Data Visualization of the current state of electric mobility Market

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Abstract

Currently there is a lack of data visualization in the electric mobility sector, in particular when it comes to Battery Electric vehicles. This project sets out to develop new data visualizations and present them in a marketable format for a client Hubject GmbH, who position themselves as thought leaders in the industry. The project targets an audience of experts in the field, in order to generate new leads for Hubject through a marketing campaign using the created data visualizations. To accomplish this goal several steps having been taken in this paper. The context analysis highlights the current state of literature and existing visualizations used in the field of Emobility as well as related fields. The methodology and execution section highlights how the data visualizations as well as a website to present these have been designed and developed. Lastly, the results section showcases the final designs, with the conclusion section discussing the results and factors that need to be considered further.

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1.0 Introduction

Global mobility, including shared mobility, is rising at a staggering pace. As globalization and population continue to grow, mobility will be one of the most crucial developing sectors. Taking a plane, train or car at a moment's notice has become standard and expected. It has become a necessity for our economy and society. According to the United Nations, the global transportation fleet is expected to double by 2050. With the majority of this happening in the developing nations, where three-quarters of all cars will be found by that time.

Yet, mobility is the largest contributor of greenhouse gas emissions globally, contributing to a staggering 20.45% of all global greenhouse gas emissions [1]. This is expected to increase to a third within the next decade alone. Road transportation accounts for approximately 72% of emissions within the transportation industry [2]. In order to achieve the global climate goals set out during the Paris Agreement [3], a combination of different solutions must be implemented including; increasing public transport; designing better cities and converting our transportation fleet to greener alternatives.

Thus, we need to have a strong development of electric mobility. Both for private and public transport, as well as implementation of shared mobility systems. The most prominent solution and campaign being EV30@30 by the Clean Energy Ministerial (CEM), setting the objective to reach a 30% sales share for electric vehicles (EVs) by 2030.

However, despite the ambitious goals of various campaigns, the current projections indicate that we are unlikely to meet them with the pace of growth that we have right now [4]. This paper will focus on answering questions about the current state of the electric mobility market and possible ways to visualize the data and how to present it. This research paper is split into several parts including, context analysis, methodology, execution and lastly the results and conclusion of the data visualizations created.

1.1 Objectives

The primary goal of the project is to generate leads for Hubject GmbH by creating data visualizations that showcase the current state of electric mobility. This will therefore put Hubject as a thought leader in the industry and help attract new clients. In addition to that, the goal of the project is to increase awareness of where Emobility is currently at with the general public who might have an interest in the field. This is done by providing a range of visualizations and key insights in a single and concise story flow. As decided by all the stakeholders involved within the company, the visualiations will be showcased on a landing page that will then be hosted directly at hubject.com. To measure the success, the landing page will be tracked using analytical tools. The page will also be promoted through social channels of the company. Data will then be analyzed regarding reach and engagement, time spent on the website and shares across social networks.

1.2 Target Audience

The primary target audience consists of companies and experts in the field of Emobility, such as OEMs or car manufacturers, charging network providers, government agencies as well as

independent people working in the field. In addition to the primary target audience the website needs to still be appealing and understandable by the general public.

1.3 Requirements

Several requirements have been established by the client to ensure the success of the project and its use in the future including:

- The design must be marketable and visually appealing to the target audience as well as the general public.
- The data visualizations must educate the audience about the myths of Emobility
- The project needs to combine both market and infrastructure data together in a single format of presentation

2.0 Context Analysis

2.1 Motivation

The context analysis is done by performing a state of the art research into the current state of Emobility as well as existing visualizations being used within the field of Emobility or those related to the types of visualizations to be created. This will help determine what visualizations can be created for Hubject to educate experts as well as the general public on the topic, as well as what methods and technologies can be used and implemented taking into account the feasibility and scope of the project. In the end there should be a thorough understanding of what are the primary facts in the Emobility market, and what visualizations can potentially be derived. The research is split into two parts; literature review and existing data visualization review. Literature review focuses on analysis of existing scientific articles and privately funded papers published in the domain. Existing data visualization focuses on analysis of visualizations in the domain of Emobility as well as related additional related domains.

2.3 Research Questions

How can we effectively design and present data visualizations of the current state of Emobility market?

To answer the primary research question, the following sub questions will be used:

Research and literature

- How willing are consumers to switch to EVs?
- How ready are car manufacturers to produce EVs?
- What advancements in technology have taken place?
- How successful has EV deployment been?
- What is the current status of mass market adoption?

Data visualization

- What visualizations exist in the emobility domain?
- What visualizations exist in related domains?
- How informative are the existing visualizations?
- Are the visualizations convincing and easy to understand?

2.4 State of the Art

Consumer perception and outlook on EVs

How willing are consumers to switch to EVs?

At present, range and cost are the two main influences on consumers' willingness to choose EVs over combustion engine vehicles (CEVs). Globally 36 to 51 percent of consumers report a consideration for purchasing an EV. However we are observing only a small increase in actual purchases, the percentage of car buyers choosing an EV (BEV or PHEV) remains in the single digits outside Norway as reported by McKinsey & Company [5]. In choosing to buy an EV, surprisingly, Range Anxiety is not a negative purchasing factor [6], instead, financial incentives and the charging network play a more crucial role in consumers willing to do the switch [7]. According to a survey by autolist.com, EVs being too expensive is stated as the second most common reason that consumers are not willing to switch [8]. However, this is a perception that is outdated, as found according to the International Council for Clean Transportation (ICCT), electric cars are in fact already cheaper to own and run than diesel alternatives in many European countries [9]. While a large number of consumers consider EV as an option, only a few go with it as the selected one, largely due to the sticking perceptions.

How ready are car manufacturers to produce competitively priced EVs?

In order to increase consumers' willingness to switch to EVs, remaining negative perceptions of EV pricing and range need to be addressed. Consumers still have many negative perceptions of EVs, however, those are largely psychological and not based on real-world needs. The primary focus is the perception of compatibility with their daily life [7], however, most consumers have ignorance of their actual daily range requirements. Today's average Electric car range meets 95% of the average person's needs in a year. The only concern is the remaining 5% of annual trips, for which, charging networks come into play [10]. There are several critical questions that are still being asked today by consumers, including "will the battery capacity provide the driving range needed? and "How will I charge my EV?" [5]. despite the fact that range is not an issue in real-world needs. In addition, confusingly, range anxiety has been found to both increase and decrease after individual experiences driving an EV.

EV Mass Market Adoption

What advancements in technology have taken place?

Battery technology advancements and powertrain supply chain improvements are delivering substantial cost cuts to the EV market without a need for additional fiscal policies. EVs in the A segment (microcars or city cars) and B segment (small sedan or hatchback) in Europe have already achieved a lower Total Cost of Ownership (TCO) over three years than ICE vehicles The decreasing battery prices make battery EVs the least expensive power train option in terms of TCO in various segments and markets already. For instance, the average price (before government subsidies) of the five least expensive EVs in the Chinese market has already decreased by 16 percent over the last three years to approximately 11,500 euros. Simultaneously, while battery costs have been going down, the range has been increasing [5]. Understanding of resource depletion is also driving the shift towards e-mobility. short-range BEVs are attractive even without climate policy support in the case of more pessimistic resource assumptions. These results suggest that the promotion of HEVs, natural gas, and short-range BEVs may represent a means to manage resource depletion and some of the uncertainty regarding ultimate resource availability [6].

How successful has EV deployment been?

The deployment of EVs has been picking up a rapid pace, however, it still has a long way to go before meeting the policy goals of EV30@30 and the Paris Agreement. In 2018 the global stock of electric cars has passed 5 million, an increase of 65 percent from the previous year [4]. A Relatively small but significant milestone. However, it is important to note that 45 percent of these cars sold were in China, therefore skewing the global growth statistic. Meanwhile Europe and the US account 24 percent and 22 percent of the global fleet respectively. During 2020-2025, a release of 400 new EV models has already been announced by OEMs globally with more to come. In addition research shows that EV sales are approaching 2.2 million

vehicles worldwide and a market penetration of 2.5 percent in 2019 [5]. However in order to propel these sales, a lot of changes still need to occur in EV mass market adoption.

What is the current status of EV mass market adoption?

EV mass market adoption can only occur if policy keeps its pace and stricter measures are enacted. Without stringer policies surrounding climate and electric mobility in place, the EV increase may be inefficient on its own to push towards the electric mobility movement [7]. Some policies such as EV30@30 are already showing a strong influence on the governing bodies involved [1]. However EV30@30 is an optional policy with nations choosing to participate. Therefore many argue that it is more of a show than a mandatory action that will take place. In addition to policy from governing bodies, OEMs themselves need to promote EVs aggressively. In findings of a mystery shopper study, highlight that OEMs and their dealerships have severe pitfalls in EV sales promotion and lose a great opportunity to promote and convince customers to purchase EVs [5]. This may be in large part due to the OEMs wanting to continue promotion of combustion engine cars due to their higher profit margin [11]. A superior sales experience is crucial for customers to not only consider EV purchases but go through with that decision.

Conclusion

In the early 20th century we saw the movement from horse carriages to cars. The similar situation is currently happening, however this time not the mode of transport is being replaced, but the engine that drives it. E-mobility is still in its early stages. However there are clear indicators present that it will foresee exponential growth. Yet this growth does not mean that the industry as a whole will become the new standard of mobility as a whole. There are still many challenges and need to be addressed and overcome before that can take place. The EV disruption will be the strongest in developed regions where policy plays a major rule. This includes major cities, and also major global political regions such as the EU. OEMs have a huge challenge ahead in order to please the consumers, which are being incentivized by governments all around the world to choose EV already. The effective model of Norway will

undoubtedly spread across Europe in the next ten years. However major markets such as Germany and France, who house their own large OEMs, will need to be prepared for this market shift in order to not lose to smaller and quicker start ups in the market. Fortunately, we can see ambitious plans from European car manufacturers to design, develop and launch hundreds of EVs. Future key technologies, related to battery technology, power terrain and other mobiliti technologies such as automated vehicles will help steer the consumers further into the direction of e-mobility.

It should be highlighted that the vast majority of the studies available on the subject of e-mobility comes from private research firms. This is not to state that they are not valid sources, however we do need to take with caution where their backing comes from and what biases may be present.

Existing Data Visualization Review

Introduction

In order to understand the approaches for visualizing the data, a research on existing visualizations in the field of electric mobility needed to be conducted. In addition, I have focused on research visualizations in related fields including, Urban mobility, Climate change, and Market demand. Electric mobility alone as a field does not yet have a lot of visualizations to go by, and the ones that do exist, are limited. Therefore I have broadened the scope to gather more input to go by. Research papers usually only contain limited and basic data visualizations, it has been decided to also include other, non-scientific sources such as news journals and web platforms and websites.

Summary table

Number	Title	Type	Field	Source
1	Why data visualization is critical to driving sustainable change	Alluvial Diagram	Climate Change	https://www.metabolic.nl/news/why-data-visualization-is-critical-to-driving-sustainable-change/
2	The road ahead for e-mobility	Various, Primarily Matrix Diagrams	Electric Mobility	https://www.mckinsey.com/~/media/mckinsey/industries/automotive%20and%20assembly/our%20insights/the%20road%20ahead%20for%20e%20mobility/the-road-ahead-for-e-mobility.ashx
3	Visualizing the Rise of electric vehicles	Bubble chart (nested), Infographic	Electric Mobility	https://www.visualcapitalist.com/rise-electric-vehicle/
4	Who drives electric cars?	Infographic, Charticle	Electric Mobility	https://www.wsj.com/articles/who-drives-electric-cars-1379884645?tesla=y#project=ECARSCHRTPRNT&articleTabs=interactive
5	International electric vehicle consumer survey	Matrix, Pictorial fraction chart	Electric Mobility	https://www.alixpartners.de/veroeffentlichungen/insights/international-electric-vehicle-consumer-survey/
6	Visualizing Cities, Malleshwaram Memoirs	Combination: Flow Map, Proportional Area chart, Concept Map	Urban Mobility	https://cityvis.io/project.php?id=115
7	Density Design, the point of no return	Concept map, Sorted stream graph, Fan, Alluvial Diagram, Hive Plot	Climate Change	https://densitydesign.github.io/teaching-dd12/es01/group01/
8	Using machine learning to visualize customer preference	Word cloud in combination with Bubble chart	Market demand	https://hackernoon.com/using-machine-learning-to-visualize-customer-preferences-6a007cfb9b97

9	Visualizing rapidly changing global diet	Bubble chart, Radia histogram, Bar chart, Line chart	Market demand, agriculture	https://www.visualcapitalist.com/visualizing-rapidly-changing-global-diet/
10	COVID-19 impact on global flight capacity	Matrix Diagram	Market demand, Air mobility	https://www.visualcapitalist.com/global-flight-capacity-coronavirus/

Table 1 Summary of existing data visualizations

Emobility Visualizations

The most common visualization for electric mobility specific information are infographics. In the figure below, Inside EVs has focused on a simple yet elegant infographic that illustrates the current, as well as the predicted market change in terms of EV sales. It also highlights companies and car brands regarding their future plans for further developing the industry.

While the infographic is interesting, and conveys information fairly easy, there is not much story being told within it. Is the information that I am seeing good? Should I be impressed by this growth? There is no relation or understanding as to what is considered to be a good figure, leaving the viewer clueless. In addition, infographics gather a lot of data within a small space. While this is useful when presenting them on a printed poster, in our digital age infographics do not do well.

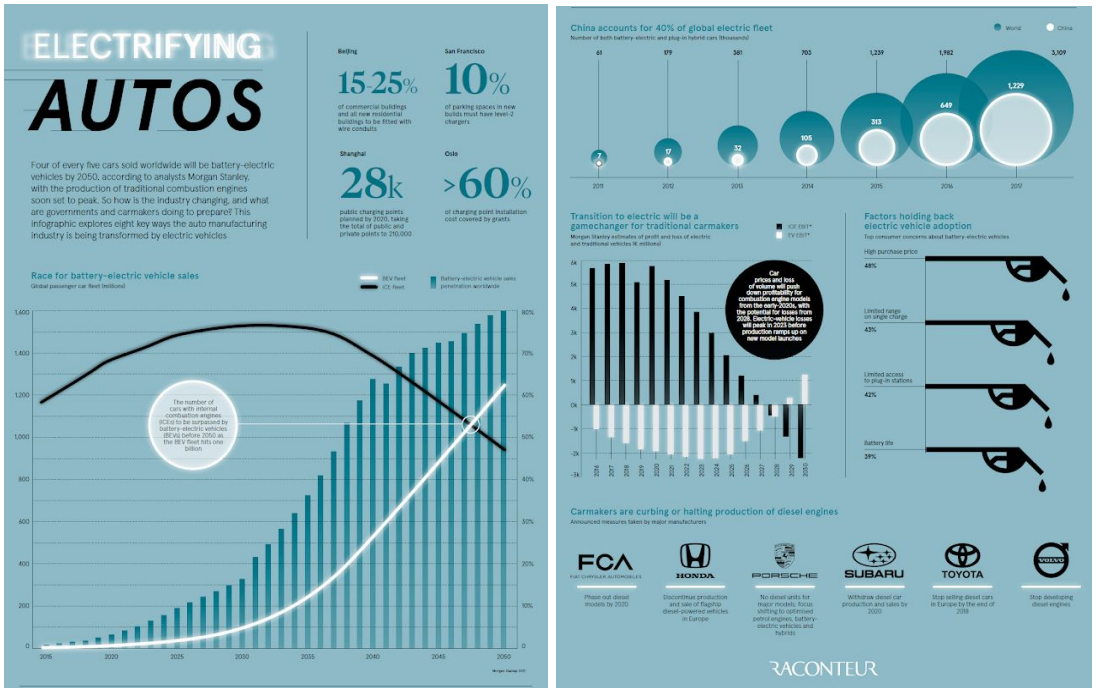

Figure 1: Electrifying Autos by insideEVs

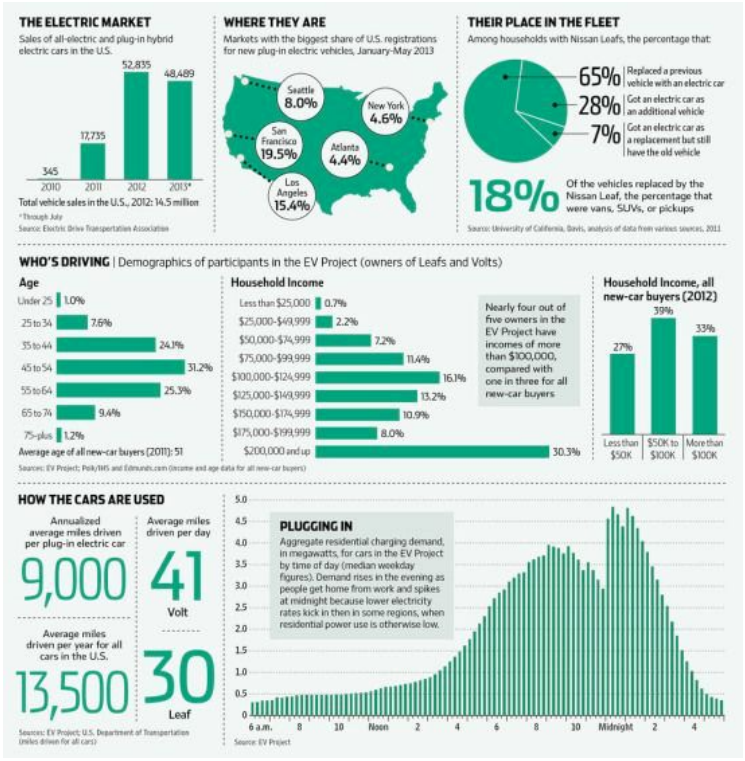

Figure 2: Wall Street Journal Who Drives electric cars?

Other visualizations that focus on consumers in this market are largely based on reports. Leading to informative, however rather boring visualizations compared to those of other sectors. For example the visualization in the figure below from the McKinsey Report on Consumer preferences.

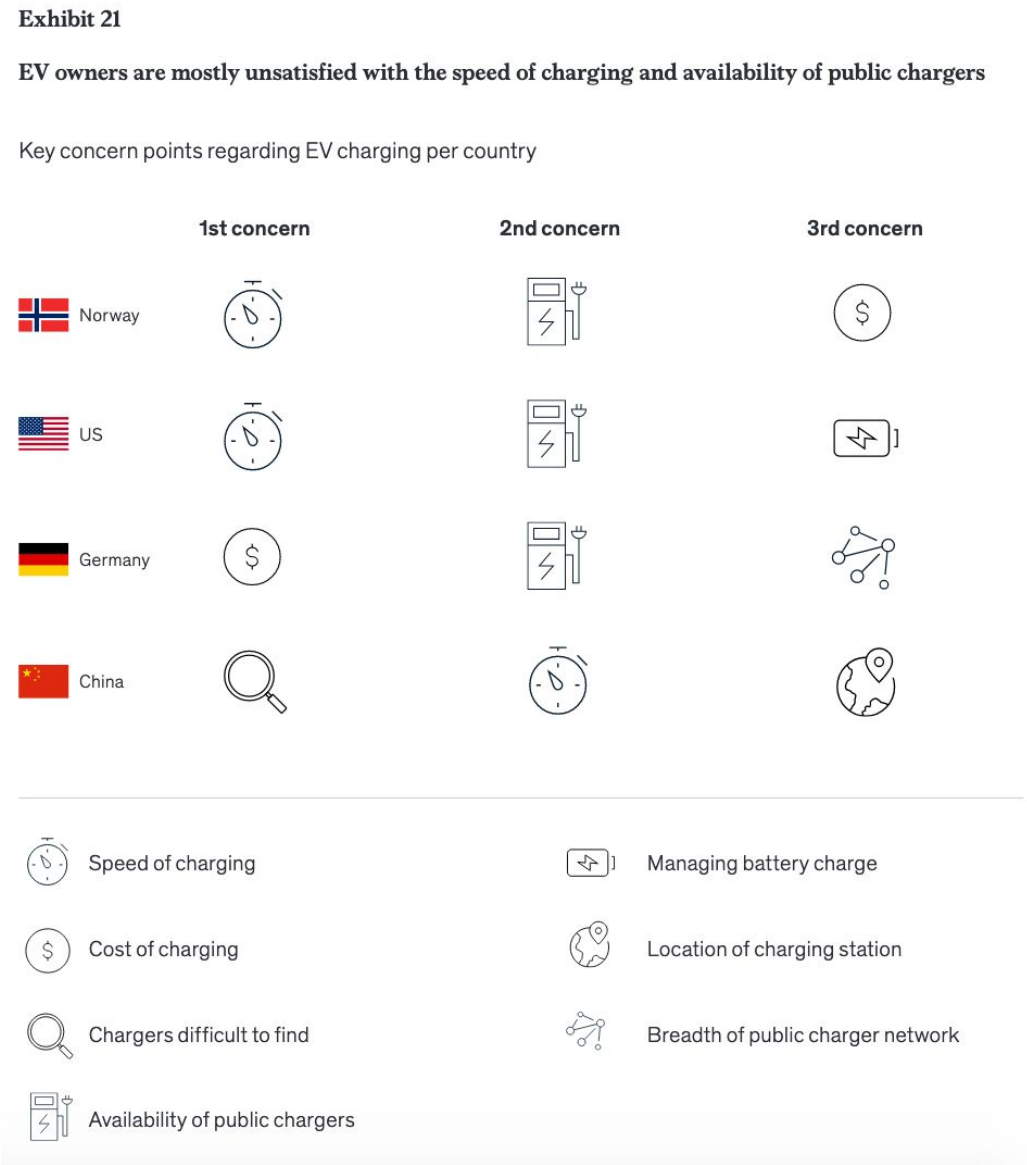

Figure 3: McKinsey Road ahead for e-mobility report 2019

Urban mobility visualizations

A lot of visualizations in the area of urban mobility focus on storytelling. This approach is interesting as it creates a foundation of a storyline rather than just presenting numbers. In the figure below of Visualization Cities Malleshwaram by Google India, the work is an experiment to entice and invite the reader to walk about the streets of Malleshwaram, a hundred year old neighbourhood characteristic of the city of Bangalore. It employs the notion of rhythms (defined by Lefebvre and others) exploring techniques for creating narratives that braid different rhythms in urban spaces.

Traditional map visualizations tend to be very informative. However with this one, they invite you to try and explore the location from a more cultural perspective and to understand how the city lives and breathes. Only criticism is that the instructions on how to read the map are fairly complicated. And even with them, I find a lot of elements difficult to understand.

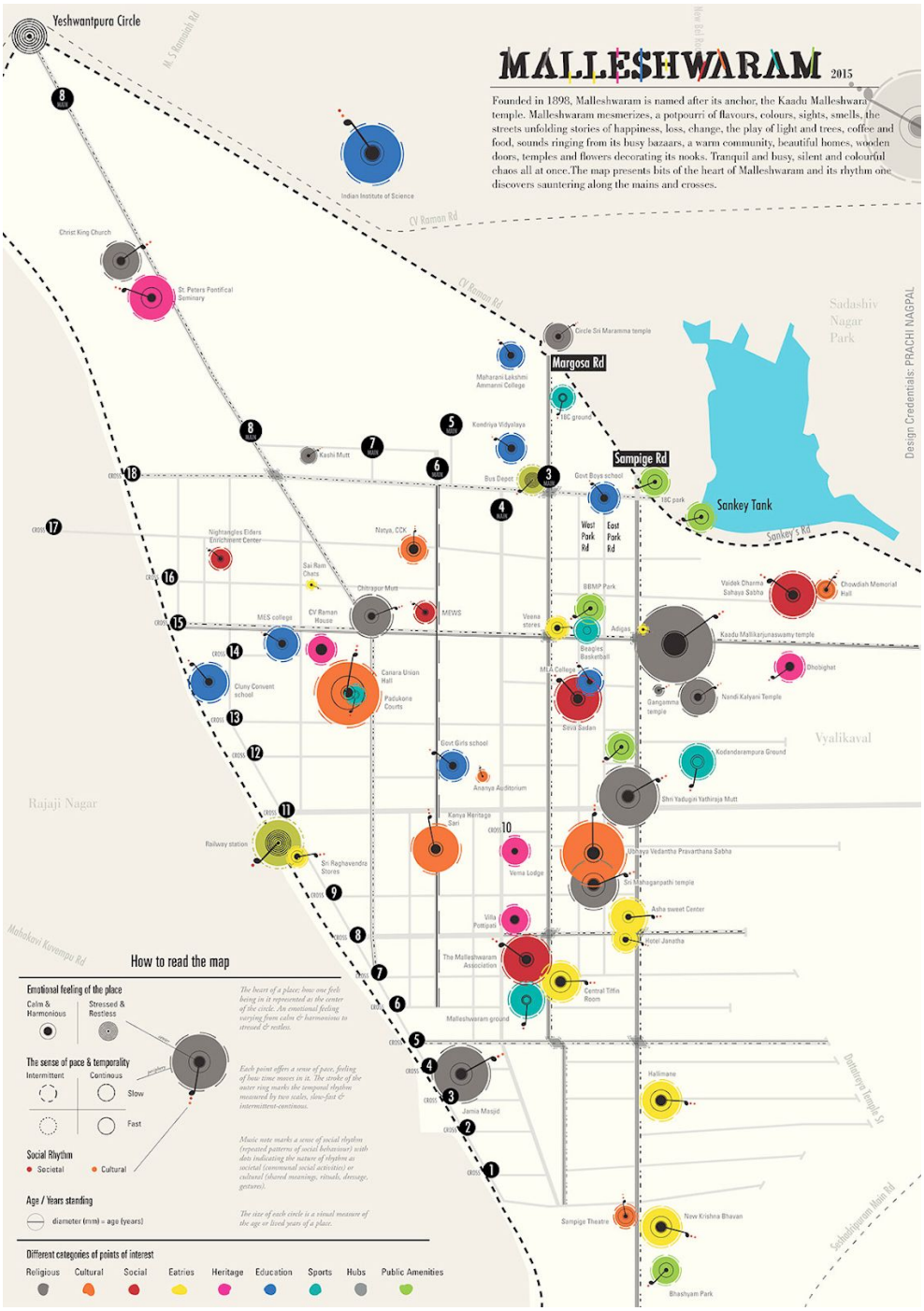

Figure 4: Visualizing Cities, Malleshwaram by Google India

Other visualizations in urban mobility largely focus on spatial information. SIDL-WeAreHereNow project by Design Lab Center (not from the UT) visualized location data in a stunning way. The colors are bright and well have a good contrast on the dark themed background. Using the simple key in the footer, we can easily understand the measurements and the clusters

presented. While it is interesting, it is not useful for my methodology as within electric mobility, such a method is good to visualize electric charging networks available.

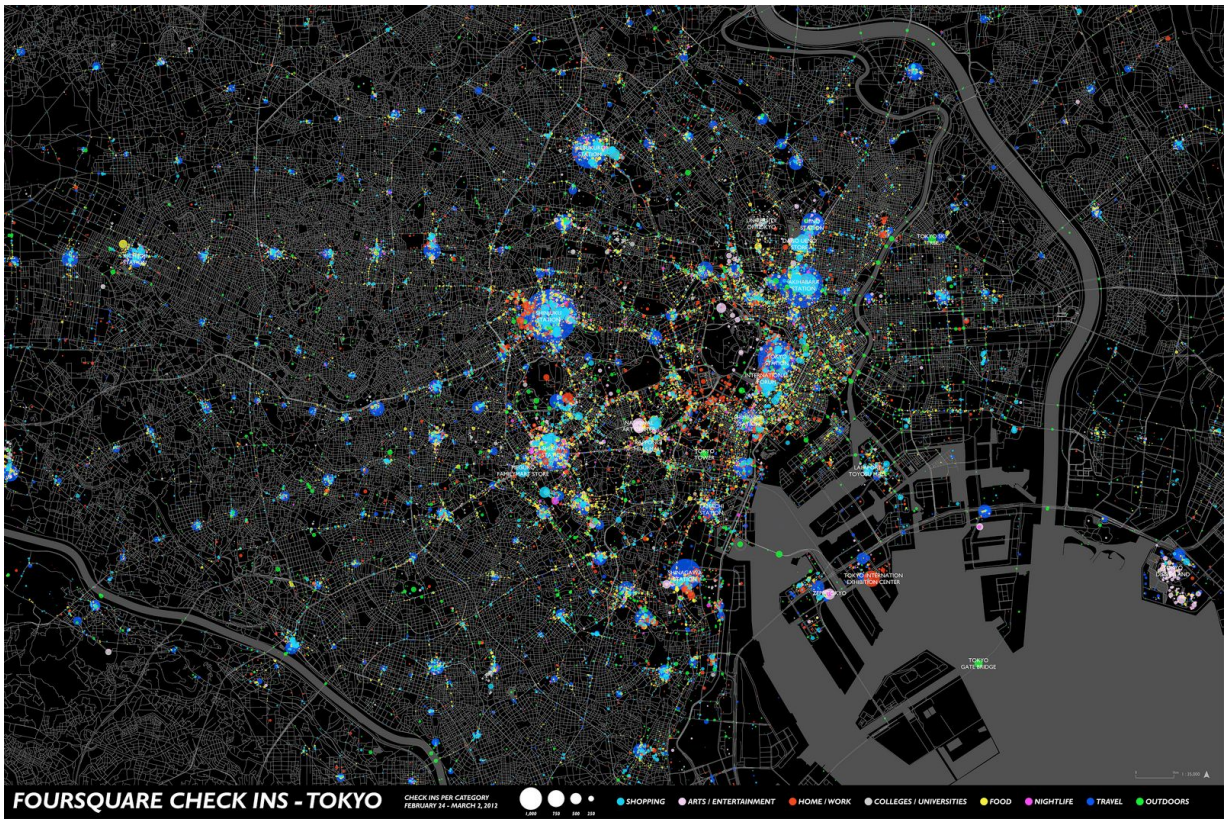

Figure 5: Spatial information Design Lab Center

Climate Change Visualizations

Climate change is possibly the most interesting topic in data visualization right now. From my research experience there is a vast amount of visualizations available on this topic. I have chosen to research climate change as a lot of the methodology techniques used, can be implemented within electric mobility visualizations as well. Metabolic Industries from the figure below presents various visualizations from several sources. Including Urgenta which is an organization based in the Netherlands. I like the overall styling as it clearly showcases links between for example countries and energy sources. It is often difficult to comprehend energy numbers, however when put into perspective with colors and weight, things are much easier for the general public to understand.

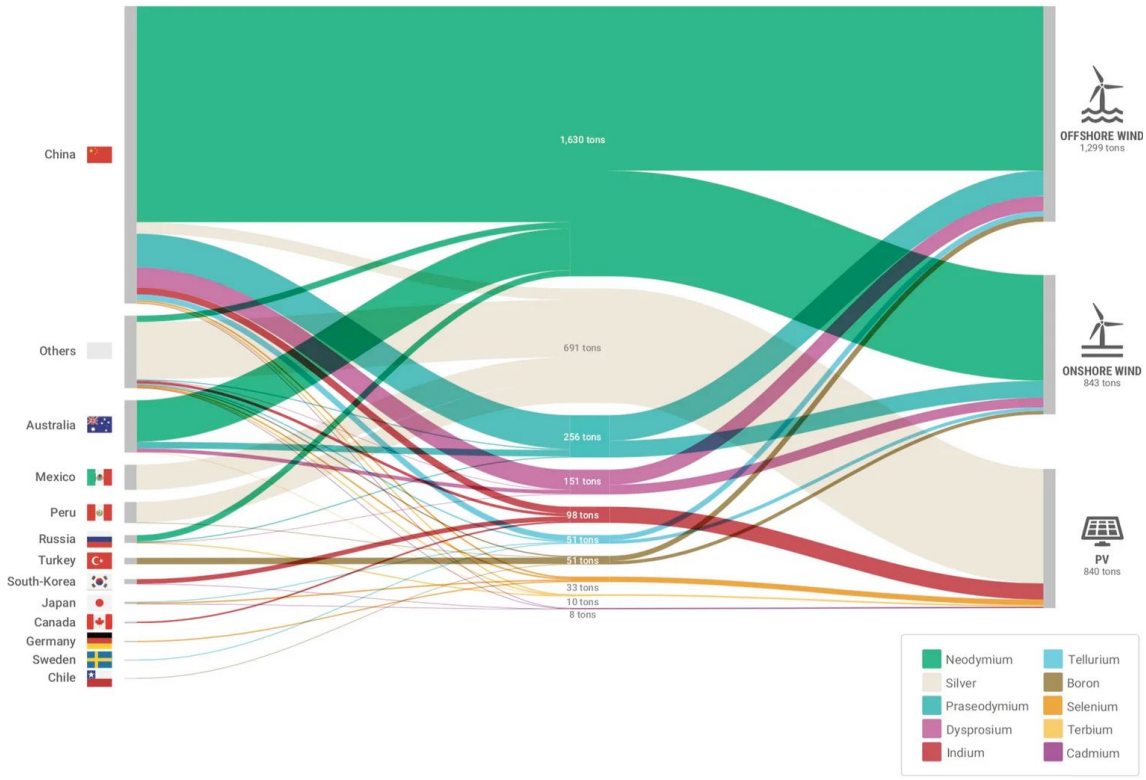

Figure 6: Why data visualization is critical to driving sustainable change

As a whole climate change visualizations showcase a vast amount of methods. In the figure below, my favorite combination from the research is presented. An entire landing page developed to showcase data on climate change titled “Point of no return”. I found the approach of using web design to tell a story most suitable when talking about such a complex topic as climate change. This is a good reflection of electric mobility complexity as well. This approach in addition helps merge various visualizations together, creating coherence.

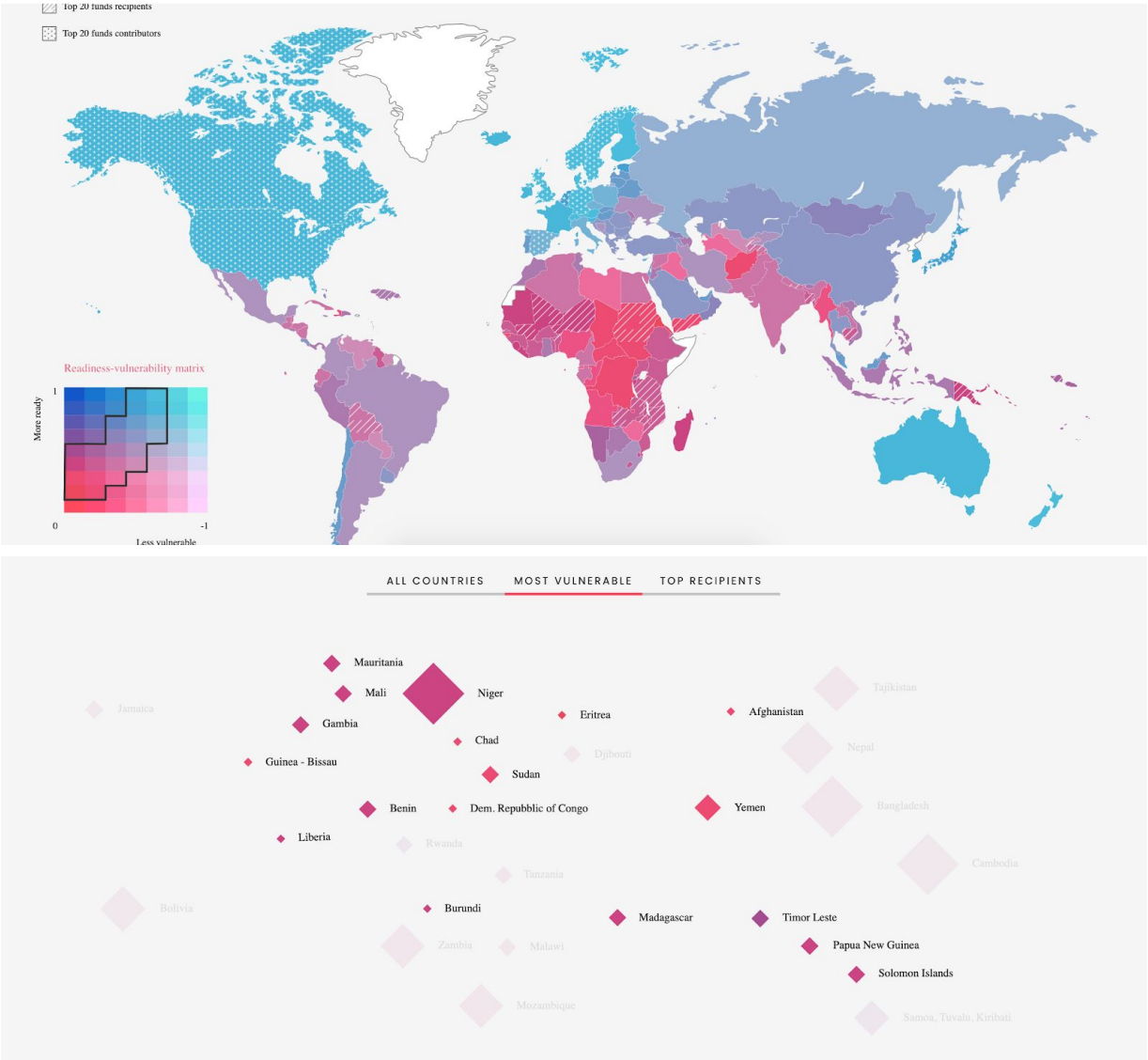

Figure 7: Density Design, the point of no return

Market Demand Visualizations

Since my research focus is on consumers and the market within the electric mobility industry, I have set out to find general market demand visualizations. The methods used are some of the most appropriate for my topics, especially when it comes to specifics such as what do consumers prefer. As market demand on its own is a big topic, the visualizations within this range from infographics, to interactive detailed graphs.

The infographic below, which comes from Raconteur, makes it clear that the challenge of feeding the global population is actually magnitudes greater. The global diet is changing rapidly in both size and composition, especially in developing countries in Africa and Asia. While the infographic presents a lot of different data, it is overall easy to understand. It has a very good and solid flow. I like the incorporation of factual figures with the addition of consumer demand in terms of diet. Unlike infographics related to electric mobility, which I have found to lack in context, visualization about demand for food does not need an extensive story behind it, since food is a very close and easy to understand topic for people of any background.

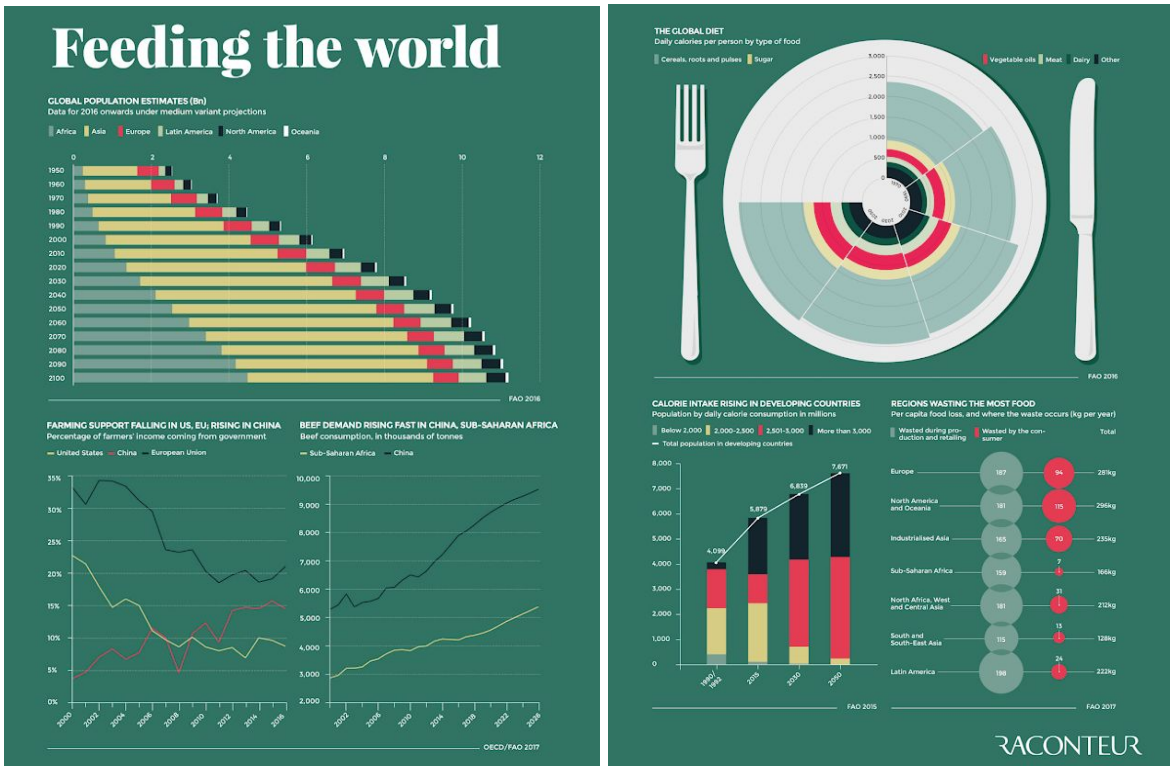

Figure 8: Visualization Rapidly changing global diet, Raconteur,

Another visualization on market demand that really interested me in the figure below, is very relevant at this time. It's not an exaggeration to say that the COVID-19 pandemic has thrown the world into a tailspin. As the number of new cases continues to surge in parts of the world, numbers are beginning to decline in others as public health officials and governments tirelessly

work to slow the contagion and reach of the virus. In this visualization I like the focus on a single industry. This is a good example of showing change in the industry based on a current situation.

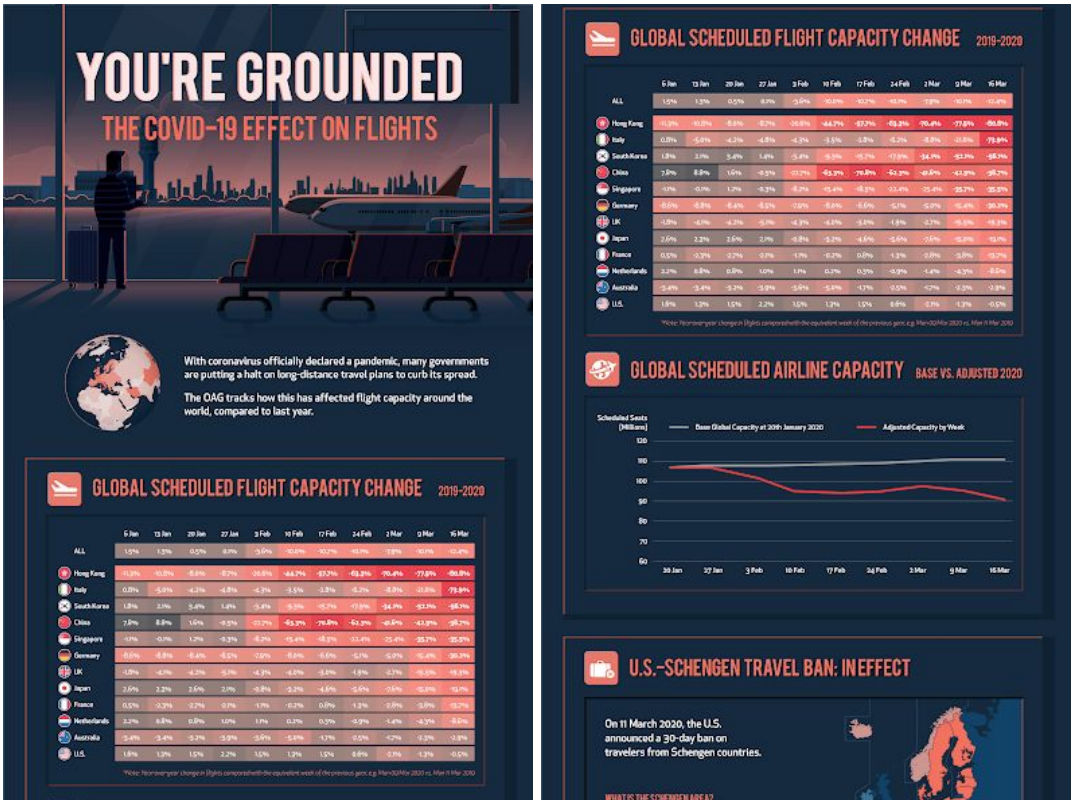

Figure 9: You're grounded, the covid-19 flight capacity visualization

Conclusion

Due to the fact that electric mobility is still on the rise, being a new topic within research, there is not a lot of data available yet. We are just in the beginning of the e-mobility era, therefore the majority of the available data, focuses on predictions, rather than the current market. In addition, research papers largely focus on visualizing the market, including sales as well as technical areas such as battery technology and the drivetrain. Consumer behaviour data is still largely unavailable. Majority of the useful data that is available in that field, comes from private research firms such as Deloitte. This is largely due to the fact that a lot of resources are needed to gather data in such a fragmented field, compared to gathering data about general car drivers.

3.0 Approach and Methodology

Building upon the researched and related work, this chapter provides a detailed description of the methodology adopted to develop the data visualizations and website within this thesis. The chapter outlines four sections, which together present the tools used, software used, and methods such as the design thinking methodology that has been employed and implemented for each stage of the process: (1) Data Research; (2) Data Visualization design; (3) Web Design & Development; and (4) User Study.

3.1 Data Research

All the data used is secondary. The data has been collected through research into various papers published in the topic of Emobility with a focus on the market. There is unfortunately a lack of available data from institutions, with the majority of data coming from privately owned research companies such as KPMG, Deloitte and more. In addition, there is a lack of raw data available on the topics, as the companies primarily sell this data for large amounts to companies for further market analysis. Despite that I was able to gather enough data from within the papers through tables, summaries and what is available to use for my visualizations. The data gathered resulted in a breakdown of available data sets for several topics including:

- Customer EV awareness and purchase actualization
- Customer first mover EV consideration 17 markets
- Perceived EV benefits and concerns
- Consumer car preference across 17 markets
- OEM (car manufacturer) EV pipeline for 2019-2025
- EV deployment to date
- EV growth outlook

3.1.1 Data Sources Summary

Number	Title	Information	Source
1	Customer EV awareness and purchase actualization	Showcasing that the consideration in EV purchases largely increases across the market in the last 3 years, however the actual % of purchases is increasing at a much slower pace	https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/The%20road%20ahead%20for%20e%20mobility/The-road-ahead-for-e-mobility-vF.ashx
2	Customer first mover EV consideration 17 markets	This dataset highlight how likely a market is to switch to an EV	https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx_us_auto_DTTGlobalAutoSurvey_ElectricVehicles_100411.pdf
3	Perceived EV benefits and concerns	Over 3 years consumers have become largely not concerned regarding where they are able to obtain the vehicle in terms of sale, but rather much larger concern is charging, battery and network	https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/The%20road%20ahead%20for%20e%20mobility/The-road-ahead-for-e-mobility-vF.ashx
4	Consumer car preference across 17 markets	This dataset highlighted what cars consumers prefer, medium, small or large as well as further breakdown into SUV etc.	https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx_us_auto_DTTGlobalAutoSurvey_ElectricVehicles_100411.pdf
5	OEM (car manufacturer) EV pipeline for 2019-2025	that OEMs are putting a strong focus on releasing more EVs. In addition to tap into new markets such as large sized EVs	https://www.mckinsey.com/~/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/The%20road%20ahead%20for%20e%20mobility/The-road-ahead-for-e-mobility-vF.ashx

6	EV deployment to date	Highlights the amount of EVs currently deployed	https://www.iea.org/data-and-statistics/charts/electric-car-deployment-in-selected-countries-2013-2018
7	EV growth outlook	Highlight scenarios for possible EV growth	https://www.iea.org/data-and-statistics/charts/global-ev-deployment-in-the-new-policies-scenario-2017-2030

Table 2: Visualizing Cities, Malleshwaram by Google India

3.2 Data Visualization Design

The objectives established for this thesis study demand a structured methodology for developing well thought out data visualizations. As a matter of fact, there exists a well-defined framework, namely the Design Thinking Methodology, for providing a solution-based approach, it is extremely useful for tackling complex problems that have a lot of unknown factors. Proposed by the Hasso-Plattner Institute of Design at Stanford (d.school), it is used widely across various areas of design within many institutions and private companies. Several methodologies have since been derived from it, such as design sprints. Hence, this thesis study will adopt the stated framework and this chapter describes in brief the theory of the said methodology and how it is used within the data visualization design process.

Design thinking is defined as a non-linear, iterative process that teams use to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. In the case of data visualizations, data is placed in the place of the user for certain stages. Involving five phases—Empathize, Define, Ideate, Prototype and Test as seen in the figure 10 below.

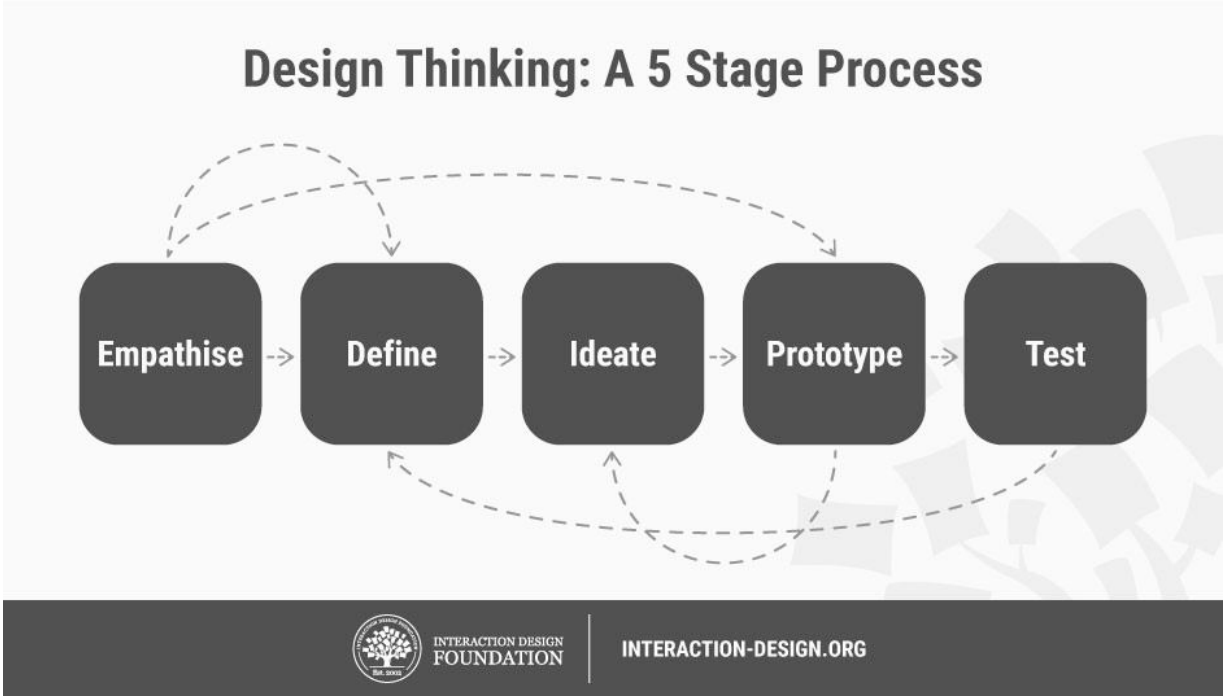

Figure 10: Design Thinking Methodology Approach

Empathize

During the empathize stage, the goal is to gain an empathetic understanding of the problem you're trying to solve, typically through user research. Empathy is crucial to a human-centered design process such as design thinking because it allows you to set aside your own assumptions about the world and gain real insight into users and their needs. In other words this stage focuses on learning about the problem that is being solved.

Developing well designed visualizations requires a good knowledge of the visualization literature, including visual encoding, interaction techniques, design guidelines and evaluation methods. Solid knowledge of a background is good for an effective design thinking approach and can be useful in every stage. It can help to choose good solutions over the bad ones in a design stage and can accelerate the process of finding the right visualization toolkits and methods in the implementation stage.

Define

During the Define stage, I put together the information I have gathered during the Empathise stage. This is where I analyse the observations and synthesise them in order to define the core problems within embolity right now.

The define stage helps gather great ideas to establish functions, features and design elements such as visualizations to be used which allows us to solve the problem.

Ideate

During the third stage of the Design Thinking process, I focus on generating ideas for visualizing each of the data sets and how to present the story. There are hundreds of Ideation techniques such as Brainstorm, Brainwrite, and Worst Possible Idea. Brainstorm and Worst Possible Idea sessions are typically used to stimulate free thinking and to expand the problem space. For the data visualization approach, brainstorming and execution through trial and error of various visualization methods is the most appropriate in this use case.

Prototype

This is an experimental phase. The aim is to identify the best possible solution for each visualization topic. This is usually quick, and minimum developed prototypes, such as sketches and wireframes which are inexpensive and easy to produce and test. The prototyping phase allows for testing ideas rapidly, to fail quickly and move on to the next prototype.

Testing

The prototypes can then be tested within the design thinking methodology. Although this is the final phase, design thinking is iterative: the results are used to make adjustments to the previously developed visualizations until a final prototype is tested. So, I can return to previous

stages to make further iterations, alterations and refinements – to find or rule out alternative visualization methods.

Non-linear nature of Design Thinking

I may have outlined a direct and linear Design Thinking process in which one stage seemingly leads to the next with a logical conclusion at user testing. However, it is important to highlight that in practice, the process is carried out in a more flexible and non-linear fashion such as illustrated in figure 10 above. In addition, this process can be continuously used even after the execution and implementation stages have been completed, to continuously learn from feedback and make adjustments to test the visualizations further.

3.3 Web Design and development

An important part of the data visualization requirements in marketability as mentioned in section 1.2. In order to make data visualizations maketable, they need to be delivered using a modern tool, where the users are able to interact, understand and share the visualizations in an easy to use format. Based on these requirements, it has been agreed with the client as well as Corbinian Buchberger working in parallel on infrastructure data visualizations, to use a website landing page as a method of presentation.

Other methods considered were creating infographics, which while being interesting, are much harder to market and advertise using social campaigns. In addition, tools such as educational animated videos were also considered to present the data visualizations, but are ultimately not as fitting as a website landing page.

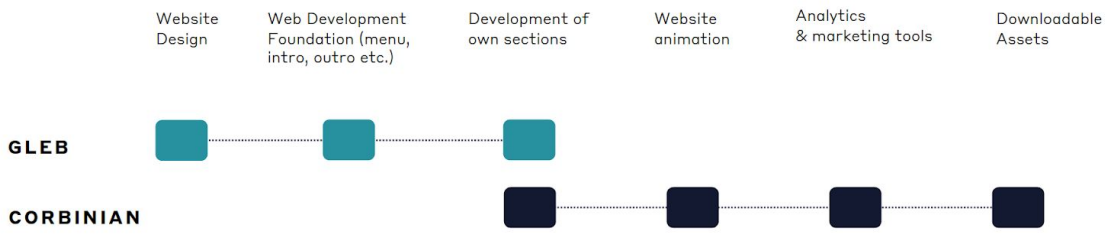

Figure 11: work split of the website landing page

The roles for the development of the website have been split up as seen in the figure 11 above. My responsibilities include the website design, foundation development, including menu, introduction section and conclusion section, as well as the overall interactivity and mobile responsiveness. Corbinian Buchberger has taken on the responsibilities of developing his own sections, provided a wireframe from me, as well as the website animations, analytics and marketing tools and downloadable assets which can be used for sharing on social media channels.

3.4 User Testing

The success of the data visualizations and the website largely depend on several factors, such as the design and development, debugging and ensuring that no errors occur, understanding of the problem being solved, and of course implementation of evaluation stages that should be conducted with users. There it is crucial to conduct an interface and design evaluation study for both the data visualizations as well as the website itself to test the usability and overall understanding.

Two categories of user testing are to be introduced. General user testing and expert user testing. While the target audience of the project consists of professionals in the field of Emobility, it is important to still perform a general user test to ensure that there is an overall understanding of the data visualizations and that usability remains high. Therefore two separate user tests are to be conducted for the two groups.

To guarantee a successful understanding of the data visualizations, user evaluation has to be carried out at multiple stages in the design and development process. This of course, has a high dependency on many resources, such as time and user availability. Nonetheless it is crucial to conduct at least one user evaluation.

4.0 Execution

This chapter contains how the methodology described was executed and implemented to design the data visualizations with a website landing page. The first section introduces the final data visualization designs, the second section describes how the web design and development has been executed in collaboration with another student thesis on the same topic using co-design. Finally, the last section introduces the user testing study conducted and the results.

4.1 Data Visualizations Conceptualization

As outlined in section 3.2, the Design Thinking methodology has been implemented throughout the process, starting with the data research and onwardards to the visualization design with the Define, Ideate and prototype sections.

In order to properly define the direction of the visualizations, the data gathered has been converted into possible themes and topics. This resulted in two distinct separations: market analysis, that includes car manufacturers and sales; as well as consumer behaviour, which includes interest, preference and perceptions. The defined results lead to a total of four visualization topics:

- Consumer Purchase Interest
- Consumer Perception
- Car Preference & Willingness to Switch
- Car manufacturers pipeline for the next five years in comparison to the past

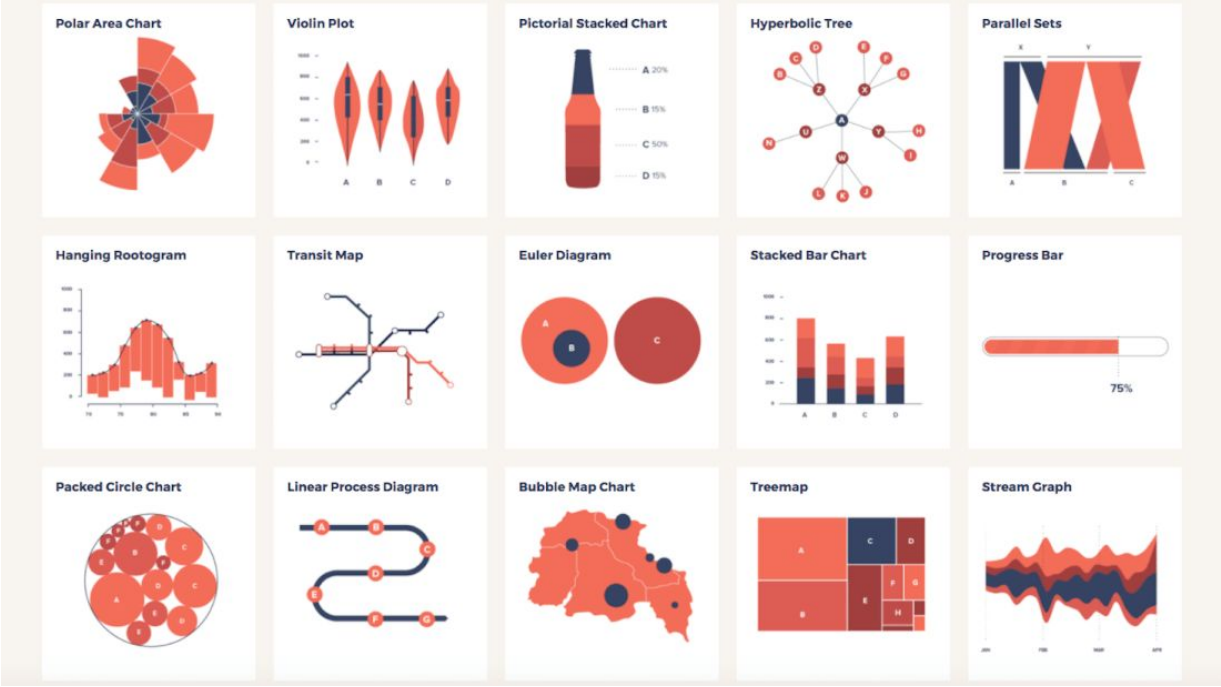

Figure 12 examples of data visualizations

Ideation of the visualization took place by analyzing appropriate visualization methods. As seen in the figure 12 above showcasing some examples of data visualization methods, there are a lot of options for various types of data sources, therefore it was crucial to find appropriate directions for each data set.

Four ideas were derived, for the visualization topics mentioned above respectively: Sales funnel to visualize purchase interest; modified bubble chart for visualization of perceptions; custom diagram using shapes and color to visualize car preference and willingness to switch; and lastly bubble chart with incorporation of a funnel to visualize sales.

Once the appropriate visualization types have been selected, prototypes and concept designs were made.

4.1.1 Visualization 1: Consumer purchase interest

Based on the data gathered as outlined in section 3.1, visualization 1 consists of consumer purchase interest. This dataset is split into four sections: Awareness of EVs, Familiarity with the technology, Consideration in purchasing an EV as the next car, and lastly realized purchase of EVs. The data is then split into four example markets, including: Germany, Norway, China and the United States. For each market data is available for comparison of the year 2016 and 2019, with China being an exception as no data was gathered in 2016.

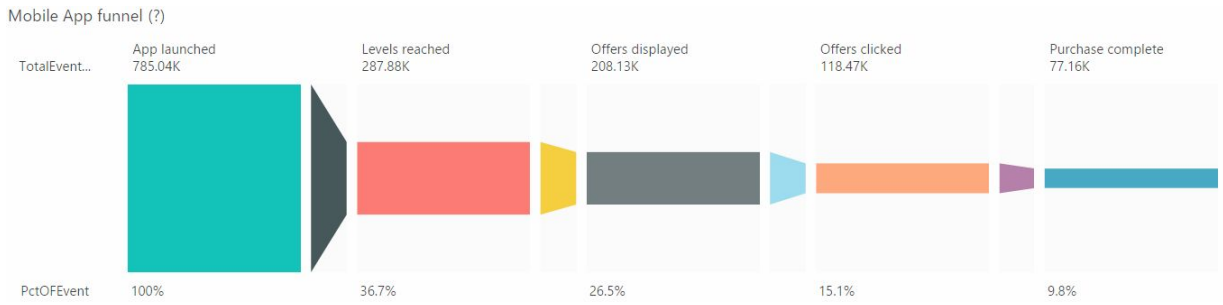

Figure 13: mobile app purchase sales funnel

This data greatly presents that while a lot of us may be discussing EVs, penetration rates globally remains at 2.2% [12]. To represent the various stages, I have decided to use the sales funnel to showcase the difference between them as seen is an example figure 13 above showcasing purchase completion of mobile applications.

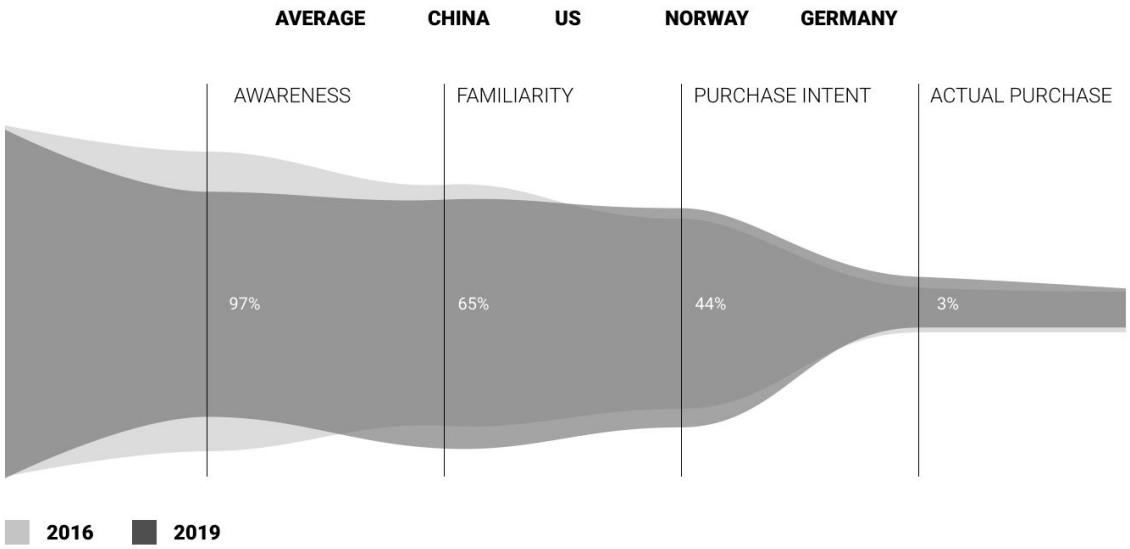

Figure 14: Visualization 1: realized purchase sales funnel wireframe

For the prototype I have created a sales funnel wireframe to illustrate how this data presentation would work. When developing the wireframes, I have used simple tools, such as digital whiteboards, sketching and excel. Creating quick prototypes such as the example above, allows for rapid testing of ideas with the client and users.

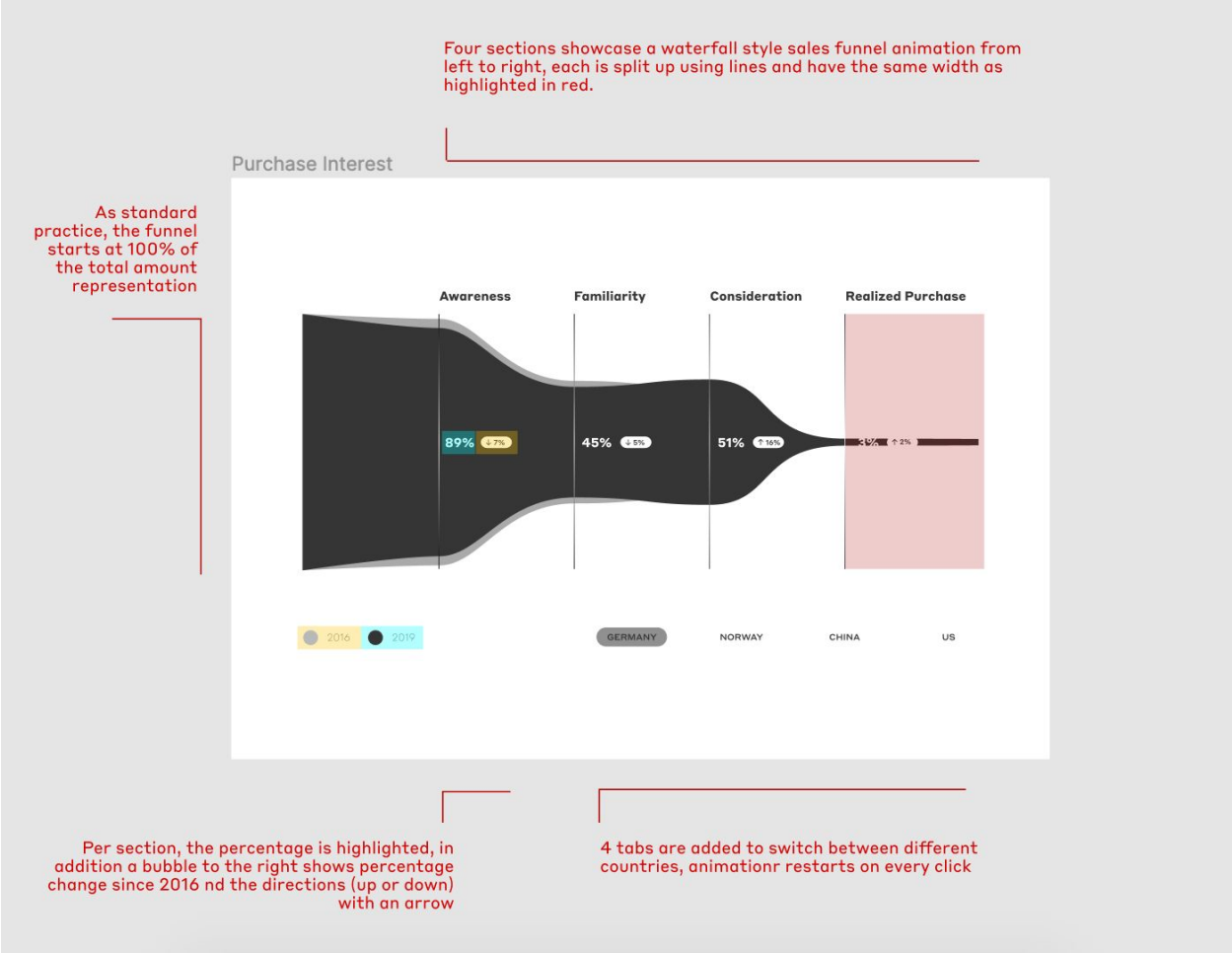

Figure 15: Visualization 1: realized purchase sales funnel wireframe final iteration

Figure 15 above presents the final iteration of the purchase interest visualization wireframe with detailed explanations behind the choice of each element. Final wireframes incorporate all the true data and can already be analyzed in detail and understood in context. Based on the wireframe, the color can be implemented and the visualization can be included in the website for testing. The sales funnel is split into four stages, every single stage animated after each other from left to right. The four tabs at the bottom right allow users to switch between different markets. In addition, for every stage two numbers are presented, the current percentage as highlighted in blue, and the percentage change as highlighted in yellow. The percentage change block from 2016 also indicates the direction of the change (up or down).

4.1.2 Visualization 2: Consumer Perception

The dataset, as available in the summary table in section 3.1.1, consists of consumer perceptions including several factors, split into a perceived concern and perceived benefit. Over 7,000 participants surveyed have been questioned on aspects including:

- Government subsidies for EV purchase
- Cost of Ownership of an EV
- Driving Range
- Battery and Charging
- Driving Experience
- Environmental Consciousness
- Driving Experience
- Vehicle Sales and Availability

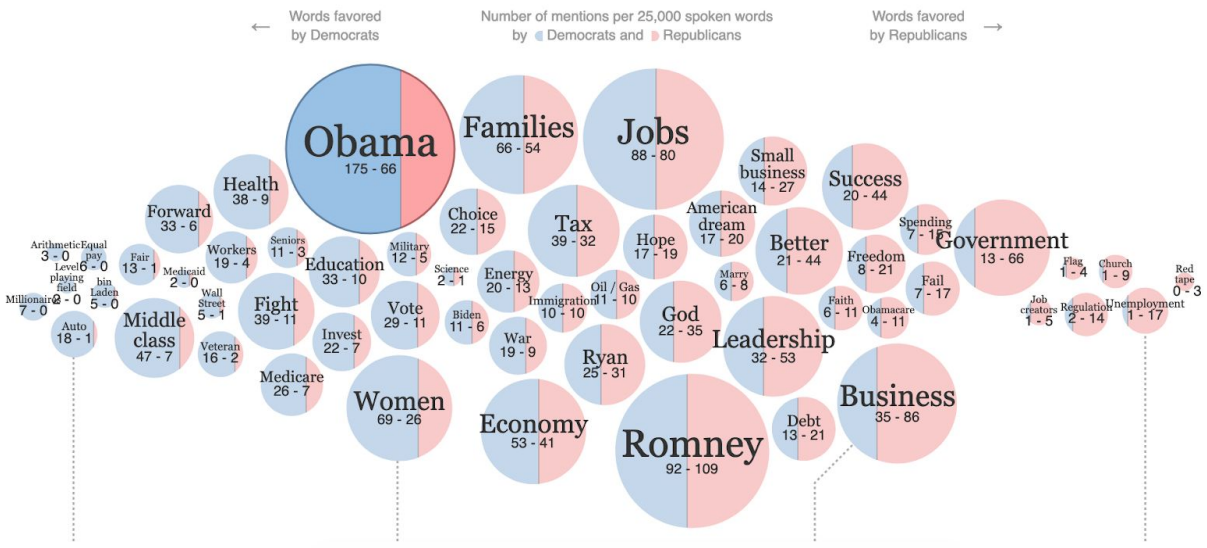

Figure 16: New York Times National Conventions Data Visualization

Bubble charts are a great use for such datasets. As seen in the figure 16 above. New york time uses bubble charts to illustrate the words used during an election, representing two parties,

democrats and republicans. The size of the bubble illustrates the amount of times a word was used in total, while the color represents the party.

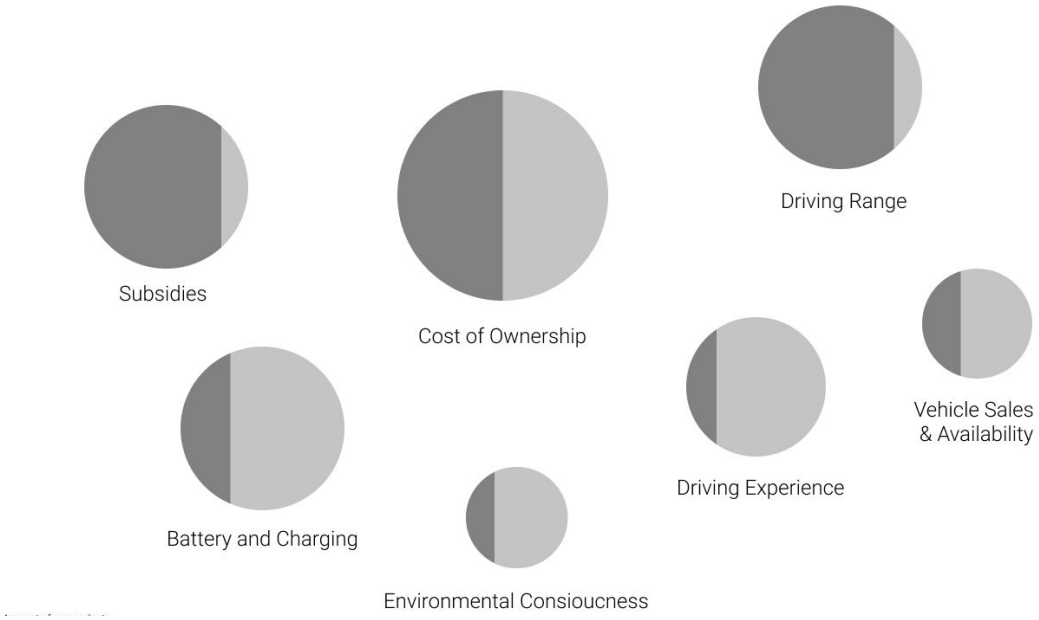

Figure 17: Visualization 2: Consumer Perception Design Wireframe

I have created wireframe iterations using this approach for the dataset. As seen in one of the wireframes in figure 17 above. The eight factors are split into bubbles, with the size indicating the amount of respondents mentioning it as a concern or benefit, and split appropriately by color. Same tools were used for this visualization prototyping phase, including sketching, excel and digital whiteboards.

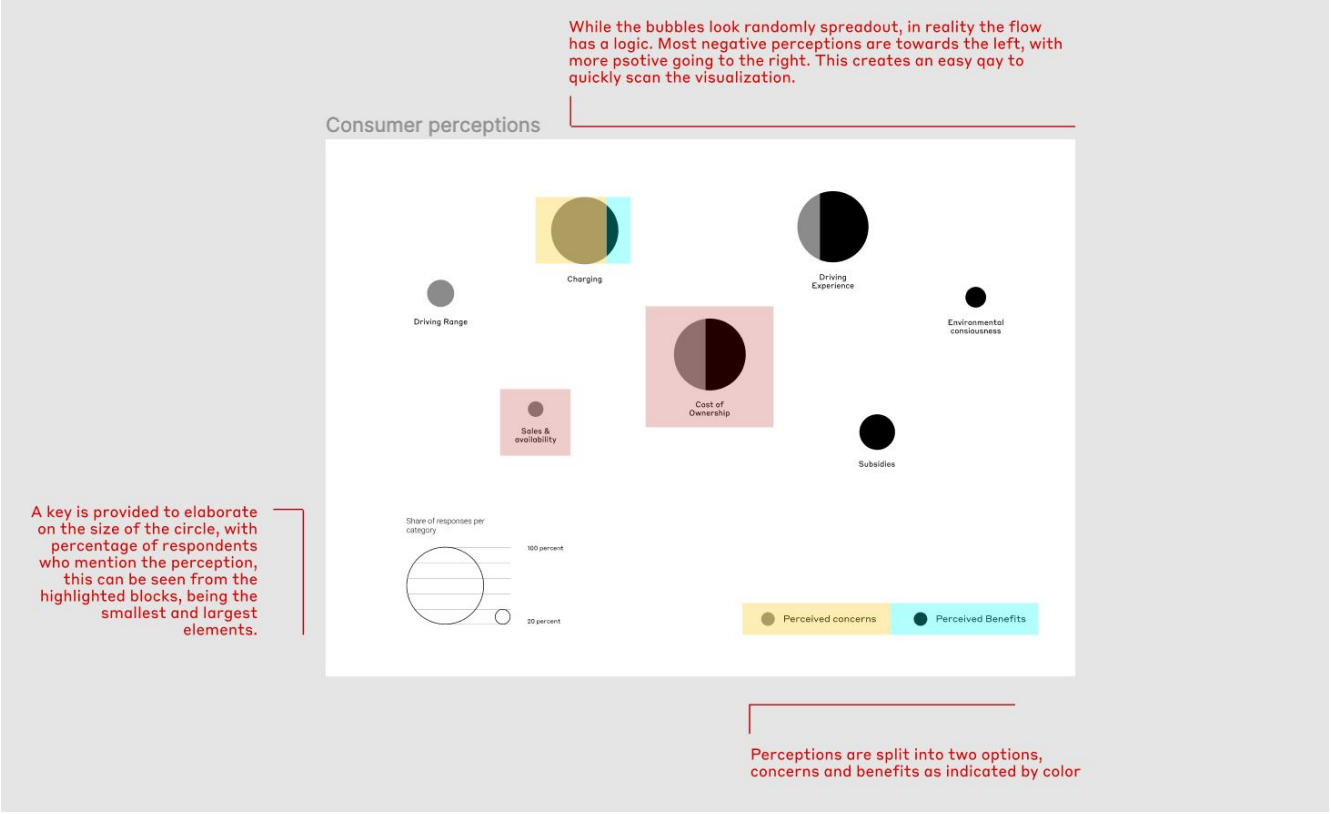

Figure 18: Visualization 2: Consumer perception wireframe final iteration

Figure 18 above showcases the final iteration of the consumer perception data visualization wireframe. In total the seven perceptions are split in order of negative to positive going from left to right. This presents a quick split of what is seen as positive and negative. Further the size of each perception indicates the percentage of respondents who have mentioned it; a figure was created to elaborate on the sizing as seen in the bottom left. Each bubble is then split depending on the percentage of negative vs positive perceptions as highlighted in yellow and blue.

4.1.3 Visualization 3: Car Preference & Willingness to Switch

The dataset used for consumer car preference and willingness to switch, is interesting as it combines two datasets. The data consists of 17 markets around the world. The participants surveyed across these markets, have been questioned about car preference in terms of size, as

well as further breakdown in details, such as an SUV, Wagon etc. The other part of the data set questions the same participants about their willingness to be an early adopter of an EV.

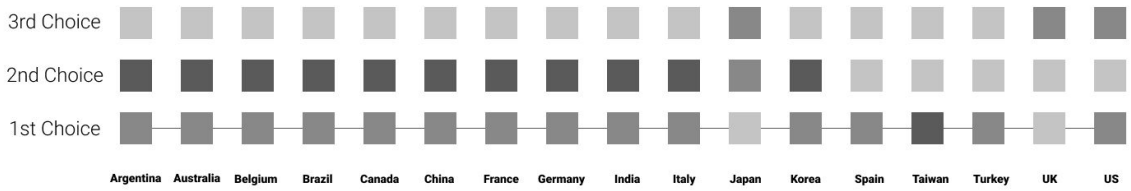

Figure 19: Visualization 3: Wireframe Car preference and willingness to switch data visualization

Several iterations have been designed for this visualization as well, with one of the showcased in the figure 19 above. The basic idea was to use shapes and colors to illustrate the two datasets together. The shapes are to represent eh car preference, and the fill in color illustrates willingness to switch based on percentage brackets.

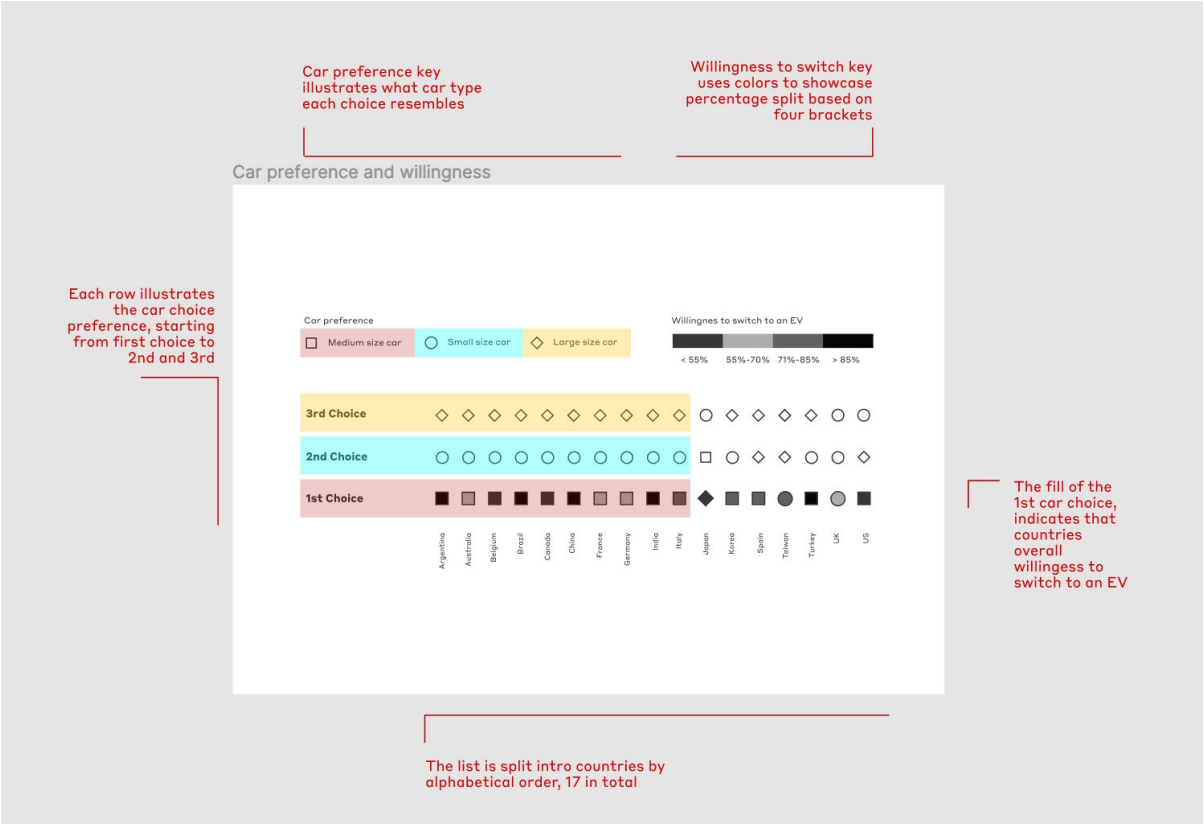

Figure 20: Visualization 3: Car preference and willingness to switch data visualization wireframe

Final iteration

Figure 20 above illustrates the final wireframe for the car preference and willingness to switch data visualization. Being the most complex visualization in regards to data, the wireframe turns out to be fairly simple. A shape is used for each car, a square for middle sized, a circle for small and a ruby for large as represented by the three colors. The information is then split into car preference including 1st, 2nd and 3rd choice. The first choice shapes are filled in with a color, depending on the willingness to switch of the corresponding country. A key is created for that to showcase the four possible colours and what percentage bracket they represent. For example, Argentinians prefer a medium sized EV, and above 85% of the market is willing to switch to an EV.

4.1.4 Visualization 4: Car manufacturers pipeline for the next five years

The dataset used for car manufacturers' release pipeline, illustrates how many new Battery Electric Vehicles (BEVs) are set to be released every year. It then further breaks down this data by categories, including Large, Medium, and Small car segments. In addition the data set includes the amount of new models that have been released in 2013-2016 alone for reference.

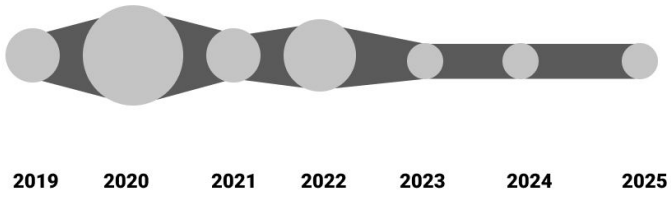

Figure 21: Visualization 4: Car Manufacturer EV release pipeline wireframe

As seen in the figure 21 above, a combination of a bubble chart and a funnel is used to showcase the upcoming EVs. The idea with the wireframe, is that the size of the bubble reflects the amount of cars coming on the market, which varies year by year. For example for the year 2020 the most EV models have been confirmed thus far, which also makes sense considering that is reflected as the current year and a lot of models are announced very quickly. In total, 485 new EV models have been confirmed according to the dataset for the next five years.

Figure 22: Visualization 4: Car Manufacturer EV release pipeline wireframe Final iteration

Figure 22 above illustrates the final wireframe for the car manufacturer release pipeline visualization. In total, three car segments are presented, including small, medium and large sized cars. These are then individually split up for the years 2019 to 2025. The bubbles in appropriate size ratio represent the amount of cars that are going to be released per year for that car segment. In addition a bubble is provided for the year 2014-2016 to create a reference point of how little EV models have been released in the past.

4.2 Web Design and Development

With the task separation divided as outlined in section 3.3, I need to first work out a structure for the website, as well as an appropriate wireframe that meets the requirements and can be passed on to Corbinian Buchberger to follow as a guideline.

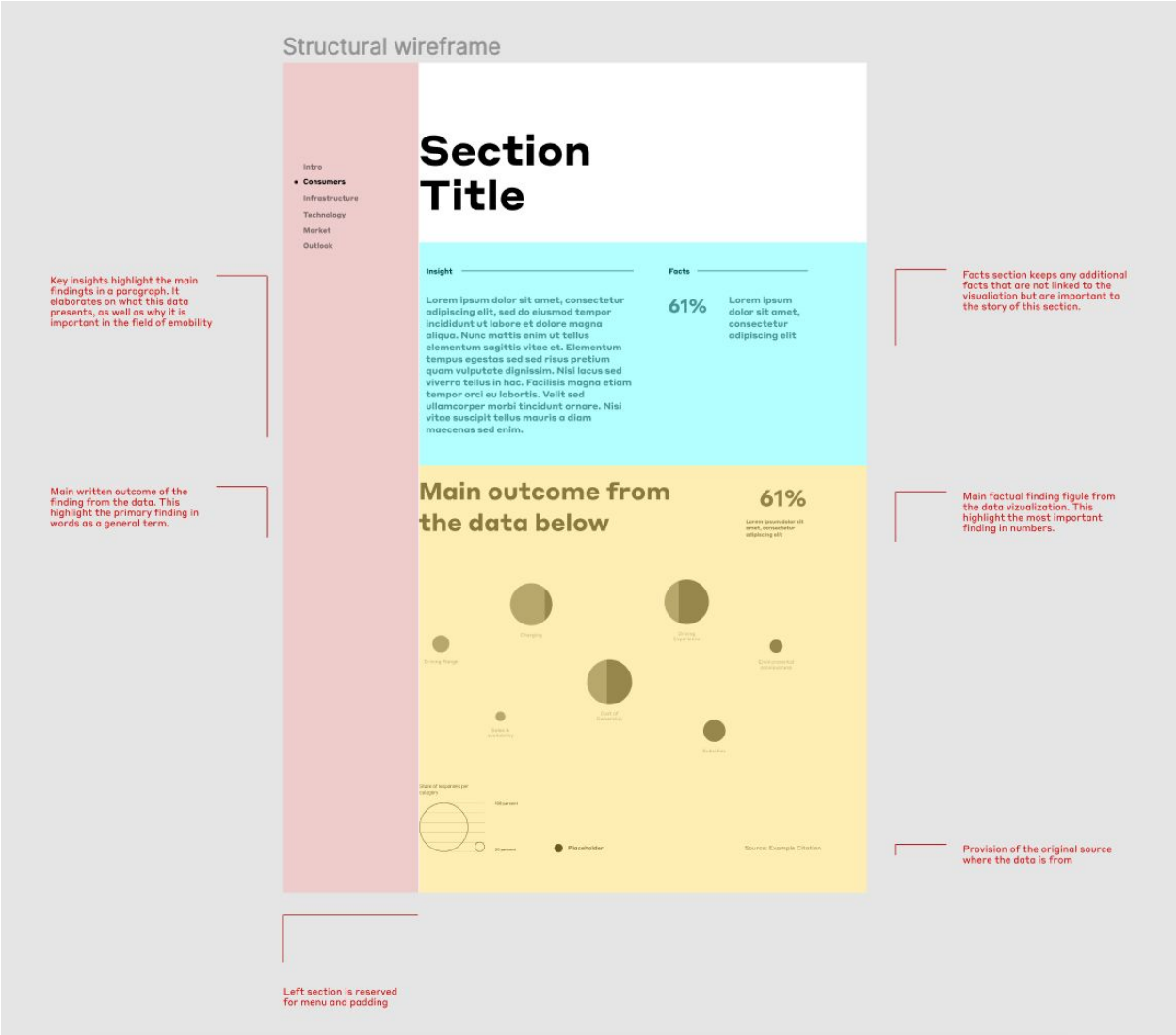

Figure 23: website data visualization section structural wireframe

As seen in figure 23 above, the website structure and specifically the section structure has a logical breakdown developed. The website is split into six sections including: Intro, Consumers, Infrastructure, Technology, Market and Outlook. The menu for these sections is on the left,

making it easy to navigate the website. Further, for each data visualization section, the structure is broken down into a title, an insight and fact as highlighted in blue, and a key take away followed by the data visualization itself as highlighted in yellow. This ensures that the user has some key background information, before viewing the visualization, which helps with the understanding. The margin on the left is always reserved for the menu.

4.3 User Testing Study

User valuation was executed online. In total two separate surveys were created and tested as outlined in the methodology. One being the general public and one being the experts. Appendix A provides the full user testing evaluation form.

The users were tested on a variety of factors, with the majority of them using a strongly disagree to strongly agree scale of 1 to 5. Data visualization attributes tested using this approach included:

- Visibility of text and number
- How is a visualization is to understand
- Clarity of purpose
- Aesthetics
- Interest
- Whether a key insight matches the visualization

In addition to the data visualizations, the overall website was user evaluated as well within the same user testing, also split between regular users and experts in the field. Regarding the website, the users were asked about attributes using the same approach as mentioned for the data visualizations:

- Website navigation
- Design coherence
- Storyflow logic
- Website experience

- Understand of Emobility after visiting the website

5.0 Results

The results section highlights the final results and designs achieved for both the data visualizations as well as the website. In addition the results from the user evaluation are presented and discussed. As the data visualizations presented ahead are also animated, It is encouraged to observe the results directly on the live website which provides a better understanding and view of what has been achieved:

https://project-hubject.webflow.io/

5.1 Data Visualizations

Below the four final visualizations are presented and discussed. Final tools that were used for all the data visualizations include: Figma, Illustrator and After effects. Figma was used for the initial design stages after the wireframes have been completed, while Illustrator and After effects were used together in order to animate the visualizations. In addition, excel was also used and linked to some of the visualizations in order to provide appropriate scale of numbers.

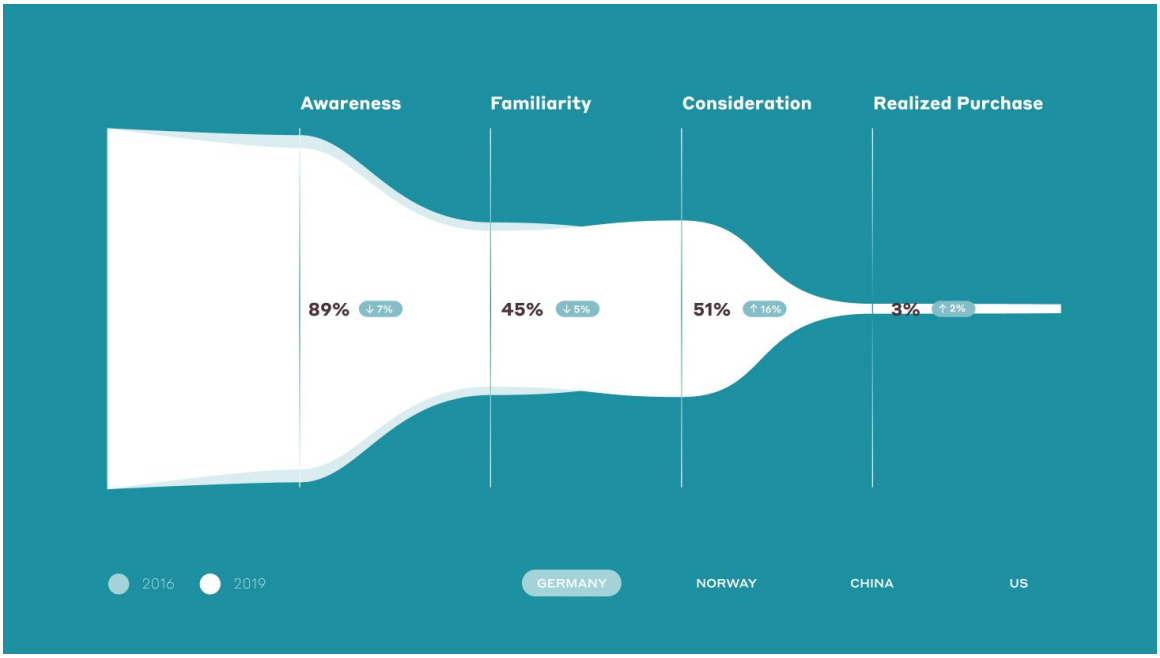

Figure 24: Visualization 1: Realized purchase interest final design

Figure 24 showcases the final design for visualization 1. With the structure established and explained in section 4.1.1, the branding can be incorporated. Based on the web design which has been done in parallel, this visualization was created in white and blue gradients, to be overlaid onto a hubject primary blue color. Several issues have been spotted since the final testing and are to be adjusted. This includes the sizing of the bubbles that indicate percentage change since 2016, as they are too small. In addition the contrast on the bubbles was perceived as too low. Lastly, it has been mentioned during feedback that the years 2016 and 2019 look clickable, which they are currently not. This can be avoided by updating the year key into something that looks less clickable. The animation of the visualization is reloaded every time a new market is selected, loading from left to right following the sales funnel.

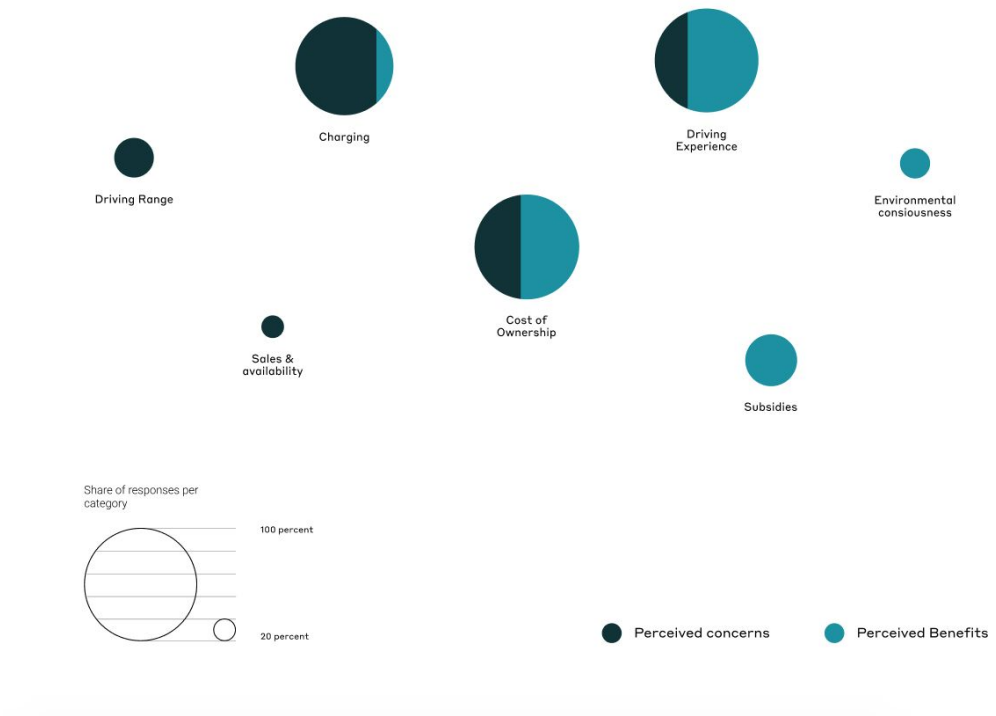

Figure 25: Visualization 2: Consumer perception final design

Figure 25 showcases the final design for visualization two. Following the wireframe structure as outlined in section 4.1.2 the branding colors have been implemented. Based on the web design this section lays on a white background, and belongs to the consumer section together with visualization 1. Therefore the hubject blue and dark blue have been used to showcase the negative and positive perceptions. The animation created for this visualization pops in the bubbles from left to right.

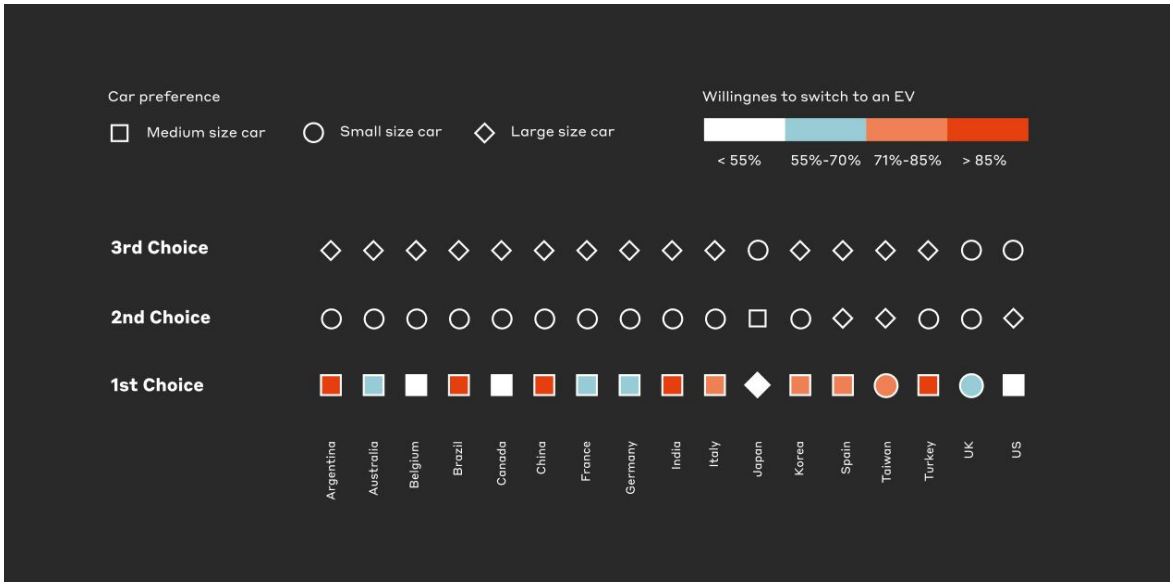

Figure 26: Visualization 3: Car preference and willingness to switch final design

Figure 26 above shows the final design for visualization 3. Following a structure of the final wireframe outlined in section 4.1.3. Based on the web design, this visualization lays on a dark background, allowing me to use brighter colors for the visualization itself to create a pleasing contrast. The willingness to switch is represented in four colours, a blue is intentionally used to showcase all countries in the second lowest bracket, as continuous gradient was not easily visible. The animation of the visualization loads each of the 17 countries one by one from left to right.

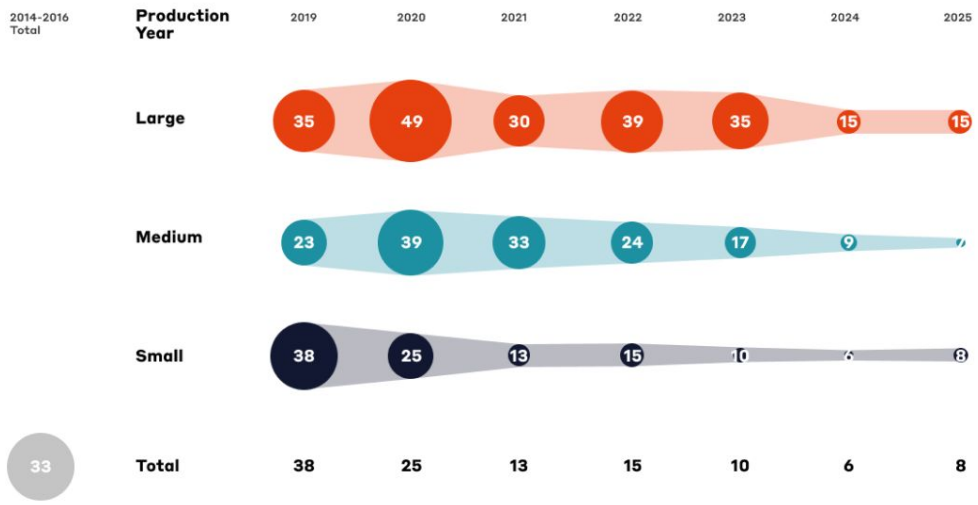

Figure 27: Visualization 4: Car manufacturer EV pipeline final design

Figure showcases the final design for visualization 4. Following the wireframe structure as outlined in section 4.1.4. Based on the web design this section belongs to the market part together with visualization 3. Three colors have been used to highlight the three car size segments as seen in the figure. The animation created, loads each year one after the other as a timeline, with the funnel background loading last.

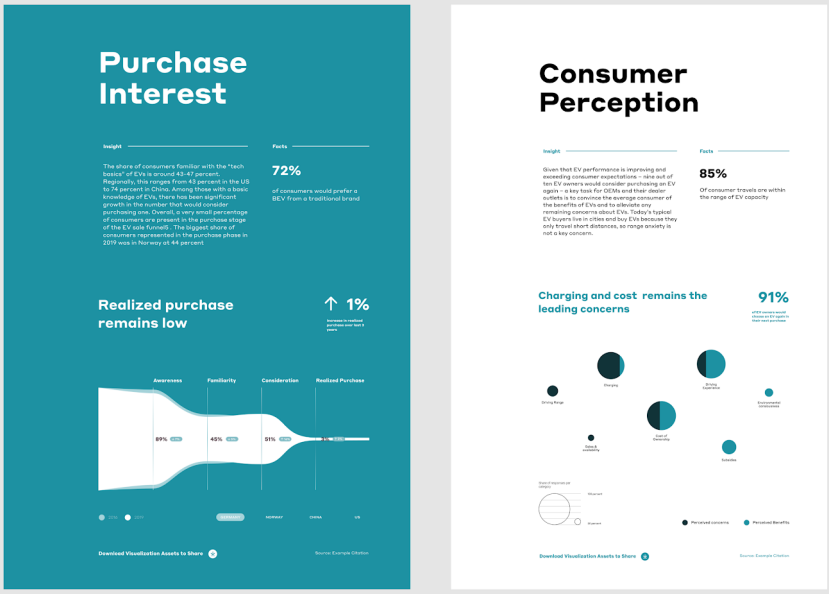

Figure 28: Visualizations 1 and 2 implemented into the web design structure

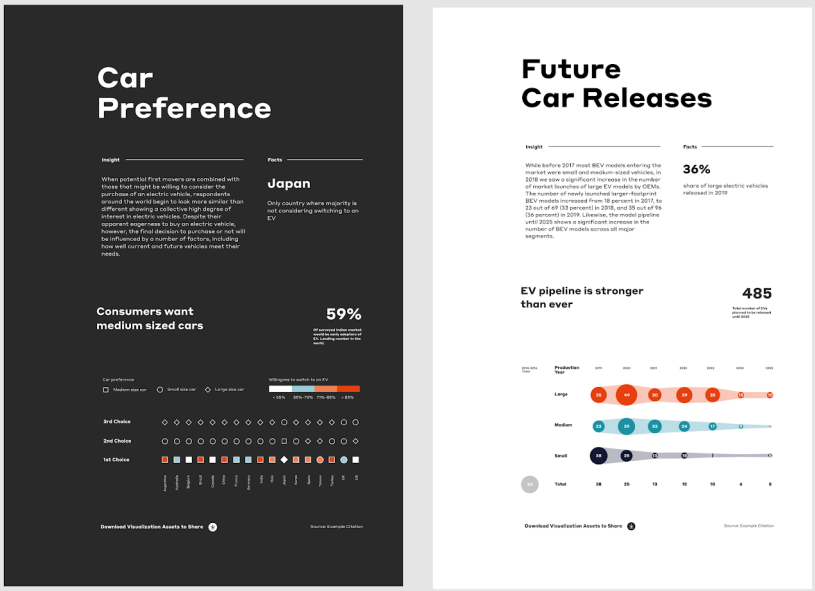

Figure 29: Visualizations 3 and 4 implemented into the web design structure

Figures 28 and 29 above illustrate how the visualizations have been implemented into the block structure created as outlined in section 4.2. The result is an overall coherence of design between the four visualizations, which helps for marketing purposes and keeps engagement of the visitor. As mentioned previously, a key insight, fact and takeaway start off the section followed by the visualization. This helps ensure that the visitor understands the background information and context before analyzing the visualization on its own.

5.2 Website Design and Development

This section presents the final design and development results of the website. Further I will showcase the overall final design, the logic behind the introduction and footer sections, as well as the mobile responsiveness. The tools used for the website include Figma for the design and prototyping, and webflow for front end and back end development.

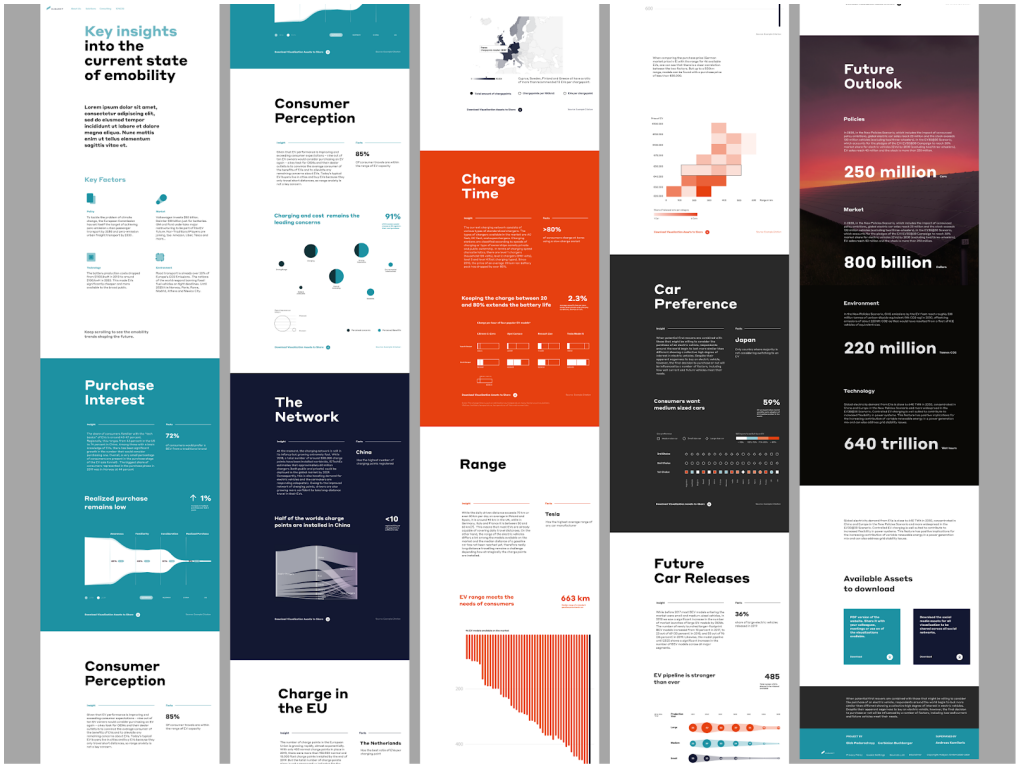

Figure 30: Final Web Design and development

Figure 31: Final Web Design Hero and footer sections

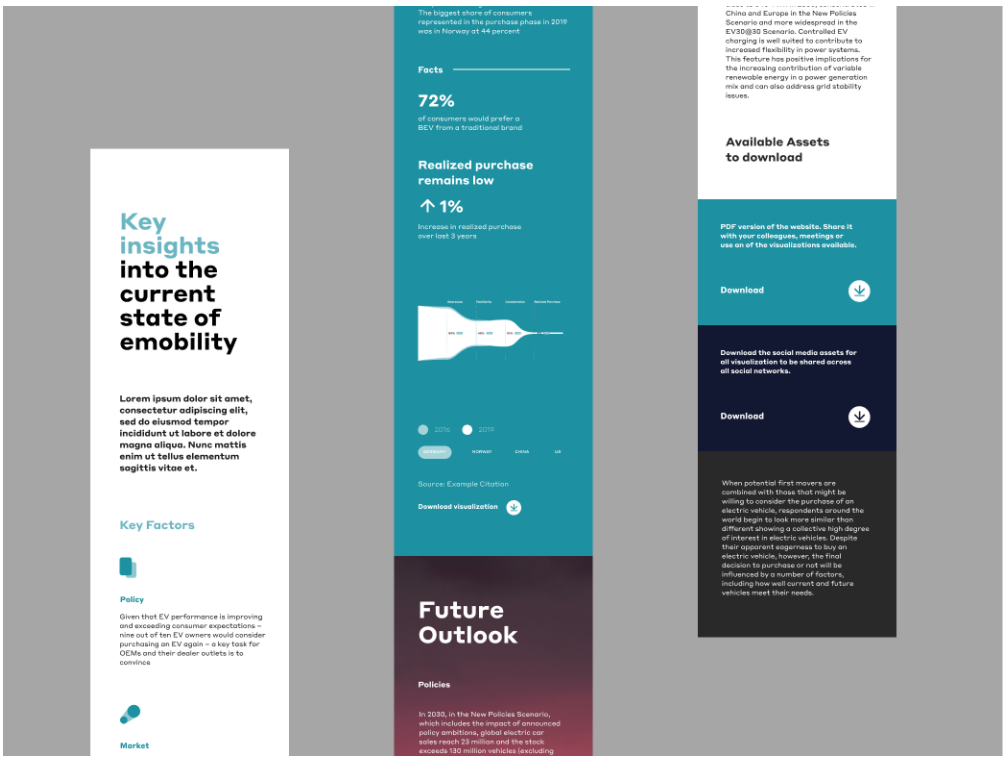

Figure 32: Final Website mobile responsive design and development

Figure 30 presents the final design for all sections. The result is a very coherent and on brand website, that matches hubject's brand identity and can be used for marketing purposes. The final design splits every new section using a new background color from hubject's branding. Blue for the consumer section, Deep purple for the infrastructure, Orage for technology and a dark grey for the consumer.

As seen in figure 31 the hero (introduction) section presents the user with a bold title of what this landing page is about. As the user scrolls, they have a preview of some important information including what are the key driving factors influencing the trends about to be presented. As the menu to the left is reserved for navigation of the landing page, links using a top bar menu have also been added. These links are leads to take a user to Hubject's primary website, including their home page, solutions page, ICNC20 conference. These can be updated as necessary with the website evolving further. The footer section presents the users an option to download the visualizations in both a PDF format to share, as well as social media kit. These downloadable assets were made by Corbinian Buchberger. Further, the footer includes a notice about this project being a thesis by the students at the University of Twente, and links where users can view sources and contact us for feedback.

The website has also been made mobile responsive as seen in figure 32. As a result, all of the sections have worked on mobile with the animations and visualizations still being understandable. Users can zoom into the visualizations to see the details where necessary.

5.3 User Evaluation

As discussed in section 4.3, a user evaluation was conducted. The total number of users tested for the general public was 17, afterward receiving initial results from the general public test, some adjustments were made based on the feedback received and an expert test was conducted.

5.3.1 General public user evaluation

Visualization	Purchase Interest	Consumer Perception	Car Preference	EV Pipeline
Text and numbers are clearly visible	4	4	4.6	4.3
Easy to understand	3.8	3.5	4.2	4.1
Purpose is clear	4.2	4.1	4.1	4
Aesthetically pleasing	4.7	4.1	4.2	4.4
Interesting	4.3	3.9	4.7	4.4
Insight matches understanding	4.2	3.5	4.2	4

Table 3 Results of all the visualizations

Figure 33: Average end results of all visualizations

Table 3 above showcases the final results, excluding the open ended questions in Appendix A, for all of the data visualizations created. Figure 33 also showcases the final average results for the 17 respondents. As seen, the average results are overall good. All parts have an average score above 4, with only the easiness of understanding being an exception. Aesthetics having the highest score at 4.5 proves that the visualizations are visually appealing, which makes them highly marketable. Out of the 4 visualizations, Consumer perception has on average received the lowest scores, making it the main visualization that is currently still not understood well.

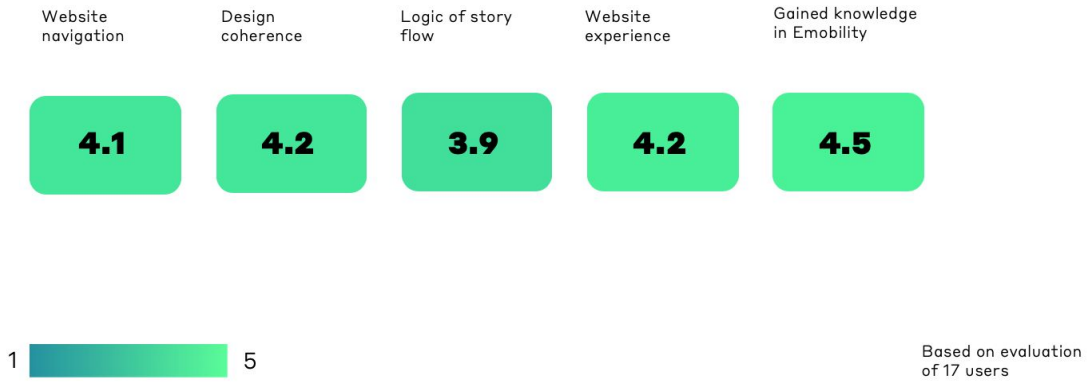

Figure 34: Average end results of the overall website general evaluation

In addition to the data visualizations, overall results for the website user evaluation are also presented above in figure 34. Overall results have been very positive for the website, including

design, navigation and the overall experience. Most notably, gained knowledge of Emobility from the overall website received an average rating of 4.5. This is a good result as that is the main objective set out by the client. Logic of storyflow received the lowest result, in open ended feedback, users mentioned a lack of introduction and conclusion being the primary reasons for this. Simple elements such as what is an EV, and some other definitions needed to be highlighted beforehand. It is important to note that during this testing, the written copy was either placeholder or work in progress, therefore there was a lack of overall written story, as Corbinian Buchberber and myself wrote everything independently.

5.3.2 Expert user evaluation

Expert evaluation has been conducted in total with 6 users and is still ongoing. These include experts in the field such as CEOs and marketing experts of companies working in the field.

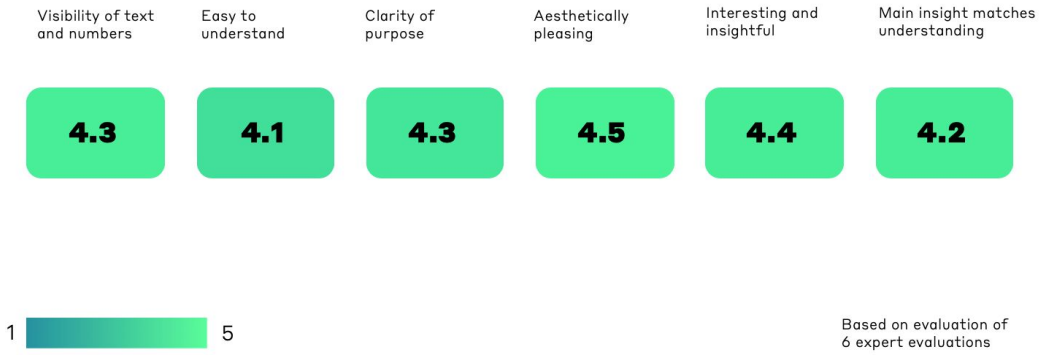

Figure 35: Average end results of data visualizations expert evaluation

Figure 35 illustrates the end result of the data visualizations based on some minor adjustments that were made. The overall results are also good, which is important as the experts are the target audience. Surprisingly in expert evaluation one of the lowest scores is the matching of key insight to the understanding, which happens to be lower than the general test. This could potentially be due to the experts being more knowledgeable in the field and therefore having deeper information of the key insights than the general users.

Figure 36: Average end results of the overall website expert evaluation

In the figure 36 above the overall website scores of the expert evaluation are presented. These results were very similar to the results of the general user testing varying only slightly. Most notably the result of gained knowledge in Emobility is the same, which shows once again that the objective was achieved for both user evaluations. Based on these results and the primary and secondary objectives set out, it can be concluded that the results were both user groups were successful and that the main objectives have been reached.

6.0 Conclusion

6.1 Client Feedback

Communication with Christian Hahn (the client) was done throughout the entire process of the thesis. A lot of information has been discussed and exchanged during that time, including the conceptualization of the website and ever evolving visualizations.
One of the primary feedbacks that was received towards the end of the project was that lead generation is a crucial objective. Based on that several parts have been implemented, top menu links as discussed previously in section 5.2 as well as downloadable assets.
The client was satisfied with the project and has set out to plan a marketing campaign to promote the website to the target audience with a budget in place. In addition, the client is looking into updating their other marketing structures, such as the Annual Electric Mobility Index towards a marketable website if the campaign for these projects proves to be well received.

6.2 Influencing factors

It is important to mention that several factors should be looked into further. In particular, data, environment and policies surrounding EV markets.

Majority of the data currently available comes from privately owned organizations, such as McKinsey, Deloitte and KPMG. While the data is still usable and deeped acceptable, there is a lot of variability. In addition, there is a lack of data surrounding aspects such as consumer behaviour. EV is still in its infancy, therefore research institutions are not yet focusing on it as much in regards to research.

Environmental factors should also be considered when discussing the current state of Emobility. It has been mentioned as feedback by several users and experts that information about where the energy comes from is just as crucial as the EVs themselves. Yet, environmental factors are often ignored when discussing the current state of the Embolity market, sometimes intentionally.

Therefore there is also a strong lack of data from the private organisations regarding its benefits on the environment.

Lastly, political aspects have a strong influence on the EV market. Majority of the big changes in sales and expansion start with strict policies. For example Norway has achieved the world's highest realized purchase, largely due to its policies, such as paying 0% tax on buying an EV for some time and paying no road tax, as well as receiving additional financial incentives, which all together result in having a 44% realized purchase in 2019.

6.3 Recommendations

In order to continuously achieve the objectives set out by Hubject GmbH, this project should be continuously updated. With the majority of the data linked to excel, this can be done at ease, with the written copy updated at ease through the backend CMS system implemented. In addition, new topics and trends should be looked into as more data sets become available.

6.4 Overall conclusion

In order to address the objectives and research questions established, literature and state of the art research has been conducted. In the state of the art, various existing visualizations have researched and analyzed and the data sets prepared. During the methodology section, a method has been derived to follow the design thinking methodology for data visualizations. Data visualizations as well as the web design have been conceptualized and prototyped. In the execution phase, the data visualizations were finalized together with the website, being presented with final designs in the results section. A user testing study was conducted with two groups, regular users as well as experts in the field to meet client objectives. In order to fully analyze the success of the landing page and the data visualizations, more time is necessary to see results from the analytics tools implemented by Corbinian Buchberger.

When reviewing the results as well as the user valuation, it can be concluded that the project has been an overall success. The client objectives have been met and most importantly a clear picture of the current state of Emobility was presented.

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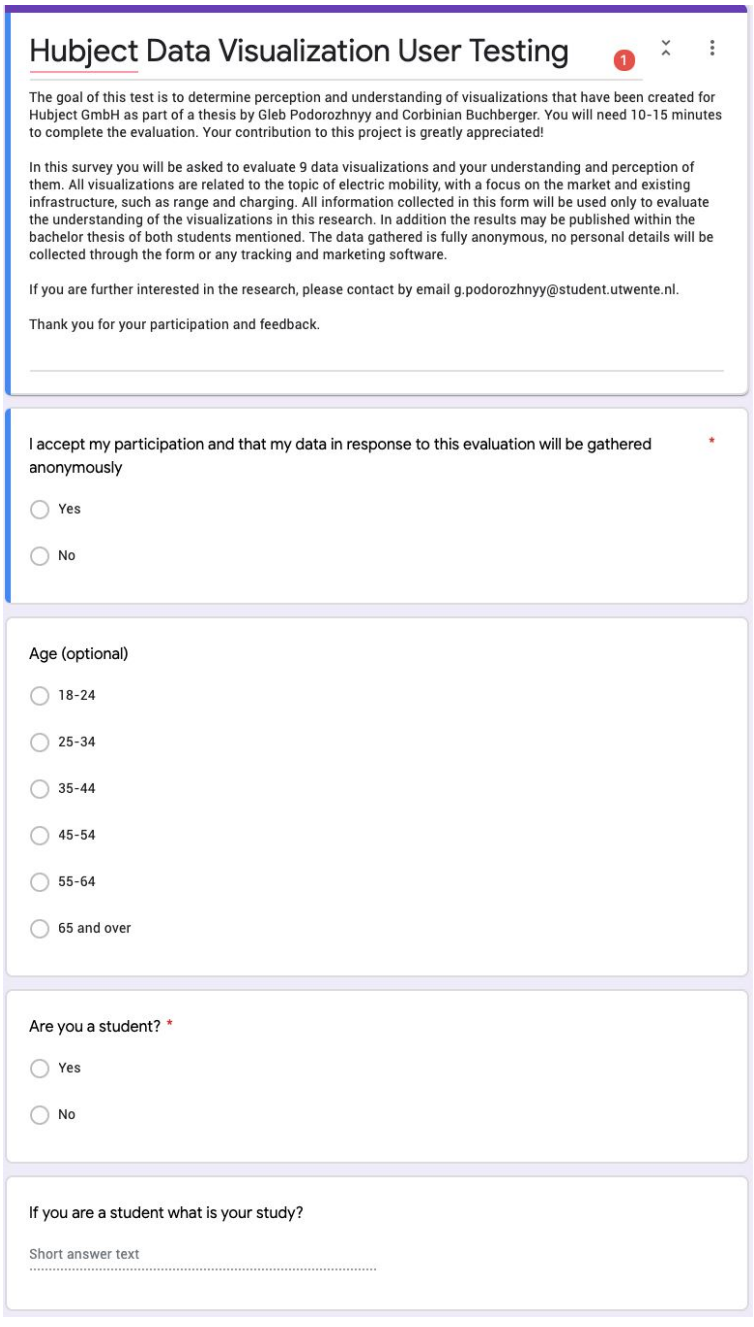
Appendix A

User test section 1



Hubject Data Visualization User Testing

The goal of this test is to determine perception and understanding of visualizations that have been created for Hubject GmbH as part of a thesis by Gleb Podorozhnyy and Corbinian Buchberger. You will need 10-15 minutes to complete the evaluation. Your contribution to this project is greatly appreciated!

In this survey you will be asked to evaluate 9 data visualizations and your understanding and perception of them. All visualizations are related to the topic of electric mobility, with a focus on the market and existing infrastructure, such as range and charging. All information collected in this form will be used only to evaluate the understanding of the visualizations in this research. In addition the results may be published within the bachelor thesis of both students mentioned. The data gathered is fully anonymous, no personal details will be collected through the form or any tracking and marketing software.

If you are further interested in the research, please contact by email g.podorozhnyy@student.utwente.nl.

Thank you for your participation and feedback.

I accept my participation and that my data in response to this evaluation will be gathered anonymously *

- Yes
- No

Age (optional)

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65 and over

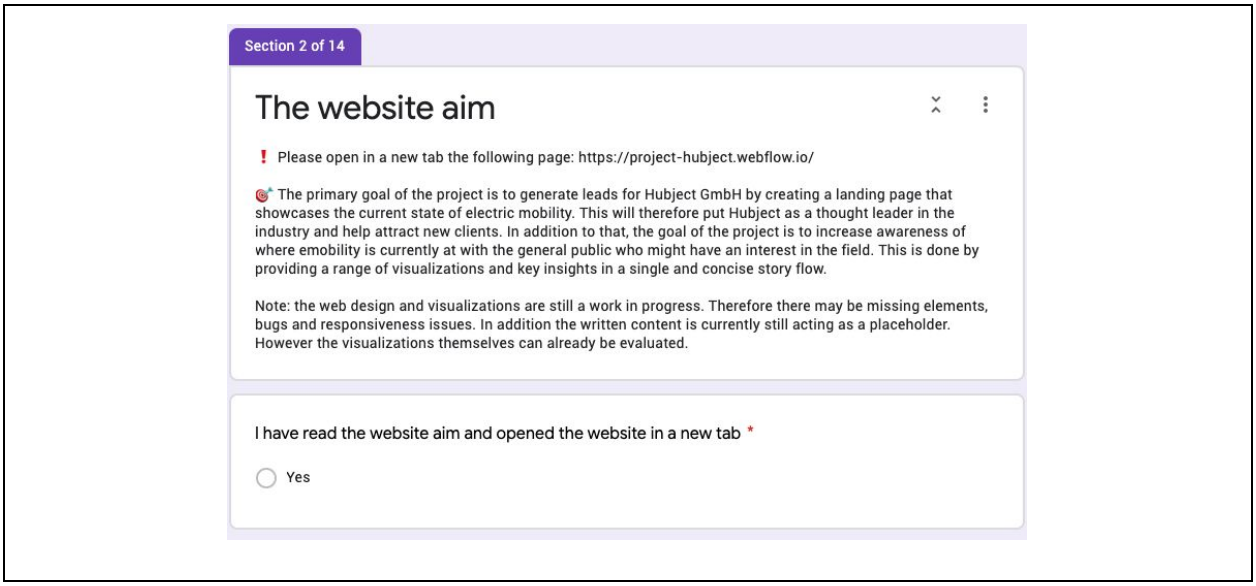
Are you a student? *

- Yes
- No

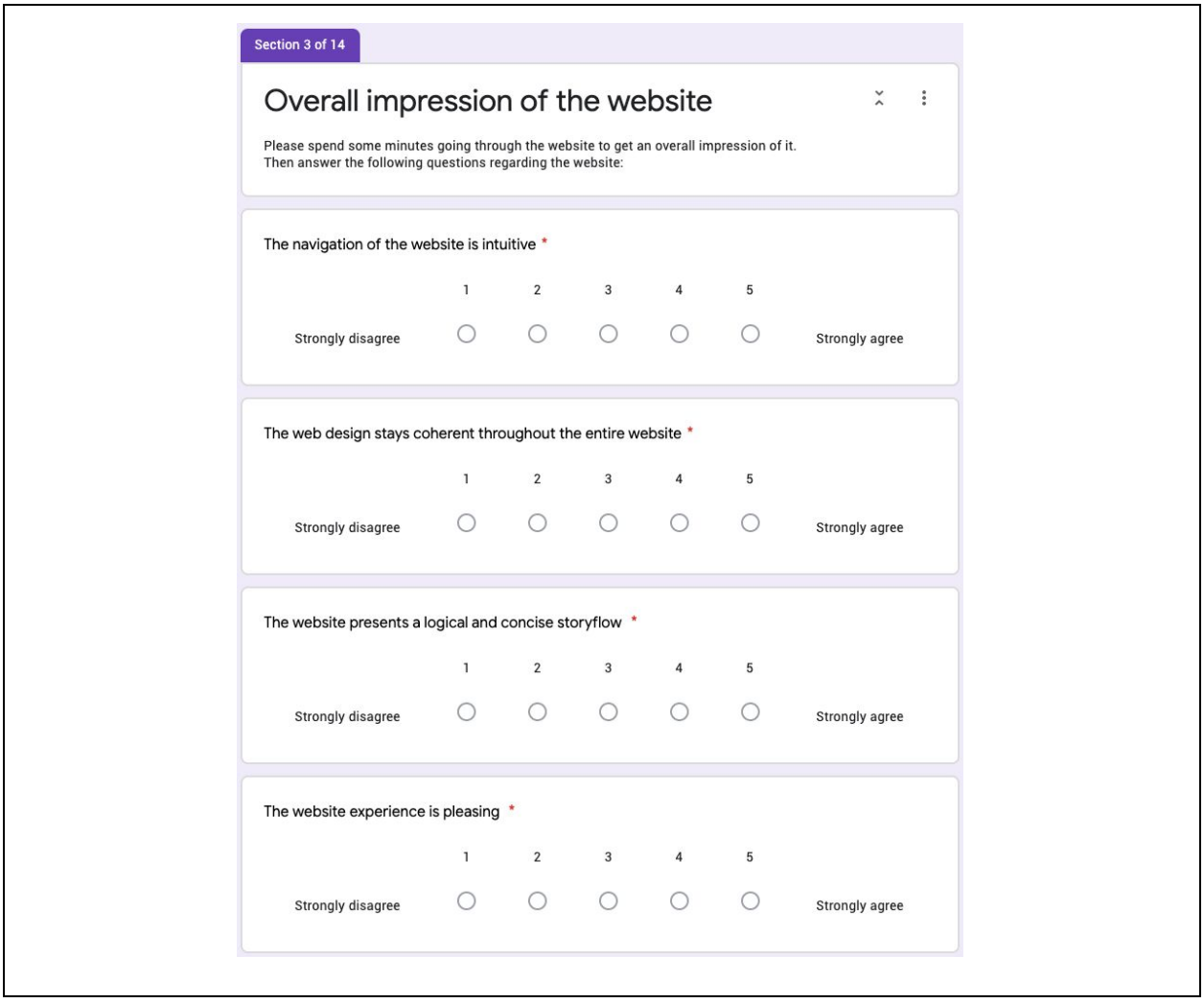
If you are a student what is your study?

Short answer text

User test section 2



User test section 3



User test section 4-12 (repeated)

I can clearly see all the information including text and *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

The visualization is easy to *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

The purpose of the visualization is *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

The visualization is aesthetically *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

The visualization is *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

The Insight and Facts sections provide useful information to understand the purpose of the visualization *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Is your understanding of the visualization the following? While interest in EVs is high, purchasing remains low. *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Is there anything misleading in the *

Short answer text

Do you have any specific policies or technologies in mind that are related to this topic which we should consider?

Long answer text

User test section 13-14