From Data to Power: Predicting Renewable Energy Generation for a Sustainable Future

SDG 7 - Affordable & Clean Energy

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Overview

- Introduction
- Processes Involved and Results
- Conclusion
- Recommendation

Problem Statement

The advancement of technology, urbanisation, and growing population, has led to a **surge in energy demand.** Despite the potential for renewable energy to fulfill two-thirds of the overall energy consumption, many still **rely on non-renewables** as **renewable energy is unreliable** due to unpredictable weather.

01

OBJECTIVES

- To analyze and forecast the energy demand and production pattern
- To determine and predict whether renewable energy can contribute 30% to total energy production by 2030
- To provide a solution for a smooth transition towards a renewable energy-powered future

02

RESEARCH QUESTIONS

- What is the projected energy demand and energy production by 2030?
- Can energy production meet energy demand by 2030?
- What percentage of the total energy production is renewable energy by 2030?

Correlation

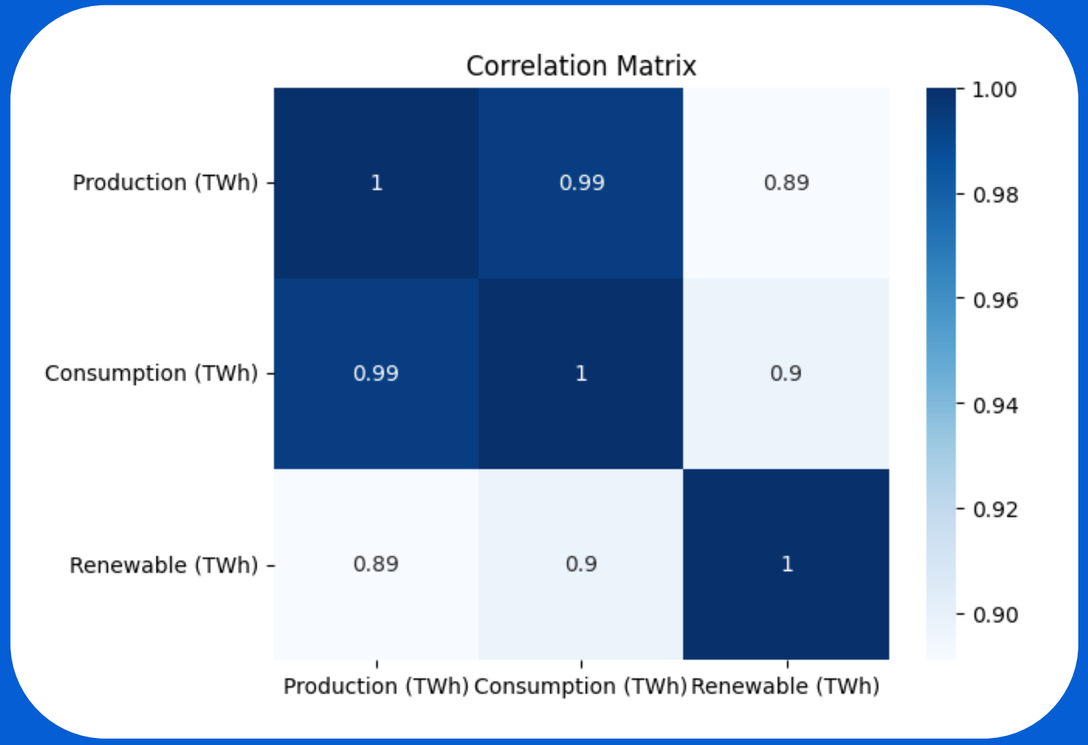


Figure 1: Correlation between Global Total Energy Production, Global Total Energy Consumption and Global Total Renewable Energy Production

Electricity demand is **strongly positively correlated** to energy production with the correlation of:

0.99

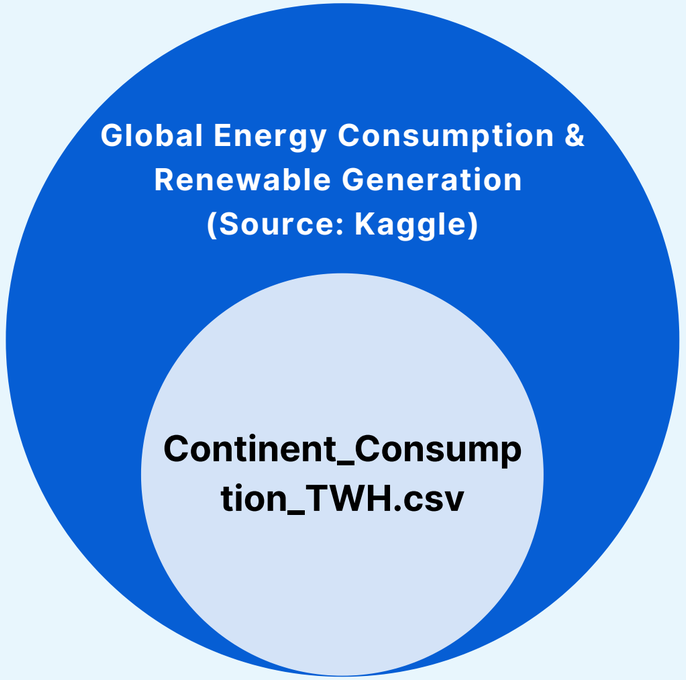
Renewable energy production is **positively correlated** to the overall energy production with the correlation of:

0.89

What is the projected energy demand by 2030?

- Time Series Analysis using Prophet -

What is the projected energy demand by 2030?



Dataset Used

	Year	World	OECD	BRICS	Europe	North America	Latin America	Asia	Pacific	Africa	Middle-East	CIS
0	1990	101855.54	52602.49	26621.07	20654.88	24667.23	5373.06	24574.19	1197.89	4407.77	2581.86	16049.40
1	1991	102483.56	53207.25	26434.99	20631.62	24841.68	5500.99	24783.53	1186.26	4535.70	2744.68	15898.21
2	1992	102588.23	53788.75	25993.05	20189.68	25341.77	5628.92	25690.67	1209.52	4582.22	3081.95	14339.79
3	1993	103646.56	54614.48	26283.80	20189.68	25830.23	5675.44	26876.93	1267.67	4721.78	3349.44	13246.57
4	1994	104449.03	55579.77	25993.05	20085.01	26365.21	5989.45	28098.08	1279.30	4803.19	3640.19	11606.74

Figure 1: Head of the dataset

- Data from 1990 - 2020 (30 rows)
- 12 columns

What is the projected energy demand by 2030?

Data Cleaning

- Check for **missing** values and **duplicated** values.
- Delete all columns except the world column.

	Year	World Power Consumption (TWh)
0	1990	101855.54
1	1991	102483.56
2	1992	102588.23

Figure 2: Modified dataframe

- Convert the 'Year' from integer to **DateTime** format

- **Rename** columns:

  Year --> ds
  World Power Consumption (TWh) --> y

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Exploratory Data Analysis

- Initial plot

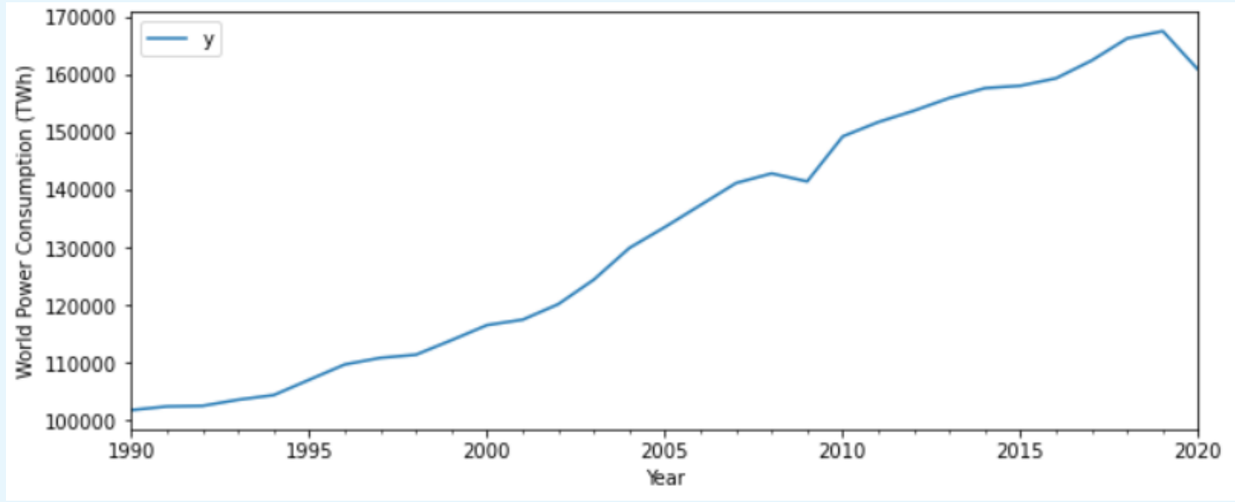

Figure 3: Graph of global energy consumption (1990 - 2020)

What is the projected energy demand by 2030?

Data Modelling

- Create a **Prophet** model
- **Fit** (train) the model to the data
- Make **prediction**
- **Plot** the prediction

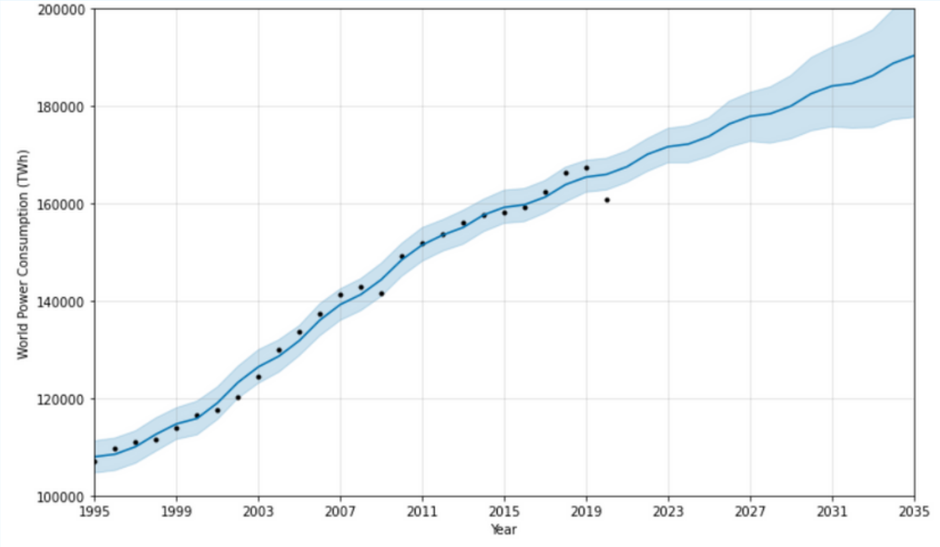

Figure 4: Graph of actual & forecasted global energy consumption (1995 - 2035)

What is the projected energy demand by 2030?

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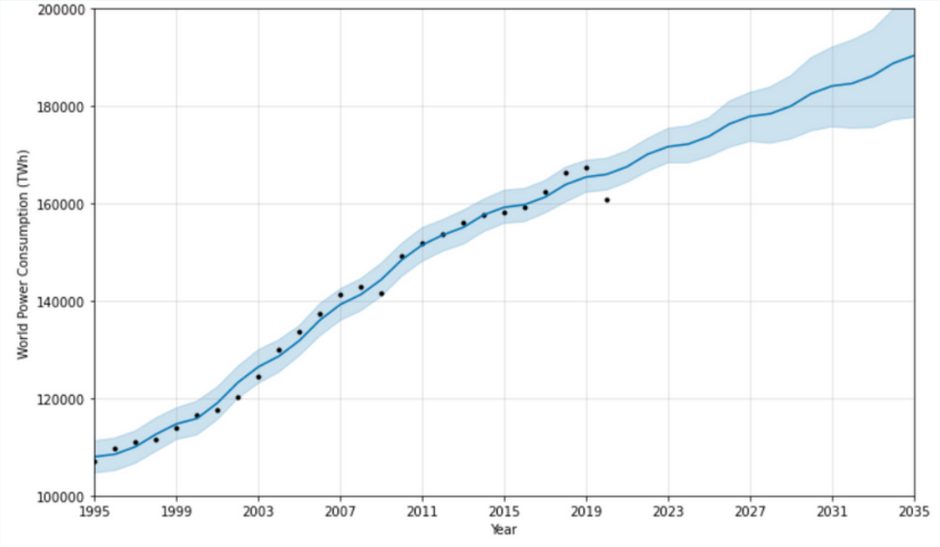

Figure 4: Graph of actual & forecasted global energy consumption (1995 - 2035)

Model Evaluation

- Evaluate the model with RMSE & R-squared

RMSE = **3152.16 TWh**

R-Squared = **0.97**

What is the projected energy demand by 2030?

The projected energy demand by 2030 is

182,573.61 TWh

What is the projected energy production by 2030?

- Linear Regression -

Dataset Used

- Electricity_Production_By_Source.csv (Source: Kaggle)

Entity	Code	Year	Coal (TWh)	Gas (TWh)	Hydro (TWh)	Other renewables (TWh)	Solar (TWh)	Oil (TWh)	Wind (TWh)	Nuclear (TWh)
Argentina	ARG	1985	0.607	12.46381379	20.646	0.103321614	0	5.706	0	5.766
Argentina	ARG	1986	1.013	13.27074408	21.009	0.107078921	0	7.894	0	5.711
Argentina	ARG	1987	1.016	12.55825178	21.841	0.108156823	0	10.078	0	6.465
Argentina	ARG	1988	1.586	20.55537675	15.033	0.121116047	0	8.635	0	5.798
Argentina	ARG	1989	0.865	24.30740969	12.965	0.119376908	0	7.204	0	5.039

Figure 5: Head of the dataset

- Data from 1985 - 2020 (6241 rows)
- 11 columns

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Data Cleaning

- Check for **null** and **duplicated** values
- Calculate the **sum** of energy production by different sources for each entity

Entity	Code	Year	Coal (TWh)	Gas (TWh)	Hydro (TWh)	Other renewables (TWh)	Solar (TWh)	Oil (TWh)	Wind (TWh)	Nuclear (TWh)	Total Energy (TWh)
Argentina	ARG	1985	0.607	12.4638138	20.646	0.103321614	0	5.706	0	5.766	45.2921354
Argentina	ARG	1986	1.013	13.2707441	21.009	0.107078921	0	7.894	0	5.711	49.004823
Argentina	ARG	1987	1.016	12.5582518	21.841	0.108156823	0	10.078	0	6.465	52.0664086
Argentina	ARG	1988	1.586	20.5553768	15.033	0.121116047	0	8.635	0	5.798	51.7284928
Argentina	ARG	1989	0.865	24.3074097	12.965	0.119376908	0	7.204	0	5.039	50.4997866

Figure 6: Modified dataframe

- **Remove** unnecessary rows and columns

Entity	Code	Year	Total Energy (TWh)
World	OWID_WRL	1985	9825.320895
World	OWID_WRL	1986	10120.31776
World	OWID_WRL	1987	10611.5288
World	OWID_WRL	1988	11074.62838
World	OWID_WRL	1989	11588.06717

Figure 7: Final dataframe

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Data Cleaning

- Check for **null** and **duplicated** values
- Calculate the **sum** of renewable energy production for each year

Entity	Code	Year	Coal (TWh)	Gas (TWh)	Hydro (TWh)	Other renewables (TWh)	Solar (TWh)	Oil (TWh)	Wind (TWh)	Nuclear (TWh)	Total Energy (TWh)
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Figure 7: Final dataframe

Exploratory Data Analysis

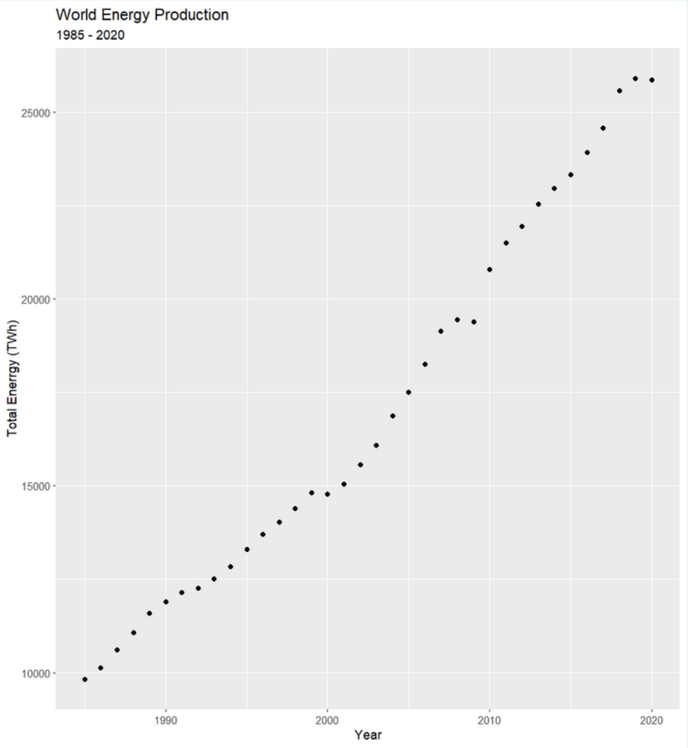


Figure 8: Graph of global energy production (1985 - 2020)

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Data Modelling

- Create a **Linear** model
- **Fit** (train) data
- Make **prediction**
- **Plot** the prediction

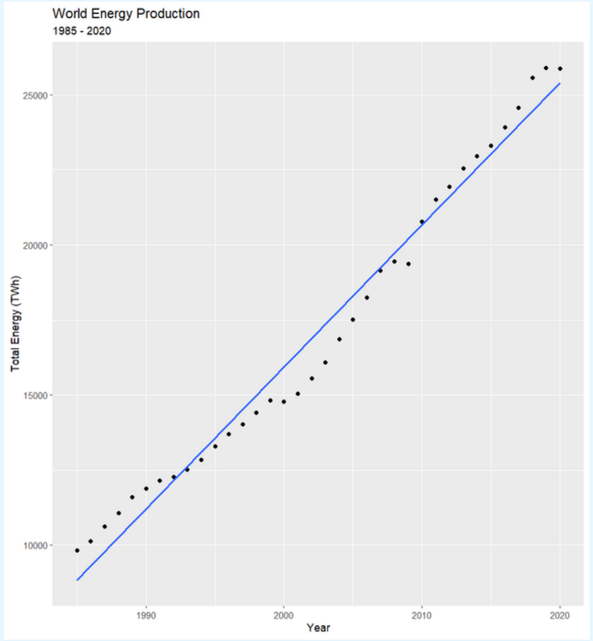


Figure 9: Graph of actual and forecasted renewables production (1990 - 2030)

Formula:

Total Energy= -930907.6902 + (473.4178 * Year)

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Data Modelling

- Create a **Linear** model
- **Fit** (train) data
- Make **prediction**
- **Plot** the prediction

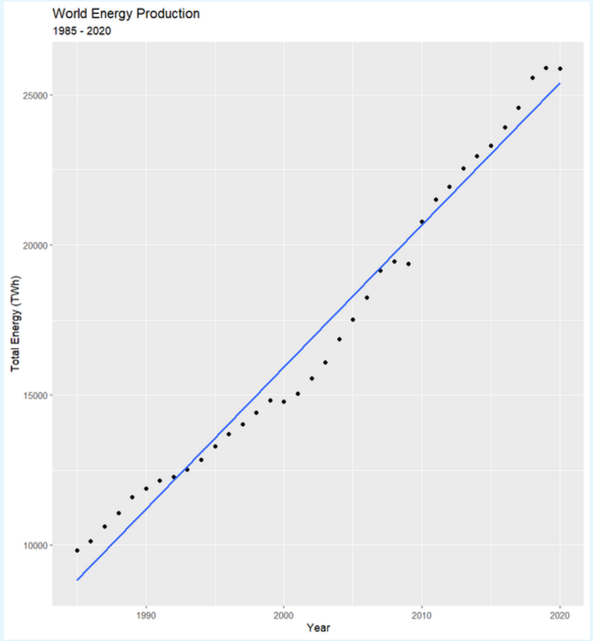


Figure 9: Graph of actual and forecasted renewables production (1990 - 2030)

Model Evaluation

- Evaluate the model with RMSE & R-squared

RMSE = **737.4TWh**
R-Squared = **0.9786**

Formula:

Total Energy= -930907.6902 + (473.4178 * Year)

What is the projected energy demand by 2030?

Outcome

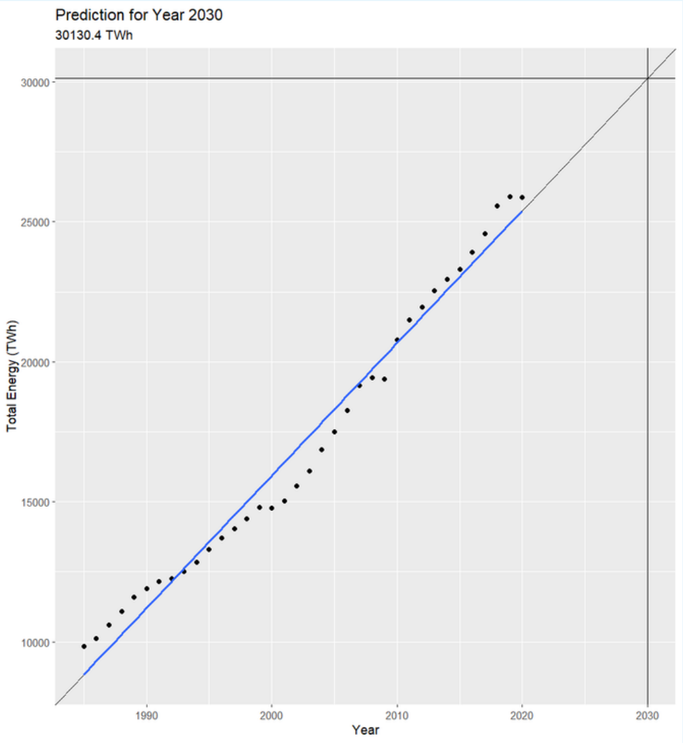


Figure 10: Graph of prediction for year 2030

The projected energy production by 2030 is **30,130.4 TWh.**

Can energy production meet energy demand by 2030?

Can energy production meet energy demand by 2030?

Energy Demand:

182,573.61 TWh

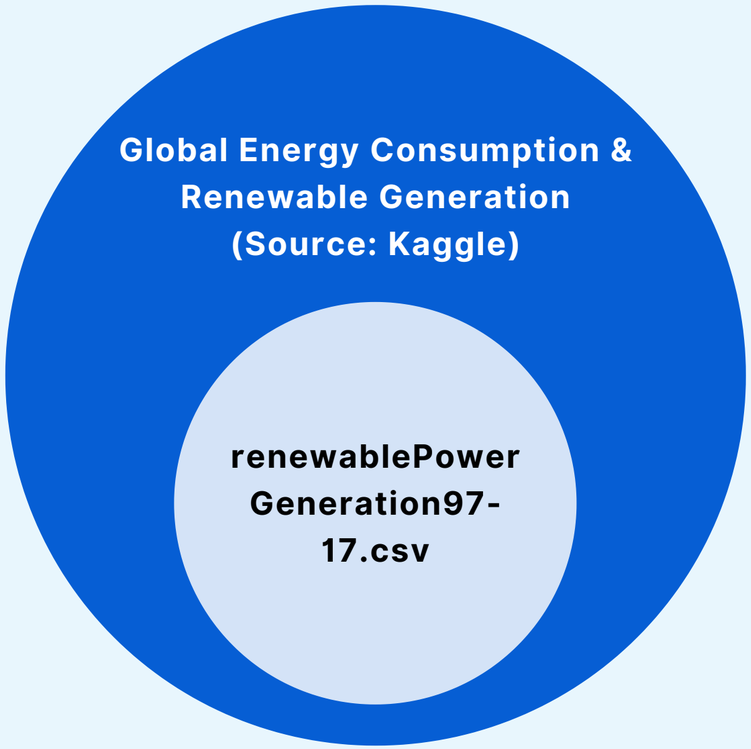
>

Energy Production:

30,130.40 TWh

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

- Time Series Analysis using Prophet -



Dataset Used

	Year	Hydro(TWh)	Biofuel(TWh)	Solar PV (TWh)	Geothermal (TWh)
0	1990	2191.67	3.88	0.09	36.42
1	1991	2268.63	4.19	0.10	37.39
2	1992	2267.16	4.63	0.12	39.30
3	1993	2397.67	5.61	0.15	40.23
4	1994	2419.73	7.31	0.17	41.05

Figure 11: Head of the dataset

- Data from 1990 - 2017 (28 rows)
- 5 columns

Data Cleaning

- Check for **null** and **duplicated** values
- Calculate the **sum** of renewable energy production for each year

	Year	Hydro(TWh)	Biofuel(TWh)	Solar PV (TWh)	Geothermal (TWh)
0	1990	2191.67	3.88	0.09	36.42
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4	1994	2419.73	7.31	0.17	41.05
5	1995	2545.96	7.95	0.19	39.89

Figure 12: Initial dataframe

	Year	Total_Renewables (TWh)
0	1990	2232.06
1	1991	2310.31
2	1992	2311.21
3	1993	2443.66
4	1994	2468.26

Figure 13: New dataframe

- Drop unused columns
- Convert the 'Year' from integer to **DateTime** format
- **Rename** columns:

  Year --> ds
  Total_Renewables (TWh) --> y

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Data Cleaning

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Exploratory Data Analysis

- Initial plot

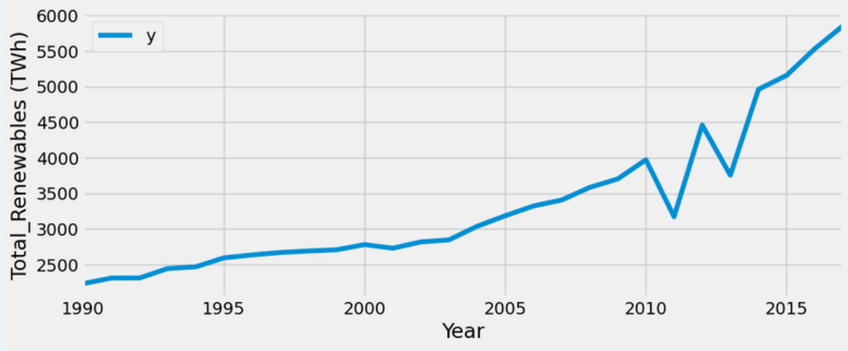

Figure 14: Graph of total renewables production (1990 - 2017)

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Data Modelling

- Create a **Prophet** model
- **Fit** (train) data
- Make **prediction**
- **Plot** the prediction
- **Compute the percentage of renewable energy** generation to total energy production

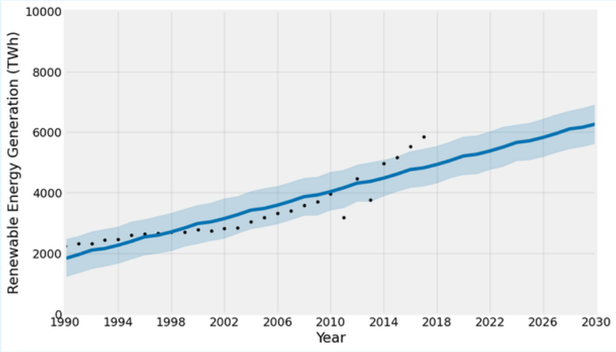

Figure 14: Graph of actual and forecasted renewables production (1990 - 2030)

Formula:

$$\frac{\text{forecasted renewable energy}}{\text{forecasted total energy}} \times 100$$

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

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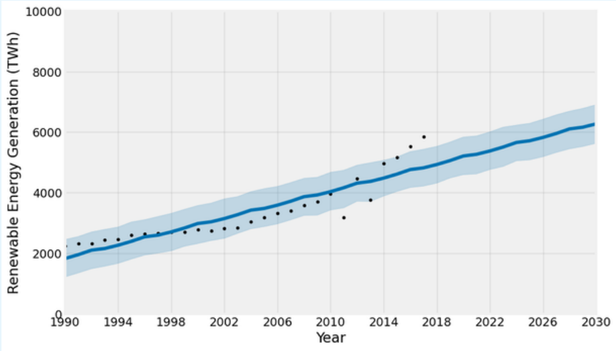

Figure 14: Graph of actual and forecasted renewables production (1990 - 2030)

Formula:

$$\frac{\text{forecasted renewable energy}}{\text{forecasted total energy}} \times 100$$

Model Evaluation

- Evaluate the model with RMSE & R-squared

RMSE = **533.62 TWh**
R-Squared = **0.67**

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Outcome

Answer: No

It is predicted that renewable energy contributes only **22.59%** to the total energy production by 2030.

Can renewable energy reach the SDG target of a 30% contribution to overall energy production by 2030?

Outcome

Answer: No

It is predicted that renewable energy contributes only **22.59%** to the total energy production by 2030.

Fails to achieve SDG Target of 30% by 2030.

Conclusion

01

Energy demand is forecasted to **exceed** the energy production.

02

Renewable energy only contributes **22.6%** to the overall energy production which is clearly against the SDG 7's **Target of 30%.**

03

Effective measures are needed to be taken to **put us back on track** to hit the 30% mark by 2030.

04

Our recommendation is to optimize and utilise **smart grids** by implementing **Energy Storage Systems (ESS).**

Recommendation

RES Integration

CHALLENGES

- Heavily dependent on **weather**
- When energy is **generated more than the demand**, the generated energy will be unused, lost and wasted because there is **no storage system** to store the excess energy generated

How to overcome?

SUGGESTION

Build **Energy Storage System (ESS)** within the smart grids

PURPOSE

Store the excessive renewable energy generated by the RES

OPPORTUNITY

Allows customer-owned renewable energy generators (e.g. solar panels) to **sell** excess energy generated to Distribution Licensees (e.g., TNB)

IMPACT

- **Extra income** via a fixed premium rate per unit of renewable energy sold.
- Encourage **more people to invest** in renewable energy generators

Increasing renewable energy to overall energy generation

Thank you