

Personal Project Bernardo Freire

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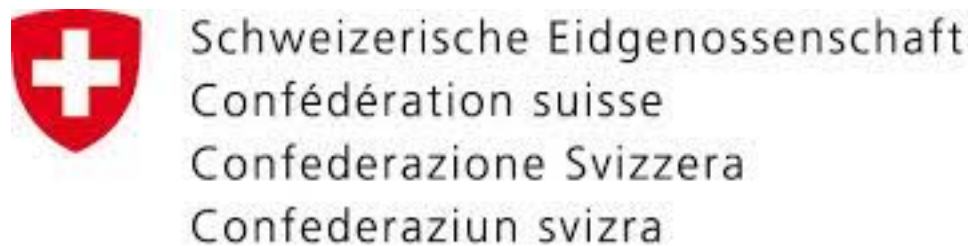


1 Overview

In the course of this semester the war in Ukraine has changed my perception of fossil-fuels and how we as society is dependent from it. For the transition of all economies from a fossil-fuel-based economy to an renewable-energy based economy (it is my opinion), mobility is one of the most controvesial discussed topics. From the technical point of view, electric engines are efficient, and using electricity means that renewable energies can also be used. Electric mobility is for that reason, a key technology for more sustainable mobility and is one way of achieving ambitious energy and climate policy goals. Everything sounds amazing and fun, but, the central question when buying an electric vehicle (at least for me) are:

- Who are the best operators?
- Which city/region is best for electric vehicle users
- Do I have more or less choice of recharge stations depending on which city/canton I live in?
- Do I still need special accessories, depending on the charging stations?

This question are answered using two APIs, a MongoDB database and graphs in order to vizualize the data. The used API is based on the page recharge-my-car.ch and is the face of the **National Data Infrastructure For Electromobility (DIEMO)** and shows where charging points for electric vehicles are and provides specific detailed information, everything available in real time.



Swiss Federal Office of Energy SFOE

At this point it should be mentioned, that not all operators are registered in this database.

The correct assignment of postal codes and cities has proven to be extremely difficult, since a city can have several postal codes and several municipalities can share one postal code. To reduce the assignment of cities to a single number, a second API was needed, directly from the Swiss Post. Using this second database, the entries of the DIEMO database were cleaned and enriched. Last but not least, the MongoDB database is hosted on MongoDB Atlas and available via URL.

2 Document Structure: DIEMO API

The documents returned by the SFOE API were converted to JSON format and straight away imported into their respective collection in the SFOE database (**ChargingStations** collection). The class diagram below represents what a *single document* looks like. However, all collections have the same structure.

The size of the array **EVSEDataRecord** is the number of charging stations accross Switzerland. The array **EVSEDataRecord** contains further sub-arrays with the relevant information of each charging station. The ‘{ }’ indicates a nested substructure where the additional data is found linked below the main document. Other fields have not been presented in a separate entity in the diagramm.

- The collection **ChargingStations** contains the fields **OperatorID**, **OperatorName** and **EVSEDataRecord**.
- The **EVSEDataRecord** itself contains for each charging station a separate array containing the **Address**.
 - Within **Address** there are several sub-fields, the most important one is the **Address** array, which contains the details, such as City, Street, StreetNumber, PostalCode etc., of each charging station.

3 Extract & Load

In the ETL phase, data is extracted from the [SFOE](#) database using their API. Then, the data is transformed into a JSON format and is then loaded into our MongoDB database.

3.1 Connect to MongoDB and create database

Now, since the data is fetched from the API, we need to connect to the MongoDB database and load the data. Only the data **EVSEData** is of interest will be loaded and which operator will be save as own document within the collection **ChargingStations**.

33 operators have so far registered in DIEMO.

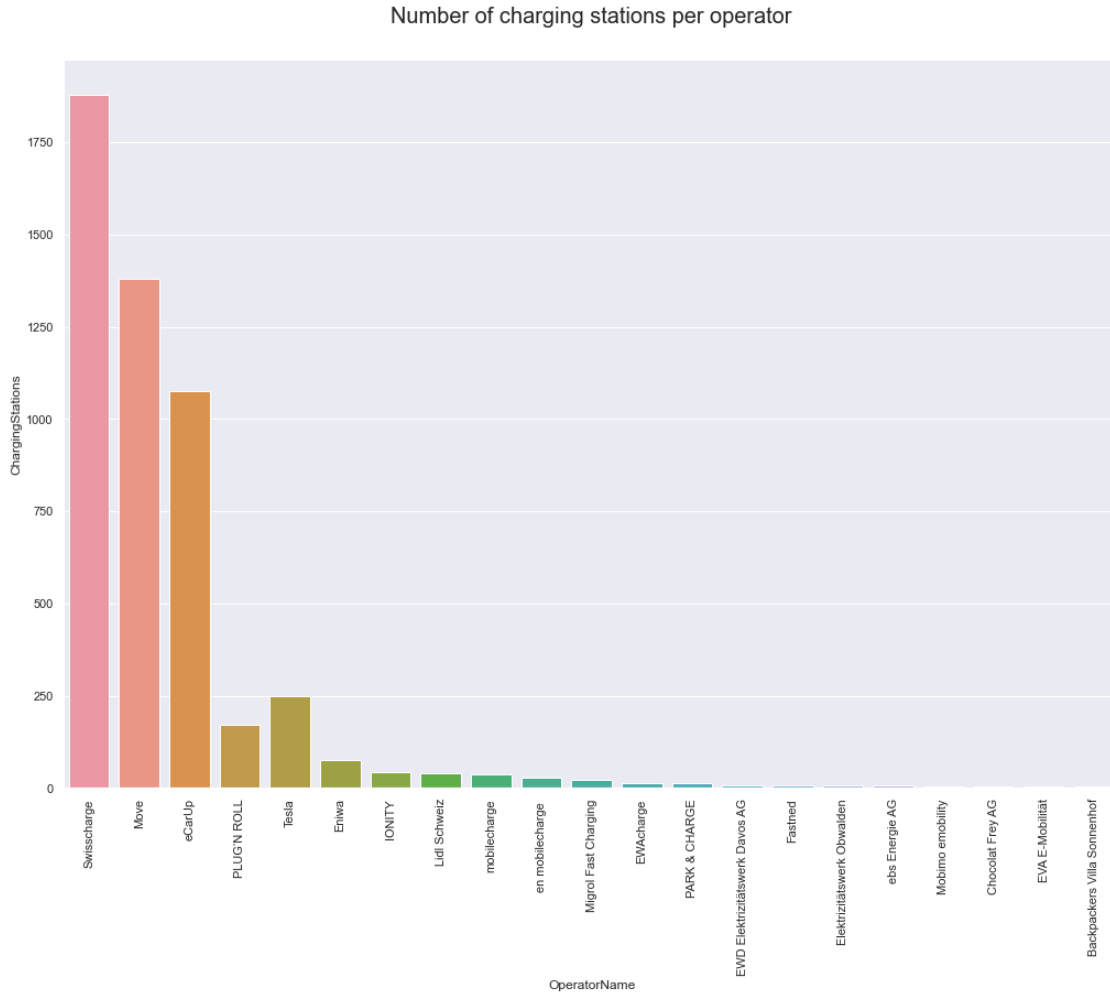
Each of the operators have a different number of charging points, adresses etc. Each operator is stored in a separate document within the collection called **ChargingStations**. The following table shows, as the first step, the operators of the charging station.

The API returned the following operators with empty values: Bgdi_Admin , IBC , Martin Hertach , S-Charge , Test Operator , evpass

4 Transform & Analysis

4.1 Best operators by number of stations

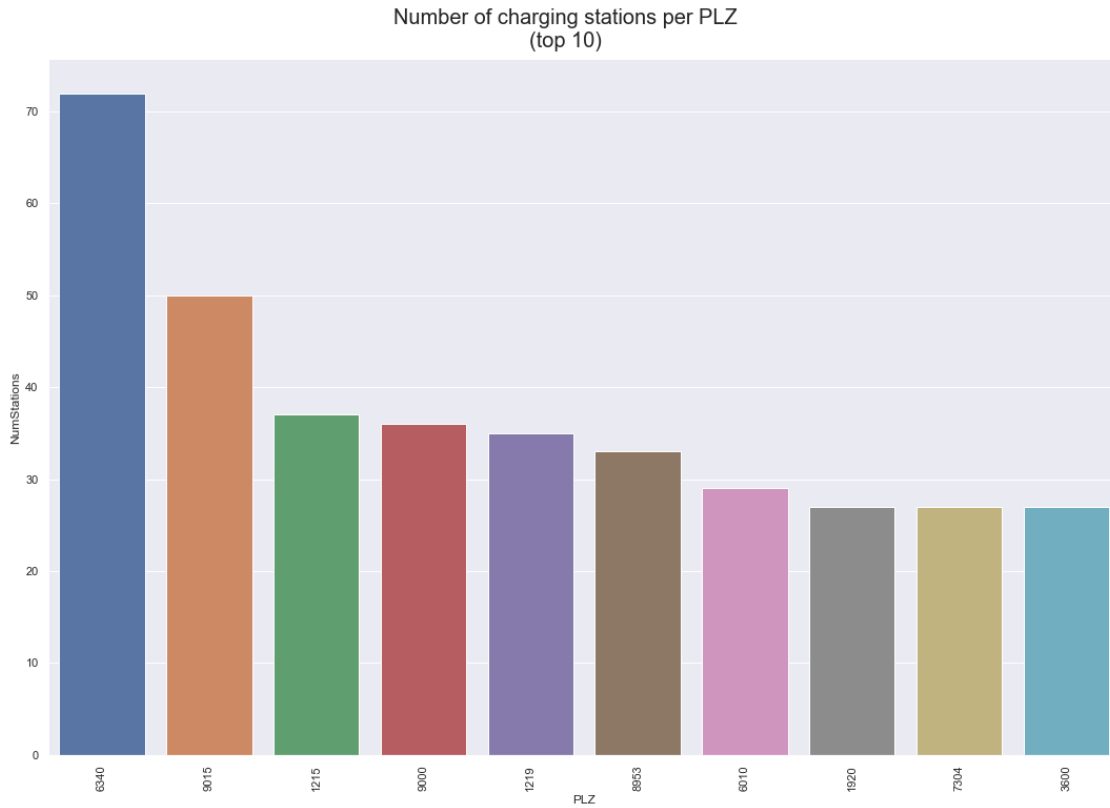
The best operators, in terms of number of charging stations, are as follows:



The companies **Swisscharge** (1878), **Move** (1379), **eCarUp** (1077), **Plug'n'roll** (331) and **Tesla** (250) have the highest number of charging stations.

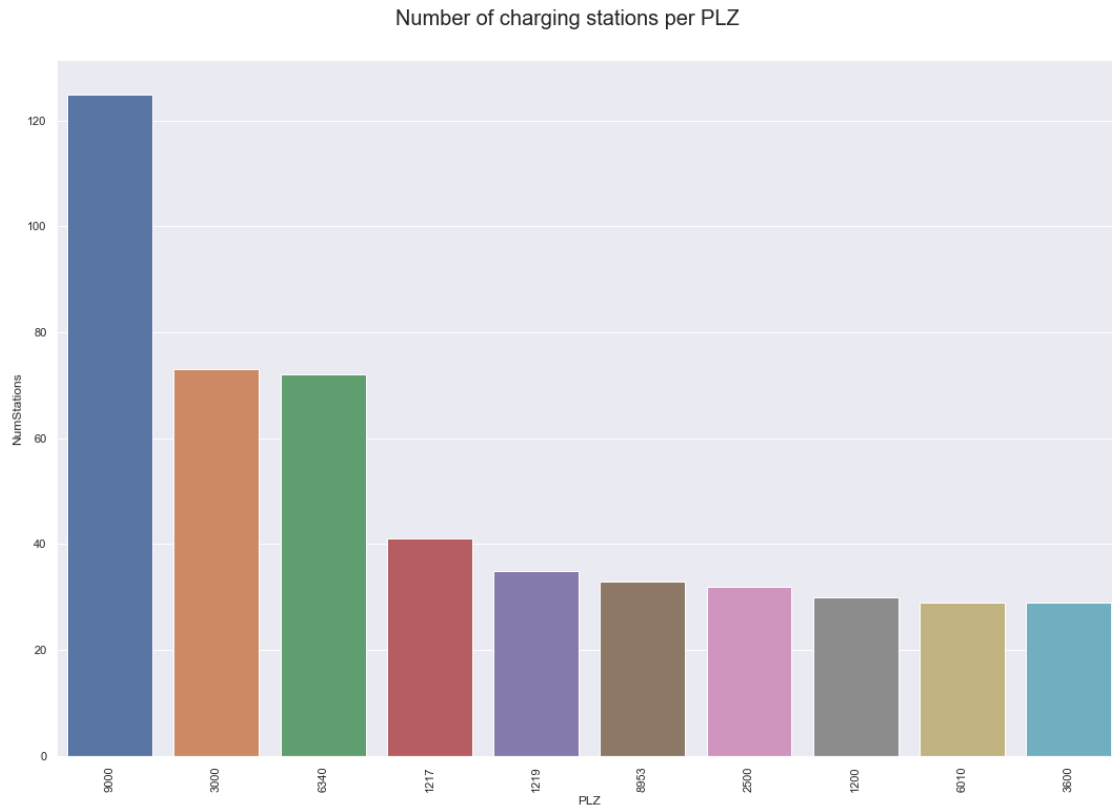
The companies **ebs Energie AG** (6), **Mobimo emobility** (5), **Chocolat Frey AG** (4), **EVA E-Mobilität** (4) and **Backpackers Villa Sonnenhof** (3) have the lowest number of charging stations.

4.2 Best cities by number of stations



The most attractive cities by postal code (Postleitzahl - PLZ) are shown above. As mentioned in the introduction, the problem with the postal code is that this number does not necessarily correspond to the city. Some cities in Switzerland have more than one postal code. For example, the city **Zurich** has two postal codes: **8050**, **8056** etc.

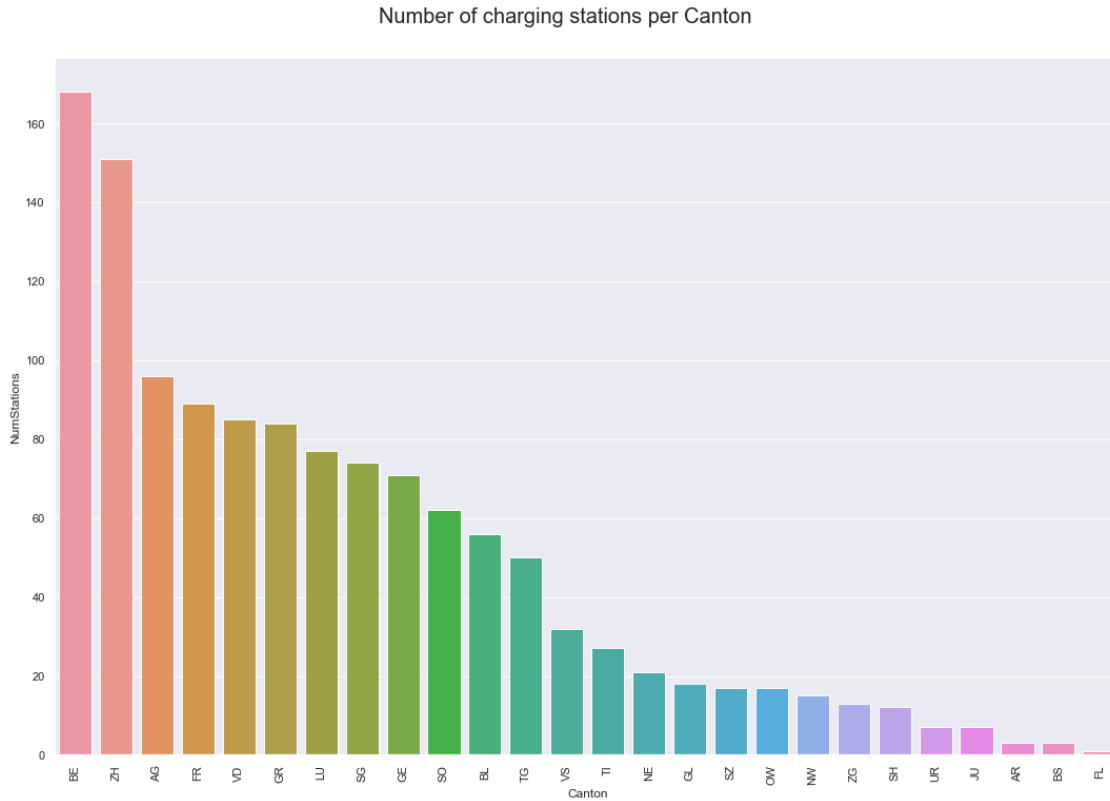
For that reason a second data set is used, which contains the postal code, city and corresponding cantons - this dataset is provided by [Swiss Post](#). First, the same analysis is repeated, but this time, the postal code is merged and only the **GPLZ** (Gemeindepostleitzahl - City Postal Code) is then used. Further, due to the manageable distances within the cantons, the summary is provided at cantonal level as well.



One can see now, that the diagram above now shows the city of Baar (6340) and St. Gallen is on the pole-position followed by the capital Bern.

4.3 Best cantons by number of stations

As previously mentioned, the size of the cantons allows also a practical charging of cars in the neighborhood. Therefore, the analysis is repeated and this time presented on cantonal level as follows.

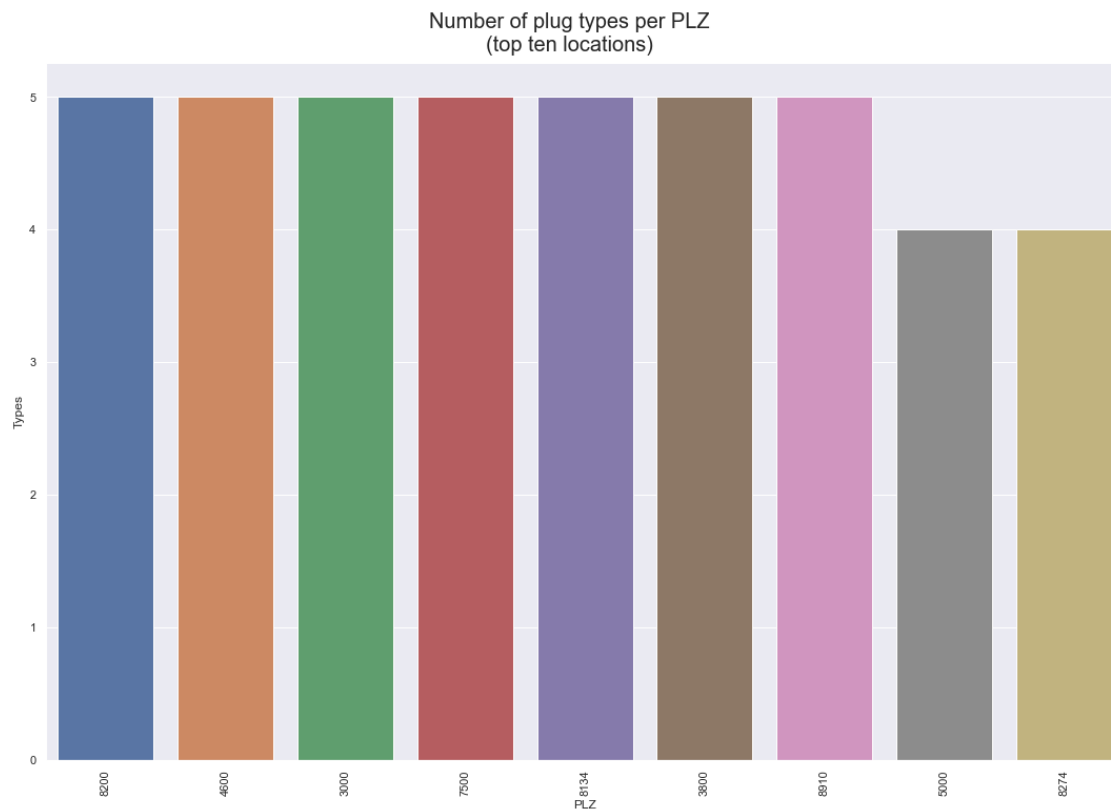


The best canton in Switzerland is Bern, followed by Zurich and Aargau, just to mention a few. Basel-Stadt, Appenzell-Ausserrhoden and Jura come in last among the cantons.

4.4 Best cities by number of plug types

Imagine you are driving around Switzerland and suddenly you need to charge your car. Where do you go if you have to assume that you will not be able to plug in your car.

You drive to where the most plug-in types are available, right?



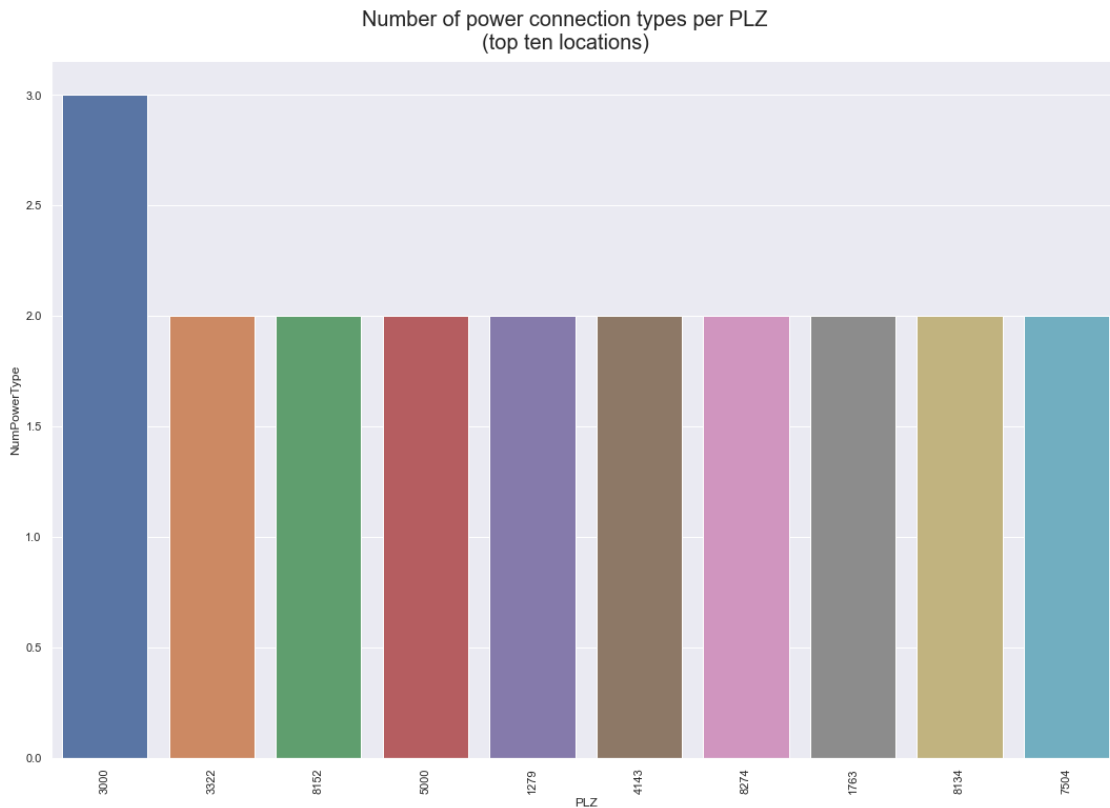
The best locations are: Adliswil, Interlaken, Bern, Olten St. Moritz, Schaffhausen and Affoltern am Albis: All those cities would have five different kind of plugs available for your car.

4.5 Best cities by Power, Amperage & Voltage

Last but not least, we are now going to analyze the power (and type), amperage and voltage of each location (again, with the city-wide postal code). The power type describes the connection type in terms of AC and DC power supply, the number of phases. The voltage describes the voltage on the supply station, the amperage the maximal amount of amperes and last but not least the power (basically the product of voltage and amperage).

Why is this important? The charging time of electrical cars are exactly from those parameters dependent.

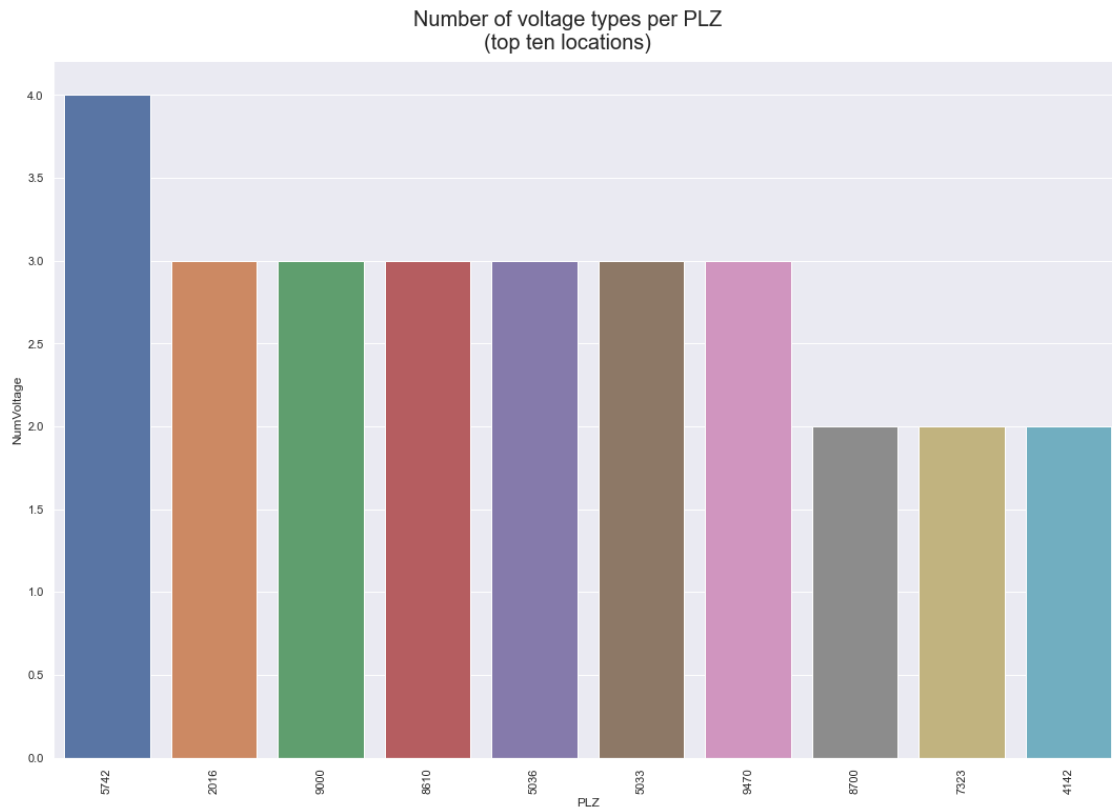
Let now start with the power connection type per city:



Again, as one of the top-scorers is the city of Bern, with 3 different available types. The following cities have all only two different kind of power connections available. In particular, the city of Bern has the following power types available:

AC_1_PHASE , AC_3_PHASE , DC

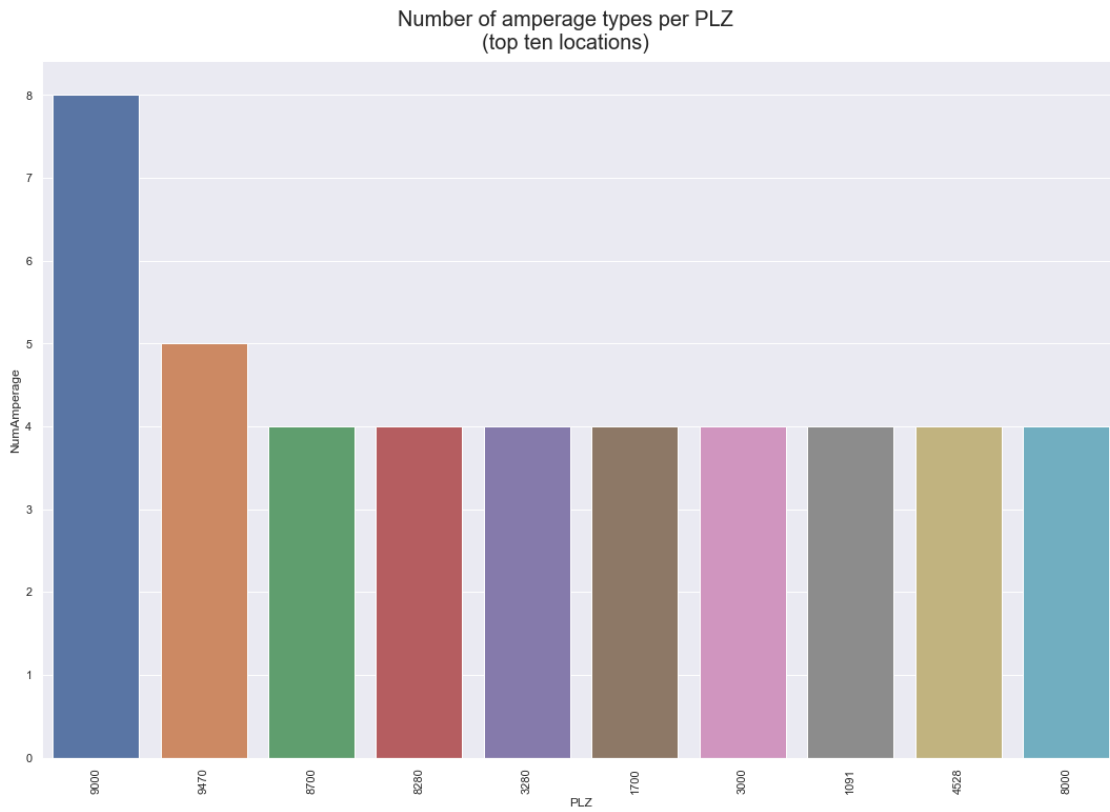
Proceeding to the next question, what is the number of available voltage per PLZ? Let's check:



Again, as one of the top-scorers is the city of Bern, but the **best city is this time Kölliken**. The following cities have all only 3 or 2 different kind of connections available. In particular, the city of Kölliken has the following voltage types available:

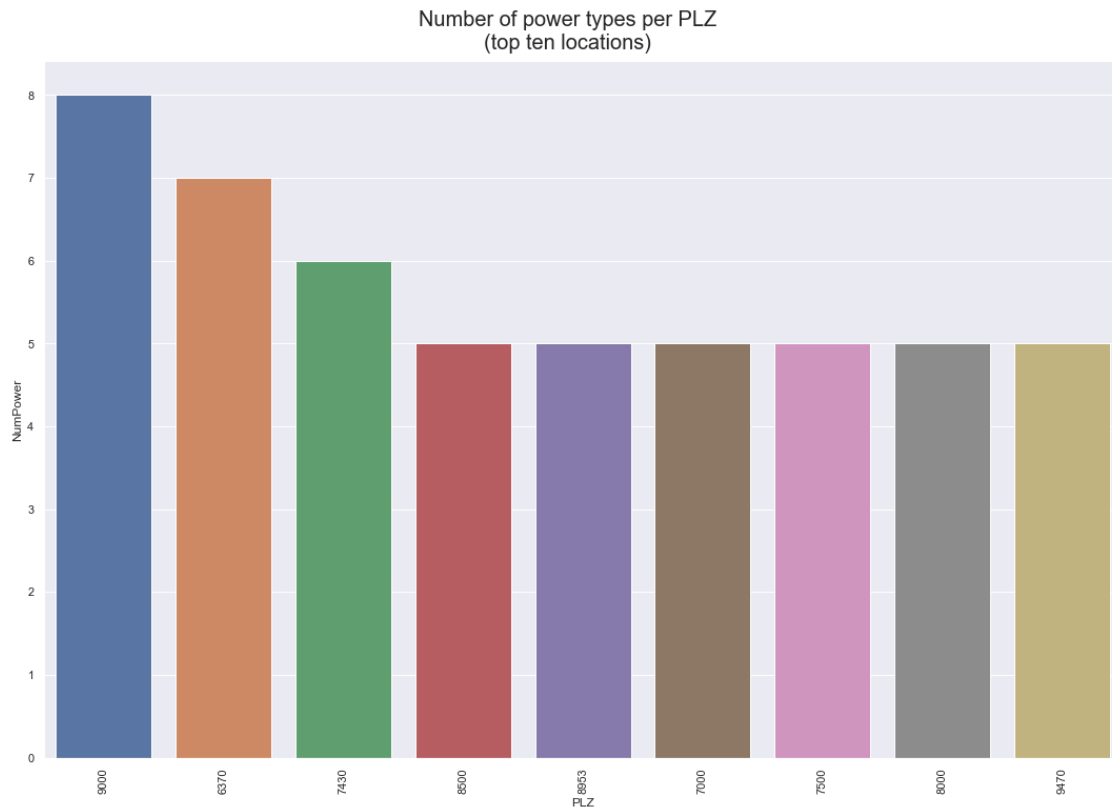
400 , 920 , 500 , 230

Proceeding to the next question, what is the number of available amperage per PLZ? Let's check:



The **best city is this time St. Gallen**. The following cities have all only 5 or 4 different kind of connections available. In particular, the city of St. Gallen has the following voltage types available: **31 , 15 , 63 , 218 , 16 , 0 , 32 , 60**

Proceeding to the last question, what is the number of available power per PLZ? Let's check:



The **best city is this time St. Gallen**. The following cities have all only 5 or 4 different kind of connections available. In particular, the city of St. Gallen has the following voltage types available: **22.0 , 22.0 , 120.0 , 50.0 , 11.0 , 22.08 , 50.0 , 24.0**

5 Conclusion

In regard of the two used APIs, I have learned new insights such as the most relevant operators in the field, the best cities for electrical mobility and as well which cantons have been building infrastructure in the past. This report answers the following questions:

- Best operator by number of stations
- Best cities by number of stations
- Best cantons number of stations
- Best cities by number of plug types
- Best cities by Power, Amperage & Voltage

6 Learnings

In this project, I have learned, in more depth, about MongoDB and its document based schema, querying syntax, importing data and aggregation pipelines. In the beginning I was very unsure how to handle MongoDB and especially the aggregation pipelines, but after this project I even started to enjoy creating pipelines. The application of lookup and unpacking of arrays were a bit difficult to start with, but after practicing it, it already started to feel kind of natural. Furthermore, the benefits of MongoDB are not limited to its schema, but also to its ability to scale horizontally, also known as “scale-out”, which is primarily achieved through sharding - something that is not possible with traditional relational database management systems (RDBMS).