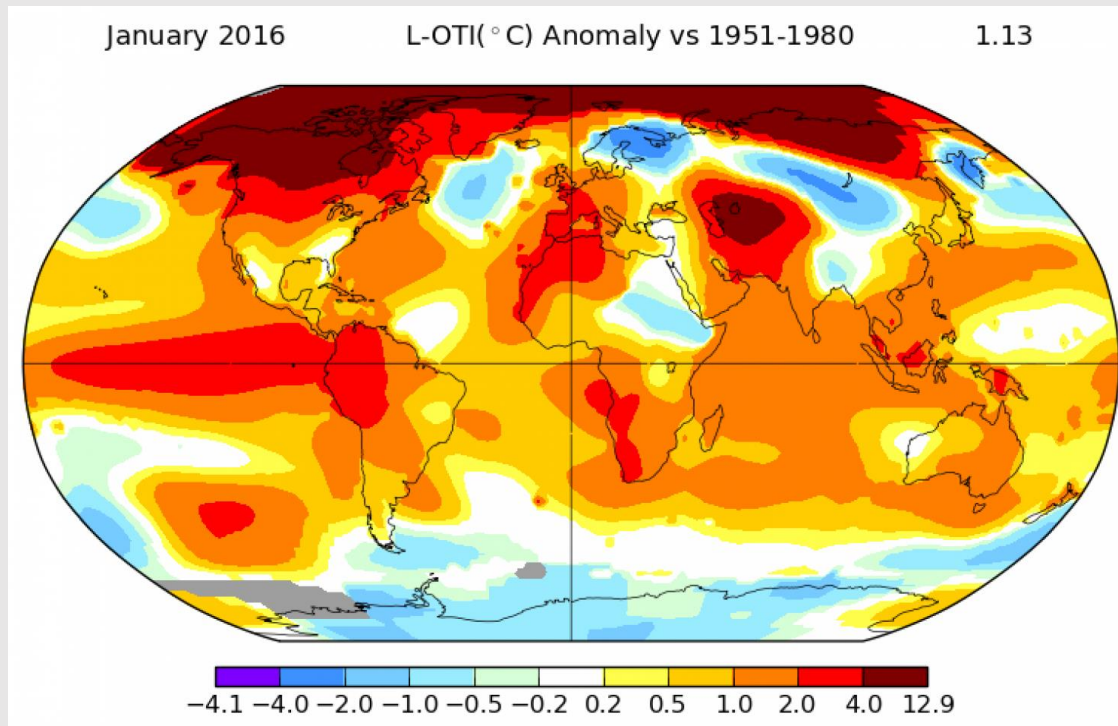
# Scientists Are Floored By What's Happening in the Arctic Right Now

Washington Post, 2/18/16

<https://www.washingtonpost.com/news/energy-environment/wp/2016/02/18/scientists-are-floored-by-whats-happening-in-the-arctic-right-now>

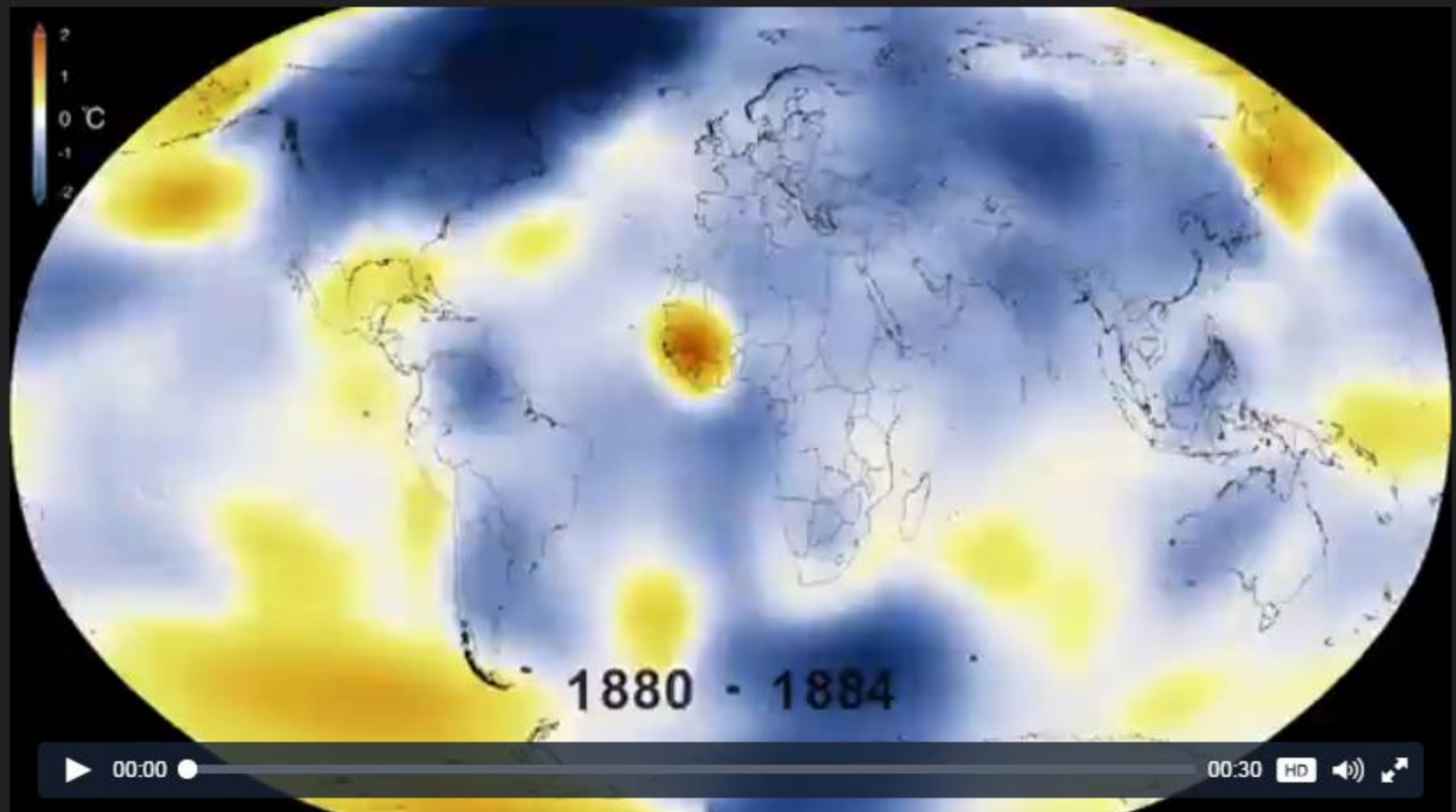
Thanks Melanie, CDFW!

January 2016 was 4 degrees Celsius (7.2 degrees F) higher than the 1951-1980 average in the Arctic

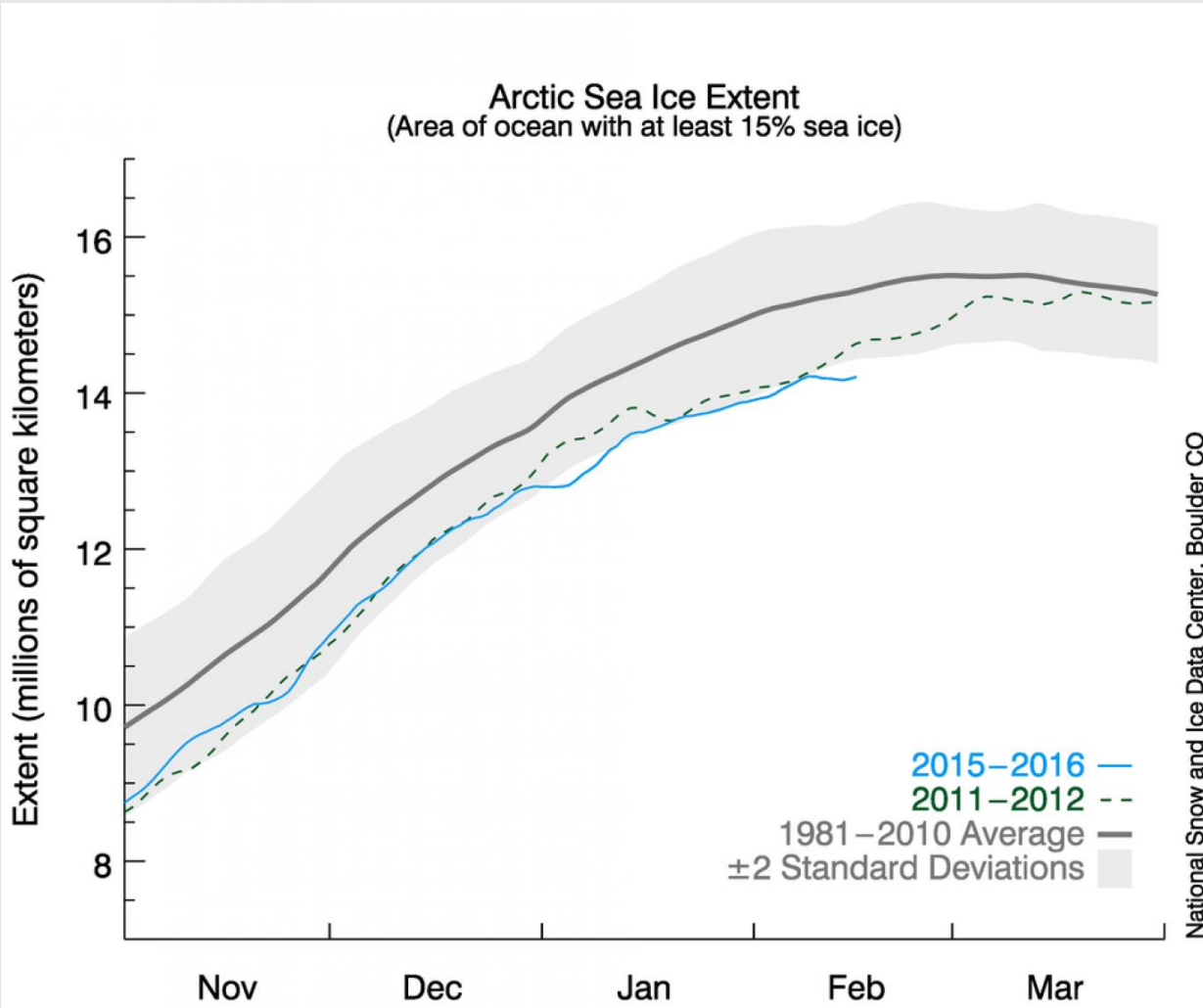


[https://www.washingtonpost.com/video/national/health-science/watch-global-temperatures-change-from-1880-to-now/2016/02/19/c3cab1ac-d6fa-11e5-a65b-587e721fb231\\_video.html](https://www.washingtonpost.com/video/national/health-science/watch-global-temperatures-change-from-1880-to-now/2016/02/19/c3cab1ac-d6fa-11e5-a65b-587e721fb231_video.html)

## Watch global temperatures change from 1880 to now



This unusual Arctic heat has been accompanied by a **new record low level for Arctic sea ice extent during the normally ice-packed month of January**, according to the National Snow and Ice Data Center — over 400,000 square miles below average for the month.



Last Time...

# Renewable Energy Sources

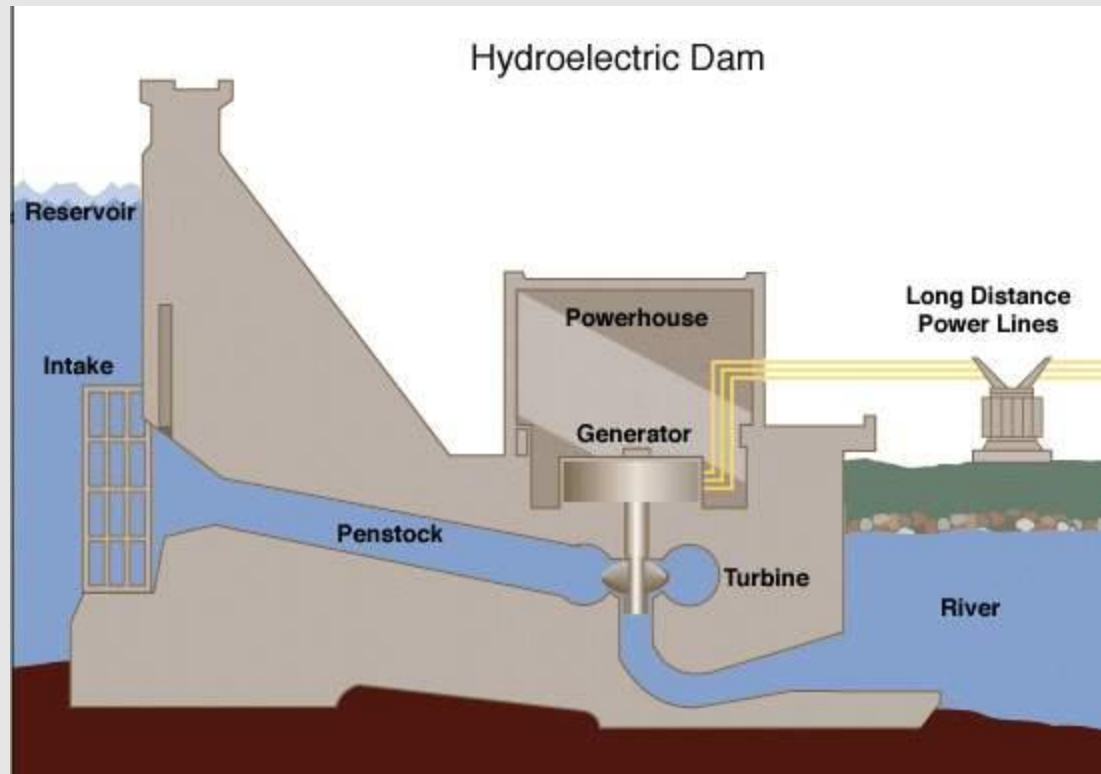
- Energy sources that are naturally replenished and do not directly emit GHGs
- Hydroelectric
- Wind
- Solar
- Geothermal
- Tide or wave



Clean Renewable Energy

# Hydroelectric

- Provides the vast majority of renewable energy worldwide
- Water flows from a reservoir, through a generator turbine, and out to the streambed below



# Hydroelectric advantages

- Predictable and flexible: can meet daily peak demands
- Low costs for operation and maintenance
- Reservoirs also serve as flood control, irrigation, and urban water supplies



# Hydroelectric disadvantages

- Enormous construction costs
- Displace communities that have developed along rivers
- Disrupt river ecosystems



# Wind

- Second-largest source of renewable energy that does not produce any GHGs
- Many countries are rapidly constructing wind power facilities. In a few decades, should provide 6% of global electricity

# Wind Advantages

- Cost has gone down. Competitive with all other energy sources.
- Low maintenance costs



# Wind Disadvantages

## Concerns about birds and bats

- Collisions with existing wind turbines kill about 368,000 birds each year
- But, this is only 0.1% of bird deaths from collisions with human structures (buildings, high-tension lines, communication towers, vehicles)



# Solar

Currently less than 0.8% of the world's electricity comes from solar power

Rapidly expanding use

–By 2050 expected to reach 27%



# Photovoltaic cells

- Becoming more efficient at converting EM radiation into electricity
  - Efficiency doubled over the past 30 years
- Lifespans of Photovoltaic cells have lengthened to over 20 years
- Cell manufacturing has become more efficient
- Installation costs have declined
- Operating costs are low
- Reliable



Switzerland

# Solar Disadvantages

Solar power not available at night or during cloudy weather. Energy storage required (like wind)

Impacts on wildlife

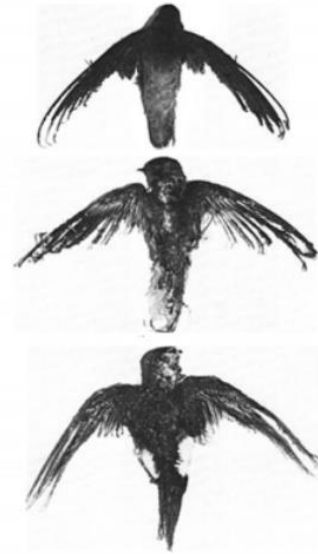
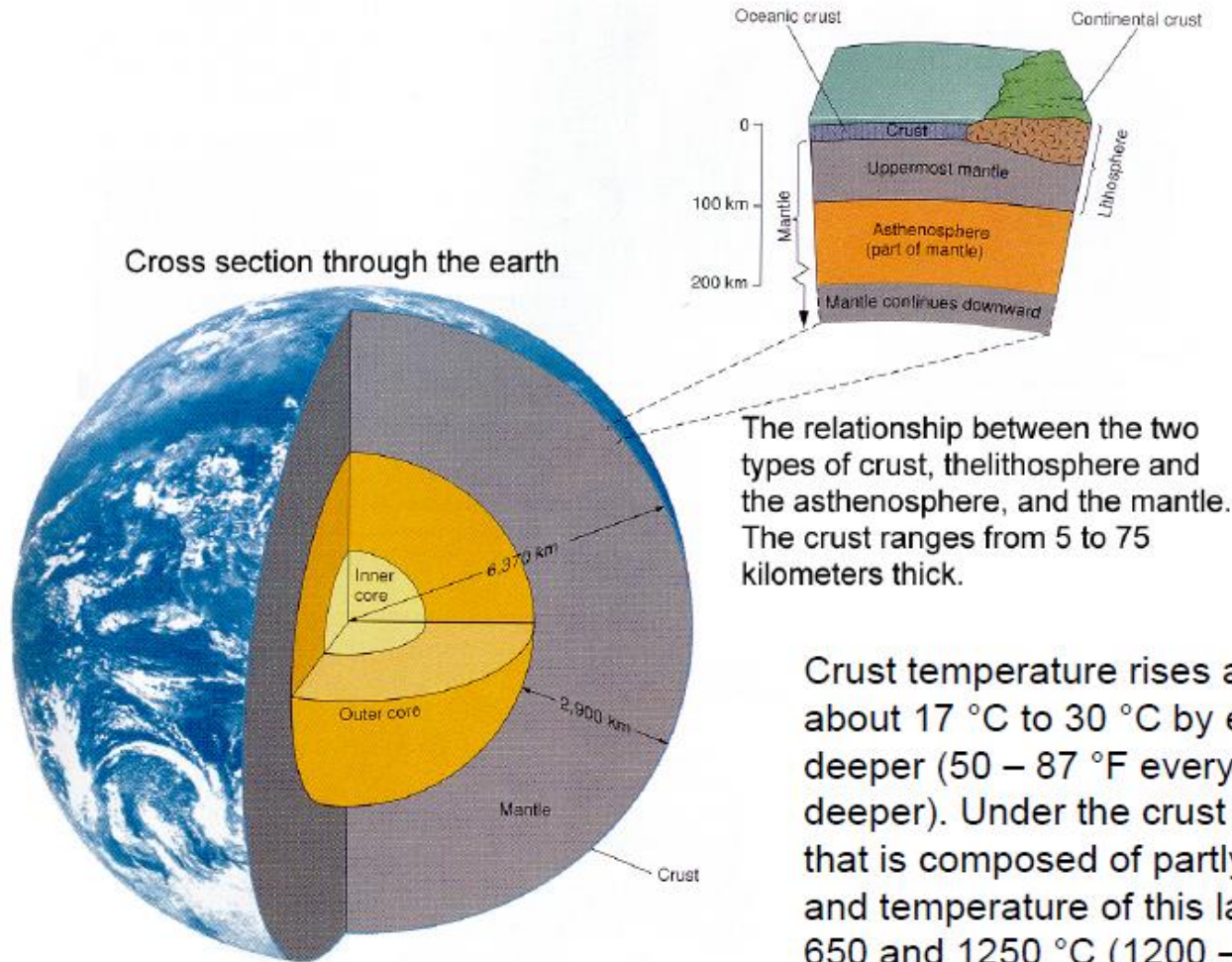


FIGURE 2. Three birds burned in standby points at Solar One. Top to bottom: Vaux's Swift (*Chaerurus vociferans*), Barn Swallow (*Hirundo rustica*), and White-throated Swift (*Aeronautes saxatilis*). Note the heavily singed rectrices and remiges especially in the Barn Swallow.





# Geothermal



The relationship between the two types of crust, the lithosphere and the asthenosphere, and the mantle. The crust ranges from 5 to 75 kilometers thick.

Crust temperature rises approximately about  $17^{\circ}\text{C}$  to  $30^{\circ}\text{C}$  by every kilometer deeper ( $50 - 87^{\circ}\text{F}$  every one mile deeper). Under the crust there is Mantle that is composed of partly melted rocks and temperature of this layer is between  $650$  and  $1250^{\circ}\text{C}$  ( $1200 - 2280^{\circ}\text{F}$ ). In Earth's core temperatures could be according to some estimations between  $4000$  and  $7000^{\circ}\text{C}$  ( $7200 - 12600^{\circ}\text{F}$ ).

# Geothermal

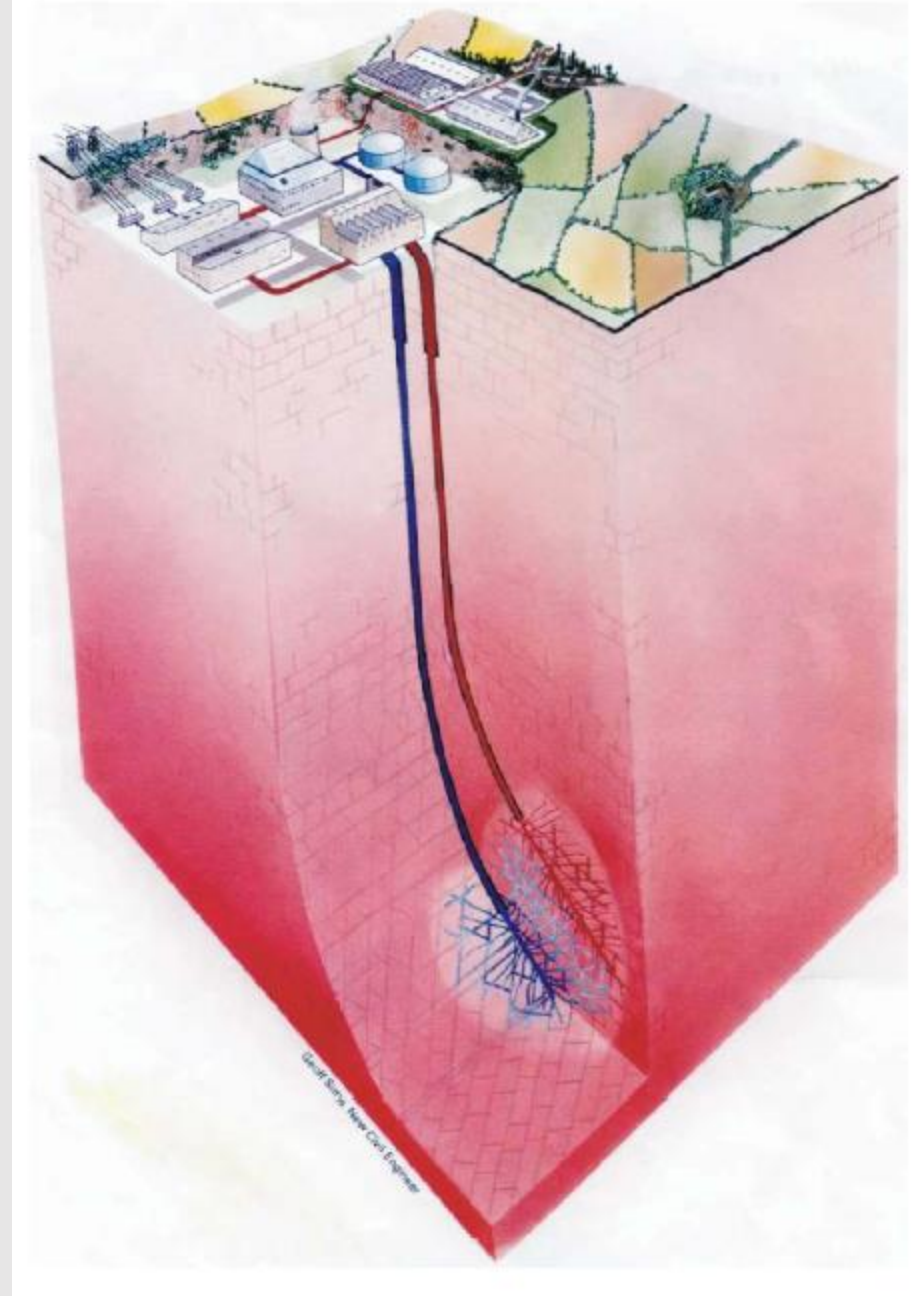
- Locations where the crust is thinner
  - Volcanoes
  - Boundaries of tectonic plates
  - Fault lines
- Receive more heat from the interior
- Promising sites for geothermal power

# Geothermal in California

- Intersect between Pacific and North American tectonic plates
- More geothermal plants than anywhere else on Earth
- Supplies CA with over 7% of electricity
- Supplies the US with 78% of geothermal electricity

The US produces more geothermal energy than any other country!

- Power plant pumps water down a deep injection well
- Water flows through heated granite, heats up until it escapes up a second borehole
- Steam or superheated water, drives a turbine to generate electricity
- Water is condensed/cooled and injected again



# Geothermal Advantages

- Economical
- Potential for expansion
- Provides power day and night, in any weather

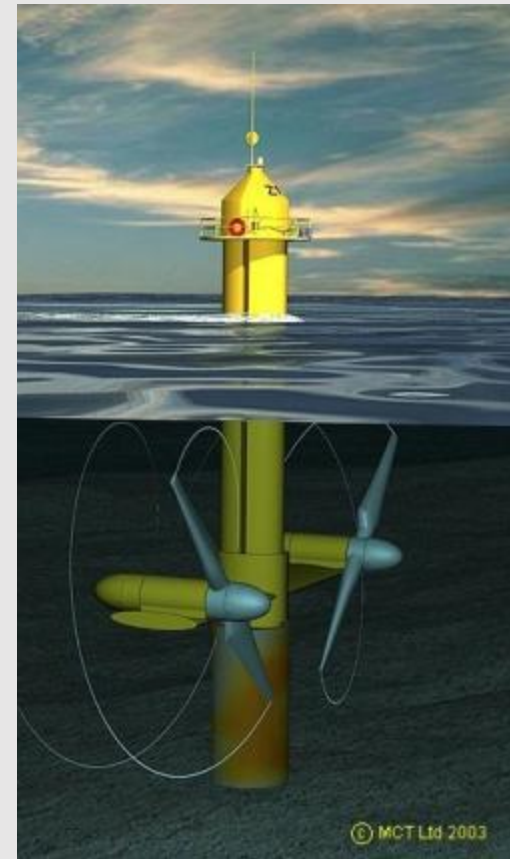
# Geothermal Disadvantages

- Good sites usually far from population center
- Injection of water into wells could destabilize surrounding geological formations
- Overexploitation of a site may cause it to cool

# Tidal and Wave



Tidal plant: power plant uses gates to trap water during high tide. Slowly released at low tide through a turbine



Wave power plant: couples rising and falling of a float with the turning of a generator

# Tidal/Wave advantages

- Could generate lots of electricity
- Negligible emissions of GHGs or other pollutants



# Tidal/Wave disadvantages

- High costs: equipment has to work reliably under constant buffeting of the sea and saltwater corrosion
  - Only 3 tidal plants, no wave power plants yet
- Possibility of interfering with fish and marine mammals



Thanks Nydia!



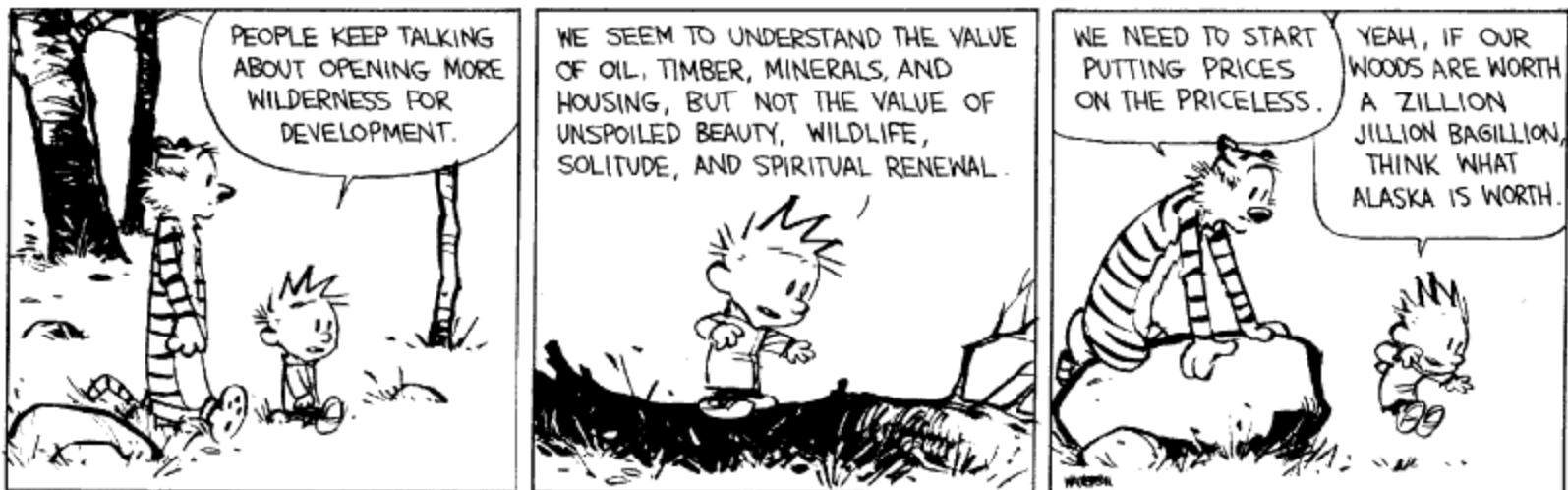
Katie Bradley  
TortAddiction.blogspot.com

# Economics of Global Climate Change



# Economics of Climate Change

- Can we apply economic concepts to natural resources like Earth's atmosphere?
- Can we use cost-benefit analysis to select mitigation strategies?
- How do we evaluate things like human welfare and peace of mind?



# First, Some Terms

- Market forces: the influence of supply and demand on the distribution of goods and services
- Can market forces be applied to natural resources?

# Supply and Demand

- **Demand** refers to how much (quantity) of a product/service is desired by buyers
  - The quantity demanded is the amount of a product people are willing to buy at a certain price
- **Supply** represents how much producer can offer
  - The quantity supplied is the amount of a product producers are willing to sell at a certain price
- **Price**, therefore, is a reflection of supply and demand

# New special edition iPhone, \$1,000



- Price is high in comparison with other similar products. Apple only produces 20 of them.
- The small supply increases demand. 20 people are willing to pay \$1,000 for them. Apple will soon produce more to meet the demand. They could also increase the price to \$1,500.

# New iPhone, \$1,000



–What if Apple produces 500 phones?

–A large supply, with a large price

**low demand**

–Only 20 of them are sold for \$1,000. Soon Apple reduces the price to \$500, and the remainder of the phones are sold. Low price increases demand



# Addressing Climate Change: Market-based or Prescriptive

## Market-based:

- Supply and demand will drive solutions (e.g., new technologies)
- Benefit of approaches must outweigh costs
- Offers flexibility

## Prescriptive

- Regulations/laws with punishments for non-compliance
- Inflexible

Global Climate Change  $\neq$  Market Economy

# Global Climate Change $\neq$ Market Economy

- Divergent national interests distort global markets for goods or services



# National Interests



- The US, Japan, and EU countries have been responsible for most GHG emissions so far
- China and India have become major emitters only recently
  - Reluctant to implement policies that might constrain economic growth
  - Developing Country Perspective: they have contributed so little to emissions in the past that they should not be held accountable for current global climate change conditions



Developed Country Perspective: If China and India continue to accelerate emissions, it won't matter what mitigation strategies other countries implement

# Global Climate Change $\neq$ Market Economy

- Divergent national interests distort global markets for goods or services
- Monopolies or cartels control the supply of some goods or services

# Monopolies and cartels

Monopoly: a single company owns all or nearly all of the market for a given type of product or service.

- Electricity
- Natural gas
- Drinking water
- Sewage disposal
- Telephone service
- Cable television
- General mail delivery

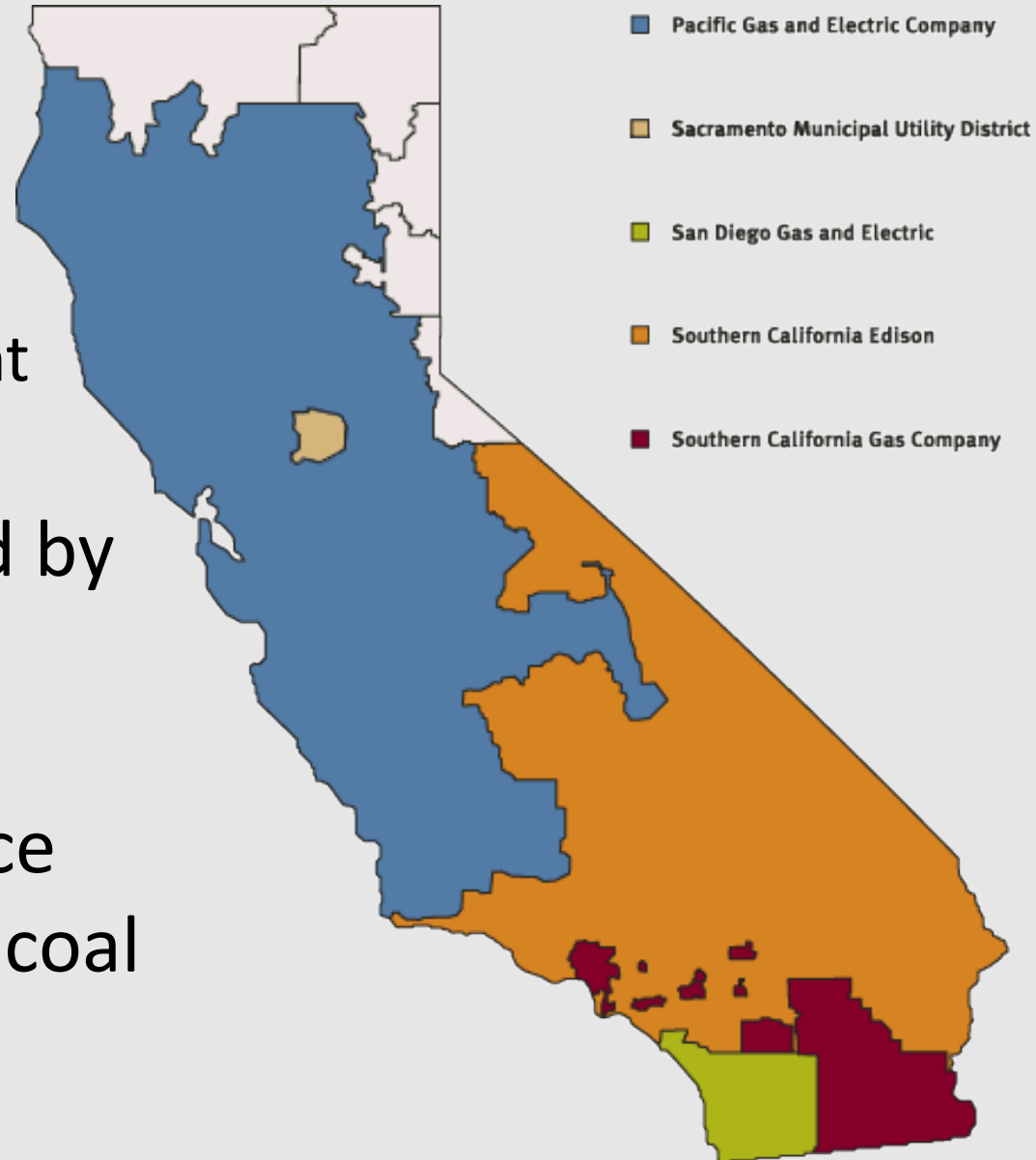


Utilities have high start-up costs. A barrier to entry into the industry

- Buying land
- Constructing facilities
- Purchasing equipment

Your supplier is dictated by where you live

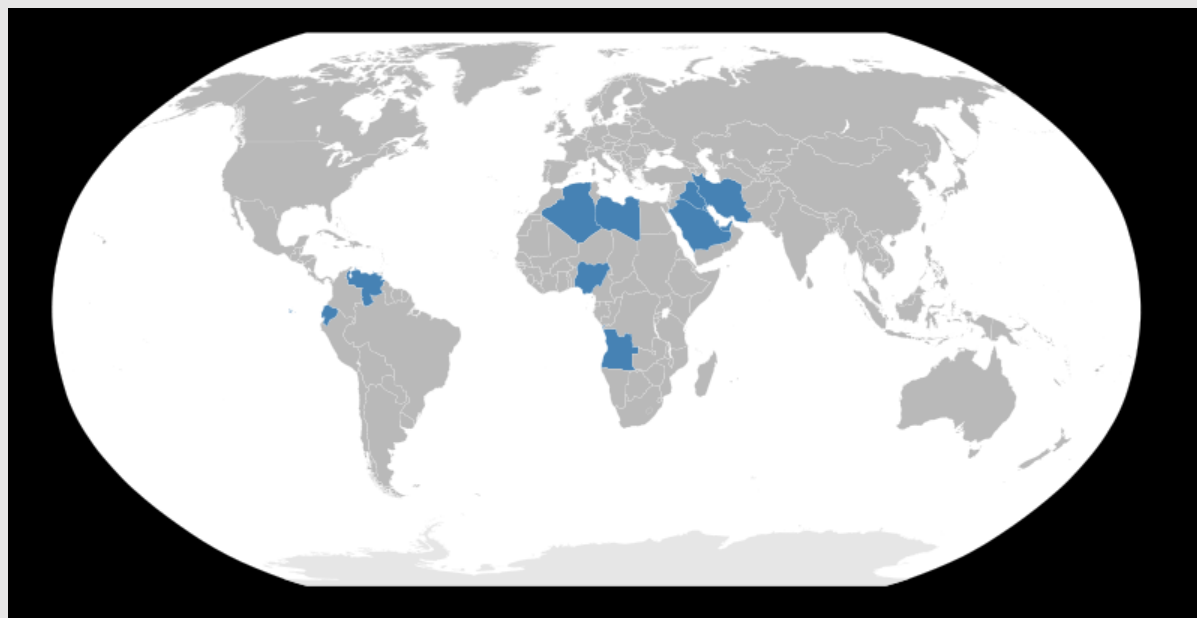
No choice in what source electricity comes from (coal vs hydroelectric)





Cartel: A group of companies which collectively attempt to affect market prices by controlling production and marketing

The Organization of the Petroleum Exporting Countries (OPEC): a cartel made up of 12 countries. Collectively determine production and price of oil



# Global Climate Change $\neq$ Market Economy

- Divergent national interests distort global markets for goods or services
- Monopolies or cartels control the supply of some goods or services
- Goods or services are free and invite indiscriminate use

# RKB PRESENTS THE RUSTY MUFFLER ORACLE

## The Rusty Muffler ORACLE

...THERE'S NO TECHNOLOGICAL FIX FOR THE TRAGEDY OF THE COMMONS\*

BEFORE THE MODERN ERA, HUMANS EARNED THEIR LIVELIHOODS FROM THE "COMMONS."



...NO INDIVIDUAL OWNED THE COMMONS. BUT, ALL WERE FREE TO TAKE WHAT THEY NEEDED.



...THE OCEANS, LAKES, RIVERS AND STREAMS WERE FULL OF FISH, FREE FOR THE TAKING...



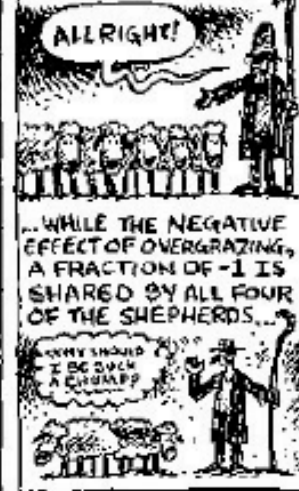
...I MEDIATE THERE ARE FOUR SHEPHERDS WHO EACH OWN FOUR SHEEP THEY GRAZE TOGETHER ON A COMMONS THAT PROVIDES ENOUGH GRASS FOR SIXTEEN SHEEP...



...AS LONG AS EACH OF THE SHEPHERDS LIMIT THEIR FLOCKS TO FOUR SHEEP, THE COMMONS WILL SUSTAIN THEM INDEFINITELY...



...THE "SMART" SHEPHERD FIGURES HE CAN ADD A SHEEP TO HIS FLOCKS AND GET A POSITIVE BENEFIT OF +1...



...THE FORESTS WERE A SELF-REPLENISHING STOREHOUSE OF FOOD, BUILDING MATERIALS AND CRAFT SUPPLIES...



...THE GRASSLANDS AND PASTURES SUPPORTED HERDS OF RUMINANTS THAT PROVIDED MILK, FIBER, HIDES AND MEAT...



...AS LONG AS HUMANS RESISTED THE URGE TO TAKE MORE THAN THEY NEEDED, THE COMMONS PROVIDED EVERYTHING FOR HUMAN SUBSISTENCE BEFORE THE INDUSTRIAL ERA.



...EACH SHEPHERD MUST ADD ANOTHER SHEEP.. THEN ANOTHER..UNTIL THERE'S NO GRASS LEFT ON THE COMMONS...



...IN FISHERIES, FORESTS AND FARMLAND WE SEE HOW THE LOGIC OF SELF-INTEREST ALWAYS LEADS HUMANS INTO A CYCLE OF BOOM & BUST...



...AIR AND WATER ARE ALSO A COMMONS. INSTEAD OF TAKING STUFF OUT, HUMANS ARE PUTTING STUFF IN ... A TRAGEDY OF THE COMMONS IN REVERSE!



\*GARRETT HARDIN - SCIENCE 162 (1968)

# Tragedy of the Commons

- A polluter benefits indirectly from polluting. They do not have to buy expensive new equipment that decreases GHG emissions
- The costs of pollution is spread among many (all of us)
- There is little incentive for the polluter to stop polluting



# The atmosphere as a commons

- One person producing GHGs does not perceptibly diminish the quality/quantity of atmosphere available to others
- One person/entity can not keep another from producing GHGs
  - No one owns the atmosphere. It is a commons and will tend to be overused



# Global Climate Change $\neq$ Market Economy

- Divergent national interests distort global markets for goods or services
- Monopolies or cartels control the supply of some goods or services
- Other relevant goods or services are free and invite indiscriminate use
- Crucial information about many goods or service is sparse, uncertain, or not publicly available

# Lack of Information

- In a free market, decisions are based on cost, quantity, and quality of available goods and services
- Information about climate change is sparse, uncertain, and not always publicly available



Estimates of GHG emissions from various sources are uncertain

Estimates of petroleum reserves in various locations not publicly available



# Global Climate Change $\neq$ Market Economy

- Divergent national interests distort global markets for goods or services
- Monopolies or cartels control the supply of some goods or services
- Other relevant goods or services are free and invite indiscriminate use
- Crucial information about many goods or service is sparse, uncertain, or not publicly available
- Processes span several generations of human beings