Physics 162; Spring 2021
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Project 1: Hydroelectric Potential

Goals: We've learned about fundamental aspects of how hydroelectric power works. We've also made some very simple estimates of potential hydroelectric power – in other words, how much we coul possibly tap, in principle. Let's build on all these things, and also compare to more sophisticated assessments of hydroelectric potential in the United States (and possibly elsewhere).

Groups: You are encouraged (but not required) to work in groups of up to three students. Feel free to use the Discussion board to find classmates. I suggest posting your major, which might help connect with similarly inclined students.

Due date: Wednesday April 21, by 5:00 pm, **via Canvas**. No late assignments will be accepted. Submit your assignment as one PDF. Clearly indicate all group members' names.

Hydroelectric Potential Assessment
For various states, as detailed below, you'll calculate a very rough estimate of the maximum possible power we could get from hydroelectricity, *just like we did for the state of Oregon*.

- To find the annual precipitation (which includes rain and snow), go to https://www.currentresults.com/Weather/US/average-annual-state-precipitation.php , which tabulates data from the NOAA National Climatic Data Center.
- The area of each U.S. state is very standard data; you can get this from Wikipedia.
- For the elevation of each state, go to https://www.infoplease.com/us/geography/highest-lowest-and-mean-elevations-united-states. For the height difference, subtract the state's minimum (right column) from the mean elevation (first data column) – this is average drop in height water could take in that state. For States with negative values (like California, in which Death Valley is below Sea Level) use zero as the minimum height, since we'll need water to drain to the sea and not collect in those basins.
- The area of each U.S. state is very standard data; you can get this from Wikipedia: https://en.wikipedia.org/wiki/List_of_states_and_territories_of_the_United_States_by_population .
- Be sure to consistently **use SI units.** Also note that M = Mega = 10^6, and G = Giga = 10^9.
- As in class, we'll very roughly estimate that a state can capture as electricity at most **10%** of the maximum gravitational potential energy available from its precipitation. (This is an "order of magnitude" estimate – the true efficiency isn't 100%, and is probably better than 1%, so 10% is reasonable.)

Actual hydroelectric output:

- To find the *actual* hydroelectric power output of a state, go to the U.S. Energy Information Administration site: https://www.eia.gov/. There are several ways to get state-level data. One is to go to https://www.eia.gov/electricity/data/state/, then get the Excel file for "Net Generation by State by Type of Producer by Energy Source". This lists a *lot* of information for each state, for each year from 1990 to 2019. Scroll to 2019. For whatever state you want, look for "Total Electric Power Industry" and "Hydroelectric Conventional" – the number tells you the **MWh** of energy generated in 2019. For Oregon in 2019, for example, it is

2019	**OR**	Total Electric Power Industry	Hydroelectric Conventional	30,322,003

  This is line 53132 of the file.
  Note that it's 30,322,003 MWh in 2019, or about 30,000,000 MWh/year (not a typo – it really is 3 x 10^{13} WattHours/year), which you can convert to GW.

Sources

You're welcome to use other data sources if you want. If you use sources other than those I list here, cite them in your writeup.

Part 1: States

Group A: WA, CA, ID
Group B: CT, MA, LA, SC
Group C: KS, AK

Pick one state each from groups A, B, and C, and pick 3 other states. Pick states that don't border each other.

OR: Pick one state each from groups A, B, and C, and pick 2 other countries. NOTE: It may be hard to find data on other countries, so look into this before you decide. Also, don't pick large countries, since treating them as one "patch" will be very inaccurate. (Or you can pick particular states or provinces of large countries.)

1.1 Calculate (24 pts.)

For each state, calculate the following and write your results in a table.

- The estimated maximum possible power that state could get from hydroelectricity, in GW
- The estimated maximum possible power that state could get from hydroelectricity, per capita, in kW
- The actual hydroelectric output of that state, in GW
- The actual hydroelectric output of that state, per capita, in kW

1.2 Comment (10 pts.)

In a few sentences, comment on your results. Are the states similar, or different? Which of them currently uses the greatest fraction of its potentially available hydropower? Do any of the states use

less than 5% of their potential *and* have a hydroelectric potential of more than 1 kW per person? (These might be great places to develop more hydroelectric plants.)

Part 2: Better Assessments

"Real" hydrologists and civil engineers make more accurate assessments of the hydroelectric potential of states. How do our rough assessments compare?

2.1 Compare (6 pts.)
The table on Page 2 of the following document from the U. S. Department of Energy (DOE) notes accessible hydroelectric capacity in each state, assessed by a realistic study of hydropower resources: https://www.energy.gov/sites/default/files/2014/04/f15/New%20Stream-Reach%20Development%20Potential%20April%202014.pdf . For each of the states you considered, how does your simple estimate compare with the DOE estimate? If they differ by less than a factor of 5, we should be impressed!

2.2 Outlook (8 pts.)
Write down the following:

- From the above DOE document, note its statement of *total* accessible hydroelectric capacity that remains in the United States, in GW.
- From another U.S. Government document here, https://www.energy.gov/eere/water/hydropower-resource-assessment-and-characterization, note the hydroelectric power (in GW) available from dams that are already built, but that don't generate electricity.
- From whatever sources you want, note the current total hydroelectric power generation in the US, in GW. (Cite your sources.)

OR

- Do a similar exercise for the other countries you examined earlier, if you examined other countries. Cite any sources you use.

2.3 Guessing the U.S. Comparison (4 pts.)

Later (not part of this assignment), we'll combine everyone's estimates of states' potential hydropower and compare to the overall assessments for the United States we saw in Part 2.2. Based on what you've calculated for a handful of states so far, how well do you think these will agree?

Other scoring

General clarity: 10 pts.