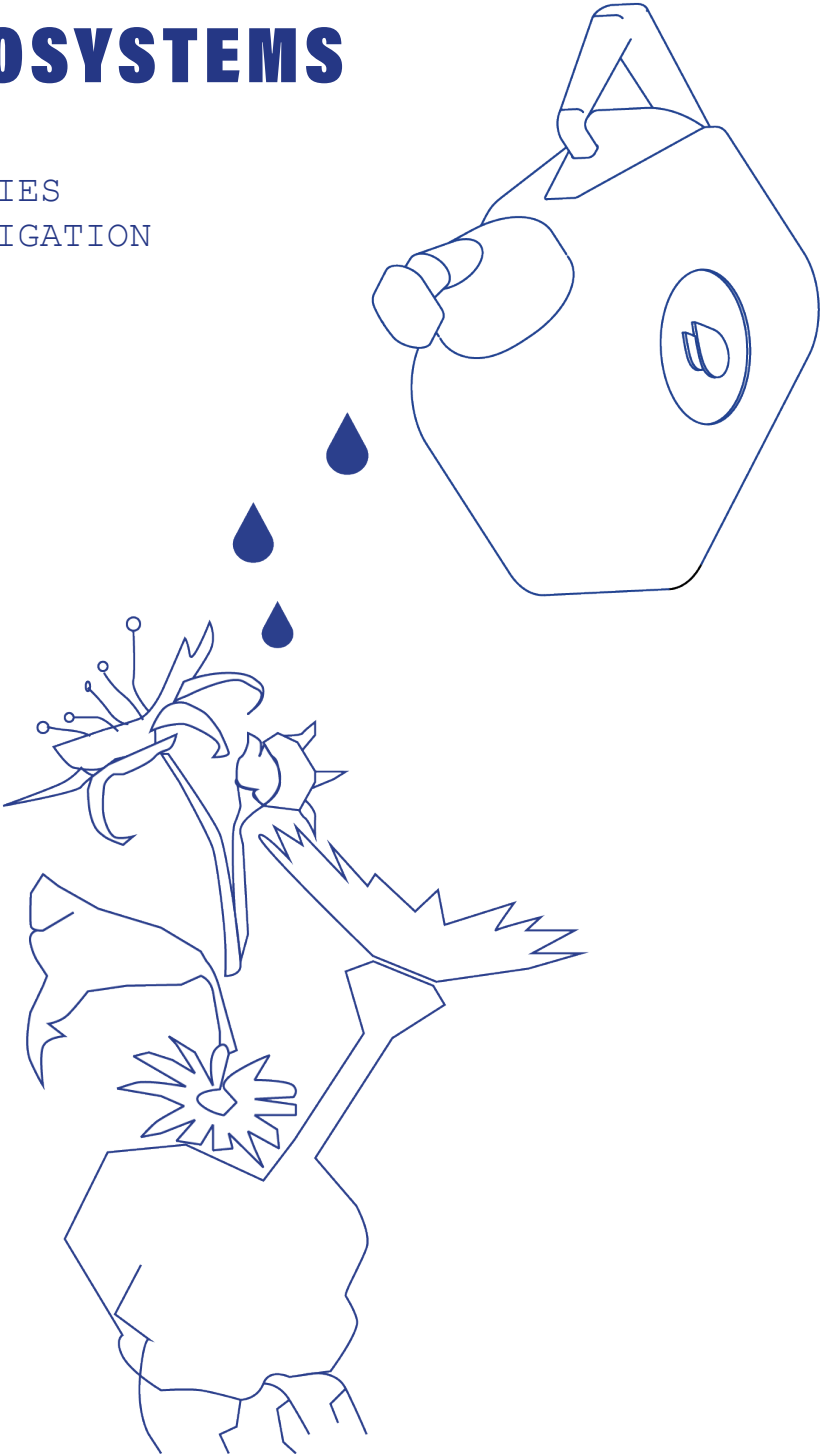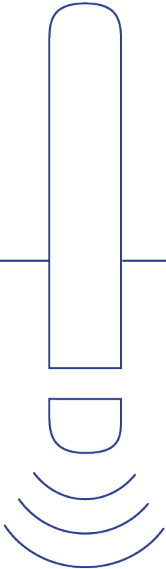# EXPLORING MINI'S CONTRIBUTION TO URBAN ECOSYSTEMS

IGNITING STRATEGIES
ON HEAT WAVE MITIGATION

MASTERTHESIS
JUTTA ROTH

JUTTA ROTH

MSC. STRATEGIC PRODUCT DESIGN
FACULTY OF INDUSTRIAL DESIGN ENGINEERING
DELFT UNIVERSITY OF TECHNOLOGY

IN COLLABORATION WITH
THE BMW GROUP & MINI

ACKNOWLEDGEMENTS

Dear reader,

this is my final deliverable of my Master's thesis in Strategic Product Design at TU Delft. It marks the end of my graduation project and two inspiring years in the Netherlands and Munich. A journey I look back with gratitude to all the amazing people I have met. I can say with pride that I had many rolemodels during this time, who inspired me to reflect, improve and challenged me to think about my contribution as a designer on this planet and my role to foster change.

Before diving into the content of this thesis, I would like to give my acknowledgements to a couple of people. First to Rebecca Price for the inspiration to this timely topic and for always pushing us students to be critical and as impactful as we can.

I would also like to thank my Supervisors at TU Delft, Nazli Cila and Euiyoung Kim for being so open to this topic, diving into the unknown and for always challenging me and inspiring me with new perspectives.

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This would not have been possible without the support of my friends and family who have always been there for me. I am happy that my friends at TU Delft and in Munich made my time at University, in the city, Jaagpad, the beach or the mountains so special and supported me in my graduation project. Thank you Ben for taking the time proofreading this report!

And finally a big thank you to my partner in crime Clemens, for always inspiring and believing in me. Thank you for taking this adventure to the Netherlands and for all the support whenever I needed it during this final graduation project.

Danke :)

EXECUTIVE SUMMARY

This executive summary provides an overview of the key findings and insights presented in the master's thesis named "Exploring MINIs contribution to urban ecosystems. Igniting Strategies on heat wave mitigation.". The study investigates the role of the brand MINI, in addressing the pressing issue of urban heat waves and its transformation to an ecosystem-focused contributor. With systemic design, a transition of viewpoint is offered in this thesis, and an additional planet centered approach is used to find new solutions which take the entanglements of the city into consideration.

Urban heat waves have become a critical concern within the context of global climate change and urban development. Within the auto-motive industry, the heat generated by vehicles in cities has been identified as a blind spot that has received insufficient attention in recent decades. With this thesis a possible strategy with examplary interventions to address this gap is derived to make a meaningful contribution. This executive summary outlines the different chapters which include strategies, solutions, and recommendations presented in the thesis to address this challenge. After the introduction and table of figures the following chapters are:

Chapter 3 – Background: This chapter introduces the urban heat wave problem and its impacts on urban ecosystems. It highlights the pivotal role of MINI in recognizing the challenge and aligning its strategies with the broader initiatives of urban development. Additionally, a comprehensive trend and context analysis, identifying the crucial role of automobiles in exacerbating this problem.

Chapter 4 – Design Process: Chapter 4 explains the Design Process of this Master Thesis in three diamonds, which involves exploration through research, envisioning potential futures and third, defining a strategy for action.

Chapter 5 – Stakeholder Analysis: In this chapter the outcome of Interviews conducted with both citizens and experts are presented, to shed light on the system's issues and deepening the understanding of the problems at hand.

Chapter 6 – Co-creation: To foster a co-creative approach, three workshops to facilitate dialogue and solution generation in collaboration with stakeholders where conducted.

Chapter 7 – Synthesis: In a final Synthesis a Strategy for MINI is presented with the goal to shift the mindset of citizens and vehicle users through a three step approach. The first step involves raising awareness on heat waves by providing information. The second step focuses on developing vehicles that minimize heat generation. The third and most transformative step encourages a change in consumer mindset towards a concept where individuals gain access to mobility in exchange for contributing to society. The overarching goal is to reduce heat in cities effectively and contribute to the larger city eco-system.

Chapter 8 – Conclusion: By aligning MINIs strategy with the city goals, advocating for sustainable mobility, and collaborating with stake-holders, MINI can strive to create cooler, more sustainable urban environments for all. With the transition of MINI towards an ecosystem mindset and active contribution to the fight against urban heat waves, a transformation of users and citizens mindset can be achieved (figure 1). The democratization of mobility through collaboration with city governments, citizens, and relevant stakeholders to determine the optimal vehicle solutions is recommended. The recognition that there is no one-size-fits-all solution underscores the need for a democratic approach.
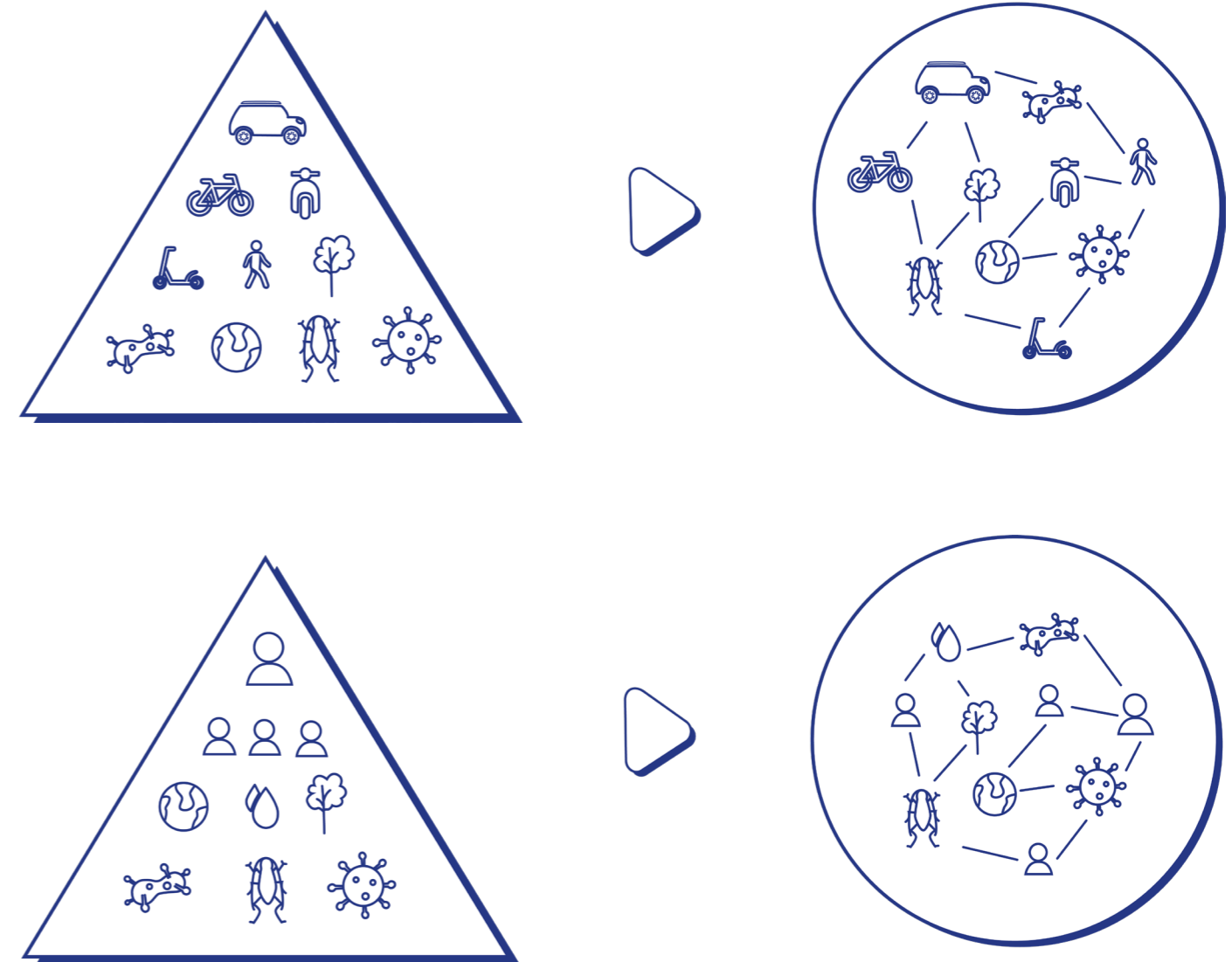

Figure 1 Changing mindsets from ego-system to eco-system

TABLE OF CONTENTS

1. TABLE OF FIGURES

2. INTRODUCTION

At the commencement of this project, headlines in April read: "Spain bakes in summer-like heat and worries about what comes next" (Méheut, 2023). As summer approached and temperatures rose, newspapers declared July the hottest month ever recorded. The Arizona Burn Centre was fully occupied due to people who fell on scorching hot asphalt (Indeka, 2023). Additionally, the UN secretary declared an end to global warming, instead stating that we are in the middle of global boiling (Niranjan, 2023).

Heatwaves are unusually long periods of consecutive remarkably hot days. One of the aspects related to urban heat concerns transportation. The challenges ahead on extreme urban heatwaves pressure the mobility sector and lead not only to increased mortality rates (Kovats, 2006) but also impact health, nature, economy, and infrastructure.

Combustion engines are contributing to the heat island effect, which means that urban areas experience higher temperatures than surrounding rural areas. Electric cars reduce the amount of near-surface air temperature by up to 0,6°C (Mussetti, 2022) and air pollution in urban areas. Due to air conditioning and the higher use of electricity consumption, individual mobility is still contributing to environmental problems during heat waves. Individual transport is criticized in many ways as a part of the urban landscape, but residents also want and need to move freely and some cannot do without, especially citizens vulnerable to heat, such as children or the elderly. It is estimated that 70% of people will be living in cities by 2050 (Nations, 2018). With more severe and frequent heat waves, floods, droughts, biodiversity loss, and air pollution, the question arises of how the urban environment needs to change to mitigate climate change.

Heat waves are part of wicked problems we are facing, which ask us to design "entirely new sociotechnical systems" (Price, 2019). To understand the complexity that comes along with heat waves – especially within the urban environment, methods such as systemic design are possible scenarios to understand the relationships between the actors that play a role in this complex ecosystem.

As the values of society are changing towards a more responsible and sustainable future, brands such as the BMW Group are asked to participate in the debate on future cities. This thesis aims to look at the well-being of citizens, the city, and drivers during extreme heat waves from different angles by moving from Design Strategy towards a Systemic Design approach. It aims to identify possible actions how the brand "MINI", which belongs to the BMW Group, can be an active participant in the fight against heatwave mitigation, translated into an actionable Strategic Roadmap for future engagement.

3. BACKGROUND

A)   CONTEXT OF SYSTEMIC DESIGN AND PLANET CENTERED DESIGN

Due to the complex nature of urban heatwaves, it became clear that traditional linear tools and methods don't provide enough answers to complexity. Systemic design is a combination of design thinking and systems thinking, which is often associated with change management. Complex sociotechnical systems can for example be governmental policy, environmental protection, healthcare, or transportation. As Norman and Stappers argue, designers should not stop at the design, but instead be an active contributor in implementation and solution finding (Norman & Stappers, 2015). Today, system oriented design is positioned closer to design practice as part of the design process (Sevaldson, 2017). Different tools of systemic thinking are therefore used to look at the problem of heatwaves. Generally systemic design is acknowledging the interrelatedness of problems to tackle complex societal challenges (Van Der Bijl-Brouwer, 2020). Where the practices of traditional product design work on product solutions, systemic design identifies the interdependencies in ecosystems and maps out interrelatedness. In this thesis, systems thinking is used as part of the design process to understand relationships in the city ecosystem and design for the ecosystem rather than for the human only. Instead of focusing on analyzing and visualizing the system map, insights were translated to tangible actions for the MINI brand, to overcome the theoretical gap to translate thoughts into practice.

As systemic design focuses on current problems and interrelations, Design Futuring was used in co-creation with citizens to help overcome the gap between the present and the future. Design Futuring is using Design Fiction to engage lay people and other stakeholders emotionally instead of using data and numbers to achieve this goal. Design Futuring uses as a design inten either, innovation, critical design, or speculative design as a tool to constructively discuss futures with criticizing actual misfortunes or desirable futures. As Kiialainen (Kiialainen, 2022) explores in her work, speculative design can be valuable for organizations as an intermediate step, to learn and discuss and afterwards bring the future back into the present day with product implications. Possible futures which are desired by the system stakeholders are explored and used to create an intervention roadmap.

During the process of the thesis, it became clear that the term "sustainability" is not disruptive enough within the context of this project
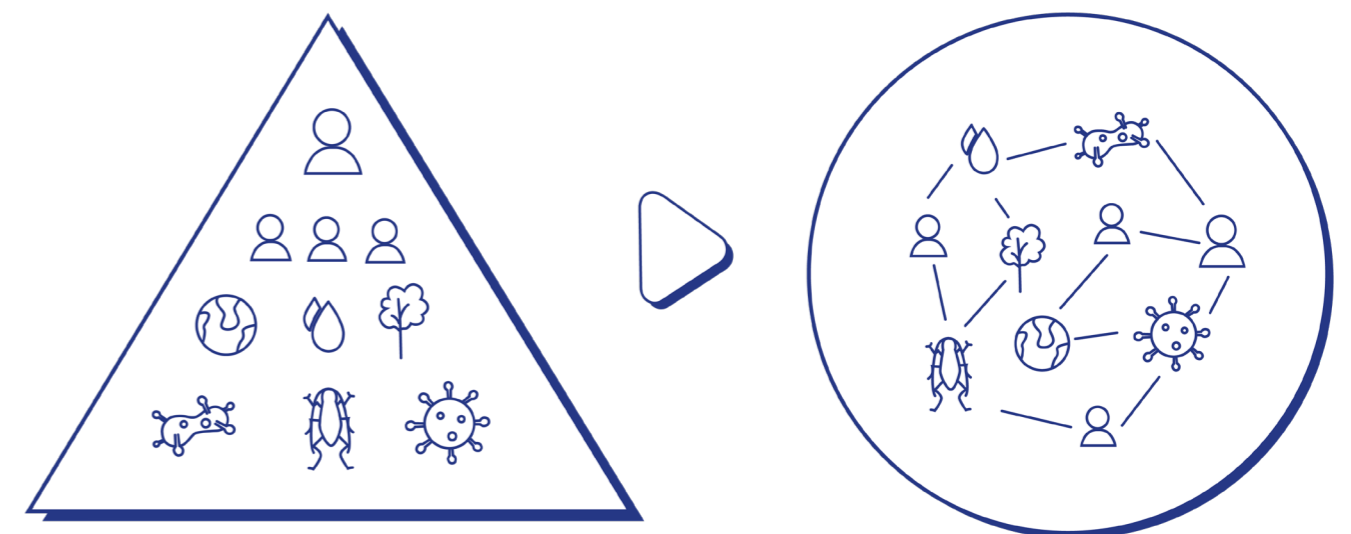
Figure 2 From ego-system to eco-system

(Waseem & Kota, 2017). For many years we have designed "human-centred", which most likely added to the climate crisis we are facing right now. We currently find ourselves in the age of the "Anthropocene", or the so-called "age of humans", where the human made artifacts exceed the biomass on earth and lead to a global imbalance. With systemic design, a transition of viewpoint is offered in this thesis, and an additional planet centered approach is used to find new solutions which take the entanglements of things into consideration.

Glenn Albrecht (Albrecht, 2019) proposes a transition from the Anthropocene to the Symbiocene, where the humans live in a symbiosis with all other beings. Planet centered design is challenging the current ego-system to change and instead serve the entire eco-system (Vignoli, Roversi, Jatwani, & Tiriduzzi, 2021). The term planet-centred design communicates the need of eco-entangledness and moves away from a product focus to an eco-system focus (see figure 2). Which means, that we need a shift in consciousness to not only care for ourselves and other stakeholders, instead to act in the interest of the entire ecosystem.

Which suggests that, from the standpoint of the consumer, we need to shift our perspective from one of exploitation to one of stewardship. This implies, from a commercial standpoint, to create value for the entire ecosystem, where profit and people are a part of the larger picture of the world.

Figure 3 The MINI Concept Aceman

B) CONTEXT OF THE BMW BUSINESS

The BMW Group with its four brands – BMW, MINI, Rolls-Royce and BMW Motorrad, is the world's leading premium manufacturer of automobiles and motorcycles selling into more than 140 countries. Sustainability and efficient resource management are central to BMW Group's strategic direction, from supply chain, production, and the end of use phase (BMW Group, 2023). The BMW Group is committed to the Paris Agreement (Nations U. , n.d.) and is aiming for Climate neutrality until 2050. The concept car "I Vision Circular" by BMW gives a glimpse into BMW's vision on sustainability and is exploring circular economy as a main driver for a future sustainable car (BMW Group Press, 2021).

In the context of the urban future, BMW is engaged in projects on future urban mobility concepts together with Los Angeles, Berlin, Beijing, Munich, Hamburg and Rotterdam, to understand the needs and challenges cities are facing, especially the fast-growing cities with congested infrastructure, traffic jams, air pollution and noise (BMW Group, 2021).
In cooperation with the city of Rotterdam, BMW is focusing on five different pilot projects to improve

the citizen's life. As the image of the vision of the city of Rotterdam (see figure 4) shows, the urban environment is changing and BMW is collaborating with cities to find answers those five topics:
1.   **Multimodality**: choosing different means of transportation to get from A to B the fastest
2.   **Traffic management**:   intelligent, connected vehicles for safer roads
3.   **Parking and Charging**: finding charging stations at any time
4.   **Green Charging**: Electric vehicles used for energy storage (BMW Group, 2021)

Due to the time limitation, this thesis is focusing on the MINI brand as one brand of the BMW Group only. The brand MINI, as part of the BMW Group, is known as the car born out of the Suez Crisis of the 1950s by engineer Alec Issigonis (see figure 5). He invented an economical compact car as an answer to the fear of an oil crisis (MINI, 2023). Today MINI is still striving to find answers to a complex world and is aiming for a sustainable future and for a fully electric fleet in 2030 (MINI, 2023). MINI is known for its urban history, as a small car which fits to urban needs and concept cars such as the MINI Vision "Urbanaut", and the Concept Aceman are explorations on future urban mobility (see figure 3, MINI, 2021) . This thesis aims to find possible actions for the changing urban environment and to one part of the current "polycrisis", which means that multiple crisis interact and create bigger harm than each one alone. Part of this polycrisis is climate change, which in itself consists of many different occuring problems. The problem statement for this thesis was framed to focus on heatwaves in the context of urban areas. Especially within mobility on the context of cars (see figure 6).

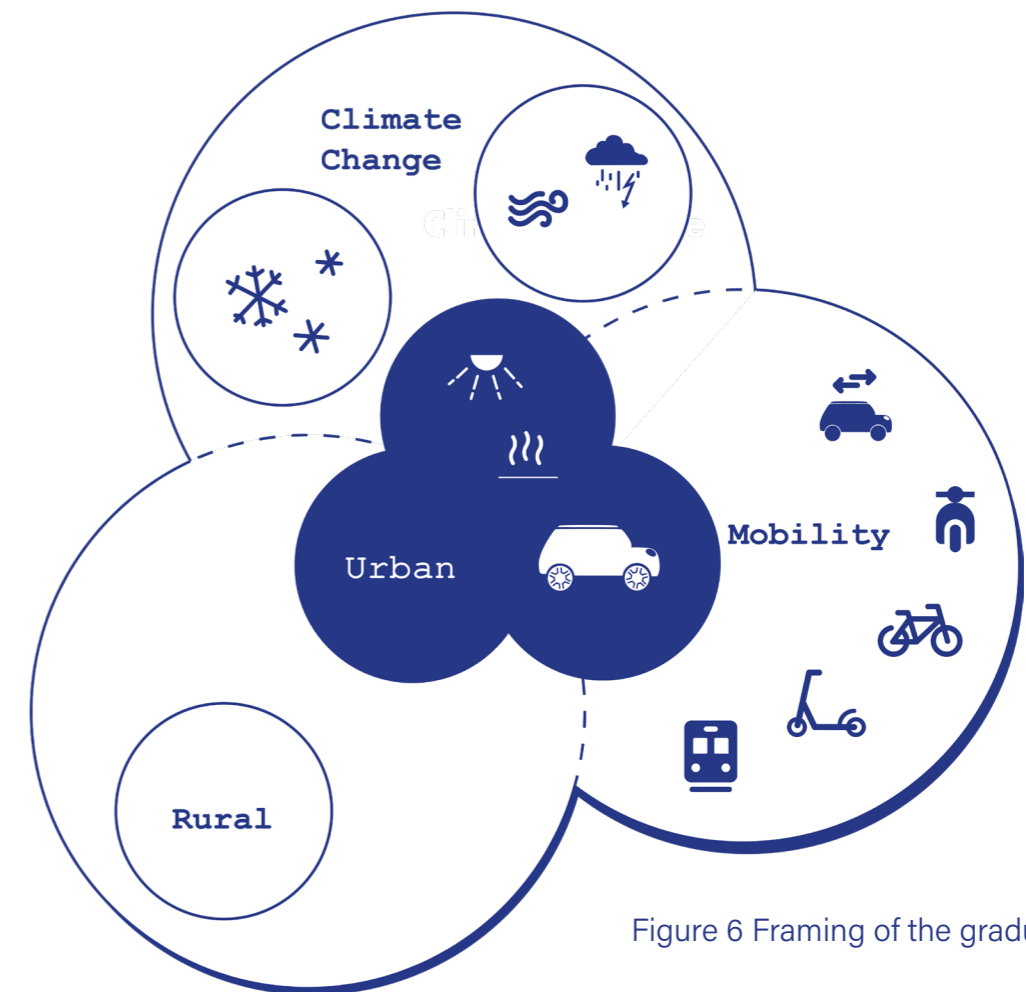Figure 5 Alec Issigonis sketch of the MINI and himself infront of a MINI
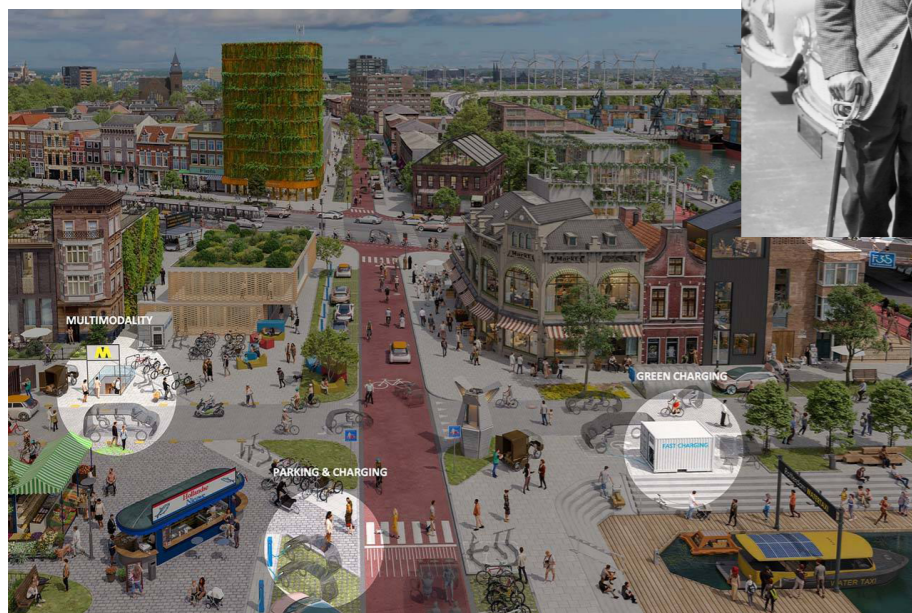
Figure 4 Future vision of the city of Rotterdam in 2030

Figure 6 Framing of the graduation project

C) BACKGROUND ON HEATWAVES

To understand urban heat, this chapter aims to provide a basic understanding of heat waves and how they arise. Heat waves are defined as "a period of unusually hot weather" (Merriam-Webster, 2023). Which means that in "a period of at least 48h during which neither the overnight low nor the daytime high heat index falls below the National Weather Service heat stress thresholds" (Robinson, 2001). The determined temperature defined as "unusually hot" depends on each region and varies from region to region. Extremely hot weather has become more common in our lives and are predicted to become more frequent and intense with climate change. Since 1884 the top ten warmest years occurred in the last two decades (Kendon, 2021).

Heat waves are also known as the "silent killers". In 2003 more than 70.000 additional deaths occurred in Europe during the summer (Robine, 2008). Projected annual deaths for 2100 without adaption are severe, especially in southern European countries. Forecasts estimate 90.000 additional annual deaths with global warming of 3°C and 15.000 with 1,5°C (Commission, Joint Research Centre, 2022).

When it comes to urban heat waves, higher temperatures are experienced in urban areas in comparison to the surrounding countryside and are also called the urban heat island effect. Urban temperatures can be 5-15°C higher due to this effect (Santamouris, 2013). The figure derived and modified from Yamamoto summarizes the different aspects that add to the urban heat island effect (see figure 7, adapted from Yamamoto, 2006). Increased urbanization and anthropogenic heat production and soil sealing by manmade materials such as asphalt or concrete, are the main causes of the urban heat island phenomenon (Mohajerani, 2017). The heat islands are caused by the changing environment of cities with less vegetation and evapotranspiration, as much as more dark surfaces with less albedo, which means to increase whiteness or the reflection of a surface (Data, 2023) and buildings that trap heat (Stone B. H., 2010). Therefore, the increasing

temperatures due to the urban heat island effect require a higher energy demand to cool down for example housing with air conditioning, which adds up to the heating of the urban landscape from air conditioning (Mohajerani, 2017). The boost of energy consumption accelerates urban air pollution and greenhouse gas emission during urban heat and contributes to global warming.
The different geographies of cities and architectures are also influencing the heat creation. Tall buildings for example can block the wind flow and emissions of heat energy which would speed up evaporation otherwise (Heat.gov, n.d.).

Additionally, it is to be considered, that different types of cities are also having different types of problems. To minimize travelling to supermarkets, work etc. condensed cities are better for heat than sprawling cities. Citizens of sprawling cities have additional problems in comparison to dense cites due to their exposure to ozone exceedance, poor water quality, fatal traffic injuries but also decreased physical activity and health problems from obesity (Stone B. H., 2010).

The influence of cars on the heat island effect plays a role as well. Therefore, the European Parliament has announced the "European Green Deal" to a climate-neutral society. For transportation this means to reduce greenhouse gas emissions by 90% from transport by 2050 and decoupling economic growth from the use of resources (Commission, EUR-Lex, 2019) to reach the goal.

Combustion engines are generally contributing to the heat island effect by air pollution and additional energy creation. The growing use of individual road transportation has increased greenhouse gas emissions which has impacts on the environment, direct and indirect health effects as much as economic effects (Requia, 2018). The European Environment Agency estimates that poor air quality led to 400 000 premature deaths yearly, through heart diseases and strokes. The increase of medical costs and damage on infrastructure, bridges, houses etc. as much as harming crops, soil, lakes, rivers, and forests (Agency, 2020). In 2019 about a quarter of the Europeans total CO_2 emissions was due to transportation, of which 71,7% came from road transportation. Thereof 60,6% greenhouse gas emissions came from cars (Commission, 2019).
It is difficult to calculate how big the impact of cars is, but due to research by Yang et al, data from the traffic restrictions during the Olympic games in Beijing in 2008 show a bigger impact of traffic on urban heat than expected. The research shows that the mean surface temperature decreased by 1.5–2.4°C from cutting off half of the traffic volume (Yang, et al., 2022). Calculations estimate that electric cars could reduce the amount of near-surface air temperature by up to 0,6°C (Mussetti, 2022) and air pollution in urban areas.
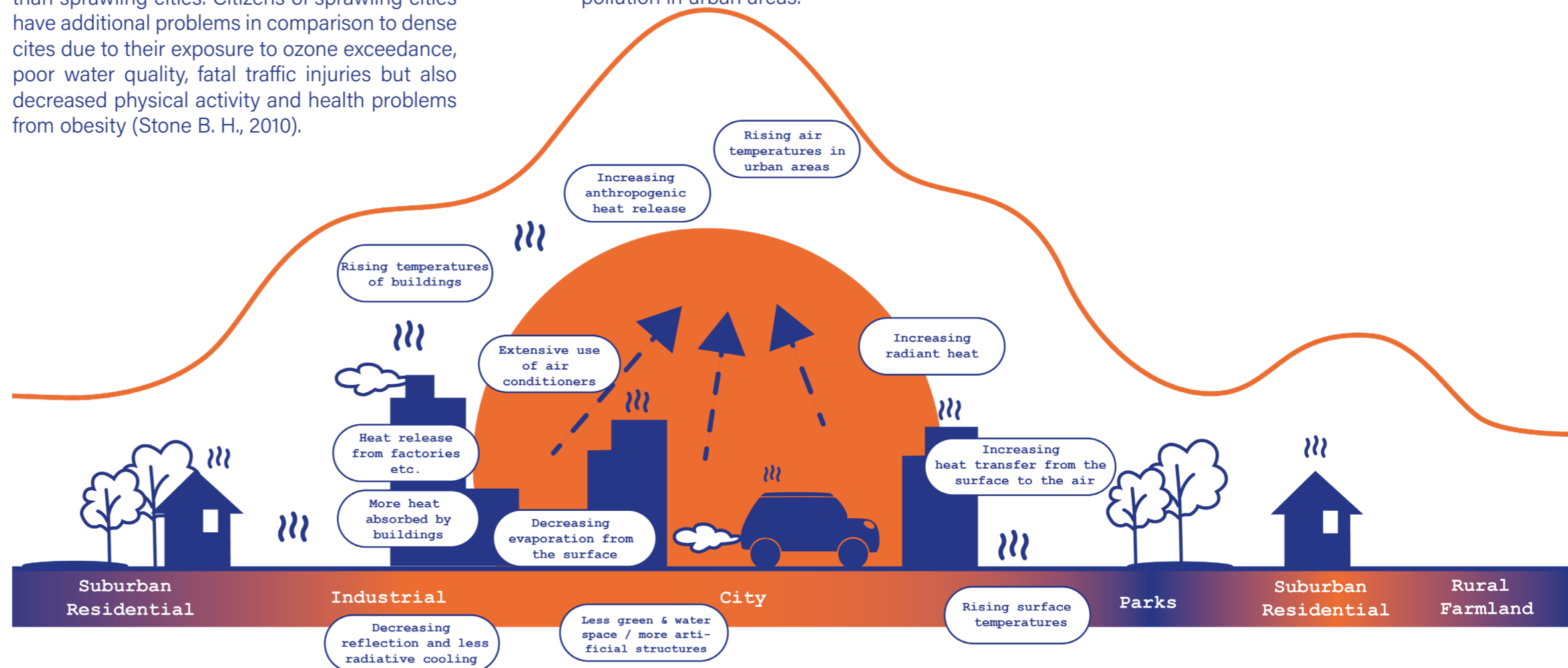
Figure 7 How the urban heat island effect occurs adopted from Yamamoto

C) I) HEAT WAVE EFFECTS ON HUMANS

Rising daytime temperatures and sweltering nights are increasing and are challenging especially citizens. Vulnerability to heat can affect anyone, however, specific groups such as young children and infants, older adults, pregnant women, people with low income and chronic medical conditions are particularly affected. These particular groups find it harder to maintain their body temperature at 37°C. Additionally, people who work or train outdoors, emergency responders but also pets are vulnerable to heat as well (Centers for Disease Control and Prevention, 2022) (Heat.gov, (n.d)).

Heat can lead to dehydration, heat exhaustion and heatstroke. Increasing the risk of heart attack and strokes, lung problems and other diseases (UK, (n.d.)).

A household survey by Laranjera (2021) (666 households) in southern Germany, Ludwigsburg has found that most of the heat-related health problems mentioned in the survey of the general public are:
1)   lethargy/exhaustion
2)   sleeping problems
3)   concentration problems

In addition to this, 11% state dizziness, headaches, or cardiovascular problems as a reoccurring problem when exposed to extreme heat. Furthermore, it was found that the lack of a private heat-protected retreat is linked to the identification of heat as a problem (Laranjeira, 2021). Low-income groups are generally more vulnerable to heat than others. Which also shows the study differentiating between 44% of low-income households, with at least one member suffering from cardiovascular problems, diabetes, or a chronical disease in contrast to only 1,7% of high-income groups reported to have sick persons or medical care (Laranjeira, 2021).

When it comes to mobility, generally, in summer more people are using bicycles than in winter. On the other hand, with temperatures above 28°C and humidity higher than 60% there is a decrease on ridership (Miranda-Moreno, 2011). Concrete and asphalt store heat, are slow in releasing it, can reach temperatures of up to 60°C and are threats to humans and non-humans (Mohajerani, 2017). Blow ups in streets, bursting tyres are results of increased heat on asphalt. But heat also affects railway infrastructures and especially in Germany, intense heat is felt in public transport (Laranjeira, 2021).
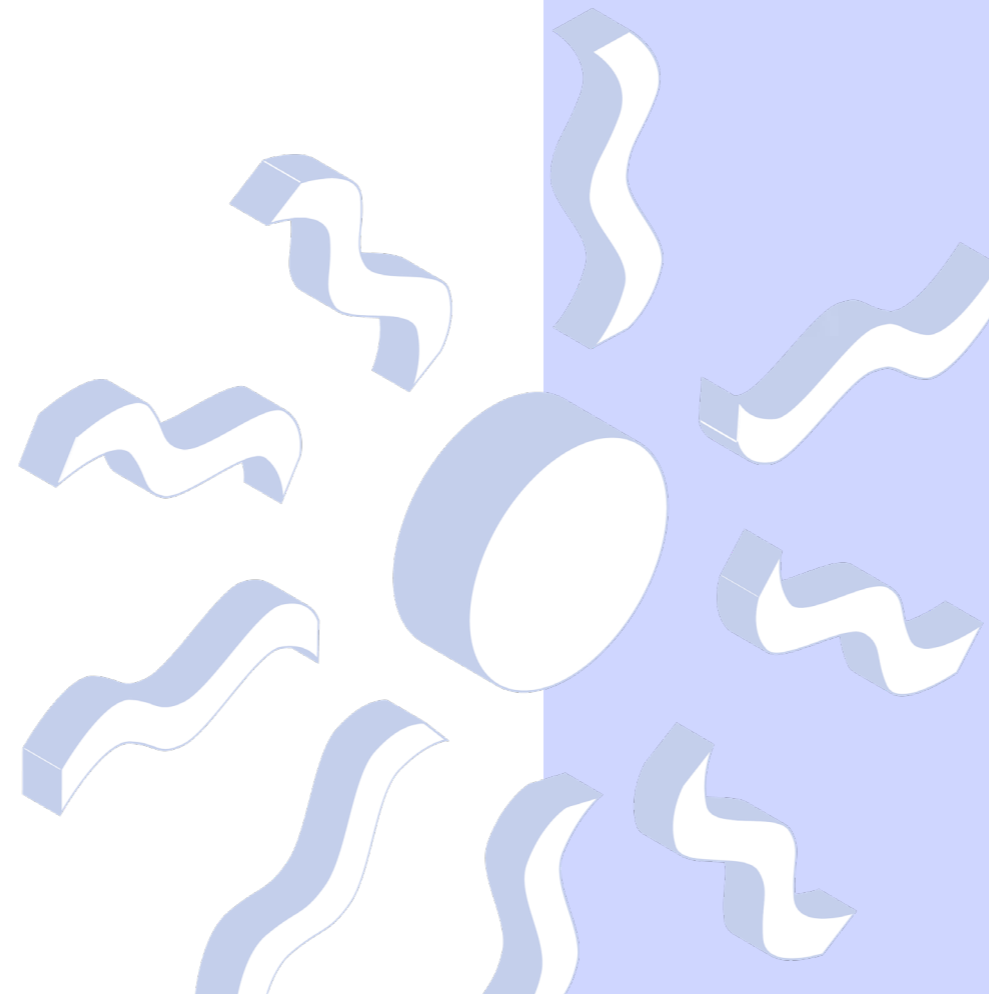
HEAT WAVES

Cities around the world are facing growing heat temperatures. As cities are heating up around the globe, many cities are trying out different experiments to reduce heat and the urban island effects in the city.

Those actions can be short term, such as heat alerts to inform their citizens about an upcoming heat wave, but are also educating on the risks of heat to sensitize the general public on the consequences of extreme heat. Athens for example is the first country to introduce a Chief Heat Officer to work on mitigation plans to ensure the future of the capital (Horowitz, 2021).

To mitigate the heat, but also to reach sustainability goals and make the cities more livable, many cities around the globe are working on more sustainable cities (see details in chapter 5.b). In the following this report gives some examples on how cities are responding to the increasing temperatures.

Generally, mitigating heat in urban cities can be categorized in changes to buildings and planting vegetation (Venter, 2020). Increasing albedo and planting more greenery can reduce temperature up to of 0,1°C–0,5°C and up to 0,6°C–1,0°C on a summer day, saving up to 400t–CO_2 per day (Hirano, 2016). Grass-covered parking is an additional improvement to reduce air temperature about 0,1°C (Takebayashi, 2009). To create more space for trees and greenery, cities are aiming for less cars in the center of the city to increase life quality by reducing noise, air pollution and in order to provide space for sustainable transport, more trees, shade and space to play and meet.
Barcelona is going through a major urban transformation by implementing Car-Free Superblocks (Ajuntament de Barcelona, n.d.) and other cities are following this innovative approach.
As heatwaves are becoming more severe Seville in Spain named its first heat wave in 2022, a tradition which is common for hurricanes but not heatwaves.

Increasing albedo by more reflective materials and even painting streets white as for example in LA are strategies to cool areas down.
Rotterdam grows greenery on rooftops to help keep the city cool. Medellin in Columbia has created a network of shaded routes, the "green corridors" across the city to provide cool space (World Economic Forum, 2023). Miami has figured that its bus stops are "death traps" and is planting trees to provide shade and Vienna is building "cool streets" with fountains to cool down the city temperature.
Cities such as New York City develop heat vulnerability indices which are mapped to identify populations vulnerable to extreme heat. Environmental and social factors in neighborhoods are associated with increased risk to protect people by creating neighborhood-level policies. By identifying those high-risk areas, resources can be added where they are needed the most. Factors which affect neighborhood heat vulnerability are temperature, air conditioning, green space, and poverty (NYC Government, 2023).

Within architecture, different new solutions are implemented, such as the Abu Dhabi Al Bahar Tower. These towers are surrounded by folding screens which open like umbrellas to shield the tower from sun. Architecture is also learning from areas which have been adapting to heat since they exist, as for example, Architect Diana Kellogg who worked with natural cooling materials such as tick sandstone bricks and smart ways to create circulating cool air for a Girl School in the desert area Jaisalmer in India by creating comfortable temperatures without adding air conditioning. Traditional jail-style lattice stonework (see figure 8, Dalzell,2023) passively cools the building. Rain-collecting techniques with underground cisterns, solar panels and parapets against wind help the building sustain the desert conditions (Dalzell, 2023).

With climate change, climate anxiety is also increasing. Cities are additionally working towards mental health and wellbeing in urban design (Roe, 2021). Concepts like "the restorative city Framework" (see figure 9) are redesigning the city from different angles to make the future

Figure 8 Diana Kelloggs passively cooled Sandstone School in India

city a city for healthy and resilient citizens. The framework includes to make the city more green, blue, sensory, neighborly, active, playable and inclusive.

Taking into account cultural differences, historic and infrastructure differences, heat mitigation

to deal with heat waves in their cities. General mitigation strategies are to keep the house cool and stay hydrated, avoid heat, outdoor spaces and strenuous exercises (UK, (n.d.)).

The awareness on heatwaves and its consequences is very low in Germany in comparison to the rest of the world. For the first

time in history, Berlin is installing publicly available cooling rooms for the summer 2023 (Trippel, 2023) which have been implemented for years in countries like the USA.

Heat-relief zones help to mitigate heat in the form of easily accessible recreational green areas. 56% of the survey by Laranjera consider to install air conditioning (Laranjeira, 2021). Which would again increase CO_2 emission (Lundgren K., 2013).

Public heat relief locations in Germany are the following:
- Public green spaces (forests)
- Public green spaces (parks)
- Catering trade locations
- (outdoor) swimming pools
- Public stretches of water
- Commerce locations
- Market spaces/pedestrian zones
- Playgrounds
- Other (Neht, 2017)

Figure 9 Restorative City Framework

strategies can be summarized in (see figure 10, adapted from Ichinose, 2008):

- Sun shading
- Rooftop vegetation
- Light surfaces/high albedo
- Indoor ventilation
- Process and building heat recovery
- District heating and cooling
- Minimizing heat loss
- Energy efficiency
- Opening green space
- Water surface
- Air corridors
- Easy public transport access

Many countries and cities around the world provide the residents with information on how

Figure 10 Heat mitigation strategies in cities

Electric Vehicles (EVs) are generally contributing to the reduction of greenhouse gas emissions. Due to air conditioning and the higher use of electricity consumption, individual mobility is still contributing to the amplification of heat in urban areas.

Citizens interviews where conducted to understand the problems people face during heat waves and is captured in Chapter 6, the Stakeholder Analysis. After conducting the interviews it became clear that heat creation inside the cars is also part of the systemic problem. To better understand which factors play a role, expert interviews within the BMW Group were conducted, as well as a literature deep dive, summarised and added to this background section.

Due to solar irradiation, cars are heating up and the cabin air temperature quickly rises up to 20-30°C above the ambient temperature (Lv, 2021). On sunny days this can be up to 80°C and 50°C on a cloudy day (Lahimer A. A., 2023). The front area just below the windshield can also heat up to 110°C (Internal Expert Interview). This is not only causing the heat island effect to rise but also increases risks to drivers and passengers. When cars are turned off, temperatures increase within seconds and cause threat to pets or children left in the car. A study showed that there is an annual death rate of 37 children in the USA due to lethal heat strokes, because they are left in the car (Horak, Schmerold, Wimmer, & Schauberger, 2016).

Today most cars have air conditioning to overcome the heat, but electric vehicles suffer a lot from high energy consumption and lose cruising range. Additionally, the use of air conditioning further raises the outdoor temperature in the city. There are only few studies on the impact of standing cars and their impact on heat creation in the urban environment. It was found that one of the most efficient mitigation strategies for the city center, is removing vehicle heat which could lower urban heat by 0.12° C (Zhou, 2022). Improvement on cabin temperature is therefore a necessity when it comes to heat mitigation (Lv, 2021).

Up to 75% of a car's interior is created by solar radiation through windows and 40% through the windshield alone (Lahimer A. A., 2023). The size of glass as much as the angle of reflecting sunlight through front and rear windshields play a role in rising temperatures as well (Internal Interview). The body color of the automobile should also be considered because it significantly affects how hot the cabin air is (Lahimer A. A., 2023). Thermal mass is another factor for rising indoor temperature. The higher the thermal mass, the longer it takes to cool or heat up the car, which also means additional energy consumption. For thermal mass especially seating plays a big role, due to foam which stores heat inside the material. The challenge is to find the optimal average between sustainable and light construction, energy efficiency and comfort. Looking at the average driving time of people, 30-50min are the general commuting time and only 4-5% drive over an hour. This means generally that the cost of cooling down a car is high in comparison to the driving time (Internal Expert Interview).

Additional factors that consume energy in a car regardless of direct sun or outdoor temperature are infotainment, assisted steering systems and lighting systems. On the other hand, heating, ventilation and air conditioning systems consume more energy depending on the outdoor temperature to cool or heat up the passenger compartment (Nastase, et al., 2022).

Electric vehicles generally need cooling as well, due to the maximum battery temperature of around 35°C. Cooling just by the environment is therefore not possible and additional air conditioning for the batteries is needed (Internal Expert Interview). In the future the heat creation of charging stations should be considered for urban heat creation as well (Internal Expert Interview). Furthermore materials inside the car are affected by heat and lose quality, such as rubber, plastic, foams, synthetic fiber or leather (Ciocanea & Buretea, 2014). Especially in new cars the smell of glues and rubber can affect occupants.

Phase-change materials (PCMs), solar chimneys, aluminum covers, solar-powered ventilation, and reflecting glass are among the most practical passive cooling technologies. Promising new engineered colors are the butterfly inspired colored film which could passively cool the cars (Newatlas, 2023). The soak temperature of breath-level air was found to be reduced by roughly 5–6°C by increasing the solar reflectance of a car's exterior by about 0.5, according to an experimental comparison of otherwise comparable black and silver compact sedans (Levinson, 2011).

According to Lahimer (Lahimer A. A., 2023), a solar chimney, a hot air outlet on the roof of the car, is the most effective passive cooling system in comparison to other solutions which could reduce the cabin soak temperature by 20,5°C. This can result in a significant impact on the initial thermal solar loads, which can reduce exposure time to high temperatures (thermal stress and anxiety), as well as improve interior air quality, increase vehicle fuel efficiency, reduce compressor power by 85%, increase driving range by 26.25 km in the city and 17.5 km on the highway while using the AC system, and lower tailpipe emissions while driving (Lahimer, Sopian, Razak, Ruslan, & Alghoul, 2019).

The following figure 11, summarizes all components of heat creation in the car, which are: sunlight reflection, color, size, glass surfaces, surface structure and materials, thermal mass, battery cooling, air conditioning, heating, infotainment, assistant driving, lighting. External sources such as charging stations should be considered as well.
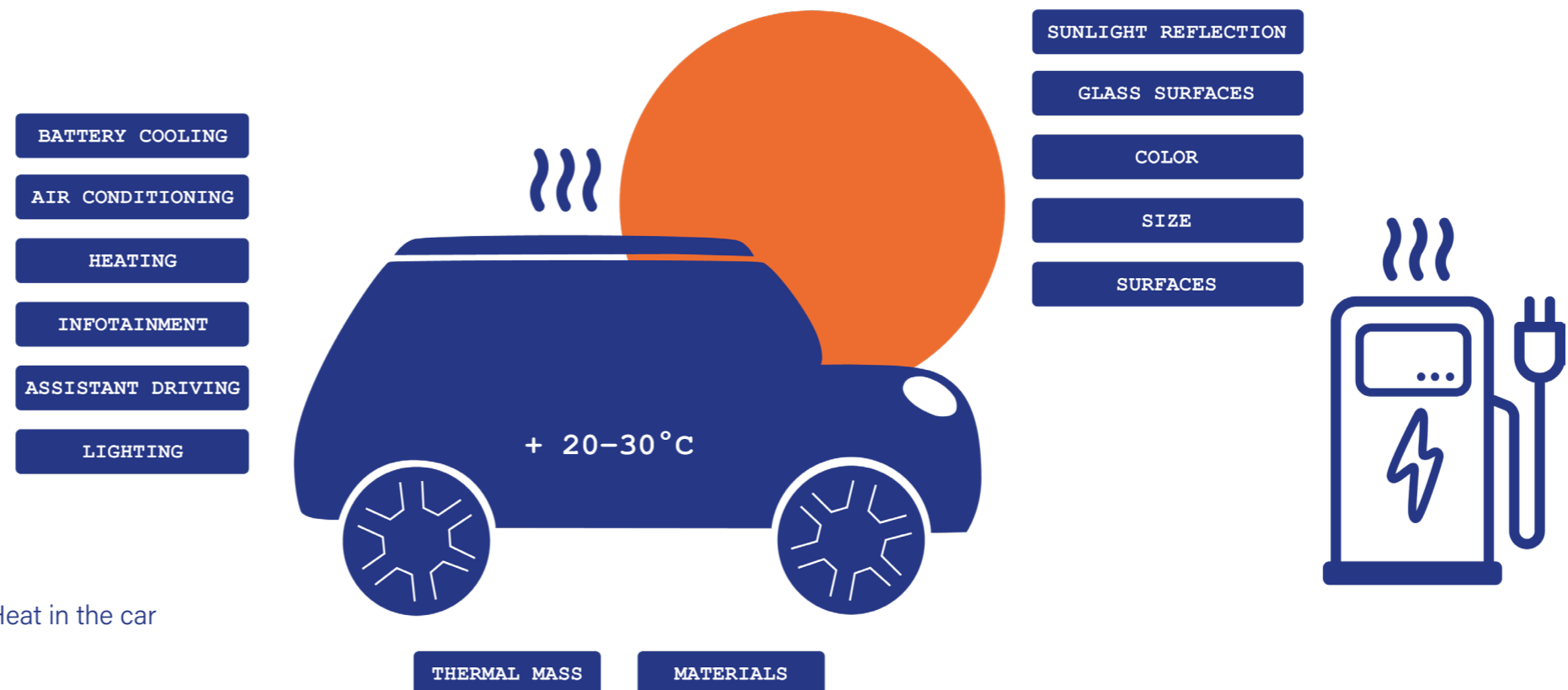
Figure 11 Rising Heat in the car

BATTERY COOLING

AIR CONDITIONING

HEATING

INFOTAINMENT

ASSISTANT DRIVING

LIGHTING

SUNLIGHT REFLECTION

GLASS SURFACES

COLOR

SIZE

SURFACES

+ 20–30°C

THERMAL MASS   MATERIALS

D) TREND ANALYSIS

To be able to make suggestions for the future, it is necessary to look at current trends in the mobility sector and how cities are changing in the future. During the 20th century mobility planning worldwide focused on the infrastructure of cars. To change mobility towards a more sustainable transportation, the "mobility pyramid" in Europe is turned upside down. This means pedestrians and cyclers become the central part of mobility instead of the cars (see figure 11 adapted from Pricewaterhouse Coopers, (Pricewaterhouse Coopers, n.d.)).

This concept was originally introduced 1994 by the German Parliamentarian report in the framework "Avoid-Shift-Improve", which categorizes transportation policy options to reduce environmental impact. This frameworks was later adopted more widely.

The categorization is divided in three parts:
1)   Avoid travelling at all, by reducing total distances
2)   Shifting to other low-emission modes
3)   Improving vehicles to less carbon-intensity and more energy-efficiency (Leroutier & Quirion, 2023)

Cities especially in Europe are already working towards this goal to have less cars in the center of the city and more space for the well-being of the citizens, but also to avoid further CO_2 emissions and pollution. Different strategies are implemented to get closer to this goal. Offering different means of transportation through multi-modal mobility opportunities, such as public transport or micro mobility is one direction. The intermodal urban transport and e-micro mobility in many cities are expected to grow further by about 20% per year through 2030. At the same time there is a value shift towards a declining fixation to car ownership. Car driver trips have declined by 36% per person by people aged 17-29, between 1995 – 99 and 2010 -14 (Chatterjee, 2018). Projected usage of private cars differ from country to country. Whereas sales are projected to decline in EU and US, they will rise in China and all other countries.

A survey with more than 4.000 European customers by McKinsey reveals mobility preferences of Gen Z, which is increasingly multimodal, but still hold on to private vehicles (Heineke, 2023) (see figure 12). Additionally, McKinsey is expecting the micro mobility market to double by 2030 (Heineke, 2023).

TOMORROW

WALKING & CYCLING

PUBLIC TRANSPORT

SHARED MOBILITY

CAR

TODAY

Figure 12 Transport pyramid inverted

Agencies such as Posad Maxwan, a global city development agency, is thinking of future concepts which dissects the street in different lanes, sorted by the speed. To create a safe mobility space for the growing multimodal mobility opportunities (Ditech Media, n.d.).

Due to the density of cities, the lack of available parking space and more sustainable mobility, many car owners are no longer using their cars daily, leading to many dormant vehicles within the cities, which are not moved for longer times (Spurling, 2020).
Experiments in cities around the globe are proving and showcasing the global change of cities. The prioritization of walking over driving is implemented in different ways. In Paris the 15 Minute City concepts or the hyperlocal, one-minute concepts based in Stockholm aim to make the city accessible and easy to reach supermarkets, doctors, parks etc. nearby without the need of transportation.
London is working towards "healthy streets" to reduce congestion, improve air quality and make the city more attractive to live and work (Transport for London, (n.d.)).

As a response to the changing urban environment the automotive market is changing as well. Looking at the market, there is a transformation of safety to be seen. As an example, Renault introduces the Concept Renault Scénic Vision, a mix of hydrogen fuel and electric engine which the company calls "the car in care". The concept works as a holistic safety concept to reduce accidents but has also additional features. Three main pillars are the "Safety Score", which analyses driving and gives tips for further improvement. The "Safety Coach", which warns on the road and the "Safety Guardian", which is an attention assistant also working with face tracking to analyze fatigue on the road (Aitamrouche, 2022). The concept of the Renault air purification system adds another safety and health-oriented feature to help drivers with allergies against pollen but also against potential viruses and pollution (cardesigntv, 2022). Tesla's answer to global warming and the

increasing heat is their so called "dog mode", where the car owner has the possibility to leave the air conditioning on, while going inside a supermarket for example. The message on the screen tells passengers who pass by that the dog left inside is doing fine and the car keeps its temperature at 24°C.

Very niche car concepts such as the Arcfox Kaola, which is focusing on the needs of parents and kids and the Telo Truck, an EV pickup for urban living and adventures at the weekend, are further upcoming Trends. More and more space efficient microcars are entering the market, such as the Microlino, the Citroen Ami or Fiat Topolino which are offering space efficient, affordable transportation. Many Microcars have a vintage feeling, taking over elements from their heritage. The citroen ami for example has flip windows like the original Citroen 2CV to create better air circulation.
The Fiat Topolino is an urban EV microcar for the city, with less emission, less space needed (2,53 meters) and less noise pollution. The car is meant to be for Gen Z who are looking for sustainable transportation solutions. With a maximum speed of 45 km/h, teenagers from 15 years on can drive the car. As the car is aiming for a "dolce vita" flair, it is meant to cater to the needs of southern European hot cities and comes in two versions – with doors or no doors. The car has very minimalistic furnishing, which can be individualized. It has no air condition, but a ventilator can be added or a shower. The closed version has an additional sun visor protection. All accessories fit the interior, such as a bluetooth music box, a ventilator, an insulated bag for hot or cold drinks (see figure 13, derived from Netcarshow, 2023). Cheaper and more efficient production is assured by interchangeable parts such as for example the doors, so they only need to fabricate one door model for the left and right side (Serban, 2023).

Furthermore car manufactures enter the multi-modal market and design different cargo bikes, trikes, scooters etc. Bike manufacturers are
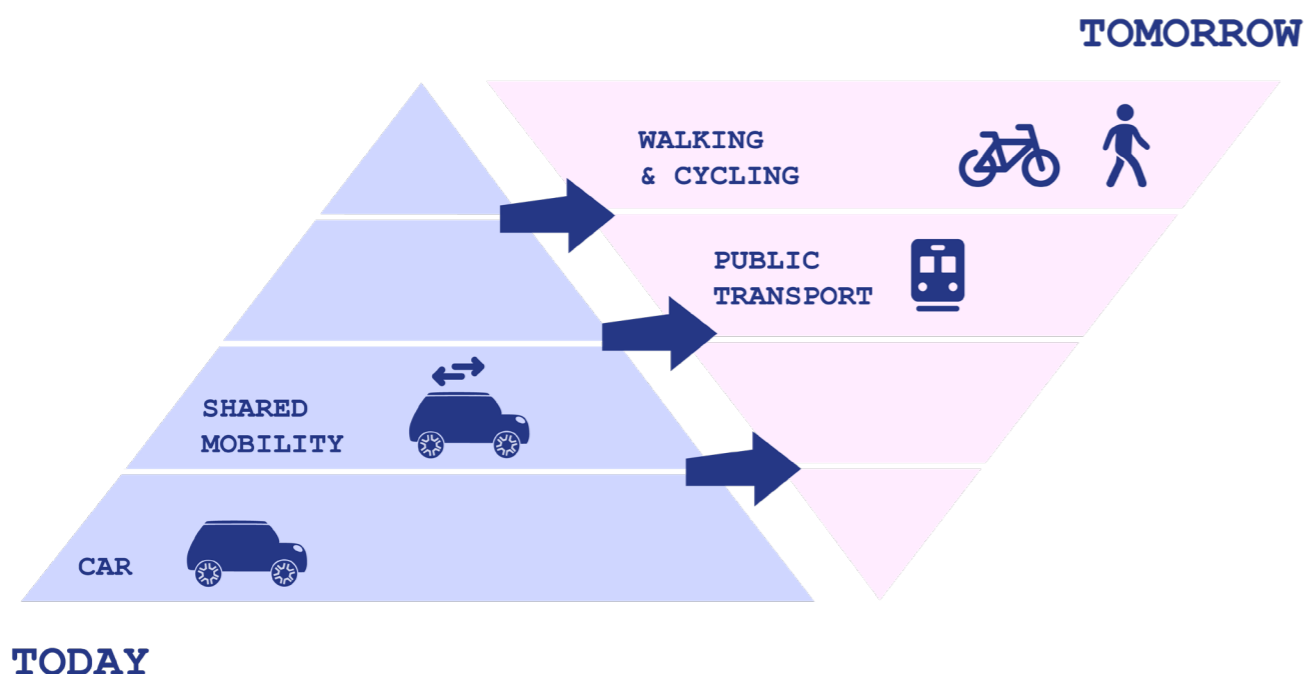
additionally working on answers to new needs such as the bike manufacturer Canyon working on a pedal powered trike (WGSN, n.d.)

MINI has offered multimodality options such as fa olding bike before and has just launched a collaboration with french e-bike manufacturer Angell, offering a MINI E-Bike in the future (Hundert, 2023).

Figure 13 Fiat Topolinos answer to the changing city needs

The transformation of urban mobility is complex due to its historic background, infrastructure and many forces that are intertwined with the topic. To not out on other influences it is important to get an overview of the related environment. Therefore a methodology often used in design foresight was used to summarize different phenomena and trends.

The strategic trend scanning technique STEP (an acronym for Social, Technological, Economic and Political) was extended by Demographic and Ecological Trends and is therefore called DESTEP. The DESTEP methodology helps to understand the change of a business environment and its trends from six different angles (Simonse, 2018). Those are Demographic, Economic, Socio-Cultural, Technological, Ecological and Political forces to understand and analyze the context.

Demographic Forces
Worldwide the population is aging which is challenging cities and communities. The world's population of over 60-year-olds will nearly double between 2015 and 2050 from 12% to 22% (WHO, 2022). With the heat waves in many areas around the world other threats such as heavy rainfall or droughts and wildfires come along which could adversely affect humans. The additional anxiety and mental health problems are further consequences which should be kept in mind. 30,7 Million people around the world were displaced by floods, windstorms, earthquakes, or droughts in 2020 alone and the number of climate refugees could double by 2050 (Union, 2021).

Economic Forces
We are finding ourselves in a "polycrisis", where multiple crisis interact and create bigger harm than each one alone. We are living in uncertain times. The current Ukraine war, inflation and the energy crisis are influencing our daily lives. Society is feeling financially insecure. Prices are rising in every sector and wealth inequality is rising too.
Consumers are demanding strategies beyond Net Growth and have a general growth skepticism. Companies answer by transforming into cultural incubators and a shift in status, connecting intellectually via sponsoring awards, educating etc. Old paradigms and values are challenged. The art collective MSCHF for example challenged the assumption of "big" equalizing "valuable"

with a microscopic handbag which was sold for 63.750$ (see picture 14 derived from Russh (Dimitroff, 2023)).

Socio-Cultural Forces
One of the consequences of the growing uncertainty through the crisis is the rising Prepper Culture which is no longer only common in the USA but also in Europe. People are feeling more insecure and therefore want to arm themselves against what there is to come. They are not only preparing for catastrophes in their houses but also in their cars for example for snow storms (Lennart, 2021). This is also resulting in new fashion trends such as chinese street wear which is taking sun protection to new dimensions. The so called "Facekini", swimwear for the face is now trending at Chinese beaches.
A general sense of urgency to our ecological crisis is affecting the general public and no longer only activists. Movements such as Fridays for Future have awakened the general societies sense of urgency. "The last generation" is taking it to a different extreme, not only creating sense of urgency but also anger and frustration. Communities are taking more and more action within the cities and create out of the box ideas to get back the space in the streets. Residents of Stuttgart, Germany for example created a mobile park bench as a vehicle to be allowed to park anywhere within the city centre (Spiegel, 2023).

Technological Forces
The rapid growth of daily emerging topics within the technology sector is changing the mobility sector as well. Ranging from new materials, which are more sustainable, to Artificial Intelligence, Quantum Computing, the Metaverse, NFTs or even Biotechnology are technologies which have an influence on all the industries worldwide and are pushing for example automated driving. The possibility for technological advancements such as 5G enables more connectivity within the city. The smart city approach employs technology to build intelligent systems that offer holistic solutions to urban challenges.
Examples such as the "City Brain" by Alibaba are showcasing how technology can help citizens shorten commutes and improve traffic. With the help of artificial intelligence, cameras, GPS data on cars and buses (Toh, 2019) are monitoring air pollution (Jamil, 2015). The responsive city

approach goes even further and places the human as a social and cultural being in the center of action. Where technology supports the citizens in designing their city (Zukunftsinstitut, n.d.).

Ecological Forces

For past generations climate change has always been very abstract and unrelatable. Due to floods, droughts and fires the contemporary generations are affected by climate change in their daily life. In a current study 59% of 10.000 young people age 16-25 said they are extremely worried about climate change, 84% are moderately worried (Whitlock, 2023). Climate anxiety can lead to mental health problems and is already linked to suicidal thoughts and substance use (Clayton, 2017). Health and wellbeing related topics are becoming more and more important, and consumers are more aware about their health due to technology. At the same time society is avoiding technology in episode for example by social media detoxing. Additionally, people are becoming more aware of the human alienation from nature and work towards rewilding the city, but also, to reduce their carbon footprints and set statements against the fast paced, productivity oriented and capitalistic societies. Organizations such as the Nap Ministry use Sleep not only to gain energy but to use it for activism and resistance (The nap ministry, (n.d.)). Tech companies foster low tech and reduce energy consumption such as company "Dalkia" who put an expiry date to their Instagram posts.

Political Forces

With the European Green Deal aiming for a climate-neutral society, reducing greenhouse gas emissions by 90% from transport by 2050 (Commission, EUR-Lex, 2019) it is clear urban mobility needs to transform. Additionally, the "vision zero", the goal that no deaths and serious injuries are happening on European roads by 2050 are further changing the automotive landscape. Cities are pushing towards sustainable city development and are investing into public transport and other multimodal opportunities, such as Germany introducing the nationwide 49€ ticket for public local and regional transit. Other new political concepts from China are "social credits", where residents can earn credits for fulfilling tasks and duties in their community. Which might also affect their social lives, jobs and other.
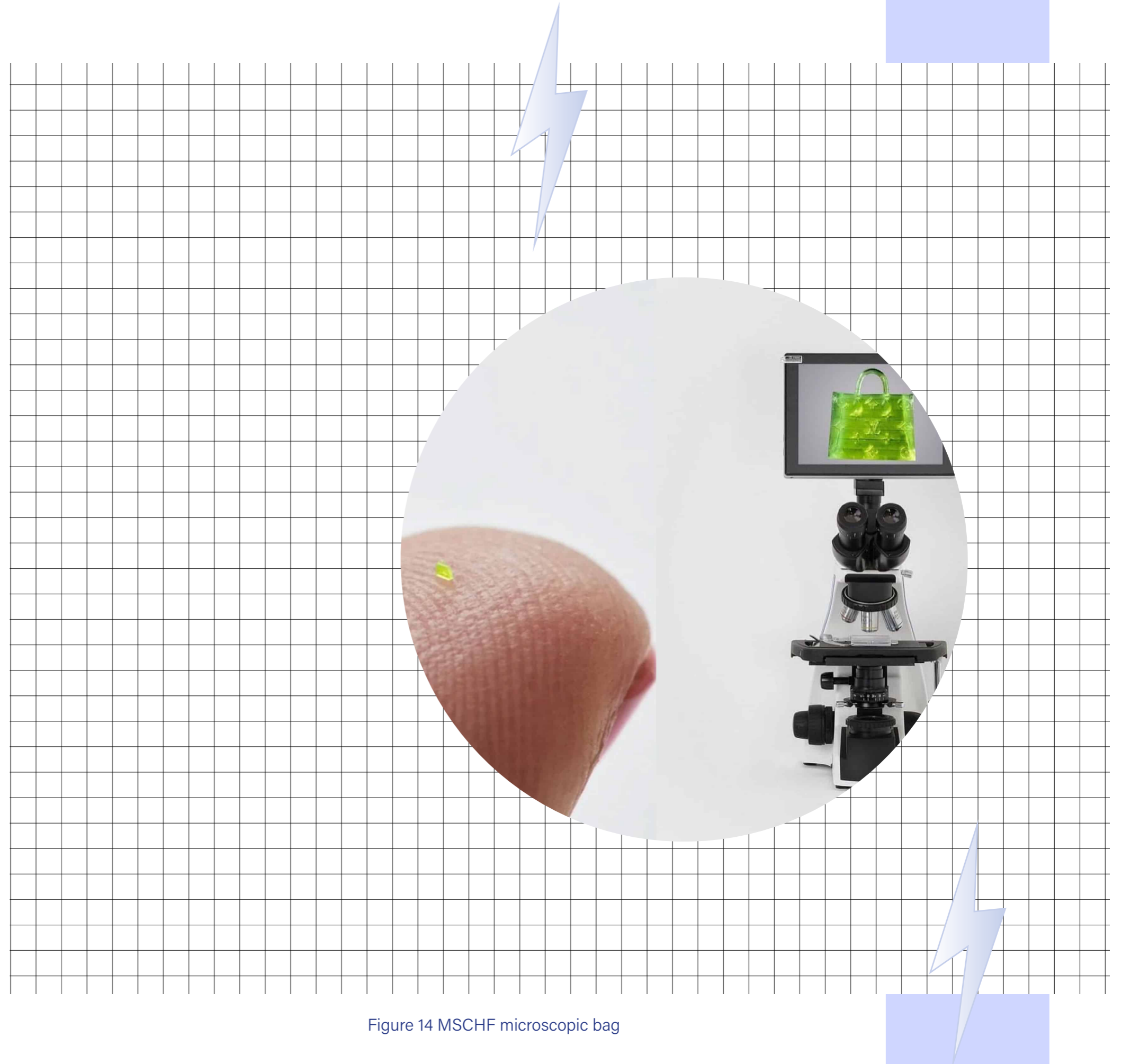
Figure 14 MSCHF microscopic bag

4) DESIGN PROCESS

The process of this Masterthesis can be divided into three diamonds, moving from exploration to imagined futures and resulting in strategy implications (see figure 15 adapted from Groß & Mandir, 2022). Before starting the project, the scope was defined as „How can technological advancements empower BMW to act upon the well-being of citizens and the city landscape of urban heatwaves?" A first deep dive into the topic of heatwaves was necessary to make the problem statement more concrete.

Exploration
The first exploration part contains the background research. To better understand what heatwaves are and what cars have to do with it. External Interviews with heat wave affected citizens were conducted to understand which dilemmas people are facing during heat waves, how people are affected in their daily lives and their mobility and car usage during heat waves. Furthermore, internal and external expert Interviews were conducted to understand the system of stakeholders within heatwaves. Additionally, it was explored what the BMW Group was already doing and where it was possible to engage.
A Trend Analysis completed the exploration part, to not miss out on other factors which influence the potential outcome of the project.

Imagined Futures
The gathered output from the interviews was transferred into assumptions, to further define the research problem. It was found that driving cars are a major contributor to urban heat waves, but furthermore that dormant cars are also contributing and the awareness is pretty low on the topic. The gathered insights from experts and laypeople were validated during a first internal workshop and consolidated into the problem statement: How can MINI be an active participant in the city ecosystem to fight against urban heatwave mitigation?
A future workshop with citizens of Munich was conducted to move the discussion from the present to the future. To get a better understanding on how citizens imagine their cities' future.

Different Narratives were explored and tested with citizens by the creation of artifacts. Using the insights gathered during the workshop, a roadmap was created to make suggestions for future interventions and make discussions more concrete.

Strategy
The interpretation of the results was derived into three concrete concepts. These were validated within a third workshop between the city of Rotterdam and the BMW Group. The insights were used to iterate on the roadmap to define which concepts have the biggest potential to be used as conversation starters. All insights were derived into a booklet of snackable bites to create more awareness within BMW and get the conversation started internally at the Design Department.

EXPLORATION
What is happening?

IMAGINED FUTURES
Which futures should be developed?

STRATEGY
What should be done?

Desk Research — Interviews — Scenarios — Narratives — Shaping opinion — Transformation

Start — Assumptions — Artifacts — Goals & Actions
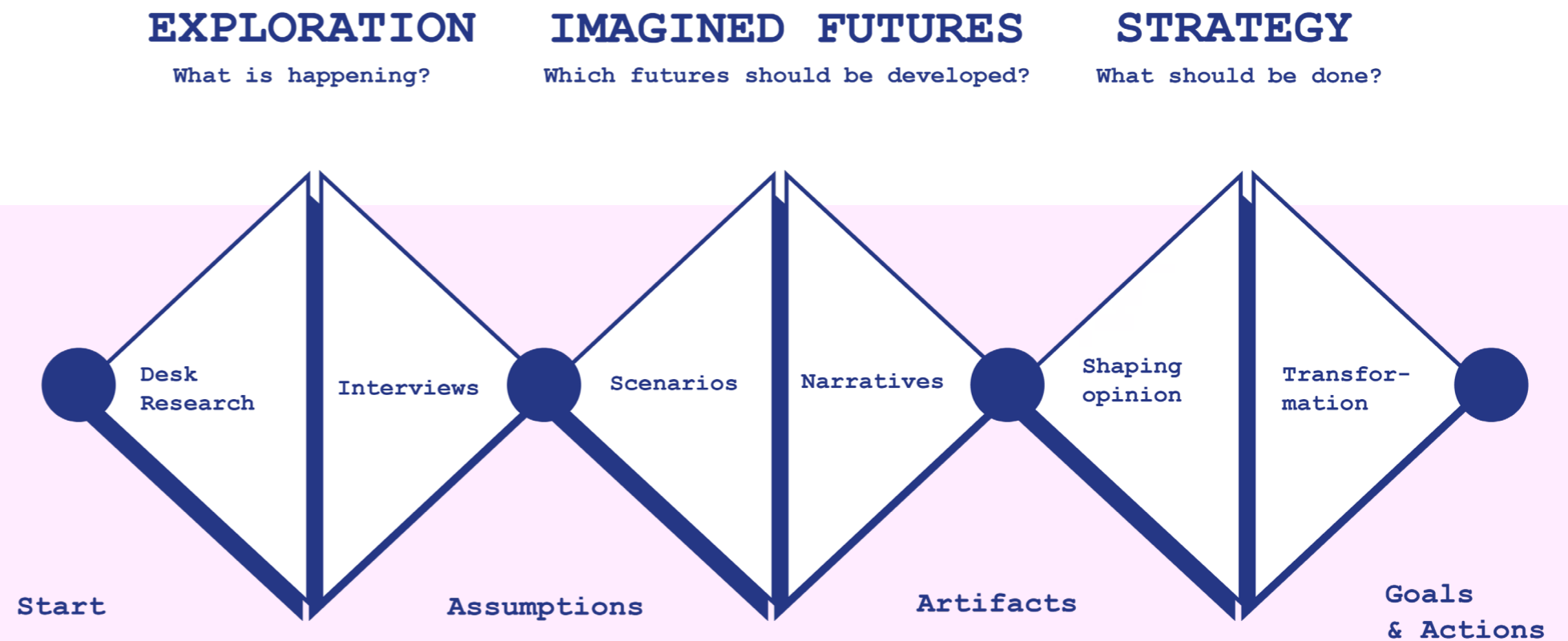
Figure 15 Altered Design futuring process from Groß and Mandir

5) STAKEHOLDER ANALYSIS

During desk research the different stakeholders of heatwaves were identified to later conduct interviews with the different actors. Those stakeholders are:
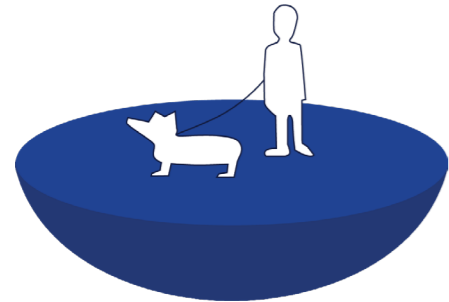
1) Citizens and heat vulnerable groups such as children, elderly, pets and outdoor workers
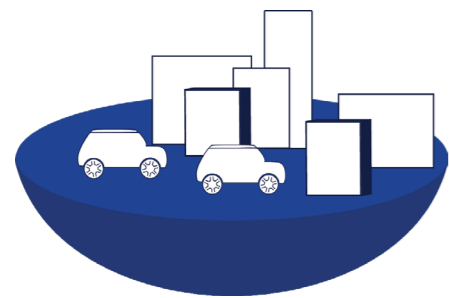
2) City planning and architecture
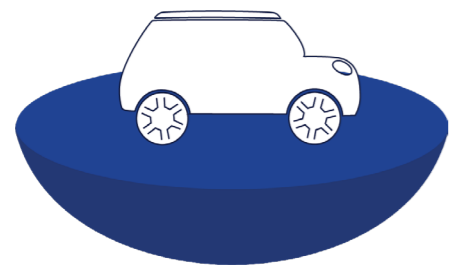
3) Mobility such as cars, public transport, multi-modal options
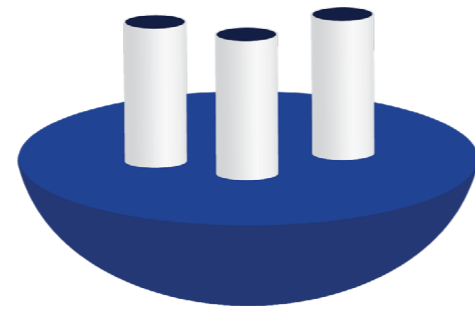
4) City management and house owners

5) Laws, regulations and politics

To understand the problems and needs of all stakeholders, different Interviews were set up to get views and insights from all perspectives. First Experts within BMW were interviewed to gather insights on the current internal developments. Afterwards heat wave affected citizens around the globe were interviewed to understand the urgency, needs, learnings and global perspective from citizens. Thirdly, citizens from the city of Munich were interviewed to get a better perspective on the needs of the "Dreimühlen-viertel", to get insights before a workshop was conducted in that specific district.
Additionally, Experts from the Industry, from architecture, city and law were interviewed to understand how things are entangled.
In the following the insights from citizens who have been affected in the past by heatwaves are gathered to verify the initial hypothesis created through desk research.

A) STAKEHOLDER RESEARCH

To properly understand the system of heatwaves, citizens who have experienced heat waves were interviewed about their experiences and needs to find answers to the question – How can we design mobility for the well-being of the citizens in the light of urban heat waves?
Therefore, questions on citizens' mobility behavior during extreme heat were asked. What are problems, dilemmas, fears and needs when it comes to heat waves and mobility? In addition, the first hypothesis, if cars are used as a heat retreat space was tested.

The goal of this stakeholder research was to get an idea of the effect of heat waves on people's lives and mobility behavior. To understand the urgency and the system of heat waves in urban areas, first interviews with citizens where conducted who have experienced heat waves in the past. Since especially northern Europe's heat wave frequency has not reached an annuity yet, people from different countries and continents were recruited to learn from more experienced citizens and the differences between them. People from metropolitan areas who are using (e.g. shared) or owning a car were selected.
A sample of 11 citizens of urban areas (7 female, 4 male – see table 1) were interviewed through convenience sampling, as well as 4 Experts from the industry. All interviewees were sampled through the BMW network, friends, and snowball sampling (Johnson, 2014).

B) RESEARCH METHODOLOGIES

The 15 in-depth interviews took approximately 60 minutes. A semi-structured interview approach was followed with a prepared interview guide for the citizen interviews (see Appendix A). For the expert Interviews an explorative Interview was conducted. All of the interviews were conducted with the internet-based conversation tool Microsoft Teams, making it possible to meet people face-to-face regardless of where they were situated. Before the Interviews, all Interviewees received the informed consent form and a sensitizing booklet (see Appendix B). Unfortunately, only 3 participants sent back the sensitizing booklet which would be recommended for future research.

The coding of the citizens interviews was structured and collected in Microsoft excel and coded in 4 Cycles. The coding of the expert Interviews was done in a Miro board (see Appendix C).

NO	Country	City	Suburb	Gender	Car Usage
1	China	Shanghai		female	yes
2	USA	LA – Santa Monica		male	yes
3	Germany	Berlin	X	female	yes
4	Great Britain	London – Paddington	X	female	no
5	USA	LA – Thousand Oaks	X	male	yes
6	Australia	Brisbane	X	female	yes
7	Great Britain	London	X	female	shared
8	Israel	Natanya	X	female	yes
9	Germany	Munich		male	yes
10	Germany	Munich		male	no
11	Germany	Munich		female	yes

Table 1 Citizen interviews

NO	Country	City	Profession
1	Australia	Sydney	Architectural Lawyer
2	Germany	Berlin	Urbanist
3	Austria	Vienna	Activist
4	Germany	Munich	Sustainability city manager

Table 2 Expert interviews

C) RESEARCH LIMITATIONS

The findings of this study should be viewed with caution due to its limitations. Due to the limited context and research participants the generalizability of the research is limited. The sample is not representing the wider population and the expressed views are not generalizable or representative of the experiences of people from diverse social and cultural backgrounds. A second limitation comes with the sample profile due to the convenience and snowball sampling of befriended friends who share similar values and make the sample homogenous. Additionally, the self-reported data shows a high participant bias, a friendliness bias and social desirability bias. Researcher bias such as confirmation bias, question-order bias and wording bias are likely as well.

A larger sample size was beyond the scope of the study but would be recommended for future studies in this area to get a larger and more diverse number of participants.

D) INSIGHT OVERVIEW

Insights from Citizens

The sense of urgency for the topic depends on the countries and cities. Cultural differences play a big role when it comes to heat. For citizens of countries such as Israel and Australia, where heat is part of their daily lives and have already adapted, it is not as big of a big topic as in countries who are new to heat, such as Great Britain. Here architecture, city landscapes and culture which have not yet adapted to heat waves play a big part. In UK for example weather is part of people's daily Smalltalk and the citizens are making jokes about their ability to deal with heat with, for example, memes (Ausrys, 2019).

People mitigation Strategies

People are adapting and finding strategies to cope with climate change. Depending on the severity of the heat, people are adapting their daily lives to cope with it. They are finding different heat retreats such as going to green space, finding shade and cooler areas such as air-conditioned supermarkets or places with water. Adaption is also taking place inside the house to protect the house from heating up, adapting one's wardrobe but also by completely avoiding and changing schedules and behaviors.

City problems

During the interviews it became clear that many people are not aware of which climate adapting strategies their cities are following, or if one exists at all. They usually do not know what the cities are planning to mitigate climate change and especially heat waves.

Some cities have communication strategies and are raising awareness about heatwaves for citizens and remind them to drink enough water and find areas to cool down. Water fountains or misters and drinking water fountains are increasing or experiments with higher albedo by painting the ground for example. Concepts such as the 15-minute cities, to densify infrastructure and make it more available are known as well.

The problems that come along heat are diverse depending on the city and country people live in. Humidity, wildfires, floods and droughts are different additional problems that occur.

> "NORMALLY THE FIRE SEASONS ARE LATER IN THE YEAR, YOU KNOW, BUT NOW BECAUSE IT'S SO HOT, IT'S LIKE ALL YEAR ROUND." (INTERVIEWEE 5)

This causes higher energy prices, higher water prices, rising insurance and health issues. Mental health, but also skin cancer, mosquitos and diseases are part of it.

Most of the interviewees are also connecting heat with social injustice. Air conditioning also means a higher energy demand and therefore higher prices. The energy and water bills are increasing and threating all interviewees around the world. The additional anxiety and mental health problems are further consequences to keep in mind. The concern about poorer neighbors and districts were addressed by most of the Interviewees. Especially rent in areas close to water or green space are higher than in concrete areas.

Poverty is part of heat vulnerability but other groups such as elderly, children, pets and pregnant women are having a hard time during heat as well.

> "WELL, LIKE I THINK (IT) ALSO AFFECTS MY DOG A LOT BECAUSE IF I TAKE HIM TO THE PARK AND EVERYTHING, BY THE TIME WE GET BACK, WHERE HE SITS GETS REALLY HOT AND HE DOESN'T HAVE SHOES, RIGHT? LIKE, SO HIS FEET JUST WOULDN'T TOUCH IT."
> (INTERVIEWEE 1)

Many interviewees are complaining about missing green space in a concrete jungle. Sometimes if there is green space, it gets dried out and yellow during summer. In some countries it is just not allowed at all to plant for example grass, due to water shortages. Often water areas such as lakes or swimming pools are overcrowded and private pools cannot be used due to high water prices.

Mobility issues

In many cities safety is still an issue when it comes to alternative mobility opportunities. Infrastructure to use the bike or other multimodal opportunities are missing, due to the lack of cool green space and safety infrastructure. Not only due to cars, but also for example scooter, skating and rollerblading are not designed to be able to be used on the same lane.

> "PLUS, I ROLLERBLADE, SO AT THE MOMENT THE PROBLEM IS, I WOULD LIKE TO SKATE MORE OFTEN TO THE OFFICE, OR BACK FROM THE OFFICE. BUT THE CYCLISTS ARE REAL ANIMALS WHEN IT COMES TO WELCOMING OTHER BEINGS APART FROM BIKES ON THE BIKE LANES." (INTERVIEWEE 7)

Especially in big countries such as the USA or Australia public transport is barely available. In Europe Public transport is often a problem when it comes to heat. Missing cooling systems in buses and underground make it unpleasant to use.

> "I AVOID PUBLIC TRANSPORT BECAUSE IT'S EXTREMELY HOT, BECAUSE IT'S NOT AIR-CONDITIONED (...) SO I AVOID IT ANYWAY, IF I CAN. BUT ESPECIALLY WHEN IT'S HOT, BECAUSE IT'S SO CROWDED AND SO HOT IN THEM. YOU DON'T DO THAT TO YOURSELF." (INTERVIEWEE 3)

Additionally public transport is often very expensive, and people are calculating which opportunities are the cheapest. Car sharing is for many still too expensive. But some are sharing their rides, testing new shared mobility opportunities with cars, scooters, or e-bikes. Not only because of eco-consciousness but also because of social consciousness. One example for this is TURO, an air bnb like car sharing opportunity. One interviewee also thought about sharing a car with less wealthy neighbors to share expenses based on income (Interviewee 7). Depending on the city sometimes owning a car is the cheapest and quickest opportunity to get around, for example in LA.

When it comes to heat there is a difference between hot days and extreme heat. Generally, people avoid walking, due to the burning sun and missing shade. During hot days interviewees prefer anything "with a breeze", like bikes or scooters in early mornings or evenings.

"SO IF IT'S MORNING AND EVENING, I WOULD SAY THE BIKE BECAUSE IT'S A VERY PLEASANT JOURNEY AND ESPECIALLY WITH THIS ELECTRIC BIKE, I'M REALLY DISCOVERING THAT IT DOESN'T NEED TO BE SO PAINFUL. UM, AND THEN IF IT'S A LUNCHTIME, OR IF IT'S A SUPER SUPER HOT DAY, THEN I WOULD GO IN THE UNDERGROUND AND IF I CAN WALK I CAN. I HAPPILY WALK, BUT THEN YEAH, IT DEPENDS ON THE. IT REALLY DEPENDS ON HOW HARD IT IS, BECAUSE IF I KNOW THAT I CAN GET TO THE PLACE QUITE QUICKLY. IT'S HOT AND UNDERGROUND, EVEN IF IT'S HOT, BUT IT'S QUICK."
(INTERVIEWEE 8)

Leaving the house is generally avoided during the hot times of the day and the mobility schedule is shifted towards mornings and evenings, if possible.
Many cities are still depending on the car infrastructure due to the spread-out cities.
The car is used for long drives to work, vacation, or weekends to escape heat when it is too hot in the city. If it is too hot some people are avoiding cars due to the heat it creates and the time it needs to cool down to be bearable to sit in, if other opportunities such as cheap taxis are available as in China (Interviewee 1).

"AND I LIKE TAXI A LOT BECAUSE IT'S ALWAYS LIKE THE RIGHT TEMPERATURE. SOMEONE'S SITTING THERE." (INTERVIEWEE 1)

The choice of the means of transportation depends on needs and occasion. Time, money and bearability are also factors that are taken into account. Avoiding heat but also avoiding UV-rays or the unpleasantness of crowded transportation. It very much depends on the availability and pleasantness to use in a city.
"So mobility, mobility behaviors, I would say it doesn't really change because of the heat wave, but because of the occasion like by occasions. I'm not saying like what I need to do, but for like there's so many parts is influencing how I choose mobility tools. If it's raining, that's where it gets really complicated because I can bike, I can scoop, get a scooter and there's a line for taxi,

and walking to subway station is also terrible." (Interviewee 1)

Furthermore the vulnerability to heat is another factor people take into account when choosing their transportation device. Children, pregnant women or pets for example are often a factor to use and buy a car, due to the air conditioning.

"AND THE CLINCHER FOR ME THEN WAS ACTUALLY WHEN WE HAVE A BABY AND THE AIR CONDITIONING STOPPED WORKING, IT JUST DIDN'T GET COLD. YES, I SAID, IF I HAVE A BABY AND GET INTO SUCH A HOT CAR AS THE AIR CONDITIONING DOES NOT GO, THAT'S A NOGO FOR ME" (INTERVIEWEE 3)

Car problems
When it comes to car usage it quickly became clear that heat plays a big role, but because everyone is used to cars becoming super-hot, no one is thinking too much about it. In countries such as USA or Australia where heat has always been part of the culture, leaving pets and kids inside the car is forbidden by law. The car itself quickly becomes a death trap. Materials are often mentioned, such as leather on seats and steering wheels which get too hot to be used. Wheels loose air and new cars smell a lot like hot glue. People are more cautious about parking their cars in shaded areas. The color of the car plays a huge role as well. In Israel for example only people who have a garage would buy a black car. This basically means that black cars mean in some country's wealth, because it also means you need to afford a garage.

„YEAH, THE MAIN THING IS THAT YOU DON'T SEE SO OFTEN BLACK IT CAR LIKE IT'S NOT SO POPULAR AT ALL IN ISRAEL MORE THEY SAY LIKE DON'T BUY A BLACK CAR BECAUSE THEY REALLY CATCH THE HEAT AND IT'S REALLY NOT NICE TO GO IN A BLACK CAR AFTER IT STAND A LOT OF TIME OUTSIDE. BUT MY CAR ACTUALLY IT'S PINK." (INTERVIEWEE 8)

For electric cars people are also scared about battery blow ups.

"I MEAN, THERE ARE SO MANY, LIKE, UH, FIRE INCIDENTS OR LIKE, EXPLOSION INCIDENT OF TESLA IN CHINA OR, LIKE, JUST BEV CARS INTERNAL THE BATTERY BLOW UP. SO I'M KIND OF SITTING ON A BOMB. SO I DON'T WANT TO OVERWORK THIS THING."
(INTERVIEWEE 1)

Where possible people try to use the cars less and be eco-conscious. Owning a car is often associated with a bad image, but family, commute or infrastructure are often designed for car usage only.
On the other hand, in some cities such as Tel-Aviv traffic jams can be too heavy to even use a car. But not only for ecological reasons, furthermore, also to be socially conscious. Few people understand the city as an ecosystem, especially in more dense cities. In countries like the USA, citizens are having a bad conscience driving the car all the time but don't have another option.
None of the interviewees used their car as a heat-retreat space due to sustainability reasons. But in some countries, it is common to keep a car running while, for example being inside a store, to keep it cool. One interviewee has used it to warm up again after being too cool from air-condition spaces.

Air Conditioning is in some countries disliked or avoided in housing due to cultural or health beliefs. But also due to sustainability aspects and rising energy prices and the costs that come along. Inside a car it is just not possible to not have air conditioning due to the heat. In this case they rather prefer to precool their car in case it takes too long to cool down. Citizens feel a dilemma when they need to use a car but know that it is polluting the environment. The same goes along with the use of air conditioning inside the house. This dilemma of air conditioing is not felt when using a car.

Insights from Expert Interviews

Architectural Lawyer
To learn from experts who are dealing with heat already since years, an expert interview with an Australian Lawyer involved in the sustainable Quay Quarter Tower in Sydney was interviewed.

From his perspective, we are not adapting yet to climate change. Looking at the Maslows Hierarchy, we are paying the price for a thriving history and need to adapt to new needs. Architecture and design need to design for higher temperatures and plan for 2,5°C – plan for the worst hope for the best.
Energy bills are continuously rising, which is why we need to find better ways for efficient energy management, as for example to transform sunlight into energy. Trapping heat for warmth but also planning for ways to release it. The gap between rich and poor is getting bigger and bigger which is why social security is important and generosity will play a more important role in the future. Creating more awareness to not leave people behind and think about solutions on how we can welcome climate refugees and integrate first nation people.

From an architectural perspective we need to learn from the past .

"BIG WINDOWS AND GREAT CROSS FLOW OF AIR TO ALLOW US TO LIVE IN HOT CONDITIONS AND THEN AS WE GO WEALTHIER AND MORE AMBITIOUS AND DEVELOPERS GOT IN CONTROL AND MONEY IS TO FLOW INTO HOUSES, WE BUILT OUT THOSE SPACES, WE TOOK AWAY THAT OPEN AREA AND WE CREATED THESE BOXES. AND SO WHEN YOU HAD THESE BOXES IN A HOT COUNTRY, YOU HAVE TO PUT AIR CONDITIONING IN AND THEN YOU HAVE TO PLUG THE POWER IN AND THEN POWER JUST BECOMES A HUGE DRAWDOWN."
(EXPERT 1)

Architecture is connecting the inside with the outdoors again, to feel like being outdoors while staying indoors. In Australia for example, whirly birds help with air circulation when air conditioning is not an option. We need to learn from other disciplines and look outside of our own world. What are other disciplines doing which seem to be very far from our own discipline such as, for example pizza makers and tailors?

Urbanist
New disciplines are arising such as urbanists, to be more generalists than specialists. Urbanists

are the bridge between different specialists to translate insights. One Urbanist from an architecture company was interviewed on their challenges. It became clear that multidisciplinary work is needed for the complexity of future cities. Where for years cities have mainly been planned around one transportation system in Germany – the car, the cities are becoming multimodal and complex systems. Therefore, many different disciplines and departments need to work together. If we want to foster walking in cities this also means it is needed to create pleasant climate conditions to walk in, for example. Current city structures in Germany are often not prepared for complexity and lack in holistic thinking and acting. Silos in city management lead to fail in techno-logical advancements such as the digital twin, since many disciplines need to work together.

Politics in cities can make big changes but in Germany the transformation towards sustainable cities is making slow progress in comparison to other countries. According to the interviewed urbanist, the concepts are not the problem, it is missing action and legislation. German politics are not investing in new infrastructure of alter-native transportation.

Sponge cities are concepts in Europe to create more regional water supply, where it becomes clear that it is always easier to build things from scratch instead of changing the entire existing system. When it comes to urban heatwaves it is all about saving space. The space that is missing now for trees and greenery to create shade, is taken by other things, such as houses, parking lots and cars. In Germany a common concept are "Schwammstädte" – cities that act as sponges. This meanst that the cities are saving rainwater more localized and decentralized, instead of carrying it away through sewage systems. Furthermore, asphalt and concrete are surfaces that are not permeable, which is leading to higher risks of floods with increasing rainwater. With local water reservoirs costs can be saved for infrastructure and the water could be stored and used for greenery or toilet flushes instead of using expensive freshwater. Local water such as "Wadis" are areas used for periodic storage of water in smaller rivers or lake areas.
More space is also created by reducing the amount of individual transportation. This does

not mean, that there are no more cars, but rather to add many other options for transportation. Opportunities for this are space reduced solutions such as walking and biking, shared or collective systems, such as public transport, autonomous busses, and shared cars, to lead to the fact that not every individual person needs one car, but one car is distributed to many people over time. This additionally created space is used for new ways of transportation and to create green space to enhance the residence quality.
In the end some people will still need a car, but it is generally about minimizing the people who own an individual car.

"SO IT REALLY DOESN'T WORK – AND THAT'S ALSO THE PROBLEM WITH POLITICS, WHICH IS EXTREMELY POLARIZING. I HAVEN'T SEEN ANY MOBILITY CONCEPT IN RECENT TIMES WHERE THERE IS NO LONGER A CAR. THAT'S NONSENSE. BUT THAT IS OFTEN SO POLARIZED IN POLITICS, SO CAR VERSUS BICYCLE AND THAT IS SIMPLY A PROBLEM. BUT THAT'S NOT TRUE. OF COURSE, IT'S IMPORTANT TO GIVE EVERYONE GOOD ALTERNATIVES."
(EXPERT 2)

Especially in Germany politics are polarizing and are advertising either "only cars" or "only bikes", which splits the countries opinion into two. From the urbanist perspective it is not possible to plan without cars and it is sometimes not making sense especially in rural areas. This means that mobility is dependent on the region and infrastructure but also needs to offer inclusive solutions to all users to be mobile. Another important factor are new forms of renewable energy supply but also using mono-functional infrastructure such as railroad tracks to create energy.

To reduce the amount of cars, ease of use and convenience play a big role, but also price and time. If it is not efficient to use public transportation, this would mean that no one will use it. The same goes for cost of transportation – if it is cheaper to use a car, it is still the most convient option to use and therefore used preferably. This is why many cities are making an effort to enhance parking prices and reduce public transportation prices (e.g. "Deutschland ticket"). Laws and regulations

are changed such as the European green deal.

Activist
To get insights from all actors within the system it is important to understand the viewpoint of activists. During the interview with an Expert from Greenpeace Austria, it became clear that from an activists perspective mobility should be designed in a way to first and foremost avoid motorized travel. Lowering the distances to supermarkets, kindergartens and work etc. to be in close walking distance. Secondly it is necessary to shift traffic from harmful to more environmentally friendly modes such as bikes and trains. And thirdly, improving efficiency of transportation such as combustion engine to electro mobility.
Price plays a big role to make public transport available to everyone while increasing parking prices, but also increasing accessibility and convenience.

"BUT QUITE HONESTLY, THERE IS NO ROOM FOR THE PERSON WHO DRIVES FROM THE „SPECKGÜRTEL" IN A SUIT ALONE IN AN SUV TO HIS OFFICE AND THE ONLY THING HE HAS TO TRANSPORT IS A LAPTOP. SO SUCH PEOPLE THEN IN THE FUTURE SIMPLY WILL NOT BE GRANTED THE SPACE THAT THEY THEN DRIVE ACCORDINGLY BY CAR, BECAUSE IT IS SIMPLY NOT JUSTIFIED."
(EXPERT 3)

From the activist perspective, the political system is generally wrong, when politics support fossil fuel consumption which makes it hard for citizens to change their behaviors. Big problems are already existing buildings which are hard to renew, but governmental subsidies are supporting for example the exchange of old windows to more efficient insulation.

Additionally, cars are producing waste heat and heat up the city, no matter if they are driving or parking and capture the cities heat. Positive communication for behavior change can help to promote walking and biking as healthy alter-natives to show how it is affecting citizens positively. Extreme heat waves can also help to communicate the urgency of the climate situation, because climate change is felt immediately in

everyday situations.

Overall the activist's concern is to not forget to tackle climate change while designing for heat. Easy and quick solutions are not helping to fight the real problem, instead they are just Band-Aids to the bigger problem, as for example water misters in the streets of Vienna. If we don't take action, future southern European areas will be uninhabitable.

City management
Talking to an employee of the city showed the entanglements of problems very clearly. In the interviews before, citizens and experts were complaining about how slow the cities are changing. Questioning if and why this is the case made it clear that the current structure of the city management which is working in solitude, makes it hard to tackle the complexity of the city. Cities are trying to work more interdisciplinarily, but it all comes down to final decisions and responsibilities. It is often very hard for citizens to understand what the cities are working on, due to a lack of transparency which is leading to frustration when it feels to them like there is no progress. Planting trees is often hard due to existing infrastructures underground for sewage, internet, cables etc.

Hurdles for the city management are especially to reach out to private owners and investors of existing houses due to data protection. Laws and regulations for sustainable architecture only exist for new buildings but not for existing ones.
Due to the missing awareness of the population and missing laws for green roofs and facades, it is hard to make a change in existing structures. Therefore, cities are trying to raise more awareness to reach the right people who own buildings. This can be done by educating people for climate adaptation in the city and informing and sensitizing on renewable energy alternatives and governmental fundings. But even then, now many private owners have inherited houses and do not have the money to make bigger invest-ments. It becomes clear that the problems of the different Stakeholders are intertwined.
Sustainable City planning needs to reach out to owners of houses to create awareness on renewable energy.

Now the cars are taking over most of the space. This is why cities are trying to minimize parking to create space for trees and greenery. The parking lots that are left should be green but breaking up the asphalt costs money. Furthermore, the maintenance of the green parking is also more expensive than usual asphalt parking. Young trees that are just planted are especially vulnerable to heat and not all tree species are made for the future climate in the cities and lists for future improvement are created.

In northern European cities, such as Munich, heat has not been an urgent topic up to now. This is why action plans are missing for extreme heat wave situations. But the city management is realizing the urgency due to Munich's dense building structure in the city center. Furthermore, a digital twin of the city is seen as opportunity to visualize plans for citizens, for communication and transparency.

E) RESULTS

To summarize the findings, although people and cities are individual, they share common challenges.

Individuals
Many people are not aware of heat as a danger or problem in their city. But generally the "sense of urgency" to heatwaves is growing, depending on the country and city they live in. Climate change is becoming more tangible every day, due to heat waves, floods, droughts and wildfires. The rising energy prices that come along lead to mental health problems and climate anxiety. Heat vulnerable groups such as kids and pets are the main drivers to be aware and to protect them from heat. Additionally individuals are worried about their poorer neighborhoods and the wealth gap that is growing in society.

City planning and architecture
Every city is unique, but they all have problems with rising heat. In general many cities are not prepared for climate change and are treating symptoms while at the same time trying to build resilience. Most of the cities are fixated on cars and less on public transport or bike access. Furthermore dormant cars in the city center are

problematic.

City management and house owners
The fact that city management is working in silos makes the progress in cities very slow. This leads to frustration of citizens, and they feel like the cities are not adapting yet. Furthermore, owners of buildings often do not live in the city and are not aware to invest money in renewable energy, green space or water reservoirs to create sustainable living. In general, there is a gap to break up silos between all disciplines, from city management, citizens and the city on solutions that create a symbiosis between the car and the city.

Legislation
People are becoming more aware of social injustice. Especially when it comes to heat accessibility to shadow and cooling, the wealth gap is becoming clear. Additionally in Germany the automotive industry is blamed for lobbyism and their influence on missing legislations and slowing change for more sustainable cities.

Mobility
Even though urban mobility is transforming it became clear that there will be less cars and more multimodality but that there will still be cars. The freedom of being mobile no matter if with shared or privately owned vehicles, to be able to decide to visit friends and family now or explore undiscovered places is part of human identity. The car itself is still the most powerful "horse" on the street and from a safety perspective – in comparison to biking for example especially for hot days a comfortable alternative.
Research has shown that cities are in massive transition to become more sustainable, adapt and become more resilient to climate change. The question after all gathered insights for this project is – how are cars adapting to the changing environment?

During the conducted interviews it became clear that driving cars, but also dormant cars influence the heat creation in a city. A lot of attention so far is on combustion engines and their influence on pollution and heat creation in the city. Electric vehicles can bring improvements, but is that already enough?

Talking to the different stakeholders made clear that the city is an ecosystem and entangled in many ways. Therefore, changes should deliberately be designed to understand which further consequences it might have. Especially when it comes to heatwaves, cities are dealing with reinforcing loops. According to Meadows, regulating so called positive feedback loops are places to intervene in a system. Positive feedback loops are self-reinforcing, and gain strength over time. Slowing down the growth of the loop can be a powerful leverage point to address, instead of leaving the loop running (Meadows, 1999). One major reinforcing loop was discovered during the process: When heat rises in the city, not only air conditioning in housing rises but also in cars, which leads to more anthropogenic heat creation, and this again leads to higher temperatures in the city – coming back to the drivers cooling their cars even more (see figure 16).

Humanities aim for comfort has made cars higher in thermal mass. More and more mass is added in the car which traps heat increasingly. The past sense for luxury, such as the bigger glass surfaces bring luxurious experiences but also increase cabin temperature.

Currently it is not possible for a passenger to not use air conditioning and at the same time there is a lack of awareness. Using for example open windows instead of air conditioning would not be possible due to pollution and health issues. To change this behavior the structure of the car itself would need to be changed to allow for behavior change. But if legislations are changing and cities in the future will not have combustion engines in the city anymore, pollution should not be a problem anymore, either. Looking at cars form the 60s, where air conditioning was not implemented yet, other passive cooling systems lowered the temperature.

As a next step six possible directions for intervention where derived.
Those are:
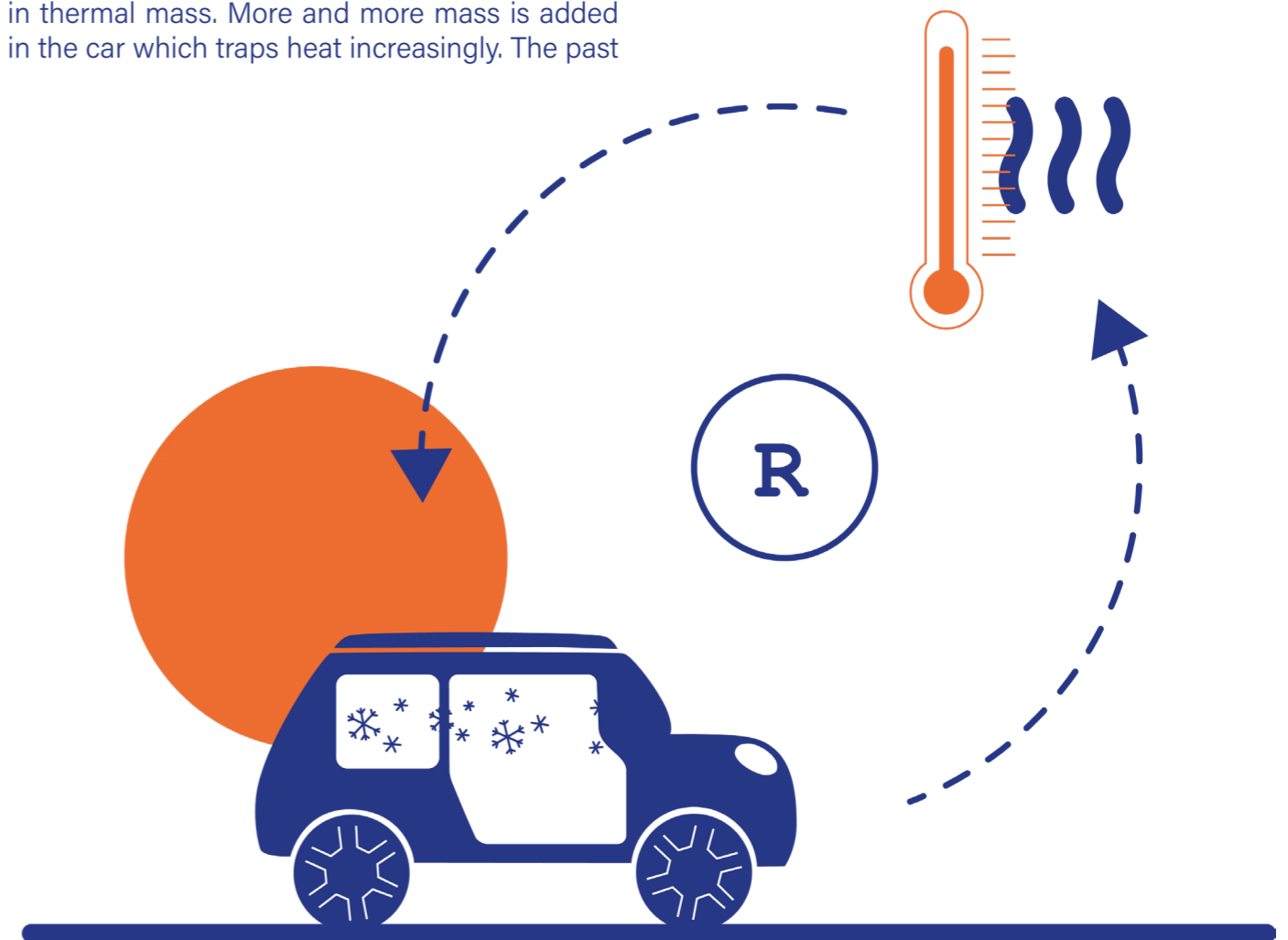
Figure 16 Positive reinforcing loop

PHYSICAL & MATERIALS
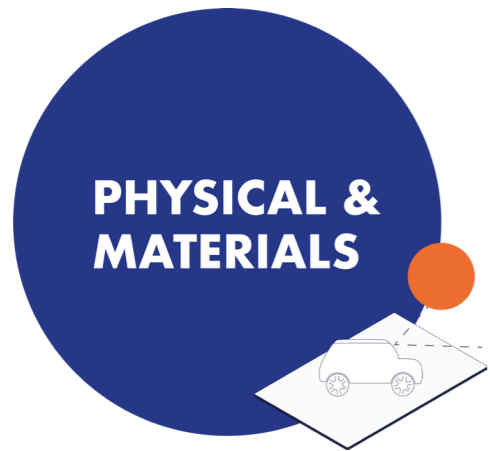
Looking at the insights from architecture, which find inspiration in past building techniques, to work with nature as a passive cooling strategy we could use those insights for natural, passive cooling in the car. Therefore physical and material changes are one solution to adapt to climate change. Taking color, shade, less glass, reflection and air flow into account to create new solutions for passive cooling instead of air conditioning. Furthermore lowering thermal mass and adjusting materials to growing heat.

SOCIAL

A second direction is about contributing on a social level and giving something back to the community, as for example shade or solar power. Furthermore the car structure could be adjusted for community usage, to create a space for districts and invite everyone to share and use the car as a community hub.

ADAPTING TO THE CITY

As a third strategy, new ways to adapt to the city by modularity are opportunities to make the car smaller or bigger depending on the needs. By adding last mile opportunities in the car, such as for example a foldable scooter to drive from the car to the drivers apartment is an idea to adapt to cities needs. Furthermore the car could be used to collect rainwater in external cisterns for the growing value of water. Future hydrogen cars could be used as producers of water.

CITY ECOSYSTEM

Another possibility are ways to connect cars with the ecosystem. For example by collecting data for the city or to track weather for micro climate improvements. The car could show cool corridors and roads, water accessibility etc. and find ways to track heat and respond to it. For example by implementing sensors which would stop charging in areas where it is already too hot.

LEGISLATIVE

The opportunity area "legislation" is the most complicated sector, as legislations are also difficult to implement. Ideas are experimental packages to foster creativity of the citizens, for example by fostering parklets through BMW employees.

INDIVIDUAL/ DIGITAL

The direction of individual, digital help is the concept of a car, which is taking care of you. The car could assist the driver with digital reminders for example to drink water, find shade and cooler areas and create awareness on heatwaves.

6. CO-CREATION

A)   INTERNAL WORKSHOP WITH CO-WORKERS

The derived concepts from the Results Section of the Stakeholder analysis were visualized and summarized to discuss first intervention opportunities and ideas internally. As a first step towards co-creation a workshop with co-workers interested in the heat wave system was carried out. Stakeholders from design, brand strategy and research and development took part to discuss the findings and next steps.

First a presentation about the gained insights from interviews and literature was held to introduce everyone to systemic design and heatwaves in general and align everyone's knowledge about heatwaves.

The workshop was also intended to bring different departments and projects together, to have a knowledge exchange. Furthermore, to discuss findings on the question – now that the cities are changing, how can cars adapt? How can we design a heat-resilient car which addresses the needs of the changing city, people, and the environment?

The six different identified directions were presented: physical and material, social, legislative, adaption to the city, ecosystem of the city and individual and digital. Collected ideas during time were mapped on the different sections and the workshop was used to validate the first derived concepts (see figure 19).

The participants chose their favorite ideas and a possible timeline, from "quick fixes" to long term implementations. Furthermore internal projects were linked with ideas and discussed. Physical changes are a "quick fix" for the city environment, but from a manufacturing perspective, those are implementations that take time. Digital interventions are the easiest and quickest to implement inside a car, but have the smallest impact on the bigger problem. The workshop made clear, that it is important to switch the mindset from the car as a solitary object towards a car as part of the city ecosystem.

Out of the collected insights on heat creation inside cars, 10 design principles for heat resilient car design were derived (see figure 18).

Those are:
1) Color
2) Reflection
3) Air flow
4) Thermal mass
5) No additional heat creation
6) Cooling without additional heat creation
7) The least possible amount of glass
8) Surface structures
9) Creation of shade
10) General sustainability goals such as reuse, reduce, recycle
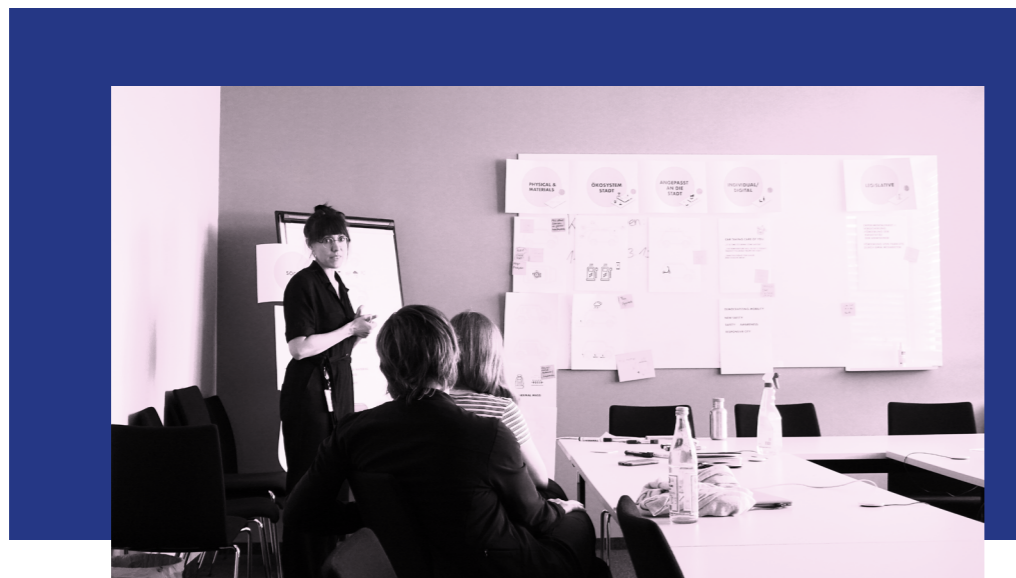
Figure 17 Internal Workshop

DESIGN PRINCIPLES

TEN PRINCIPLES OF HEAT RESILIENT CAR DESIGN

1
COLOR

2
REFLECTION

3
AIR FLOW

4
THERMAL MASS

5
NO HEAT CREATION

6
COOLING WITHOUT HEAT CREATION

7
LEAST GLASS

8
SURFACES

9
SHADE

10
SUSTAINABILITY

Figure 18 Design Principles for heat resilient car design

INDIVIDUAL/
DIGITAL

SOCIAL

LEGISLATIVE

PHYSICAL &
MATERIALS

CITY
ECOSYSTEM

ADAPTING
TO THE
CITY

EMERGENCY

CAR TAKING CARE OF
YOU

„IT IS TIME TO
DRINK SOME WATER"

"THE TEMPERATU-
RE WILL BE 42°C
TODAY! PRORTECT
YOURSELF FROM THE
HEAT"

„TAKE THIS ROAD
FOR SHADE AND
COOLER AREAS"
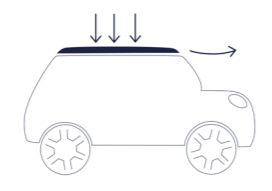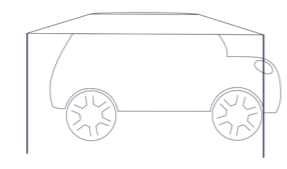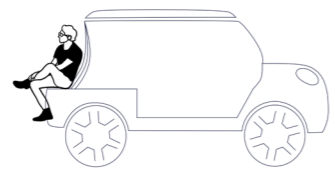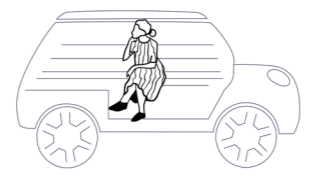
EXPERIMENTAL
PACKAGE + IN-
SURANCE
TO FOSTER
CREATIVITY OF
THE RESIDENTS

ENCOURAGING EM-
PLOYERS TO SUP-
PORT PARKLETS
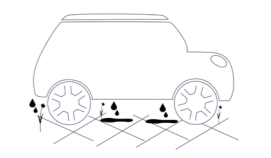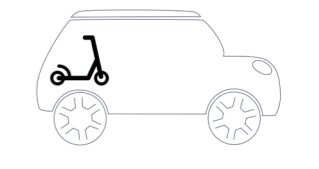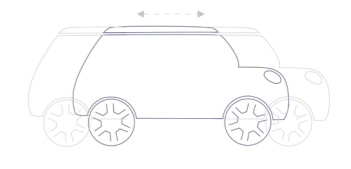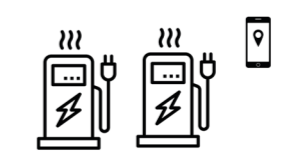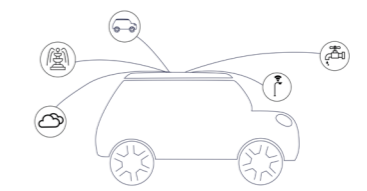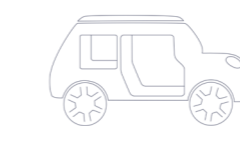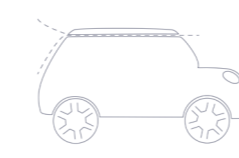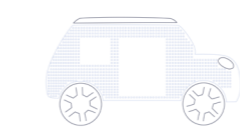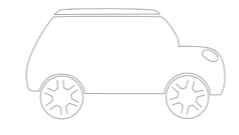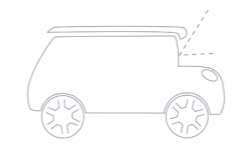
Figure 19 Overview of intervention opportunities

B) WORKSHOP WITH CITIZENS

After the first workshop was conducted it became clear that so far the solutions were focusing mainly on the car itself. Furthermore, a systemic design toolkit developed by another Master student was used to identify the systemic potential of this project by "reframing" the goal of the project. It became clear that to make any change, first of all it is important to communicate the problem, raise awareness, and talk about the topic of heatwaves. As heatwaves are no linear problem, instead rather complex it requires more interactive communication and discussion (Snowden, 2007). Therefore, a co-creation workshop was organized within a district of Munich called "Dreimühlenviertel" to derive ideas on the future urban landscape.

In summer 2023 the BMW Group was working on a collaborative project in the "Dreimühlenviertel" within the city of Munich. It was intended to show in an exemplary manner how, in dialogue with residents, the city and business people, change can be shaped to the benefit of all: for the general public by offering mobility with the use of innovative solutions. The ideas and requirements of the residents are at the center of the district development. Together they developed ideas on how the district should develop and change. Over the summer holidays an exemplary setting of greenery, trees and mobility alternatives are implemented in the streets of the Dreimühlenviertel to encourage more citizens to actively engage in the redesign of their district (MZM-Allianz, 2023). Within this project a "neighborhood lounge" was used to get into contact with citizens of the district. To talk to the citizens about the future rather than talking about the current problems, "provotypes", or "diagetic prototypes" were used to quickly transition the minds of the participants into future scenarios.

> "ORIGINATING IN SYSTEMS DESIGN, PROVOTYPES ARE PROTOTYPES USED AT THE FRONT-END OF A DESIGN PROCESS TO REVEAL HIDDEN TENSIONS IN A GIVEN DESIGN CONTEXT. THEY DO SO BY PROVOKING EXPERIENCES OF PHENOMENA, WHICH UNDER NORMAL CIRCUMSTANCES ARE PRESUMED AND SO REMAIN HIDDEN" (MOGENSEN, 1992)

Tangible artifacts help to build future scenarios vividly, which makes it easier for workshop participants to understand and imagine the possible future and to be directly involved. In a museum historic artifacts transition the viewers into the past, diagetic prototypes are doing the same, but into the future. With these "props", which are known as movable objects from a set or play, a future world can be tangibly staged, and it is easier to imagine how it would be to live in this future world. To close the perceptual gap between reality and fictional reality, storytelling is used to construct a vivid future in the participants minds step by step. To make that possible, a future mundane is created, where a good balance is needed between elements we are used to from the everyday and the imagined fictional future (Groß & Mandir, 2022). A future mundane is aiming for everyday scenarios in a future, which is in contrast to the fictional fantasy laden stories we are used to from cinemas. Sterling puts design fiction and the use of diegetic prototypes as opportunities "to suspend disbelief about change." (Sterling, 2012). These "everyday" scenarios help residents to imagine realistic future scenarios, which portraye the everyday in the future. Instead of building a hole future world for storytelling, "world hinting" uses fragments of the future to create a vivid future scenario with only few artifacts.

The idea for the workshop was to create a MINI fictional future accessories store. This store contained accessories for a future MINI car, which are helping the ecosystem of the city instead of focusing solely on the car. With an additional story around these accessories, which explains the context of the props, a picture of the future was created.

B) I) DESIGNING THE PROTOTYPES

For the workshop three different diegetic prototypes were designed, modelled in Fusion 360 and 3D printed. As Stompff and Smulders argue the right fidelity is important in Product Development (Stompff, 2015). The Prototypes were deliberately 3D printed in low fidelity to convey the message of the product with abstraction.

The three concepts are scenarios, which are building up from a dystopian to a utopian view. As the future cone from Haylock (see figure 21) shows, in design foresight multiple futures are imagined and how they and the environment can evolve over time. With the Prototypes Participants were provoked to imagine with which view they relate the most and generate new ideas and actively think about what the preferable future would be and make them engage emotionally with the topic.
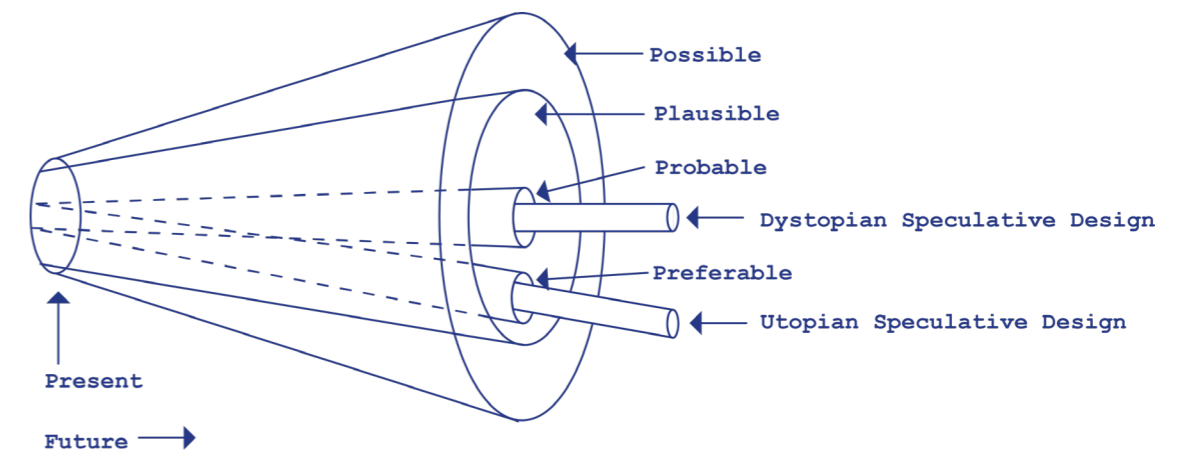
Figure 21 Future cone adapted from Haylock

Additional plastic wrappings and product labels should enhance the feeling of an actual purchasable product. All products were printed in white to convey the abstracted level of the prototypes. Features which have additional functions were highlighted in different colors.

Figure 20 Pictures of the Workshop in the Dreimühlenviertel

The three prototypes are the following:

HEAT WAVE - FIRST AID KIT
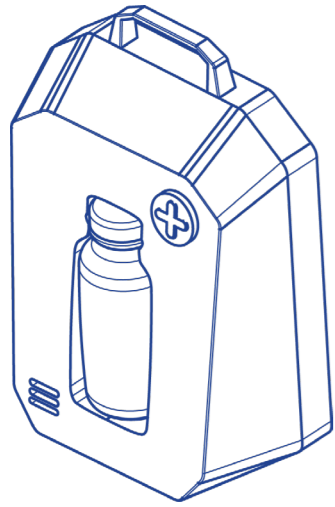
This First Aid Kit is showing the participants the heat wave context in an obvious way. It is an Emergency Kit deliberately made for extreme heat wave scenarios. It proposes a future city, where unbearable 40°C are common summer temperatures. The Asphalt is boiling and is causing harm to animals and people. To help out in extreme situations the Kit has an emergency button which connects directly with the ambulance, when pressed. Furthermore, family members will get a notification with the current location and are advised to stay calm after getting further instructions from the hospital.

Inside the Kit is a water concentrate, for direct dehydration prevention, an instant ice pack for immediate cooling, an emergency blanket and wound ointment for treatment after skin burns. The Emergency Kit in the car can be accessed by anyone, not the car owner only and is a publicly available medicine cabinet (see figure 24).

This prop is very close to the everyday scenario, looking at cities near deserts etc. and is making the urgency of heat and its consequences very tangible. It illustrates a solution in a rather dystopian way and how to mitigate with the heat and the possible health problems.

The design of the first aid kit is inspired by dystopian first aid kits, more edgy and less round to deliver the sense of urgency in a visual manner. The water bottle as the central device is printed in a different color to lift its importance. The emergency button is highlighted in orange to communicate its additional feature.

Figure 22 Prototype – First Aid Kit
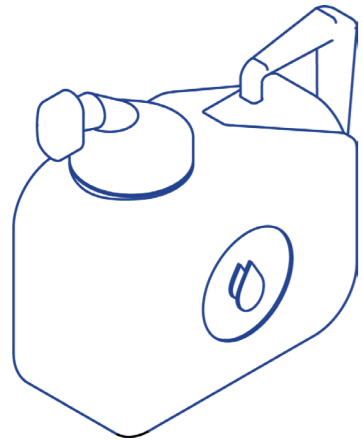
The second scenario visualizes that water will be a valuable good in the future. In the fictional story, every citizen will be an active participant in the city infrastructure and must collect rainwater to water trees, cool down the streets or use it for toilet usage. The cars rain barrel is a collaboration tool between consumer, car owner and the environment. In this future it is necessary to also give back something to the environment and the city, to be allowed to own a car in the city. The rain barrel acts as an extension of the car, captures rain, and gives the owner the possibility to water the plants and trees right away. The users can become a tree patron in the city and gain credits for taking care of plants in the city.

The design of the rain barrel is very close to everyday rain barrels to make the story as imaginable in the everyday as possible. The additional pouring device visually explains the easy usage of the device.

Figure 23 Prototype - Rain barrel

The third scenario is a utopian view on future cities. In this scenario the city has already tried to change the current infrastructure. Closed surfaces such as asphalt and concrete are gone, and the city is full of grass and greenery. To help the future cities to deal with the new infrastructure, new investments and actors would need to be added to the system. Therefore a mower is added to the car to take care of the green parking lots. Users can gain credits if they mow more than their own parking lot. An additional digital gamification lifts up the experience to a fun and community lead interaction.

The design of the mower is deliberately "comicy", to underline the utopian view on the world of this prototype. The face of the mower and the little green bumps on the wheels give it a light and fun overall look but underline its outdoor usage. Scissors which would be needed to cut the grass are hidden to make the mower look less aggressive.

The MINI Mower

Hilf der Stadt dabei die grünen Parkflächen sauber und befahrbar zu halten. Dein MINI Rasenmäher mäht Deinen Parkplatz während du unterwegs bist.

Smart - City Connectivity

Stadt   Handy
Auto   Wetter

Wartungsklappe

Status LED

Sensor um Insekten und andere Tiere zu detektieren

Räder für un ebenes Terrain

Bekomme extra Credits wenn du mehr als eine Parkfläche mähst!

To set the three prototypes in the car context, a vehicle with the three accessories was created to convey the story more easily. All three prototypes are part of the car context in different user scenarios and can be stored inside the car.
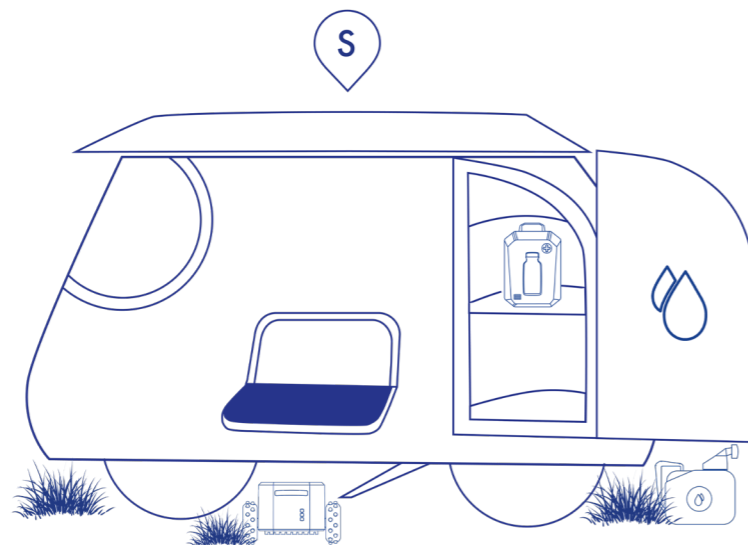
Figure 24 The context of the three prototypes

Figure 25 Prototype – Mower

FICTIONAL

ACCESSORIES

The future Workshop was held in the "Drei-mühlenviertel" in a "Quartierslounge" during the summer holidays by the MZM Allianz. Citizens of the district were informed beforehand about the Programme by the city of Munich and residents were invited to participate. All in all, 10 people joined for the workshop, with a mix of 3 female and 7 male participants, aged between 29 and 58. The citizens were asked to sign an informed consent before, and the workshop took two hours to not take up too much time of the citizens but still gain output.

First an infographic was used to simplify the system about heatwaves (see figure 26). By presenting the information to all the participants an equal level of knowledge about urban heat waves and how they occur was generated.

After a welcome and an introduction to the topic, in a second step the problem as perceived was given as the following:
How can MINI be an active participant in the heat affected cities of the future?

After a purge of the first ideas that came to mind the participants were challenged with the future prototypes to go beyond the obvious. Citizens exchanged concerns about dystopian views in which they did not want to live in and utopian ideas which were giving more hope. While telling the stories about the Prototypes, the participants wrote down further ideas, concerns and thoughts which were discussed afterwards.
Reactions on the First Aid Kit where, even though scenarios like these are already part of the everyday, rejection and frustration. Residents did not want to imagine the dystopia but felt the urgency of the topic from it.
The rain barrel sparked debate about the possibility to change the values of society from owning a car as an "ego extension of themselves" towards societal engagement. People were enthusiastic to think about what people could collect or give back to the city ecosystem to actively engage. Topics that citizens touched upon were how to engage citizens to be responsible and give back to the city and to "gain the right" to own a car.
Additionally smart city connectivity and how

to connect with nature and the city such as questioning "Is the tree feeling alright?", "Is the city harmed?" where interesting ideas.
The final concept about the mower provoked hopeful concepts for the future and residents found back to more joyful solutions.
From the stories of the Prototypes people moved to ideation and generated new ideas.
After a clustering of the ideas each participant dot voted on their favorite ideas and had a moment for reflection in a short break.

In the next session the three concepts with the most votes were taken further in smaller groups and force fit back to the problem as perceived. The citizens were challenged to make their ideas more tangible and brought back to the context of MINI to derive future business models. The three concepts were pitched in 30 seconds in a video for MINI co-workers.

Those three concepts were
1.   Investing into parking houses outside the city, to get cars out of the city center by connecting them with autonomous shuttle busses and car sharing.
2.   Collecting water as a future task for citizens to engage in the city ecosystem. Water was chosen as the future most valuable resource and a new value stream for MINI. Residents would collect credits through handing the water in at special collection areas, which could be for example old gas stations. In return you would get hydrogen and at the same time give something back to the ecosystem.
3.   Centralized transportation systems for citizens to avoid individual deliveries to reduce the need for transportation.

In the end the participants were happy to derive future concepts which give hope for the future of their city.
The three derived concepts were taken further to map out the community driven foresight and interpret it into a tangible roadmap.
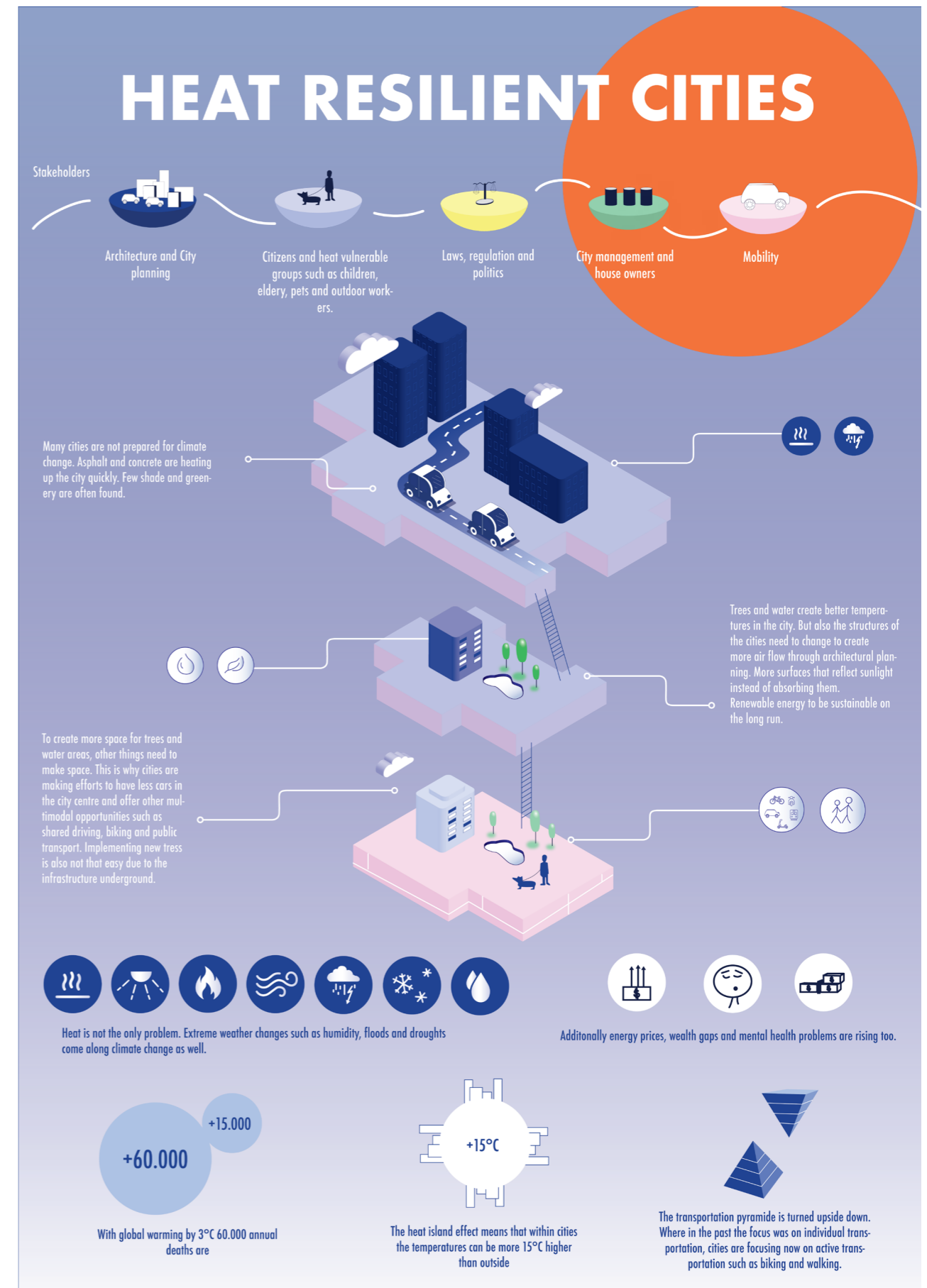
Figure 26 Infographic on heatwaves

C) WORKSHOP WITH REPRESENTATIVES OF BMW AND THE MUNICIPALITY OF ROTTERDAM

After the future workshop the created ideas were interpreted and concluded into a roadmap which would fit the MINI brand. All gathered information and insights were synthesized and translated into a tangible roadmap to help translate ideas into actions.

It was found that focusing on the product only wouldn't change the overarching paradigm. According to Meadows changing the goal of the system and "Changing the mindset or paradigm out of which the system arises" are places for intervention in a systemic design project. Therefore instead of focusing on the product only, the roadmap was understood from an ecosystem perspective. As systemic design is thriving for societal change, actions from micro, to meso to macro level were derived. As the values of the MINI brand are also connected to making a societal impact, fulfillment and community, a transition towards social change is a good fit for the brand. Further values to keep in mind are emotional spirit, unconventionality, and joy.

Transition by Design is a tool from the Systemic Design Toolkit by Jones (Jones, 2018) which envisions a transition towards a desired macro level change. Starting off at the micro level with a transformation pilot. Moving towards the Meso level and scaling to the macro level. The following concepts were presented at the gathering of the City of Rotterdam and representatives of the BMW Group and discussed. At the meeting Representatives of Deloitte, 5 from the BMW Group and 6 from the city of Rotterdam attended.
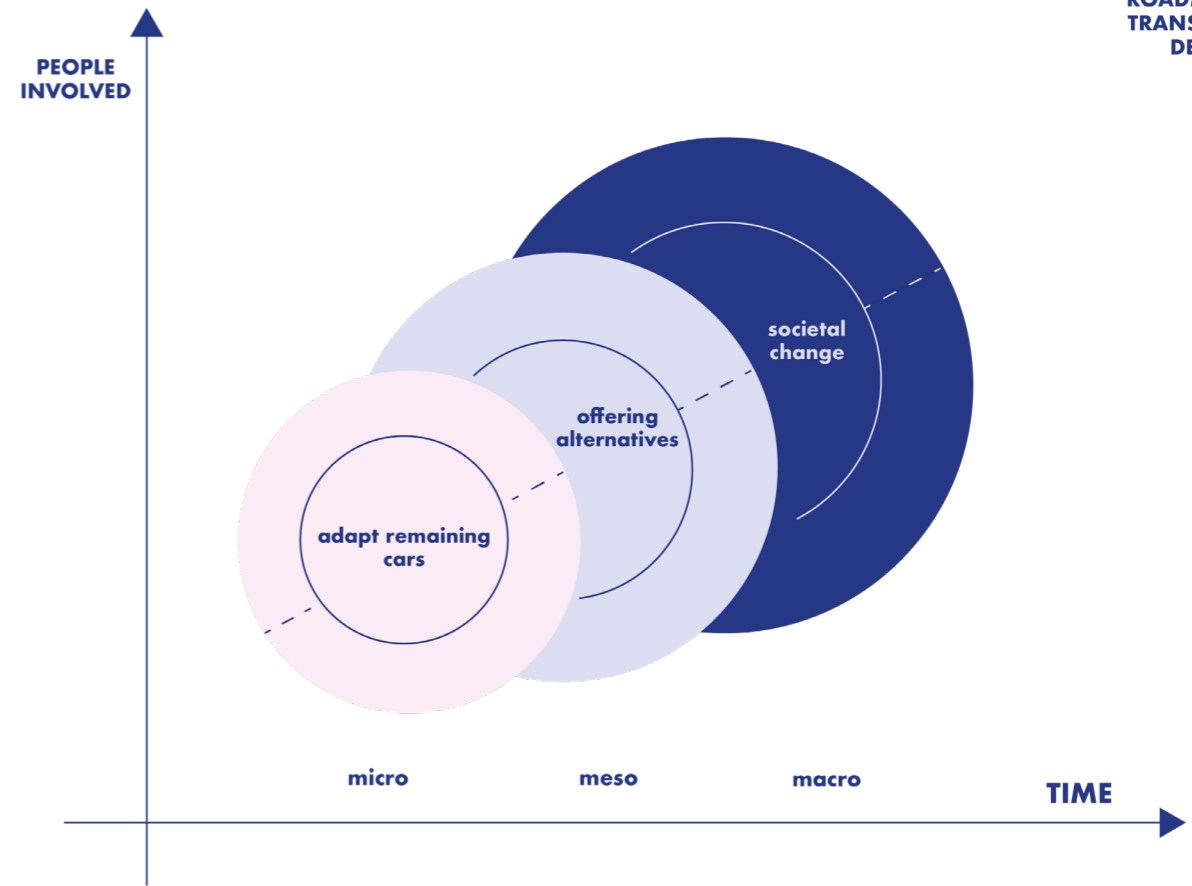
Figure 28 Transition by design Roadmap

On the micro level the focus of the roadmap is on product improvements and adaptations towards climate change. These are:
- saving energy, by preventing heat creation inside the car
- using color and reflective glass to prevent sun rays to get inside the car
- using less energy by avoiding data overconsumption during hot days
- reducing thermal mass and create natural air flow inside the cabin
- Additionally exchanging cabin air condition for solar powered ventilation
- giving back to the system, by connecting with the city infrastructure, to be prepared for emergencies, show cool roads and water recreation areas
- Create awareness and alarms such as reminding the driver to drink enough water and tracking the water supply, but also tracking the back seat to not forget pets inside the car.
- telling the passengers that the battery is doing good even though it is very hot. Also heat maintenance areas such as wheels should be reminded to check.
Through a solar powered roof, energy can be
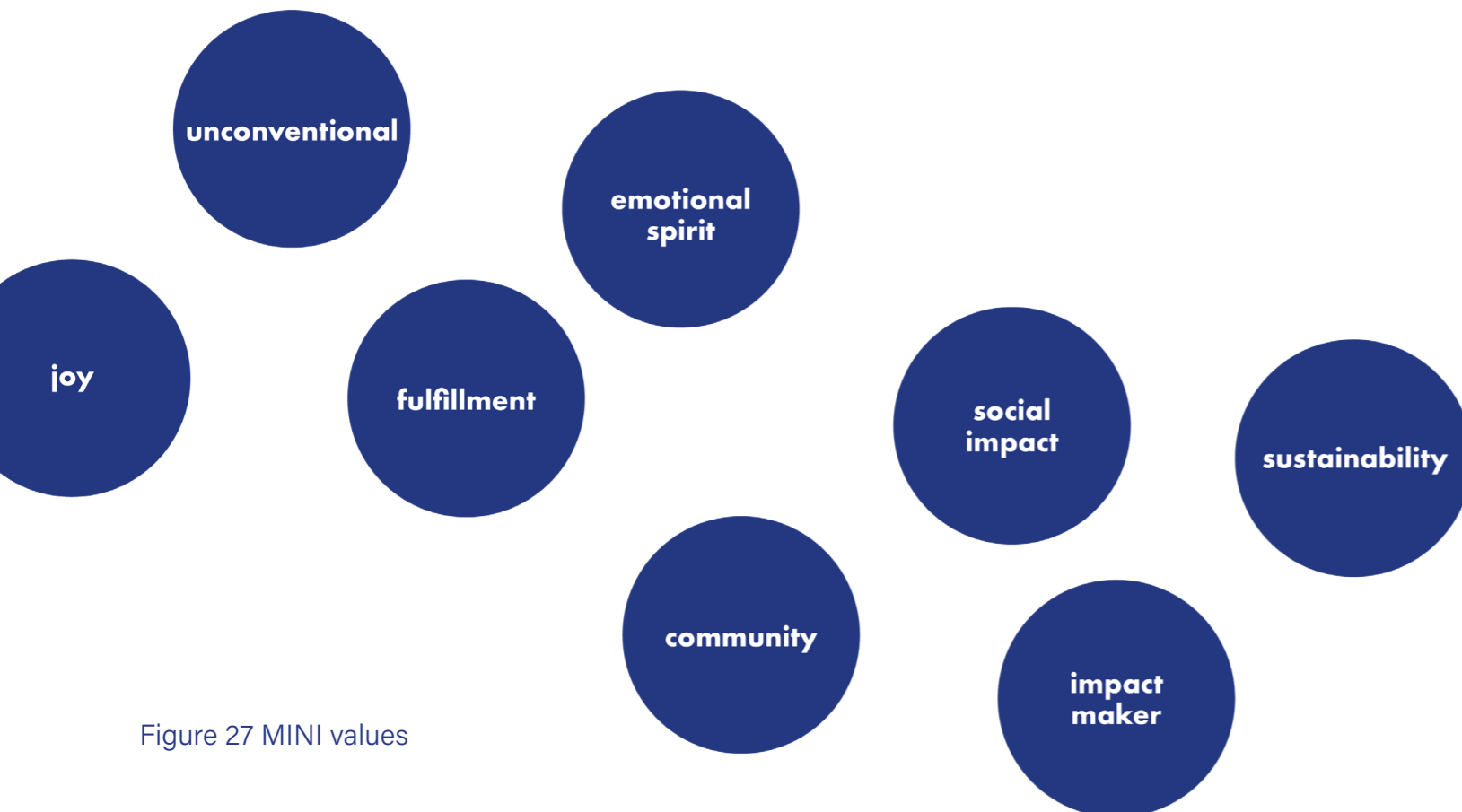
Figure 27 MINI values

collected and given back to the system. In the future, hydrogen cars could additionally provide the city with collected water.

Furthermore the ecosystem would need to adapt as well. Energy supply would be turned off for electric vehicles, in case areas are already too heated up. And cars could be parked on green parking rather than on asphalt.

On a meso level, MINI could support alternatives to gain space in the city for trees, greenery or other cooling support. To make sharing more attractive to urban car drivers, a community driven approach would be implemented. Dormant cars could be used as a community platform, to connect, sit down and chat on the outside of the car. But districts could also own a car, where more and less wealthy people share a car according to
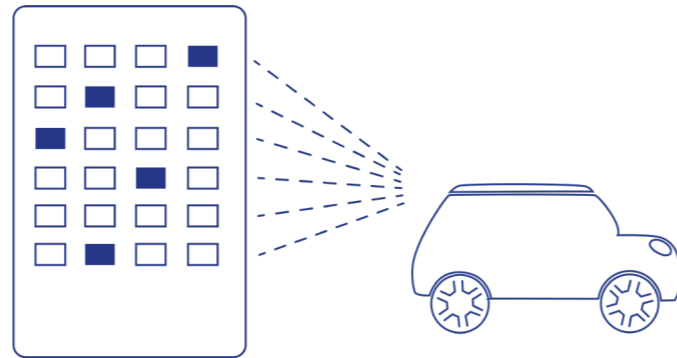
their available resources. This is how owning a car can be more democratic and socially valuable.

On the macro level, social change is fostered. In the future mobility can be accessed in return for helping the ecosystem of the city. Duties could be for example: collecting water, watering trees, organizing an event for the community etc.
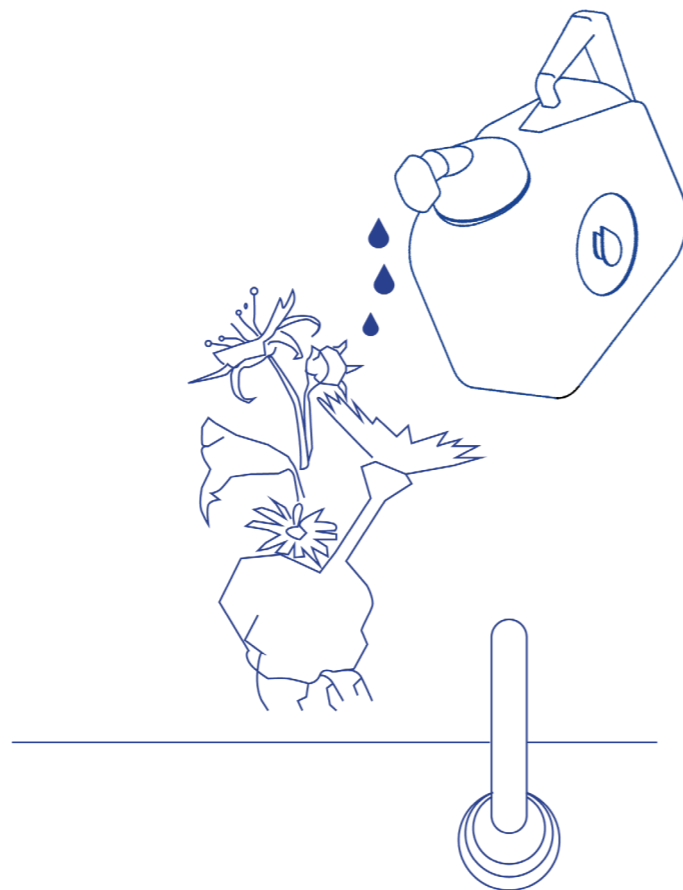
Social engagement will be valued as a currency for mobility. And a transition from ownership towards social engagement can be actively fostered.

After the presentation all participants discussed the different findings and again it got clear that awareness on heatwaves and the different actors within the network is missing.
Discussions went on about examples from Tesla's electric cars which did blow up in the past and what to do about those "bombs" in the city. As much as the problem about heat creation of charging stations for electric vehicles. It became clear that there needs to be a differentiation between driving cars and non-driving cars.

Furthermore, the idea on allowing white cars only in the city was discussed and the problem of the reflection of the bright cars which would also blind for example bikers.

What can we actually do to cool down the city and

the idea of the hydrogen car providing water was discussed. Additional inspiration was drawn from the camel living in the desert and how it cools its skin.
Furthermore, a connection with an apple watch for direct health tracking and emergency connection was discussed.

The overall conclusion was that there is not one solution. One representative of the city of Rotterdam answered to that "Welcome to our world". It became clear, that it is important to talk about problems that could occur in the future and see what the best solution for all is. Furthermore making an impact on the society as a bigger goal is important and to make mobility democratic.

Figure 29 Picture of the Workshop in Rotterdam
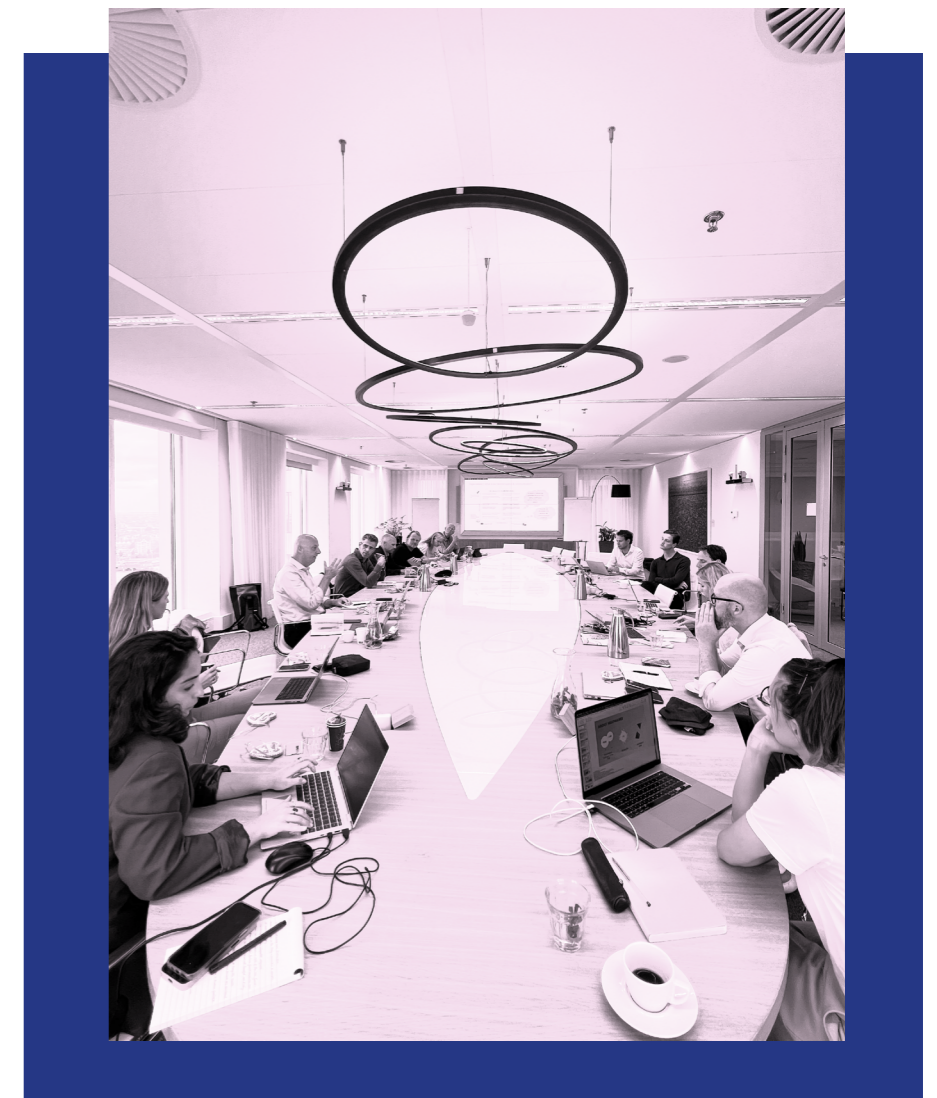
7. SYNTHESIS

The previous chapters have shown the different iterations on ideation for possible interventions in heat wave mitigation, synthesized in this chapter, into a strategic roadmap for the brand MINI (see figure 30). The first step is to map out the general trend of european city strategies, to align the brands goals with the city. Especially European cities are becoming more aware of heat waves and the impact of heat on the livability. The conducted interviews show that the city management needs to work closely with citizens to raise awareness on the topic of heatwaves and make them understand why the cities need to change and how they can contribute. Raising awareness is the first step for cities to lower temperatures and move towards the acceptance and action of more healthy and sustainable cities, through actions such as the reduction of cars in cities, creating more green and blue areas and reducing pollution and energy consumption. Further improvements to lower temperatures from a car perspective are:

1)   Avoiding or minimizing combustion engines
2)   Foster electric vehicles
3)   Minimize car ownership.

The interviews and workshops have shown that many people need, or feel the need to use a car in the city, but more and more people have a bad conscious to use it. The image to own a car, especially in urban contexts is conflicting due to a growing eco-consciousness through a more tangible climate change.
So far, automotive manufacturers have mainly focused on the symptoms of heat with solutions like for example Tesla's "dog mode", which is only putting a band aid to the symptoms of global warming and heat creation. As the values of MINI focus on "being an impact maker", the proposed Vision for the brand MINI is to actively participate in the fight against heat wave mitigation.
As a first step, it is proposed to foster electric vehicles and make it easier for citizens to share cars by offering low entry opportunities. Peer-to-peer sharing platforms which offer sharing with a

smaller community such as neighbors and new, more social pricing strategies which help lower income residents to get access to mobility, would fit to the values of the MINI brand. Possible investments in underground parking lots, or houses outside the city are additional investments and business models for the future, which align with the city strategies and make change as easy as possible.

The suggested, integrated strategy for MINI is divided into three horizons, aligned with the previous described city strategy. The sequence of actions is based on the insight, that many citizens are currently not aware of the impact of cars to the urban heat island effects and their contribution to increasing temperatures.

Meadows has identified 12 principles to bring upon change in systems. The following three ensure the largest impact but are also the hardest to achieve. Those are:

1)   The power to transcend paradigms
2)   The mindset or paradigm out of which the system – its goals, structure, rules, delays, parameters arise
3)   The goal of the system (Meadows, 1999)

Inspired by these principles, the goal of the strategy is to move towards a mindset change in citizens and car users. A mindset which is aiming for more shared usage of cars and the least impact on heat island effects as a citizen in the city.
To actively change the mindset of users, it is recommended to think about how machines, in this case the car itself, users and producers can steer values and political goals by technology (Latour, 1992). The aim is to find something similar to the alarm tone that reminds us to fasten our seat belt in a car. Doing that by designing technologies, which shape us humans and raise awareness of heat island effects in cities and nudge in a way to change actions and behavior. To actively steer a mindset shift, it is recommended to start changing the mindset of MINI drivers by

creating awareness and providing different information via product services on heat waves. In a next step, deliberately designing and changing vehicles towards heat neutrality can shape action and foster behavioral change of humans on the long run.
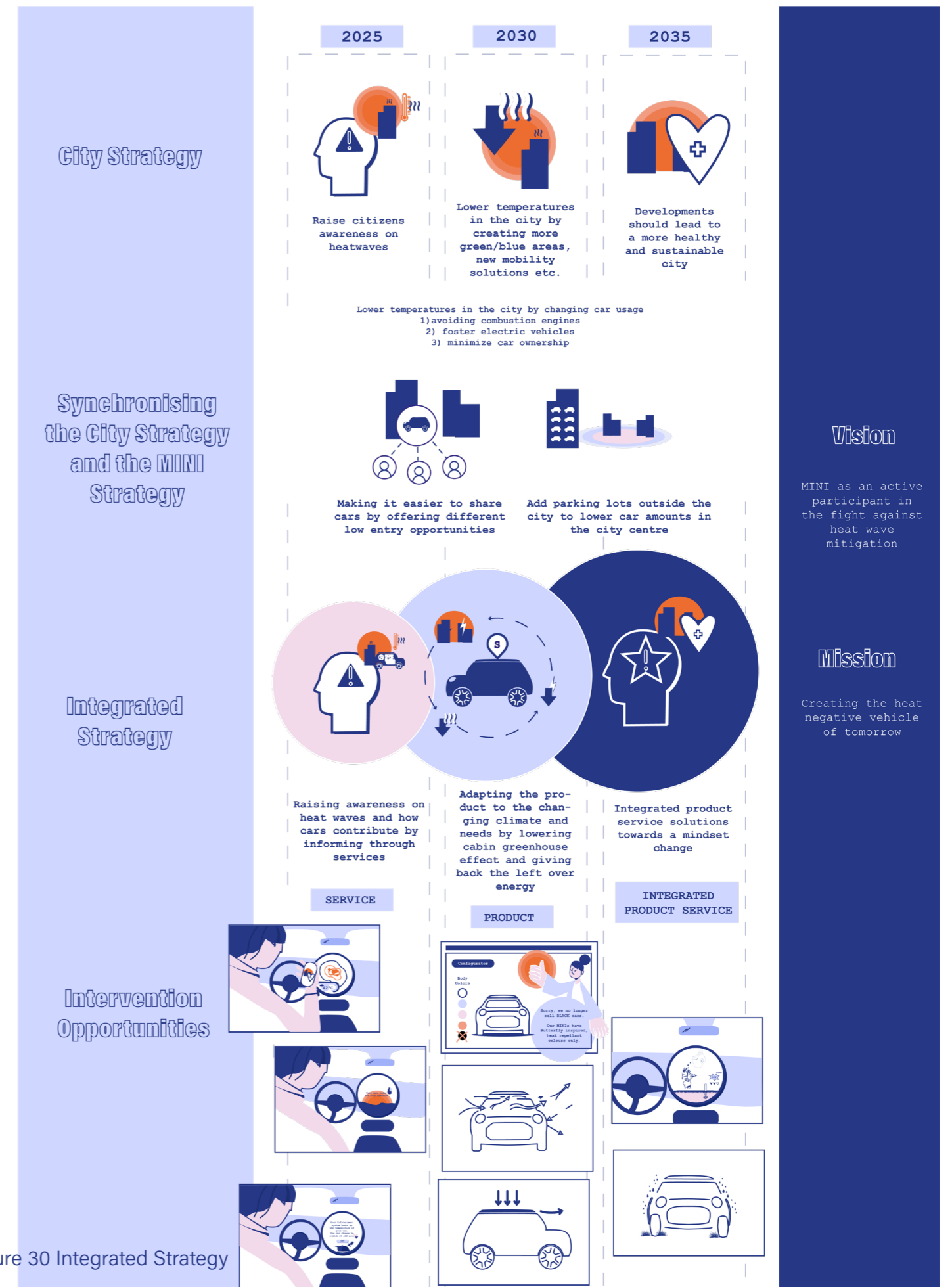
Figure 30 Integrated Strategy

The strategic roadmaps time pacing strategy is set up in three stages from 2025, to 2030, to 2035. The key objective is to redirect the perception of a car from being solely a status symbol to transforming it into a product-service system that actively promotes community impact.

Horizon 1 by 2025
Raise awareness on heatwaves

Horizon 2 by 2030
Heat Action towards heat neutral vehicles

Horizon 3 by 2035
Mindset change

A)   STRATEGIC ROADMAP
Horizon 1 - 2025

In the first horizon it is important to create awareness of the impact of cars as part of the heat island effect in the city. Therefore, educating passengers about the additional heat they are creating and informing about opportunities and alternatives is essential. Furthermore, it is an opportunity to make climate change personal, urgent and local and make people care.

Intervention opportunities would be, to connect a health tracking device such as an apple watch with the vehicle to show the passengers current health during extreme heatwaves and remind drivers for example to stay hydrated or in the shade. Informing about heat areas in their city through heat maps could raise awareness on their local heat severity and create awareness. The connection with sensors in the city could further exchange information between the car and the

citizen and make the driver more connected with the surrounding. The data can be translated into information on how the city is feeling, which would raise empathy with the city and create a more emotional connection.

Secondly, giving passengers the opportunity to already take simple actions and make a small impact to reduce heat, are first steps towards behavior change. As an example, the driving assistant could inform during extreme heat waves that the Infotainment system heats up the temperature of the car and the surrounding additionally. "Click no, if you do not want to switch it off now." - gives them the opportunity to still use the Infotainment but the user would also need to actively uncheck if usage is not wanted.

It is 42°C outside. Your Infotainment system heats up the temperature of your car and the surrounding additionally.

Click no, if you do not want to switch it off now.

No

Take care today and stay hydrated

42°C

AWARENESS

Horizon 2 - 2030

In Horizon two it is proposed that MINI adapts the vehicle development to the changing climate and increasing heat. The Vehicles allowed on high risk days or time periods are designed in a way, that technology no longer adds to the heat island effect and become heat neutral or even heat negative vehicles (if this is possible). All vehicle components are designed to lower heat creation and the cabin greenhouse effect. As the conducted interviews showed, air conditioning in homes is felt as a dilemma and is often not prefered in comparison to natural cooling. Within the car, air conditioning is felt as a necessity due to the cabin temperature. To lower future energy consumption and the need for air conditioning, new technological developments would need to be derived to make this ambitious goal possible. As there is no one-size-fits all solution and new developments are likely to create different new problems, the development should be democratized to find the best way possible. To achieve this goal a democratic way to develop a new mobility solution, by working with citizens and the city is used to find the best solution for city, citzens and the environment.

First easy interventions could be for example the possibility for MINI to no longer offer black cars. Further developments for the vehicles design, aim towards zero addition to the heat island effect to. All vehicle components are designed to lower heat creation, the car itself can be super light and max. 50 km/h because of the low distance they must reach.
The most effective solutions such as solar chimneys, cabin cross ventilation and solar powered ventilation are possible solutions to reduce the need of air conditioning. Any heat and energy which is still created can be given back to the ecosystem by connecting with the city's energy ecosystem.

Configurator

Body Colors

Sorry, we no longer sell BLACK cars.

Our MINIs have Butterfly inspired, heat repellant colours only.

TOWARDS HEAT NEUTRALITY

S
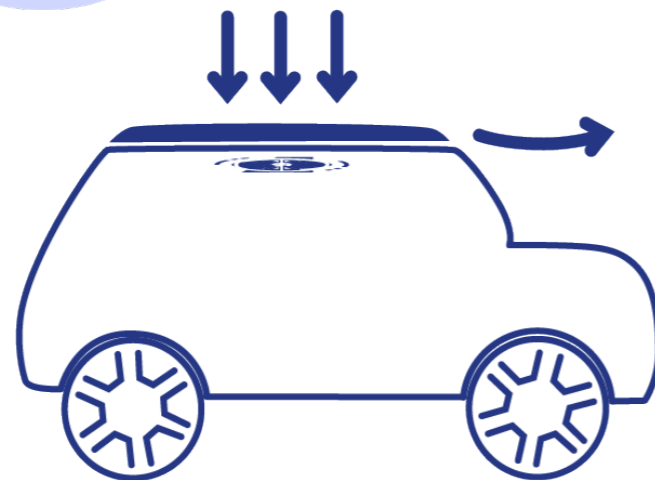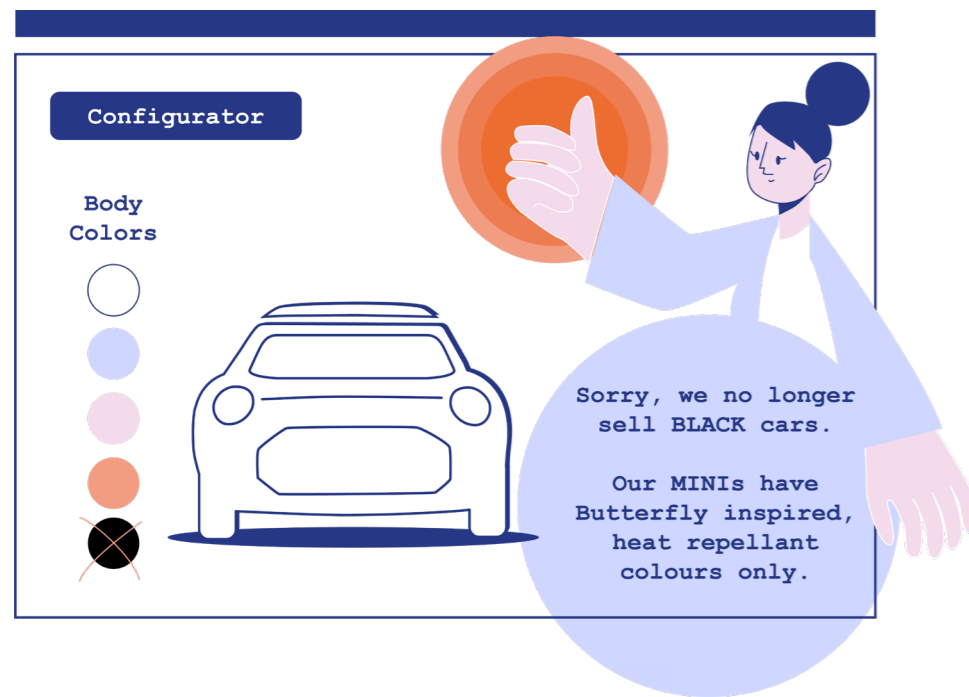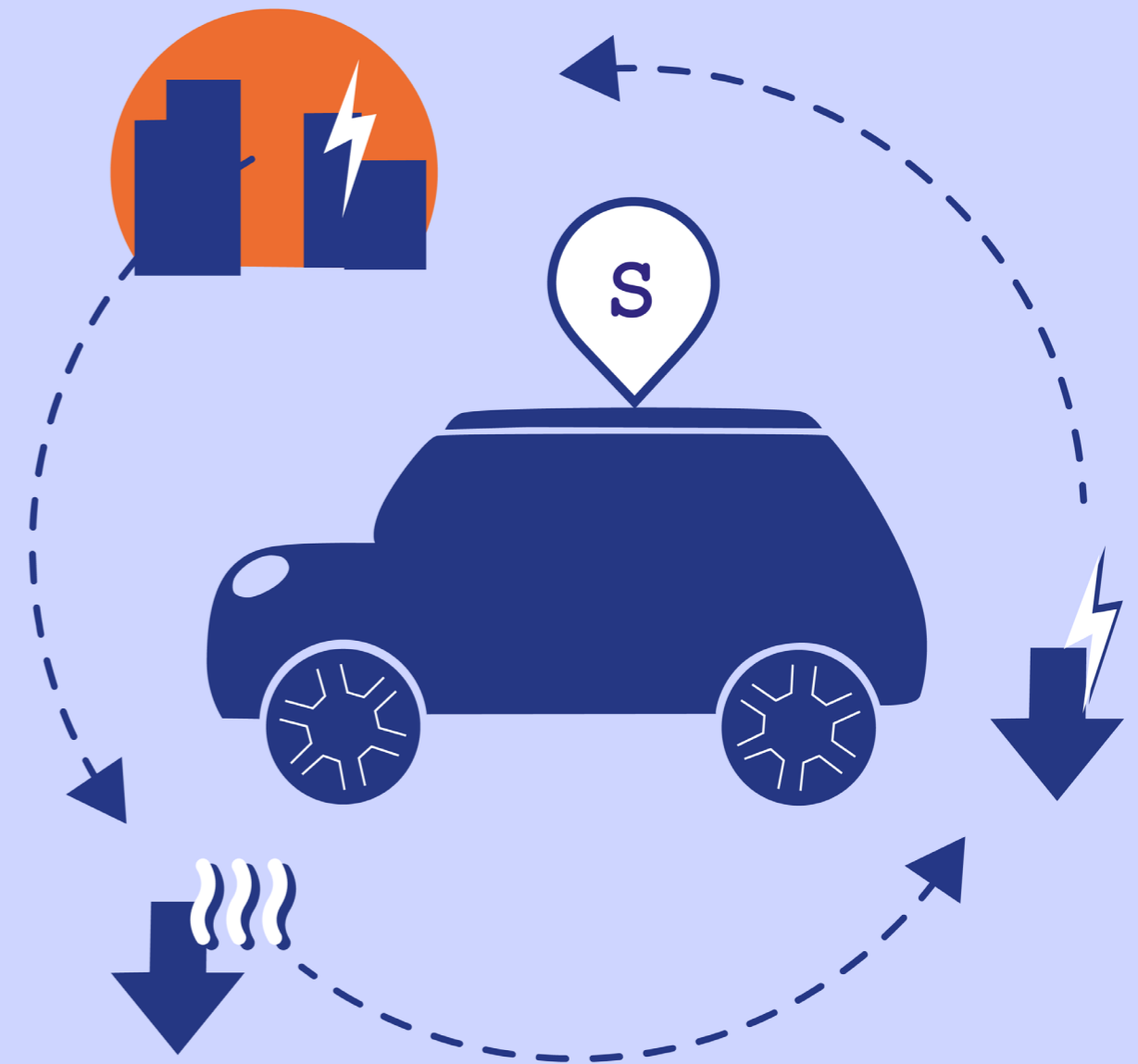
Horizon 3 – 2035

In the third horizon the aim to gain heat neutral cars is reached and possible solutions for heat negative vehicles are developed. A second skin technology, inspired by the camel, passively cools the car and the environment.

Cities with adequate public transport are moving towards a shared car strategy only. The number of needed cars is cut down to a small percentage. Parking areas are transformed into green areas and entire streets are given back to public use. In stage three, car owners are used to have their car outside the city which are designed for long distance rides between cities. The vehicles inside the city are for sharing only.

The most transformative step revolutionizes consumer thinking and encourages a mindset shift towards a concept where individuals gain mobility access in exchange for contributing to society. With an app, contributions to the city ecosystem and social impact can be monitored. This is provided by the sensors in the city ecosystem, to monitor the health of plants, trees and water reservoirs. Residents are encouraged to water plants, mow grass, collect water etc. and contribute to the bigger city ecosystem. This transformative appraoch seeks to not only address urban heat but also make a substantial contribution to the broader city ecosystem.

SCORE

152

MINDSET SHIFT

B) DELIVERABLES

As one of the most important parts of the strategic roadmap is to create awareness, it made sense to think about how to foster awareness at the Design Department of BMW as well. The derived insights are condensed into small, „snackable bite" booklets to add to the strategic roadmap. These booklets are inspired by the Kidsbooks "Pixie", which are short, illustrated stories (see appendix H). These are meant to inspire co-workers in the Design Departments Coffee point, which is the central networking space. To create interest and awareness on the topic as much as inspiration for possible interventions. The booklets can be part of an exhibition concept in the coffee space with the fictional accessories, movies and posters to create interest in the topic and lead readers to more information.

ABOUT HEATWAVES

HOW CAN WE CONTRIBUTE?
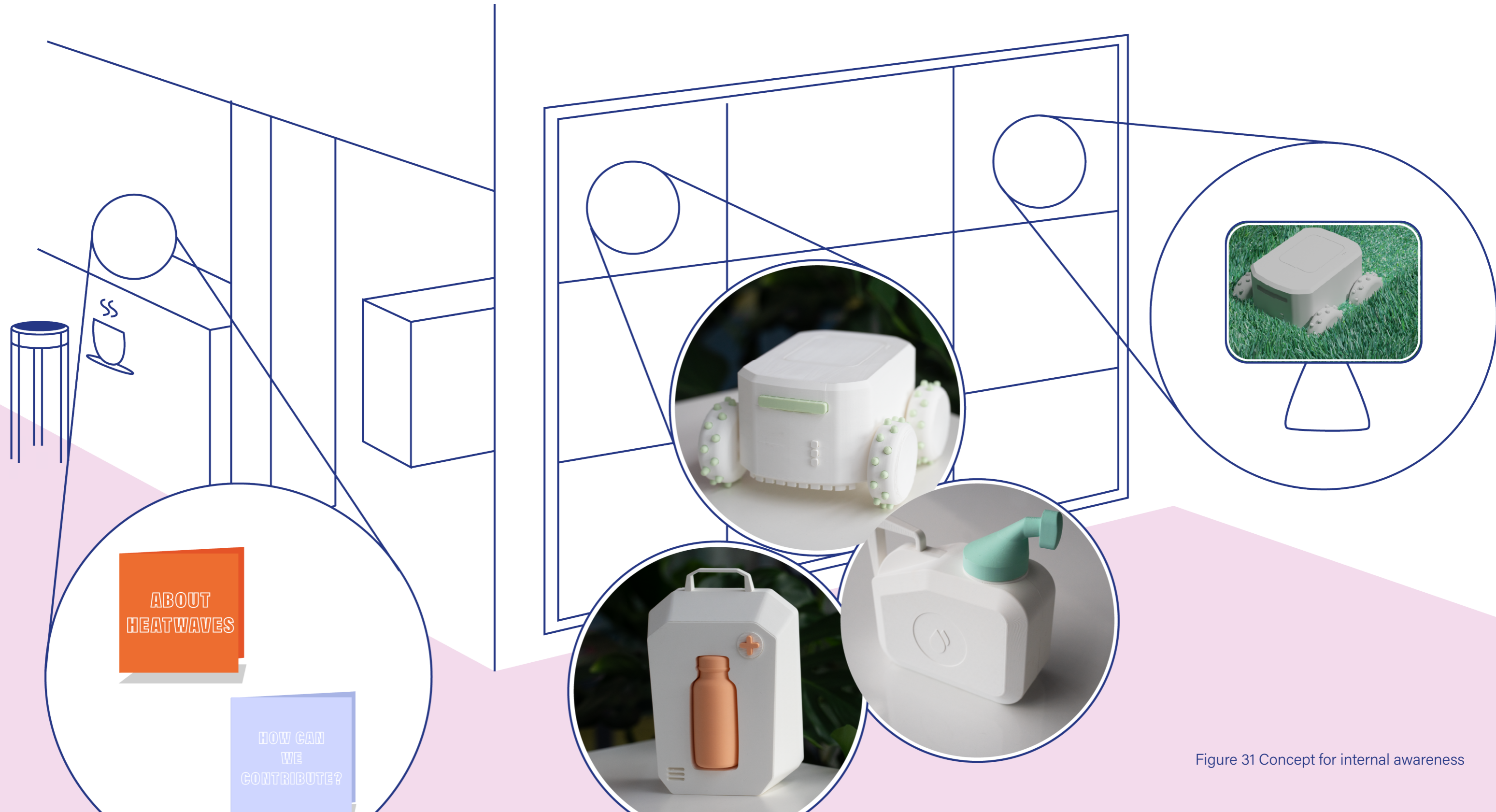
Figure 31 Concept for internal awareness

8. CONCLUSION AND RECOMMENDATION

This thesis is designed to foster dialogues and inspiration for future interventions in the light of heat waves. The research and provided strategy aims to inspire action on the topic of heat waves at MINI and the BMW Group, instead of focusing on theory only. Increasing heat waves in cities and the increasing number of fatalities is an important topic which is currently lacking attention.

Heat waves gain more and more awareness and the users experienced dilemma on car usage is expected to grow as well. Finding ways to reduce heat and lower the total amount of heat creation in the car is a logical step towards a holisitc view on sustainable product development. It became clear that there is not one-size-fits-all solution and all derived concepts need negotiations to cut down in other directions. It is recommended to democratize mobility and find the best way possible. Due to the limit of time, it is recommended to invest further research on the effect of dormant cars temperature on the city's heat island effect. The derived technical opportunities need to be further researched and it is recommended to rethink the car under the light of heat waves from scratch. The vision to design for heat neutrality is challenging and needs new ways of thinking to come up with effective solutions. Furthermore research on modern ways of heat resilient car exterior and interior designs is needed to make heat neutrality aestheticly pleasing. Additionally, investing research into modern solutions on solar chimneys, to create vehicles with the least heat impact from a technical perspective.

Looking at this topic from a systemic design perspective it was found that we cannot stop at improving on the product level. Instead, to create change towards planet centered design, there needs to be a mindset shift. This change needs to start within car manufacturers, who heed to take the lead towards technological change adaptations to force a change of mindset from a „healthy me" to a „healthy us" within actors of ecosystems.

The complexity of climate change and heat waves make it clear that this complex problem cannot be tackled alone. Therefore, alliances between cities, residents and manufacturers need to be further fostered. However, alliances between manufacturers and OEMs also need to be formed. Furthermore it is recommended to turn systemic design within the BMW Group into a culture and make it part of the organizational identity.

Cities, manufacturers and universities should focus on projects that could find ways to implement the provided three horizons and make all stakeholders work together towards future, livable cities.
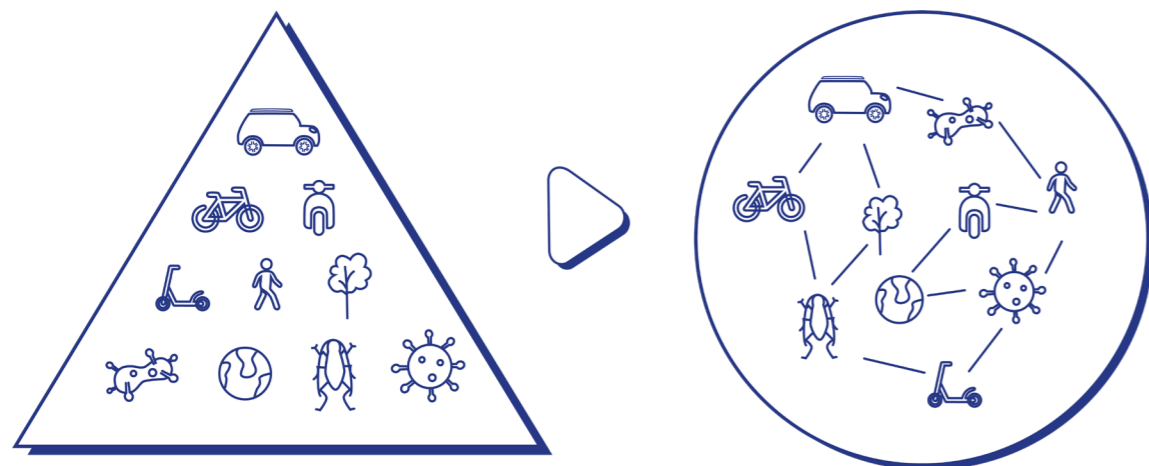
Figure 32 Envisioning the car as part of the ecosystem

9. REFERENCES

Agency, E. E. (2020). European Environment Agency. Retrieved from https://www.eea.europa.eu/publications/signals-2020

Aitamrouche. (2022, July 11). Renault Scenic Vision: The „car" in care - Renault. Retrieved from https://events.renault.com/en/2022/05/18/renault-scenic-vision-the-concept-care-car/

Ajuntament de Barcelona. (n.d.). Retrieved from https://www.barcelona.cat/pla-superilla-barcelona/en

Albrecht, G. (2019). Earth Emotions: New words for a new world. Cornell University Press.

Ausrys, U. (2019). Retrieved from Demilked: https://www.demilked.com/great-britain-heatwave-2019/

BMWGroup. (2021, 11 04). BMW Group. Retrieved from https://www.bmwgroup.com/en/news/retrieved 15.06.2023general/2021/lighthouse-city-rotterdam.html

BMWGroup. (2023). BMWGroup. Retrieved from retrieved 15.06.2023 from: https://www.bmwgroup.com/en/company/business-segments.html

BMWGroup Press. (2021, Septembre 06). Press BMWGroup. Retrieved from https://www.press.bmwgroup.com/deutschland/article/detail/T0341253DE/der-bmw-i-vision-circular?language=de BMWGroupdesignworks. (2022, May 13). BMWGroupdesignworks.com. Retrieved from https://www.bmwgroupdesignworks.com/how-the-intersection-of-architecture-and-mobility-will-shape-the-cities-of-tomorrow/, 16.06.2023

cardesigntv. (2022, 05 22). Youtube. Retrieved from https://www.youtube.com/watch?app=desktop&v=pXDdkBpXivg

Centers for Disease Control and Prevention. (2022, 25). Retrieved from https://www.cdc.gov/disasters/extremeheat/specificgroups.html

Chatterjee, K. G. (2018, January 23). Government.UK. Retrieved from Young People's Travel – What's Changed and Why? Review and Analysis. Report to Department for Transport. UWE Bristol, UK.: www.gov.uk/government/publications/young-peoples-travel-whats-changed-and- why

Ciocanea, A., & Buretea, D. (2014). Cabin heat removal from parked cars. Hidraulica, Magazine of Hydraulics, Pneumatics, Tribology, Ecology, Sensorics, Mechatronics, No.3 .

Clayton, S. M. (2017). Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. . Washington, D.C.: American Psychological Association, and ecoAmerica.

Climatecentral. (n.d.). Climatecentral. Retrieved from https://www.climatecentral.org/graphic/2022-in-review-global-temperature?graphicSet=2022+Top+10+Hottest+Years

Commission, E. (2019, 12 11). EUR-Lex. Retrieved from COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN

Commission, E. (2019). The European Green Deal. ESDN Report, December 2020, ESDN Office, Vienna.

Commission, E. (2022). Joint Research Centre. Retrieved from https://joint-research-centre.ec.europa.eu/peseta-projects/jrc-peseta-iv/human-mortality-extreme-heat-and-cold_en

Dalzell, R. (2023, April 11). Diana Kellogg Architects designs a sandstone school in India. Interior Design. Retrieved from https://interiordesign.net/projects/diana-kellogg-architects-designs-an-oval-sandstone-school-in-northern-india/

Data, M. N. (2023, 06 06). My NASA Data. Retrieved from https://mynasadata.larc.nasa.gov/mini-lessonactivity/what-albedo

Dimitroff, C. (2023). MSCHF's microscopic handbag takes the itty-bitty mini bag trend to the extreme. RUSSH. Retrieved from https://www.russh.com/mschf-microscopic-bag/

Ditech Media. (n.d.). Ditech Media. Retrieved from Image by Posad Maxwan, https://ditech.media/news/telecommunications/mobility-in-a-5g-world-how-can-we-design-for-a-positive-impact/

Groß, B., & Mandir, E. (2022). Zukünfte gestalten. Schmidt Hermann Verlag.

Heat.gov. ((n.d)). National Integrated Heat Health Information System. Retrieved from https://www.heat.gov/pages/who-is-at-risk-to-extreme-heat

Heat.gov. (n.d.). National Integrated Heat Health Information System. Retrieved from https://www.heat.gov/pages/urban-heat-islands

Heineke, K. L. (2023, April 28). McKinsey Quarterly. Retrieved from https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/europes-gen-z-and-the-future-of-mobility

Hirano, Y. &. (2016). Simulating the CO2 reduction caused by decreasing the air conditioning load in an urban area. Energy and Buildings, 114; https://doi.org/10.1016/j.enbuild.2015.06.033, pp. 87-95.

Horak, J., Schmerold, I., Wimmer, K., & Schauberger, G. (2016). Cabin air temperature of parked vehicles in summer conditions: life-threatening environment for children and pets calculated by a dynamic model. . Theoretical and Applied Climatology, 130(1–2).

Horowitz, J. (2021, August 21). The New York Times. Retrieved from https://www.nytimes.com/2021/08/21/world/europe/athens-is-only-getting-hotter-its-new-chief-heat-officer-hopes-to-cool-it-down.html

Hundert, P. (2023). BMW Group kooperiert mit E-Bike-Marke Angell: Das BMW-MINI E-Bike kommt. Nimms Rad. Retrieved from https://www.nimms-rad.de/news/angell-bmw-mini-e-bike/

Ichinose, F. M. (2008). Counteracting Urban Heat Islands in Japan P. Droege (Ed.). Urban Energy Transition, Elsevier, Amsterdam, pp. Chapter 15 - pp. 365-380.

Indeka, M. (2023, July). LS:N Global. Retrieved from Heat casualties are crowding Arizona's emergency rooms. Heat Casualties Are Crowding Arizona's Emergency Rooms: https://www.lsnglobal.com/news/article/29790/heat-casualties-are-crowding-arizona-s-emergency-rooms

Jamil, M. J. (2015). Smart Environment Monitoring System by Employing Wireless Sensor Networks on Vehicles for Pollution Free Smart Cities. Procedia Engineering, 107; https://doi.org/, pp. 480-484.

Johnson, T. P. (2014). Snowball Sampling: Introduction. Wiley StatsRef: Statistics Reference Online. https://doi.org/10.1002/9781118445112.stat05720.

Jones, P. (2018). The Systemic Turn: Leverage for World Changing. . She Ji: The Journal of Design, Economics, and Innovation, 3, 157–163. https://doi.org/10.1016/j.sheji.2017.11.001.

Kendon, M. M. (2021). State of the UK Climate 2020. International Journal of Climatology, 41(S2), 1–76. https://doi.org/10.1002/joc.7285.

Kiialainen, E. (2022). Value Of Speculative Design In Organizations. Retrieved from Aaltodoc: https://aaltodoc.aalto.fi/bitstream/handle/123456789/114093/master_Kiialainen_Emilia_2022.pdf?sequence=1&isAllowed=y

Kovats, R. S. (2006). Heatwaves and public health in Europe. . European Journal of Public Health, 16(6); https://doi.org/10.1093/eurpub/ckl049 , pp. 592–599.

Lahimer, A. A. (2023). Automotive Cabin soak Temperature Control Strategies for Improved safety, comfort and Fuel efficiency: A review. . Solar Energy, 259, 416–436. https://doi.org/10.1016/j.solener.2023.05.039. Lahimer, A. A., Sopian, K., Razak, A., Ruslan, M. H., & Alghoul, M. A. (2019). Experimental investigation on the performance of solar chimney for reduction of vehicle cabin soak temperature. Applied Thermal Engineering, 152, 247–260. https://doi.org/10.10.

Laranjeira, K. G. (2021). Heat vulnerability and adaptive capacities: findings of a household survey in Ludwigsburg, BW, Germany. Climatic Change, https://doi.org/10.1007/s10584-021-03103-2, pp. 166(1–2).

Latour, B. (1992). Where are the missing masses, sociology of a few mundane artefact. Shaping Technology-Building Society. Studies in Sociotechnical Change, Wiebe Bijker and John Law (editors), MIT Press, Cambridge Mass.

Lennart, P. (2021, 06 03). Deutschlandfunk. Retrieved from https://www.deutschlandfunk.de/prepper-in-deutschland-immer-bereit-fuer-die-naechste-100.html

Leroutier, M., & Quirion, P. (2023). Tackling car emissions in urban areas: Shift, avoid, improve. . Ecological Economics, 213, 107951. https://doi.org/10.1016/j.ecolecon.2023.107951.

Levinson, R. P.-W. (2011). Potential benefits of solar reflective car shells: cooler cabins, fuel savings and emission reductions. . Applied Energy, 88(12), 4343–4357. https://doi.org/10.1016/j.apenerg.

Lundgren K., K. T. (2013). Sustainability challenges from climate change and air conditioning use in urban areas. Sustainability 5: https://doi.org/10.3390/su5073116, pp. 3116–3128.

Lv, Y. H. (2021). Improving cabin thermal environment of parked vehicles under direct sunlight using a daytime radiative cooling cover. . Applied Thermal Engineering, 190, 116776. https://doi.org/10.1016/j.applthermaleng.

Meadows, D. (1999). Leverage Points: Places to Intervene in a System. The Sustainability Insitute.

Méheut, C. (2023, April 28). New York Times. Retrieved from https://www.nytimes.com/2023/04/28/world/europe/spain-heat-wave.html

Merriam-Webster. (2023, Accessed 12 Jun.). "Heat wave." Merriam-Webster.com Dictionary, Merriam-Webster, https://www.merriam-webster.com/dictionary/heat%20wave. Retrieved from Merria-Webster.com: https://www.merriam-webster.com/dictionary/heat%20wave#:_:text=%3A%20a%20period%20of%20unusually%20hot%20weather

MINI. (2021). MINI.de. Retrieved from https://www.mini.de/de_DE/home/explore/concept-cars/mini-vision-next100.html

MINI. (2023). MINI.com. Retrieved from 14.06.2023; https://www.mini.com/en_MS/home/heritage.html

MINI. (2023, 05 16). MINI.de. Retrieved from https://www.mini.de/de_DE/home/news/sustainability.html

Miranda-Moreno, L. F. (2011). Weather or Not to Cycle. Transportation Research Record, 2247(1); https://doi.org/10.3141/2247-06. pp. 42-52.

Mohajerani, A. B.-B. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. Journal of Environmental Management, 197; https://doi.org/10.1016/j.j. 522-538.

Mussetti, G. D. (2022). Do Electric Vehicles Mitigate Urban Heat? The Case of a Tropical City. . Frontiers in Environmental Science, 10., https://doi.org/10.3389/fenvs.

MZM-Allianz. (2023). MZM Allianz.net. Retrieved from https://www.mzm-allianz.net/projekte/bestandsquartier-der-zukunft-dreimuehlenviertel/

Nastase, I., Danca, P., Bode, F., Croitoru, C., Fechete, L., & Sandu, M. &. (2022). A regard on the thermal comfort theories from the standpoint of electric vehicle design — review and perspectives. Energy Reports, 8, 10501–10517.

Nations, U. (2018, May 16). 68% of the world population projected to live in urban areas by 2050, says UN | UN DESA | United Nations Department of Economic and Social Affairs. United Nations | Department of Economic and Social Affair. Retrieved from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Nations, U. (n.d.). United Nations. Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement

Neht, A. D.-B. (2017). Heat Retreat Locations in Cities – The Survey-Based Location Analysis of Heat Relief. IOP Conference Series: Earth and Environmental Science, 95, 052006; https://doi.org/10.1088/1755-1315/95/5/0.

Netcarshow. (2023). Retrieved from https://www.netcarshow.com/fiat/2024-topolino/1280x960/wallpaper_36.htm

Newatlas. (2023). Retrieved from https://newatlas.com/materials/vibrantly-colored-film-passive-cooling-cars-buildings/?utm_source=New+Atlas+Subscribers&utm_campaign=b0fe7b65d0-EMAIL_CAMPAIGN_2023_08_07_08_06&utm_medium=email&utm_term=0_65b67362bd-b0fe7b65d0-%5BLIST_EMAIL_ID%5D

Niranjan, A. (2023, July 28). The Guardian. Retrieved from 'Era of global boiling has arrived,' says UN chief as July set to be hottest month on record. The Guardian. : https://www.theguardian.com/science/2023/

jul/27/scientists-july-world-hottest-month-record-climate-temperatures

Norman, D. A., & Stappers, P. J. (2015). DesignX: Complex Sociotechnical systems. She Ji: The Journal of Design, Economics, and Innovation, 1(2);83-106; https://doi.org/10.1016/j.sheji.2016.01.002.

NYC Government. (2023). Interactive Heat Vulnerability Index. Retrieved from https://a816-dohbesp.nyc.gov/IndicatorPublic/beta/key-topics/climatehealth/hvi/

Parliament, E. (2019, 03 22). European Parliament. Retrieved from CO2 emissions from cars: facts and figures (infographics): https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics

Price, R. B. (2019). Advancing Industry through Design: A Longitudinal Case Study of the Aviation Industry. https://doi.org/10.1016/j.sheji.2019.07.003. She Ji: The Journal of Design, Economics, and Innovation, 5(4),, pp. pp. 304–326.

PricewaterhouseCoopers. (n.d.). strategyandpwc. Retrieved from https://www.strategyand.pwc.com/m1/en/reports/2021/sustainable-mobility.html

Requia, W. J. (2018). How clean are electric vehicles? Evidence-based review of the effects of electric mobility on air pollutants, greenhouse gas emissions and human health. . Atmospheric Environment, 185, pp. 64-77.

Robine, J. C. (2008). Death toll exceeded 70,000 in Europe during the summer of 2003. . Comptes Rendus Biologies, 331(2); https://doi.org/10.1016/j.crvi.2007.12.001, pp. 171-178.

Robinson, P. J. (2001). On the Definition of a Heat Wave. . AMETSOC. https://doi.org/10.1175/1520-0450(2001)040, 762-775.
Roe, J. &. (2021). Restorative Cities. In Bloomsbury Publishing Plc eBooks; https://doi.org/10.5040/9781350112919.

Santamouris, M. (2013). On the built environment - the urban influence. Energy and Climate in the Urban Built Environment. Routledge, Abingdon-on-Thames, UK.

Serban, T. (2023). Autoevolution. Retrieved from https://www.autoevolution.com/cars/fiat-topolino-2023.html#aeng_fiat-topolino-2023-54-kwh

Sevaldson, B. (2017). Redesigning systems thinking. Form Akademisk - Research Journal of Design and Design Education, 10(1); https://doi.org/10.7577/formakademisk.1755.

Simonse, L. (2018). Design Roadmapping. BISPublishers.
Snowden, D. J. (2007). A Leader's Framework for Decision Making. Harvard Business Review 85(11), 68-76, 149.

Sommer, M. (2019, February 15). Tesla Dog Mode: Damit Frauchen sorgenfrei shoppen gehen kann. auto motor und sport. Retrieved from https://www.auto-motor-und-sport.de/tech-zukunft/tesla-dog-mode/
Spiegel. (2023). Retrieved from https://www.spiegel.de/stil/social-design-award-wie-ein-parkplatzbesetzer-staedte-lebenswerter-macht-a-d9e06fd2-5766-4704-b9c2-1af236a2144e

Spurling, N. J. (2020). Parking futures: The relationship between parking space, everyday life and travel demand in the UK. Land Use Policy, 91, 103872. https://doi.org/10.1016/j.landusepol.2019.02.031.

Sterling, B. (2012). Bruce Sterling Explains the Intriguing New Concept of Design Fiction (Interview by Torie Bosch). Slate. Retrieved from http://www.slate.com/blogs/future_tense/2012/03/02/bruce_sterling_on_design_fictions_.html; (retrieved 31. August, 2023)

Stompff, G. &. (2015). The right fidelity: representations that speed up innovation processes. . Design management journal, 10(1), 14–26, https://doi.org/10.1111/dmj.12019.

Stone, B. H. (2010). Urban Form and Extreme Heat Events: Are Sprawling Cities More Vulnerable to Climate Change Than Compact Cities? Environmental Health Perspectives, 118(10), https://doi.org/10.1289/ehp.0901879, pp. 1425–1428.

Stone, B. H. (2010). Urban Form and Extreme Heat Events: Are Sprawling Cities More Vulnerable to Climate Change Than Compact Cities? Environmental Health Perspectives, 118(10); https://doi.org/10.1289/ehp.0901879. 1425–1428.

Systemicdesigntoolkit. (n.d.). Retrieved from retrieved 31.8.2023: https://www.systemicdesigntoolkit.org/methodology

Takebayashi, H. &. (2009). Study on the urban heat island mitigation effect achieved by converting to grass-covered parking. . Solar Energy, 83(8); , 1211–1223. https://doi.org/10.1016/j.solener.2009.01.019. The nap ministry. ((n.d.)). Retrieved from https://thenapministry.com/

Toh, M. E. (2019, January 15). CNN Business. Retrieved from https://edition.cnn.com/2019/01/15/tech/alibaba-city-brain-hangzhou/index.html

Transport for London. ((n.d.)). Mayor of London. Retrieved from https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets

Trippel, K. S. (2023, 06 15). Vor dem Hitzschlag. Die Zeit No 26, pp. 27-28.

UK, G. ((n.d.)). Retrieved from https://www.gov.uk/government/publications/hot-weather-and-health-supporting-vulnerable-people/supporting-vulnerable-people-before-and-during-hot-weather-social-care-managers-staff-and-carers

Union, E. (2021). European Parliamentary Research Service . Retrieved from https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698753/EPRS_BRI(2021)698753_EN.pdf

Van Der Bijl-Brouwer, M. &. (2020). Systemic Design Principles in Social Innovation: A study of expert practices and design Rationales. She Ji: The Journal of Design, Economics, and Innovation, 6(3); https://doi.org/10.1016/j.sheji.20, 386–407.

Venter, Z. S. (2020). Linking green infrastructure to urban heat and human health risk mitigation in Oslo, Norway. . Science of The Total Environment, 709, 136193. https://doi.org/10.1016/j.scitotenv.2019.136193.

Vignoli, M., Roversi, S., Jatwani, C., & Tiriduzzi, M. (2021). Human and planet centred approach: Prosperity thinking in action . Proceedings of the Design Society, 1, 1797–1806; https://doi. org/10.1017/pds.2021.441.

Wakkary, R. (2021). Things We Could Design: For More Than Human-Centered Worlds. MITpress.

Waseem, N., & Kota, S. (2017). Sustainability Definitions—An Analysis. In Smart innovation, systems and technologies, 361–371; https://doi.org/10.1007/978-981-10-3521-0_31.

WGSN. ((n.d.)). Retrieved from https://www.wgsn.com/insight/article/64b670000317f2eeaaf9453a#page3.

WGSN. (n.d.). Retrieved from https://www.wgsn.com/interiors/article/87649

Whitlock, J. (2023). Climate change anxiety in young people. . Nature Mental Health 1, https://doi.org/10.1038/s44220-023-00059-3, pp. 297–298.

WHO. (2022, October 01). World Health Organization. Retrieved from https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

World Economic Forum. (2023, May 10). Weforum. Retrieved from https://www.weforum.org/agenda/2023/05/cities-heatwaves-climate-solutions/

Yamamoto, Y. (2006). Measures to mitigate urban heat islands . Sci. Tech. Trends Q. Rev., 18 (1) , pp. 65-83.

Yang, B., Liu, H., Kang, E. L., Hawthorne, T. L., Tong, S. Y., & Shu, S. &. (2022). Traffic restrictions during the 2008 Olympic Games reduced urban heat intensity and extent in Beijing. Communications earth & environment, 3(1). https://doi.org/10.103.

Zhou, X. Y.-F. (2022). Exploring the impacts of heat release of vehicles on urban heat mitigation in Sendai, Japan using WRF model integrated with urban LCZ. Sustainable Cities and Society, 82, 103922. https://doi.org/10.1016/j.scs.2022.103922.

Zukunftsinstitut. (n.d.). Retrieved from https://www.zukunftsinstitut.de/artikel/megatrend-glossar/urbanisierung-glossar/

APPENDIX

APPENDIX

A) CITIZEN INTERVIEW GUIDE

Research Question
How are citizens using different means of transportation, especially the car during heat waves and which dilemmas are they facing?

Welcome
1. Hi XX,
2. Thank you for taking the time for this interview and sending me the consent form and booklet – do you have any remaining questions?
3. I am Jutta from TU Delft, studying Strategic Product Design and currently writing on my Master thesis about the future of mobility urban heat waves with BMW.
4. I am especially interested in how people are moving during heat waves and if means of transportation are changing when it gets hotter.
5. I would like to record the video and audio of this interview to be able to transcribe it for our research if that is ok for you?
6. Your answers will be anonymized before I use it for my research.
7. I am going to start the recording now PRESS BUTTTON
8. Just let me know if you need a break or anything during the interview.

Introduction
1. Thank you for filling out the sensitizing booklet and sending it to me. I hope it introduced you a little bit to the topic.
2. Could you tell me a little bite about who you are, where you come from and where do you live?
   a. Since when do you live in this city?
   b. What is your current temperature?

Experiencing heat waves
1. In the last two years many cities around the globe have faced heat waves. You mentioned XXX that you were affected by a heat wave in the booklet
   a. Can you describe the event?
   b. That is an interesting thought, could you explain that a bit more for me?
2. How did you practically respond or get through this situation?
3.
4. How are you mitigating during extreme heat?
   a. Did you find something helpful?
   i. Parks and green spaces
   ii. Balcony/garden
   iii. Air conditioning
   b. Can you give me more examples?
   c. You mentioned X, Y, Z – was there anything else you did?
5. Do you have private heat retreat spaces?
6. What will you do differently next time?
7. Do you know if your city is doing something to mitigate the heat?

We are about halfway through the interview and from my point of view it is going very well. You have been telling me some interesting things. How is it going for you? Do you need a break to get some water or are you fine with continuing?

About the mobility behavior
8. Now that we have talked about the heat waves, I would be interested to hear about your activities in the city
   a. Can you describe typical day in your city?
9. What activities are you doing during heat waves?
   a. What are your hobbies during extreme heat?
   b. Is anything changing?
10. You mentioned in the booklet you are using XXX for transportation in your city
   a. Which ones are you using during extreme heat?
   b. How are you using your car during extreme heat?
   i. Do you have any problems with the car?
   ii. Are you using it as a heat retreat space?
   c. Which ones are you specifically not using during extreme heat?
   d. Which dilemmas are you facing when it comes to transportation in extreme heat?
   i. For example, sustainability aspects etc.
   ii. Which fears are you facing?
11. How do you think should the city change to adapt to heat?

Final take aways
1. From your personal perspective – how do you think should the city and mobility change?
2. How should the car change?

Closing Questions

3. What should I have asked you that I didn't think to ask?
   a. Is there anything else you want to add?
4. Are there people you would recommend me to interview?
5. Thanks a lot for your time and giving me such good insights into your experiences. You are really helping me understand the difficulties.
6. You will always have the possibility to withdraw from the research.
7. Thank you again for your time!
8. Don't turn mic off until you close the meeting.
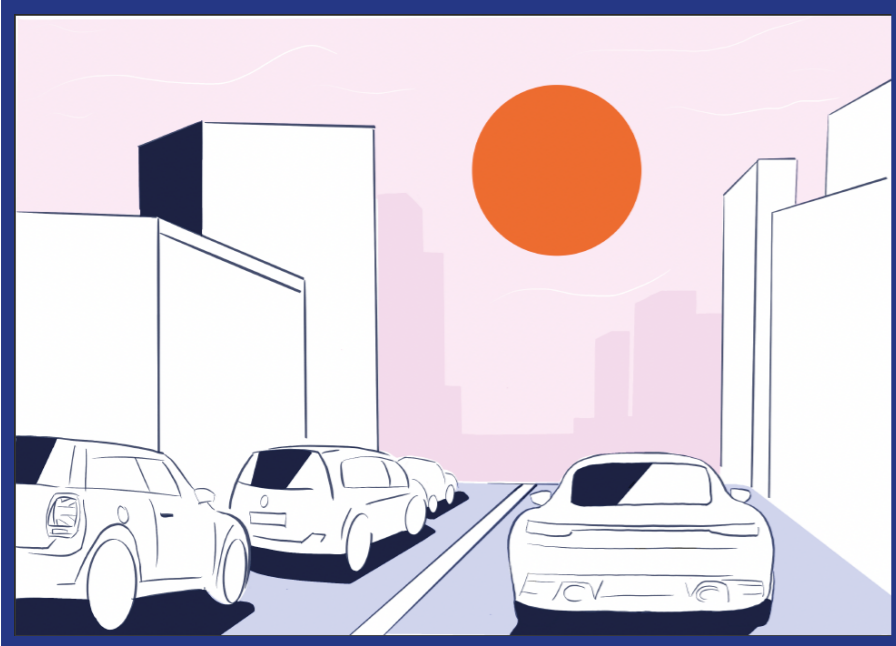
HI ☺

Hello and Welcome to my graduation project. Thanks a lot for participating in this study!
To get you acquainted about the topic „Heat waves and mobility in urban environments" I am asking you to answer some questions before our Interview. You can click on the buttons and upload pictures and insert texts. If it doesn't work - no worries. You can also just bring the pictures to our interview session and take notes on an extra sheet of paper! Have fun!

WHO ARE YOU?
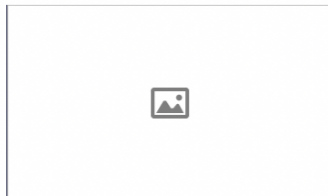
📍 Please insert a map of your city and where you aproximately live.

📷 Please insert a picture of your city.

WHAT ARE YOUR MEANS OF TRANSPORTATION IN YOUR CITY?

In the following pages I will ask you to list your means of transportation. Here you can find some inspiration.
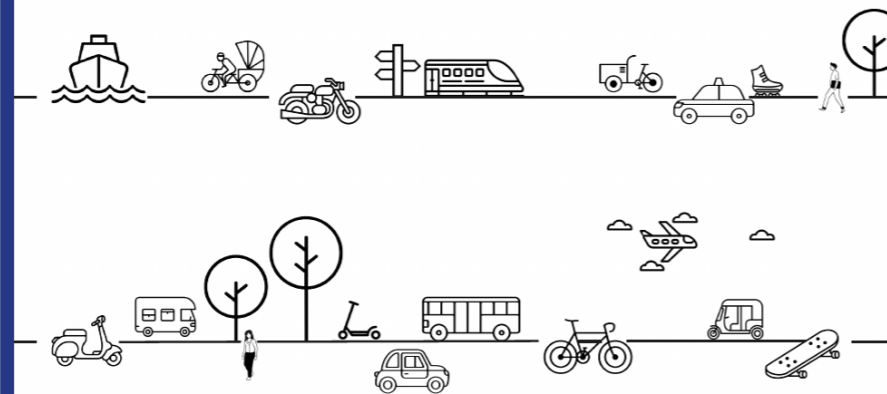
YOUR WEEK

Which means of transportation are you using in your city to get from A to B during the week? Which are you using for work? And which are you using for leisure? You can use the overview of the previous page as inspiration.

Commute/Work..   Leisure...   Other...

Please take some pictures of your different means of transportation and the surrounding. To see and understand in which context your device is used. How the city looks like, the landscape, the people. And for what kind of activities you are using it.
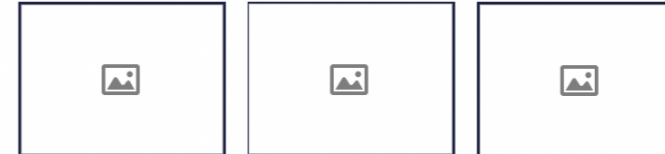
HEAT WAVES IN YOUR CITY

In the last two years many cities around the globe have faced heat waves.
Can you recall the last time you where affected by a heat wave? Can you describe the event?
Take some notes for the interview

What activities are you doing during heat waves? How are you mitigating the heat?

What is your city doing for the mobility well-being of the citizens during heat waves?

THANK YOU! ☺

C) CITIZEN CODING

People mitigation Strategies

Inside the house

171	Mitigating heat	Cooking behavior during heat	doesn't involve turning on an oven or cooking too much.	Interview7	#mitigation
174	Heat retreat	Basement nice and cool	something that I remember because before I moved into this apt, I was living in a basement in	Interview7	#mitigation
130	Power off	Looking at the brightside, seeing it as a	You know, it's OK, you know, I'll take the opportunity to like, OK, now it's like digital detox.	Interview5	#staypositive
77	Mitigating heat	Close lids	"Oder wir machen dann halt tagsüber alles dunkel, in der Hoffnung, dass das Haus sich nicht allzu au	Interview3	#mitigation
78	Mitigating heat	Ventilators	"Wir haben uns auf jeden Fall ausgestattet mit Ventilatoren, Sitzen und sechs Ventilatoren, die wir	Interview3	#mitigation
43	Mitigation	Keep house cool	traps a lot of uh, hold air inside the house or cooler air, and then it takes a longer time for it to	Interview2	#mitigation
40	Preparation	Preparing for fires	me that makes it much more fire resistant.So like the roofing is uh got metal instead of like some	Interview2	#preparation

Shade and cool areas

88	Mitigation	Choosing the coolest road	"Also dass wir unsere Wege wirklich immer so gelegt, dass wir unter diesen Bäumen langlaufen kö	Interview3	#citydesign
111	Avoiding heat	Avoiding heat	"Heat waves would put me off going to places."	Interview4	#adaptation
71	Mitigating heat	Staying inside or in shadow	"Wenn es erträglich ist, dann versuchen wir eigentlich nicht rauszugehen, sondern zu bleiben. Oder	Interview3	#mitigation
112	Avoiding sun	there are people who are very sun avoid	"I cannot swim, so I don't like to do like beach holidays. I'm very conscious of of the sun. I don't like	Interview4	#sunavoidance

Green Space

37	Green Space	Trees around the house	But we do have a lot like uh spaces where we have some large trees that create more shade in the	Interview2	#mitigating
168	Mitigating heat	Lunch under trees	garden that has a shaded like a shade shade area.	Interview7	#mitigation

Wardrobe

101	Mitigating heat	Find cooling	"I'm barefoot within the apartment. Uh, very loose clothing.And the colder showers not cold shower	Interview4	#heatprotection
166	Mitigating strategies	Tricky to find appropriate wardrobe	trying to plan for everything."	Interview7	#mitigation
102	Mitigating heat	Protect yourself	"And if I go outside, I always wear a baseball cap. So that I am like sunscreen and I put on SPF all th	Interview4	#heatprotection

Water to cool down

204	Mitigating strategies	Mitigation at water places	popular to go to the beach. But there is also some big and not a big lake, but I don't know the word	Interview 8	#mitigation
170	Mitigating heat	Can't cool down in the river	places because I mean, I wouldn't wanna swim.I think I would come out with an extra arm or	Interview7	#mitigation
175	Heat retreat	Showers to cool down	My heat retreat space is my shower.	Interview7	#mitigation
197	Mitigating strategies	Misters in spain	I think it's a very Spanish thing, but I've never seen them in London and it's something that, you kno	Interview7	#mitigation
180	City support	Water playgrounds for kids	the floor and there's loads of kids playing there and, you know, they put their swimming suit and	Interview7	#mitigation
79	Mitigating heat	Water playgrounds for kids	"Also Berlin ist ja generell schön grün, es gibt wahnsinnig viele Möglichkeiten für Kinder, habe ich da	Interview3	#mitigation
72	Mitigating heat	Pool to cool down	"Heute aufgebaut wird, wo wir uns dann auch einfach mal gerade die Kinder abkühlen können, weil	Interview3	#pool

Adaption and behavior change

94	Climate change	Changing vacation destination	"Deswegen wir jetzt auch eher in den Norden, in den Urlaub, weil es einfach so unerträglich ist. "	Interview3	#behaviorchange
157	Heat schedule	Closing work when too hot	you know we're closing and everyone goes home because it is just too hard to do work in a kitchen	Interview6	#schedule
147	Adapting to heat	Adapt schedule to heat	morning to to run because for 6:00 o'clock already.It is just too hot.	Interview6	#adaptation
45	Heat schedule	Changing schedule	So, umm, you know, I do a lot of work around my house trimming trees and and cutting the grass	Interview2	#adaptation

31	Adjusting	Adjust schedule to heat	"You always wait until the evenings to either take a walk with our dog or do any kind of physical spo	Interview2	#adaptation
41	Preparation	Preparation lowers insurance	lot of companies will not ensure homes anymore. Umm, in California, because of the the fire issue	Interview2	#insurance
122	Online shopping	No need to carry groceries	everything and they even bring it up to the apartment so."	Interview4	#adaptation

Avoid and Escape heat places

| 30 | Escape heat | Travelling | "This is around the first week of July, it was so hot that we decided that wer were gonna take a trip, | Interview2 | #mitigating |
| 42 | Avoid heat | Escape from heat | holiday if you're not gonna be if you don't, if you can. Right. | Interview2 | #heatretreat |

Heat Retreat Spaces

32	City support	Common heat retreat	homes, they'll end up going to these places called cooling centers and they'll.	Interview2	#heatretreat
58	Energy	Car is not a heat retreat	"Yeah, I'd I'd rather not burn gasoline to just to cool down the car"	Interview2	#heatretreat
148	Heat retreat	Supermarket as heatreat	because it's it's usually it's cool because there's a lot of air conditioning in there."	Interview6	#heatretreat

Sports

205	Mitigating strategies	Frozen weasts for dutch athletes	And now I just remember something as an athlete, normally when we go to train. also in spain you	Interview 8	#mitigation
206	Mitigating strategies	Drink water and isotonic salt	training like one and a half hour because you sweat so much, really. in places there is no air	Interview 8	#mitigation
104	Mitigating heat	Working out in gym for AC	also like, it's really nice and cold in the gym and it's literally in the neighboring building."	Interview4	#mitigation
202	Adapting to heat	Doing all sports inside	the machine or to make it like really early in the morning or really late like in the night but it is still	Interview 8	#adaptation
44	Exercise	exercise when cooler	off for a an hour ride or so. So.	Interview2	#adaptation
4	Dilemma	Snowboarding in summer	"That's yeah, that's pretty interesting. I have to say. It's where you get a natural cooling system and	Interview1	#mitigation #dilemm

City problems

Architecture

| 3 | Nature | No Balcony | " I want to be able to feel the real nature or real outside, but I don't have the luxury of doing so. " | Interview1 | #architecture |

Climate change

91	City change	Water fountains are empty	"Also ich habe das Gefühl, in Berlin sind ganz viele Springbrunnen stillgelegt worden, die hier früher	Interview3	#citydesign
127	Fire	Fire threats	sparks fires, you know, so every year now there's a helicopter going around for like a couple of	Interview5	#fire
126	City problem	Extreme heat is 1-2 months	I said, like the rest of the year is like really comfortable."	Interview5	#heatperiod
128	Fire	Fire season is now all year round	year round.	Interview5	#fire
129	Fire	Devil wind alerts - turn off power	windy that they turn the power off."	Interview5	#fire
184	Systemic problem	Floods but also rationing water in italy	water, and that's maybe something that they're not. Let's say they have had things like this before,	Interview7	#climatechange

City Planning

69	Asphalt	City centre	"Also es ist nicht, es ist ein bisschen grüner und dadurch noch ein bisschen empfindlich, wenn man a	Interview3	#citycentre
22	Heat Transportation	Way to the car	"It's it's an old structure, so I have to walk probably like 15 minutes to get to a car. So even when it':	Interview1	#citydesign
34	Green Space	Not enough green space	"I don't think that there's enough of those places.	Interview2	#cityproblems
108	Heat in concrete areas	Heat in concrete jungle	In the concrete jungle."	Interview4	#cityproblems

| 181 | Problems with grass | Parks green grass becomes yellow | becomes this really desert like this was last summer. | Interview7 | #heatperiod |

Traffic Jam

210	Traffic jams	High traffic in Tel Aviv	is a lot of traffic. If you live in Tel Aviv and you work in Tel Aviv. So yeah, you use the scooter, you	Interview 8	#cityproblems
51	Memo	Living in the city centre	The more you are in the city centre the more different transportation devices they use	Interview 7	#citycentre
87	Mitigation	Mitigation places are full	"Aber die Freibäder sind halt überfüllt, die Seen sind am Wochenende total voll, weil alle dann raus	Interview3	#citydesign

City mitigation Strategies

Mobility

119	City change	Put Transportation underground	Underground so that you can't see and it's perfect."	Interview4	#citydesign
121	Car in the city	Cars in the city centre	if you enter those zones, you have to pay extra."	Interview4	#citycentre
110	Availability in the city	15 minute city	"Everything is within walking distance. For me...I wish you know every place would be this like 15 m	Interview4	#citydesign

Water

36	Water	Water Misters	Purified water and they spray these little misters and so it creates like a a feeling of cooling.	Interview2	#citymitigation
95	Adapting cities	waterpark in melbourne	"Also in Melbourne gab es einen riesengroßen Public Pool, aber das war nicht wie so ein langweilige	Interview3	#climateadaptation
105	City change	Water to cool down	"So I know that they invested in some paddling pools, if you know what that is."	Interview4	#citymitigation
106	City change	Sprinkler water	"Like it's like if you go on like the Main Street on the shopping street where only people can go and	Interview4	#citymitigation
80	City change	Drinking water fountains	"Das finde ich cool, wenn die Städte so was machen würden, dass sie einfach mehr Trinkwasser Mö	Interview3	#citydesign

Communication

179	City support	City is creating awareness	and that's the underground system.Say make sure you stay hydrated in this hot time.	Interview7	#communication
152	Cultural differences	Lots of Communication about protectio	sunscreen.	Interview6	#communication
177	Neighbour support	Shopping center, library as public coolin	seen advertised and some of my local notice boards, as you know, for old people especially like,	Interview7	#citymitigation

Albedo

| 35 | Asphalt | Painting the ground | "LA County, where there are experimenting with painting the the roadways that are that are made | Interview2 | #citymitigation |

City Mobility problems

Safety

109	Biking	Biking is scary	"I wouldn't bike in London, so I think it's too dangerous."	Interview4	#biking
133	Biking	USA no infrastructure for biking	bring it, put the bicycle, you can lock the bike to the itself, you know, maybe and then going to the	Interview5	#biking
188	Transportation safety	Cyclists are not willing to share the lan	office, or back from the office. But the cyclists are real animals when it comes to welcoming other	Interview7	#safety
212	Means of transportation	Taking the bike is too dangerous	minutes. But I still use the car. Its also because (...) I am not allowed to take the bicycle. Because	Interview 8	#safety
220	Safety	Scooters also too dangerous	crashes and people really get injured from it so it's allowed only on the road in the well when you	Interview 8	#safety
211	Public transport	No subway or underground available	To the airport also you can go by train. There is no subway or underground rail. Now they want to m	Interview 8	#publictransport

Public Transport

Infrastructure

48	Mobility changes	Public transport is bad	I wish the metro infrastructure was a lot better.	Interview2	#publictransport
134	Public transport	Public transport in US takes a long time	ride, you know."	Interview5	#publictransport
143	Public transport	Public transport should be easier to rea	"If they don't make it easy, you're always gonna take the car."	Interview5	#publictransport
208	Public transport	No good public transport infrastructure	people they go with the car it is really problem in Israel at the moment because there is so many	Interview 8	#publictransport
221	Public transport	Public transport in Japan super crowded	like in there everyone use it's crazy how it's full you know and when when it's in the rush hour it's	Interview 8	#publictransport
219	Mobility changes	People want other solutions but politics	other solution, but, but we just don't believe it's will happen.	Interview 8	#publictransport

Price

99	Adaptation needed	Public transport is too hot	"But then people just go into the offices more, I guess, for the for the AC, but even the even the pub	Interview4	#publictransport
116	Public transport	Generally public transport is great - wh	public transport is a very nice thing.	Interview4	#publictransport
53	Public transport	Metro is expensive	"Umm, it's almost exactly the same in terms of the cost and uh, so when you look at it, it's like do, \	Interview2	#publictransport

Heat

167	Public transport during hea	Public transport is very hot	and yeah, then you, you, you you pray it's gonna go very fast so that you can get out of there	Interview7	#publictransport
196	Public transport	Bus has only tiny windows	you could open them all and it was completely different.And for someone that is using the bus it	Interview7	#publictransport
118	Public transport	Short pants and materials on the bus	"I would prefer not taking the bus and you know, and I would like not if it's too warm and I'm in a sh	Interview4	#publictransport

Shared mobility

Bikes

169	Mobility behavior in heat	Hire a bike to get home in the evening t	gonna start to be sweaty already from the morning.I easily get sick and it's like if I'm gonna be wet	Interview7	#sharingmobility
186	Sharing mobility	Sharing an e-bike with flatmates	so it's a subscription bike and we're trying it out to see how it works before we invest into one	Interview7	#sharingmobility
187	Mobility changes	Bike lease via companyJobrad	business will help you to pay the bike out of your salary as part of like a salary sacrifice.	Interview7	#sharingmobility

Cars

191	Sharing mobility	Different car sharing options	drive them around.And so you have the flex ones that you can drive them from A to B or you have	Interview7	#sharingmobility
192	Sharing mobility	Scooters are not treated nicely by publi	conveniently located everywhere around the city, those are I think, 18 or 22 pence per minute as	Interview7	#sharingmobility
198	Mobility changes	Sharing a car with neighbours	of the box because we live in an area where we can have a normal car without having to pay for	Interview7	#sharingmobility
47	Mobility behavior	Sharing a ride	there's the reason that you don't wanna be burning gasoline for everybody for all these cars.	Interview2	#ridesharing

E-scooters

49	Means of transportation	e-scooters	place to place.It's, you know, it's easy to be able to go like, you know, four or five kilometers in, in a	Interview2	#scooters

Mobility hehavior during heat

Walking

135	Walking	Avoid walking in heat	"I would not try to walk."	Interview5	#walking
163	Walking	Avoid walking in heat	Uh, yeah, it is hard to walk in the sun.	Interview6	#walking

Biking

54	Biking	Biking is scary	"The the part that's the worse is that you would it be more exposed to uh traffic on the road and tha	Interview2	#biking

207	Means of transportation	Biking is too hot	In general it it's not like in Germany that people walk or they use bicycle. In Israel it does not happer	Interview 8	#biking
6	Heat Transportation	Skateboarding best activity	"Other than that, I actually do like skateboarding a lot in the heat waves. Like, better than, like, othe	Interview1	#mobilitybehavior
185	Mobility behavior in heat	Biking during heat is too exhaustive	Having said that, I wouldn't put myself on a bike at midday because it's just too hard.	Interview7	#mobilitybehavior
5	Heat Transportation	Bikes are too hot to handle	"Um, the only thing I wouldn't do is probably biking in the heat waves because we do have a lot sha	Interview1	#material #biking

Car

20	Car usage	Car used for long drives	"I try to go back home for holidays and it's like, nine hour drive, well, it's 3 hours by train, by like driv	Interview1	#carusage
21	Car usage	Car not used for a long time	"I try to use it at least once a week.	Interview1	#carusage
52	Memo	Cars in the city centre	Inside the city cars are needed to escape the city or leave it for work	Interview 7	#carusage
89	Car usage	Car to escape the city	"Also hätte ich mir auch nicht angeschafft, weil es einfach die Wege viel kürzer waren. Die sind jetz	Interview3	#carusage
82	Transportation for kids	Heat as purchase decision	"Und der ausschlaggebende Punkt war für mich dann tatsächlich, wenn wir ein Baby haben und die	Interview3	#car
209	Means of transportation	Car is the general means of transportat	One family have at least two cars. Sometimes three, sometimes four. And every year it's become n	Interview 8	#transportation
160	Car	Need cars in australia	family will have one or two cars."	Interview6	#carneed

Taxi

| 7 | Heat Transportation | Taxiing | "A lot like driving myself or, um, just taxiing. Um, because, I mean, I do.. I'm allergic to, like, sunligh | Interview1 | #mobilitybehavior |
| 11 | Heat Transportation | Taxi has right temperature | "And I like Taxi a lot because it's always like the right temperature. Someone's sitting there." | Interview1 | #mobilitybehavior |

Public Transport

| 81 | Transportation in heat | Public transport is too hot | "Öffentliche Verkehrsmittel meide ich extrem. Und heiß ist, weil die nicht klimatisiert, sondern wen | Interview3 | #transportation |
| 193 | Public transport during hea | Prefering sauna in the room than using | the heat a bit more in my house, especially in the afternoon because we had the window that at | Interview7 | #mobilitybehavior |

Needs and Occasion

8	Heat Transportation	UV rays	"But like it's not necessarily temperature related about like sunlight related."	Interview1	#mobilitybehavior
18	Mobility behavior	Choosing transportation by occasion	"So mobility, mobility behaviors, I would say it doesn't really change because of the heat wave, but l	Interview1	#mobilitybehavior
213	Means of transportation	Travel behavior job dependend	Yeah I think this week I spend 21 hours on the plane. From Mongolia to Japan it was 6 hours. And th	Interview 8	#mobilitybehavior
194	Mobility behavior in heat	Depends on how fast you need to go	especially with this electric bike, I'm really discovering that it's a it doesn't need to be so	Interview7	#mobilitybehavior
195	Mobility behavior in heat	Choice of mobility depends on your nee	So I don't think I can say there's there's one I would avoid because I don't have the luxury of choice c	Interview7	#mobilitybehavior

Cultural differences

Heat resilience people and city

1	Culture	Chinese Medicine	"I was going to say like, because in China, like there's a thing saying that...I don't know how to transl	Interview1	#culture #balancehe
50	Memo	Culutural differences	Cultural difference - weather is always a topic in england	Interview7	#culture
97	Cultural differences	British can't handle the heat	"For a longer time and here there are even some memes about it in the in the British media that if i	Interview4	#culture
100	Cultural differences	British are not used to heat	"Yes, 30 degrees in Spain. No problem. 30 degrees in the UK, that's a big problem, right?"	Interview4	#culture
183	Cultural differences	Italy is more prepared	there's pools, there's like it's more part of the culture of the heat and especially the summers are	Interview7	#culture
165	Northern europe is not prep	London not designed for heat wave	massive heat wave."	Interview7	#culture

#	Category	Label	Quote	Interview	Tag
24	Car Materials	Car color	Like when my first car was like when I was 17 or 18, 18, something like that. And it was black and I	Interview1	#material
19	Car Problems	Heat vulnerable car	And I don't know, like for that car, the biggest part I'm worried about is the paint, might come off, ju	Interview1	#carproblems
27	Health concerns	Hot glue smell	"Also, there are so many glues, or because you can smell like, you know, the new car smell when wa	Interview1	#carproblems
29	Car Problems	Covering the windows	"Um, there are so many ways people cover their vehicles up, like we have these tinted windows tha	Interview1	#carproblems
55	Car Problems	Old cars can't handle the heat	"So you see cars on the side of the road that are overheating or they have the breakdown on the on	Interview2	#carproblems
60	Car Problems	Avoid windows	"Umm, they they sit more in areas that don't have open, exposed windows."	Interview2	#carproblems
61	Car solutions	Seal the vehicle	"I mean, it would be nice if there was a way to, uh, seal the vehicle.	Interview2	#carsolutions
63	Steering wheel	Steering wheel burns	"If you touch a steering wheel after it's been in the sun, sometimes you can't even touch it cause it':	Interview2	#carproblems
214	Car problems	Wheels loose air	wheels really often. it really goes out that I get I really I can really recognize during the summer it	Interview 8	#carproblems
46	Materials	Leather is hot	most part. Like people think that's how high standards luxury cars standard. But leather is terrible	Interview1	#material
137	Materials	Leather is hot	Ohh yeah, I I don't know if I mean I don't like I don't like leather in the car.	Interview5	#material
140	Leather burns your skind	Leather is hot	hot.You know, you sit on this like if you have shorts on you, you burn your legs off, you know.	Interview5	#material
222	Materials	No black cars	popular at all in Israel more they say like don't buy a black car because they really catch the heat	Interview 8	#material
64	Shaded park mode	Shaded park mode	"Hey, I mean, obviously you could park it under something if you had a way of doing that under a sha	Interview2	#carproblems
65	Precool	Precool	"I'm sitting in the vehicle and I'm cooling the car down before uh, my dog and my wife getting the v	Interview2	#carproblems

Heat trap

#	Category	Label	Quote	Interview	Tag
12	Car Problems	Car is too hot	"Because like, I seriously just can't sit in a car without like, any sort of, uh, well, ventilation beforeha	Interview1	#carproblems
17	Car Problems	Car is too hot	" would rather, like, walk there than driving because, like, by the time I get there, my car's still prob	Interview1	#carproblems
23	Car Problems	Car too hot	I mean, I'm not expecting the car to be like a refrigerator, you know, you just walk in and its just sup	Interview1	#carproblems
62	Car Problems	Car traps heat	"So it didn't because if you notice that if a car's out exposed to the sun, and if it's, you know, 100 de	Interview2	#carproblems

Air condition

#	Category	Label	Quote	Interview	Tag
215	Car problems	No air con is not bearable	So my air conditioner stopped working. So it's really shit because you cannot survive without air con	Interview 8	#airconditioning
138	Car as heat trap	Temperature inside the car is extremel	and it's like it's so hot.You start freezing little bit because your body is like normal temperature,	Interview5	#carheat

EV

#	Category	Label	Quote	Interview	Tag
56	Electric car	EV preferred	"So it I think that if you can charge your vehicle, umm where you are at home or at work, then you it	Interview2	#electriccar
66	Precool	EV cooling	"Yeah, it's easier, I think to run a cooling system because you don't have to turn the gas engine on. S	Interview2	#electriccar
83	Sustainability aspect EV	Energy prises go up for EV	"Und dann sind die Strompreise gestiegen. Deswegen also dieser Kostenfaktor, der ist nicht mehr ga	Interview3	#electriccar
216	Electric car	EV not popular	need to put a lot of money and it is still not so popular in Israel. there is not a lot of stations or to	Interview 8	#electriccar
10	Safety	Fear of explosion	"I mean, there are so many, like, uh, fire incidents or like, explosion incident of Tesla in China or, like	Interview1	#safety
136	Dog mode	Tesla Dog mode	you know, and the thing forward have the same thing"	Interview5	#carusage

Costs

#	Category	Label	Quote	Interview	Tag
120	Car in the city	expensive to have a car in the city	zones, you have to pay like a fee."	Interview4	#carproblems

Air conditioning

Avoiding AC - health

#	Category	Label	Quote	Interview	Tag
1	Culture	Chinese Medicine	"I was going to say like, because in China, like there's a thing saying that...I don't know how to transl	Interview1	#culture #balanceha
173	Air conditioning	Rather fans than airconditioning	houses you have.	Interview7	#airconditioning
113	AC feels wrong	AC feels unhealthy	"Somewhere where it would feel unbearable for me to be there and like I don't want to go on a holi	Interview4	#airconditioning

114	AC feels wrong	AC feels unhealthy and unsustainable	"Nee. Also wie gesagt, die Klimaanlage ist eine Überlegung, aber das hat natürlich auch wieder neg	Interview3	#airconditioning
124	Air conditioning	Avoiding AC	"I rather have a fan on than than using AC, yeah."	Interview5	#airconditioning
172	Air conditioning	Europeans dont like airconditioning	Generally, a big fan of air conditioning.	Interview7	#airconditioning

Avoiding AC - culture

67	Air conditioning	Cultural differences	"I was gonna say because we have a lot of colleagues here from Munich and other countries, umm,	Interview2	#airconditioning

Avoiding AC - costs

154	Air conditioning	Aircon not needed near the coast	because you're so close to the ocean. This if we open all the windows and doors, this really nice	Interview6	#airconditioning
59	AC	Not everyone has AC in USA	"But you know, if you have to compare like like Munich or Munich is and think about it like Santa Mo	Interview2	#airconditioning
33	AC	Suffering through heat	People on the coast are probably a less because they don't end up, they don't end up uh.	Interview2	#airconditioning

Cant avoid AC

201	Cultural differences	Air conditioner everywhere	Well in my normal life when I am in my apartment I use the air conditioner and in my car I use the a	Interview 8	#airconditioning
215	Car problems	No air con is not bearable	So my air conditioner stopped working. So it's really shit because you cannot survive without air con	Interview 8	#airconditioning

Precool car

139	Car cooling	Remote cooling in car	be cool down the car.I mean a probably that will probably help.I have not used it yet, but sure	Interview5	#cooling
162	Air conditioning	Leave car on for aircon	car and keep it running.	Interview6	#airconditioning
25	Future Car	Automatic cooling	Yeah, but like, just you don't have to turn on anything that it can just adjust the environment. That w	Interview1	#ac
28	AC	Automatic cooling	"Like almost automatically adjust to the way that I would prefer almost. Um, I think Tesla does it a l	Interview1	#ac
9	Car behavior in heat	BEV better than gasoline to precool	"But that, that is a something to keep in mind. But if it's super hot, you would rather use the Tesla i	Interview1	#ac

Warmth

15	AC	warm yourself in car	"Like I think this is not like heat related as much, but I do sometimes, like when I'm not super comfc	Interview1	#ac

Costs of the polycrisis

Water bills

38	Water bills	Water is expensive	right now is that water is very expensive commodity in California. Uh, you know, this last year we	Interview2	#costs
57	Electric car	EV makes sense with heat	"I could put a battery in there and then also that can be used to charge a vehicle at night and so I ca	Interview2	#solarenergy
218	Climate change	Water shortage	like. make sure to take short baths and the don't use the water you don't need.	Interview 8	#climatechange
125	Water bills	Expensive to grow grass, and not allow	forever. I mean, you have to spend a lot of money on water to make it green."	Interview5	#energy

Wildfires

141	Energy	Preparing for power shortage	like, I should put solar panel on my home, you know, with the battery because it's power outage."	Interview5	#enery

Shared mobility expense

189	Transportation costs	Public transport is expensive	because there is an element of me that it's very expensive in London at the moment.So every every	Interview7	#costs
190	Transportation costs	London emission restrictions	because London is very. Restricted they've and they've expanded more and more the unless, which	Interview7	#costs
199	Expenses for transportatio	Uber is expensive	And so or you know, like 1 evening, you decide you need to go wherever or you know there's a few p	Interview7	#costs

Heat

| 70 | Mitigating heat | Heat is pushing you to do things you dic | wollte ich eigentlich nie haben und siehe da, jetzt ist er doch da. | Interview3 | #change |
| 164 | Northern europe becomes | Climate Change makes northern parts c | weatherwise London is actually really good in summer." | Interview7 | #climatechange |

Energy costs

| 155 | Energy bills | Energy for Aircon is high | but a lot of people are installing solar panels now because there's so much sun." | Interview6 | #energy |
| 156 | Energy bills | Government supplements solar panels | live in this warmer parts of Australia because in the. | Interview6 | #enery |

War

| 217 | Cultural differences | Israel has other problems than climate | And so it's really hard to take care of the climate. To use electric instead of the other stuff that, | Interview 8 | #climatechange |

Heat - Society & Health & Wellbeing

Mental health

96	Droughts	Depressing - Parks get yellow	"UM and the rain was not falling for a lot of time last year, so most of the grass got like yellow in th	Interview4	#systemic
123	Climate change	No Climate anxiety	will die by the time it becomes a very big problem."	Interview4	#fear
85	Climate change	Future anxiety	"Aber das war auch sehr munitions geladenes Gelände, wo da nicht so gelöscht werden konnte. Klar	Interview3	#fear
26	Future Car	Set my mind at ease	"Yeah. So this kind of well-being related topic I think under..When it is extremely hot. I do have thos	Interview1	#wellbeing

Wealth gap

107	Wealth gap	Trees in more affluent areas	"more affluent neighborhoods have more trees and poorer neighborhoods have less."	Interview4	#wealthgap
176	Social problems	Cost of living crisis	seen advertised and some of my local notice boards, as you know, for old people especially like,	Interview7	#wealthgap
178	Neighbour support	Poorer elderly people use public space	keep warm in shared space, especially old people.	Interview7	#wealthgap

Skin cancer

| 144 | UV raise | Protecting your skin | sunscreen." | Interview6 | #health |
| 146 | UV raise | Skin checks for skin cancer | that a lot of people do, yeah. | Interview6 | #health |

Dehydration

| 132 | Heat emergencies | People on trails with heat stroke | "They do rescue people all the time for heat stroke. | Interview5 | #health |
| 142 | Heat extremes | Robot tells people to drink | though.The heat?Because of the heat only. Umm.Yeah, I just heard on the radio that I have like this | Interview5 | #health |

Insects / Mosquitos and diseases

| 150 | Malaria | Malaria in SA | and from it and people die sometimes.I OK malaria.So at least we don't have that. | Interview6 | #health |

| 149 | Mosquitos | Mosquitos are annoying | and then really itchy afterwards.Yeah, summer is quite challenging. | Interview6 | #mosquitos |

Life threat

| 39 | Evacuation | Wildfires mitigation | fires as soon as possible because, like where I live locally in my neighborhood, we've had in the last | Interview2 | #systemic |

Exhaustion

2	Exercise	Hot as part of the exercise	"Like super, super hot? I promise I'll stay inside. Or like sometimes I do go against my rule just beca	Interview1	#exercise
131	Heat as training	Exercising in heat	you know, I kind of like it though.	Interview5	#exercise
158	Heat schedule	Lower energy with heat	that I feel or can't do."	Interview6	#health
161	Heat schedule	Schedule exercise around heat	around it."	Interview6	#exercise

Expert Interview 1

We pay the price for a thriving history

It comes at a cost

"But they always come at a cost. This is a price. It's like change. It's like the change that will have with these vehicles. I won't get to drive my big V8 fuel guzzler status symbol around town anymore. I'm gonna drive an e-moped thing with electricity in my else is gonna drive? energy."

We pay the price for a thriving history

Uncertain times

"Well, I think the LNG gas generation, my view, you're work with my children to a degree we gonna pay it out sort of change times and costs, we've got the benefit too, of living in the most productive..."

We are not adapting yet

"One sort of mentioned our 150 years to work history.... So we've modified from all of that, but we need to catch up anyway. Because we have all sort of something and before re-something. Gotta be re ready down and sort of now and now the climate."

It is not just heat

"And all of that's influenced by heat, but not only heat, but, but climate itself. So I don't think it's just a heat discussion, because I think again that's a fault of the argument if we just say it's heat."

Plan for 2,5°C

"In practical terms come, you got have yourself 10 years before you are now decease and or does you catch up for so long. So we have to start saying, well, I'm gonna have and start with that risk and adapt away about your things coordinating it in to degrees further life even 1.5 but we're better be out to hit it in 1.5. not not I think so yes the"

Plan for 2,5°

Plan for the worst, hope for the best

"So whatever you plan in to whatever thing you design, if there's an ethic for me, it would be to be hopeful hearing for the future, plan for the worst. But you're gonna hope for the best every time."

⬤ (orange dot)

Maslows hierarchy

"Have you studied Maslow's hierarchy of needs?... Safety and security is right there underneath the self. Actually, who am I and what's my role in the world? People need to feel that, but before you can feel that they're valued. And then have do I feel like I'm part of something? Because if you're not part it's very lonely. You don't wanna be"

A room can adapt to personal needs

"A room can adapt to your personal needs and wellbeing within a range you know within the parameters that are tolerable. And the renewable sources and the efficiency of those resources are the building can better across-over maybe the passive set the and having the life we'd"

Adapt to new needs

Learn from the past

Learn from other disciplines

"So if you're building a building, or if you're writing a paper or an argument for the Supreme Court, you've got an understanding around coding out of your mind to What are the past few different industries to yours and see what they're doing from different. You know what's the provocation doing in which the relevance?"

Learn from the past

"So I think it's an analysis of what's up, what a, what sign, what do people who are looking to far out and more ambitious and developers got to control and parent and they discovering that's now, that can help us understand."

Architecture history - Cross air flow and big balconies

"Big Windows and direct cross flow of air to allow us to feel in hot conditions and then as range would be and more ambitious and developers got to control and parent and they discovering that's now, that can help us understand. So they've all got air so is concerned this for I would one to"

We pay the price for a thriving history

Architecture designs now for higher temperatures

Flow of air

"So we're really a part of your superhot institute a lot go on the outside and letting it flow and circulate which gave back to those very early column buildings with a huge big presence. So you could not find they created windows and position themselves so that you can get across flow of all through there in long, still one"

Whirly birds

"You did a some heritage buildings where we can't touch the frame of the building but when on the roof create now whirly birds that re-circulate that rotates out draws it out through the venting thing and the is part of the envelope important it component"

feeling of outdoor when indoors

"And then there's intimate ventilation points throughout the building and almost two hectares of greens and greenery inside of the building. That's part of the envelope of the building that gives you that, umm, feeling that you're indoors when you're outdoors"

Car problems

Cars as deathtrap

"People die in cars, children, dogs and animals die in these things. You know how lethal it is and the temperature that's generated from it? It's also something that destroys these limits. The lifespan of the vehicle, even and damage to the components."

Old car overheat

"You know, we'd just strong leave 40 in my and got the cooling and the radiator so that we could go and that and to because I found to me. So, umm, how do we maintain the limbs of open air and absorb it keep cycling through the vehicle without it, without it without it being away from the perfromance of the vehicle?"

Energy bills now

"We're talking about now. Now I can't pay my bill now. I can't feed the kids now now. So you've gotta find that innate need, that sort of R1 on the Maslow hierarchy. Meet that so that they can meet some of their other greater ambitious for life longer sort of people."

Transform sunlight into energy

"If you think about that car driving in the Australian sun for hours on end, if that had an ability to absorb that heat into that, absorb that sunlight into that and transform it into energy, that could be you could take it home, you can plug it in and transfer it into the use house."

Efficient energy managament for the price

Efficient and self sufficient vehicles

"Should the sadness and that may it was with, how would be alright all up I won't send of the with aid I'd to conserve and store later now better sort and the is a mindset of well, it, and consider your about it it completely and cleverly and taking and creating in new energy might be a thing that I require to you as it and plug it in and transfer it into the use house."

Transform sunlight into energy

"I'm passionate about having every glass frame on anything being a receptor and store and creator of energy."

Trap heat for warmth but also release it

"But, umm, we, you know, the the glass that is designed to trap warmth. So you don't need it in winter, but for Design of the quay quarter building"

Energy bills

"And I'm sure the debates worldwide is the cost of electricity bills or the cost of housing or the cost of it's everywhere."

Gap between rich and poor

"Well, I hope that we move towards a more giving and. Conscientious as well, we have a bigger gap now between rich and poor than any time in human history. It's getting worse. We need to conquer that so people are gonna suffer immensely."

Leaving people behind

"If you don't make rules for everybody, if you just make rules to protect the climate, you are gonna leave so many people behind you."

how can we welcome climate refugees

"There will be more displaced people on the globe. How do we welcome them open our borders and create places for them to feel safe and secure?"

First nation people - land vs. things

"But if you look at first Nations people and their cultural ethos and their religions and the basis of those, you know, it's different land it's never they will have, they much responsibility to. back that it's sacred is them, they've that own has nothing to do but"

Social security is important

Design is many things

"Holly and the happiness factor comes from not wanting more. So again, when you're creating a design, you've got so many social, economic human things that you've gotta put into that design, not just the design itself, but it speaks to a lot of these issues to be successful."

The future is about generosity

"Hope I just want people to be more hopeful and more generous to each other."

Expert Interview 2

create shadow and cool spaces

Green Parking means costs

If people should walk we need to make the environment nice to walk

Local water reservoirs for cooling

Schwammstadt - creating local water supply

disciplines need to work together

Multifunctionality through interdisciplinarity

Thinking holistically is the future

new forms of energy creation

Get energy from mono-functional infrastructure

Create shadow with solar panel

it is all about saving space

german problems

Germany is behind because of politics

Legislative - Laws and rules are missing

Dezibel Zahl für Urbane gebiete - nicht wirklich mehr

Reducing space of the cars to have space for other things

There are cars and other dreams such as sharing emissionfree systems and collective systems

Using the car not for one person only but for several - reducing the used up space

Sharing not only cars but public transport, autonomous busses etc. --- collective systems

Germany is not investing in building infrastructure of other transportation devices

The problems aren't the concepts it is the missing action

Multifunctional traffic, with more usage such as energy, cooling

city administration works isolated - in silos

City Administration is a problem - working in silos

Monofunctional cities are easier than multifunctional

City administration needs to change

New distribution of space due to multifunctional

Use the new space (where cars where before) for greenery to cool the city

Individual Systems for space reduced solutions - such as walking, biking etc.

New space for higher livability

Exchange cars in the city for emission free mobility solutions

Cars need to be small to be space efficient

digital twin

With the digital twin we can predict the future

Digital twin as a hopeful device

Digital twin fails because of silos

making it harder to use an individual car in town

see also greenpeace

see also citizens interviews

User-oriented form of mobility

If it is a pain to use the car I will use other systems

Price, time and convenience play a role

Minimizing the people who own an individual car

the future still has cars in it

Countryside - also ridesharing concepts (taxi, autonomous)

There is no concept without cars - its just politics

No cars is not possible

"Also ich glaube nicht dass, dass es möglich ist, ohne das Auto zu planen. Es vielleicht auch nicht sinnvoll, gerade im ländlichen Raum."

laws change

Laws changing - 2030 only EVs

Hydrogen cars - doesnt need rare earth

politics

If political powers are there things change

Expert Interview 3

Green space

Lower temperature by green space

Creating cool space oasis

Using flow of cool air from outside to cool the inner city

Using heat maps of the city to identify heat problems

avoid shift improve

Money needs to go into public transport not the streets

Public transport is now cheaper to attract people to use it

Parking lots are payed now to keep the people from outside the city drive inside

Avoid Shift Improve

Climate change is still the bigger goal

Water misters are just a bandaid to the bigger problem

Parking lots take up space for green areas

we can not just make car usage more expensive - public transport needs to get cheaper and easier as well

Slowly adapting public transport to the heat

If we don't change things areas will be uninhabitable

Don't forget about climate change while designing for heat

Easy and quick solutions are not helping to fight the real problem

Problems with "Bestand"

Other solutions in building houses than AC

Subsidies from the government to exchange windows

Even the new buildings are not built to sustain climate change

Old buildings with bad insulation

Change for communication - positivity

Communicating how change is affecting citizens positively

Walk and bike - Healthy alternative

Climate change is experiencable now

System is wrong

Air conditioning as a social gap

Politics are supporting fossil fuel consumption and make it hard for citizens to change

Cars

Cars produce waste heat

People driving alone in an SUV into town is selfish

The car also standing produces heat

Cars heat up the city no matter if BEV or not

EVs are only an option if there is no other option

Expert Interview 4

Trying to work interdisciplinary

Microclimatic models are helping for planning

Silos are trying to work together

Work with climate researchers

Working with German weather service - climate function map

The best thing the city can do is sensitizing

Sensitizing

People want their Parking lots

Going to the people to sensitize and inform about energy

Working with funding and sensitization

Silos

Each administration has its own area of responsibility

"I am not a professional"

Hard to change old infrastructure

Problem ist not the new but changing the old

Hard to plant trees due to sewerage, internet, cables etc.

System problems

Owners are young and don't have the money

Can't reach the owners of the buildings due to data protection

Laws are missing

No influence on private investors or owners

Digital twin

Digital twin as potential

Digital Twins for Climate-Neutral and Resilient Cities. State of the Art and Future Development as Tools to Support Urban Decision-Making

Things go slow to be put in action

Politics rule the world

Politics change speed

Climate adaption is a voluntary task not mandatory

Human resources are missing to take action

Missing money for bigger changes

City is not transparent

Citizens dont know who is working on what

Heat wasnt a problem up to now

Heat wasn't a problem in munich up to now

Heat islands in munichs centre due to dense building structure

Politics rule the world

Missing transparency

No heat action plan at the moment

https://galk.de/arbeitskreise/stadtbaeume/themenuebersicht/strassenbaumliste

Privately owned parking lots to plant trees

Building greening

Green

List of trees - which future proof

Actions

Start educating people

Schwammstadt

Mobilitätswende

Working with Green City EV as a marketing tool

Rules for tree root space to be heat resilient for weeks

Blue and green infrastructure

Wanderbaumallee

Planting 2000 new trees

Advertisements for Climate adaptation

Creating awareness with events

DESTEP

Ukraine war
Inflation energy crisis
water crisis
aging population
gender equality wealth inequality
climate refugees growth skepticism

vision zero
1,5 target prepper culture
  climate activism (last generation)
  inclusion
climate change anxiety
  quantum computing
social justice artificial intelligence
  biotech
  metaverse
  digital twin of the city
  robotaxis

DESIGN TRENDS

more than human design
systemic design
technature
speculative design

wandering between digital and real
limiting entry to the
city e.g. tolls for cars progressive province
in the inner circle
  smart traffic
ICE Bans management
  inverting the transport pyramid
15 minute city
city concepts 1 minute city **CITY TRENDS** rewild the city
  smart city 30km/h lanes
responsive city - democratizing mobility
  last mile power of choice

TRANSPORTATION

drones
Delivery people
food/packages Delivery robots
etc.
  tram
  bus temperature
taxi train
  public transport
  air quality
combustine engine
car traffic jam bike
  motorbike scooter
electric vehicle micromobility
  multimodality

inclusivity

CAR

dormant cars ICE
EV air pollution

heat trap
air conditioning

water supply energy supply

municipality city planning
elderly homes

HEAT VULNERABLE CITIZENS
  infants
air pollution elderly people
  chronic disesase
  athletes
outdoor workers
  commuters
delivery people low income

water supply
mental health silent killers
food security illness
  heat wild fires
climate change anxiety
  extreme cold
  floods hurricanes
  droughts snow storms
  biodiversity loss

HEAT WAVES

uninhabitable environments

humans government
  STAKEHOLDERS
municipality politicians
  institutions municipality
  school
  kindergarten
humanitarian aid
hospitals families
  pregnant women

urban landscape
  concrete
  houses
  infrastructure
asphalt
  combustion engines
  high energy costs

non-human citizens water-life
  rabbits
land-life

  microorganisms

BIODIVERSITY
urban farming
vertical farming river
  smart city
private heat urban forests green space connected
protected retreat nature
spaces recreational space

  social areas
MITIGATION STRATEGIES green space
  CITY LEVEL water areas
  active space
city planning air corridors quite space
sponge cities shade
  high albedo
ARCHITECTURE surfaces

shadow
buffer zones

HUMAN

adjust schedule to heat

loose clothes

water areas

go to greenery

shade

drink enough

sun screen

long sleeves/pants

bike lanes need to become safe

hat

shaded infrastructure

escape heat

fountains and sprinklers

cooling rooms

electrolytes

albedo

available drinking water

using transportation with a roof

bike lanes need to have shade

using transportation with a breeze

CITY PLANNING

shaded infrastructure

air corridors

public transport needs to be available

greenery

trees

electromobility

Transportation Infrastructure

reduce pollution

public transport needs to be cooled

less cars

using transportation not at all during extreme weather

bi-directional charging

MOBILITY

create community

absorbed heat goes back into the energy system

keeping temperature at certain degree

albedo outside

using transportation with AC for kids and pets

create awareness

heat releasing materials inside

CAR

send alerts

water prices

send alerts

charging the car creates heat

thermal mass inside - leightweight

MUNICIPALITY

energy prices

geofencing - no entrance for cars in certain zones

cooling the battery creates heat

check on neighbours

Data

show fountains

show shade

show lakes/rivers etc

legislation

collaboration

ecosystem city

government

structure of the car

adapting to the city

educating students to foster transtition

municipality

owners of buildings

individual

I want to move freely but also feel bad when driving a car in the city

green & blue environment

architecture & city planning

mobility

mental health

we want to make green parking but costs and maintenance are too high

BMW

legislative
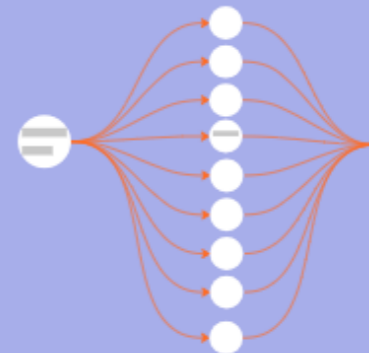
Reframing Canvas: Shaping Systemic Projects

How to move project context and content from a simple/complicated focus, to being able to deal with complexity.

4. Feasibility

4.3 What impact could be achieved if this were to be a systemic project?
Is it more than it being a non- systemic project?
Is it more than currently envisioned?

If necessary, put an arrow between the impact and a goal down below in the schematic.

4.4 What impact could be achieved if this were not to be a systemic project?
Is it more realistic than it being a systemic project?
Is it easier to implement?

If necessary, put an arrow between the impact and a goal down below in the schematic.

4.5 Which critical factors are in place, and which need to be accommodated for?

- Openness in the process (open or discussive design brief & deliverables)
- Realistic schedule
- Mandate / client ownership
- Close collaboration (with client & consultancy, and external actors)
- Right insights to trigger the reframe
- Design Maturity within the client
- Trust between client and consultancy (openness to new approach)
- Execution of the project in the right place of hierarchy at the client's organisation
- Systemic maturity within the client
- Systemic approach within the consultancy
- Right Goal setting / Mission
- Support throughout the company
- Good Change management on the client's side
- Right mindset

4.6 What critical factors are we worried about not being in place?

- Resources (time, money, skilled client employees, mandate, training provision)
- Risks addressed/ assessed/ managed

4.7 What can be the effects of the critical factor(s) being absent?
- no future impact and sales
- no solution at all
- not the right solution

4.8 How can we ensure implementation of this project?
Which critical factors need to be put into place?
- communication

How to foster for implementation in the current state of the project?
- spread the word internally

How to foster for implementation if the project will be systemic?
- more complicated and takes more time
- use different disciplines to work on it

4.9 How can we ensure impact?
Which critical factors need to be put into place?
- the right collaborations

How to foster for impact in the current state of the project?
- communication

How to foster for impact if the project will be systemic?
- good preparation to easily implement ideas and for dialogue

4.10 How hard would you rate it to make implementation and impact happen in the current state of the project?

Implementation /10   Impact /10

4.11 How hard would you rate it to make implementation and impact happen if the project were to be systemic?

/10   /10

4.12 What are the potential risks of this reframe failing?
- politics
- too complicated - working in silos is not easy

4.13 Why is or isn't it worth to pursue a reframe?
Is it still worth to pursue this project?
Compare answers from section 4 and decide whether or not it is valuable to pursue a reframe. If not, the canvas does not have to be filled in further.
- longer term liability impairment
- long term impact
- long term existence

4.1 When approached in a (more) systemic way, what value can this project deliver?
To us?

To the client?
- long term impact

To potential actors & stakeholders?
- longer term liability impairment

4.2 When not approached in a (more) systemic way, what value can this project deliver?
To us?

To the client?
- short term impact

To potential actors & stakeholders?
- maybe not full potential

Do the impact, goal and project content align?
Does the project content align with the goal we want to achieve?
Does the goal align with the impact we want to achieve?
If not, consider reframing or wait for this in step 5.

5. Reframe

Use seperate 'Reframing canvas: Shaping Systemic Project Context and Content' to fill in!

5.1 How can we accommodate for each needed element?
Which tactic(s) can we apply?
How will we apply them?
When?

Fill in the reframe canvas to individually reframe the different elements.

- Close collaboration (with client & consultancy, and external actors)
- Good communication (internally on client side and between client & consultancy)
- Resources (time, money, skilled client employee, mandate, training provision)
- Risks addressed/ assessed/ managed
- Right Relationships (internally, client & consultancy)

5.10 How does this affect the project (continuity)?
Can we continue reframing efforts?
Do other elements need to be reframed first?
If this element cannot be accommodated for, can we proceed systemically?
Can we continue the project at all?
Are we happy with the results if the project will not be executed in a systemic way?

3. Impact Use seperate 'Impact canvas' with client to fill in!

3.5 How does this project contribute towards the envisioned impact?
It could help to think of what could long and short term goals be to achieve this impact, and where among those goals, the project goal lies.

3.4 What is the impact that we want to achieve together?
What value will be generated for whom in which "capital"?

- Societal capital (social, cultural, political)
- Manufactured capital (intellectual, digital)
- Natural capital
- Financial capital

Long term goals to achieve impact

Short term goals to achieve impact

3.2 What are the consultancy's desired area(s) of impact*?
Internal areas of impact should be described in the internal strategy document, Sec. 0.
Prerequisities.
What value will be generated for the different "capitals"?

3.3 What is the client's desired area(s) of impact?
What value will be generated for the different "capitals"?
Often aligned with company vision.

3.1 What is the higher goal this project contributes to?
What is the effect of the project outcome?
What will the project solve?

1. Indicator

1.1 What are indicators in this project that could point towards room for a (different) systemic design approach?
(e.g.) amount of stakeholders involved, internal and/or external ambitions, problem structure, project insights indicating a different approach or deliverable is needed, complexity of the problem, scope of the problem, a reframe in the project content (problem, scope, deliverable, approach, goal)

Stakeholders
- interior
- exterior
  - city management
  - citizens
  - architects
  - urban planners

Impact

2. Content

2.1 What are the project "elements"

Problem
What is the problem(s) focused on in the project?
- allows change lead & fastness
- problems people have / problems mobility has problems the car has

Use Problem Framing canvas if needed
- make the problem clear and easy to digest

Scope
What (other) problems are left in and out
- in scope
  - city
  - citizens
  - city planning
- out of scope
  - architecture

out of scope

Use Iceberg canvas and boundary critique if needed

Deliverable
What is the deliverable as currently decided, to solve the problem?
- minimize impacts for mangers together with stakeholders
- staging process

Use the problem and scope to redefine the deliverable.
- short and easy digestable presentation
- inspiration at hand
- conversation starters

make people internally talk to people outside

make people inside talk to other disciplines

call for action?

Approach
What is the approach as currently decided, to define out the correct problem, scope and deliverable?
- citizens interviews
- expert interviews
- validation in city
- benchmark
- talk to designers

Use the project prerequisites in step 0, or explore different modes of practice, processes, methods

What is the initial goal of this project?
Re-align impact, goal and project problem, scope, deliverable and approach in step 2 and 3.
- bottom up - awareness creation
- make people talk
- make people work together

7. Notes

6. Reflect

What did we learn?
What are new received insights?
Which of these insights are for internal use?

there can be impact if there is action

are we still on track for creating our desired impact?

yes, but I think I need to shift more to internal communication than outside

What are the next (new) steps?
What needs to happen within the project content?

find tools to make people work together - how can I bring everyone to the table and start talking

ABOUT HEATWAVES

As global warming increases, heat is not the only problem. Extreme weather changes such as floods, droughts, extreme wind, fire but also extreme cold and humidity can come along climate change as well. Additonally energy prices, wealth gaps and mental health problems are rising too.
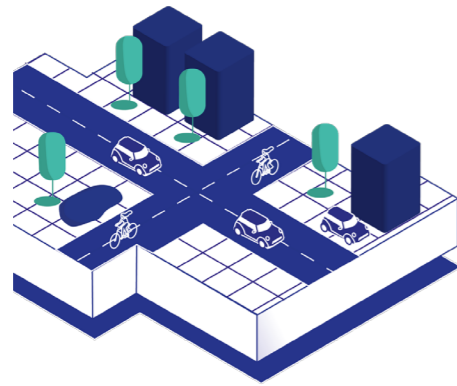
+15°C
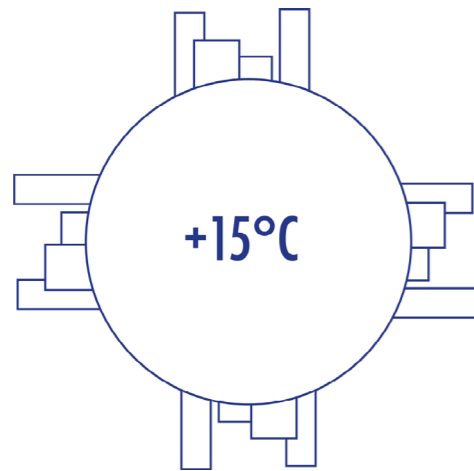
The heat island effect means that within cities the temperatures can be higher than 15°C in comparison to temperatures outside the city.
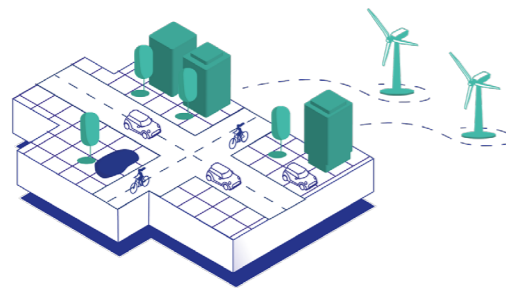
The heat creation in the city is caused by the urban environment of the cities with less vegetation and evaporation.
Dark surfaces with less albedo such as asphalt and concrete trap additional heat.

Anthropogenic heat such as emissions of vehicles add to the urban climate. To cool down the city with air conditioning, more energy is required, which adds up to the warming of the urban landscape and creates a reinforcing loop.

When heat rises in the city, not only air conditioning in housing rises but also in cars, which leads to more anthropogenic heat creation, and this again leads to higher temperatures in the city – coming back to the drivers cooling their cars even more.
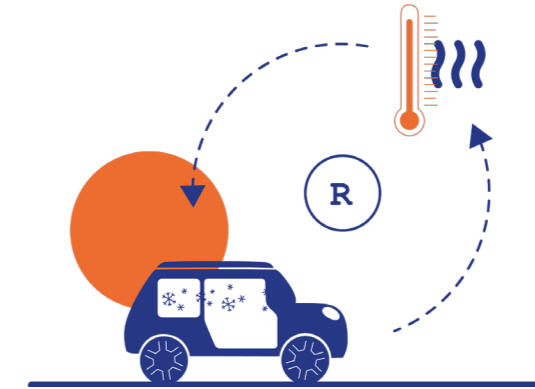
Tall buildings can block the flow of wind and the emission of thermal energy, which would otherwise accelerate evaporation. To mitigate the heat, cool corridors with lots of trees, greenery and water are created. Additionally surfaces that reflect sunlight instead of absorbing heat are further improvements. Furthermore renewable energy is a sustainable opportunity for energy efficiency.

Not only air conditioning lead to heat creation in the car. Other factors are:
Sunlight reflection, color, size, glass surfaces, surface structure and materials, thermal mass, battery cooling, air conditioning, heating, infotainment, assistant driving, lighting. External sources such as charging stations should be considered as well.

BATTERY COOLING
AIR CONDITIONING
HEATING
INFOTAINMENT
ASSISTANT DRIVING
LIGHTING
SUNLIGHT REFLECTION
GLASS SURFACES
COLOR
SIZE
SURFACES
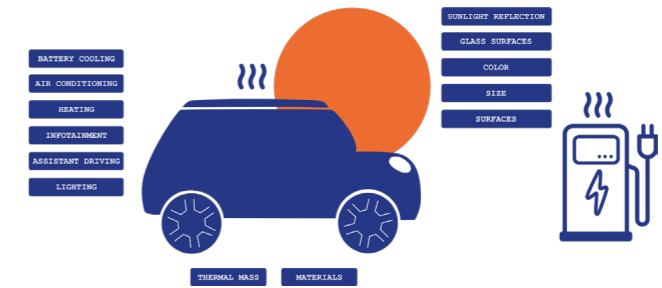**THERMAL MASS**
MATERIALS

To create more space for trees and water areas, the city infrastructure needs to change to gain more space. This is why cities are making efforts to have less emission but also more space by less individual transportation in the city centre. Multimodal opportunities offer a variety of emissionfree, shared and collective systems. Such as biking, public transport and shared driving.

WHAT CAN WE DO ABOUT IT?

A transition of MINI towards an eco-system mindset and active contribution to the fight against urban heat waves is recommended to transform the mindset of users and citizens. The democratization of mobility through collaboration with city governments, citizens, and relevant stake-holders to determine the optimal vehicle solutions is recommended, because there is no one-size-fits-all solution.

CITY STRATEGY

AWARENESS **LOWER HEAT** **HEALTHY CITY**

Aligning the MINI Strategy to the City Strategy towards a healthy city.

SYNCHRONISING STRATEGIES

SHARING MADE EASY **PARKING ALTERNATIVES OUTSIDE THE CENTRE**

INTEGRATED STRATEGY

RAISE AWARENESS **HEAT NEUTRALITY** **MINDSET TOWARDS A HEALTHY CITY**

RAISE AWARENESS

In the first horizon it is important to create awareness of the impact of cars as part of the heat island effect in the city. Therefore, educating passengers about the additional heat they are creating and informing about opportunities and alter-natives is essential. Furthermore, it is an opportunity to make climate change personal, urgent and local and make people care.

Take care today and stay hydrated

42°C

It is 42°C outside. Your Infotainment system heats up the temperature of your car and the sur-rounding additionally.

Click no, if you do not want to switch it off now.
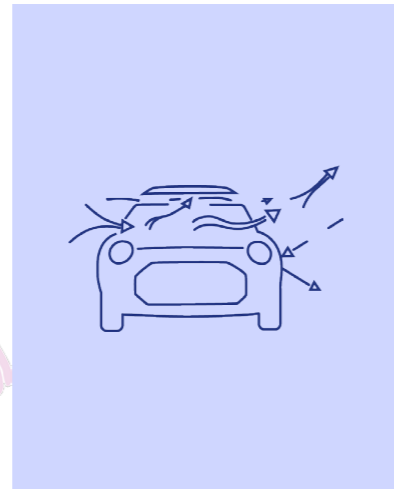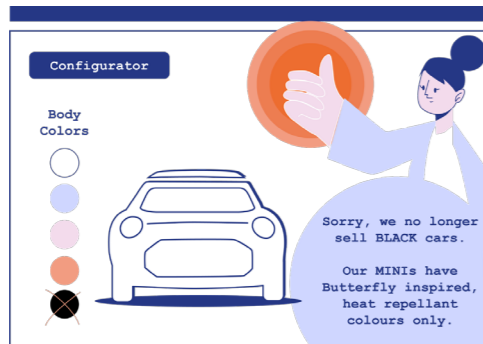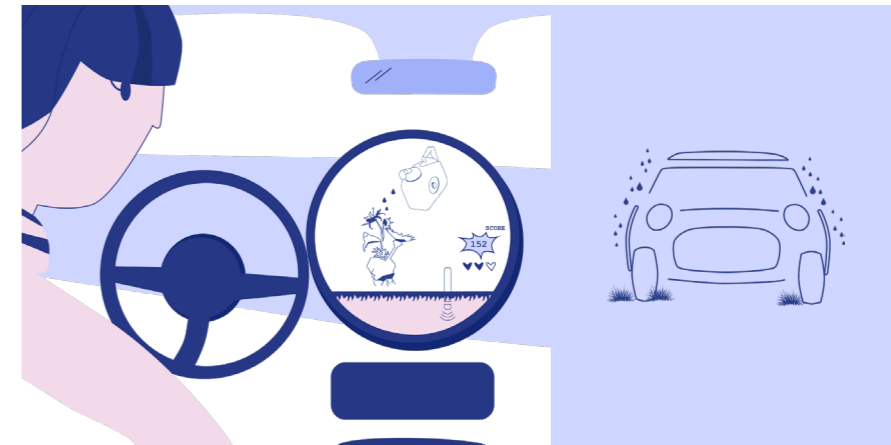
No

PRODUCTS TOWARDS HEAT NEUTRALITY

In Horizon two it is proposed that MINI adapts the vehicle development to the changing climate and increasing heat. The Vehicles allowed in the city on high risk days are designed in a way, that technology no longer adds to the heat island effect and become heat neutral or even heat negative vehicles. All vehicle components are designed to lower heat creation and the cabin greenhouse effect.

Configurator

Body Colors

Sorry, we no longer sell BLACK cars.

Our MINIs have Butterfly inspired, heat repellant colours only.

Different factors in the car lead to a rise in cabin temperature: Sunlight reflection, color, size, glass surfaces, surface structure and materials, thermal mass, battery cooling, air conditioning, heating, infotainment, assistant driving, lighting. External sources such as charging stations should be considered as well.

DESIGN PRINCIPLES

TEN PRINCIPLES OF HEAT RESILIENT CAR DESIGN

1 COLOR	2 REFLECTION	3 AIR FLOW
4 THERMAL MASS	5 NO HEAT CREATION	6 COOLING WITHOUT HEAT CREATION
7 LEAST GLASS	8 SURFACES	9 SHADE
10 SUSTAINABILITY		

MINDSET TOWARDS A HEALTHY CITY

The most transformative step revolutionizes consumer thinking and encourages a mindset shift towards a concept where individuals gain mobility access in exchange for contributing to society. With an app, contributions to the city ecosystem and social impact can be monitored. This transformative appraoch seeks to not only address urban heat but also make a substantial contribution to the broader city ecosystem.

LET'S TALK ABOUT SOLUTIONS

I) PROJECT BRIEF

DESIGN FOR our future

TUDelft

IDE Master Graduation
Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

❗ **USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT**
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME
Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 ! ⓘ

family name	Roth
initials	JR given name Jutta
student number	
street & no.	
zipcode & city	
country	
phone	
email	

Your master programme (only select the options that apply to you):
IDE master(s): ( ) IPD   ( ) DfI   (★) SPD
2nd non-IDE master: _____
individual programme: __ - __ (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ( ) Medisign
( ) Tech. in Sustainable Design
( ) Entrepeneurship

SUPERVISORY TEAM **
Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair	Dr. Nazli Cila	dept. / section: HCD
** mentor	Dr. Euiyoung Kim	dept. / section: DOS
2nd mentor	Diana Kolbeck	
	organisation:	BMW Group
	city: Munich	country: Germany

comments (optional)

❗ Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

❗ Second mentor only applies in case the assignment is hosted by an external organisation.

❗ Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF
To be filled in by the chair of the supervisory team.

chair _____ date 15 - 05 - 2023   signature _____

CHECK STUDY PROGRESS
To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: _____ EC
Of which, taking the conditional requirements into account, can be part of the exam programme _____ EC
List of electives obtained before the third semester without approval of the BoE _____

(✓) **YES** all 1st year master courses passed
( ) **NO** missing 1st year master courses are:

name _____ date 17 - 05 - 2023   signature _____

FORMAL APPROVAL GRADUATION PROJECT
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (✓) APPROVED   ( ) NOT APPROVED
Procedure: (✓) APPROVED   ( ) NOT APPROVED

comments

name Monique von Morgen   date 30 - 05 - 2023   signature _____

Initials & Name JR   Roth   Student number _____
Title of Project Designing for the wellbeing of European heat wave affected citizens through technological advancement

Designing for the wellbeing of European heat wave affected citizens through technological advancements in the mobility sector

_____ project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple.
Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 11 - 05 - 2023   08 - 10 - 2023 end date

INTRODUCTION *

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Headlines in April this year are worrisome "Spain bakes in summer-like heat and worries about what comes next" (Méheut, 2023). Estimations say that 70% of people will be living in cities by 2050 (Nations, 2018). With more severe and frequent heat waves, floods, droughts, biodiversity loss and air pollution the question arises how the urban environment needs to change to be bearable to live in. The challenges ahead on extreme urban heatwaves pressure transportation and lead not only to increased mortality rates (Kovats, 2006) but impact besides health, nature, economy and infrastructure.
Combustion engines are contributing to the heat island effect, which means that urban areas experience higher temperatures than surrounding rural areas. Electric cars reduce the amount of near-surface air temperature by up to 0,6°C (Mussetti et al., 2022) and air pollution in urban areas. Due to air conditioning and the higher use of electricity consumption, individual mobility is still contributing to environmental problems during heat waves. Individual transport is criticized in many ways as a part of the urban landscape, but is also needed to be inclusive, as for example for heat vulnerable citizens.
Heat waves are part of wicked problems we are facing, which ask us to design "entirely new sociotechnical systems" (Price, 2019). To understand the complexity that comes along heat waves - especially within the urban environment, methods such as systemic and things centered design are possible scenarios to understand the relationships between the agents.
As the values of society are changing towards a more responsible and sustainable future, brands such as BMW are asked to participate in the debate of future cities. This thesis aims to look at the well-being of citizens, the city and drivers during extreme heat waves from different angles. Moving from Design Strategy towards a Systemic Design approach.

References
Kovats, R. S. (2006). Heatwaves and public health in Europe. European Journal of Public Health, 16(6), 592–599. https://doi.org/10.1093/eurpub/ckl049 .
Méheut, C. (2023, April 28). New York Times. Retrieved from https://www.nytimes.com/2023/04/28/world/europe/spain-heat-wave.html
Mussetti, G. D. (2022). Do Electric Vehicles Mitigate Urban Heat? The Case of a Tropical City. Frontiers in Environmental Science, 10. https://doi.org/10.3389/fenvs.
Nations, U. (2018, May 16). 68% of the world population projected to live in urban areas by 2050, says UN I UN DESA I United Nations Department of Economic and Social Affairs. United Nations I Department of Economic and Social Affairs. Retrieved from United Nations: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
Price, R. B. (2019). Advancing Industry through Design: A Longitudinal Case Study of the Aviation Industry. https://doi.org/10.1016/j.sheji.2019.07.003. She Ji: The Journal of Design, Economics, and Innovation, 5(4), pp. 304–326.

space available for images / figures on next page

Initials & Name JR   Roth_____ Student number _____
Title of Project Designing for the wellbeing of European heat wave affected citizens through technological advancement

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introduction (continued): space for images

TO PLACE YOUR IMAGE IN THIS AREA:
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- **CLICK AREA TO PLACE IMAGE / FIGURE**

PLEASE NOTE:
- **IMAGE WILL SCALE TO FIT AUTOMATICALLY**
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- **IF YOU EXPERIENCE PROBLEMS IN UPLOADING, COVERT IMAGE TO PDF AND TRY AGAIN**

image / figure 1: _____

TO PLACE YOUR IMAGE IN THIS AREA:
- **SAVE THIS DOCUMENT TO YOUR COMPUTER AND OPEN IT IN ADOBE READER**
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PLEASE NOTE:
- **IMAGE WILL SCALE TO FIT AUTOMATICALLY**
- **NATIVE IMAGE RATIO IS 16:10**
- **IF YOU EXPERIENCE PROBLEMS IN UPLOADING, COVERT IMAGE TO PDF AND TRY AGAIN**

image / figure 2: _____

Initials & Name JR   Roth_____ Student number _____
Title of Project Designing for the wellbeing of European heat wave affected citizens through technological advancement

PROBLEM DEFINITION **
Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Cities and municipalities are working hard to find possible solutions for the effects of urban heat waves. But national policies in solitude can not bring change alone to tackle the complexity of the problems that we are facing. As the temperatures in european cities are still rising and heatwaves are already part of our summers, long term solutions need to be implemented. The infrastructure and mobility itself within cities is changing. We are moving towards smarter cities, which holds possibilites to bring upon change for extreme weather situations such as heat waves. As BMW is working towards a sustainable future, designing a strategy to tackle heat waves and the well-being of citizens is an opportunity for the mobility industry to engage and cooperate.

The problem is defined as:
How can technological advancements empower BMW to act upon the well-being of citizens and the city landscape of urban heatwaves?

ASSIGNMENT **
State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

How can BMW use technological advancements to design for the well-being of citizens and heat vulnerable citizens? Creating a vision for the 2035 BMW as part of a socio-technical and – cultural landscape. Aiming for a vision that looks at the wellbeing of citizens from several directions to design possible concepts for BMW to be an active participant in the changing urban environment.

1) Desk Research
First understand how heat waves affect the city landscape in Europe? How is extreme heat influencing humans and the city environment? Who are the current participants? How are cities changing in the future? Creating a system map.
Expert Interviews: Understanding future city concepts at the BMW Group. What are possible technological advancements in cars for the future.
2) Field Research
What are the needs of citizens during heat waves? In-depth interviews of 5 European heat vulnerable citizens of heat affected cities. Method - context mapping and cultural probe kits.
Create portraits of the interviewees how they live with their cars as citizens in cities affected by heat waves. What are the needs of non-humans during heat waves? Method - "Interview with things".
3) Design
Using technological advancements to improve citizens well-being not only within the car. Designing scenarios for future improvements how to help citizens during heat waves. Mitigating between what can and what should we do. Designing possible product-services for the citizens. Derive concepts for BMW in the city context to be an active participant in the changing urban environment.

PLANNING AND APPROACH **
Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date ___11___-___5___-___2023___   ___8___-___10___-___2023___ end date

Graduation Project Overview

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30   Page 5 of 7

Initials & Name ___JR___ ___Roth___   Student number _____

Title of Project ___Designing for the wellbeing of European heat wave affected citizens through technological advancement___

136

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30   Page 6 of 7

Initials & Name ___JR___ ___Roth___   Student number _____

Title of Project ___Designing for the wellbeing of European heat wave affected citizens through technological advancement___

137

MOTIVATION AND PERSONAL AMBITIONS
Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your
MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed.
Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives
of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a
specific tool and/or methodology, … . Stick to no more than five ambitions.

As a german, my identity is highly intertwined with the mobility industry. Due to the environmental problems our
planet is facing, the mobility sector is asked to redefine their identity to be part of a sustainable future. I am happy to
be able to try and actively shape and understand possibilities for the transition. As much as working towards a
sustainable future. Urban heat waves are affecting us right now and create problems that have not been given much
attention for a long time. The urge of change can be felt directly and need to be addressed. This is a project to
hopefully see that we can use design to find innovative solutions to complex problems.

This final project in my master is the possibility to put the knowledge to practice I have gained. It is my final personal
project as a student which I want to enjoy and also fill my brain with knowledge and capabilities. I want to explore the
changing design and technology landscape and use the opportunity to practice evolving design disciplines such as
systemic and more than human design. Furthermore I want to showcase my strategy capabilities and develop my
storytelling and sketching skills. A final icing on the cake would be, if I can inspire BMW in any way.

FINAL COMMENTS
In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name   JR   Roth   Student number _____

Title of Project   Designing for the wellbeing of European heat wave affected citizens through technological advancement