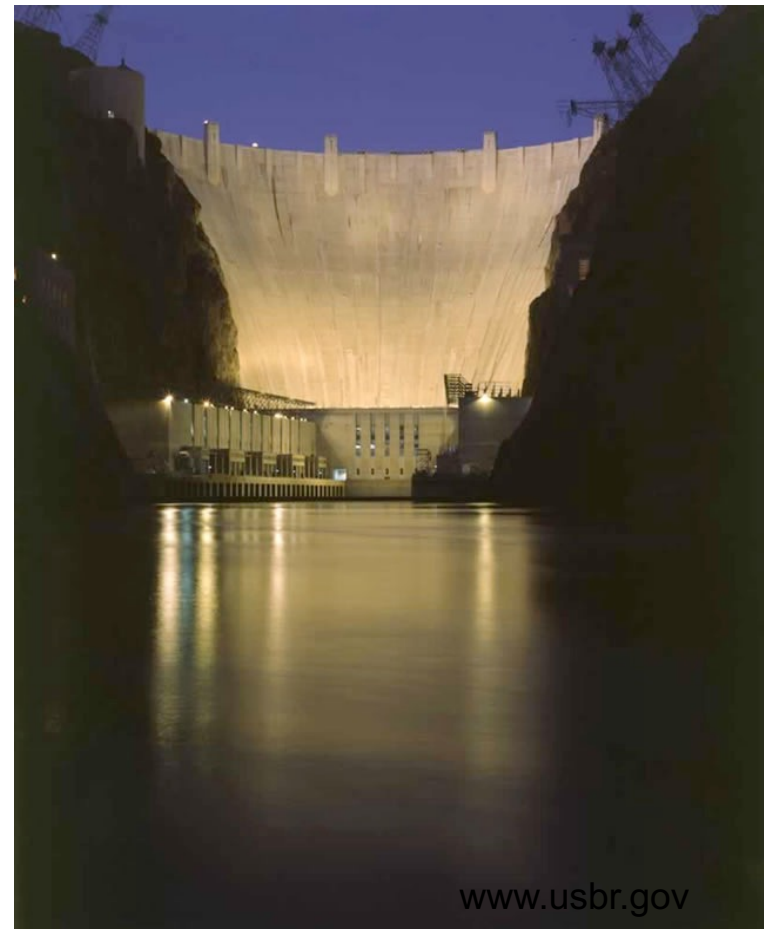
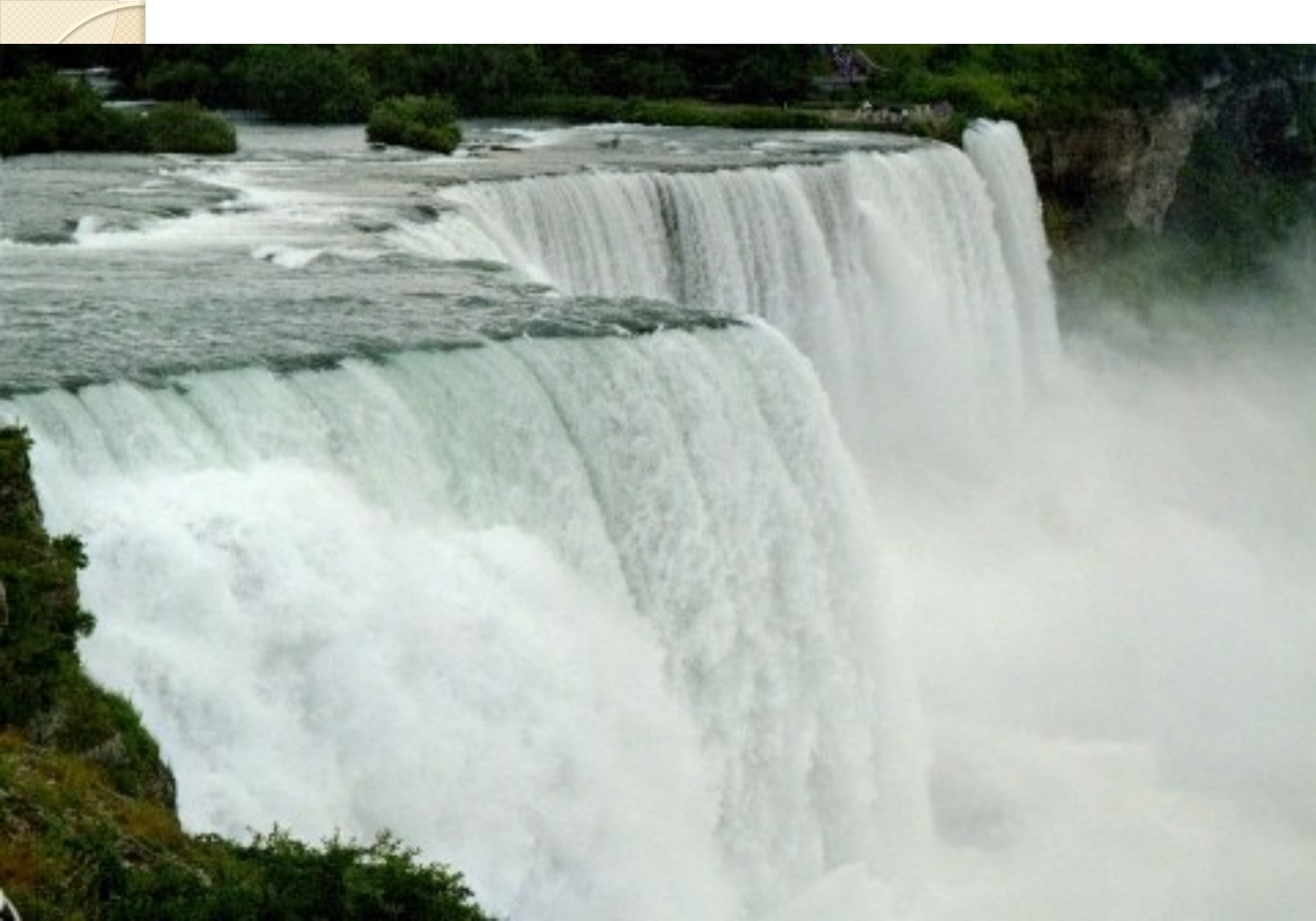


Hydroelectric Energy: An Overview

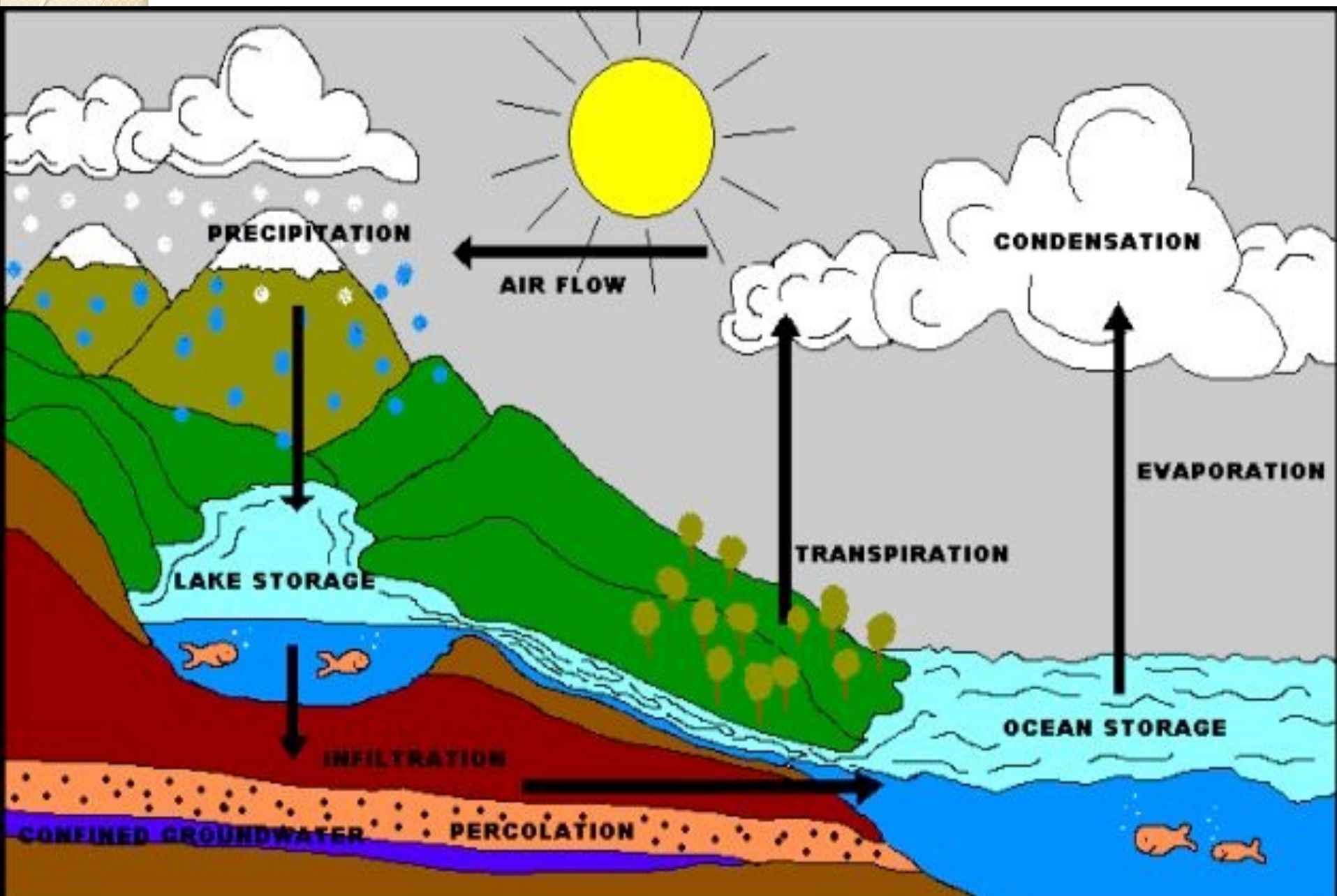
Kenneth M. Klemow, Ph.D.
Wilkes University





Points to be covered

- The water cycle
- Flowing water as a source of power
- Historic uses of hydro power
- Types of hydroelectric generation
- Benefits of hydroelectric power generation
- Current levels of hydroelectrical generation capacity worldwide and in US
- Issues regarding hydroelectric
- Potential new sources of hydroelectricity



Flowing water is a source of power

$$\text{POWER (kW)} = 5.9 \times \text{FLOW} \times \text{HEAD}$$

- FLOW is measured in m³/sec
- HEAD is measured in meters

Hydro power is used in two ways

Direct



www.mastergardenproducts.com/

Electrical generation



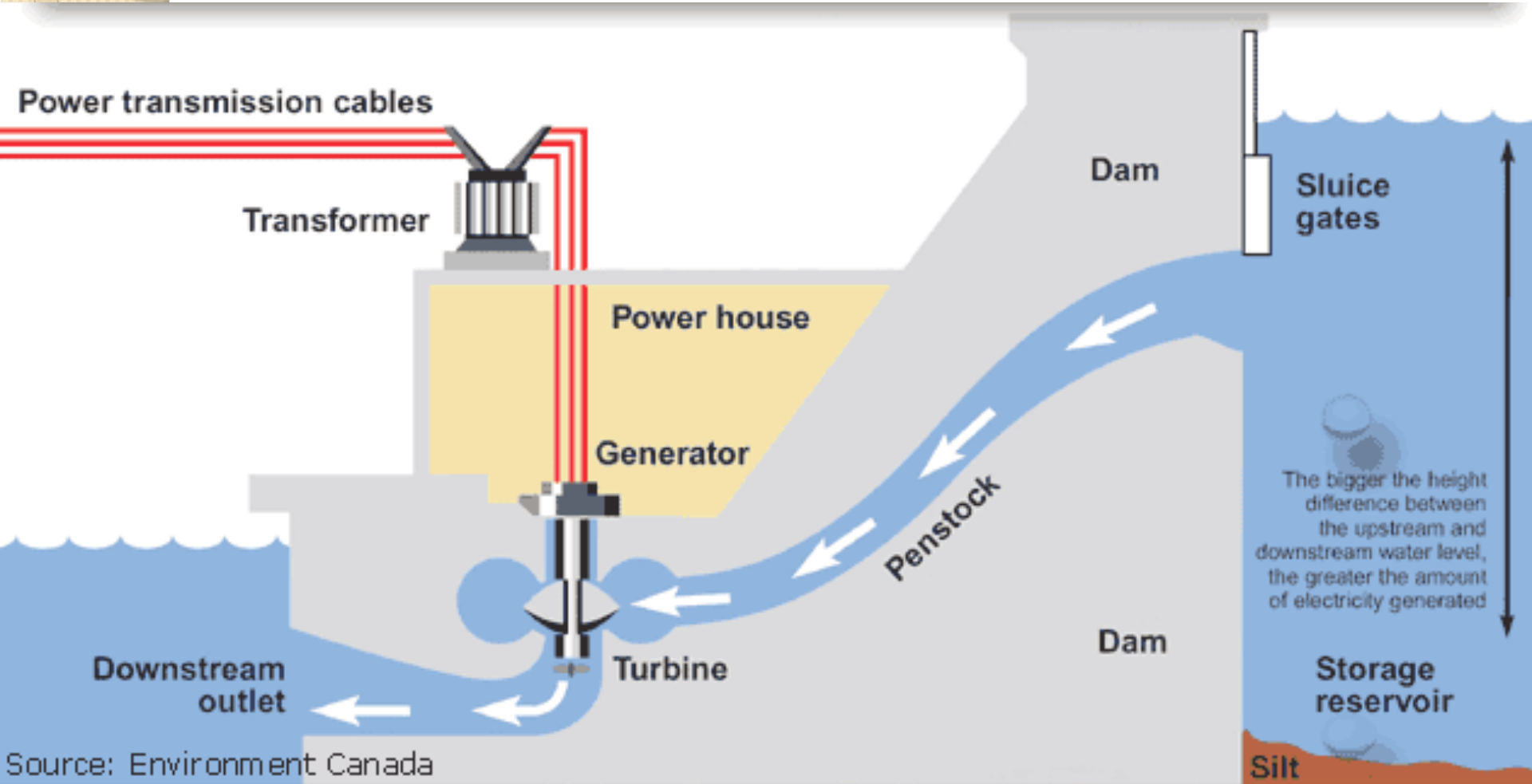
plaza.ufl.edu/cjk11/

Direct uses of hydro energy

- Textile manufacturing
- Grist mills
- Sawmills
- Irrigation



Hydroelectric power generation



Source: Environment Canada

Types of hydroelectrical generation

- Impoundment
- Pumped storage capacity
- Run of river (diversion)

Impoundment generating facility



Pumped storage capacity



Ffestiniog Pumped Storage, Wales

<http://en.wikipedia.org/wiki/Image:Stwlan.dam.jpg>

Diversion facility

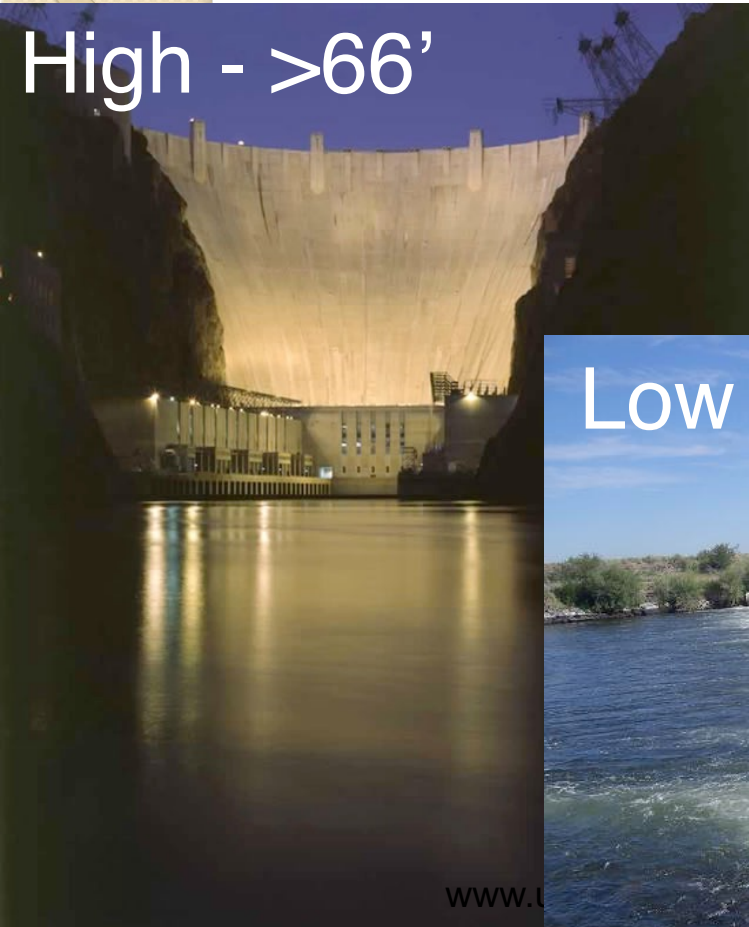


- Tazimina facility, Alaska

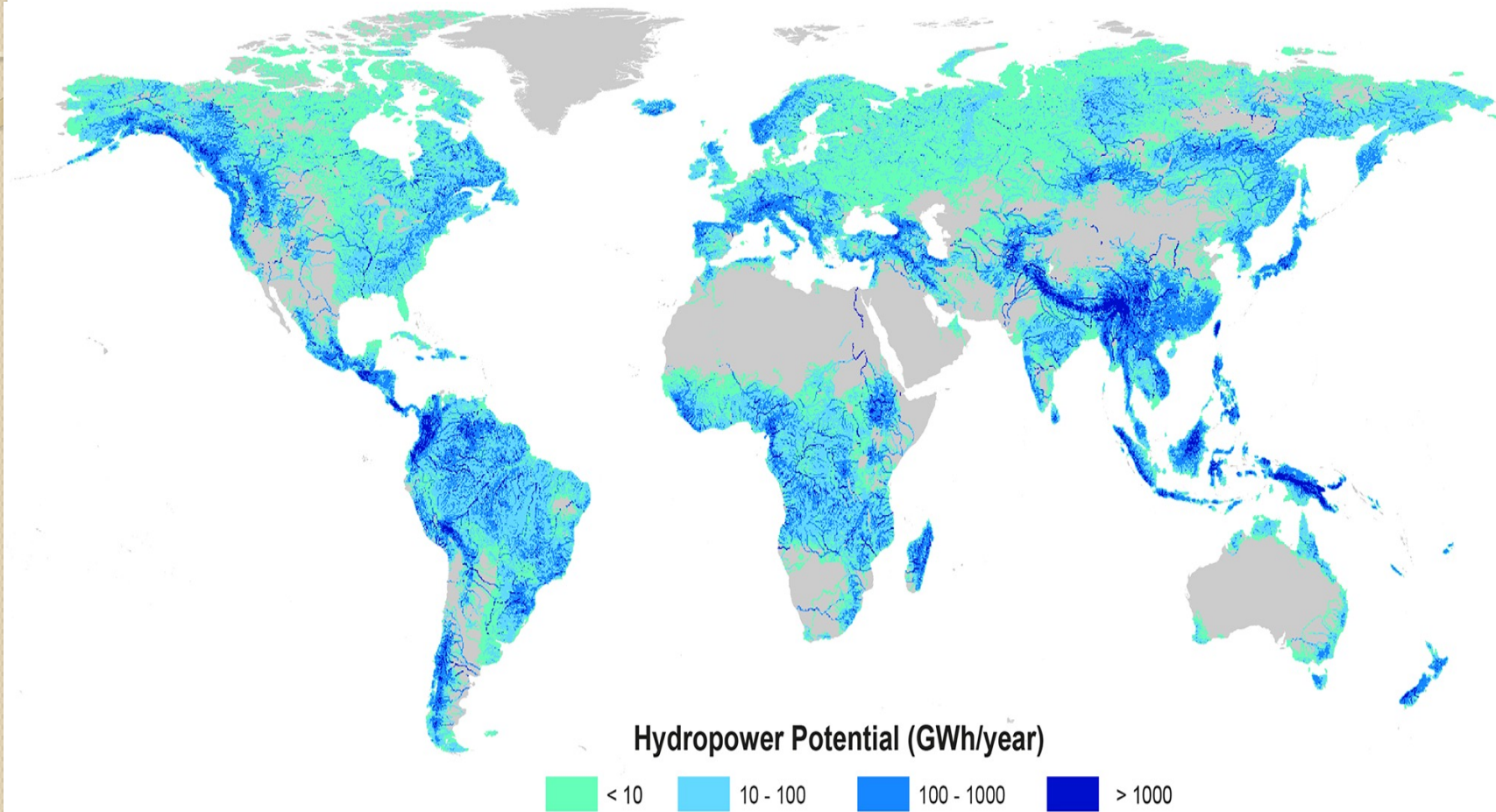
Classification of Hydro Plants Based on Generating Capacity

- Micro - < 0.1 mW
- Small - $0.1 - 30$ mW
- Large - >30 mW

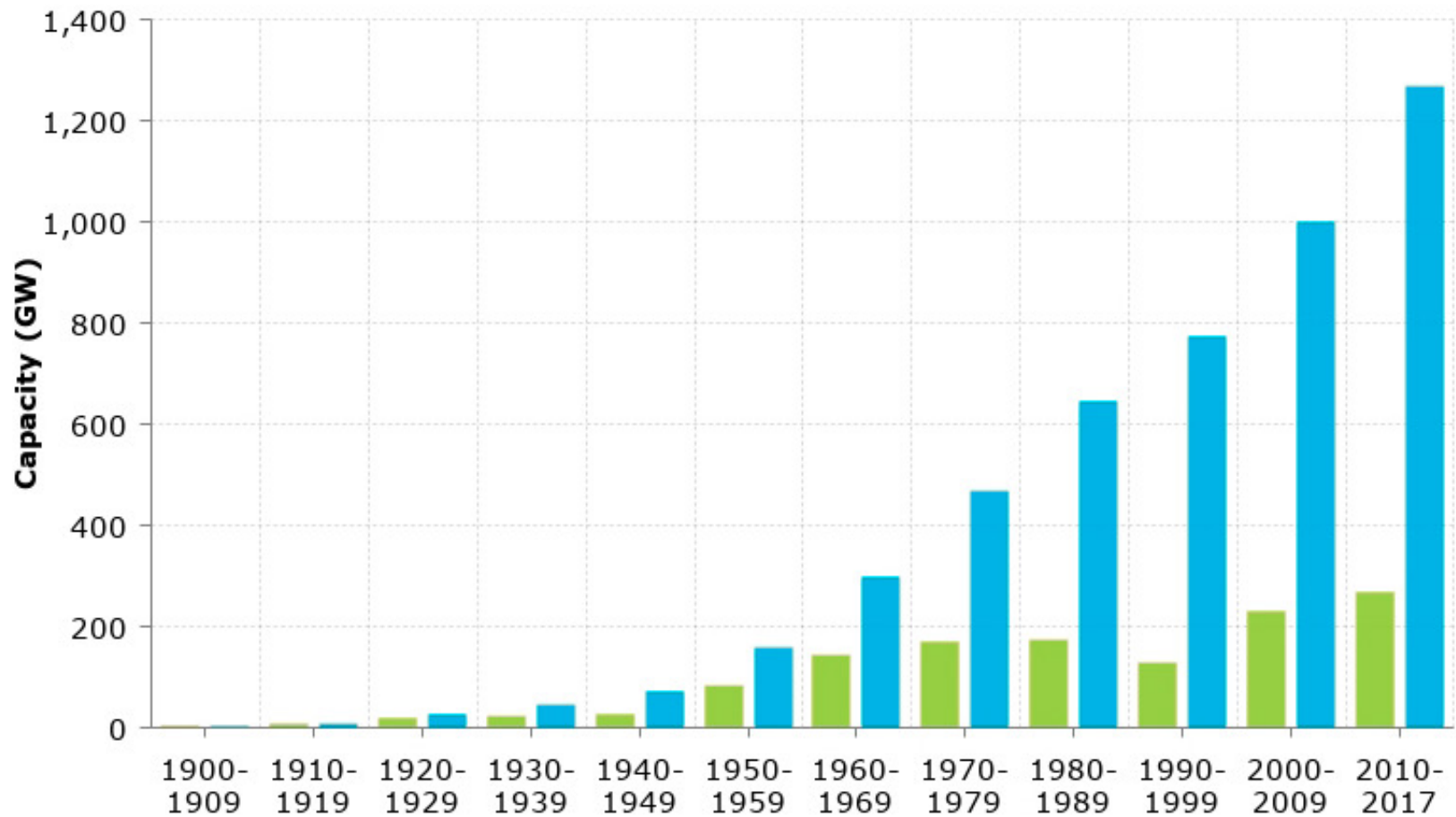
Classification of Hydro Plants Based on Head



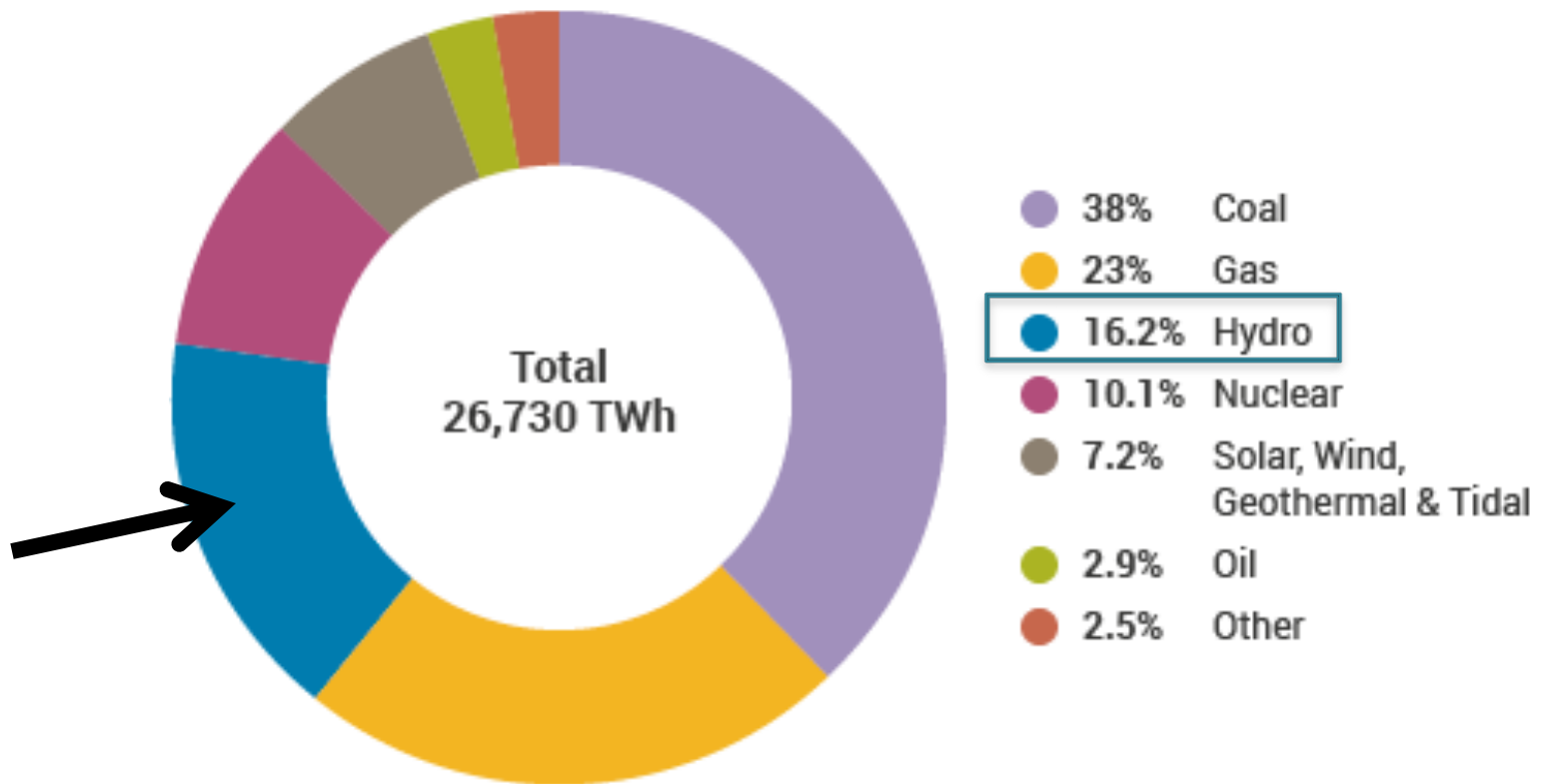
Global hydropower potential



Hydropower installed capacity growth since 1900

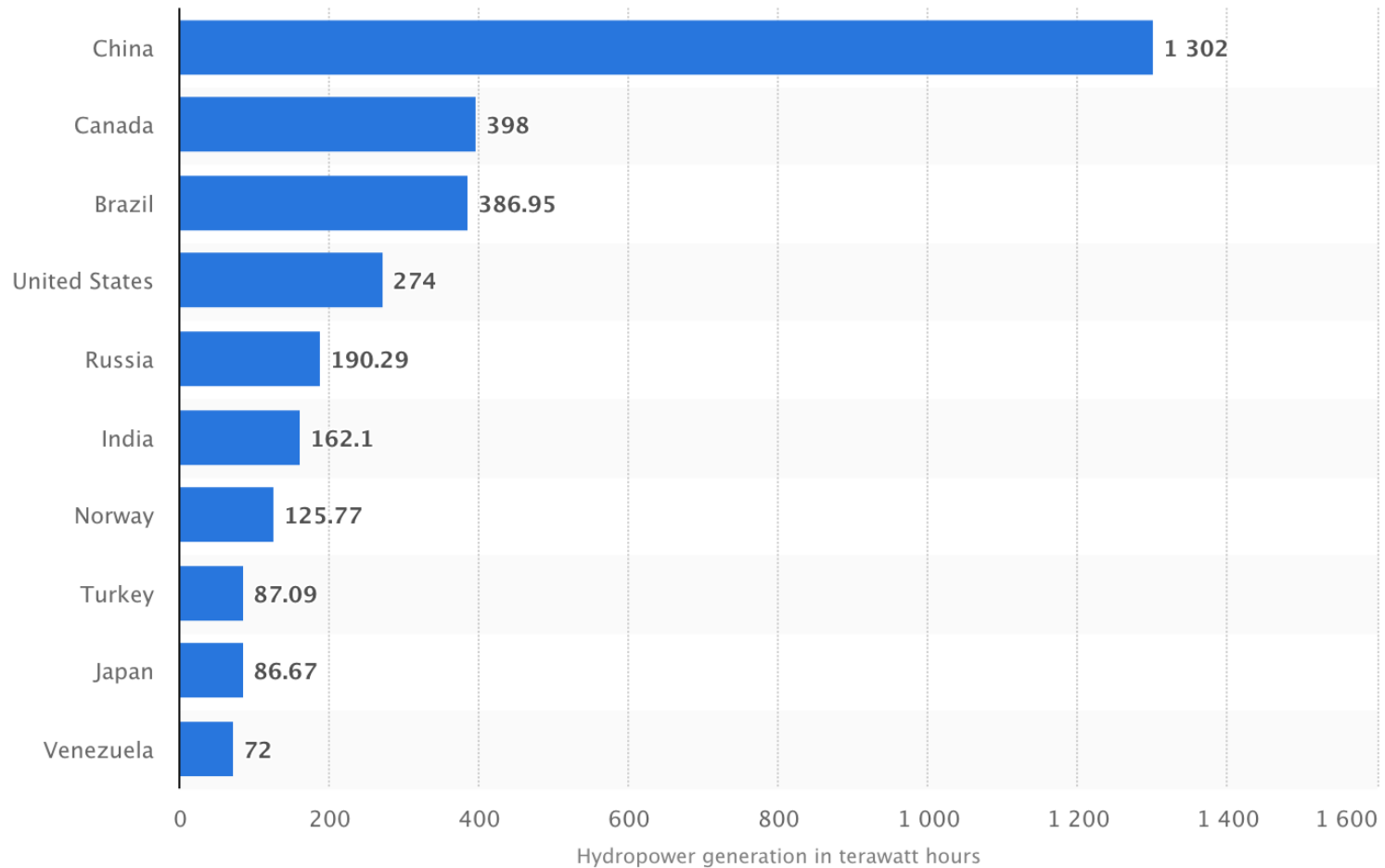


World electricity production by source - 2020.

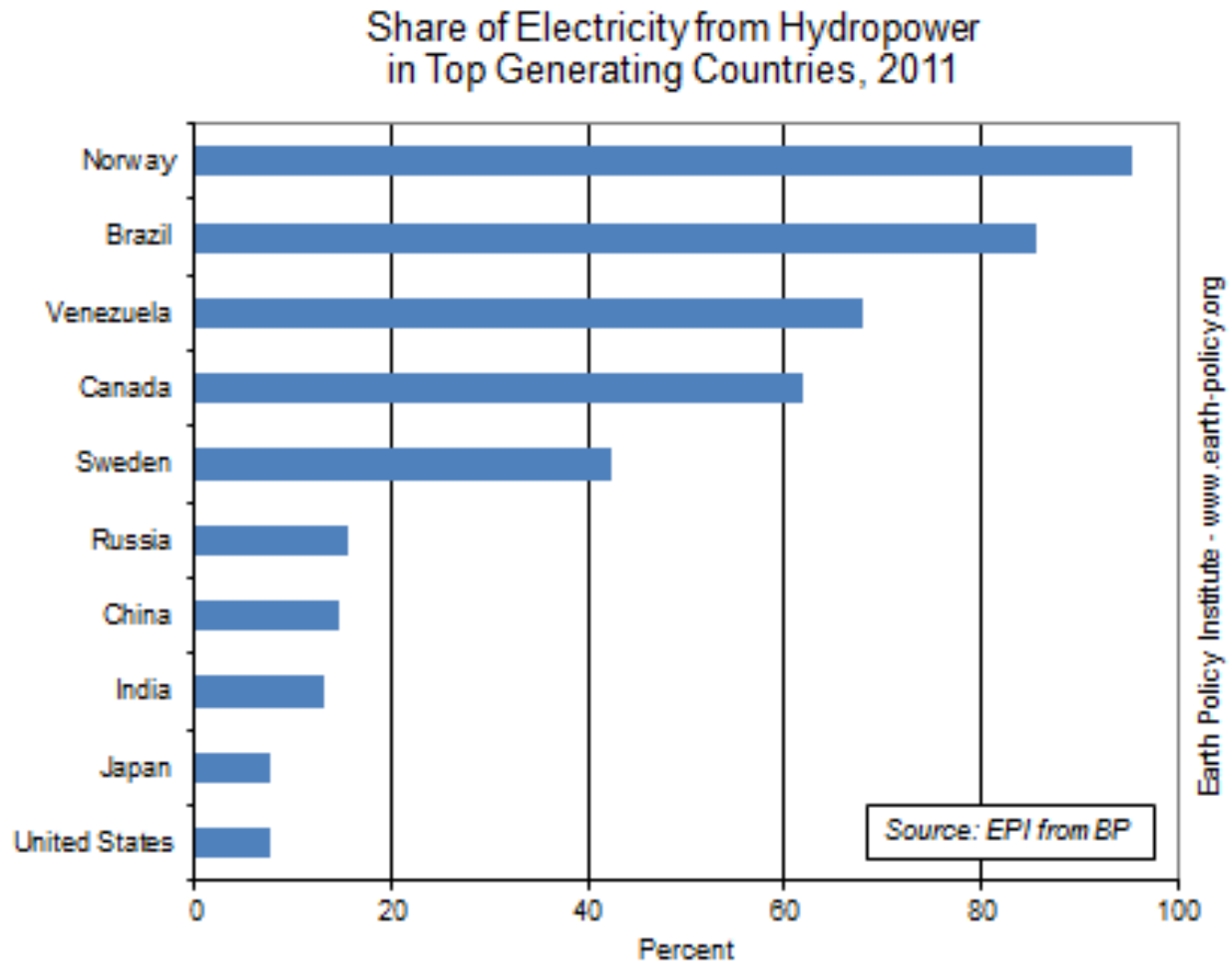


Source: IEA

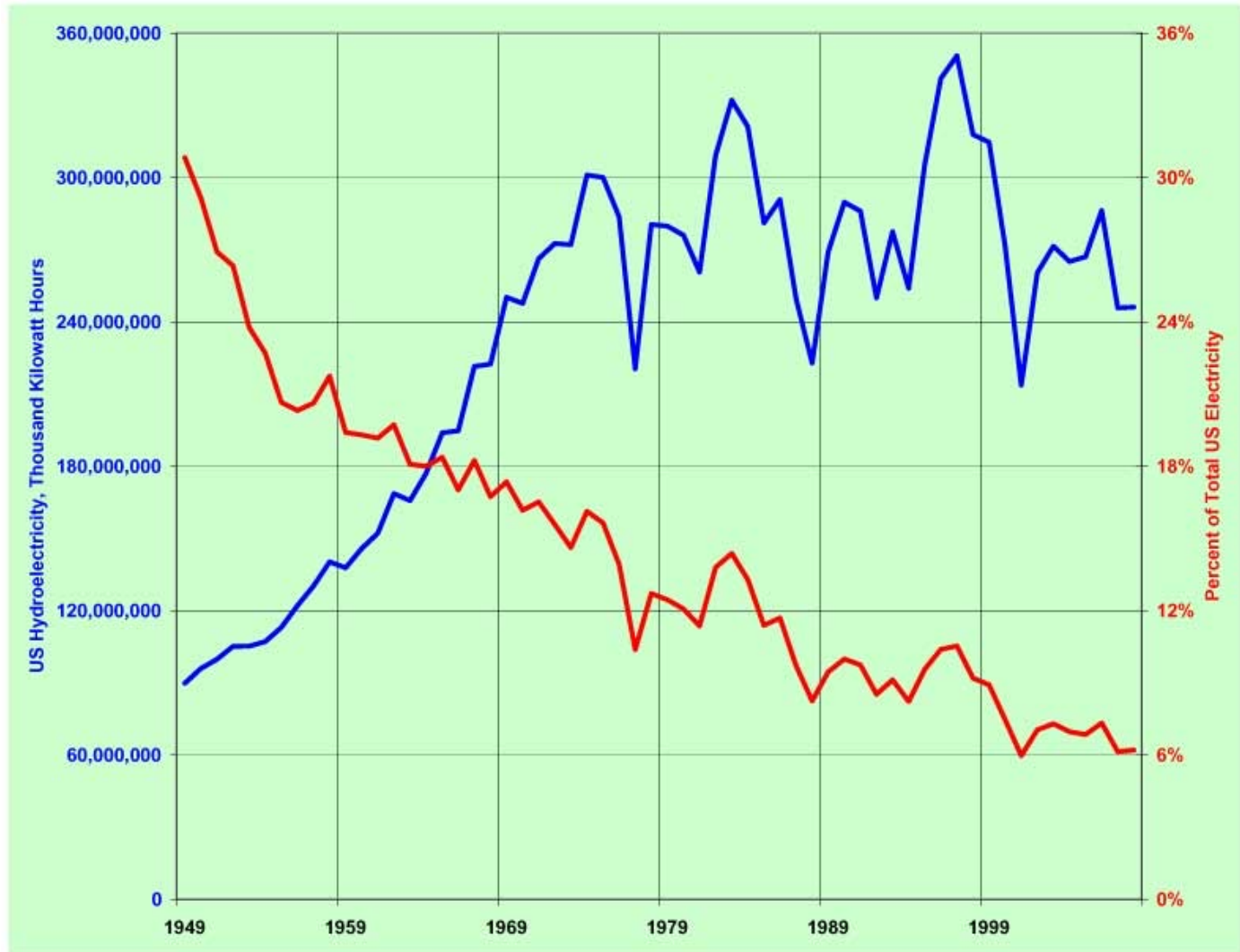
Hydropower by country 2019



Which countries rely on hydropower?

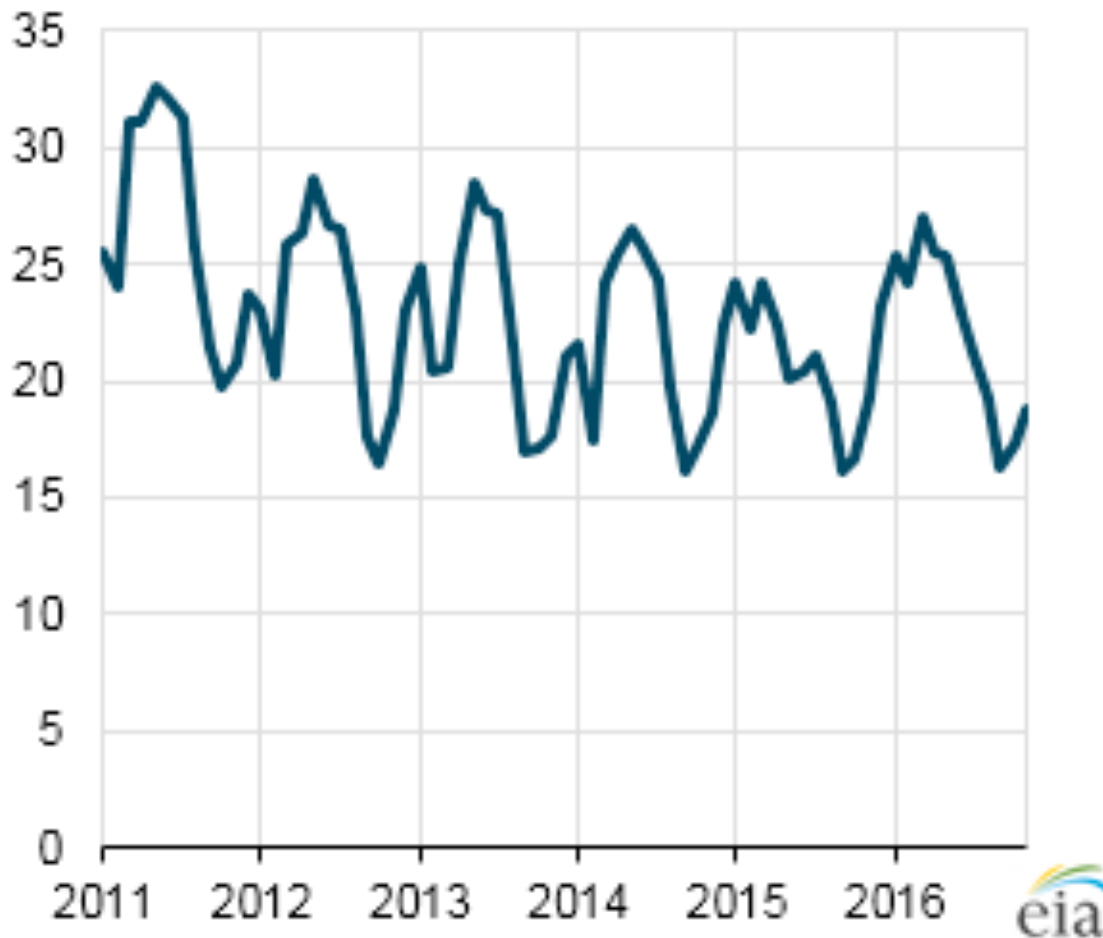


US Hydropower generation 1949-2009



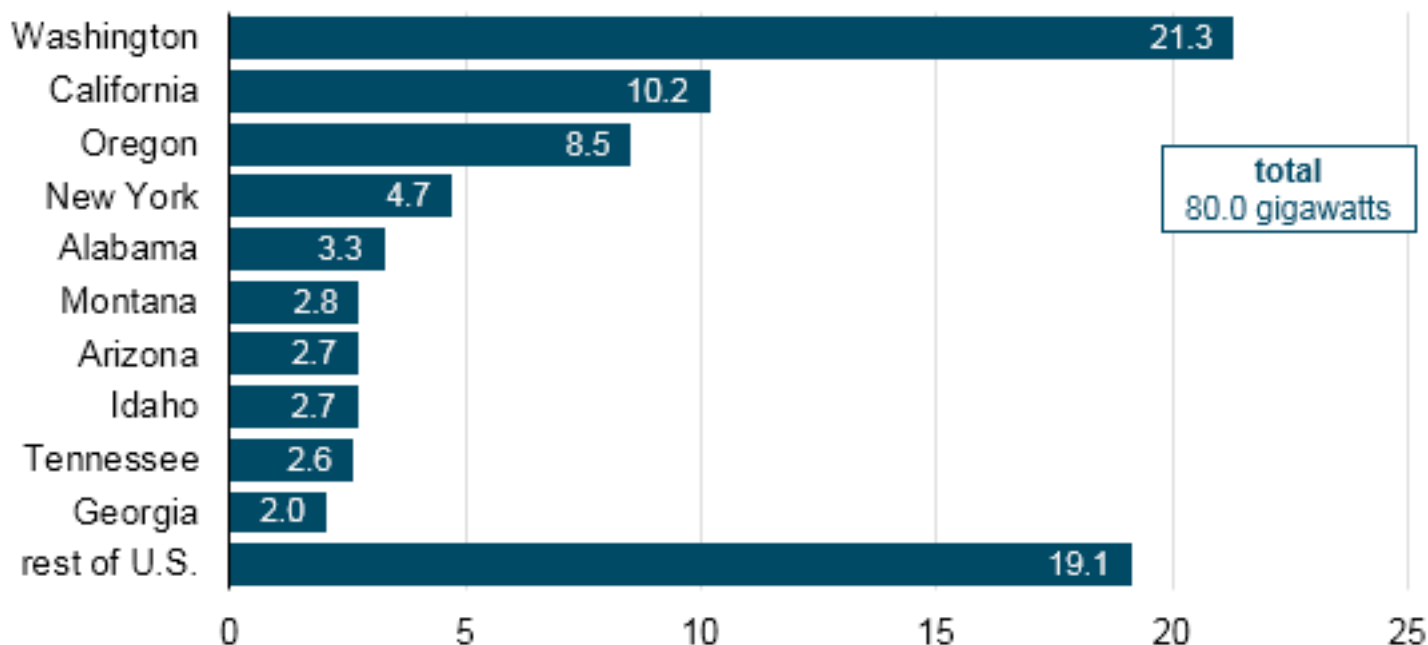
More recent data (2011-2017)

Conventional hydroelectric net generation
million megawatthours

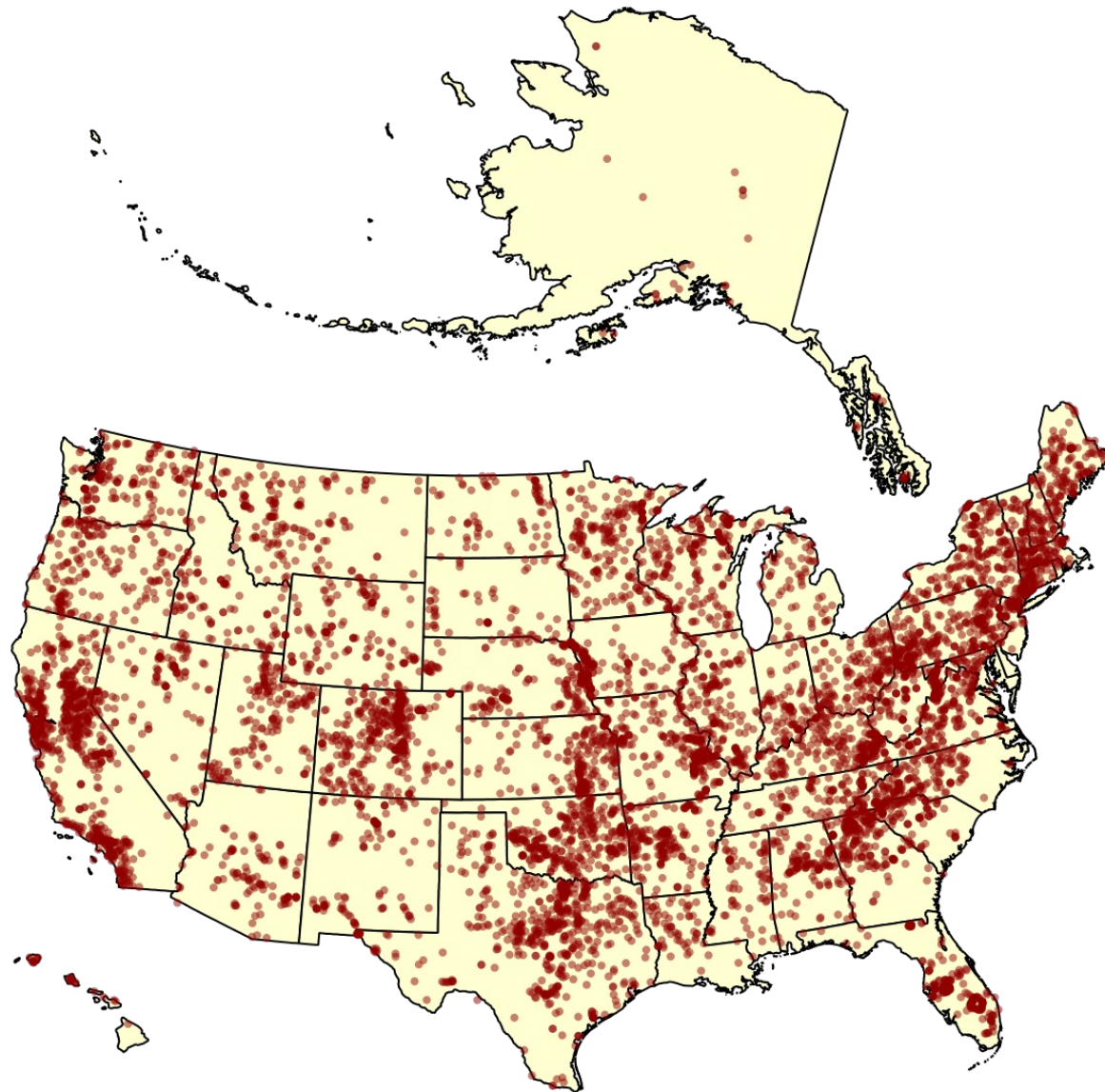


U.S. Hydropower by State

Operating conventional hydroelectric generating capacity by state (as of Dec 2016)
gigawatts



Dams in US; 2006



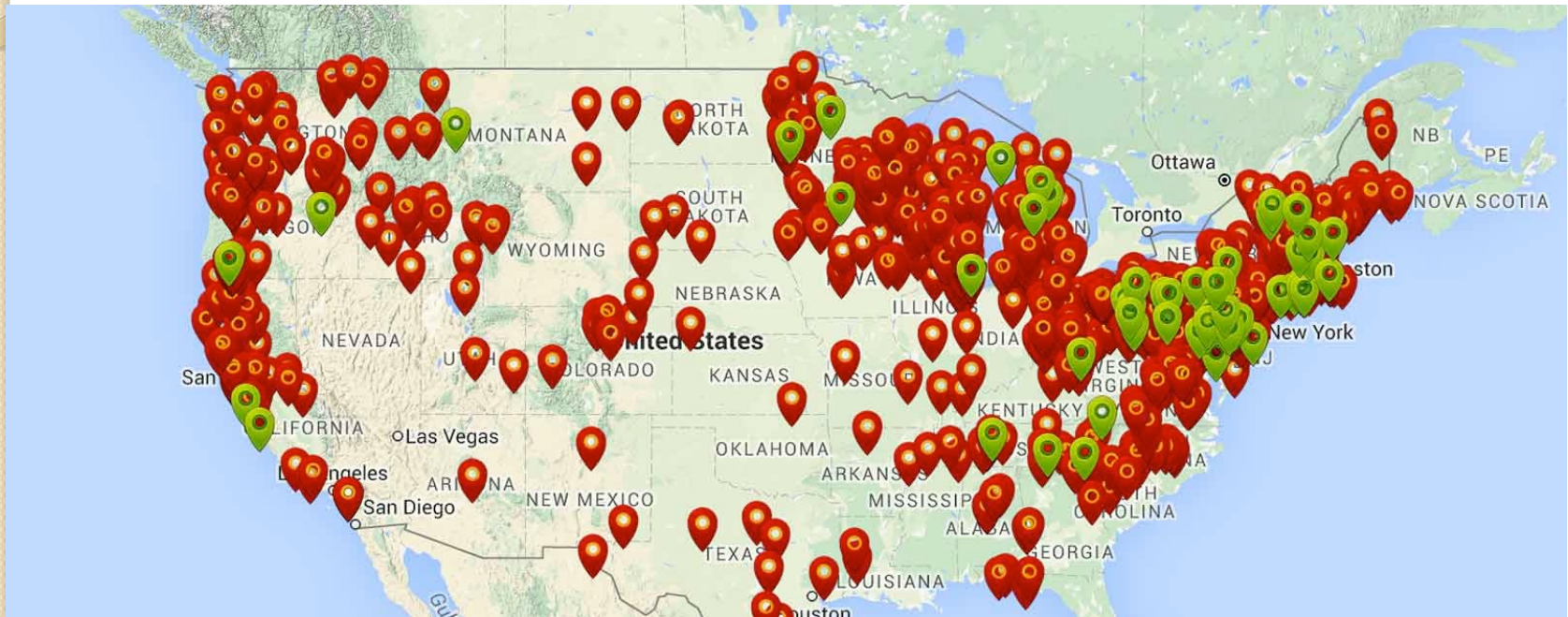
Benefits of hydroelectric power

- Economic benefits
 - No fuel costs
 - Low labor
- Dams provide recreation and flood protection
- Systems are long-lived (decades)
- Provides relatively constant power
- Conserves fossil fuels
- Benefits local economies
- Can be implemented remotely
- Can prevent pollution caused by fossil fuels

Problems associated with hydropower

- Impacts to fish and birds
- Upstream impacts
 - Wetlands are flooded
 - Humans often displaced
 - Siltation behind dams
 - Release of greenhouse gasses
- Downstream effects
 - Scouring
 - Temperature impacts
 - Dam failures can flood downstream communities

Dams removed in United States



<https://www.americanrivers.org/threats-solutions/restoring-damaged-rivers/dam-removal-map/>

Examples of dams being removed in the U.S.

- Embrey Dam, Rappahannock R., VA (22' – 2004)
- Marmot Dam, Sandy R., OR (50' – 2007)
- Condit Dam, White Salmon R., WA (123' – 2011)
- Elwha and Glines Canyon Dams, Elwha R., WA (108' – 210' – 2012)

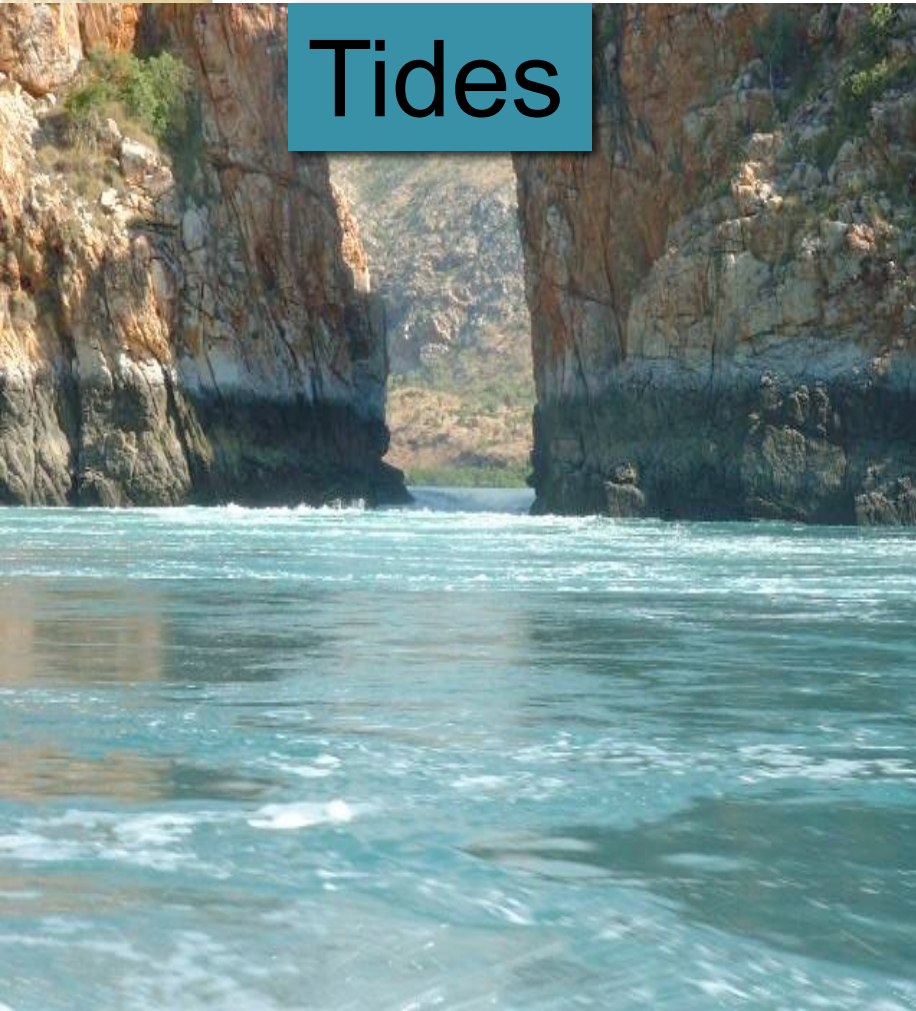


<https://sge.clark.edu>

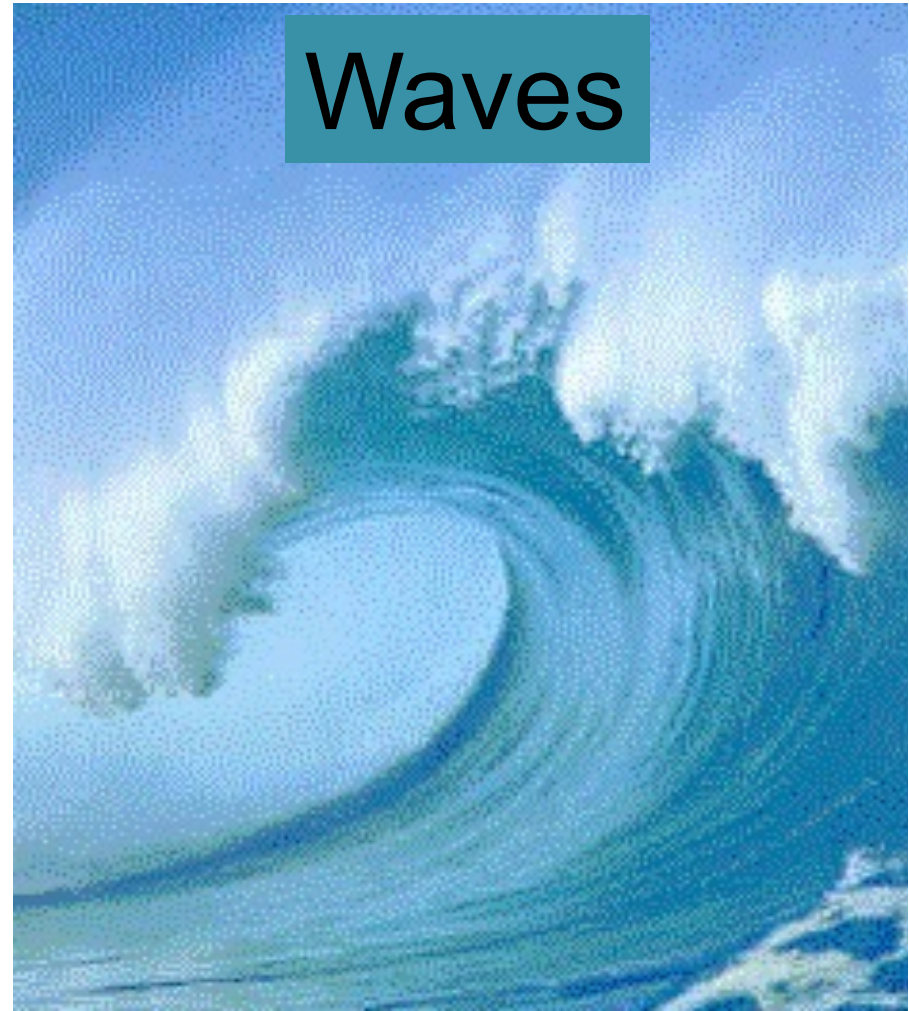
Marmot Dam Removal

Potential new sources of hydroelectricity

Tides



Waves



Tide Power

- Based on diurnal movements of water in oceans
- Most effective in areas with pronounced tides
- Include
 - Tidal stream systems (kinetic energy of flow)
 - Barrages (head energy of surface differences)



Tidal stream systems

- Dominant technology is shrouded turbine
- Prototypes have been tested in England, Australia, and Italy.
- Outputs up to 1.2 MW are noted



en.wikipedia.org/wiki/

Barrage systems

- Depend upon impoundments built along coastlines
- Developed in Canada, Russia, and France
- Largest generates 240 MW.
- Limited by geography, environmental considerations



Wave Power

- Based on up-and-down motion of sea surface
- Can be captured using devices that convert motion to electricity
- Could yield more electricity than tidal
- Recently deployed systems include
 - Portuguese project - 2.25 MW
 - Scotland project - 3.0 MW
- Challenges include low speeds, corrosion, wind damage



Capturing energy of gulf stream

- Project proposes to capture ocean currents
- Harnessing Gulf Stream off Florida can provide 1/3 state's energy needs

