

electricityMap data analyst challenge

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1 Two electricity zones in Denmark

Denmark has two electricity zones:

- The Eastern part of Denmark covering Zealand with islands and Bornholm is connected to the synchronous electrical grid of Norway, Sweden and Finland. The hydroelectricity produced by Sweden and Norway provides a stable source of renewable energy that complement the domestic green production of wind energy.
- The Western part of Denmark is part of the synchronous grid of Continental Europe which is the largest synchronous electrical grid in the world and includes most of the European Union

2 Changes of the carbon footprint of electricity throughout the day

The total energy production varies throughout the day, and is higher during the day, peaking at 1pm (figure 1). The demand on the grid for electricity is therefore higher during the day than at night. However to know when it is the best time to use energy, we should look into the energy sources and their variation across the day.

The energy produced in eastern Denmark comes from both renewable sources such as biomass, solar and wind; and from large carbon emitters sources such as gas, oil and coal that come in complement when the energy consumption exceeds the production of renewables.

When looking at the carbon emission produced per energy (figure 2), we can see that the lowest time is during business hours (8am to 5pm), in particular around 1pm.

Similarly if we look at the average fraction of energy produced throughout the day from renewable versus non-renewable (figure 3), we can see a similar pattern where the highest renewable energy is produced during the day.

The renewable energy produced from wind and solar sources are intermittent, however the main diurnal variation can be explained by the solar energy production (figure 4, and appendix A, figure 6 for a focus on solar production)

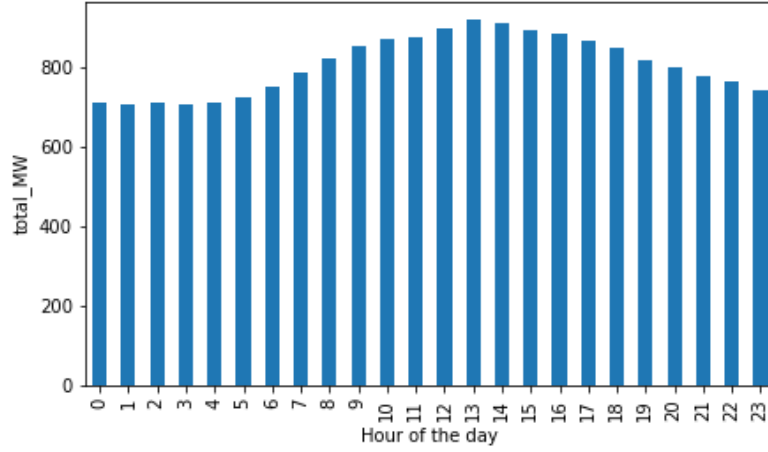


Figure 1: Carbon emitted per energy produced throughout the day in average over the year 2020.

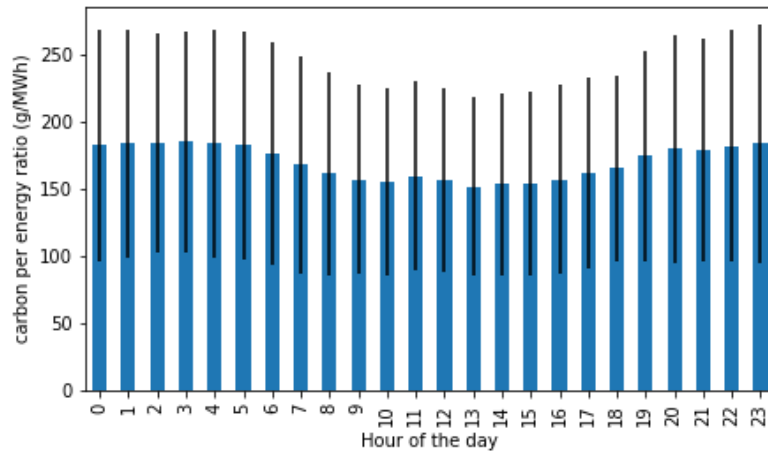


Figure 2: Carbon emitted per energy produced throughout the day in average over the year 2020.

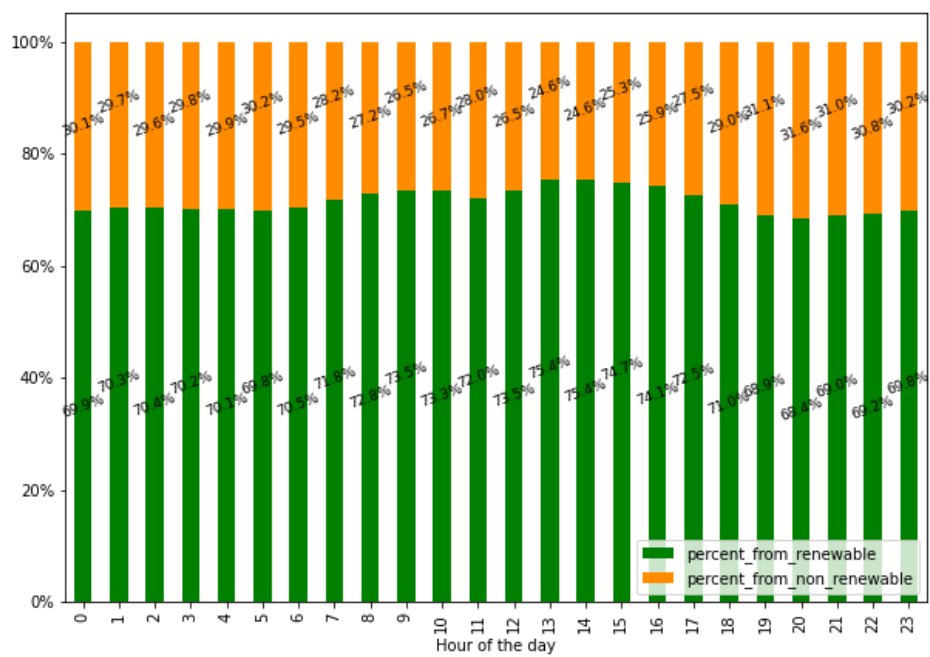


Figure 3: Production of renewable and non-renewable energy produced throughout the day in average over the year 2020.

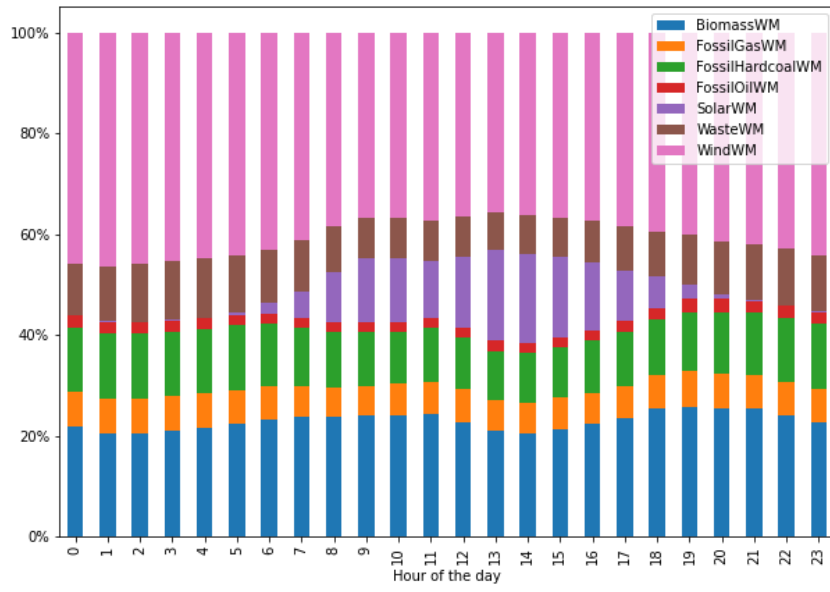


Figure 4: Production of renewable and non-renewable energy produced throughout the day in average over the year 2020.

3 Utilizing the data to charge at the greenest time

In the previous section, we show the average daily variation of the impact of energy on the carbon emission, and showed that on average throughout the day, it is better to use energy during business hours.

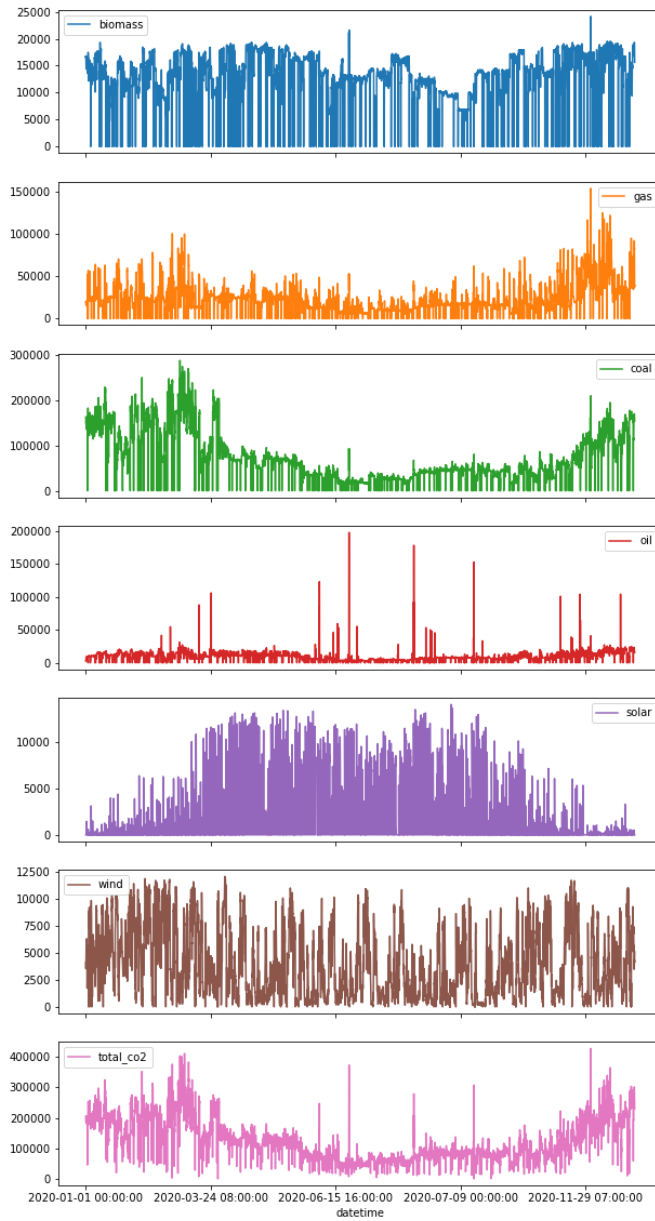


Figure 5: Time series visualisation of the energy produced in eastern denmark and the carbon emission over the year 2020. The top 6 graphs shows the energy produced from the different sources, and is expressed in kWh, while the bottom graph shows the carbon emission and is expressed in gram of CO₂

A Renewable available production over the day

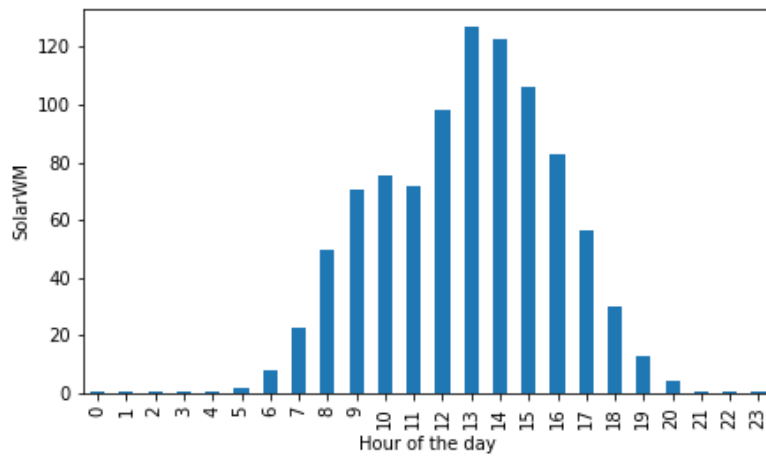


Figure 6: Solar energy produced throughout the day in average over the year 2020.

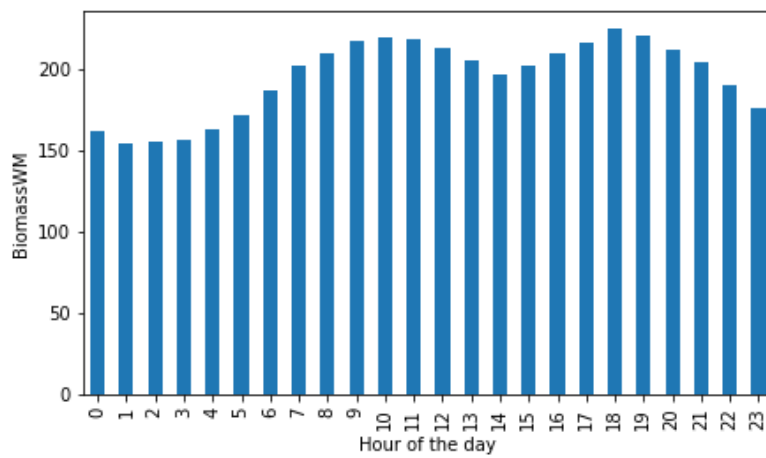


Figure 7: Biomass energy produced throughout the day in average over the year 2020.

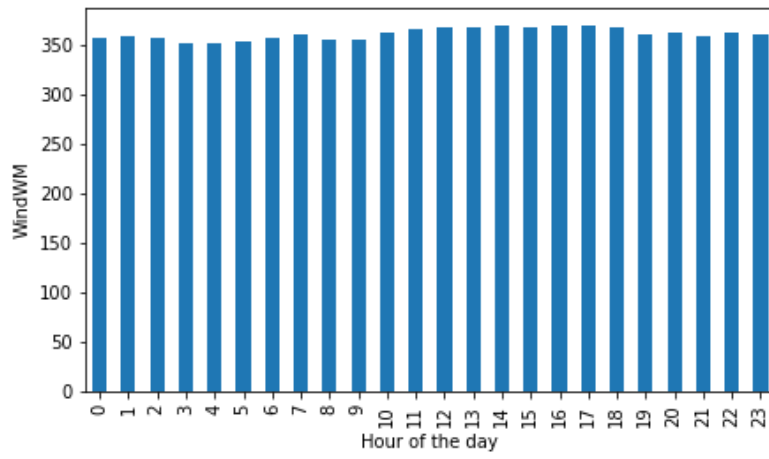


Figure 8: Wind energy produced throughout the day in average over the year 2020.

B Non-renewable averable production over the day

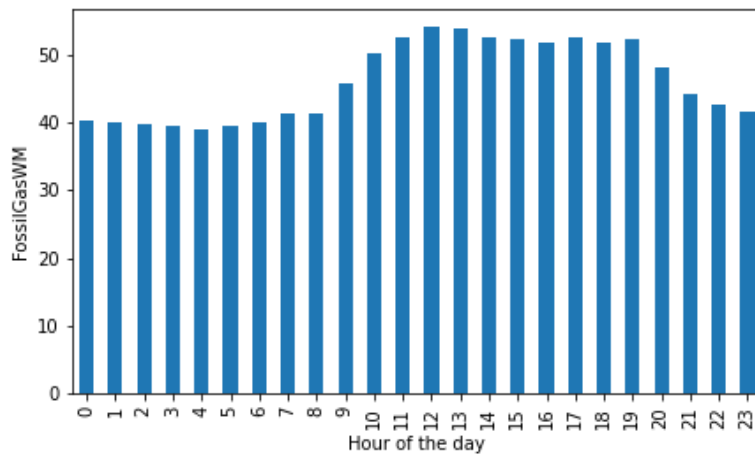


Figure 9: Fossil gas energy produced throughout the day in average over the year 2020.

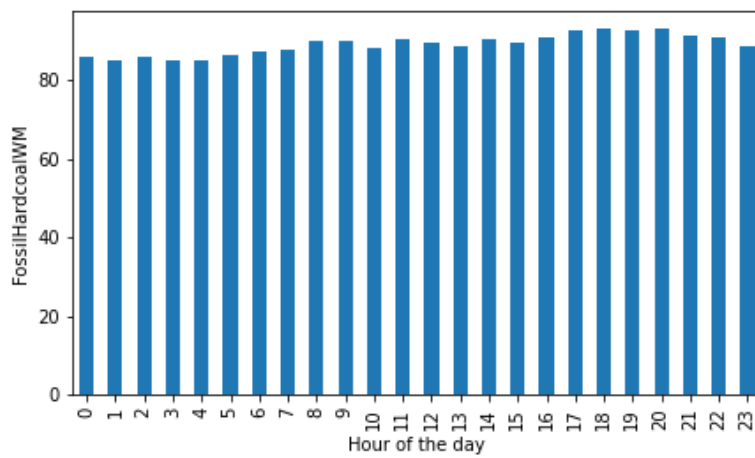


Figure 10: Fossil hard coal energy produced throughout the day in average over the year 2020.

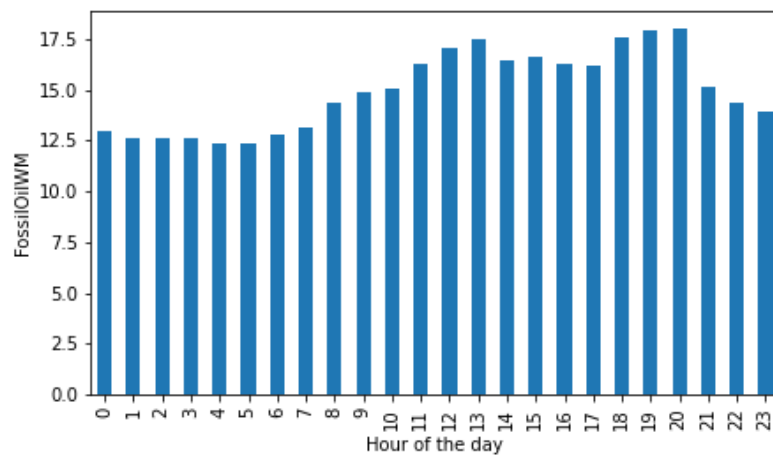


Figure 11: Fossil Oil energy produced throughout the day in average over the year 2020.