ES110 - Mid-Chapter Review
Weeks 1 - 4

TEST CONSISTS OF
- 5 multiple choice questions
- 10 short answer/fill in the blank questions
- 1 written answer questions worth 10 marks

Lecture 1: Sustainability

→ Anthropocene:
- Period when human activity replaced natural processes as the dominant force shaping the Earth

→ Consumption
- We consume more resources than can be naturally replenished
- "Overshoot day" = day each year we go in deficit
    - In Canada, Overshoot day is March 11 (i.e., Canadians damage the earth for 9.5 months)

→ Biodiversity Loss
- ⅓ of land vertebrate species are declining in numbers
- 5 past mass-extinctions events in last 600 million years
- Most recents was 66 million years ago
- Caused by major volcanic events, asteroids, natural changes in temperature/sea level

Lecture 2: Sustainability
****Definitions of**: *Environment*, *Environmentalism*, and *Environmental Studies/Science*

→ Environmental Change
- Continually changing
- Occurs naturally, operating at multiple time scales
- Daily change = Day/Night; Seasonal Changes; Annual Change; decadal change
    - Glacials/Interglacials occur over thousands of years, wildfires last for days/weeks with each leaving significant change behind

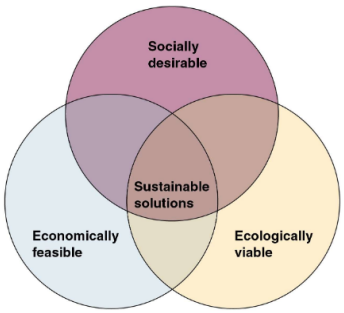
↳ Anthropogenic Environmental Change
- Changes caused by human activity
- Occur locally, regionally, and globally
- Examples:
    1. Global
        - Climate system (e.g., elevated CO2 levels)
        - Stratosphere (e.g., ozone-depleting substances)
        - Oceans (e.g., acidication, plastic debris)

2. Local and Regional
    - Deforestation
    - Land degradation
    - Freshwater quality/availability
    - Increasing toxicity from mining, agro-chemicals (water, soil)

→ Natural Resources:
- → Air
- → Water
- → Soil
- → Energy
- → Minerals
- → Forests
    - Can be renewable & non-renewable
- → Ecosystem services
    - Ability of environment to break down waste
    - Nutrient cycling
    - Water purification
    - Natural control on pests, diseases

→ Ecological Footprint:
- The impact of a person or community on the environment, expressed as the amount of land required to sustain their use of natural resources.

→ Sustainability
- Idea developed in the 1970s
- Sustainable development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs
    - ↳ Key elements:
        1. Intragenerational equity
        2. Intergenerational equity
        3. Integration of economic, social, political, and the environment in decision-making, policy-making, management, etc



→ Sustainable Development Goals (MDGs)
- 17 goals an international community has agreed to achieve by 2030
    1. No poverty
    2. Zero hunger
    3. Good health and Well being
    4. Quality education

5. Gender equality
6. Clean water and sanitation
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, innovation, and infrastructure
10. Reduced inequalities
11. Sustainable cities and communities
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace, Justice, and Strong institutions
17. Partnerships for the goals

→ Impact Model

- I = P x A* x T
- Where:
  - **I** = impact on the environment
  - **P** = population
  - **A*** = affluence
  - **T** = technology
  - Or **C** = Consumption
- Assumes that affluence and technology always lead to higher levels of consumption of natural capital
- Affluence can cause our environmental impact to grow or shrink
- Some technologies are environmentally harmful (e.g., gasoline-powered cars), others not (e.g., bicycles)
- As affluence goes up, we have a greater choice of what technologies we use

Lecture 3: Biodiversity Loss

→ Bison population Decline

- Approx. 60-100 million animals when Europeans had contact
- Late 1800's: few hundred Plain Bisons in wild
- Wood Bison pop. : declined from 150,000+ to a few hundred by 1900

→ European Bison Hunting

- Used for:
  - Skins
  - To open grazing land for cattle
  - Trying to exterminate Indigenous people on the Plain

→ Limiting Factors for Bison Population Before European Contact

1. Human Predation
2. Non-Human Predation
3. Climate/Weather
4. Disease
5. Availability of Grass
6. Natural Hazards (eg. floods/fires)

→ Limiting Factors for Bison Population After European Contact

1. European Predation
2. Anthropogenic Habitat Change
    i. (availability of grass, non-human predation, natural hazards)
3. Climate/Weather
4. Disease

→ Canadian Conservation Efforts to Save the Plains Bison

- By **1888**: 8 Plains Bison in Canada
- **1907**: Canadian Govrn. Bought 400 Bison (ranchers in Montana). They released them at Elk Island National park
- Western Canadian bison got infected by cattle diseases, making recovery difficult
- **Today**: approx. 2000 wild Plains Bison in Canada

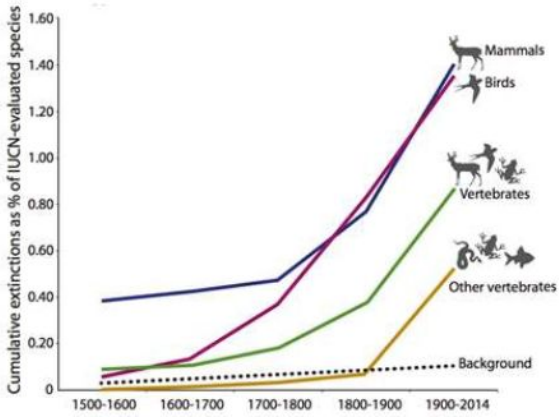
**Q. *Why are Plains bison not listed as a protected or endangered species in Canada?*

→ Biodiversity Loss

- Bison decline shows an ex. of over ten thousand species declining and becoming extinct
- Scientists believe we are in a human-caused mass extinction

→ Scale of the Global Biodiversity Crisis

- ⅓ of known land vertebrate species are declining
- *"Background" Extinction*
    - # of species that may go extinct for natural reasons



→ Key Causes of Biodiversity Decline & Species Extinction:

1. Human-caused destruction/damage to habitat
2. Pollution
3. Overexploitation
4. Invasive species
5. Climate change *(emerging threat)*

→ Why is Biodiversity important?

1. Livelihood importance
2. Economic importance
    - **Ex**. Costanza (1997) est. the $ value of ecological good & services > value of human economy
    - **Ex**. a house under a tree with lots of shade will save the homeowner $ of air conditioning
3. Food systems
    - Native pollinator species declining
    - ⅓ of food crops need insect pollination
4. Cultural, Spiritual and Intrinsic Value
    - WWF est. 3900 tigers in the wild

→ What is Biodiversity?

- Short for "biological diversity"
- Refers to:
    - @ local scales: variety of species in a habitat ("richness") and their relative abundance ("evenness")
    - @ larger scales: genetic diversity of species
    - @ still larger scales: diversity of habitats in ecosystems
    - @ still larger scales: diversity of ecosystem

→ Species Diversity

- Boreal Forest
    - Small # of tree species
    - Larges #s of each species/unit area
- Tropical Rainforest
    - Large # of tree species
    - Smaller # of each species/unit area

→ Structural Diversity within Habitats
- Fewer niches = Few Species
- More Niches = Many Species

→ Habitats Nested Within Habitats
- Large spatial scale = rocky shoreline
- Small spatial scale = tide pool along rocky shoreline

→ Habitat Integrity
- Intact vs. Fragmented Habitats
    - Large, contiguous forest supports more forest species (large animals too)
    - Fragmented forest supports fewer species (few large animals)

→ Keystone Species:
- Causes habitat or ecosystem to change
    - Ex. Beavers alter rivers/streams to create better habitats
- When this species is removed, other species grow/decline in #
    → Wolves vs. No Wolves
        - Rocky Mountain National Park, Colorado
        - This keystone species were removed from the valley decades ago; Elk #s rose quick and their behaviour changed

→ Population Dynamics:
- The science that explains the rise/fall of # of people within a given species

→ Species #'s are Always Changing
- The # of organisms within an ecosystem from any given species is not static
- Fluctuates along w environmental conditions
- Extremely favourable/unfavourable conditions = dramatic shifts

→ Carrying Capacity:
- Describes upper limit to the # of organisms that an ecosystem can support over long term

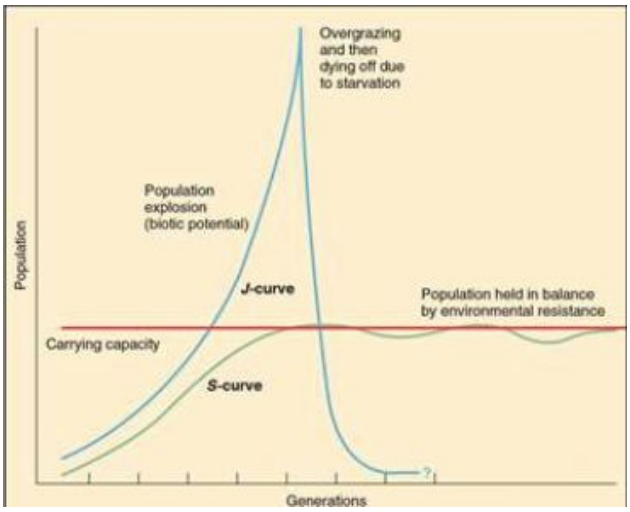
→ Environmental Resistance
- = sum total of factors which limit potential for a species to grow its pop. or geographic range
- Can be abiotic (ex. Temp, nutrients) or biotic (ex. Disease, parasites, predation, lack of food)

→ Biotic Potential
- = the ability for a species to grow under optimum conditions

- Use "r" to rep the theoretically fastest rate of pop. growth
- *r-rate* doesn't occur in nature
    - Always environmental resistance & limiting factors

→ We Classify Wildlife Species by Potential of Pop. growth

- Quick reproductive species w many offspring = *r*-selected species
- Slow reproductive species w less offspring = *k*-selected species
    - → Ex. Fruit flies = *R*-selected Species
        - Go from egg to reproductive adult in few days
        - Fruit fly pop. could reproduce @ 100% success & there were no environmental resistance, the world would be covered with fruit flies
        - ➢ ***Growth Experiment***
            - Put fruit flies in a jar with food, water and air holes
            - 

            - After charting the experiment:
            - 

→ R-Selected Species = Opportunists

- Characteristics:
    - Early reproductive age
    - Many offspring, little care for them
    - Pop. #s fluctuate quickly
    - Many pests/nuisance species
        - Eg. june bugs, cockroaches, army worms

→ K-Selected Species are the Opposite
- Characteristics:
    - Later reproduction
    - Few offspring
    - Attentive parents
    - Pop. #s slowly increase

→ When Other Species Encounter Humans...
- K-selected species typically have trouble competing with humans
    - Suffer b/c of humans
- Some r-selected species actually thrive alongside humans
    - Love humans

→ Predator-Prey Relationships
- A basic principle of biology is that populations of predators and prey fluctuate, but tend to stabilize over the long-term
    - Doesn't apply to humans

→ Critical Number
- Min # of organisms required to ensure that pop. won't go extinct
- Without human intervention, a species below the critical # disappears

→ Summary
- Ecological, economic and social reasons make biodiversity important
- Extinction rates increasing because of human activity
- Certain species (mostly k-species) are more at risk
- R-selected species prosper b/c of humans
- Species pop. below critical # become extinct without human intervention

Lecture 4: Preventing Biodiversity Loss

→ Trees In Danger
- Numerous plant/tree species are at risk
    → American Chestnut
        - the native chestnut was a common tree in east US, and south-west Ontario
        - Early 1900s: billions of trees died due to blight (fungus) which came from chestnuts from Asia
        - Surviving trees # in the hundreds (in small isolated pockets)
    → Ash Trees
        - Was common as well
        - Now dying in large #s

→ Emerald Ash Borer = Invasive Species
- 1990s: exported from Asia to North America
- Spreading cross Ontario
- Ash pop. are not below critical # yet
- Destined to same fate as the American chestnut

→ Extinct birds
- Extinction causes:
  - Human predation
  - Habitat loss

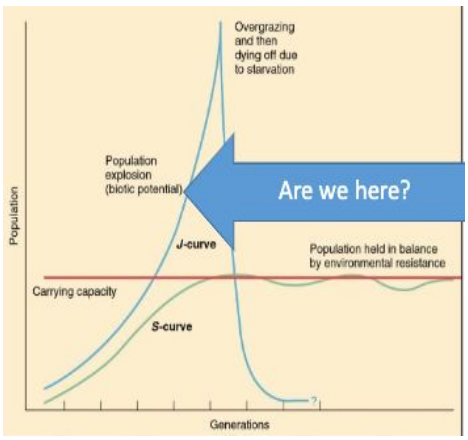
  → Passenger Pigeons
  - Once widespread across eastern North America
  - Early Europeans describe enormous flocks of millions of birds

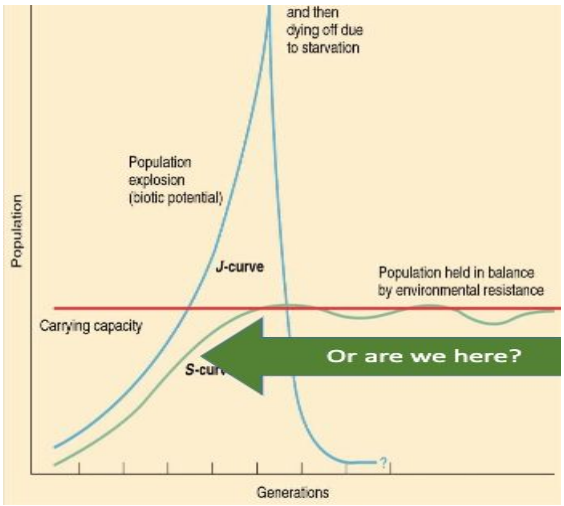
  → Great Auk
  - Flightless shorebird was common in atlantic Canada, British isles, Scandinavia
  - Similar to penguins
  - mid-1800s : last ones died

→ Human Pop. Growth = Underlying Cause of Biodiversity Loss
- Human pop # grow:
  - Use more resources
  - Change land/aquatic systems
  - Out-compete species
  - Cause other species to disappear

  → how fast is the world's human pop. growing?
  - Over 2 of Canada's pop. added to planet every year
  - 1 heart beat = 3 babies
  - 1 death = 3 babies

AS HUMAN POP. ↑, EXTINCTION RATES ↑
→ Human Pop. growth
- Currently on a J-curve
- Relative to carrying capacity, we are...





→ Demographic Transition

- Before, birth rates/death rates were similar
- Improvements in hygiene and health care lowered death rates
- Birth rates dropped after a lag period
  - Pop #'s grew fast
- Why a lag period
  - A period of cultural adjustment as people learn pro's of small families when most kids survive to adulthood

World examples

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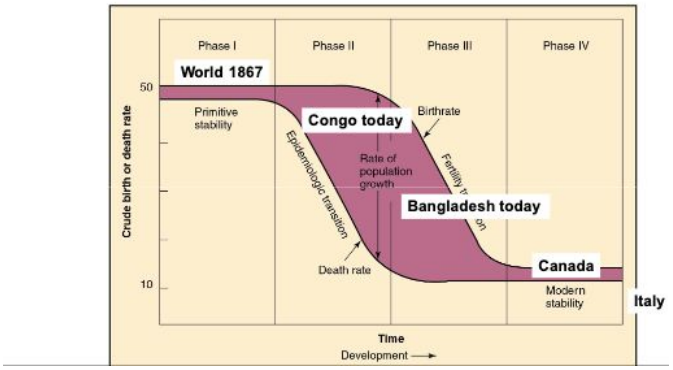


→ Reversing Causes of Biodiversity Loss

- Key causes:
  - Human-destruction to habitat
  - Pollution
  - Overexploitation
  - Invasive species
  - Climate change (emerging threat)
- Options:
  - protect habitat/species
  - Laws and regulations
  - Create protected areas
  - Educate and encourage collective action
  - Through active interventions

→ Trumpeter Swans

- North America's largest waterfowl
- Protected by Migratory Birds Convention Act
- Common before European contact
- Hunted for feathers/skin
- Habitat loss: draining wetlands from farming
- Extinct by 1900, (except survived in Canada, Alaska, Rockies)
- Still protected, no longer peril

    - Captive-raised one's are taught how and where to migrate

→ Whooping Crane
- Tallest birds in North America
- Protected by Migratory Birds Convention Act
- Mitigate from north Canada to Gulf of Mexico
- #'ed in the thousands before European contact
- By 1941, only 21 left b/c of habitat loss in US (key factor)
- 1960s: intense conservation efforts
- Endangered today: ~350 wild birds

→ Migratory Birds Convention Act
- 1916: Canada & US signed convention protecting these birds
- Midst of WW1 & within 24 months of passenger pigeon death
- Protects birds including: robins, ducks, geese, swans, loons etc...
- Protecting is challenging, we must protect them & their habitat
    - Through legal jurisdictions

→ Law Use for Wildlife Protection
- Most provinces under Canadian government have wildlife protection laws
- 1973: international convention made to restrict trading endangered species

→ Canada's Species at Risk Act, 2003
- Purpose:
    - Prevent endangered/threatened wildlife from extinction and to help their recovery
- Federal cabinet decides on listed species
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC)
    - A committee of experts
    - Advises cabinet on listing of species

→ Common Characteristics of SARA Species
- Small, isolated sub-species of organisms more common to the US; or
- Species needing large territories
- Endemic to areas with heavy human use; or
- Formerly targeted by humans for hunting

→ Implications of SARA Listing
- If an aquatic/migratory bird species, cannot harm species or destroy habitat in Canada
- Any other organism, prohibition applies only to federally owned lands
- Provinces have their own laws & may apply to private land

→ Special Regulations
- SARA can't always protect species
- Govern. can make special rules

→ Atlantic Northern Right Whales
- Were common, humans hunted to near extinction
- 450 left today
- Summer: feed in Canadian waters
- Summer 2017: significant #'s died
- Causes:
    - Collisions w ships
    - Tangled in fishing lines

→ Speed Limits on Ships
- Protects whales
- Govt. of Can conducts surveillance flights in specific areas from April-November
- If right whales spotted, boats required to slow down for 2 weeks

→ Parks and Protected Areas
- Protected areas
    - Areas set aside to minimize human disturbance
- Parks
    - Areas set aside for many reasons, may be conservation or protection of species/habitats
    - Have a mandate to protect biodiversity, as well as other purposes
    - Canada = 48 parks
    - Ontario = 280 parks

→ Canada Protected Areas
- Most often found where there's few people, min. human use
- Protected by federal, provincial or local governments

→ CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora
- Agreement trying to protect endangered species through limited trade
- Most countries signed
- Protection to 5000 animal species and 29,000 plant species
- ~1200 near-extinct species illegal to trade (eg. pandas,tigers)

→ Proactive Interventions
- Citizen interventions
- Habitat recreation/modification

- Zoos, sanctuaries (last ditch effort)

→ Citizen Interventions
- When concerned people group together to protect species/habitats
- Forces govn. To take action
- Challenges = mobilizing funds, long-term momentum

→ Habitat Modification
- Try to undo past damage, make human land-use more compatible w biodiversity
- Initiated by govern./private landowners

→ Zoos & Captive Breeding Programs
- Are a final-resort attempt to keep species from extinction

Lecture 5: Environmental Impacts

Energy Defined
- Capacity to do work, move things, or cause changes of state

Three Types of Energy
- Kinetic
  - When matter is moving (e.g., wind blowing, streams flowing, heat, electricity)
  - Vehicles such as boats rely on kinetic energy
- Potential
  - Energy not in use at this moment, but that could be release (e.g., unlit match, water stored behind a dam, tank of gas)
    - Nuclear Energy - A form of potential energy until released
      - A spontaneous change in the nucleus of an atom releases energy, most commonly done by fission (e.g., split the nucleus)
  - Vehicles such as cars rely on potential energy
- Electromagnetic radiation
  - Waves of energy that are emitted and passed through space (e.g., sunlight, x-rays)

2 Laws of Thermodynamics
1. New energy can not be spontaneously created
   a. Can change existing energys form (e.g., potential to kinetic) or transfer it from one place to another but you can not destroy or create energy
      i. Energy comes from the sun and matter
2. When energy changes from one form to another, you always lose some efficiency

a. You can never gain energy nor break even. You always waste some
    i. <25- l-% of the energy in gasoline propels a car, the rest gets lost to heat escaping the engine baldock, exhaust pipe, etc

Important Global Energy Patterns

- Consumption of energy is growing most rapidly in Asia
- Asia has low reserves of oil, natural gas, but lots of coal
- North America has large reserves of all types of fossil fuel, and high but stable rates of consumption
- Middle East has large reserves of oil and gas, relatively few people
- Russia has lots of natural gas, coal
- Central & South America have oil, some natural gas
- Africa has relatively little fossil fuel of any type; reserves are concentrated in Libya, Nigeria, Algeria and Angola

Coal

- Used primarily as fuel to generate electricity
- Abundant in North America, Asia, Australia, Europe & Russia
- Scarce in Africa and South America

Environmental Impacts...

Fossil Fuels

- Extraction
- Transportation
- Consumption

Coal Mines

- 2 types of mines: Shaft & Open pit
- Shafts are more dangerous workplaces
- Open pit is safer but damaging to the environment
- Burning Coal
    - Emits more greenhouse gases per unit energy than other fossil fuels
    - Emits more air pollution than other fossil fuels
    - Can cause acid rain that damages forests, lakes, etc

Conventional Oil and Gas Uses

Oil

- Refined into gasoline, jet fuel, other products for transportation
- Can also be burned to generate heat

Natural Gas

- Burned directly for heating, cooking
- Aldo burned to generate electricity
- An input for other products like fertilizer

Environmental Impacts from Extraction & Transportation of oil/gas

- Depends on where extraction and transport happen

- Spills from offshore oil rigs and from tanker ships are harmful to wildlife, contaminate water and coastlines
- Onshore rigs, leaky pipelines can contaminate soil, rivers

Alberta Tar Sands

- Some tar sands are mined from open pits; some are pumped out of the ground after first injecting steam to loosen it up
- In upgrading facilities team is used to separate tar from sand
- Chemicals are added to dilute the tar (aka "bitumen") so that it flows like a liquid and can be sent down a pipeline
- Outcome = "heavy oil", a low-quality product that at refinery is mixed with higher quality oil
- Alberta Tar Sands are inefficient and produce pollution
- Approx. 1 unit of crude oil for every 15 units of tar sand unearthed
- Extremely energy intensive and uses large amounts of water
- Not cost-effective when oil prices are low
- Contaminates large amounts of water, generates large amount of greenhouse gas emissions

Fracking (Horizontal Slickwater Hydraulic Fracturing)

- A process whereby pressurized water, chemicals and sand are injected into rock (usually shale) containing oil or natural gas
- Creates cracks in rocks, making it easier for oil % gas to flow
- Increase the 5 of oil % gas that can be extracted
- Generates large amounts of toxic waste above and below ground, and mini earthquakes

Unremediated Mines and Wells

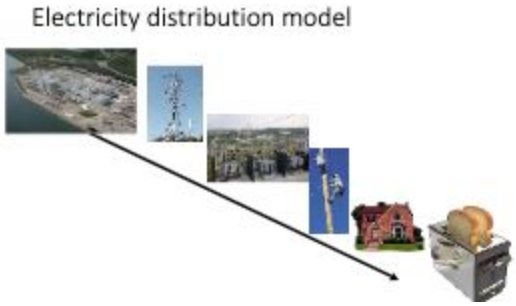
- Remediation means the removal of toxins from site, cap & seal pipe, wells + revegetate site
- Many companies try to avoid cleaning to avoid paying the cleanup cost, many declare bankruptcy. There are about 170,000 abandoned oil wells in alberta
- Lack of Remediation in Tar Sands
    - By law, tar sands are supposed to remediate 100% of the land they damage. Amount actually remediated is small

Environmental problems caused by consuming oil/natural gas

- Release greenhouse gases, air pollutants

Electricity Distribution Model

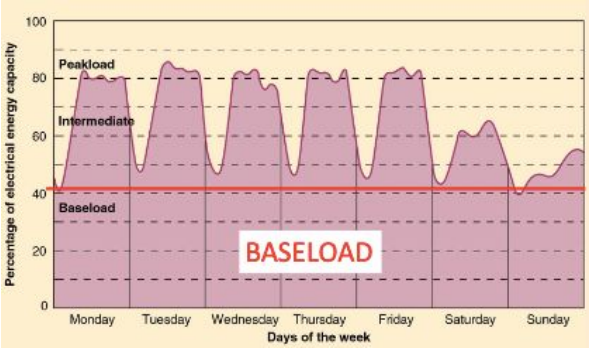
- Large amounts of electricity are generated at single points and then distributed by a network of wires to consumers
- "The grid"

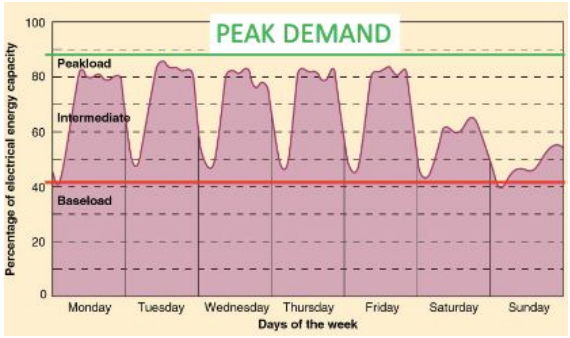


Daily Electricity Consumption Patterns

For the grid to meet the baseload + peak demand...

- We use a combination of technologies:
  - We use ones that can operate all the time, cheaply and efficiently (e.g., hydroelectric, nuclear)
  - We also use ones that can be turned on and off again as needed (e.g., hydroelectric, thermal)





Turbines

- Transform kinetic energy to a more usable form
- Can perform mechanical work directly or generate electricity
- Old, simple & effective technology still used

Environmental Impacts of Uranium Mining

- Uranium is most common fuel
- Rock containing uranium is excavated, ground up, chemicals applied to separate uranium from other material
- Damages surface land cover (forests, soil)
- Mine tailings (wastewater) are toxic and not easily disposed of

Disposal of Waste from Nuclear Fission

- Nuclear reactor waste is radioactive, harmful for centuries
- Is usually stored on site, first in pools of water, later in cement bins

Nuclear Accidents

- Chernobyl, Ukraine, 1986
- Fukushima, Japan, 2011
- In both cases, the nuclear plant had significant design flaws
- Radioactive fallout renders immediate vicinity dangerous for many years to follow

Alternative, Renewable Energy Sources

- Hydroelectric
- Solar
- Wind
- Biomass
- Biofuels
- Hydrogen

Benefits/Costs of Large Hydro Dams

Benefits

- Great for baseload
- Efficient, long life span
- Cheap to operate once built
- Low GHG emissions, no air pollution
- Dams may have other uses (irrigation, recreation, flood control)

Costs

- High up-front construction costs
- Floods land upstream
- Changes river water chemistry
- Affects biology of water, can harm fish stocks
- Not all rivers are suitable
- Best locations often far from consumers

Benefits/Costs of Tidal/Run-of-River Hydro

Benefits

- Does not require construction of dams
- Less disruptive than dams to fish, water chemistry
- Can in theory be used in multiple places along same watercourse
- Works continuously, so long as there is flow

Costs

- Existing technologies are expensive
- Not many good locations for tidal
- Maintenance, connecting to a grid may present challenges

Benefits/Costs of Solar Power

Benefits

- Almost no operating cost
- A good panel lasts 20+ years
- Price of panels is falling steadily
- No GHG emission, no air pollution, no noise pollution
- Few impacts on wildlife
- Can be very inconspicuous
- Scalable (i.e., install 1 panel or hundreds, as space allows)

Costs

- Not 100% reliable: sun does not shine all the time, clouds interfere
- Sun does not shine at same angle at all times, latitudes
- No good for nightime baseload

Benefits/Costs of Wind Turbines

Benefits

- Low maintenance costs
- Relatively efficient
- No GHG emission, no pollutants
- Lots of windy locations around the world

Costs

- Not reliable - wind does not always blow
- No documented health impacts, but people perceive them to be bad for health
- Small numbers of birds are killed
- Some people think they are ugly, don't want to see them

Biomass Energy

- Term that refers to the burning of any number of combustible materials to generate heat
- Biomass fuels used in the home can include firewood, charcoal, wood chips, coffee grounds, cattle dung, wastepaper....
- Can also use large quantities of biomass material for generating electricity with turbines
- Biomass Energy Farming
    - Planting fast-growing plants specifically for use as fuel for steam turbines
        - e.g., willows, poplars, tall grasses

Benefits/Costs of Burning Biomass

Benefits

- Abundant in some places
- Can be cheap
- Can be grown on marginal farmland
- Can be integrated into sustainable forest management
- Minimal impact on carbon cycle

Costs

- Produces local air pollution
- Amount of energy produced per amount of fuel is not as high as fossil fuel
- Is often most abundant in areas far from urban centre
- Heavy, expensive to transport over distances

→ Must adapt grid to accommodate renewable energies

- The baseload requirement of the grid model is too great for renewables to meet alone
- We need more local, small scale tie-ins to the grid
- We also need to reduce baseload requirements (e.g, practice more energy conservation)

Energy Portability

- Most transportation is private
- Few alternative fuels are as cheap, efficient & portable as gasoline
- Electric Cars
    - Currently more expensive
    - Range is not as great as gasoline powered; charging takes time
    - Batteries are expensive, not long lived
    - Charging network still being built
    - Attractiveness: electrical power can be generated without producing CO_2 emissions, unlike gasoline