Expanding California's Wind Farms

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Abstract and Goal

The research aims to increase California's renewable energy portfolio by scaling and expanding wind energy to have comparable production to solar energy to meet the state's clean energy standard by 2045. We focus on expansion of current wind farms with modern wind turbines and see how the addition of modern plants can increase the power produced at each location. Evaluating data from the Energy Information Association (EIA) and Wind Turbine Database we see how expansion of wind farms with new technology can grow the wind energy profile in California. Expanding wind could supplement the power grid when solar PV cells are no longer producing energy during non solar hours.

Overview

Introduction

How does a wind turbine?

California’s Renewable energy Portfolio?

Ways to Expand Wind - Offshore Wind, Repowering, Expanding Wind Farms

Change in Wind Turbine technology

Increased Deployments of Wind Turbines

The resulting change in Capacity Factor

Conclusion

Introduction

California currently has a goal to reach zero-carbon emission by 2045 using renewable energy.

Wind and Solar technologies are complementary to each other with Solar being strong during the day and wind strong during the night.

Image: https://coleofduty.com/news/2020/06/08/clean-energy-market-2020-manufacturers-analysis-share-size-growth-outlook-future-trends-and-forecast-2026-kior-elevance-acwa-power-meil-godawari/

How does a Wind Turbine work?

A wind turbine works by harnessing aerodynamic force created by wind to turn the rotor blades to generate power that is then transferred to the grid.

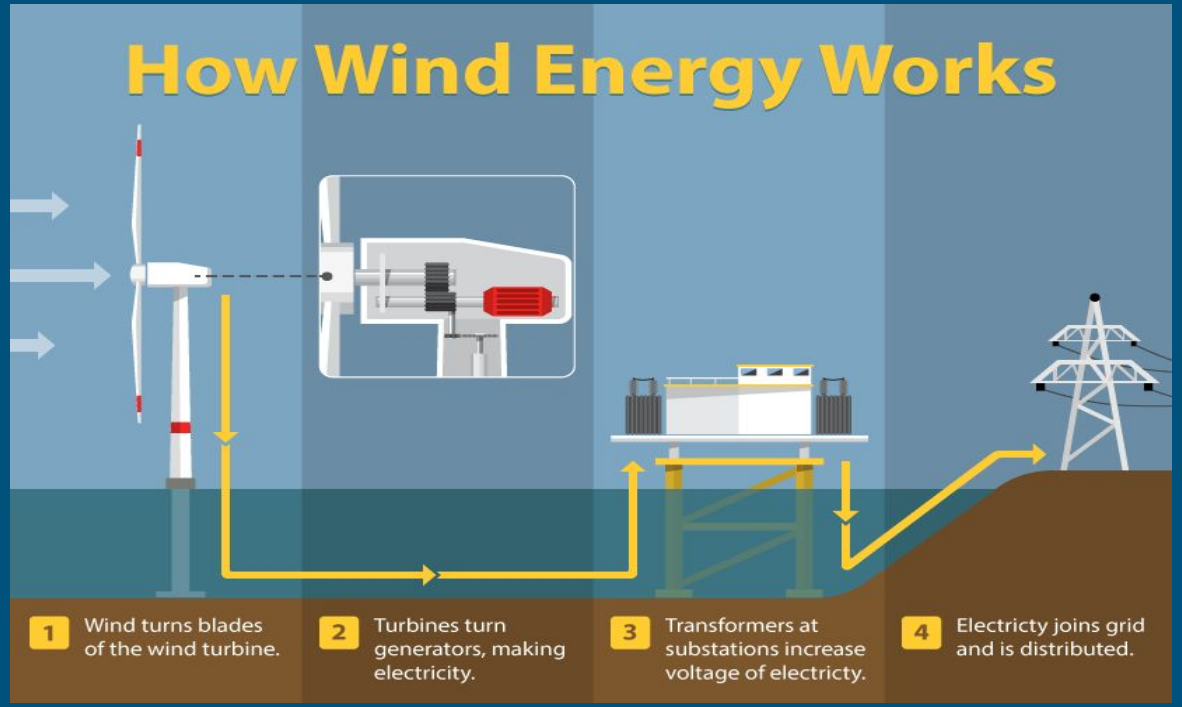


Image: http://windpowernejikata.blogspot.com/2017/06/what-is-wind-power-and-how-does-it-work.html

What is the California Renewable Energy Portfolio?

The California renewable energy portfolio standard program started in 2002 and was amended in 2018 with the goal of having all the state's electricity generated by zero carbon sources.

Zero carbon sources, such as wind, solar and hydroelectric, do not produce carbon emissions post construction completion of the energy producing site.

Image: https://www.yellowlite.com/blog/post/all-you-need-to-know-about-cleveland-ready-s-first-green-energy-initiative/

Ways to expand wind energy- Offshore Wind

Northern California has the best offshore wind and greatest energy potential.

There currently is zero infrastructure established for offshore wind.

Are floating wind turbine good enough?

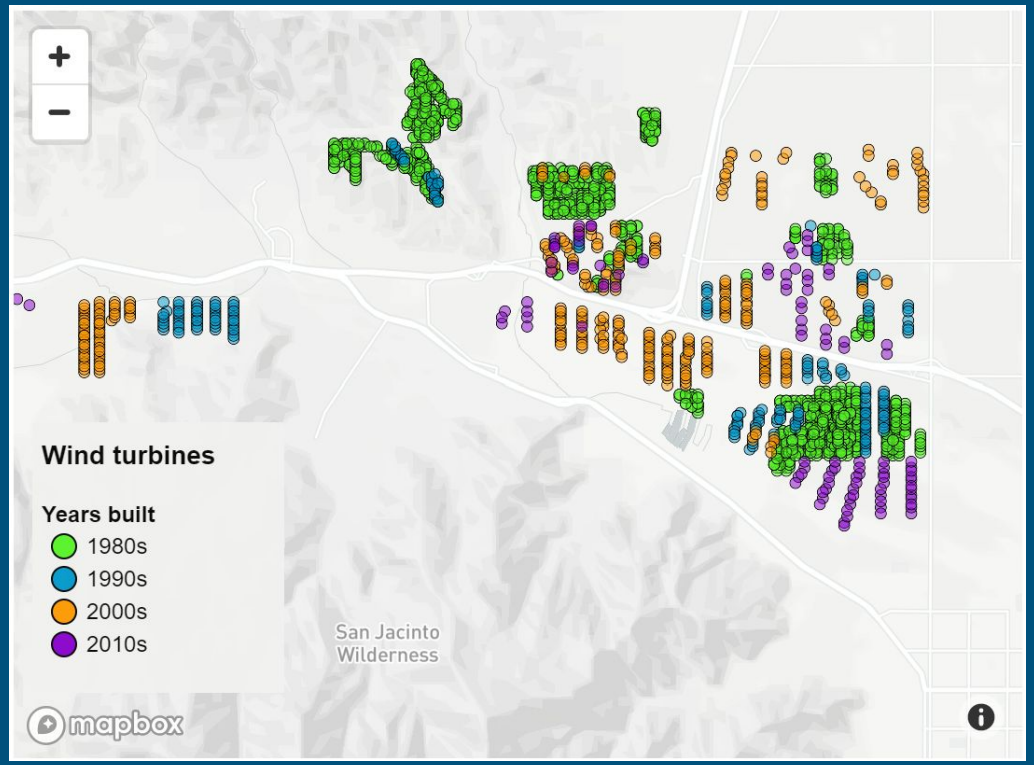
Image: https://www.bcg.com/de-de/publications/2018/will-your-offshore-wind-strategy-sink-swim

Ways to expand wind energy- Repowering

Projects from the 1980s-90s are still functioning today

Weighing the cost of disposing old wind turbines materials and new installation versus the revenue generated by modern designs

Does the repowering generate enough revenue for the cost?



https://eerscmap.usgs.gov/uswtdb/

Ways to expand wind energy- Expanding Wind Farms

Allows California to use already active sites in the state.

Expanding to new locations allows the state to use other wind resources.

There is already existing infrastructure at established sites and environmental reviews.

Methodology

To evaluate the effects of expanding wind farms in the state of California data were taken from the United States Energy Information Administration (EIA) and the Wind Turbine database. Taking data from the EIA 923 form and 860 form, we compare the annual net generation with nameplate capacity to get the capacity factor for California's wind farms. Using the Wind Turbine Database we compare how the technology has changed over time. Comparing the data, we can measure the effects of how applying modern wind turbines to active wind farms increase the power produced.

https://www.eia.gov/electricity/data/eia860/

https://www.eia.gov/electricity/data/eia923/eia906u.php

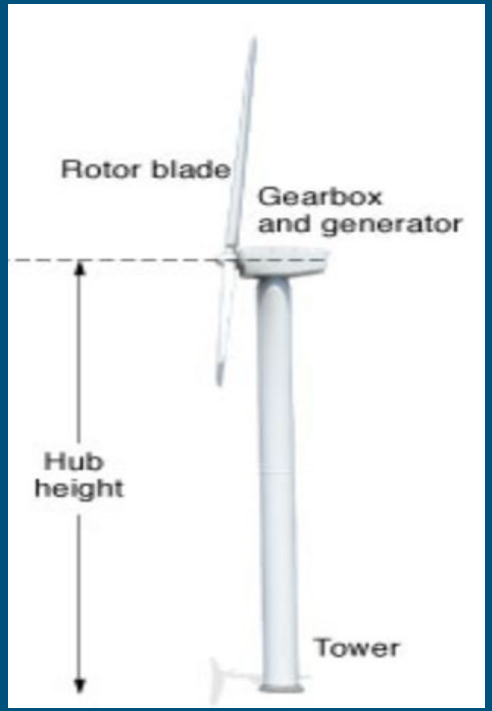
California's 5 largest Wind farms

Wind Farm	Initial Construction	# of Wind Turbines	Nameplate Capacity
Tehachapi Pass Wind Farm	1980	4731	705 MW
San Gorgonio Pass Wind Farm	1980	3128	615 MW
Altamont Wind Farm	1981	4930	576 MW
Shiloh Wind Power Plant	2005	275	505 MW
Mojave Wind Farm	2010	600	1550 MW

Nameplate capacity: intended full-load sustained output of a facility such as a power plant, electric generator, a chemical plant, fuel plant, metal refinery, mine, and many others.

Definition from:https://openei.org/wiki/Definition:Nameplate_Capacity#:~:text=Nameplate%20capacity%2C%20also%20known%20as,%2C%20mine%2C%20and%20many%20others.

The change in Wind Technology over Time: Hub height



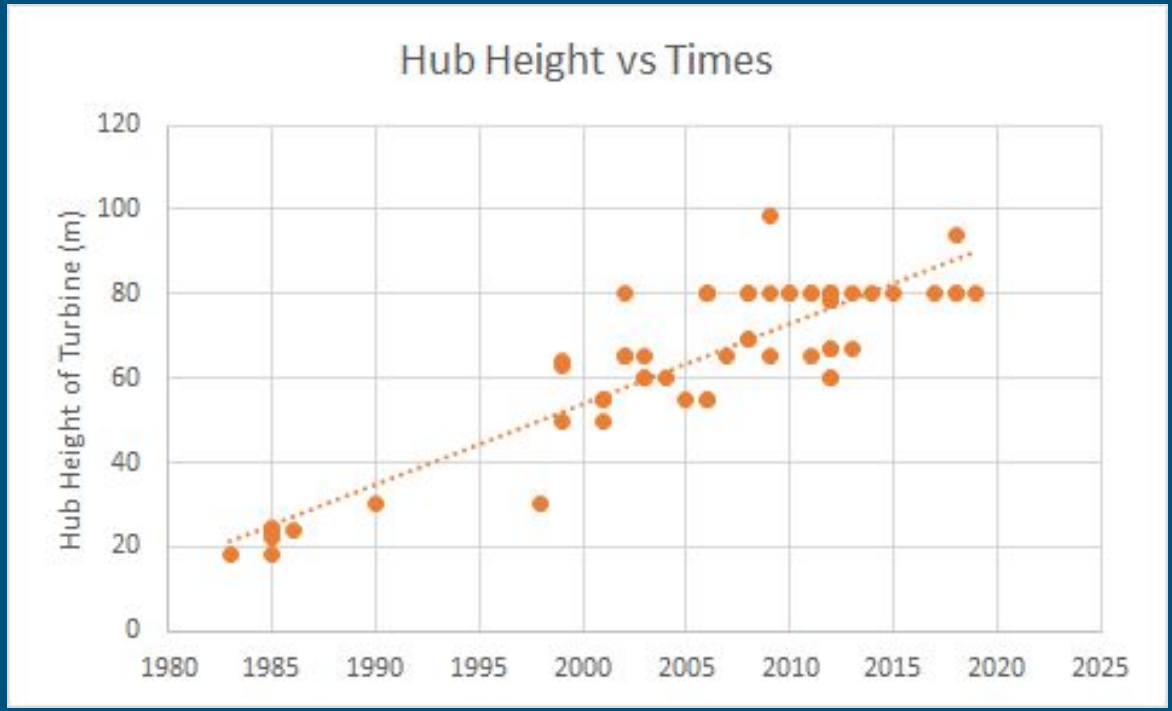
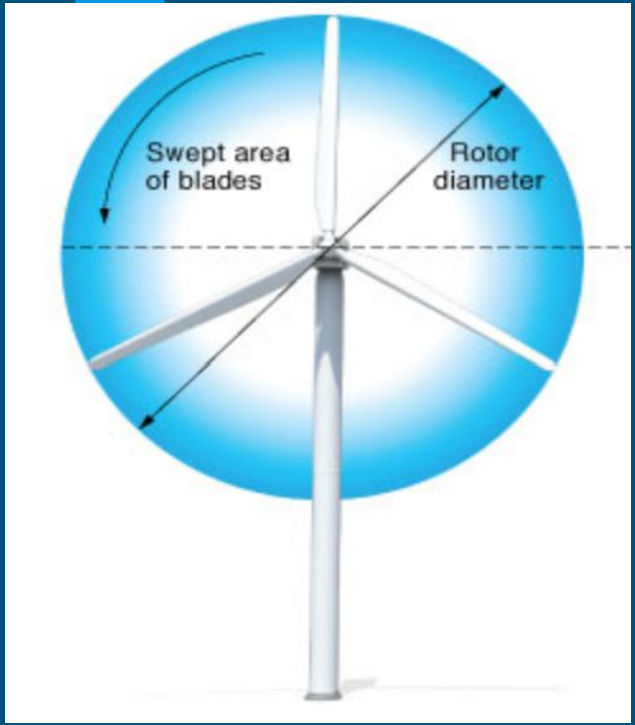


Image: https://str.llnl.gov/april-2014/miller

The change in Wind Technology over Time: Rotor Diameter



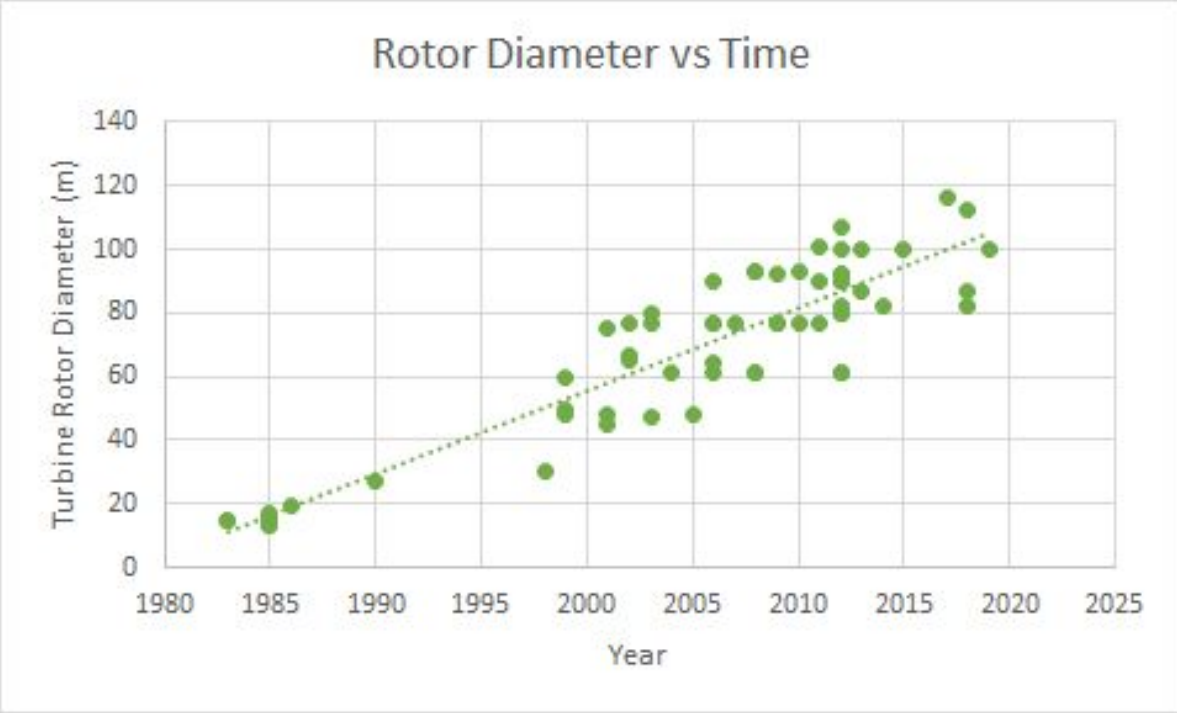
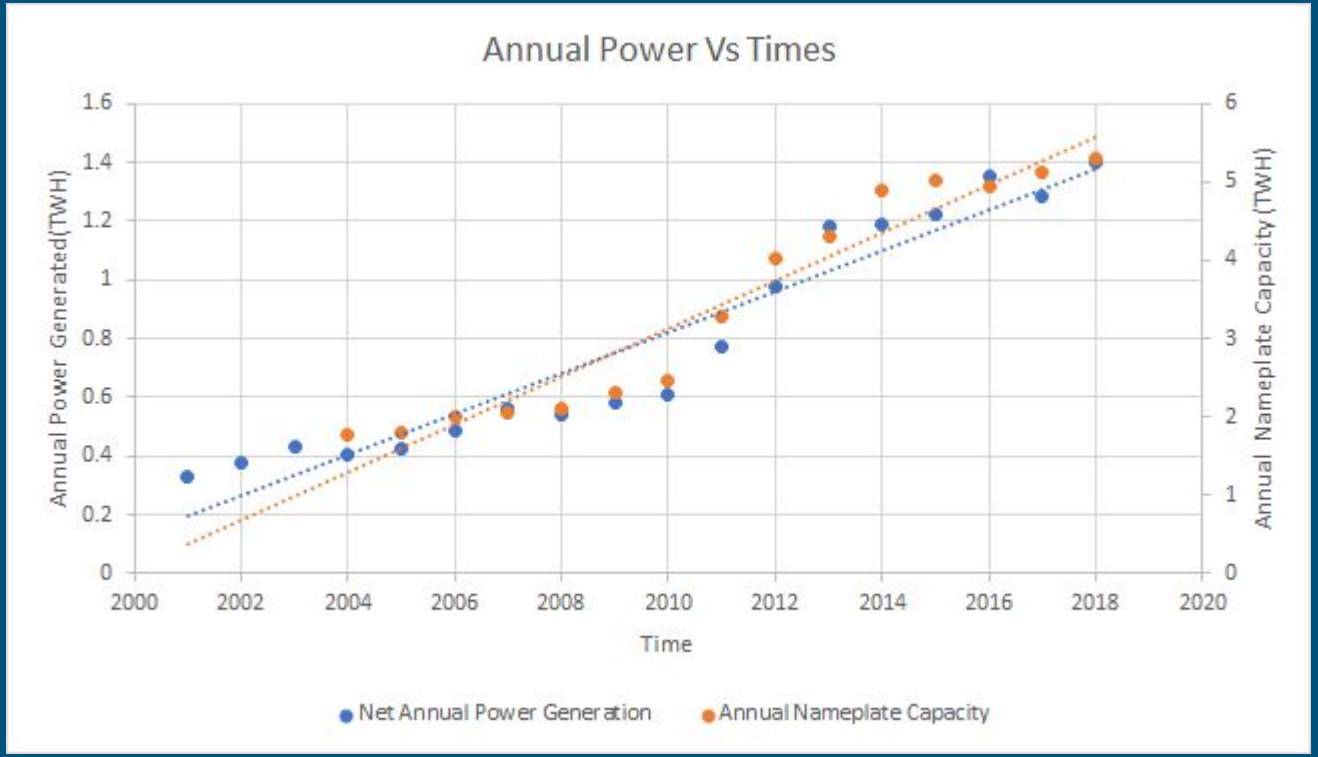


Image: https://str.llnl.gov/april-2014/miller

Increased Deployment of Wind Turbines

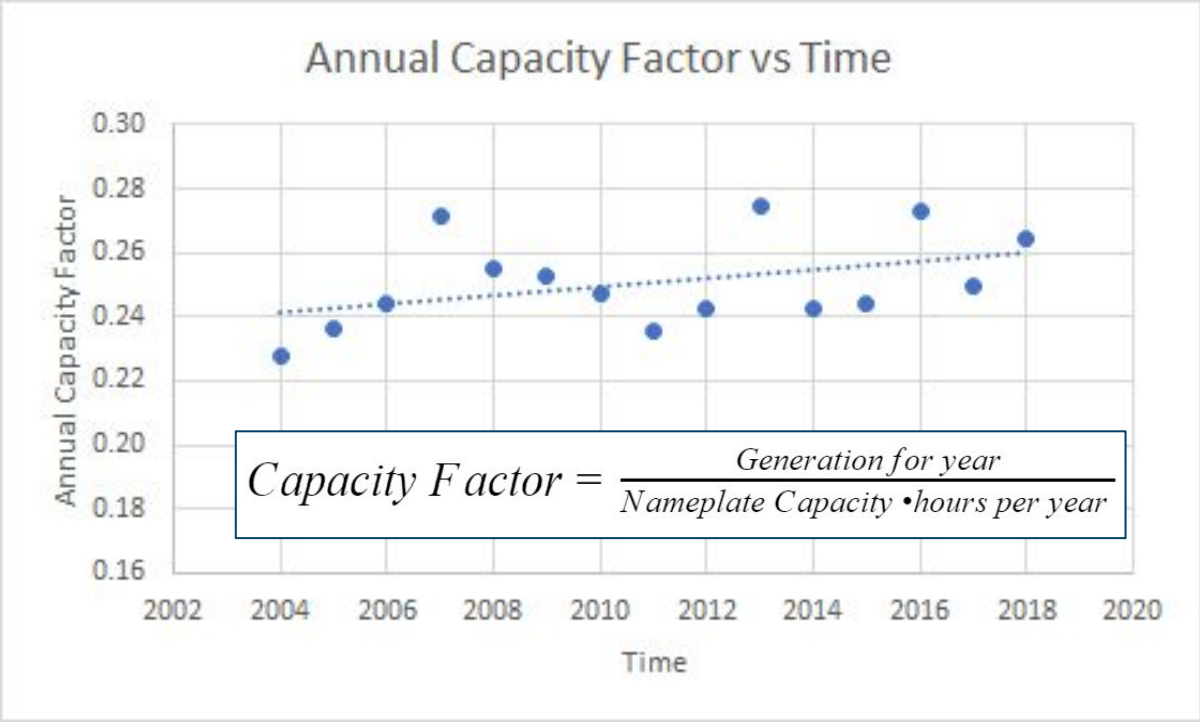
The jump in 2011-2012 was due to the completion of projects at the Shiloh and Mojave Wind Farms.

The nameplate and generation are increasing same rate.



The resulting change in Capacity factor

As reflected by the annual power vs time graph the capacity factor steadily increases over time with the change in wind turbine technology.



Conclusion

The expansion of California's wind farm is currently the best way to increase the state's wind energy profile to meet the green energy standard of 2045. Modern designs allow California to have fewer installations than past projects while also having a greater energy yield. Expanding California's wind farms with modern designs would allow the state to supplement power at night when solar power is no longer working. Expanding current locations would diversify California's renewable energy profile and help meet the green energy standard by 2045.