CLIMATE CHANGE IMPACTS ON RENEWABLE SOURCES OF ENERGY

Guido Franco
Team Lead for Environmental Research
Public Interest Energy Research Program
California Energy Commission

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Acknowledgements

Outline

- Hydropower generation (Josh Viers)
- Wind resources
- Photovoltaic and Concentrated Solar
- Bioenergy
- Water availability and the electricity system
- Conclusions

Wind resources

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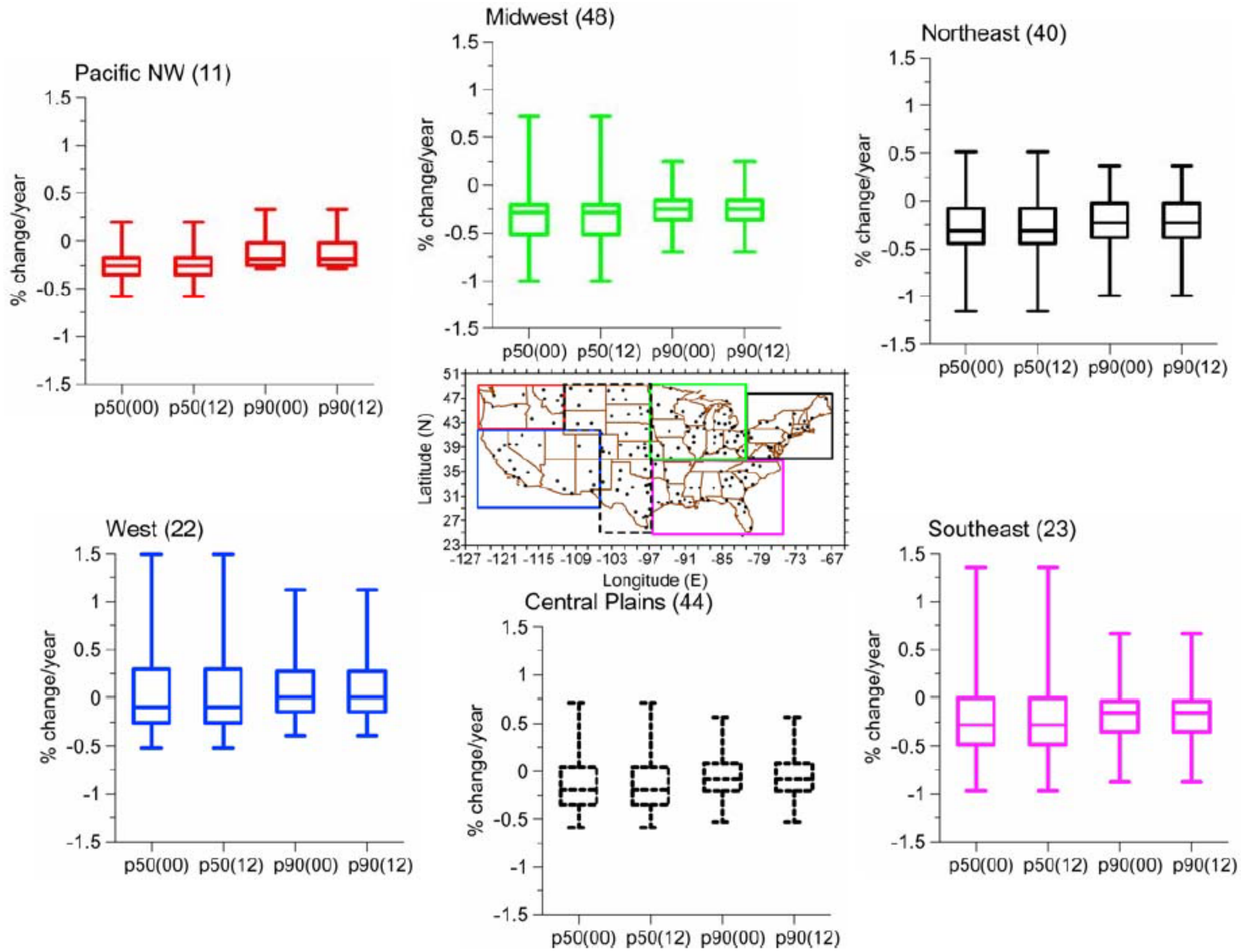


Figure 1. Regional synthesis of temporal trends in the annual median (p50) and 90th percentile (p90) wind speeds from the NCDC DS3505 data set for the 0000 and 1200 UTC observation times (shown as (00) and (12) in the box plots). The box plots are the synthesis of trends computed for all stations within the six regions: Pacific Northwest, West, Central Plains, Midwest, Northeast, and Southeast (the numbers in the title of each frame indicate the number of stations in each region). The horizontal bar in the center of the box plots shows the median value of the annual trend (in %/yr) and the upper and lower bars on the box show the 25th and 75th percentile values, while the vertical bars extend from the minimum to the maximum values.

Pryor, S. C., and J. Ledolter (2010), Addendum to “Wind speed trends over the contiguous United States,” J. Geophys. Res., 115, D10103, oi:10.1029/2009JD013281.

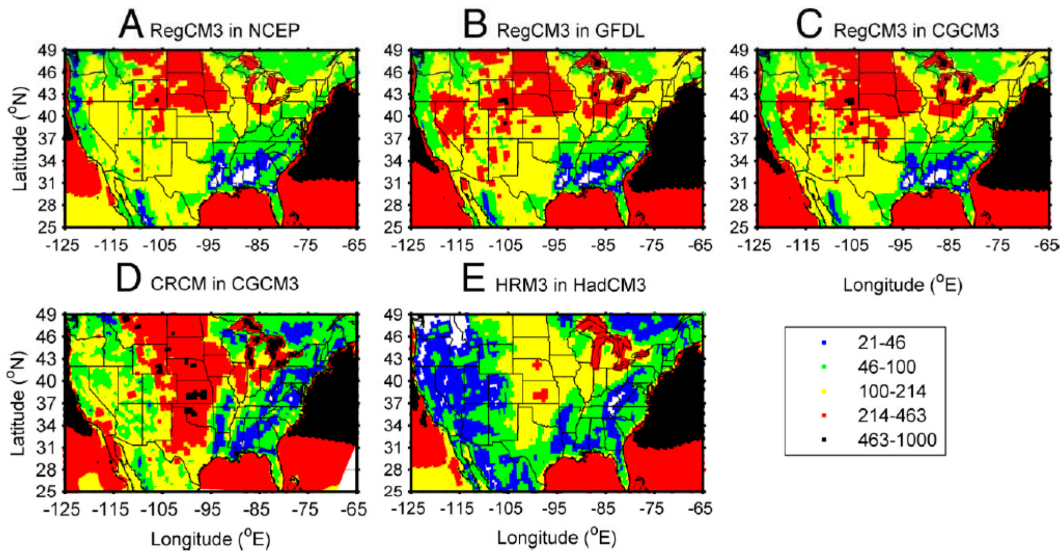
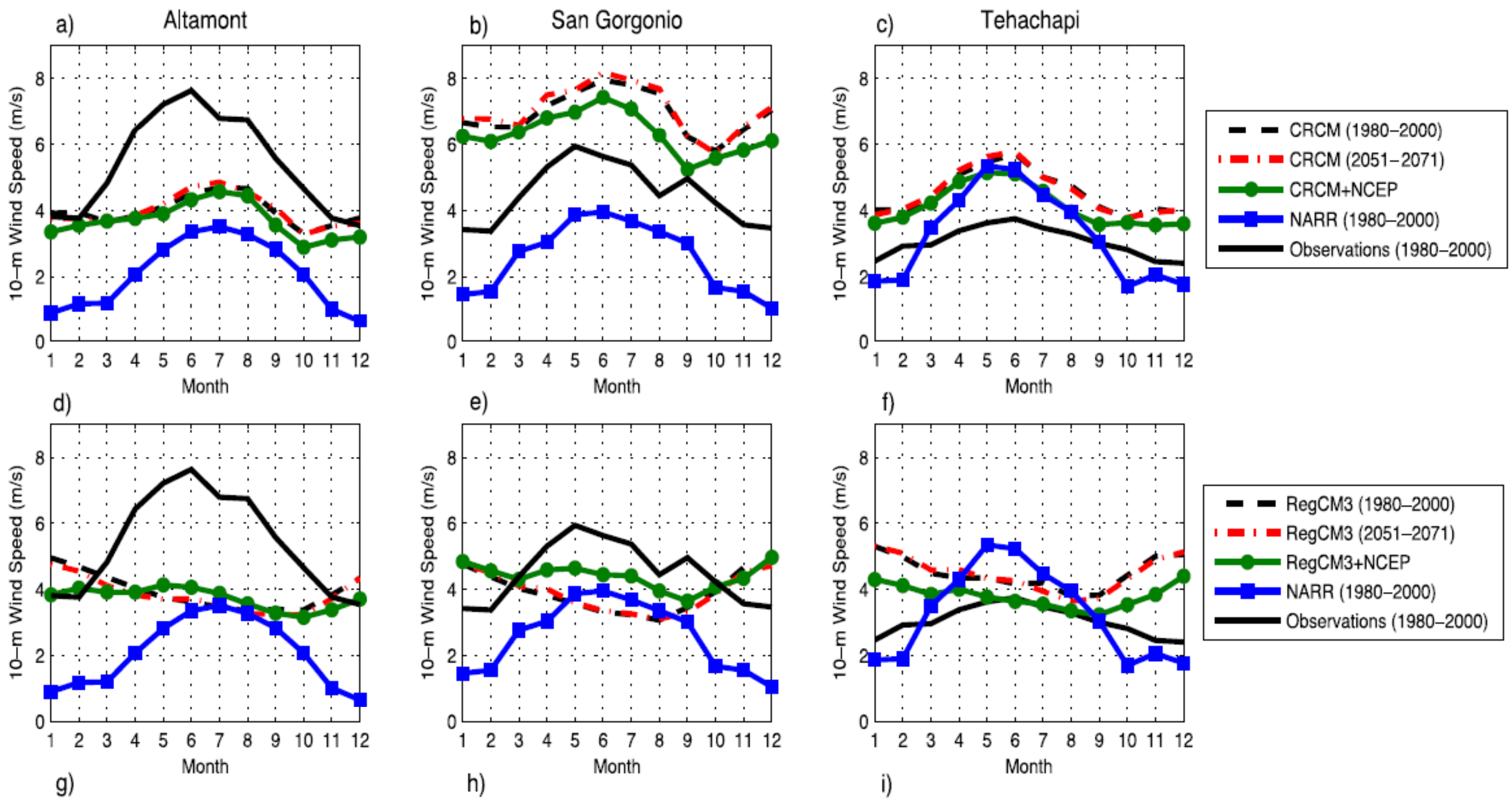


Fig. 1. Mean energy density (in W m^{-2}) for 1979–2000 at a height of 10 m above the surface computed using output from RCM simulations with Regional Climate Model 3 (RegCM3), Canadian Regional Climate Model (CRCM), and Third Generation Hadley Centre Regional Climate Model (HRM3). The different frames show the RCM–AOGCM model chains. The AOGCM abbreviations are Geophysical Fluid Dynamics Laboratory model (CM2.1) (GFDL), Canadian model third generation (CGCM3), third generation Hadley Centre model (HadCM3). *A* shows an example of the wind energy density from the RegCM3 simulation using observed lateral boundary conditions (as specified by the NCEP–DoE reanalysis dataset). Grid cells that are shown in white have an energy density below 21 Wm^{-2}, or in the case of the CRCM–CGCM3 simulation, lie beyond the boundaries of valid RCM output. Note the scale used to depict the wind energy density is logarithmic.

"We then analyze simulations from the current generation of regional climate models and show, at least for the next 50 years, the wind resource in the regions of greatest wind energy penetration will not move beyond the historical envelope of variability. Thus this work suggests that the wind energy industry can, and will, continue to make a contribution to electricity provision in these regions for at least the next several decades."

Pryor, S. C., and R. J. Barthelmie, 2011: Assessing climate change impacts on the near-term stability of the wind energy resource over the United States. Proceedings of the National Academy of Sciences. doi: 10.1073/pnas.1019388108.



Rasmussen, D. J., T. Holloway, and G. F. Neme, 2011: Opportunities and challenges in assessing climate change impacts on wind energy – a critical comparison of wind speed projections in California. Environ. Res. Lett. 6, 024008 (9pp). doi:10.1088/1748-9326/6/2/024008.

Statistical Downscaling

- Formulation of a Statistical Downscaling Model for California Site Winds, with Application to 21st Century Climate Scenarios. D. Mansbach and D. Cayan. Draft final PIER report. 2012
- Wind farms in Solano County, Tehachapi Pass, and San Gorgonio Pass
- Three global climate models. A1b global emission scenario
- Conclusion: "….the discrepancies between climate models prevent any definitive consensus"

Photovoltaic and Concentrated Solar

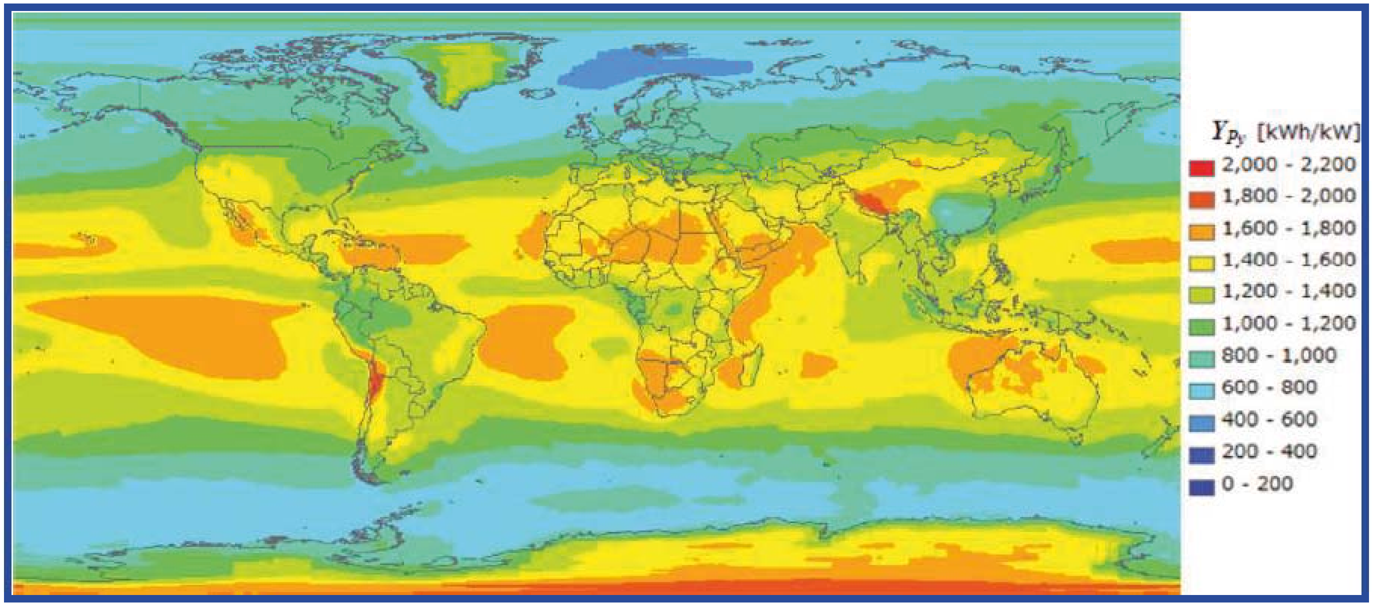


Figure 3. Global potential map of PV energy generation by c-Si PV module.

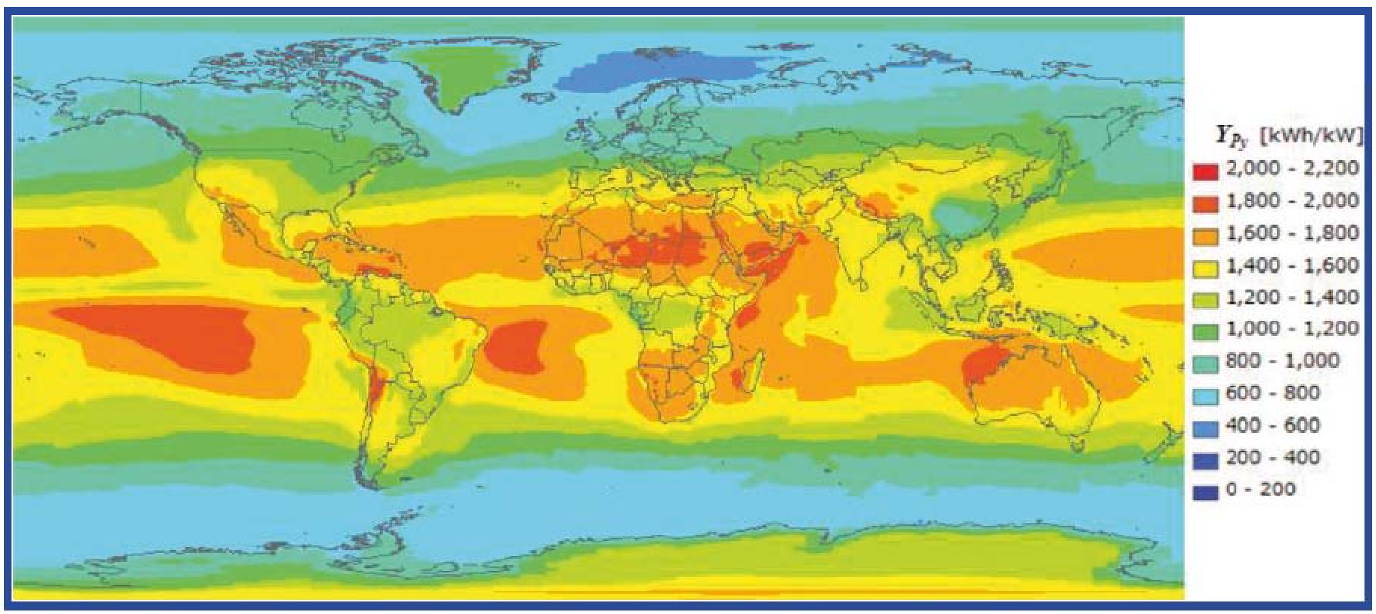


Figure 4. Global potential map of PV energy generation without considering temperature effect.

Kawajiri, K., T. Oozeki, Y. Genchi, 2011: Effect of Temperature on PV Potential in the World. Environmental Science & Technology. 45, 9030 – 9035

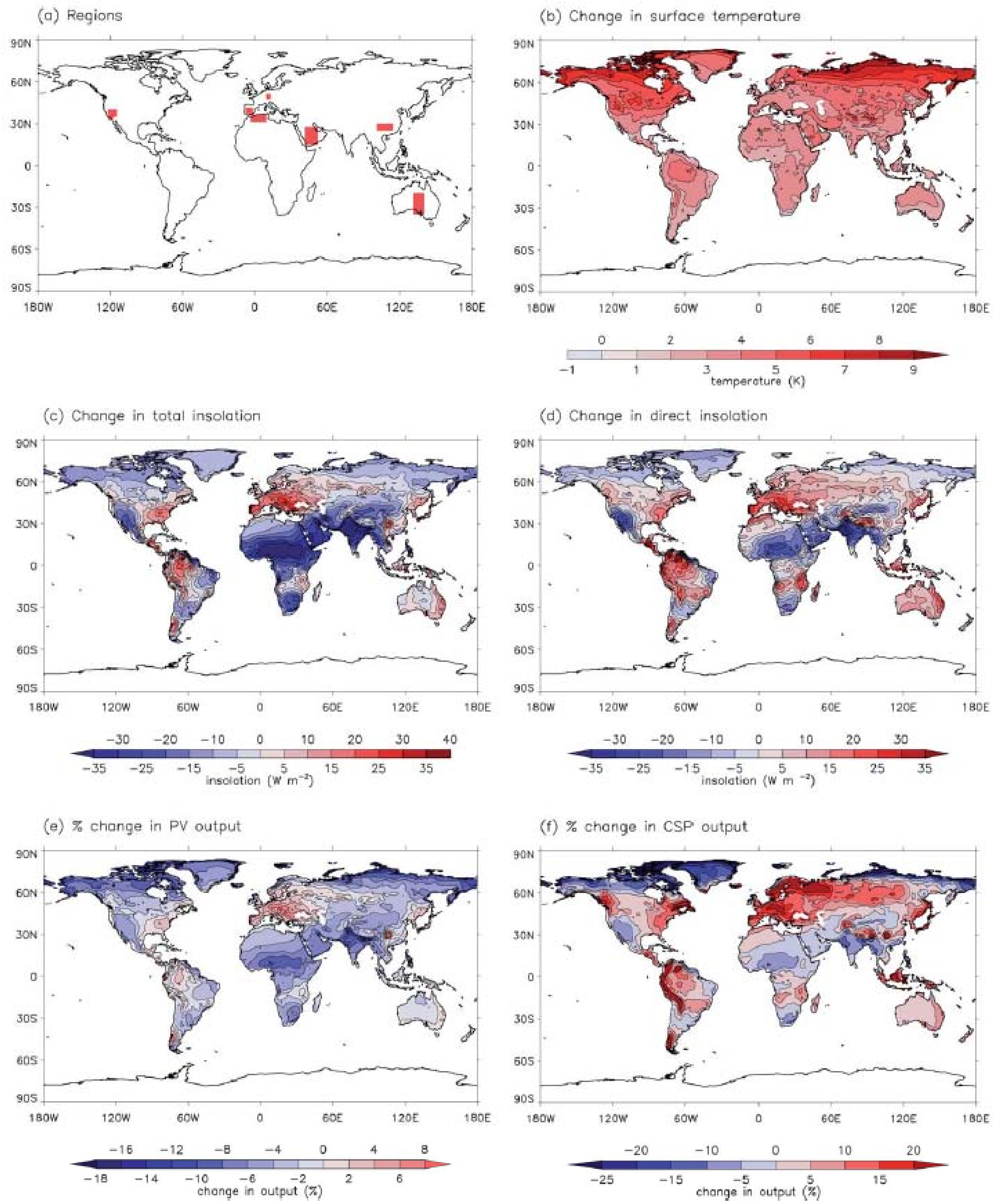


Fig. 1 (a) Global map identifying the regions included in the PV and CSP trends shown in Fig. 2–5. Global maps showing the change to 2080 in (b) daytime temperature, (c) daytime total insolation, (d) daytime direct insolation, (e) percentage change in PV output, and (f) percentage change in CSP output. Data is from the HadGEM1 model simulation.

Crook, J. A., L. A. Jones, P. M. Forster, and R. Crook, 2011: Climate change impacts on future photovoltaic and concentrated solar power energy output. Energy Environ. Sci. 4, 3101-3109. DOI: 10.1039/C1EE01495A.

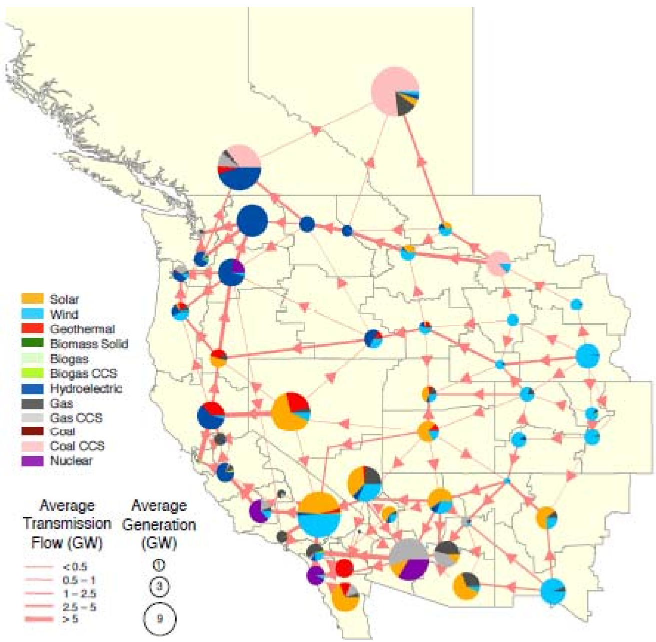
7.5.2 Indirect Effects of Aerosols on Clouds and Precipitation (IPCC)

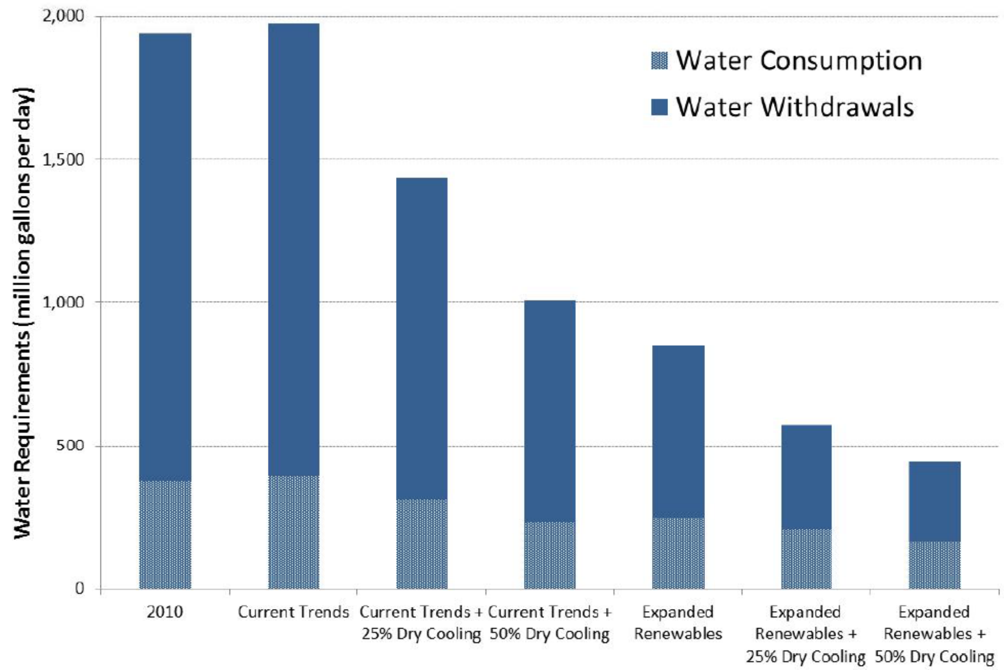
- "Aerosols can interact with clouds and precipitation in many ways, acting either as CCN or IN, or as absorbing particles, redistributing solar energy as thermal energy inside cloud layers. …….. Cloud feedbacks remain the largest source of uncertainty in climate sensitivity estimates and the relatively poor simulation of boundary layer clouds in the present climate is a reason for some concern. Therefore the results discussed below need to be considered with caution.

- Similar findings for regional climate projections for California (PIER research with Scripps, LBNL, and NOAA)

Water and the evolution of the electricity system

Water requirements for electricity generation in 2010 and in 2035 in six alternative scenarios





Source: J. Nelson and D. Kammen.
Draft Final PIER Report by Weil et al., 2012.

Source:
Water for Energy: Future Water Needs for Electricity in the Intermountain West. Pacific Institute. 2011

We are investigating these types of issues with the following study:
"Energy Scenarios for California and their Potential Environmental Implications"

Bioenergy

The scientific literature on the potential impacts of climate change on bioenergy is very limited

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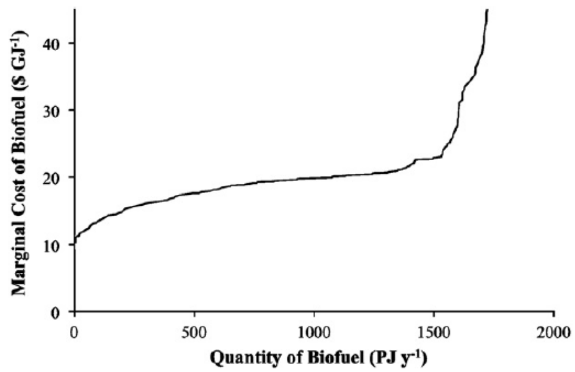

Fig. 3 – Supply curve of biofuels in Western U.S.

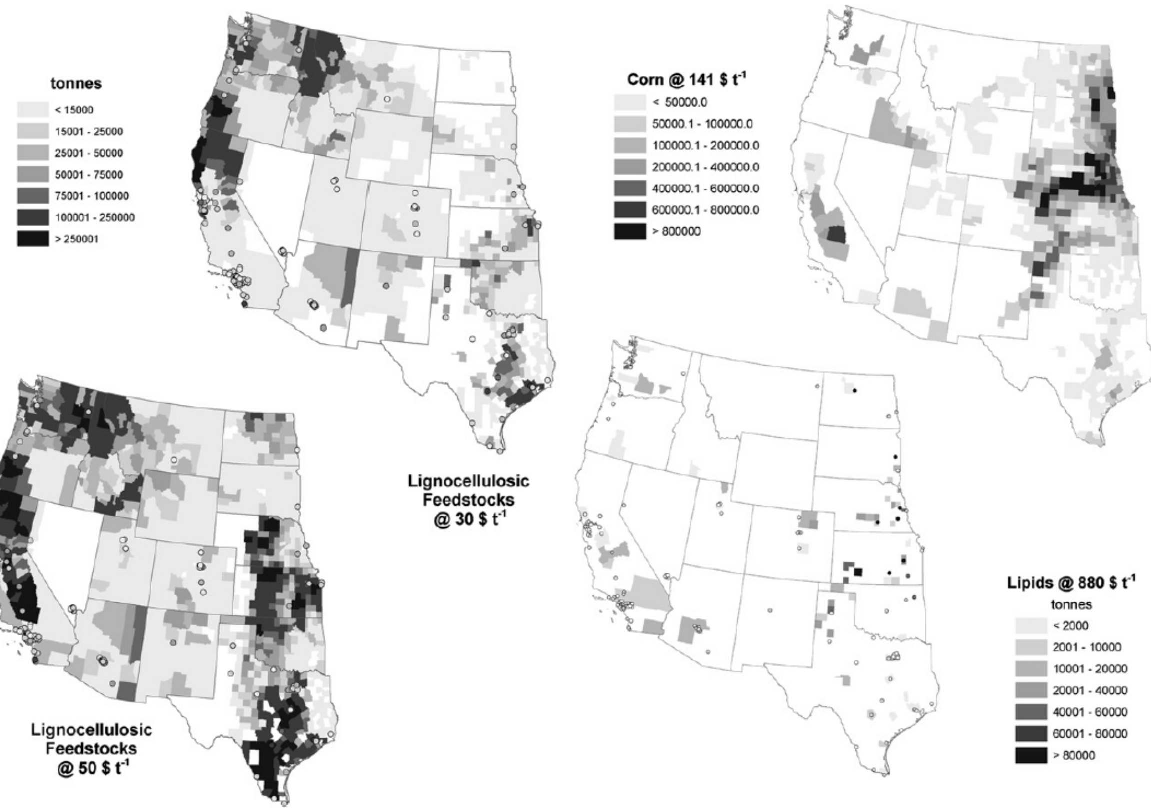

Fig. 2 – Distribution of lignocellulosic biomass feedstock in the study area.

Parker, N., P. Tittmann, Q. Hart, R. Nelson, K. Skog, A. Schmid, E. Gray, B Jenkins, 2010: Development of a biorefinery optimized biofuel supply curve for the Western United States. Biomass and Bioenergy, 34, 1597 – 1607.

Conclusions

- Hydropower resources will be affected by climate change
- Wind resources may not be affected for several decades
- PVs and Concentrated Solar units will be affected mainly due to increases in temperatures
- Impacts on bioenergy are uncertain but they may be manageable
- It is necessary to study the environmental and economic implications of alternative energy scenarios for California

Thank you!

Disclaimer

This presentation reflects the views of the author and does not necessarily reflect the views of the Energy Commission or the state of California