Residential Solar Forecast & Financial analytics
(probably more than you wanted to know)

Gautam Makani
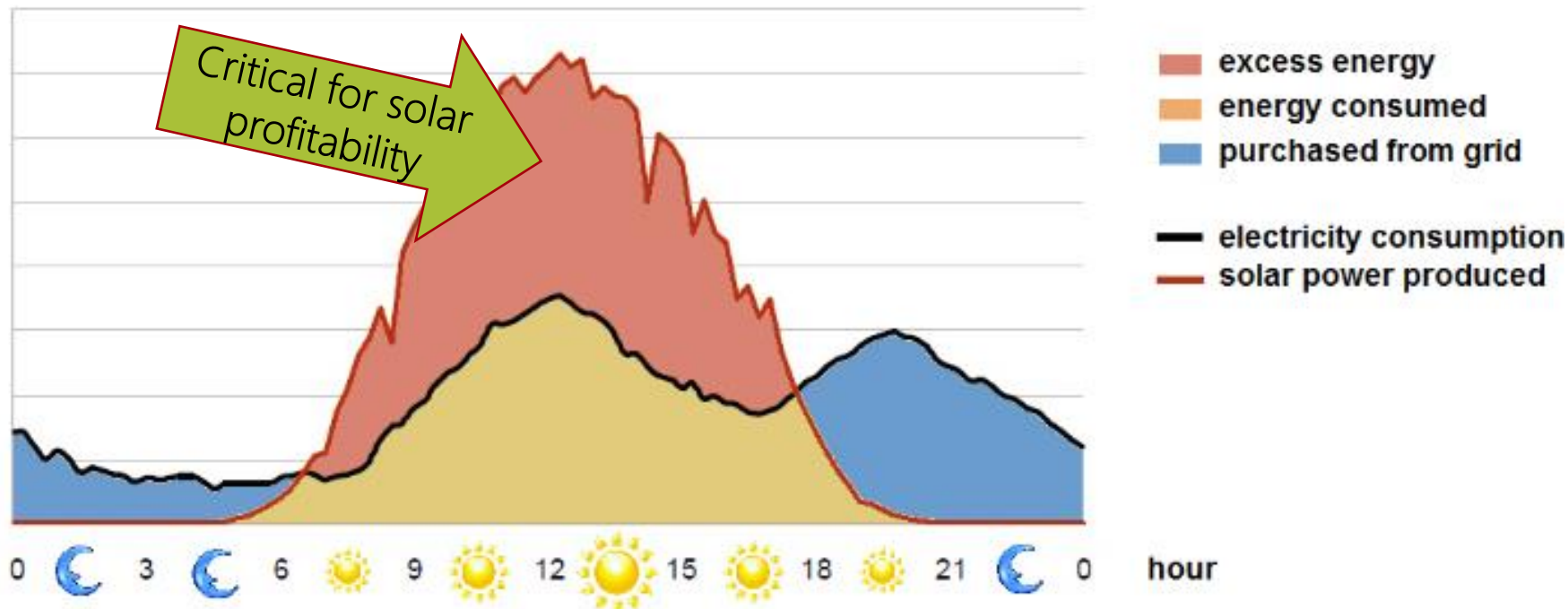https://www.linkedin.com/in/gautammakani/

Agenda

- Quick intro to Solar NEM (Net Energy Metering)

- How good are the self-service analytics at pge.com

- Analysis approach, packages and environment

- Findings – generation models, forecast, $$ savings, sensitivity

Solar NEM

Energy you **PRODUCE** − Energy you **CONSUME** = **NET ENERGY**

- PG&E credit for energy fed back into the grid at retail TOU (time of usage) rates

- 12 month True-Up billing cycle

- Under threat (especially with PG&E Bankruptcy)
  - Michigan changed NEM policy making it less profitable
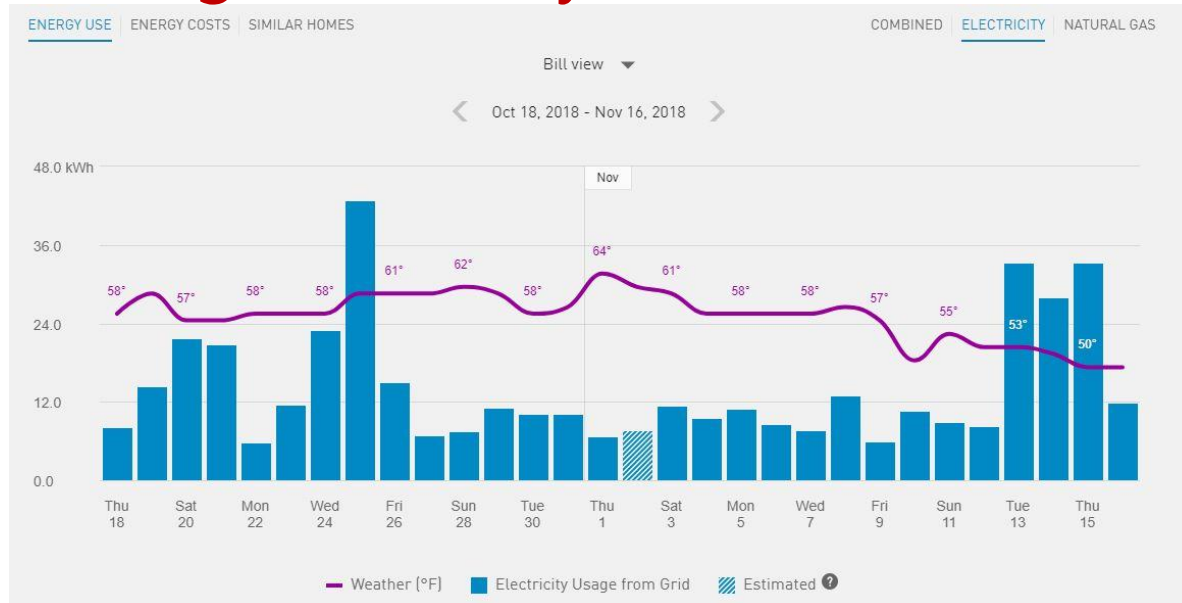 - No NEM states: *Arizona, Georgia, Hawaii, Indiana, Nevada, Maine and Mississippi ..*
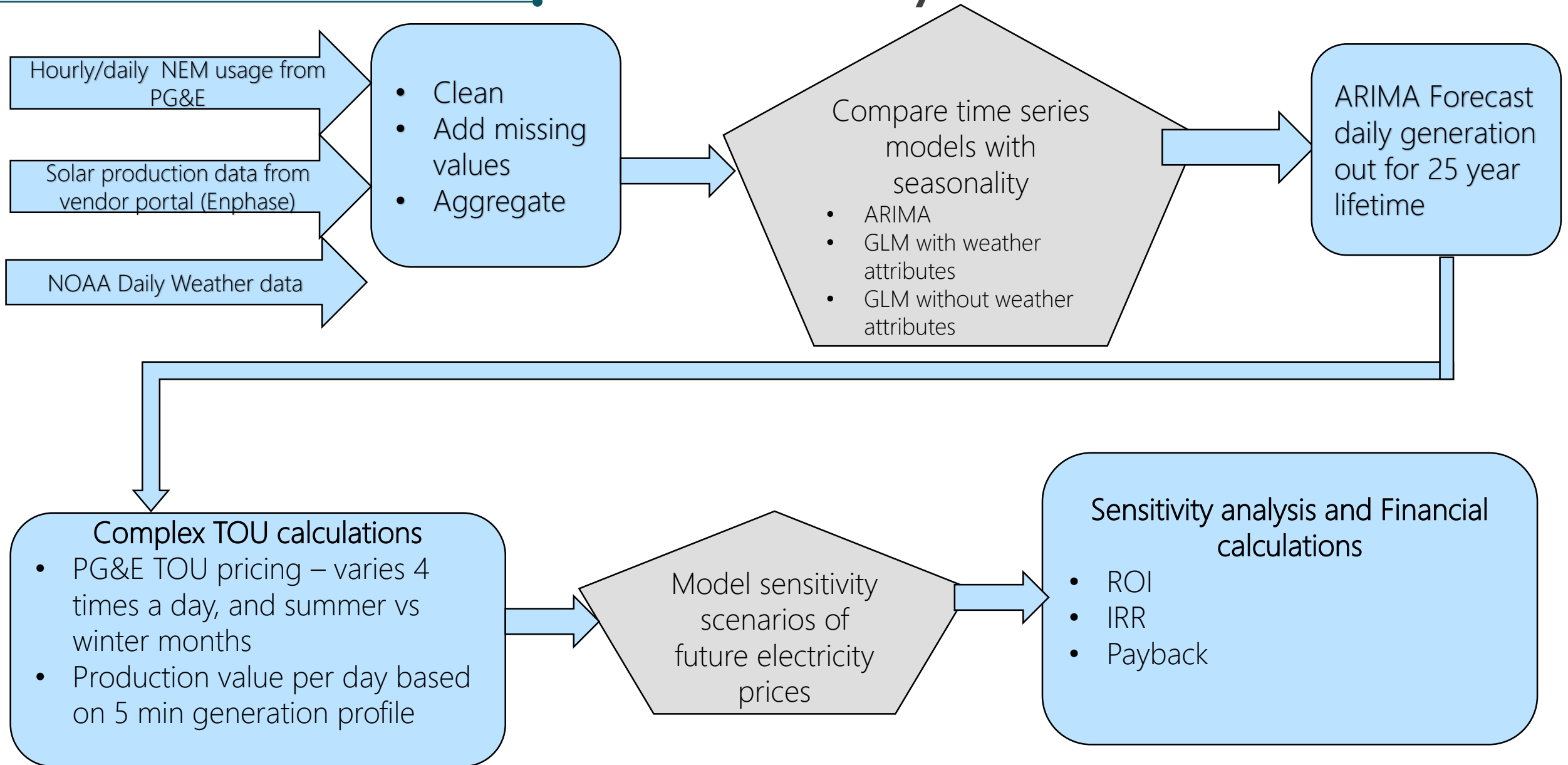
Generation and Consumption

Critical for solar profitability

excess energy
energy consumed
purchased from grid

— electricity consumption
— solar power produced

0   3   6   9   12   15   18   21   0   hour

Can't use online PG&E Opower analytics to answer:

- What is my actual usage profile (i.e. not NEM) ?
- How is my electricity usage trending on a year on year basis ?
- What is the consumption forecast ?
- Is Solar saving me money ?

R based analysis

Hourly/daily NEM usage from PG&E

Solar production data from vendor portal (Enphase)

NOAA Daily Weather data

- Clean
- Add missing values
- Aggregate

Compare time series models with seasonality
- ARIMA
- GLM with weather attributes
- GLM without weather attributes

ARIMA Forecast daily generation out for 25 year lifetime

Complex TOU calculations
- PG&E TOU pricing – varies 4 times a day, and summer vs winter months
- Production value per day based on 5 min generation profile

Model sensitivity scenarios of future electricity prices

Sensitivity analysis and Financial calculations
- ROI
- IRR
- Payback

R packages and resources

Resources and reference

- Hadley's R for Data Science book
- Rob J Hyndman blog and book on forecasting
- StackOverflow
- StackExchange.

Environment:

- RStudio
- Charts hosted on Rpubs
- Plotly visualization

Github repo:

https://github.com/makanig/solarHomeEnergyAnalytics

Key Packages

library(tidyverse)
library(forecast)
library(plotly)
library(FinCal)   => financial calcs
library(data.table)
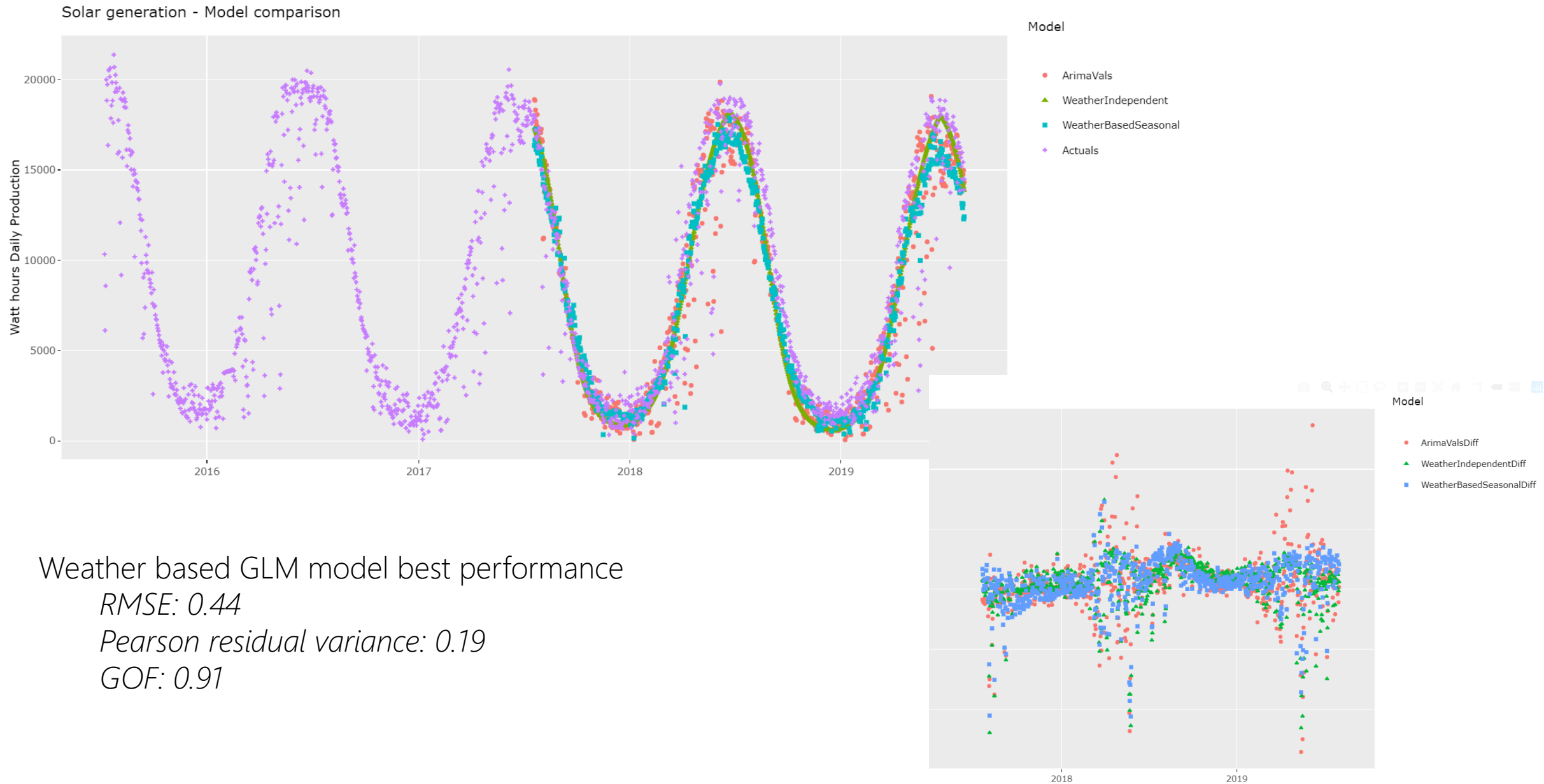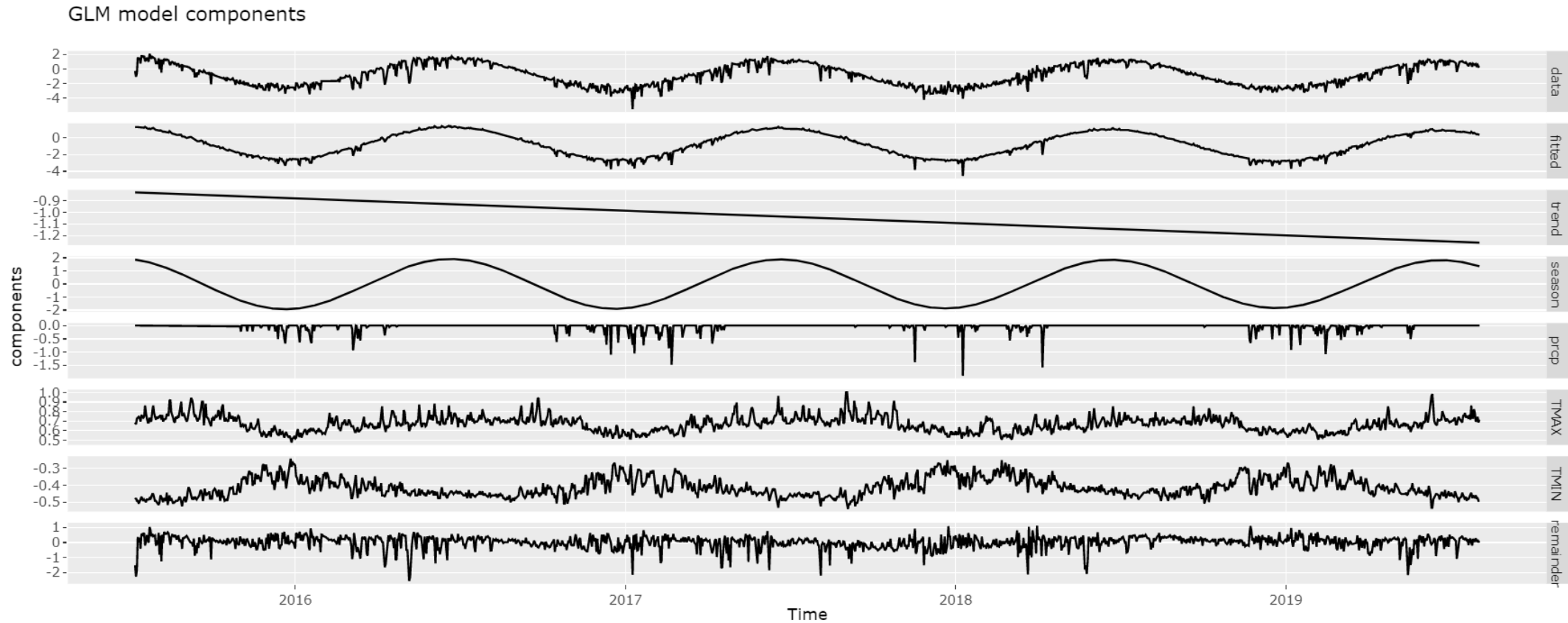*library(lubridate)*
library(TSstudio)

Findings – Generation varies more than expected

Daily Solar generation

Percentage of max monthly production

- I saw more production variation than expected
- Note slight downward trend
- For new installs, future NEM policy is key to profitability
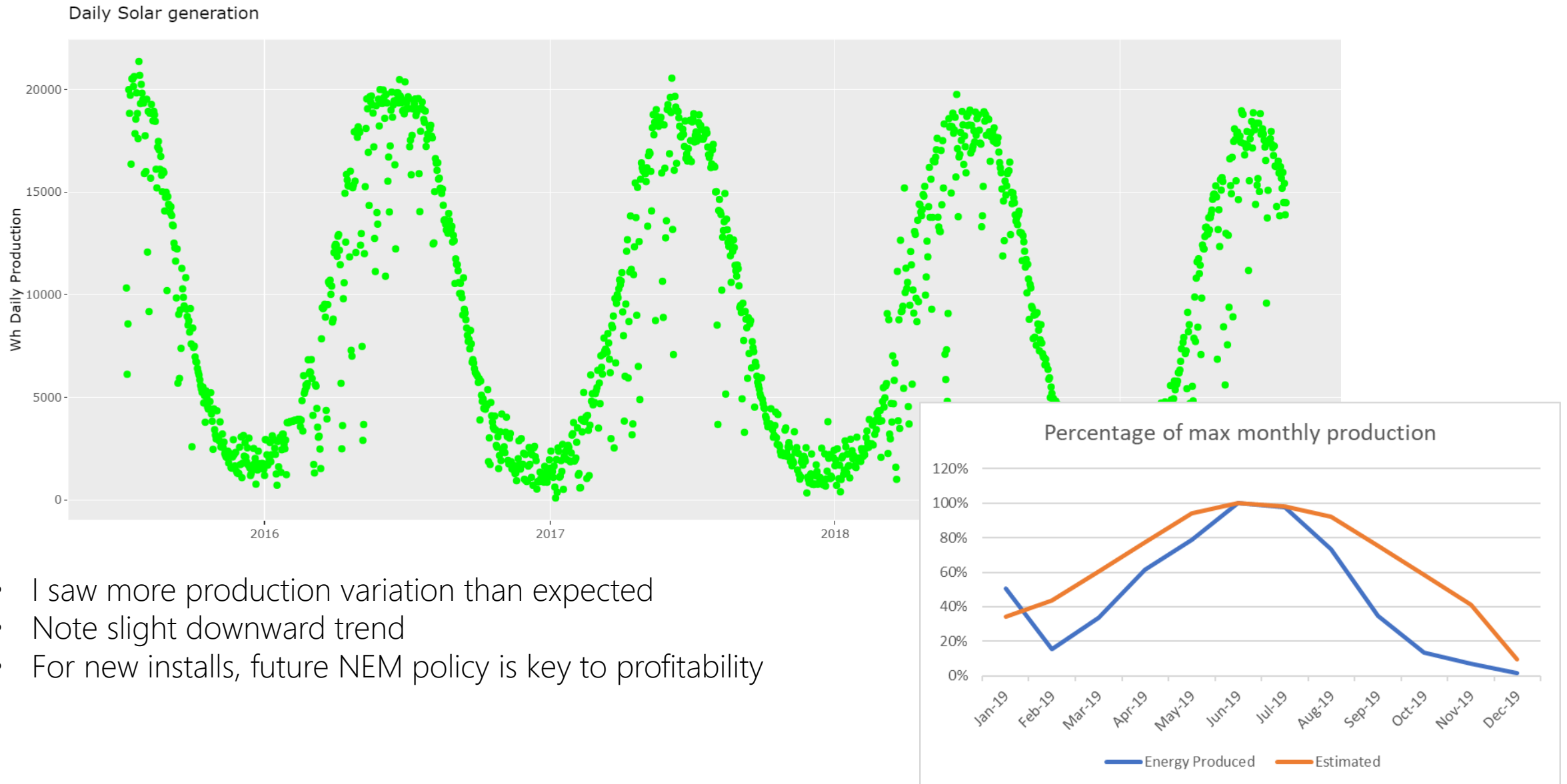
Findings – Model comparison

Solar generation - Model comparison

Weather based GLM model best performance
RMSE: 0.44
Pearson residual variance: 0.19
GOF: 0.91

GLM model components

```
# Use this to fit a seasonal/sinusoidal pattern
solarDf$xc<-cos(2*pi*solarDf$DATE_Numeric/365)
solarDf$xs<-sin(2*pi*solarDf$DATE_Numeric/365)
glm(energyProducedWhLog ~  xc+PRCP +DATE_Numeric*xc +TMAX + TMIN, data=solarDf)
```
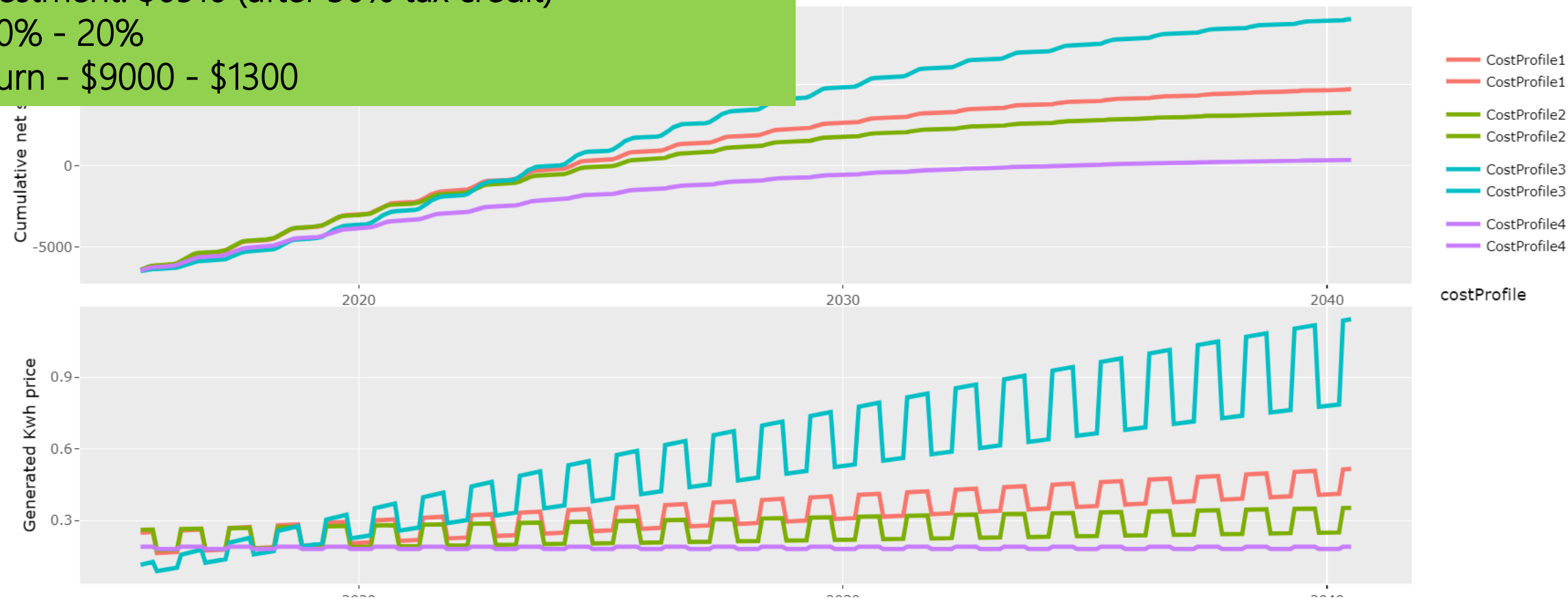
Solar generation ARIMA forecast
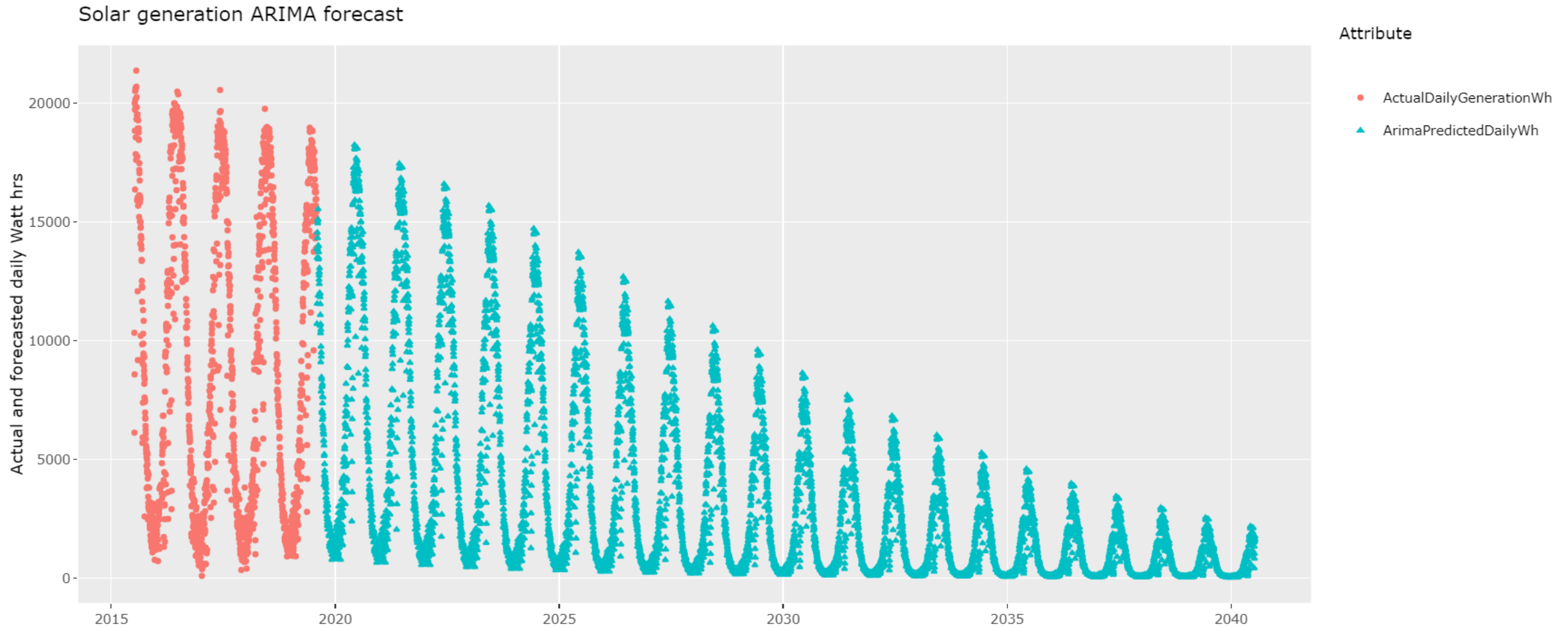
Degradation at ~2% is overestimated

Solar investment is profitable
Net investment: $6516 (after 30% tax credit)
ROI: 130% – 20%
Net return – $9000 – $1300

	paybackYrs	DATE	IRR	NetReturn	ROI
	8.65	2024-03-01	10 %	$9004	138 %
	8.91	2024-06-01	7 %	$4694	72 %
	9.82	2025-05-01	6 %	$3272	50 %
	11.91	2027-06-01	3 %	$1333	20 %