Raw Power of Floating Solar

Turn your lagoon or reservoir into a powerplant

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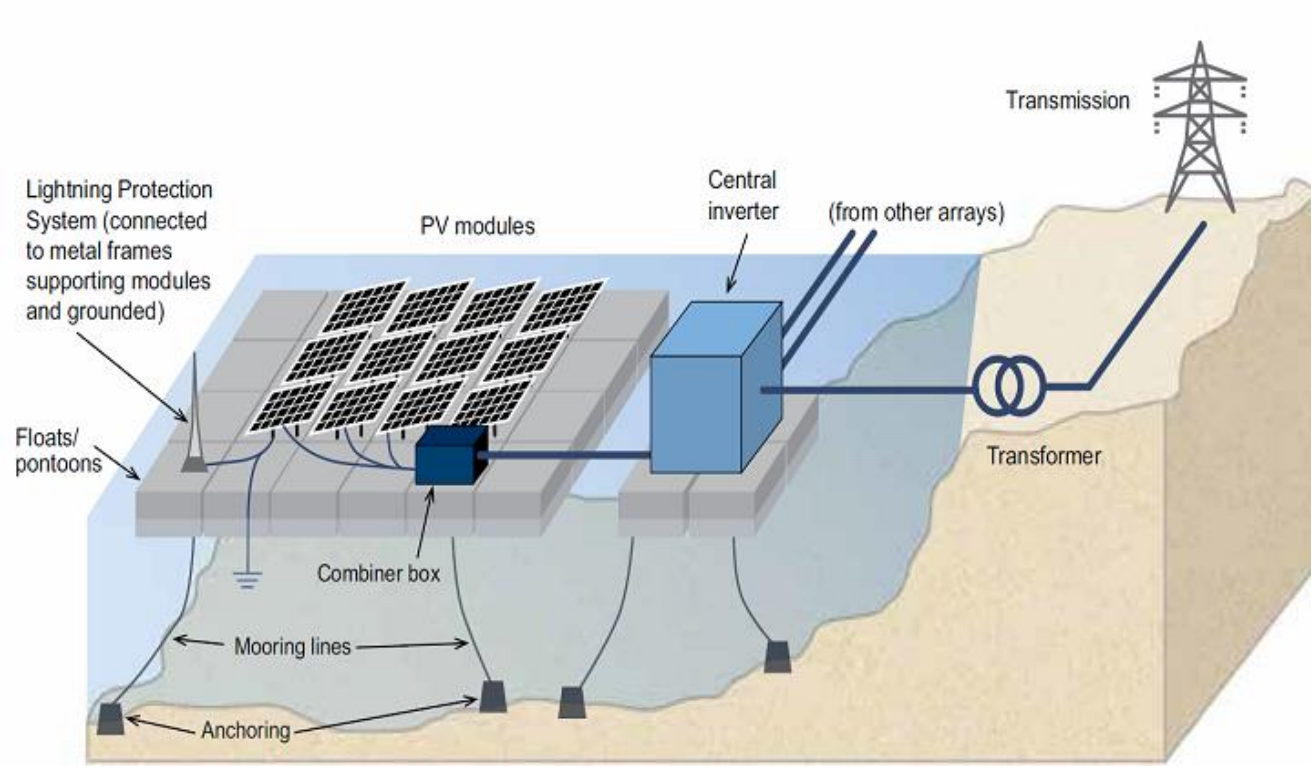
Floating Solar – A Brief History

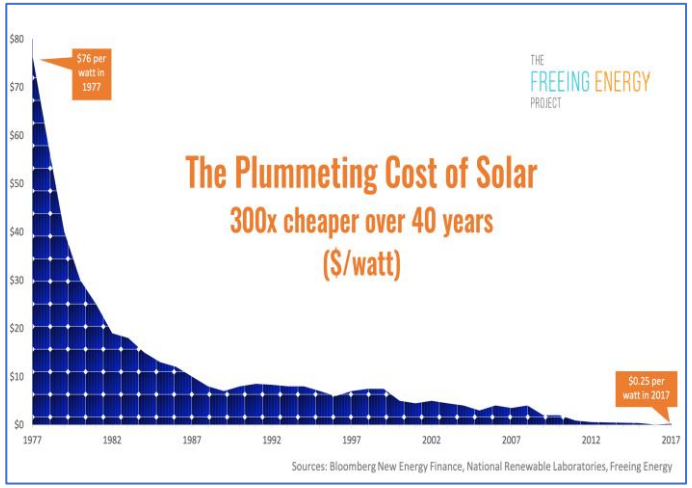
- First commercial installation in 2008
  - 0.175 MW installation at winery in California
- By 2018, more than 1,300 MW of installed capacity
  - Mostly in Asia (China, Japan, and Southeast Asia) and Europe (Germany, France, Spain, and The Netherlands)
- By the end of 2020, more than 20 installations in the United States
  - Initial installs mostly in California, Florida, and New Jersey

Floating Solar – The Basic Building Blocks

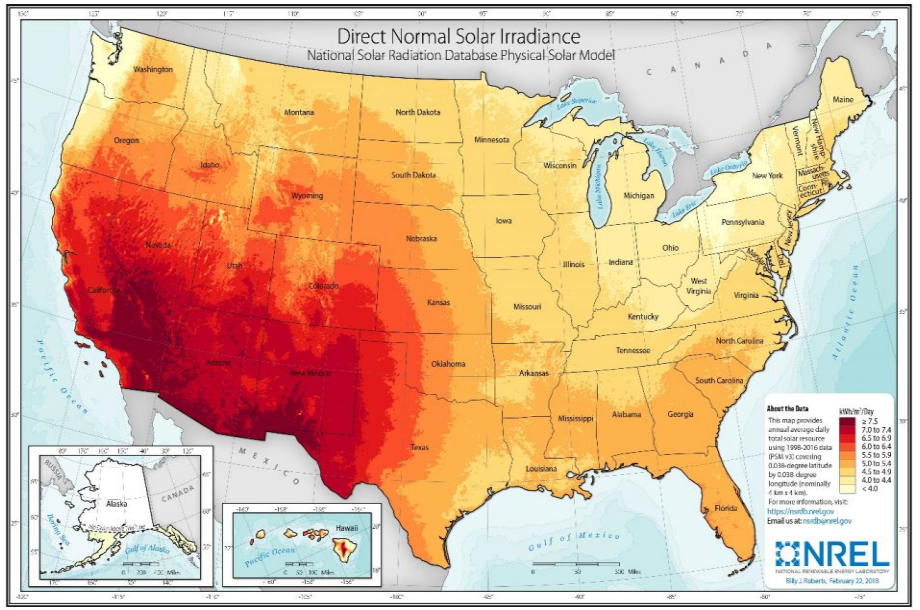


1. Pontoons/floats – Commonly HDPE (same as pipe, food containers)
2. Solar Panels – Racked on floats
3. Anchoring System – Flexible for water level fluctuations
4. Junction Boxes
5. Inverters – Convert DC to AC power
6. Transformer – Step up voltage
7. Electrical Transmission (if needed)

Why Consider Floating Solar



1. Save Money
   - Photovoltaic prices much less than the past
   - Water/WW utilities can save millions in power costs
2. Save Water
   - Floating solar decreases evaporation
3. Save The Planet
   - Reduced CO_2 emissions
   - Save humans, polar bears and oysters
4. Other good reasons as well
   - Water quality; Fisheries; Algae control



Some Recent US Utility Examples

- Healdsburg, CA (2021)
  - Largest floating solar facility in the US
  - 4.78 MW_{dc} installation
  - On tertiary wastewater ponds
  - Power purchase agreement for 25 years
    - Saves utility millions of dollars
  - Contact: Utility Director Terry Crowley, tcrowley@ci.healdsburg.ca.us

- Windsor, CA (2020)
  - Largest in floating solar in CA when built
  - 1.78 MW_{dc} installation
  - On wastewater ponds
  - Covers only 22% of pond area; Can be moved for maintenance

Some Recent US Utility Examples

- Sayreville, NJ (2019)
  - 4.4 MW_{dc} installation
  - Anchored to shore instead of reservoir bottom (atypical)
  - Can deal with hurricanes and >12 feet water level fluctuations
  - Financing through purchase power agreement; Save $150,000/year
- Walden, CO (2018)
  - Town of 600 people
  - 75 kW array on water impoundment
  - Supported by grant from Colorado Dept. of Local Affairs
  - Saves community $10,000/year

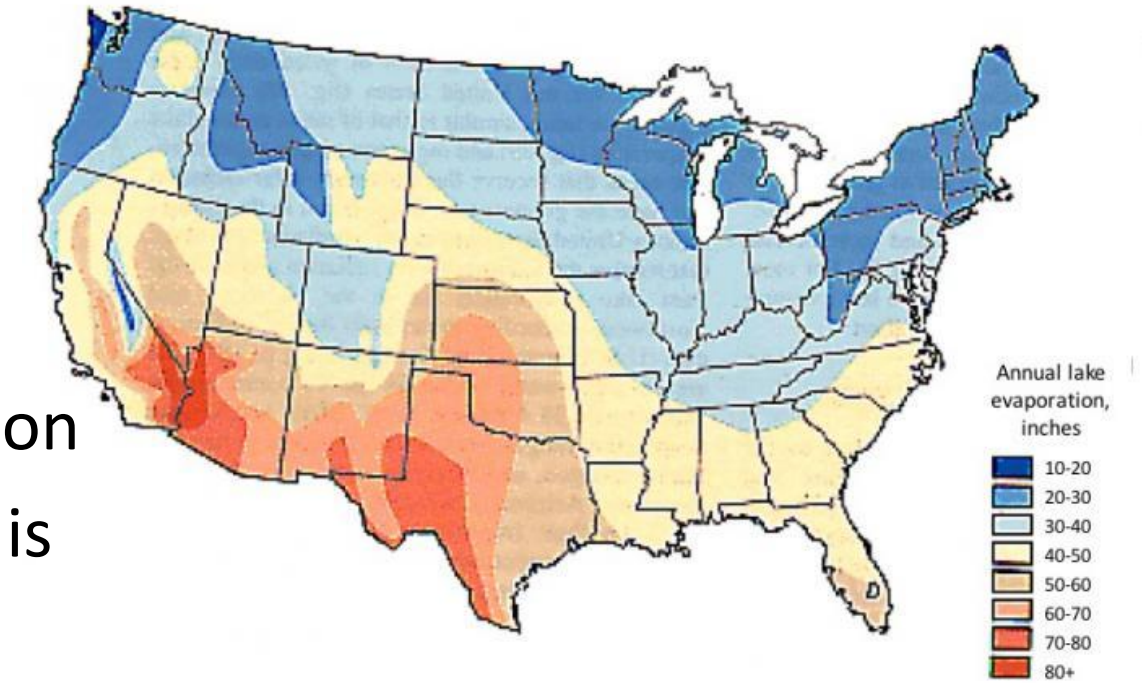
Pause/Questions/Hokey-Pokey Break

Save Money

- Healdsburg, CA
  - Used a power purchase agreement (PPA)
  - No upfront financing from the utility
  - Immediate cost savings
  - Expected to save City millions over 25 year life of PPA
- Walden, CO
  - Community owned
  - Partially grant funded; $200,000 investment
  - Expected to save the community $10,000/year in 2018 (20 year payback)
- Kelseyville County Waterworks District #3; Lake County, CA
  - Municipal lease-purchase agreement
  - Immediate savings of $1,000/month in 2018, savings rate increasing over time

Save Water

- Partial coverage of water bodies reduces solar evaporation
- Also reduces wind driven evaporation
- In eastern WA, annual evaporation is roughly 30 to 50 inches/year
- Assume evaporation of 38 inches/year and a 4 acre installation at 50% coverage; save roughly 6.3 acre-feet (2 MG/year)



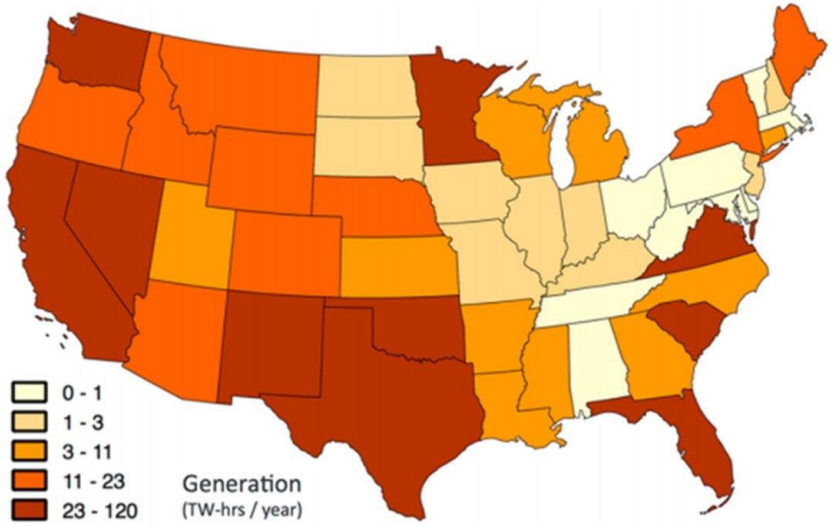
$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Other Benefits

- No land displacement
- Solar panel efficiency
  - Increases 5-20% due to cooling from water
- Reduced algae/cyanobacterial growth
  - Issue for some wastewater ponds and reservoirs
- Possible improvements for fish
  - Reduced predation by birds
  - Reduced algal growth (higher oxygen, better foraging)
- Possible co-location with electrical generation/consumption
  - Little or no need for added electrical transmission infrastructure

Information Resources

- *Assessing the Technical Potential of Photovoltaic Systems on Man-Made Water Bodies in the Continental U.S.* – NREL (2018)
  - Analyzed 24,000 larger man-made water bodies
  - Floating photovoltaic systems installed on 27% of the identified suitable water bodies could produce almost 10% of current US electrical needs
  - In WA, analysis included
    - 227 water bodies
    - 77,400 hectares of surface area
    - Power generation - 23.6 Terawatt-hrs/year

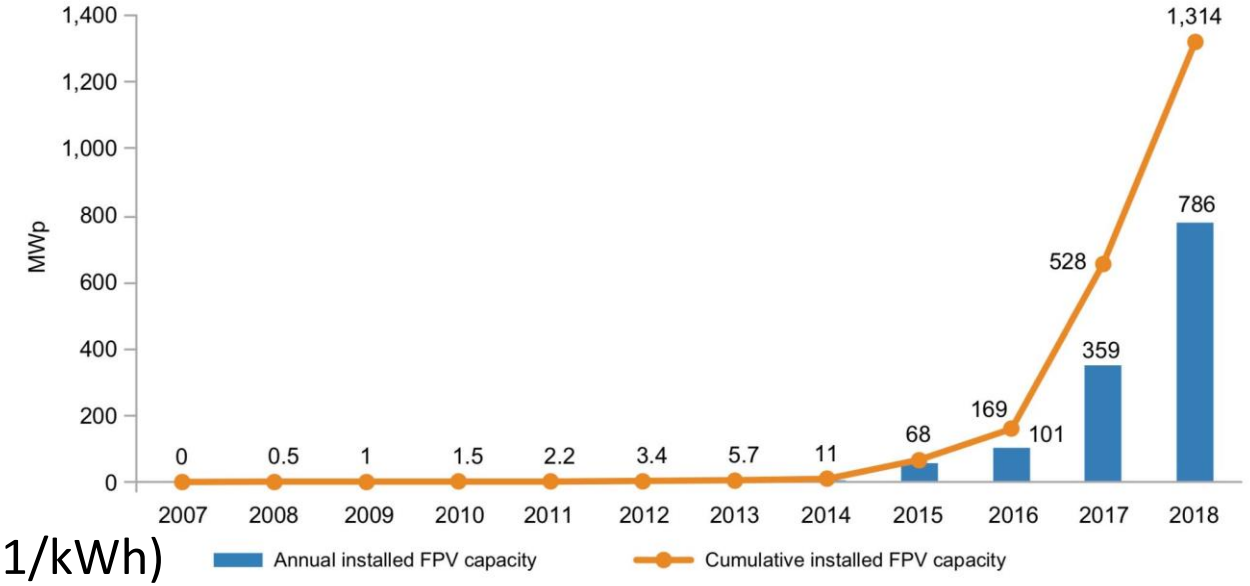


Who ya gonna call?

- Floating Solar - Equipment suppliers/manufacturers
  - Ciel & Terre – Largest supplier in the United States
    - Chris Bartle: cbartle@cieletterre.net; 707-658-4659
  - Isigenere – Large supplier in Europe; US Presence
    - Andres Franco: afranco@isigenere.com
  - BayWa RE – German company
    - Some of the largest installations outside Asia (<2 to 40 MW)
    - Mainly focused in The Netherlands
    - solarprojects@baywa-re.com
- Installations – Utility staff at Healdsburg, CA; Sayreville, NJ, etc…
- National Renewable Energy Lab (NREL)
  - Robert Spencer - robert.spencer@nrel.gov

A Few Future Floating Solar Projects

- Lots of big projects planned, and more
  - India
    - Indira Sagar Dam-1,000 MW
    - Omkareshwar Dam-600 MW
  - South Korea
    - Saemangeum/Yellow Sea-2,100 MW
    - Hapcheon Dam-41 MW
  - Indonesia
    - Duriangkang Reservoir-2,200 MW
    - Cirata Reservoir-145 MW (PPA $0.0581/kWh)
    - Other projects; 60 and 90 MW ($0.037/kWh)



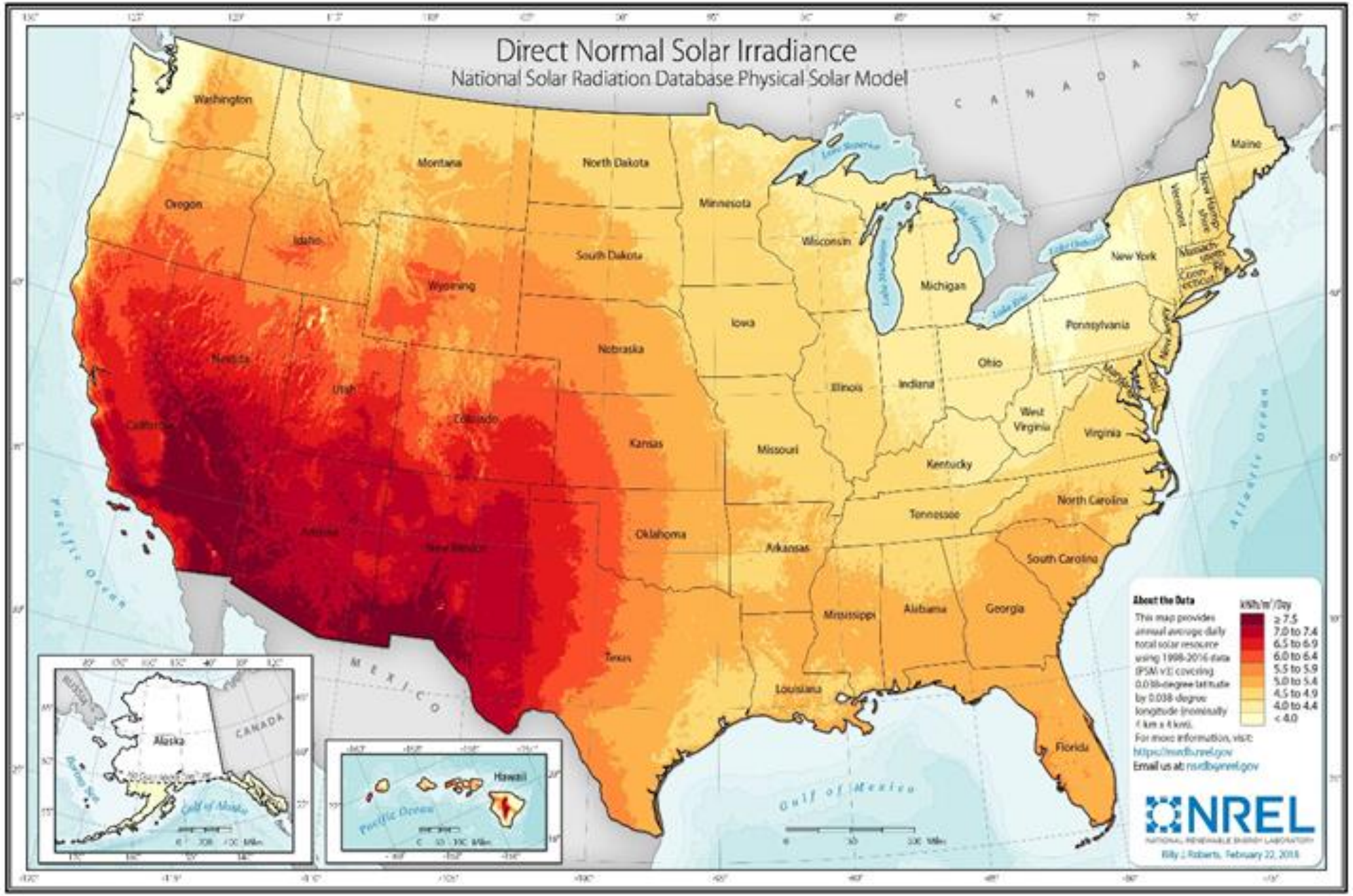
Fun Videos

- A Basic Overview
  - The World's Largest Floating Solar Farm - https://www.youtube.com/watch?v=DAEGNL56sEM (6 minutes)
- Dutch construction manager covers nuts and bolts of floating solar
  - Guided Tour of Floating PV project Bomhofsplas - https://www.youtube.com/watch?v=fxLGSGj04T8 (8 minutes)
- Singapore Public Utility Board (PUB) installation in 2021
  - Why Singapore built one of the world's largest floating solar farms - https://www.youtube.com/watch?v=4w1zNXGQxGs (6+ minutes)

Parting Thoughts

- Do your own research
  - Key terms: Floating solar; floatovoltaics; FPVs
  - Dozens of installations in the US. Mostly in California, New Jersey, Florida, and North Carolina
- Look into financing options (*this is the IACC after all*).
  - Power purchase agreements (PPAs)
  - Municipal lease-purchase agreements
  - Other options
- Consider ancillary benefits
  - Reduced evaporation/water savings
  - Preserving agricultural land
  - Reduction in algae and cyanobacterial growth

Questions/Comments/Thoughts


Direct Normal Solar Irradiance
National Solar Radiation Database Physical Solar Model
Washington
Oregon
Idaho
Montana
North Dakota
Minnesota
South Dakota
Wyoming
Nebraska
Iowa
Wisconsin
Michigan
New York
Maine
Pennsylvania
Ohio
Illinois
Indiana
West Virginia
Virginia
Kentucky
Missouri
Kansas
Oklahoma
Arkansas
Tennessee
North Carolina
South Carolina
Mississippi
Alabama
Georgia
Florida
Louisiana
Texas
Nevada
Utah
Colorado
California
Arizona
New Mexico
Alaska
Hawaii
CANADA
MEXICO
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
About the Data
This map provides annual average daily total solar resource using 1998-2016 data (PSM v3) covering 0.0 bi-degree latitude by 0.038 degree longitude (nominally 4 km x 4 km).
For more information, visit:
https://nsrdb.nrel.gov
Email us at: nsrdb@nrel.gov
kWh/m²/Day
≥ 7.5
7.0 to 7.4
6.5 to 6.9
6.0 to 6.4
5.5 to 5.9
5.0 to 5.4
4.5 to 4.9
4.0 to 4.4
< 4.0
NREL
Billy J. Roberts, February 22, 2018