US Solar Power Output
Time Series Analysis

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Agenda

01. Business Overview

Stakeholder problem

02. Data Overview

Data explanation and Exploratory Data Analysis

03. Methods

Analysis, Modeling, and Forecasting

04. Next Steps

Evaluations and Recommendations

What is the grid and why do renewables strain it?

By Irina Zhorov · April 3, 2017

Clean energy technologies threaten to overwhelm the grid. Here's how it can adapt.

The centralized, top-down power grid is outdated. Time for a bottom-up redesign.

By David Roberts | @drvolts | Updated Nov 11, 2019, 10:46am EST

Graphics: Javier Zarracina

Three Myths About Renewable Energy and the Grid, Debunked

Renewable energy skeptics argue that because of their variability, wind and solar cannot be the foundation of a dependable electricity grid. But the expansion of renewables and new methods of energy management and storage can lead to a grid that is reliable and clean.

BY AMORY B. LOVINS AND M. V. RAMANA · DECEMBER 9, 2021

Difficulty integrating Solar into current grid

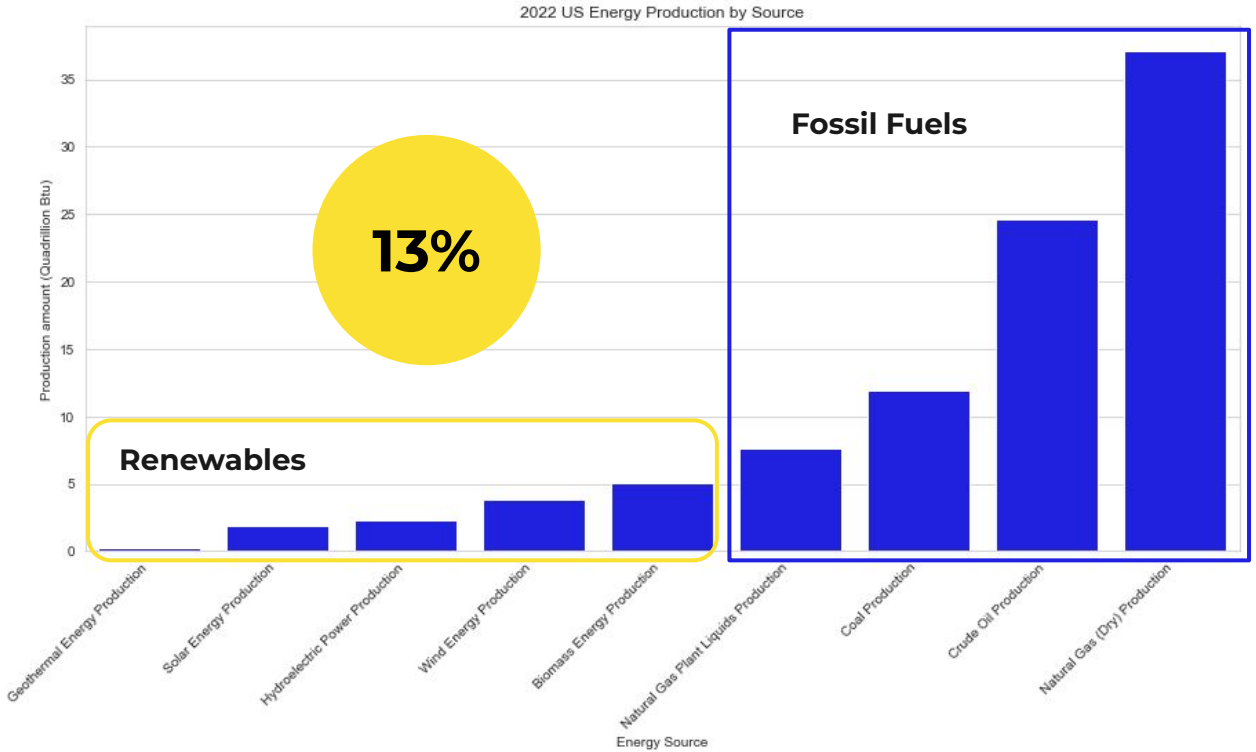
Business Overview

North American Electric Reliability Corporation (NERC)

How much power to expect from renewable sources so they can better prepare for power output variability.

They have asked us to try to forecast solar output in order to help them manage the grid better.

Renewable Energy in the US



1	Biomass	4.97%
2	Wind	3.74%
3	Hydroelectric	2.25%
4	Solar	1.82%
5	Geothermal	0.21%

Figures reflect 2022 Net Energy Production

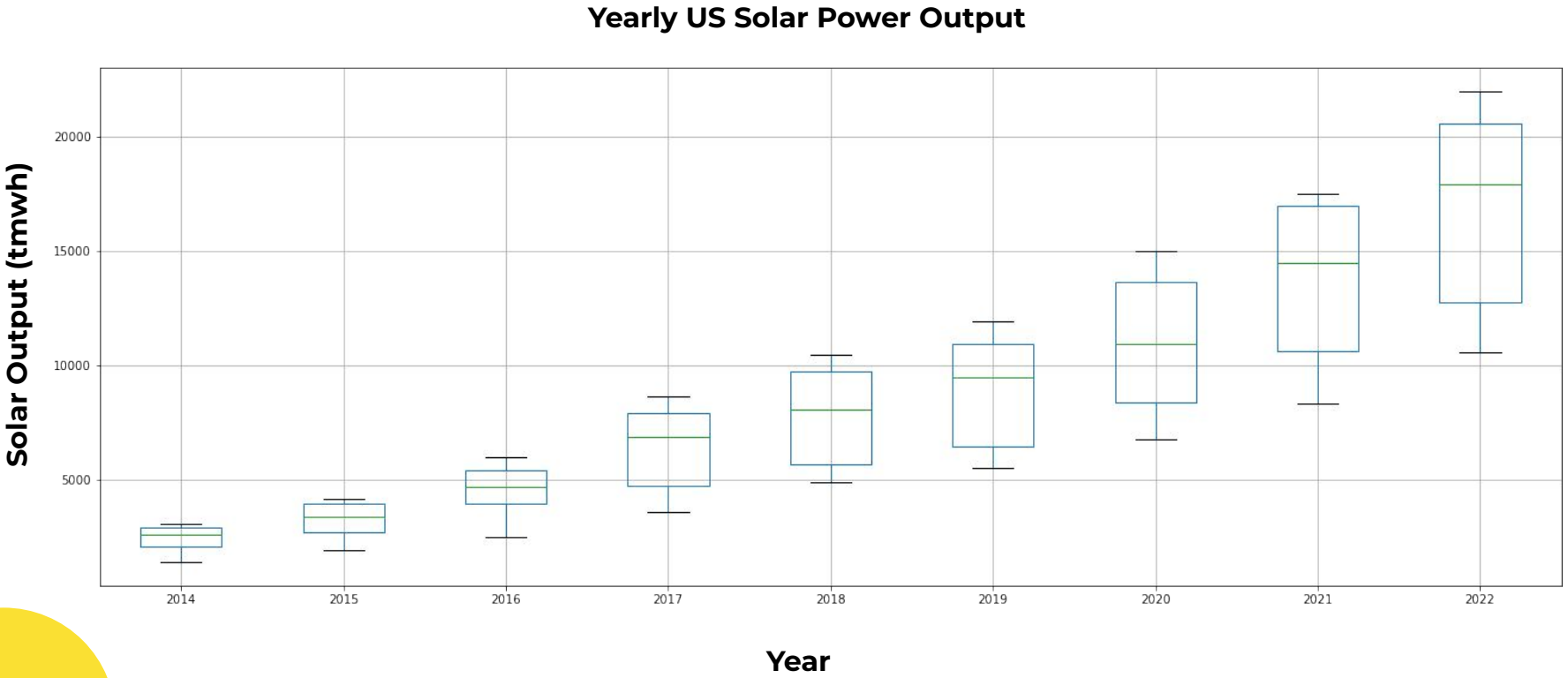
Data Understanding

- **Source:** U.S. Energy Information Administration- Electricity Data Browser

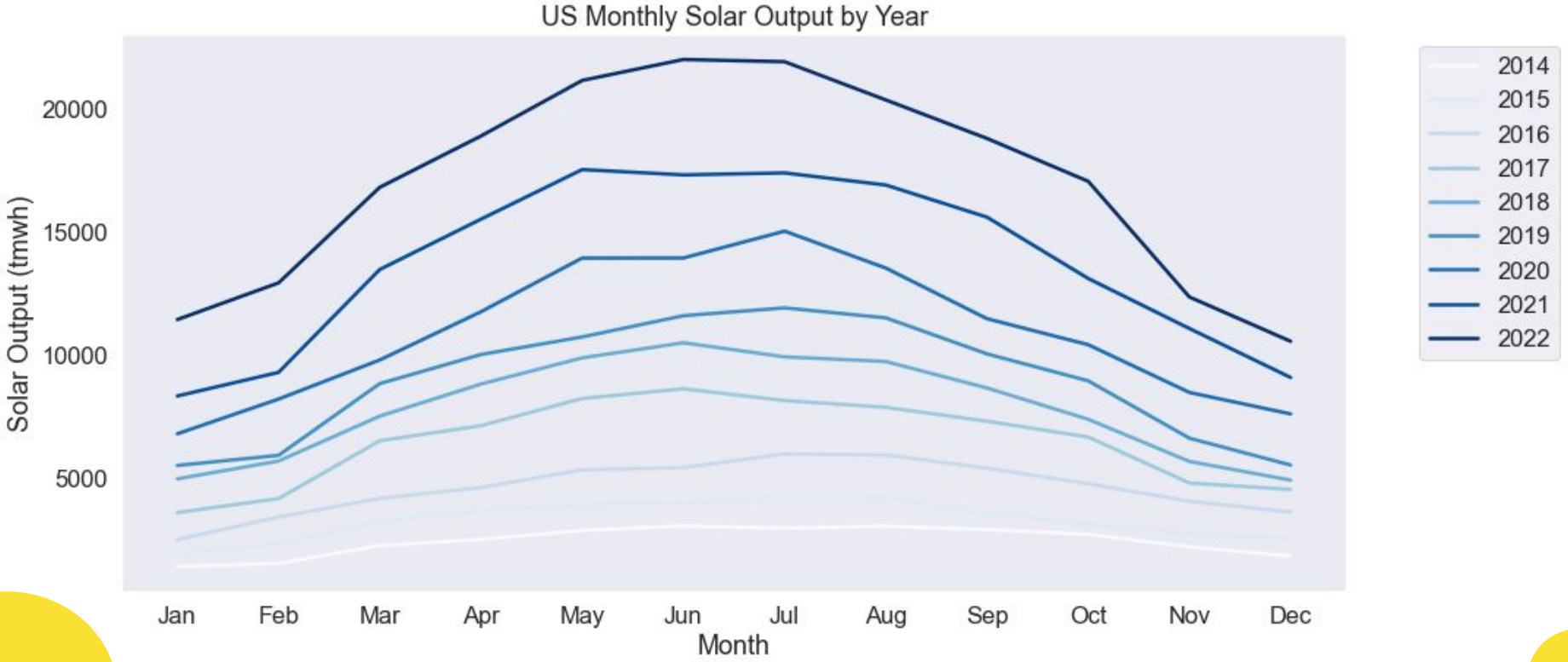
- **Solar output data** in **thousand megawatthours** grouped by state, region, and **US Total**

- **Monthly** frequency from **Jan 2014** to **Dec 2022**

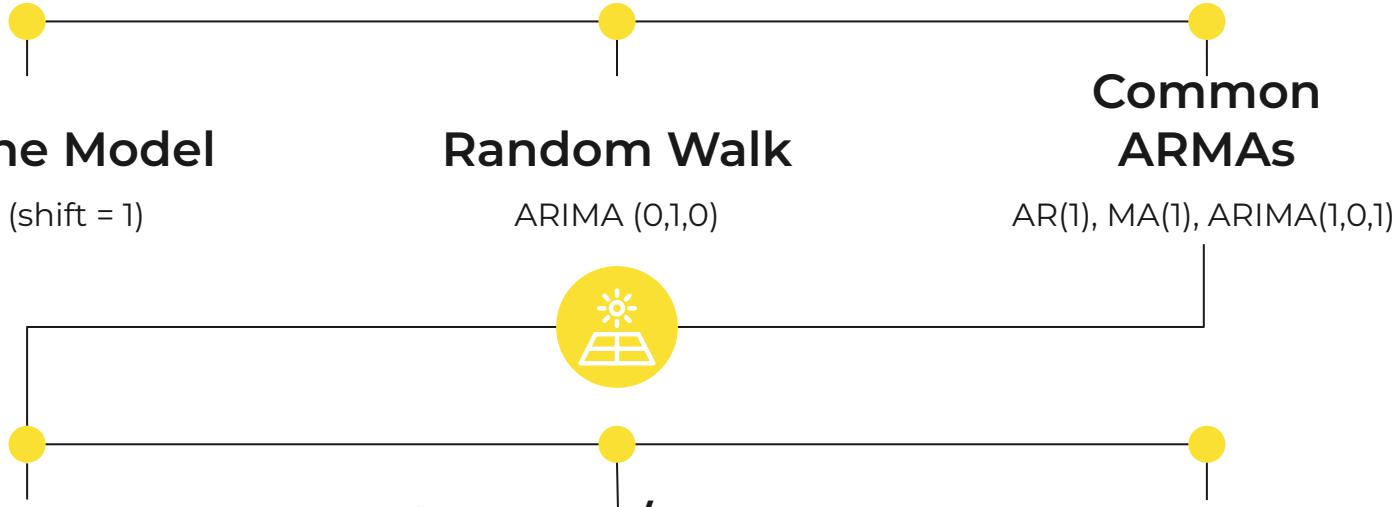
Data Understanding



Data Understanding: Seasonality

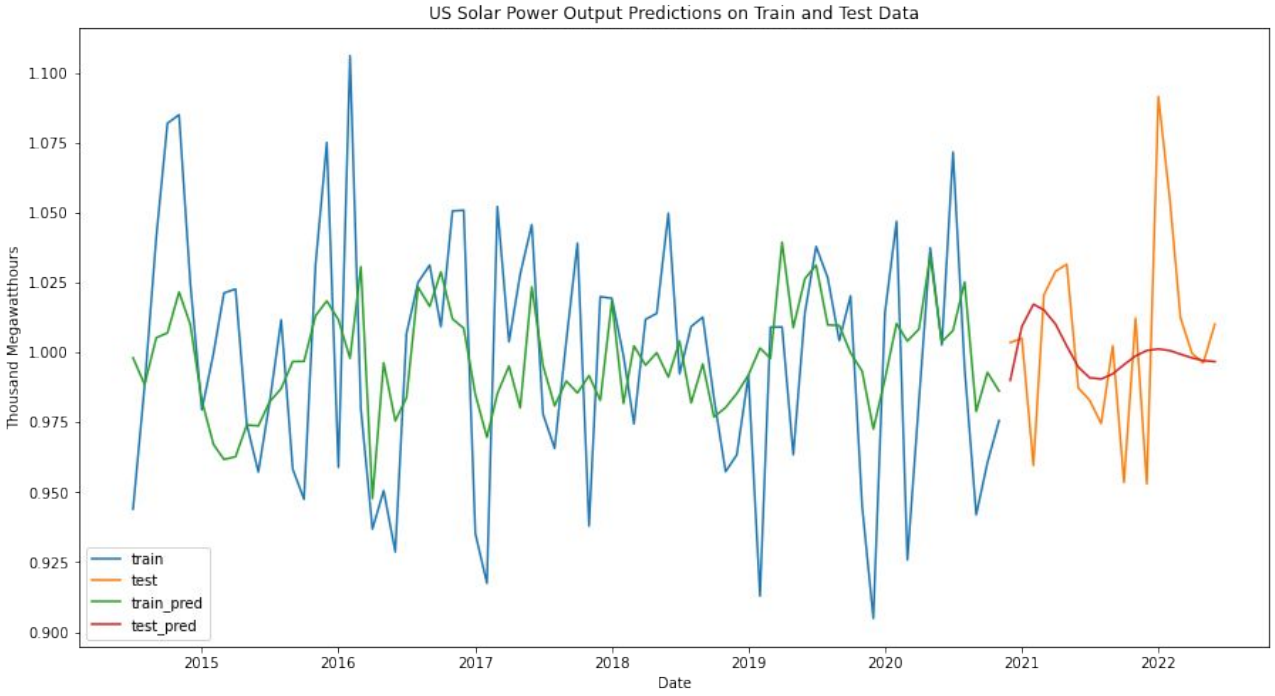


Methods

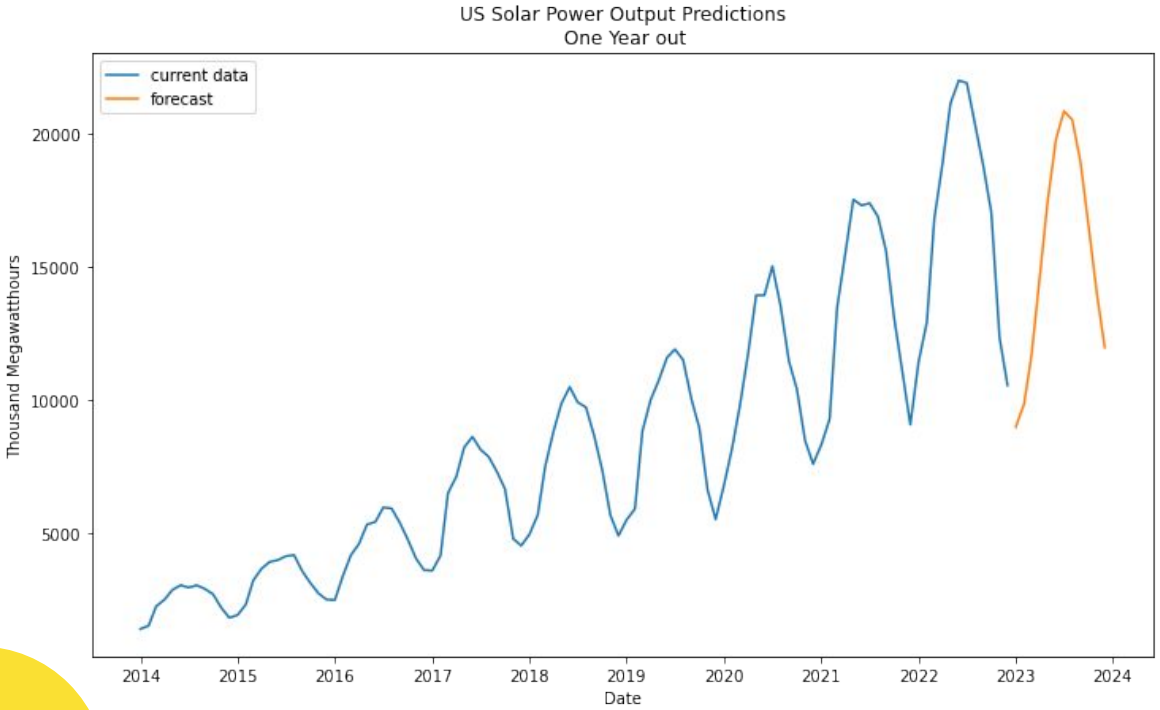

Baseline Model
Naive (shift = 1)
Random Walk
ARIMA (0,1,0)
Common ARMAs
AR(1), MA(1), ARIMA(1,0,1)
ACF/PACF
AR(2), AR(3), MA(2), MA(5), MA(12)
SARIMAX/ ARIMA Parameter Selection
SARIMAX (1,0,1)x(0,0,0,12)
ARIMA (4,0,1)
FB Prophet
Prophet() on original data

Model Evaluation

Final Model
ARIMA (4,0,1)
AIC
-266.14
RMSE (Test)
0.033 thousand megawatthours
MAPE (Test)
2.32%



Solar Power Output Forecast



ARIMA401

Follows the overall trend and multiplicative increase in variance

Recommendations

- Create a forecast to predict solar power supply and avoid blackouts/grid failure caused by under and overproduction.

- Prepare plan to meet seasonal supply and demand in conjunction with other energy sources.

Next Steps

Evaluate Forecast

Calculate error on forecast versus observed data

Add more data

Include power plant counts and environmental factors (weather, solar irradiation)

Increase specificity

Repeat forecasting at the regional and state level

Thank You

Questions?

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