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1 Introduction and executive summary

This document concerns the development of a transition pathway and how the transition from the current state to different city visions can be managed. The report will therefore describe main elements of the transition pathway for three distinct city visions developed in previous ICARUS tasks resulting from the interactions with local stakeholders: Smart Tech City, Sharing Smart Community and Connected Cobweb City. Each city vision emphasizes different elements (individual behavior change, technological innovation, urban planning) and necessary steps are differently prioritized.

At the same time, there are common steps and elements among all three city visions (energy sector and building development). However, a transition pathway not only depends on the final state of future cities, but also needs to consider the current state of activities, which is highly dependent on the actual city structure. Starting point is therefore the development of more specific example visions for the ICARUS participating cities, which are based on the aforementioned general city visions described in ICARUS D6.2. Main elements of the transition pathway for the three city visions are presented along with steps that need to be taken by different actors to reach the final state of the vision.

2 Description of 3 city visions in 2050

An outcome of the previous work in ICARUS WP6 are three distinct visions of future cities that would be broadly sustainable, smart and healthy. These general ICARUS visions and their attributes are:

- Smart Tech City – The Smart Tech City has more emphasis on technology as a solution to environmental and health issues, with individualistic values being important.

- Sharing Smart Communities – Sharing Smart Communities take the community at the center and consider interconnection to be an important driver for improved societies.

- Connected Cobweb City – Connected Cobweb Cities consider a more dispersed, individualistic society, with more of a balance between technology and socially contingent solutions to the challenges facing our cities.

Based on the previous work in WP6 the three general city visions have been refined and specific visions for each ICARUS city have been designed that are broadly in line with the general visions. Therefore, aims and characteristics of the city vision as described in D6.2 have been compared and analyzed with regard to the current state and intended future of the ICARUS participating cities.

The categories for the vision description build on the previously identified sectors and factors relevant to the city development (cf. ICARUS D6.2). Sectors represent a sub-component of the city system (e.g. Energy and Transport Systems) while factors present an aspect of a social or natural system around which broad policy issues are of particular interest (e.g. Economy and Employment, Society and Culture). Later in the report necessary steps taken by different actors are presented. Actors are defined as individuals or organizations of individuals with the capacity to effect and/or influence change. (Absar and Preston 2015; Kok et al. 2006)

The vision description categories (combination of sectors and factors) are as follows:

- Economy and Employment
- Mobility and Transport Systems
- Energy Systems
- Heating and Buildings
- Society and Culture
- Consumption and waste management
- Land use and urban form

2.1 Smart Tech City

The Smart Tech City puts emphasis on technology as a solution to environmental and health issues and shows a societal culture in with individualistic values are important. The following chapter presents two examples for the Smart Tech City (Stuttgart and Brno). Both ICARUS cities have also developed a vision for the Sharing Smart Community, which is presented for comparability in this section.

2.1.1 Stuttgart

For the city of Stuttgart, two distinct visions have been created that are broadly in line with the common ICARUS pathways “Smart Tech City” and “Sharing Smart Communities”. The overall goal is

the same for both visions and can be described as optimized welfare and wellbeing with lower pressures to the environment. In the following both visions are presented.

	Stuttgart 2050 **"Smart Tech City"**	**Stuttgart 2050** **"Sharing Smart Communities"**
Main aims/description: **Main aim of the vision of a green, healthy and smart Stuttgart is increased and optimized welfare and wellbeing with much lower pressure to the environment and no or nearly no pressure on climate (climate neutrality) taking into account life cycle emissions caused by activities of citizens. Therefore, two subordinate aims are:** • **Almost complete reduction of greenhouse gas emissions within the city of Stuttgart (reductions until 2050 approx. 95% compared to 1990 levels; with CO2 neutrality in the building and transport sector and limited emission in industry and agriculture)** • **Fulfillment of WHO air quality targets:** o **PM2.5: 10 µg/m3 annual mean, 25 µg/m3 24-hour mean** o **PM10: 20 µg/m3 annual mean, 50 µg/m3 24-hour mean** o **O3: 100 µg/m3 8-hour mean** o **NO2: 40 µg/m3 annual mean, 200 µg/m3 1-hour mean** o **SO2: 20 µg/m3 24-hour mean, 500 µg/m3 10-minute mean**		
Economy and Employment	• Economic efforts have led to common welfare and social added value. Both city visions foresee increased digitalization in economy and process optimization. Digitalization links production processes and creates innovative business models. Rising digitalization has affected employment options and led to an increased demand for highly qualified employees. High energy efficiency of heating & cooling, ICT, process energy is due to optimization of manufacturing processes. Information and communication technologies are one of the flagships of engineering and widely used in economy and employment sector. Lighting in buildings relies completely on more efficient LEDs and OLEDs with intelligent and smart control. In some companies lighting is based on dynamic day light to increase wellbeing among employees. At the same time, light pollution is minimized by intelligent control systems. The energy demand of the commercial sector within Stuttgart has been continuously reduced (44% compared to 2015 level: electricity demand reduced by 35%, fuel demand by 49%). • In general, the environment is relieved, in particular by efficiency gains in energy use and material consumption. Product development is supported by smart technologies and follows the principle of "avoid, reduce and reuse". Resource consumption for control and feedback technology remains low due to new energy and storage technologies.	
	• The digitization of the economy has led to the disappearance of a	• There are no longer any regular and permanent jobs on the labor market,

	Stuttgart 2050 **"Smart Tech City"**	**Stuttgart 2050** **"Sharing Smart Communities"**
	number of jobs through the omission of entire occupational fields through automation and centralization. At the same time, new business models and services emerged and provide new employment opportunities; smooth labor market transfers have been ensured. • The separation of work and private is mostly dissolved and physical offices and production sites are partly abandoned. Total working hours per week are not drastically reduced compared to now, but home office and other location independent, flexible models become the norm. • The increased use of robots will lead to a reduced demand for low skilled workers; at the same time there is increasing need for higher skilled workforce.	because productivity increases through digitalization led to secure income and improved equity. Future working models and the necessary reduction of total working time contributed to an increase in part-time work as preferred model. Having a smaller amount of traditional working hours anyone is free to participate in preferred social projects. Services for the society are appreciated and wage work is thought completely new. • The higher proportion of robotic work leads to a lower need for lower skilled workers while increasing the demand for highly skilled workers. However, this effect turns out to be more moderate than in the Smart Tech City.
Mobility and Transport Systems	• The mobility and transportation system is widely decarbonized. In 2050, vehicles operate with carbon-free propulsion systems; the standard for vehicles are electric drives. Combustion engines with fuels made from biomass and fuel cells using hydrogen play a minor role. Autonomous vehicles are the norm and replace conventional cars. All vehicles are interconnected, so they drive in such a way that travel times are minimized. Important element in the mobility system are car- and ride-sharing concepts. Privately owned cars in the internal traffic of the Region of Stuttgart are replaced by sharing concepts, which use autonomous, interconnected and CO2 free vehicles. Since extensive security technology can be saved through inter-connection among vehicles and automatic accident prevention, more and more ultra-light vehicles enter the market. The problem of remaining tyre wear and resuspension has been solved with solutions like tyres with a longer life time and smart and efficient street cleaning. • The mobility system would work not only in Stuttgart, but in the whole Stuttgart Region. Long-distance travellers either use the railway, where taxi-robots would bring them to the station and also pick them up at the destination, or they could	

	Stuttgart 2050 **"Smart Tech City"**	**Stuttgart 2050** **"Sharing Smart Communities"**
	order larger long-distance vehicles, where batteries might be exchanged at certain 'battery stations'.	
	• In the Smart Tech City, the urban mobility system is based on three pillars: - Autonomous and interconnected vehicles - CO2 emission free propulsion system - Private Transport: travelers are transported by a shared vehicle fleet (carsharing)	• In the Sharing Smart Community, mobility is based on three pillars: - Autonomous and interconnected vehicles - CO2 emission free propulsion system - Public Transport: Rail-bound public transport supplemented by small on-demand buses for ridesharing
	The Private Transport Concept mainly uses driverless small vehicles. Each vehicle is used by only one individual party at a time. In order to include the differences to using privately owned vehicles, an additional booking and boarding time of 4 min per carsharing trip is applied. The price of a carsharing trip is dependent on the distance traveled. Suburban and regional trains complement the carsharing system, whereas busses and LRT are omitted. To reach the stations of the railbound systems travelers can choose between the feeder systems walking or carsharing.	The Public Transport Concept combines traditional rail (LRT, suburban and regional trains) and small on-demand buses with 6 seating places per vehicle. For longer trips on relations with sufficient public transport, the ridesharing vehicles connect to rail transport at suitable public transport stops, where transfer waiting times and footpaths occur. As now several parties share one vehicle at a time, much less vehicles are required than in the Private Transport Concept case. However, as now several parties share one vehicle, the waiting time and trip length are longer than in the Private Transport Concept due to detours for collecting or dropping off fellow passengers.
Energy Systems	Energy supply has been converted into a system with complete substitution of fossil fuels by renewable electricity and synthetic fuels or hydrogen use. All renewable energy sources within the city area are exploited by their ecological maximum. Renewable energy carrier biomass will either contribute with a limited extent to energy supply as combustion in the city area will be limited to central CHPs or combustion will be totally avoided due to considerable emissions.	

	Stuttgart 2050 **"Smart Tech City"**	**Stuttgart 2050** **"Sharing Smart Communities"**
	The security of supply is guaranteed by additional back-up CHP plants. After a transitional period, in which CHP plants are still operated with fossil natural gas, a conversion to biogas from waste and synthetic gas will be carried out. As no self-sufficiency in the energy supply can be reached in Stuttgart, supply safety is further guaranteed by connection to the regional electricity and gas network. Furthermore, high-performance grids support energy distribution. These Smart grids will optimize energy usage, reduce energy losses, enable accumulation and return of energy back to power grids.	
	Renewable energies go hand in hand with smart technologies to increase energy efficiency and to reduce energy demand.	Renewable energies are supported by smart technologies to enable reuse and recycling to reduce energy demand. Furthermore, energy demand is reduced by sufficient behavior (more than in Smart Tech scenario).
Heating and Buildings	In 2050 the building stock is completely renovated or replaced by new energy-efficient buildings. Buildings are equipped by mechanical ventilation and heat recovery. Newly built buildings are plus energy buildings with a high energy efficiency. Construction of buildings uses preferably recycled materials. All suited roofs are equipped with photovoltaic panels and all houses have a storage system to become mostly self-sufficient. Flat roofs are used for greenery and combined photovoltaic plants. The facades of buildings will be greened. The heating system in the buildings sector is based on a mix of renewable sources. District and local heating will contribute with about 30% to heating supply. About 50% of heating demand are provided by electricity; either directly or predominantly with electric heat pumps. These heat pumps are inverters, i.e. they are able to heat the house in winter and cool it during hot days in summer, which increases the wellbeing of the residents. Biomass will not be used for small heating to avoid emissions. Efficiency of electric appliances has increased slightly, but higher electricity demand for ventilation and automation and connection in building technologies offset the reduction.	
	The degree of automation and digitalization in the building increases that strongly, that the influence of user behavior on energy consumption is limited.	New living and building arrangements such as multi-generation project or shared housing limit the increase of per capita living space.

	Stuttgart 2050 **"Smart Tech City"**	**Stuttgart 2050** **"Sharing Smart Communities"**
Society and Culture	• The civil society is actively involved in decision making and implementation of actions through inclusive, participatory and transparent governance structures at city level, but also in the European, national and regional context. • Regeneration and upgrading of city districts happens under the paradigm to prevent societal compartmentation.	
	• Smart Tech City shows a more individualistic society, where behavioral change is encouraged by economic incentives rather than common ideals. Most environmental issues are solved by technical solutions like efficiency increases rather than reductions in consumption, change of transport modes or increases in sufficiency. Especially, market actors have a leading position in the re-organization of market activity to integrate long-term environmental costs. • There is a societal risk of isolation from use of technology (virtual relaties). To prevent from this trend, physical interactions are specifically encouraged through social/green spaces and cultural activities.	• Sharing smart communities rely predominantly on participative and inclusive approaches for goal setting. Citizens are actively involved in the development of the city and previous decision making processes. They also take individual responsibility for the implementation of actions to reduce the carbon footprint of the society. This leads to a consumption critical approach and increased sharing of ownership – shared spaces, cars etc. • Physical interactions between the people are part of daily life and supported by the city design in smaller districts where all everyday tasks like shopping etc. take place.
Consumption and waste management	• The Smart Tech City focuses on large scale implementation of technical solutions in the food sector to satisfy their citizen's needs. Technology innovations like manure management, precision farming and artificial meat substitutes are driven by the need to reduce costs as well as the pressures on the environment. • Consumption in the Smart Tech City is generally high, but goods and services are also delivered by	• The Sharing Smart Community puts emphasis on the consumer behavior change; f.e. vegetarian and locally or regionally produced food dominates. At the same time meat consumption and food waste is limited.

	Stuttgart 2050 **"Smart Tech City"**	**Stuttgart 2050** **"Sharing Smart Communities"**
	new transport solutions like drones. Additionally, increased use of 3D printing reduces the need for transporting goods and services. • Product development is supported by smart technologies and follows the principle of avoid, reduce and reuse • To summarize, the Smart Tech City focuses on optimizing the production processes to be more independent from an otherwise necessary change of consumer habits.	• To summarize, the Sharing Smart Community focuses on consumption changes.
Land use and urban form	• Stuttgart shows a sustainable and integrative city center structure. To reach this aim inner development has been fostered prior to greenfield development. However, vacant spots and options for brownfield development have been quite limited in Stuttgart, which is why skyscrapers are also part of the city picture. In any case, special attention has been brought towards minimizing thermal stress and maintaining thermal comfort of inhabitants. • The increasing demand of space for universities and research institutes (+10% compared to 2015) due to need for highly qualified manpower and the strongly increasing demand for nursing, care and retirement homes has not been met by developing new areas, but by tapping into the 3rd dimension. Commercial buildings space (offices and retail space) demand has not increased due to simultaneously increasing share of online purchases and a partial redesign of office use towards home offices. Manufacturing, production and storage are developed space saving methods. • The distribution of green spaces over the city is organized in such a way that easy access can be guaranteed from each point of the city for all socioeconomic groups.	

2.1.2 Brno

For the city of Brno, two visions have been created that are broadly in line with the common ICARUS pathways "Smart Tech City" and "Sharing Smart Communities". Main differences between those visions occur only in the consumption and mobility sector. The overall goal is the same for both visions: Brno as sustainable and attractive city which guarantees a high quality of life. In the following both visions are presented.

	#brno2050 **"Smart Tech City"**	**#brno2050** **"Sharing Smart Communities"**
Main aims/description: "Brno in 2050 is an attractive and sustainable city" • **Brno enjoys a high quality of life, which is reflected in fair and equitable work conditions, business opportunities, thriving academic and intellectual culture, possibilities of professional advancement, and in dynamic centres of innovation which produce quality outputs at national and EU levels. It is also a place providing all inhabitants space for leisure activities and relax options** • **Research and Innovation result in socially equitable economic growth where not only individuals and companies benefit, but also the city of Brno as a whole** • **City landscape respects the surrounding nature and aims to integrate / develop new green areas** • **Barriers in the city are reduced and city is easily open to everyone (e.g. wheelchair accessible)** • **City offers health and safe environment for 500,000 inhabitants including low levels of pollution, while reducing the levels of water / air contaminants to a minimum (rather than the legal limits)** • **Brno employs experts trained in natural resource management to make sure that local resources are treated, used, and administered in the best possible way for the present and future generations. This expertise-based management model will consider all three aspects of sustainable development (economic, social, and environmental)** • **Citizens (incl. those from the metropolitan area) are actively participating in decision-making concerning future plans and projects of the city (via participatory governance model)**		
Economy and Employment	• Extend and maximize local impacts of innovation, especially when they address local challenges (*increasing share of the city budget invested).* • Participate in solving national and EU-level challenges, by providing local expertise, training, and knowledge-sharing. • Create a new economic sector (clean energy); this will bring new, young talent into the city, while also making it possible to transform it into a 'smart', better functioning, healthier city. • Create an innovation-based local economy, by supporting local young talent and recent university graduates over long-term (not only in a form of a one-time investment in a spin-off / start-up company). • Provide fair employment conditions for all Brno inhabitants so as to prevent economic marginalisation and creation of poverty pockets in the city. • Provide training and re-qualification options to workers who lack skills and training in the evolving economy. • Set up counselling and rehabilitation clinics to address and treat alcoholism, drug-addiction, psychological disorders.	

	#brno2050 **"Smart Tech City"**	**#brno2050** **"Sharing Smart Communities"**
Mobility and Transport System	"Ensure quality, capacity and reliable transport and communication links between Brno and the European and world capitals, both in passenger and freight transport, as well as in information flows." • Increase of the regular flight destinations (*from 3 to 20*) • Decrease the road travelling time (minutes) to the nearest Mid-European centres (*Wien (from 100 to 80); Budapest (from 190 to 180); Warsaw (from 400 to 330); Berlin (from 360 to 330)* • Decrease the railroad travelling time (minutes) to the nearest Mid-European centres (*Prague (from 150 to 60); Wien (from 90 to 45); Bratislava (from 90 to 45) Budapest (from 250 to 120); Warsaw (from 420 to 150); Berlin (from 440 to 180); Munich (from 400 to 150)* • New railway hub well-interconnected with city infrastructure • P+R parking (*now 177 lots to 20,000 lots localized at the main entrances to the city)* • Companies will prepare mobility plans for its employees	"City of short distances and sustainable mobility" • Decrease of the average travelling time to work and schools • Decrease of the walkability to the nearest basic services (10 minutes) and/or decrease travelling time by public transportation to the nearest basic services (10 minutes) • Change in the modal split (*actual (53% PuT, 6% pedestrians, 2% cyclists, 39% PrT) to (56% PuT, 12% pedestrians, 12 cyclists, 20 PrT)* • Decrease of the individual cars per citizens *(from 484 to 350)* • Increase of the vehicles using alternative fuels *(to 100%)* • Increase of the wheelchair accessible buses (from 66% to 100%) • Number of Senior buses *(from 3 to 30)* • Increase of the bikesharing and carsharing *(from 0,4% and 0,6%; increasing trend)*
Energy System	• Low-carbon energy policy underpins all areas of city planning and citizen mobility and is reflected in (i) modes of transport, individual and public, (ii) new construction and retrofitting wherever possible, (iii) waste disposal/re-use (recycling, incineration). This less energy-intensive, but more energy-efficient system will be supported by appropriate low-carbon, low-polluting new technologies and energy models as they become available (locally, but also in comparable environments externally). Whenever necessary, expertise will be imported and localised so that a lack of training/human capacity is not a barrier in the transition to a low-carbon economy. • Smart grids will optimise energy usage (reduce energy losses, enable accumulation and return of energy back to power grids).	

	#brno2050 **"Smart Tech City"**	**#brno2050** **"Sharing Smart Communities"**
	• Decentralisation of the energy sources- creation of the "energy island system" *(a substantial increase to be further defined).* (www.h2020smile.eu) • Decreasing share of fossil fuels in the energy mix. • Increasing share of the local-renewable energy sources *(from 5% to 50-70% of the final energy consumed by the city and region).* • Decreasing trend in energy consumption per capita (*from 4.6 kg of oil equivalent to 2.0*). • The proportion of legal entities maximizing energy performance and energy-saving processes in their activities (entities respecting the principles of sustainability and ecological footprint (De-signers Accord equiv.) The total number of legal entities operating in Brno *(increase from 10% to 80%).* • Integrate Brno into European energy initiatives in the area of renewables and low-carbon city strategies, and participate in the implementation of a pan-European grid enabling interconnection, export and delivery of clean renewable energy sources, thereby reducing the losses associated with the variability of these sources *(increasing number of projects in which Brno is a stakeholder).*	
Heating and Buildings	• Increase in the number of buildings accumulating and returning the energy back to power grid *(from 1 to 20%).* • Increase in the efficiency of the energy waste treatment. • Promotion of the green roofs and facades.	
Society and Culture	• Increase in the size of public spaces and number of buildings / non-residential premises owned and used by the city for culture *(Increasing trend).* • Increase in the proportion of outdoor sports facilities at primary schools accessible to the public and to sports clubs in Brno *(Now 61,5% to 80%).* • Evenly distributed population density within built-up area (*population area heterogeneity reduced from 80 to 60%).* • Number in the pedestrian zones and shared public spaces *(increasing trend).*	
Consumption and waste management	• Increase in food self-sufficiency *(up to 60-80%).* • Decrease in food imports that can be locally substituted (imported from distances bigger than 100 km). • Prevent construction on arable. land; instead, productive land will be used for local, optimally organic farming. • Decrease the amount of the rainwater running into the sewerage.	• Promoting healthy lifestyles, including balanced diet and adequate physical activity (sports & recreation activities). (*Indicated by decreasing trend in the population obesity).* • Prevention of the waste generation and promotion of the waste reuse (*now 98,802 tonnes/year, 80% lower).* • Increase the ratio of the separated waste (*from 19,8 to 84,8*).

	#brno2050 **"Smart Tech City"**	**#brno2050** **"Sharing Smart Communities"**
	• Increase of the capacity of the Wastewater treatment plant (*from 515,000 citizens to 600,000 citizens).* • Utilization of the energy and material flow between companies (from 20-30% to *60-80% of material flow).* • Waste products from one company will be used as a resource in other company within Brno metropolitan area (*up to 20%*). • Increase the wastewater recycling (*up to 80%).* • Establishment of the re-use centres (*now 3 to 100*). • Complete recovery of the biodegradable waste (*100%).*	• Increase the amount of the recyclable waste in the separated waste (*from 75% to 95%)*. • Community gardens *(from 5 to 200)*
Land use and urban form	• Increase in the green spaces *(now 4.3%, indication is increasing trend).* • Increase in the ratio of the proportion of permeable to impermeable areas in the city (within the urban area). • Change in the ratio of underutilised / unused areas and brownfields *(from 4 to 1).* • Regenerating brownfields *(from 0 to 90%).*	

2.2 Sharing Smart Community

Sharing Smart Communities take the community at the center and consider interconnection to be an important driver for improved societies. Several ICARUS participating cities consider this city to be a future vision worth striving for.

2.2.1 Basel

The city of Basel developed the vision of a Sharing Smart Community, which is based on full decarbonization and improved urban environment for increased wellbeing, health and sustainability.

Basel 2050 **ICARUS vision: "Sharing Smart Communities"**
Main aims/description: • **Full decarbonisation until 2050**

Basel 2050 **ICARUS vision: "Sharing Smart Communities"**	
• **Improve urban environment for better wellbeing, health and sustainability**	
Economy and Employment	• Technology facilitates interconnection between home and office space, reducing need for commuting. • Improved equity in employment. • Higher skilled employment becomes the norm.
Mobility and Transport System	• Slow traffic and public transport are the dominant form of transportation in the city. • A reduction of cars will allow for more space in the streets for slow traffic and green space. The remaining public and private parking's are equipped with charging stations for electric cars/vehicles. • A logistic city-hub near the train freight terminal will ensure a green last-mile delivery of goods into the city (with cargo bikes and electric vehicles). • Ship traffic on the Rhine continues to be a very important transportation route. All vessels will be replaced by 2050 with new, climate-neutral ships.
Energy Systems	• No consumption of fossil fuels. Electricity remains 100% renewable. • More energy will be generated locally (by photovoltaic, heat pumps, geothermal energy and new/emerging technologies).
Heating and Buildings	• New buildings are energy neutral and producers of energy. All existing buildings are renovated by 2050 to be more energy efficient. • District heating will be CO2 neutral (energy from waste/wood/other sources). The main heating systems besides district heating will be electric heat pumps, which can also be used to cool buildings in summer. Wood burning is only allowed in combination with filter technology to reduce the emission of particulate matter.
Society and Culture	• Participative approaches for decision making and planning. • Increased sharing of ownership – shared spaces, cars, to reduce footprint of society.
Consumption and waste management	• Production and consumption of locally grown food is increased. Urban farming will contribute to this.

Basel 2050 **ICARUS vision: "Sharing Smart Communities"**	
	• Industry and society are transitioning towards a circular economy by closing and narrowing energy and material loops.
Land use and urban form	• To accommodate more people as well as not to reduce the number and area of green spaces, urban density has to be increased. New ideas and concepts are needed in urban planning to ensure that an increased density is socially and environmentally compatible.

2.2.2 Ljubljana

The city of Ljubljana follows the idea of Sharing Smart Communities with a balanced, high-quality standard of living in harmony with environment and a dynamic and tolerant society. In the following the vision is described in detail.

Ljubljana 2050 **ICARUS vision: "Sharing Smart Communities"**	
Main aims/description: • **To achieve a balanced, high-quality standard of living in harmony with our environment and our era.** • **To build a society of solidarity and tolerance, a society that is inclusive and dynamic.** • **To create a nexus of the institutional, social, and technological innovations of our innovative society. These innovations help us find solutions for pressing social challenges, such as the rapidly ageing population, inequality, and poverty.** • **To further nourish environmental responsibility – to respect nature and manage natural resources in a sensible manner.** • **The enhancement in circular economy drives the economic development and creates new employment opportunities.**	
Economy and Employment	• Economic stability is one of the most important conditions for achieving high standard of living and quality of life. The basis for economic stability is a thriving economy by maintaining the key macroeconomic equilibria. The growth of the economy must be inclusive and environmentally sound, and it must be based on high competitiveness and innovation. This would allow for sustainable development, which it will to make all three aspects of development more balanced, more resilient to economic shocks, at the same time, it will allow for a high involvement of the population in creation and sharing and decrease environmental pollution. Inclusive growth also presupposes regional development uniformity.

Ljubljana 2050 **ICARUS vision: "Sharing Smart Communities"**	
	• Public finance sustainability is an important part of economic stability, and in addition to business access to a variety of funding sources also provides an adequate supportive institutional environment. This will be achieved by: • promoting sustainable and inclusive economic development that will make it possible reducing the backlog of more developed countries and increasing the quality of life for all • by ensuring an appropriate economic policy response throughout the economic cycle • strengthening functional regions as development and economic units and promoting them development based on harnessing development capabilities, transport connectivity and improving functional links between cities as development poles • creating more durable solutions for balancing the structural balance of public finances; and sustainable reduction of public debt • ensuring the competitiveness of the financial market, in particular stability and efficiency banking system, and by developing non-banking segments of the financial system. • In terms of BDP/per capita it is to grow from 83% (of EU average) to 100%.
Mobility and Transport System	• Transport planning will aim at coexistence of all road users, and will be giving priority to those forms of mobility which are the most favorable in terms of air pollution, noise, energy consumption and space occupation. That is of a great importance in terms of preserving public life on the streets to a great extent as well as contribution to improving the quality of stay in the city, social inclusion - with particular emphasis on the most vulnerable groups (children, the elderly and people with disabilities etc.). • The vision is to achieve the goal of 2/3 of the routes in Ljubljana done in a sustainable manner - walking, by bicycle or public transport, and only 1/3 to be done by personal cars. • We aim for a gradual transition to environmentally friendly vehicles and adapt their fleet to one of the forms of electro mobility.
Energy Systems	• The overarching goals of the Energy Concept of Slovenia are: o Reducing greenhouse gas emissions from energy use by at least 40% by 2030 from 1990 levels.

Ljubljana 2050 **ICARUS vision: "Sharing Smart Communities"**	
	o Reducing greenhouse gas emissions related to energy use by at least 80% by 2050 from 1990 levels. • Ljubljana is focused on fulfilling its mission to reduce environmental burdens and to have a positive impact on air quality in Ljubljana's urban environment and in central Slovenia. With stable production and distribution of energy, it enables a better quality of life and economic development of the region, and enables Slovenia to fulfill its promises in the field of energy and environmental protection more effectively. The priorities for achieving a secure energy supply are the following: • Development and utilization of hot water and gas pipelines • Ensuring adequate operating profitability, which will be a source of resources for system maintenance and further development. • Reducing the use of electricity for the operation of the system • Cooling from district heating systems of new buildings and energy-rehabilitated buildings in districts equipped with district heating systems with a cooling capacity of 250 kW and above based on a feasibility study • Construction of a gas-steam units for district heating • Replacement/modernization of peak boilers • Promotion of EEU and RES measures in all segments of energy use • Care for a clean and healthy environment by implementing the transitional national plan for Slovenia to reduce emissions of substances into the air and CO2 emissions per unit of product • Expansion of the use of compressed natural gas or methane in transport (CNG).
Heating and Buildings	• Expanding the district heating and natural gas network and promoting increased capacity utilization of energy infrastructure systems and reduction of heat losses in the district heating network (4% reduction in losses).
Society and Culture	• The social development goal is to improve the quality of life and well-being of all individuals, as measured by the indicator of human development, social risks and social cohesion. • The social development is based on the fundamental principles of the welfare state. In the coming years, we will continue to pursue a social policy in line with the goals aimed at reducing the risk of poverty, increasing the social inclusion of the vulnerable and vulnerable and to improve the availability, quality, diversity, accessibility and accessibility of services, programs and other forms of assistance.

Ljubljana 2050 **ICARUS vision: "Sharing Smart Communities"**	
Consumption and waste management	• The National Program aims to improve the nutrition and exercise habits of the population from an early age to an advanced age. In doing so, we want to stop and reverse the trend of weight gain in the population and to influence the lower incidence of chronic non infectious diseases and consequently the sustainability of the health system. The measures envisaged also aim to influence equal opportunities for health for all residents, including for socially and economically disadvantaged groups, and to positively influence the bio-psycho-social development of the individual. This includes the: • reduction of the proportion of overweight and obese people; reduction of the proportion of overweight and obese children and adolescents by 10%; reduction of the proportion of overweight and obese adults by 5% • reduction of the proportion of residents who are physically inactive • increase of the proportion of breast-fed infants • reduction of the proportion of malnourished and functionally disabled older people and patients • increase of the proportion of those who eat breakfast daily • increase of consumption of vegetables and fruits • reduction of the intake of saturated fat, sugar and salt • reduction of the trans-fat content of foods.
Land use and urban form	• Essential actions for maintaining or improving the situation in spatial development are the quality design of the organization of space and the network of settlements and the provision of rational use of space. Both are the basis of conditions for strengthening economic and social development and active protection of environmental potentials in the area of Ljubljana (and within the region) and also in the wider Slovenian area. Specifically, this refers to: • further construction within the regional city (Ljubljana Urban Region) whereby the city of Ljubljana strengthens the position of the center of the urban region as well as of the Slovenian one metropolis • the maintenance of a concentric model in the inner city center, which emphasizes the renewal of urban and architectural heritage, the renovation of degraded areas, the construction of projects already started or planned, the burden on traffic, etc. • the combination of a radiocentric and a limbless model in a compact city, mainly within the motorway bypass

Ljubljana 2050 **ICARUS vision: "Sharing Smart Communities"**	
	• updating of the winged morphological model in the suburban area (linking settlement concentrations to PT, compacting settlement at PT stations, building new concentric links) • establishment of a network of centers (central mixed-use areas: social, business, supply, residential) according to the position in the hierarchy of the settlement system and its integration with the urban space subdivision system (program and functional complementarity) • the creation of relatively autonomous units throughout the settlement area and the promotion of a more balanced distribution and diversity of programs. The city must be developed in a manner to preserve and enhance the natural quality and living environment within the wider city area. The goals of the sustainable spatial development include: • qualitatively upgrade already urbanized areas • repair scattered construction or otherwise inadequately used surfaces • complement social and economic public infrastructure • rationally expand the settlement where absolutely necessary for the development of the city • promote sustainable land use by taking into account the principles of rational land use, ensuring a lifelong living environment, long-term safe supply of natural drinking water, efficient energy use, promoting the use of public urban transport and conservation, in all new spatial plans and renovations of green areas. The starting points of City of Ljubljana spatial development planning are the existing values (natural, cultural and functional) that create the identity of the city and the potential for its quality development. Maintaining and developing the quality of the urban environment and its identity are prerequisites for the successful economic development and cultural importance of every European city. Therefore, the preservation, upgrading and further development of the quality structure of the city as a whole and its individual characteristic areas are identified as key focuses of spatial development. Modern times are characterized by an increase in the use of information and telecommunications technology, which influences the emergence of a high-tech knowledge society and changes in the organization of space (the intertwining of living and working environments). Lifestyle is changing, especially under the influence of the internet, work from home, distance education, telecom shopping and other forms of digitized services are becoming increasingly popular, dictating new relationships in land use and spatial mobility.

2.2.3 Milan

The vision for the city of Milan is in line with the concept of Sharing Smart Communities. It is focused on creating a "city of sharing" that is resilient and capable of adapting to future changes and pressures.

Milan 2050 **ICARUS vision: "Sharing Smart Communities"**	
Main aims/description: • **"City of sharing": more widespread network of public transport to connect outlying areas and to make Milan accessible and usable without a car.** • **The city and all its plans will work from the perspective of resilience, so that Milan is a city capable of adapting to changes instead of coping with their causes. Prevention is the guiding principle.**	

Economy and Employment	• Technology facilitates interconnection between home and office space, reducing need for commuting.
	
	• The circular economy will be the basis of city development. The recycling and reuse of waste is one of the main objectives of Milan. Organic waste can be used in the vertical farms or near the South Agricultural Park as fertilizers.
	
	• Milan will be a smart city, which will allow better management of city resources and networks, thus reducing energy demands and waste of money. In particular, we will implement solutions such as:
	
	  • The "Smart Lighting" service adds intelligence and control to public lighting services with the aim of reducing costs and spending on public lighting. Smart Lighting allows remote lighting control which reduces energy and maintenance costs, improving resource management.
	  • The "Smart Water" is a system of intelligent sensors that will allow Milan to monitor the pressure and water port of the infrastructure and will report any leaks or breakages in real time. It is also possible to adjust the pressure with flow modulation, differentiated day and night programming, upstream support and loop closure. It will be useful for the prevention of flooding (increasingly frequent of Saveso and Lambro) thanks to the connection to a control center via radio frequency.
	  • Smart bin is capable of detecting its fill status, frequency and time of use through a constant scan performed by a sensor and subsequent sending of the collected data to a back-end software, via wireless network low cost. The basket sends measurements related to its filling status (empty, full in half or full completion) and occlusion (occluded or not occluded). The information provided makes it possible to optimize the waste collection process in the road containers, reducing the use of resources and planned resources and also contributing to improving the quality of the service,

Milan 2050 **ICARUS vision: "Sharing Smart Communities"**	
	guaranteeing timely intervention for critical situations; thus avoiding the occurrence of situations with accumulation of waste on the container. • Working from home is likely to become increasingly common in the future, particularly among older people. As with care in the home, this can be supported by suitable design and enabling access to necessary technologies, such as high-speed broadband.
Mobility and Transport Systems	• **"**City of sharing": more widespread network of public transport to connect outlying areas and to make Milan accessible and usable without a car. • In 2050 all public transport will be electric (or similarly low-emission) and 50% of private transport is fossil fueled. Milan will become the "City of sharing": different services will be accessible even through alternative or complementary forms of private transport. • A more widespread network of public transport will be developed with the goal to include extension of the circular lines to connect outlying areas, to enhance rail service and to make Milan accessible and usable without a car. In the meanwhile, 8 to 15 cars are removed from the streets for each available car-sharing vehicle, allowing Milan to cater to its citizens, and not their cars. As operators pay the city to operate their ride share programs, the revenue can be used to improve public services. • In order to raise levels of security, pedestrian areas and environmental islands will be created in the periphery of the city, especially to link the center to surrounding suburbs. In 2050 the goal is to have a pedestrian-friendly city with shared spaces. • Mayor of Milan, Giuseppe Sala, ensures that major areas of his city are zero emission by 2030, by signing the C40 Fossil-Fuel-Free Streets Declaration (in October 2017). Signatory to the Declaration "envision a future where walking, cycling, and shared transport are how the majority of citizens move around our cities". The city therefore commits to: (a) Increase rates of walking, cycling and the use of public and shared transport; (b) Reduce the number of polluting vehicles on city streets; (c) Lead by example by procuring zero emission vehicles for city fleets; (d) Collaborate with suppliers, fleet operators and businesses to accelerate the shift to zero emissions vehicles and reduce vehicle miles in the city. The city of Milan recognises the need for a comprehensive, holistic approach to transform the way people travel around our cities that builds on pledges made as part of the C40 Clean Bus Declaration and supports those

Milan 2050 **ICARUS vision: "Sharing Smart Communities"**	
	articulated in the Global MacroRoadmap: An Actionable Vision for Transport Decarbonization.
Energy Systems	• No consumption of fossil fuels and many buildings will be able to produce energy • The projected per capita GHG emissions for 2050 are low by current standards, but the current gaps in actions result in total emissions of 1.9 million tCO2eq per year. The main cause of this is the inadequate supply of local renewable energy and a reliance on national grid supplied electricity (a large portion of which is still projected to be based on fossil fuels in 2050). • In the city will be developed new technologically innovative applications that will support co-generation (heat and electricity produced from same energy source) network to use excess heat from industry to heat residential/commercial properties through the district heating/cooling network. • The construction of new buildings and the retrofitting of existing ones concerned the reduction of 30% of energy. The reduction percentage is calculated on the base of the index of primary energy consumption for building heating (kWh/sqm*year).
Heating and Buildings	• Following the direction of the passive house, new buildings will not consume fossil fuels and they will include facilities to park soft mobility vehicles. In additional to that many buildings will be able to produce energy feed it back into the system through the smart grid.
Society and Culture	• Participative city society will become an active actor • Milan will become a city sensitive to environmental and energy issues, where citizens will reach a high awareness of their consumption and behavior. Participative city society will become an active actor in dealing different social and environmental goal. • Different projects could ensure better use of resources: being successfully engaged in the projects, the citizens of Milan feel more involved in environmental policies and are generally participating more in city initiatives; implementing new policies, they can boost social activities in many sectors and lead to job creation in the city. • At different level technology systems and networks will be integrated to

Milan 2050 **ICARUS vision: "Sharing Smart Communities"**	
	effectively support all aspects of daily life. Promote telecommuting, access to services, and reduce the need to travel these are just some the aspect of the future impacts for Milano in 2050. Conscious that this means increasing its ambition, the municipality is working on defining new sectoral targets, towards zero-emission transport, net-zero buildings, 100% renewable energy, and zero waste, that will bring big benefits to its residents, including clean air, green jobs, more efficient housing and many more.
Consumption and waste management	• One of the most tangible news will be the presence of agriculture in the city, through skyscrapers and agricultural walls that will also act as regulators of the microclimate. • The South Agricultural Park will be saved and relaunched with these means. Thus we will have the zero kilometer also in Milan. • The return after the experimentation in Expo of the interactive tables, which recall the market stalls, with the technological element of the sails that through 54 monitors are able to present an "increased label" of the products. The simple gesture of the hand towards the product will make it possible to obtain indications on the screens that go beyond what is stated on the packaging, with information on the origin of the raw materials, instructions for disposal and ongoing promotions. The interactive tables are joined by 46 totem-touch devices equipped with scanners to display information on all the products on sale, regardless of their location, in line with the needs of an increasingly wise and aware consumer.
Land use and urban form	• In 2050 Milan will become a very dense, spacious, and highly populated city. Despite the increase of human pressure, the city will have an increase of the permeable surfaces in order to increase the land capability to absorb more quantity of rain. • Considering a business as usual (BAU) scenario, urban sprawl is projected to increase by 40.4 km2 due to a population increase of 315,000. With a projected increase of 665,300 people by 2050 (due to the assumption of densification of the city), new specific strategies will be defined to ensure that urban sprawl is contained.

2.2.4 Thessaloniki

The vision for the city of Thessaloniki is in line with the concept of Sharing Smart Communities. It is focused on turning Thessaloniki in a truly resilient city improving the everyday life of its citizens. In the following the vision is described in detail.

Thessaloniki 2050 "Sharing Smart Communities"	
• Improving the quality of life in the city. • Turning the city towards the sea. • Strengthen an urban economy.	
Economy and Employment	• Develop a network of local partners to launch workshops, seminars and training programs in support of independent workers. This will focus on providing digital skills, financial education, advice on working with international clients. • Support local solutions (training platforms, networking initiatives, etc.) • Invest in entrepreneurship and strengthen economic activity of young people. - The municipality along with stakeholders (university and private sector) will provide programs to support young people to move from education to career pathways. This will improve the local economy and reduce brain-drain, and create jobs, skills and economic prosperity for all. • Invest in the economic and urban development of Thermaikos Bay in order to improve city life.
Mobility and Transport System	• Despite the completion of the main metro line by 2021 which will be a major step to improve public transportation, a new mode of transport and iusing of buses will be developed in order to alter the habit of using private car. This plan will improve the efficiency and cost effectiveness of transporting people and goods around the city. It will contribute to improve the quality of the urban environment. • Gradual replacement of all the old municipal vehicles with new electric ones will proceed.
Energy Systems	• Energy saving at least 20%. • Participation of Renewable Energy Sources in the energy balance of the municipality by more than 20%. • Reducing polluting emissions of carbon dioxide by 20%.
Heating and Buildings	• Install green roofs and green walls on public buildings. • The use of natural gas for heating in public and private buildings.
Society	• Invest in creating spaces for residents (e.g. Vegetable gardens). This will provide opportunities for neighborhoods to meet, work together, empower citizens to increase civic participation and create opportunities for networking and skills sharing. • Create awareness campaign highlighting the importance of civic participation in local decision-making processes (metropolitan scale).

Consumption and waste management	• Implement circular economy principles in the city - The Local Waste Management Action Plan commits the City to recycle 60% of its total waste by 2050. These will influence consumption patterns, encourage re-use and repair, establish Green Spots and seminars and activities for up-cycling.
Land use and urban form	• Develop a land use investment along the coastal zone – Investing in the economic and social benefits of the reactivation of the waterfront and the adjacent neighborhoods. This will help to develop the area into a more economical and sustainable zone for local commerce, tourism and leisure activities.

2.2.5 Roskilde

The vision for the City of Roskilde aligns with the concept of Sharing Smart Communities. The main aim is to integrate across the relevant sectoral policies and place Roskilde in a leading position in the Capital Region (dominated by Copenhagen), in particular through transitioning to a post carbon city which is CO2 neutral by 2040, including citizen involvement, sustainable mobility, livable and green spaces and climate resilient urban systems. The vision and its linked policy sector visions are presented below.

ICARUS vision category	Sharing Smart Communities – Roskilde conctext

Main aims/description:

Roskilde Municipality has the overall city vision:

> To become the leading municipality in the linkage of history, service, culture, employment and education in Greater Copenhagen.

The overall vision is backdrop for and has led to the development of sector policies, many of which are relevant for the ICARUS visions. The sector policies take the overall city vision as point of departure for the vision to guide policy development within the particular sector. Moreover, in the overall vision, individual sectors are specified, including climate change mitigation and climate change adaptation, transportation/mobility and health (Roskilde Kommune Vision).

The most comprehensive and influential policy based on the overall vision is the *Climate- and Energy Strategy and Plan 2019-2022* (*Strategisk Klima- og Energiplan 2019-2022*), which will be the main focus of the examination of the sustainable, smart and healthy vision aspects below. Additional data is collected from other sector policies.

The overall aims of Climate and Energy Strategy are for the Roskilde Municipality to **become CO2 neutral by 2040**, through a 35% reduction of CO2 emissions (274.000 metric tons CO2). Included in this are the goals of:

- To have a CO2-neutral electric and district heating by 2030
- To have a CO2-neutral individual heating by 2035
- To become a CO2-neutral municipality as a business by 2035
- To become a CO2-neutral municipality as a geographical area by 2040 (Klimapolitik)

The overall aim To become CO2 neutral by 2040, is intended to be realized through the following three policy themes; 1) Green Solutions for citizens and business, 2) A sustainable municipality and 3) Green transition of energy systems (Strategisk Klima- og Energiplan 2019-2022).	
Economy and Employment	*The Climate and Energy Strategy* does not specifically address the actual costs of the transition to the CO2 neutral city, but singles the cost of the transition to be elaborated in the linked A*ction Plan*. The *Strategy* notes both increases and decreases in economic costs depending on the specific policy themes and area of action. The *Strategy* has been divided into three policy thematic – *Individual citizens/businesses*, *The municipality as business* and *Green transition for the energy system* – and the strategic indicators are organized accordingly. For *Green solutions for individual citizens/businesses*, the overall focus rests on the idea of providing a general and broader education on sustainable behavior. Solutions to this are green transition on heating, increased residence value through energy-renovation, optimization on the supply of electrical vehicles and shared economic mobility-opportunities, amongst others. For *The municipal as business*, sustainability is anticipated to be achieved through loans to finance upgrading of energy systems, district heating in municipal buildings, purchases of biogas and mainstreaming the lease of hybrid or electrical cars for employees at the municipality. Thirdly, the *Green transitioning of energy systems* are predicted to need further research, the expansion of cheap and efficient district heating across the city, and increased use of renewable energy sources, specifically solar panel installations and windmills. overall, the Strategy presents a range of policy initiatives to stimulate the transitions to a green and/or post carbon Roskilde (municipality level). The costs of these transitions are not accounted for in detailed numbers. However, the Strategy forecastes that the overall transition equally will benefit the economy of the individual citizen/business and of the municipality, as proper timing, long-term efforts and careful preparation is expected to decrease the total cost of living, as a result of sustainable choices, from the perspective of overall economy (Strategisk Klima- og Energiplan 2019-2022).

Mobility and Transport System	With respect to transport and mobility, the city vision has translated into the major aim of maintaining the City Roskilde in the lead of liveable and attractive places of living, as they aim for a green and flexible municipality. In the focus areas Easy access; Health, movement and children; Green mobility; and City life, the Transport and mobility vision encompasses goals that seek to a) replace general transportation with greener alternatives, b) to facilitate green transitions and c) to improve overall green mobility. A targeted policy goal is to increase the number of bikes and users of public transport with 5%, as means to reduce the environmental impact of transport and prevent traffic jams. Another goal is to establish three additional junctions for busses and trains to improve the connectivity and public experience of public transport (Trafik og Mobilitetspolitik). Thirdly, Roskilde Municipality plans a new recreational bike and pedestrian track that will enhance connections between residential areas and nature. In the *Climate and Energy Strategy* theme 1: Green solutions for individual citizens and business, it is anticipated that green mobility and general proximity of public transportation will make greener alternatives more attractive for citizens. Over time, the municipality will facilitate and support an overall decarbonisation internally, as they plan on ensuring that 100% of cars in the municipal fleet of cars are electric drives (Strategisk Klima- og Energiplan 2019-2022).
Energy Systems	Roskilde Municipality envisions a green transition of the municipal energy system. To achieve this, Roskilde presents five strategic indicators: 1. More laboratory tests to investigate integrated and flexible energy systems, in collaboration with researchers, businesses, suppliers and local entrepreneurs and innovators. This includes the possibility of subscription-based heat pumps, hybrid heat pumps, heat storage in district heating including surplus heat. 2. Dispersion of cheap and effective district heating, including a reduction in the current temperature of the district heating system. 3. Phasing out gas oil and natural gas in the district heating system production and separation of the fossil contents of waste that is brought to the combustion landfill. 4. Increased support for the development of wind- and solar power, through promotion of local projects and potential purchase of windmill shares. 5. Creating stable conditions for further coordination of energy systems, including ongoing partnerships with Energy Across (Energi På Tværs) and the partnership with Gate 21 (Strategisk Klima- og Energiplan 2019-2022).
Heating and Buildings	At individual and municipal levels, green transitions are anticipated. This requires not only information campaigns centring on the opportunities to go green, but also on making decentralised and individual heating simpler and feasible, e.g. through subscription agreements.

	Furthermore, Roskilde Municipality states that any communal building henceforward should be renovated according to sustainability sdtandards, including the indoor climate. Roskilde Municipality is additionally looking into possibilities of actively utilizing the Voluntary Sustainability Class of the Building Act and regulations, as well as ensuring that the certification scheme DGNB consistently is used in coming constructions, to ensure that notions of the life cycle of the built environment with regards to consumptions of energy is included (Strategisk Klima- og Energiplan 2019-2022).
Society	Generally, a number of visions, strategies, policies and plans concern the overall improvement of quality of life, ranging from incentive to invite citizens to enjoy nature more, optimize their daily mobility or lowering prices on heating. (Strategisk Klima- og Energiplan 2019-2022). In the municipal Health Policy, the overall vision is to specifically ensure more years with good quality of life, both physically, mentally and socially. This includes lowering the number of overweight children with 70%, increasing accomplished municipal offers regarding chronic diseases by 20% and to have municipal plans implemented in actual agreements between the municipality and cooperating hospitals (The Health Policy/Sundhedspolitikken). However, the overall aim of these visions appears broader than this, as it concerns various perspectives on the improvement of life quality. The *Climate and Energy Strategy* aims to identify long-term implementation solutions, considering these to be crucial to the green transition envisioned. Hence, *the Climate and Energy Strategy* stresses the central role of early education, offering sustainable insights to school children as to ensure sustainable behaviour and habits from an early age. It argues for further educational aspects, including overall campaigning, information campaigning and more on e.g. green mobility, living, consumerism, heating.
Consumption (diet and products)	Consumption is not addressed directly in any sector policy. However, through the focus on energy use, waste and sustainable behaviour, consumption is indirectly addressed in the Strategy and policies based on the city vision.
Climate Adaptation	Roskilde wants to lead and improve the integration of climatic adaptation within municipal projects. This includes sustainable water catchment, utilization of the wet nature (streams, lakes, wetlands, fiords and ground water), and an embedded focus on nature and environment within efforts on waste management. a central vision here is to become the leading resource-cycle municipality within the period of 2015-2024. As such, the visions include the improvement of outdoor activities but also an improvement for local incentives to nurture for nature, namely through an increase in the accessibility of outdoor activities for citizens. Improvement of

	transport to destinations in the natural environment is envisioned to ensure and make trips easy (Trafik og Mobilitetspolitik). Four overall goals are formulated in the strategy: 1) To realize the climate efforts within the Action Plan, supported by status every March, starting in 2016. 2) To create sustainable and coherent water planning, including water catchment, protection of the groundwater, sewage treatment, water-stream maintenance and preservation of the wetlands while respecting the overall importance and coherence of the wetlands, through preparation of the Water Action Plan I by 31st of December 2016 and a subsequent Water Action Plan II by 1st of January 2018. 3) To integrate nature in the experience economy of Roskilde, and specifically develop a nature based experiences that are health promoting and eventful and which are utilized by citizens and tourists, through coordinated municipal action and in cooperation with plot owners and citizens. 4) To not only improve individual waste separation at household level, but also among businesses and in municipal institutions, by - reuse of 40% of household waste by 2018, charging no more than an additional 10% for partaking in the municipal waste separation arrangements by 2018 and ensuring that in time, 90% of households have established private separation - reuse of a minimum of 160 metric tons wood in 2018, not exceeding the municipal administrative fee of 500 DKK/year and that at least 50 businesses have their waste checked every second year - reduce of the CO2 emission level with a minimum of 100 metric ton in 2018, not exceeding the municipal administrative fee of 500 DKK/year and that at least 50 businesses have their garbage checked every second year (Trafik og Mobilitetspolitik).

2.2.6 Madrid

Madrid 2050 **"Sharing Smart Communities"**	
Economy and Employment	• Creating new business models related to car sharing services and other services such as personal mobility devices • Creating app. and other platforms for sharing mobility experiences.
Mobility and Transport System	• Madrid local government implemented an air quality plan called "PLAN A", aimed at improving the air quality in the city centre. This Plan reinforces a set of policies for reducing traffic congestion in Madrid city Centre. Despite the "PLAN A" has been approved, most of its policies continue under discussion due to a high social controversy. Actually, modifications to the policies included within the "PLAN A" are expected

	in the upcoming years • The priority actions are of a structural nature, focusing on the road network and the public space in order to reduce the intensity of private motor vehicle traffic and promote public transport and active mobility modes (pedestrian and bicycle). In addition, the design of a car parking policy using air quality criteria. • A zero emissions central area is mapped out, for which a set of specific measures are designed in order to act as a catalyzer for the necessary transition of the city as a whole towards a model of low emission mobility. • Other measures are focused in the vehicle pool and key sectors with a high impact on mobility patterns (EMT, taxi, urban goods distribution, municipal fleet and employee mobility) in order to achieve greater efficiency and technological innovation, together with the promotion of electric mobility and shared mobility.
Energy Systems	• Energy saving at least 15%. • Participation of Renewable Energy Sources in the energy balance of the municipality by more than 12%. • Reducing polluting emissions of carbon dioxide by 35%. • Urban regeneration and neighborhood rehabilitation strategies driven by the Madrid City Council, combined with energy efficiency actions, the promotion of distributed generation, the use of renewable energies, and measures aimed at reducing emissions from the residential, commercial and institutional sector, forge the path towards low emission urban management.
Society	• Creating new parks and open spaces for sharing experiences and free time (e.g. Madrid Rio). • Creating participation campaigns for bigger urban planning projects (e.g. Plaza de España). • Citizen awareness-raising. The objective is to raise citizen awareness of the consequences that poor air quality and rising greenhouse gases have in the short, medium and long term, and so encourage a change of behavior towards more sustainable habits.
Land use and urban form	• Implementing relevant urban planning transformations recovering spaces for active mobility and other mobility sharing initiatives. It is particularly relevant the project initiated in Madrid Gran Via

2.3 Connected Cobweb City

The Connected Cobweb City considers a more dispersed, individualistic society, with more of a balance between technology and socially contingent solutions to the challenges facing our cities. This future vision is more suitable for larger cities where several city centers will be connected by main highways and digital connectivity plays an important role across all sectors.

2.3.1 Athens

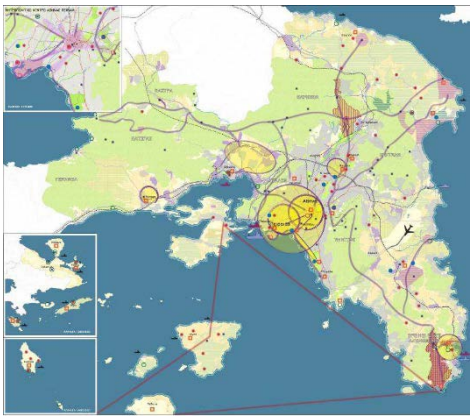

Fig. 1 Athens/Attica Regulatory Plan 2021

As regional and local authorities have not yet developed long term visions, suggested ideas on ICARUS vision sectors and factors for Attica/Athens have been provided as future projections of the existing short and medium term visions, regional/local urban planning in combination with policy trends and EU Energy Roadmaps related to climate change that could be adopted in the future. In addition, the outcomes of the expert and stakeholder workshops, organized in the frame of WP6, on developing green, smart and healthy city visions 2050 have also been taken into consideration to form the proposed idea descriptions.

Attica/Athens 2050 **Icarus Vision: "Connected Cobweb City"**	
Main aims/description: **General Targets** - **Protect the natural environment and improve the well-being and the quality of life for all** - **Sustainable urban and peri-urban development (improve social cohesion, sustainable transport network connecting metropolitan centres, support employment)** - **Support sustainable economy by promoting innovation and green technologies** **Main aims** - **Moving towards a climate-neutral economy in Europe by 2050**	
Economy and Employment	• More flexible employment, with home working. • Increased employment in health care in particular.
Mobility and Transport System	• Autonomous vehicles, with high speed connectivity between urban centers. • Increased use of virtual reality for entertainment reduces demand for leisure travel.

	• Clean, connected and competitive mobility • EVs/Shared autonomous vehicles/Shared mobility systems
Energy Systems	• Increased use of wind and solar power. • Better insulation of buildings. • ZEB: all buildings are zero energy buildings • Energy sharing communities (urban and peri urban) • Clean industrial technologies
Heating and Buildings	• District heating/cooling (CO2 neutral) • Renewable energy sources (PVs, solar collectors for heating water)
Society and Culture	• Multicultural society built on shared ethos of respect and community. • Increased immigration to support population growth.
Consumption and waste management	• Food quality improves through increased use of smart tech in traceability of food.
Land use and urban form	• Ribbon development along main highways, with dispersed urban centers. • Urban density and population equal distribution among several urban centers in Attica region

3 Development of a transition pathway

The development of transition pathways requires the definition of the term transition pathway. Turnheim and Berkhout (2016) define transition pathways as:

> "patterns of changes in socio-technical systems unfolding over time that lead to new ways of achieving specific societal functions."

Transition pathways involve varying degrees of reconfiguration across technologies, supporting infrastructure, business model and providing systems as well as behavior and preference changes of single consumers or individuals. Effective sustainability pathways – and therefore pathways towards green, smart and healthy cities – imply substantial departures from current trajectories. (Turnheim and Berkhout 2016)

Main aim of transition pathways is to better understand unfolding transition processes and intervention opportunities. They therefore give insights into the following questions:

- What key technologies must be (further) developed by R&D (e.g. autonomous driving systems)?
- Evolutionary & revolutionary changes: Which changes can be introduced gradually? What is the required renewal rate (e.g. for building renovation)? What are milestones in the implementation (e.g. ban of fossil fueled cars)?
- Behavioral change: which behavioral change must be made to support the transition (e.g. acceptance of emerging technologies, change in consumption patterns)?
- Which (legal) framework conditions need to be created?

3.1 Global Transitions in the Shared Socioeconomic Pathways

Within ICARUS D6.2 the three distinct ICARUS city visions have been linked broadly to the Shared Socioeconomic Pathways (SSPs) of the IPCC. The SSPs – Shared Socioeconomic Pathways – are narrative scenarios with additional quantitative scenarios which underpin the analysis of emissions under the Representative Concentration Pathways. The Socioeconomic Pathways describe different future storylines and therefore transformation pathways at a global level. The scales at which these global storylines have been developed are mainly incommensurate with the sub-national scales at which impacts, adaptation and, increasingly, integrated assessment modeling studies are conducted (Absar and Preston 2015). As city visions are always embedded into a larger context, a lot of elements of the SSPs transformation pathways are nevertheless relevant to the development of urban transformation pathways. Therefore, this section gives a broad overview of the linkage between the SSPs and the city visions as well as the transition pathway for the SSPs relevant to the Smart Tech City an and the Sharing Smart Community. The Cobweb City is characterized by a middle road alternative between most sustainable future and reliance on technology; which is why the transition pathway rather describes a business-as-usual trajectory (Absar and Preston 2015). With respect to urban transformations the main emphasis is on the land use and urban planning. As this is only relevant for the city level, it is described in the respective chapter (Urban Transitions – Connected Cobweb City).

The linkage between SSPs and ICARUS visions is as follows:

- The **"Smart Tech City"** would be more comparable with SSP5 and to a lesser extent with SSP3 – as the reliance on technology and underpinning assumptions on urbanization are broadly similar.
    - **SSP3:** "The pathway is developed, in the face of weak and fragmented governmental institutions and an overall lack of resources, with an **underlying motive of moving to local, circular economies and a decentralised, networked local community governance system**." (Frantzeskaki et al. 2019)
    - **SSP5:** "The underlying logic of the pathways is to use the dominant **market-based orientation** of the scenario to protect ecosystems and **to integrate environmental protection into business practice while remaining economically efficient."** (Frantzeskaki et al. 2019)
- The vision on **"Sharing Smart Communities"** is broadly comparable with SSP1, with increased awareness of environmental issues and increasing localization;
    - **SSP1:** "The pathway builds on the high level of **governance capacities** in this scenario and especially international, multi-level and bottom-up governance, technological innovation and learning (e.g. in governance and education), **as well as behavioural and market changes**." (Frantzeskaki et al. 2019)
- The vision on **"Connected Cobweb Cities"** is broadly comparable with SSP2, being a middle of the road alternative between the most sustainable future and increasing reliance on technology.
    - **SSP2:** The pathway is largely a business-as-usual trajectory. (Absar and Preston 2015)

A study by Frantzeskaki et al. (2019) analyses transition pathways and gives examples for specific actions according to the SSPs. Table 2 shows these different pathways for each European SSP and the linkage to the ICARUS city vision. The pathways mainly focus on governance, leaderships, lifestyle, technology development and innovation as well as resources management including land, water and biodiversity.

Transitions pathways link future sustainability objectives to immediate action, over time. However, different levels and types of actors are differentially enabled to act in each context scenario or SSPs. Common among all SSPs is the strong governmental actor that provides regulation, coordination financing and also incentives. This emphasize might be lower in the SSP3, with an underlying motivation towards local, circular economies and a decentralized network of local community governance. However, the pathways are generally based on a strong EU with good international as well as civil societal relations. The governance structure is multi-level and decentralized. Overall the system relies on long-term and integrated framework conditions which enable long term decisions and investments. Thereby incentives create synergies among different sectors and prevent unsustainable practices.

Especially, in the SSP5 which is interlinked with the Smart Tech City, the costs of the environmental degradation and intrinsic value of nature are internalized into economic activities. This leads to adapting prices and promotes investments in green technologies.

In contrast to the key sectors being the government and market actors, within SSP1 (linked to Sharing Smart Community) also the civil society is involved as important societal actor. At the same time civil society is also actively involved in the Smart Tech City through the willingness to uptake and accept

new technologies. In the Smart Sharing Community, civil society is furthermore part of the decision making process and implementation and development of actions through sustainable consumption, local renewable production, environmental and basic education.

Generally, the civil society is actively involved through inclusive, participatory and transparent governance structures at regional and local (=city) levels as well as at European and national levels.

Market actors have also an important role in all pathways, but the most fundamental role in the Smart Tech City embedded into SSP5 in order to push the re-orientation of market activity to integrate long-term environmental costs.

Generally, a shift towards small- and medium-sized and family-owned companies is fostered in all pathways. Main aim hereby is to avoid monopolies, facilitate local and diversified economies and ensure equality.

Actors from research and development and knowledge institutions (e.g. universities, research institutes) enable better monitoring of environmental and social problems and research for solution. (Frantzeskaki et al. 2019).

Table 1 Key actors in the SSPs and embedded city visions (adapted from Frantzeskaki et al. 2019)

	Sharing Smart Community SSP1	Smart Tech City SSP5
Key actors in scenarios	All societal actors (government, market, civil society) at multiple levels	Mainly government and market actors
Pathways Agency Capacities mobilized by pathways	All societal actors engage at multiple levels of governance: strong international collaboration and institutions for sustainability; European integration and multi-level, decentralized governance networks; support of market self-regulation, research and community action	The private sector integrates environmental protection into business practice to ensure economic profitability in the long-term, invests in research, monitoring and green innovation and changes consumption practices

Table 2 European transition pathways across the SSPs linked to general city visions, scenario specific strategies and examples of actions within each SSPs (adapted from Frantzeskaki et al. 2019)

Targets	**Smart Tech City** Exemplar scenario-specific strategies relating to pathway (SSP3 & SSP5 & SSP4)	**Smart Tech City** Examples of specific actions (within SSPs)	**Sharing Smart Communities** Exemplar scenario-specific strategies relating to pathway (SSP1)	**Sharing Smart Communities** Examples of specific actions (within SSPs)
Promote shifts towards sustainable lifestyles	• Foster awareness raising on sustainable lifestyles and social cohesion [SSP3] • Foster consumer awareness and invest in education and research for sustainable production and consumption [SSP5]	• Strengthen local initiatives – to live with less • Support sharing economy (using ICT, social media – communication) • Re-establish economic co-dependence and co-operations in regions • Introduce circular economy principles • Invest in education for nature to create a mind-set for nature • Invest in bio-based economy research and other technologies (who: business)	• Facilitate behavioral changes and well-being-oriented policy for sustainable lifestyles and well-being [SSP1]	• Reduce car dependency by increasing public transport, biking, car sharing options • Local energy production and consumptions with solar roofs • Add sustainability to civil classes > exemplary schools, administration etc.
Promote good governance systems for sustainability	• Establish local and community-based governance and infrastructure for local self-organization and networks [SSP3] • Establish and support participatory governance for sustainability [SSP5]	• Strengthen democratic inclusiveness and transparency • Protect role of experts in decision-making processes • Strengthen open communication infrastructure for citizens • Guarantee that satisfaction of basic human needs are not subject to the market • Change the indicators of prosperity to include human development • Increase participation of decision-making to research and knowledge processes	• Establish open and experimental governance for sustainability [SSP1]	• Strengthen EU-citizen connection, reinforce EU democracy • Establish more participative processes for sharing decisions across levels (bottom-up) • Develop new governance technology: massive research and application

Targets	**Smart Tech City** Exemplar scenario-specific strategies relating to pathway (SSP3 & SSP5 & SSP4)	**Smart Tech City** Examples of specific actions (within SSPs)	**Sharing Smart Communities** Exemplar scenario-specific strategies relating to pathway (SSP1)	**Sharing Smart Communities** Examples of specific actions (within SSPs)
Promote sustainable agriculture	• Support skills for local organic agriculture and ecosystem service regeneration [SSP3] • Design an integrated organic agricultural system to increase food security by scaling the CAP and incorporating ecosystem services' values [SSP5]	• Provide incentives for environmentally friendly local agriculture • Identify and protect ecological corridors and increase natural protected areas • Promote bio-refineries to mitigate climate change • Employ SME-instrument for family-owned agriculture (who: EU to employ) • Introduce irrigation water management technologies • Continue integrated farm management and organic agriculture (scale CAP over time)	• Mainstream sustainable agriculture through scaling the Common Agricultural Policy (CAP) and invest in new agriculture technology [SSP1]	• Support climate friendly farming: leg-crop action recycling, agroforestry and tillage • A CAP pillar that incentivizes and rewards environmental and socio-economic services to be 100% EU financed • Set urban agriculture target in CAP: production targets from urban agriculture and part of urban planning policy
Promote strong environmental policy	• Creating nature-based markets that push for technological innovation and account for ecosystem services [SSP5]	• Integrate value of ecosystem services in economic decisions to select what can work in management for land • Introduce higher taxes for fossil fuels • Set up funds to deal with climate impacts	• Promote holistic nature protection and restoration by mainstreaming ecosystem services and nature-based solutions into regulation and planning [SSP1]	• Integrate ocean resource planning • Introduce different models of agroforestry all over Europe • Re-nature rivers and reconnect with flood plains
Promote integrated water management	• Strengthen physical and social resilience to protect from floods and droughts [SSP3]	• Combine river-flow interventions with clearance of rivers • Link CAP with WFD objectives: less water-intensive crops have financial incentives • Household rain harvesting for specific uses		

Targets	**Smart Tech City** Exemplar scenario-specific strategies relating to pathway (SSP3 & SSP5 & SSP4)	**Smart Tech City** Examples of specific actions (within SSPs)	**Sharing Smart Communities** Exemplar scenario-specific strategies relating to pathway (SSP1)	**Sharing Smart Communities** Examples of specific actions (within SSPs)
	• Implement integrated adaptive water management across Europe [SSP5]	• Adapt and reinforce control measures for water quality and water pollution • Invest in effective and efficient water technologies • Give space to the rivers programs in Europe		
Position Europe as a global leader for sustainability	-	-	• Position Europe as a global leader for sustainability [SSP1]	• Implement stronger EU solidary mechanisms • Develop clear EU-wide sustainability vision and more effective communication • Set compulsory building codes for flood resilient houses
Establish a circular economy with green energy technologies	• Strengthen Europe's market position in developing and applying green technologies for water efficiency and sustainable energy [SSP4]	• Move from local to regional energy provision and generation • Promote development of virtual regional energy grids for green energy distribution • Move towards global European energy grids – implementation of cross-border connections		

3.2 Urban Transitions for ICARUS city visions

This section describes the transition for various sectors and factors for each city vision (Smart Tech City, Sharing Smart Community and Connected Cobweb City). The transitions for each sector/factor are presented in the tables in the Annex of this report. The following sections present a selection of key elements within each transition pathway in order to highlight the differences between them. They also focus on the necessary steps at the municipal level that need to be taken now and in the next decades as well as critical elements such as technological innovations to support the transition.

General trends are described for a generic future city following the basic ideas of the three distinct city visions. Whenever city specific assumptions are necessary to better illustrate transition steps, the example City of Stuttgart has been used as a case study.

3.2.1 Smart Tech City

Main elements subject to transitions in the Smart Tech City are the “Mobility and Transport System”, the “Energy System” and the “Heating and Buildings” sector.

Mobility and Transport System

Above all, in the Smart Tech City the problem of climate change and CO2 emission reduction is technically tackled without transport users changing their everyday behavior drastically. At the same time, the benefits of sharing mobility are leveraged. The urban mobility system is based on three pillars:

- Autonomous and interconnected vehicles
- CO2 emission free propulsion system
- Private Transport: Widespread use of car-sharing

Autonomous and interconnected vehicles

Autonomous driving has become completely established within cities by 2050 and changed the structure of private and public transportation. Decisive jumps in the transport system occur only after 2030, as full autonomous driving (stage 5) becomes possible (probably) only after 2030. Autonomous vehicles are not yet ready to operate without drivers and still technical challenges need to be solved. In the meantime, lower levels of autonomous vehicles will dominate the road. Driver-assisting vehicles are already available on the EU market (level 1, 2), while automated vehicles that can drive themselves in a limited number of driving situations are being tested and might be available by 2020. (European Commission 2018b) As an intermediate step towards a completely autonomous vehicle fleet in the city, car- and ride-sharing systems will firstly operate autonomous.

Another major factor of the mobility system in the Smart Tech City is vehicle connectivity. Connectivity is not necessarily linked to autonomous driving, but when combined with automation it allows for truly smart traffic management which leads to safety and reduced congestion (Alonso Raposo et al. 2018). New cars are expected to operate in connected mode from 2022 on. As of 2020, 5G connectivity infrastructure is expected to enable not only connected and automated mobility, but also innovative digital ecosystems around cars. (European Commission 2018b)

Actions to support the transition towards autonomous and connected vehicles include (Alonso Raposo et al. 2018; European Commission 2018b):

- Technological improvements (higher levels of automation need to be reached, especially in urban traffic)
- Provision of data infrastructure (5G)
- New approaches for certifying the safety of autonomous vehicles
- Ensuring consistency between national traffic rules and avoidance of contradiction with EU rules
- Addressing liability issues
- Research and assessment of long-term effects, finding ways to prevent for rebound effects, tackling emerging ethical issues
- Certifying safety of automated vehicles
- Provision of smooth labor market transfers for affected workers

Private Transport: Widespread use of car-sharing

Security technology can be saved to a certain degree through inter-connection among vehicles and automatic accident prevention. Thus, more and more highly efficient small vehicles will enter the market. Many ultra-light vehicles with carbon-free propulsion systems will be operated predominantly in the car-sharing mode. It is expected that car sharing concepts evolve naturally as alternative to individual transport and car ownership. This can be fostered by privileging sharing concepts (station based and non-station based) on federal (urban) roads by the national government, as introduced in 2017 in Germany. Further promoting opportunities for sharing concepts need to be supported and made concrete on the regional and local level. Possible options are giving additional rights to sharing providers and the promotion of information and cooperation exchange between car sharing providers and the environmental network to simplify sharing offers. In the long-term, it might be possible to even restrict individual car ownership to allow for drastic reductions in vehicle numbers.

CO2 emission free propulsion system

CO2 emission reduction in the transport sector in the Smart City is tackled technically and not by a drastic change of the user behavior. In 2050 vehicles operate completely with carbon-free propulsion systems like an electric drive or fuel cells using hydrogen. A combustion engine with fuels made from biomass is less preferred due to air pollution reasons. To reach a completely electrified fleet by 2050, it is necessary to reach the phase out of the combustion engine by 2035 (Baden-Württemberg Stiftung 2017).

Promoting actions include the expansion of the charging infrastructure (and the necessary network infrastructure) in the 2020s (Schrade 2017). For industrial planning and investment security as well as clear investment signals in new infrastructures (especially charging infrastructure), early communication and legal fixation of measures with clear standards for the future are necessary (e.g.

CO2 standards 2030). Research, development and higher education for new key-technologies need to be strengthened to build future-proof competencies. (Baden-Württemberg Stiftung 2017)

Not all transport modes can be electrified by 2050 and the remaining demand is met by electricity-based fuels. Due to high efficiency losses in the production, synthetic fuels are only utilized when no other options are feasible (mainly for aviation and navigation). The very few exceptions of vehicles that are still equipped with internal combustion engines are also completely driven by electricity-based synthetic fuels. Due to climate protection and economic reasons, synthetic fuels are utilized only in the mid-term (after 2030).

In the case of a wide use of synthetic fuels, additional sufficiency measures are necessary since efficiency gains are partly offset by additional energy expenditures to produce synthetic fuels (efficiency approx. 50%) and the availability of energy from renewable sources is limited. In any case, use of synthetic fuels in the transport sector must not be misused to prevent the phase out of combustion engines. (Baden-Württemberg Stiftung 2017; Schrade et al. 2017)

For trucks and HDVs additional effort is necessary since highways need to be equipped with infrastructure to operate hybrid trolley vehicles. These infrastructural efforts need to be taken at a larger regional level than the city level. (Schrade et al. 2017)

The increase of electrically driven vehicles can be supported through the following policies (Baden-Württemberg Stiftung 2017):

- Regulatory instruments
    - Ambitious update of vehicle efficiency standards (Passenger car to 35-45 g CO2/km real in 2030)
    - Binding quote for electric vehicles (e.g. 50% in 2030, 100% in 2035)
    - RDE tests to limit the maximum deviation between real consumption and test cycle (e.g. 15% deviation)
    - Blue badge and temporary access restrictions
- Economic incentives:
    - Higher taxes on fossil fuels
- Infrastructural conditions:
    - Critical examination of existing charging station
    - Public funding of charging infrastructure expansion

Energy system

The future city energy system is based on three pillars:

- Complete substitution of fossil fuels
- Exploitation of municipal renewable energy potentials

- Security of supply and distribution

In 2050, all **renewable energy sources** in the municipal area (case study city Stuttgart) are exploited by their ecological maximum (potential that can be exploited under given technical restriction without irrevocable damages to the environment). Photovoltaic plants are integrated in buildings roofs and facades or at roads and sealed surfaces such as parks and storage areas. Appropriate guidelines for urban planning and design are necessary to minimize conflicts with climate adaptation or use of areas for thermal solar energy. The wind power potential is limited in Stuttgart. Furthermore, high social and legal barriers regarding utilization exist. If one would like to use available potentials, adjustments of regulations and communication towards the citizens would be needed. For Stuttgart, only modern small wind plants would be used. Since the potential of hydropower is fully exploited in Stuttgart, only efficiency improvements are possible. The same holds true for wastewater treatment. The potential of biomass is limited in the city. Furthermore, an assessment regarding complete use of all available resources and health concerns due to particulate matter emissions is needed. In the Smart Tech City, biomass will either contribute with a limited extent to energy supply as combustion in the city area will be limited to central CHPs or combustion will be totally avoided due to considerable emissions. To ensure supply safety in Stuttgart, more back-up CHP plants will be built. After a transitional period, in which CHP plants are still operated with fossil natural gas, a conversion to synthetic gas or biogas will be fostered.

The increasing share of fluctuating, renewable energies requires the use of large additional power storage. Both short-term storage and long-term storage are required. Short term storages, such as pumped-storage plants, are effective to balance fluctuations for several days. Currently the best available technology on the market for short-term storage are pumped storage plants. Pumped storage plants have been used worldwide for decades; their large-scale use is well proven for many years. New types of pumped storage concepts comprise power storage in former mines which have a depth of up to 1600 meters. In contrast to pump storage systems, chemical storages are particularly suited for compensating fluctuations over longer periods of time such as over multiple days, months or years. Chemical storage systems are based on renewable energy produced methane or hydrogen. This is possible by the conversion of electricity into hydrogen by electrolysis; depending on the system the hydrogen can be stored directly or optionally subsequently by reaction to methane and stored as synthetic methane. If necessary, this chemically stored energy can be converted back into electricity (reconversion) or used otherwise be used. All components for these storage systems are generally available. (UBA 2010)

Apart from storage systems, peaks in energy demand are to be attenuated through Demand Side Management (DSM)). At peak loads individual consumers such as refrigerators, air conditioners or heat pumps can temporarily become disconnected from the grid. This can be done either through a centralized control by the utility company or variable consumer tariffs for electricity consumption at different times. This provides a chance for the private electricity customer to contribute to increasing flexibility of energy demand by using time-independent power applications in phases with low peak loads. Therefore, the introduction of more volatile electricity pricing and the construction of a smart grid is necessary. Households need to be equipped with smart metering systems, which can receive data on price changes and transmit the power demand. Intelligent smart meters are also part of the future smart home. The municipality can actively support this development by supporting public utilities by introducing variable electricity with advisory and promotional offers. To accelerate the expansion of electrical and thermal storage in residential buildings, an urban energy saving program should be expanded. Power generation shortages on windless days and without sufficient solar energy

production need to be balanced by suitable energy storage and the flexible connection of base load power generators. The installation of electric and thermal storage in households is therefore important milestone. Furthermore, electricity distribution grids will be adapted towards load reversal. This requires an intelligent infrastructure (Smart Grid) with integrated smart metering system. (Schrade et al. 2017)

Heating and Buildings

In 2050 the **building stock is completely renovated** or replaced by new energy-efficient buildings. A completely renovated building stock has been reached by an increase of the renovation rate to 3%/year (current renovation rate in Stuttgart 1-1.5%/year). Renovation of buildings is necessary pre-requisite to enable the efficient operation of heat pumps. Insulation measures are accompanied by mechanical ventilation and heat recovery systems.

In the commercial and industrial sector, renovations of the building stock happen gradually and as soon as building's envelope or components have reached the end of their lifetime. New buildings are predominantly plus-energy buildings (from 2025 on). The energy efficiency of new building is in line with the KfW40 standard (additional insulation of roof and base plate required). They are air-tight and use renewable energy in combination with solar systems and mechanical ventilation with heat recovery.

Looking at current developments, the present transformation in Stuttgart's **heating system** primarily leads to a market shift towards natural gas. Basically, natural gas will be used as a bridging technology in the future and will be replaced by synthetic gas (or hydrogen). However, due to the high losses in the production of synthetic gas and associated high deployment costs as well as the limited potential for biogas in the region of Stuttgart, this development is seen as critical. At the same time, the politically intended expansion of heating networks happens very slowly in Stuttgart due to very limited interests of the building owners. The main reasons for the reservations are economic aspects as well as frequently missing planning safety. (Schrade et al. 2017)

The main task of the municipality must therefore be to set incentives that restrict the expansion of natural gas in the medium term and to support the conversion of existing gas boilers to cogeneration. Remaining gas boilers in households must use synthetic gas or biogas. Assuming a lifetime of 20 years for natural gas fired boilers, the structural change should be completed by the year 2030. (Schrade et al. 2017)

Another option for building heating are long distance heating systems. As Stuttgart shows an unfavorable topographic structure, long distance heating is limited to few city districts. Nevertheless, the expansion of district heating and local heating is important for climate neutral heating supply and will be fostered in the coming decades. In the short-term an increase of connection rate to the existing infrastructure is needed; especially as the heating demand within the area supplied with district heat will be continuously reduced due to building renovation measures. Generation of climate neutral heat will happen in two steps: in the mid-term, coal will be replaced by natural gas, biomass, industrial waste heat and solar thermal heat; in the long-term fossil natural gas and waste will be replaced by synthetic gas. As a further supplement, local heat networks with cogeneration plants will be created around electricity-intensive industrial and commercial enterprises.

Policies at the municipal level in addition to the targeted promotion of renewable energy, heat pumps and CHP, are also financial support of new connections to heat networks, e.g. in form of price guarantees for local heating solutions, subsidizing of local heat supply, and creation of priority areas

for specific energy carriers. In addition, information and counseling services should make alternatives to conventional boilers more visible. A superior framework for the transformation of the heating supply should be fixed in an energy plan. (Schrade et al. 2017)

The required photovoltaic systems are either integrated into the building on roofs and on facades, or on open spaces along roads and on sealed surfaces such as landfills, parking areas storages are installed. The land use conflict with measures for adaptation to climate change needs to be considered in appropriate urban planning. Thermal solar systems, that are in land use competition with photovoltaics, will continue to contribute to hot water generation and as a heating support. Since the expansion of renewable energy will be mainly in the private sector, the City of Stuttgart can only make the framework conditions as favorable as possible. These include the reduction of legal hurdles, the promotion and provision of financing (e.g. climate change funds, cooperatives and contracting offers) as well as information and advisory services on renewable energies.

Sector coupling: Energy system and energy consumption

To achieve significant reductions in GHGs, not only a transformation of single sectors like energy supply, heating/cooling, mobility/transportation or industry is required, but also the integrative coupling of those sectors. The sector coupling is enabled by several emerging technologies; from renewable energy sources to information and communication technologies. The interconnection of energy-using sectors requires the digitalization of numerous processes, synchronization of demand and supply and construction of storages. To foster the sector coupling it is important that existing techno-economic, policy and regulatory barriers are removed (van Nuffel et al. 2018). Policy recommendations according to van Nuffel et al. (2018) are the following:

- Grid charging technologies need improvement to enable proper sector coupling
- Sector coupling requires reviewed operational standards for energy infrastructure.
- Smart energy system management based on state-of-the-art IT infrastructure:
    - It is necessary to foster such IT infrastructure, which will increase the transparency of the energy system operation while guaranteeing data security and privacy.
    - Standards will have to be developed on data exchange and cyber security protocols in order to allow that smart management becomes a reality.
- Low-temperature electric heat pumps are already established solutions to provide heat and cooling in buildings, but despite advances, their uptake in the European building stock is still limited. Policies are therefore necessary to develop standards and energy efficiency labels for heat pumps and facilitate access to funding to overcome the high investments costs.
- Regarding high-temperature heat pumps, beyond focused R&D efforts, specific policy must improve the risk-aversion and extremely short payback periods required in industry, the sharing of knowledge in the form of best practices and consider the plant-wide benefits of such investments. This is essential to develop a technology central for the hard-to-decarbonize high-temperature heat needs of industry (in combination with the development of green hydrogen).

- High infrastructure costs also form a barrier to the development of the other main alternative for low-temperature heat supply, namely district heating. Even though district heating systems and local conditions vary significantly, there can be a role for EU and national institutions to help project developers by providing system design and operation benchmarks and contractual guidance.

- Care must be taken to avoid the cannibalization of policies fostering solutions such as building insulation, district heating or hydrogen admixing in gas networks. Integrated and coordinated policies can lead to synergies (such as in the connection of heat pumps to local heat networks) and value the additional benefits such as increased system flexibility these technologies provide.

- Future proof energy market design
    - Adequate and cost-reflective energy price signals
    - Adequate pricing of carbon emissions for all energy vectors and installations
    - Connection and access tariffs for electricity and gas networks can, depending on the tariff methodologies and modalities, act as a barrier or facilitator for sector coupling technologies.

- Providing guidance and funding for research and innovation
    - EU funding must focus on high-risk innovations not covered by private finance, while simultaneously developing venture capital financing for this segment.
    - This should be combined with shared European research, demonstration and validation infrastructures in order to accelerate the deployment of R&I project results.
    - R&I by network operators should be incentivized by the national regulatory frameworks.
    - Focused efforts in R&I addressing the specific technology barriers

3.2.2 Sharing Smart Community

Main elements subject to transitions in the Sharing Smart Community are the “Economy and Employment” Sector including “Consumption”, “Mobility and Transport System” and the “Heating and Buildings” sector.

Economy & Employment and Consumption

In the Sharing Smart City, economic efforts have led to common welfare and social added value. In general, the environment is relieved, in particular by efficiency gains in energy use and material consumption. The economy in the Sharing Smart City follows the principles of a **circular economy** with limited raw material consumption through digitalization and further political and societal incentives. Product development is supported by smart technologies and follows the principle of “avoid, reduce and reuse”. Resource consumption for control and feedback technology remains low due to new energy and storage technologies. In the short-term, the trend of increasing digitalization towards the smart economy will be supported by appropriate legal framework.

Rising digitalization affects employment options and leads to an increased demand for highly qualified employees in the next decades. The employment sector shows a trend towards **flexible workplace options** and puts strong emphasis on **equity**. Future working models and the necessary reduction of total working time will contribute to an increase in part-time work as preferred model. Having a smaller amount of traditional working hours, anyone is free to participate in preferred social projects. Services for the society are appreciated and wage work is thought completely new. The higher proportion of robotic work leads to a lower need for lower skilled workers while increasing the demand for highly skilled workers. However, this effect turns out to be more moderate than in the Smart Tech City. Training of employees to increase their digital skills and qualifications will be fostered by companies and supported by the municipality and state funded programs to allow a smooth labor market transfer.

In enterprises, awareness of employees for energy efficient and sufficient user behavior in everyday working life has to be fostered (e.g. sustainable procurement of materials and goods or the correct handling of machines and office equipment). Climate protection topics and sustainability aspects that reach into the private sphere and thus have a correspondingly high multiplication potential, should be basic component of the training scope. Companies need to enhance the awareness of employees for example through suitable training offers. Furthermore, the provision of manuals and guides for climate-friendly behavior in the workplace are good opportunities to positively influence the employees. Especially the younger generation allows large multiplication effects depending on appropriate training.

A **climate-friendly diet and healthy lifestyles** comprise the reduction of meat consumption and the strengthening of seasonal and regional purchasing of food and avoidance of food waste. The necessary change of consciousness of consumers can be supported by the municipality with appropriate incentive programs or support in the marketing of regional products, e.g. by strengthening the weekly market. Food offerings in municipal facilities such as schools, day nurseries, hospitals, canteens, baths etc. should be climate friendly to present positive examples. Especially cooperations with canteens can account for measurable impact at the city level. As part of urban development, areas for urban farming should be considered.

Sufficiency – the moderate consumption of products, goods and services – is often understood as self-imposed restraint, abstinence and comfort loss and is therefore difficult to communicate to the citizens. Thus, communication should rather highlight the positive side effects. The change of behaviors and lifestyles towards more sustainability can be supported by appropriate offers, services, infrastructure and information and educational material from the municipality. To measure increasing sufficiency in the city, indicators such as reductions in living space, increases in persons per household, reduction of waste reduction and water consumption as well as passenger car ownerships can be used.

Mobility and Transport System

In the Sharing Smart Community, the mobility is based on four pillars:

- Autonomous and interconnected vehicles
- CO2 emission free propulsion system
- Multi-modality/Public Transport: Rail-bound public transport supplemented by small on-demand buses for ridesharing, cycling and walking
- Sufficiency in transport

The mobility and transport system in the Sharing Smart Community assumes a similar development of technological innovations and concepts (autonomous driving, CO2 free propulsion, sharing concepts) as occurring along the transition towards a Smart Tech City. A drastic difference is however that significant changes in mobility behavior become everyday practice of citizens. In the example case of Stuttgart this is expressed by the "Public Transport Concept" which combines traditional rail (LRT, suburban and regional trains) and small on-demand buses with 6 seating places per vehicle. For longer trips on relations with sufficient public transport, the ridesharing vehicles connect to rail transport at suitable public transport stops. A description of technological developments and promoting policies can be found in chapter 3.2.1. The following section concentrates on the difference between the visions, which is at the same time the decisive element for the Sharing Smart Community: **multi-modality and sufficiency in transportation**.

The mobility orientation in larger cities already tends towards multi-modality, which is an important aspect to become strengthened by local policy makers. The significant change in mobility behavior until 2050 is based on a transformation of the "mental structure" of the citizens and their thinking about what defines mobility. This offers not only high challenges but also many opportunities for city authorities, national governments or the EU as whole. In this visionary scenario the change of orientations is to a greater extent already a prerequisite for the transformation process. Thus, it is particularly important to start immediately with additional measures and policies (communication programs, participatory pilot projects on car-free mobility). Otherwise, problems of acceptance and legitimacy would complicate or even prevent the transformation. Therefore, the transformation pathway assumes a gradual shift in the behavior, which starts immediately.

To induce behavioral change, the aspired mobility system needs to be inclusive, participative and already experienceable. Therefore, numerous soft measures such as vivid communication campaigns and pilot projects of new mobility solutions need to be taken at different levels from the city to the EU. New sustainable transportation options must be made experienceable by attractive methods especially for children and teenagers. (Baden-Württemberg Stiftung 2017)

Apart from soft principles, also hard measures need to be taken to restructure the mobility behavior, i.e. changes in the physical infrastructure and economic and legal framework conditions. In Stuttgart easy transport mode change between private car and public transport will be provided by Park + Ride facilities. An expansion of these nodes is planned in the short-term. In the long-term, P&R stations will be expanded to mobility hubs providing various services and shared spaces. The public transport has to be expanded in such a way that an increasing demand can be served. The expansion of capacities has to outreach already planned measures (in Stuttgart metropolitan express lines, S21). Non-motorized traffic should be promoted further by additional infrastructure such as dedicated bicycle lanes, car-free districts and the deconstruction of traffic areas. An initial project for car-free areas would be a car-free the inner city center until 2030.

Further actions include:

- Adjustment of legal frameworks such as the Road Traffic Regulation and Public Transport Act; changes can first be introduced temporally and spatially limited and tested in "regulatory innovation zones" (Baden-Württemberg Stiftung 2017)

- Strong price signals, e.g. introduction of toll systems and parking management, further price increases for consumption intensive transportation modes can lead to efficiency gains additionally to the technological development (for example, optimization of logistics processes,

smaller cars) and to a decrease in total transport demand (Schrade 2017), redesign of the pricing system so that sustainable mobility becomes the cheaper option for citizens (Baden-Württemberg Stiftung 2017)

- Infrastructure planning for traffic calming, deceleration and abandonment of further road expansion (push measures).
- Improvements of the supply side of green traffic forms (pull measures), f.e. easy payment methods for services, improving the technological possibilities for public transportation (f.e., real-time information, augmented reality, WLAN)
- Leveraging the megatrend of digitization for environmental goals, connected autonomous driving and related services provide accident prevention, facilitate ridesharing, automatic adjustment of speed to traffic flow and traffic light phases
- Creation of mobility nodes at district level with car-sharing spaces
- Obligations to set up mobility concepts for area development projects as well as larger individual construction projects (demand by municipality)
- Increase funding for non-motorized traffic.

The multi-modality in the Sharing Smart Community is additionally supported by ride-sharing concepts. In the final vision, small on-demand buses with 6 seating places per vehicle support long rail bound transport. To support ride-sharing concepts and make them the future and widely accepted bus-system in the city of Stuttgart, several actions/transition have to be made:

- In the short-term ridesharing concepts need to be privileged on federal (urban) roads (already in place in Germany). Ride-sharing provider would also benefit from additional rights at the regional or local level. In Stuttgart the parking space management could be expanded to the total city area and price structure should favor car- and ride-sharing options.
- Furthermore, municipalities can promote information and cooperation exchange between sharing service providers and the environmental network. This would improve usability and access for the citizens. An example are coupled pricing systems for intermodal routes.

Heating and Buildings

At the center of the overall strategy for a Sharing Smart Community is the individual citizen. This role is especially important in the heating sector as citizen behavior can lead to differences in the heating demand by factor 4, even with identical building situation (Schrade et al. 2017). In the Smart Tech City, the degree of automation and digitalization in buildings is that high, that the influence of user behavior on energy consumption is limited. Automation in the Sharing Smart City has also gradually increased, but by a lesser extent. Major factors for energy demand are therefore **energy conscious use of appliances and reduction of energy demand** (e.g. by ventilation behavior and the chosen room temperature). Apart from the heating energy demand, the user influences also the power consumption; for example, conscious turn on/turn off of electric appliances and avoidance of standby electricity losses can significantly reduce the power consumption.

To be able to fully exploit the savings potential of an energy-efficient renovation, an adapted operation of the building technology is of great importance. As the new technologies are usually much more difficult to use, a training of the responsible facility managers is necessary.

The transition pathway to a Sharing Smart City needs to take these aspects into account and ways to achieve a sustainable behavior change need to be found. This includes a larger paradigm shift concerning the western standard of living which needs to start at national or European level and not at the city level. One possibility to improve energy savings in the building stock is to make energy-efficient refurbishment a "lifestyle product". This can be promoted by targeted competitions for innovative ideas. In these competitions, representatives of different disciplines (advertising, psychology, construction, etc.) seek innovative communication approaches to make climate-friendly and energy-saving buildings an attractive option.[1]

In the Sharing Smart Community, **new living and building arrangements** such as multi-generation projects or shared housing limit the increase of per capita living space. Multi-generation houses enable active interactions between young and old, so that they support and learn from one another. They can exist as a community of shared values or may even be a place where people who are not related live and work together. Multi-generation houses can receive funding in a form of a co-financing model.[2]

3.2.3 Connected Cobweb Cities

The Connected Cobweb City is more suitable for large megacities where connectivity plays an important role. Several city centers will be spatially connected by main highways while also digital connectivity and infrastructure are substantially improved. The main elements to be considered for a transition pathway are therefore "Mobility and Transport System", "Land use and urban form" and to a lesser extent also "Economy and Employment". The transition pathway towards the Connected Cobweb City is described for general elements of large cities.

Economy & Employment and Consumption

The transition towards future employment in the Connected Cobweb City shows more and more **flexible workplace options** that are based on spatial and digital connectivity. Traditional offices will exist in a mixture with co-working spaces, telepresence, hoteling or any combination thereof. Satellite offices will break up large, centralized facilities into a network of smaller workplaces that can be located close to customers or to employees' homes. Telecommuting, home office and performing work electronically wherever the worker chooses are gaining more and more importance until 2050.

- In the short-term, flexible workplace options should be promoted by city-wide rollout of affordable childcare and nursery schemes to ensure flexibility of employees.
- In the mid-term, digital solutions will be used for matching job seekers with relevant employment and skills options in a more flexible approach.

[1] http://www.measures-odyssee-mure.eu/public/mure_pdf/household/GER109.PDF (last accessed 2019/10/24)

[2] https://epale.ec.europa.eu/en/blog/intergenerational-learning-multigenerational-house-model (last accessed 2019/10/24)

- Further mid-term measures increasing the skills of residents to meet the challenges caused by automation of jobs will be implemented before in 2050 technology is widely used for interconnection between home and office spaces.
- The trend of increasing digitalization towards the smart economy will be supported by a legal framework and further training of employees.

In the Connected Cobweb City, emphasis is put on **equity in employment** in order to ensure secure work with fair wages for all ages and abilities. Due to demographic changes, increased employment in health and elderly care is expected.

- In the short-term, the appreciation of social work needs to be supported by adequate payment.
- A short-term action for more equity in the employment sector is the implementation of new initiatives for reduced spatial inequality in unemployment rates between different city districts and neighborhoods in the Cobweb City.
- In the mid-term, further affirmative action measures must be put into practice that limit disadvantages in employment experienced by designated groups in all occupational categories and levels in the workforce.

The **retail sector** is also undergoing major transitions. Online shopping combined with drone delivery services will arise in the mid-term future. In the long-term holograms and 3D presentations will allow projections of goods to the consumer while having the comfort of their home. Ultra-fast delivery, i.e. products being delivered in few hours of being ordered will be standard in 2050. At the same time, a return to more specialization and the local stores (bakery, wine shop, etc.) in each city district will be fostered.

Mobility and Transport System

The mobility and transport system in the Connected Cobweb City is based on a similar technical development of **autonomous and interconnected vehicles** as presented in the Smart Tech City. Autonomous driving has become completely established within the Connected Cobweb City by 2050 and changed the structure of private and public transportation. Decisive jumps in the transport system occurred after 2030, as full autonomous driving (stage 5) becomes possible (probably) only after 2030. Necessary actions at comprise technological improvements (higher levels of automation need to be reached, especially in urban traffic), provision of data infrastructure (5G) and national and EU level traffic regulations (e.g. approaches for certifying the safety of autonomous vehicles). Detailed transition steps and necessary actions can be found in the respective section in Smart Tech City.

The transformation towards the Connected Cobweb City is additionally characterized by a promotion of **multi-modality** as assumed during the transition towards a Sharing Smart Community. The transport system in the Connected Cobweb Cities follows the paradigm of clean, connected and competitive mobility (European Commission 2018a). This means that especially citizen's mobility is improved through intermodal transport. The development of bus connections, offering of alternatives to private cars and increasing the use of sustainable public transport are short-term actions that need to be fostered by the municipalities and service providers. General actions at the municipal level include soft measures like promotion campaigns, adjustments of legal framework (vehicle bans), price signals (pull measures for public transportation) and infrastructure improvements.

Furthermore, **shared mobility systems** as in the other two city visions will emerge. However, in contrast to the Smart Tech City, sharing does not become mandatory in the Connected Cobweb City.

Short-term steps at the municipal level are therefore the completion of all proposed park&ride stations to improve transport links to the city and urban centers and promotion of information and cooperation exchange between car sharing providers and environmental network to improve connectivity of transport modes. The choice of the vehicle propulsion system is not determined in the city vision. The European Battery Alliance facilitates the emergence of industry-led battery cell manufacturing projects and first pilot production facilities are being built. Additionally, electric vehicles are promoted by additional investment in the deployment of infrastructure. An important aspect is that gaps in infrastructures are filled in a targeted and coordinated way. In the context of a wide-spread city with several urban centers, appropriate charging infrastructure needs to be available also on linking highways. The availability of charging infrastructure needs to be secured within the next few years.

In contrast to the previous cities, the central aspect of the Connected Cobweb City is the development of advanced transportation infrastructures and accessible communication systems to foster **urban connectivity**. The infrastructure of the Connected Cobweb City ensures rapid connections to the city center but prioritizes pedestrians, cyclists and public transport within the centers. A ribbon development along main highways with dispersed urban centers is possible. Several urban centers are connected via high speed traffic lanes. A certain problem is the mix of transport modes, such as sharing vehicles, walking and cycling. In the Connected Cobweb City this will be solved in the mid-term by infrastructure and urban planning. On the one hand there will be areas (i.e. urban centers) where traffic by foot, bicycle and electric taxi-robots is mixed. On the other hand, 'urban highways', where vehicle traffic is fully separated from other traffic, will connect urban centers. Green areas and lanes provide opportunity for commuting, access to all areas of the city centers, public buildings and recreational activities. As the Connected Cobweb City relies heavily on linking infrastructures, investments to make these green are necessary in the mid-term.

Connected Cobweb Cities become centric knots and hubs in polycentric networks, which include knowledge and innovation (Malecki 2014). Therefore, 5G connectivity needs to be commercially available across the city within the next years. Until 2030, ultrafast Wi-Fi will be available in public spaces and parks to enable new work opportunities. From 2035 on, virtual and augmented reality applications will contribute to a reduced ravel demand; especially for leisure travelling since virtual reality is more and more accepted for entertainment and relaxation. This development will be supported by 6G trials and a next generation of digital applications for work, entertainment and healthy living. At the same time, all citizens will be enabled to have control over their personal data. In 2050, the Connected Cobweb City will provide all citizens with well-connected communication infrastructure and services.

Land use and urban form

In the Connected Cobweb Cities, urban districts are developed in such a way that all daily demands of the citizens can be met. The different city districts show characteristics of climate adaptation with canals, large green rain beds, blue streams and concave street profiles. Through the urban structure into several districts with own city centers, establishing a district-wide governance structure is particularly important. These city district organizations will start with energy issues and then expand the framework towards water, waste, mobility and other community issues. In the next decades, urban density and population are regulated to be equally distributed among several urban centers.

Another highlight of the Connected Cobweb City are **green infrastructures**. Better ecosystem connectivity needs to be maintained in Connected Cobweb Cities through the integration of tunnels or bridges, which contribute to reconnection of fragmented habitats to secure and re-establish

biodiversity. This needs coordination among stakeholders, exchange of ideas and information. Initiatives will be planned on a wider scale than single infrastructure projects and include various stakeholders (planners, investors, citizens, public authorities at various governance levels etc.) (EEA 2016). The green infrastructure strategy for sustainable transport infrastructure foresees multiple measures and planning procedures relevant to the future city (EC DG ENV 2015):

- Raising awareness among decision-makers and urban planners on the importance of Green Infrastructure benefits (especially for transport).
- Knowledge gaining and dissemination regarding Green Infrastructure options and their benefits through projects
- Ensuring an integrated planning and decision-making process at the national, sectorial, regional and local levels (in order to plan and design projects considering Green Infrastructure opportunities)
- Providing necessary financial resources and prioritizing expenditure on practical actions, such as removal of barriers to restore ecological continuity (in order to implement Green Infrastructure).
- Including Green Infrastructure in Environmental Impact Assessments and Strategic Environmental Assessments for transport projects or programs, thereby integrating climate change and biodiversity into the assessments

4 Conclusion

The report presents a description of the 3 distinct ICARUS city visions and examples how these visions could look like in the ICARUS participating cities. The specification of the 3 city visions allows to draw a transition pathway which defines the scope for interventions across time and for a set of different sectors and factors. Across all sectors the following general key areas for interventions occur (Turnheim and Berkhout 2016):

1. Curbing prevailing trends (e.g. limiting the increasing living space per person, preventing isolation through virtual reality)

2. Substantial system changes at the horizon 2030 (build up and phase out of technologies, implementation of already market-ready technologies)

3. Completing the transformations in the more challenging areas/activities by 2050 (further research for new technological solutions needed)

For the transition pathway the focus has been on the steps that need to be taken now to start moving towards the vision. To this end, short-term activities for immediate action and the next decade have been presented along with the general trends they are supporting. These actions are based on policies and regulations of city authorities (or national government or the EU as whole).

Common among all city visions is a strong governmental actor that provides regulation, coordination financing and incentives. A long-term and integrated framework enables long term decision making and investments, which create synergies among different sectors and prevent of unsustainable practices in economy and civil society. Differences between the ICARUS cities in 2050 concern the key strategies supporting the transition. While the Smart Tech City mainly relies on technical solutions for environmental problems, the Sharing Smart Community puts more emphasis on the behavioral shift necessary for smart, green and healthy cities. A reliance on technical solutions requires strong efforts in innovation and R&D sectors, as well as targeted incentives to push market forces towards environmentally friendly solutions. On the other hand, the Sharing Smart Community is based on decisions taken by individuals and relies strongly on soft measures and the encouragement of participative approaches. In this city the change of orientations is to a greater extent already a prerequisite for the transformation process. Thus, it is particularly important to start immediately with implementing respective policies. Otherwise, problems of acceptance and legitimacy would complicate or even prevent the transformation. In contrast to these two visions, government, market and citizens do not drastically change in the Connected Cobweb City. Therefore, this city requires for rapid changes in urban planning and infrastructure on the road towards a sustainable city.

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Annex: Transformation Steps for 3 Cities

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
Economy and Employment	**Digitalized "smart" economy**	Increasing level of digitalization	Generation of legal framework Fostering acceptability and training of employees to increase the skills to meet the challenges caused by automation of jobs	Short-term to mid-term Gradual increase (start now)	Legislation Municipality, Companies	Smart Tech City
		Increasing demand for highly qualified employees (increasing use of robots)	Further training and retraining of employees (state funded programs, intrinsic motives of businesses) Ensuring smooth labor market transfer	Short-term to mid-term	State, Municipality Companies	Smart Tech City
	Energy efficient production	Energy efficiency of process energy increases (fEff=95 compared to 2015 due to optimization of manufacturing processes, heating demand for manufacturing and production will be reduced by 60% and electricity by 10%)	Process optimization; measures for preventing and recovery of heat waste, improvements of intralogistics, automated production and optimization of pumps	Gradual increase (start now)	R&D, Companies	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
	Energy efficient heating and cooling, ICT, lighting	Lighting in buildings relies more and more on efficient LEDs and OLEDs with intelligent and smart control	Finding new technical lighting solutions and appliance in commercial buildings	Gradual increase (start now)	R&D, Companies	Smart Tech City
		Use of ICT increases (Intensity of use increases for IKT (fInt=151 compared to 2015); for other purposes slightly reduced index, fInt=90)	Development of efficient technologies by R&D, Uptake of efficent option by companies, Training of users/employees	Short-term (gradual increase)	Companies, Employees	Smart Tech City
		Cooling and ventilation systems will be gradually replaced; Energy efficiency of heating&cooling, ICT increases (fEff=45 for heating compared to 2015, fEff=67 for IKT and cooling compared to 2015)			Companies, Employees, R&D	Smart Tech City
	Flexible workplace options	Increasing amount of home office and alternative workplace options	Enabling a mix of alternative workplace options, tailoring the options to an organization's specific needs	Long-term (gradual increase with immediate start)	Companies, R&D, Employees	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
	Flexible business models	New business models emerge	Invest in bio-based economy research and other technologies	Mid-term (gradual increase with immediate start)	Companies	Smart Tech City
Mobility and Transport System	**Autonomous and connected vehicles**	Autonomoud driving technology becomes more and more established --> Car- and ride-sharing systems are based on autonomous driving --> Autonomous driving has become completely established within cities by 2050	Technological improvements (higher levels of automation are reached, fostering connectivity)	Mid-term	R&D, private Enterprises (regulatory approaches from EU level)	Smart Tech City
			Increase acceptance of autonomous driving among citizens:	Mid-term	All	Smart Tech City
			Addressing liability issues	Mid-term	National governance, EU	Smart Tech City
			New approach for certifying the safety of automated vehicles	Mid-term	National governance, EU	Smart Tech City
			Ensure consistency between national traffic rules and avoid contradiction with EU vehicle rules	Mid-term	National governance, EU	Smart Tech City
			Ensuring cybersecurity, data protection and data access	Mid-term	National governance, EU	Smart Tech City
			Provision of data infrastructure (5G infrastructure)	Mid-term	Municipality, Service Provider	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Assess long term effects, anticipate rebound effects, tackle potentially emerging ethical issues	Mid-term	R&D	Smart Tech City
			Providing smooth labour market transitions for the affected workers through quality employment and social services, access to training, and social protection	Mid-term	National governance, Enterprises	Smart Tech City
	CO2 emission free vehicles	Efficiency increases in vehicle technologies --> New carbon-free propulsion systems like electric drives or fuel cell vehicles	Higher taxes on fossil fuels	Short-term	National governance, EU	Smart Tech City
			Blue badge and temporary access restrictions	Short-term	Municipality	Smart Tech City
			Ambitious update of vehicle efficiency standards (Passenger car to 35-45 g CO2 / km real in 2030)	Short-term	National governance, EU	Smart Tech City
			RDE tests to limit the maximum deviation between real consumption and test cycle (f.e 15% deviation)	Short-term	National governance, EU	Smart Tech City
			Examination of existing charging iinfrasdtructure and public fundign of charging infrastructure expansion	Short-term	National governance, EU	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Binding quote for electric vehicles (50% in 2030, 100% in 2035)	Mid-term	National governance	Smart Tech City
	Car-Sharing concepts dominate transport	Sharing concepts gain more and more importance in urban transport	Privileging sharing concepts (station based and non station bases) on federal (urban) roads (already in place in Germany)	Short-term	National governance	Smart Tech City
			Giving car sharing providers additional rights at regional or local level	Short-term	Municipality	Smart Tech City
			Promotion of information and cooperation exchange between car sharing providers and the environmental network to promote the sharing offer	Short-term	Municipality	Smart Tech City
		Sharing concepts are mandatory	No individual car ownership allowed	Long-term	Municipality, National governance	Smart Tech City
Energy Systems	**Complete Substitution of fossil fuels**	Restructuring powerplant operation	Rapid phase out of conventional coal power plants	Short-term	R&D, Legislation (National, European)	Smart Tech City
			Market shift towards natural gas/Increasing use of gas CHP (natural gas will be used as a bridging technology)	Short-term (until 2030)	R&D, Legislation (National, European)	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Flexible back-up power plants to compensate for fluctuating generation ((1) gas, (2) biogas from waste) Defining political targets/specifications for reserve power plants	Medium-term (from 2030 on)	R&D, Legislation (National, European)	Smart Tech City
			Developing electrolysers as flexibility option	Short-term/Medium-term (2025-2030)	R&D, Legislation (National, European)	Smart Tech City
			Conversion of back-up power plants to synthetic gas use	Mid-term(Long-term (from 2030 on)	R&D, Legislation (National, European)	Smart Tech City
		Use of hydrogen instead of natural gas/synthetic gas	Additional research to clarify overall costs of adapting current gas infrastructure to high hydrogen concentrations	Medium-term	R&D	Smart Tech City
			Adjustments in gas transmission and distribution networks in order to make them fit for the transport of hydrogen (additional insulation of pipelines, metering equipment, compressors)	Medium-term/Long-term	Business/Infrastructure operator	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
	Municipal renewable energy potentials completely exploited	Increased use of renewable energies:	Make framework conditions as favorable as possible: reduction of legal hurdles, promotion and provision of financing (eg climate change funds, cooperatives and contracting offers), information and advisory services on renewable energies.	Short-term	Municipality	Smart Tech City
		Photovoltaics will contribute with the largest share to electricity genertion in Stuttgart; they will be integrated in buildings roofs and facades or at roads and sealed surfaces such as parks and storage areas	Appropriate guidelines for urban planning and development to minimize area conflict with climate adaptation, green spaces etc.	Short-term	Municipality	Smart Tech City
		Wind power (has only a limited potential in Stuttgart)	Changing legal regulations and campaigns targeted towards citizens acceptance	Short-term	Municipality	Smart Tech City
		Hydropower (potential in Stuttgart fully exploited)	Renovation of existing plants	Short-term	Municipality	Smart Tech City
		Biomass (potential is limited in Stuttgart)	Taking into account health concerns due to particulate	Short-term	R&D	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			matter when burning biomass in the city			
	Security of supply and distribution	Storage technologies: short term storage	Decision on the use of the appropriate storage technologies (+ how many) Implementation of storage technologies	Short-term to mid-term	Several	Smart Tech City
		Storage technologies: long term storage		Short-term to mid-term	Several	Smart Tech City
		Share of back-up CHP increases to ensure supply safety. After a transition period, in which CHP are still operated with fossil natural gas, they are adapted towards the use of synthetic gas or biogas		mid-term to long-term	Several	Smart Tech City
		Electricity distribution grids adapted towards load reversal: intelligent net infrastructure (Smart Grid) with integrated smart metering system	Regulation that all electricity consumers will be equipped with smart meters	Short-term	Legislation	Smart Tech City
Heating and Buildings	**Efficient and environmental friendly heating**	Rapid phase out of conventional coal and oil boilers	Ban on these boiler types	Short-term	Legislation	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Decreasing gas demand through renovation of buildings and replacement with alternative heating systems (see below) (transition start now, but ongoing development)	Information and counceling services to make alternatives to conventional boilers more visible	Short-term	Municipality	Smart Tech City
			Targeted promotion of renewable enrgy, heat pumps, CHP	Short-term	Municipality	Smart Tech City
			Set incentives that restrict the expansion of natural gas in the medium term (to offset economic aspects and missing planning safety)	Medium-term	Municipality	Smart Tech City
		Conversion of existing gas boilers to cogeneration	Set incentives to support the conversion of existing gas boilers to cogeneration	Medium-term	Municipality	Smart Tech City
		Expansion of heating networks	(1) Increasing connection rates in areas with existing infrastructure (2) development of new areas	Short-term/Medium-term	Infrastructure operator, Municipality	Smart Tech City
			Financial support of new connections to the heat network (f.e. price guarantees for local heating solutions)	Medium-term	Municipality	Smart Tech City
		Transition to climate neutral heat generation fr district heating	Exchange of fuel in 2 steps: 1. coal>natural gas, biomass, industrial waste heat, solarthermie 2. synthetic gas replaces fossil natural gas and waste	Medium-term	Provider	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Increasing use of heat pumps (targeted replacement of oil and gas fired heating with efficient heat pumps with renovation cycles)	Rapid roll out of hybrid heat pumps	Medium-term	All	Smart Tech City
			Continued deployment of heat pumps	Medium-term	All	Smart Tech City
		Use of synthetic gas in remaing gas boilers (in not completely renovatable buildings without long distance heating)		Long term	Municipality	Smart Tech City
		Use of hydrogen instead of natural gas/synthetic gas	Additional research to clarify overall costs of adapting current gas infrastructure to high hydrogen concentrations	Medium-term	R&D	Smart Tech City
			Further development/ Gradual increase of stationary fuel cells	Medium-term	R&D, Citizens, All	Smart Tech City
			Adjustments in gas transmission and distribution networks in order to make them fit for the transport of hydrogen (additional insulation of pipelines, metering equipment, compressors)	Medium-term/Long-term	Business/Infrastructure operator, Legal framework	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Injection of regenerative hydrogen into gas system (leads to conversion of the combustion plants)			Smart Tech City
	Completely renovated building stock	The renovation rate of buildings is increased from 1.5% to 3% until 2050 (also to enable efficient operation of heat pumps) Insulation measures are accompanied by mechanical ventilation and heat recovery systems.	Financial incentives, programs and funding at different levels	Short-term	Municipality, Companies	Smart Tech City
		Gradual building renovation in commercial and industrial sector, as soon as end of lifetime of building envelope or of components has been reached.	Training in adapted operation of the building technology for facility managers	Short-term	Municipality, Companies	Smart Tech City
	Smart Homes and Energy self-sufficent buildings	Increasing tansformation of buildings towards Smart Homes	Equipment with smart meters and further technologies Training in adapted operation of	Short-term	Municipality, Companies, Other	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		New buildings from 2025 on plus energy buildings; energy efficiency in the range of KfW 40 (also in econonomy and commercial sector)	the building technology for facility managers Financial incentives, programs and funding at different levels	Short-term	organisations, Legal framework	Smart Tech City
		Suited roofs and facades are increasingly equipped with photovoltaic panels		Short-term		Smart Tech City
		Installation of electric and thermal storage systems in houses		Short-term		Smart Tech City
Society and Culture	**Actively involved civil society**	Increasingly active civil society	Set up of inclusive, participatory and transparent governance structures	Gradual trend (start now)	State, Muncipality	Smart Tech City
	No compartmention or isolation of society	Increasing trend towards individualistic society	Physical interactions are specifically encouraged through social/green spaces and cultural activities, Regenerating districts happens under the paradigm to prevent societal compartmentation.	Gradual trend (start now)	Municipality, State, Citizens, Organisations&Initiatives	Smart Tech City
		Increasing use of virtual reality				Smart Tech City
		Increasing risk of isolation				Smart Tech City
Consumption and waste management	**Smart waste management**	Increased reuse of waste (waste products from one company will be used as a		Gradual trend (start now)		Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		resource in other company)				
	Food sector with low pressures to environment while also maintaining low prices for consumers	Increasing relevance of artificial meat to reduce carbon footprint of food	Research regarding technological solutions for wide use of artificial meat, Acceptance building measuresa among society	Gradual trend (start now)	R&D, Individuals (acceptance), Companies/Producers, State	Smart Tech City
		Increasing implementation of technical solutions in agriculture (manure management, precision farming)	Gaining more knowledge for reducing environmental impacts from intensive agricultural production systems. Incentives for farmers to apply and improve developed techniques.	Gradual trend (start now)	R&D, Legislation (National, European)	Smart Tech City
	Consumption of goods and services not limited	Consumption remains high	New transport solutions like drones will be applied, 3D printing,	Gradual trend (start now)	R&D, Citizens	Smart Tech City
Land use and urban form	**Sustainable and integrative city center structure.**	Sustainable inner development	Fostering inner development prior to greenfield development. Bringing special attention towards minimizing thermal stress and maintaining thermal comfort of inhabitants.	Gradual trend (start now)	Municipality	Smart Tech City
		Increasing demand of space for universities and research institutes	No development of new areas, but tapping into the 3rd dimension.	Gradual trend (start now)	Municipality	Smart Tech City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Rising conflict between areas for climate change adaptation and renewable energies (photovoltaics in free areas)	Appropriate land use planning	Gradual trend (start now)	Municipality	Smart Tech City
	Green spaces are accessible within few minutes from each point of the city	Increasing accessability of green spaces	The city of Stuttgart already has a high share of green spaces, which is why the transition does not concentrate on further increases but on the accessibility of the green space by citizens.	Gradual increase (start now)	Municipality	Smart Tech City
Economy and Employment	**Circular & "smart" economy**	More and more companies follow the principles of circular economy	Introduce circular economy principles, Support sharing economy (using ICT, social media – communication)	Short-term	Companies, Initiatives, State	Sharing Smart Community
			Halving the use of primary raw materials by 2030	Short-term	Companies, Legislation	Sharing Smart Community
		Higher skilled employment becomes the norm	Further training and retraining of employees (state funded programs, intrinsic motives of businesses) Ensuring smooth labor market transfer	Short-term to mid-term	State, Municipality Companies	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Increasing digitalization	Generation of legal framework Fostering acceptability and training of employees to increase the skills to meet the challenges caused by automation of jobs	Short-term to mid-term Gradual increase (start now)	Legislation Municipality, Companies	Sharing Smart Community
	Flexible workplace options	Satellite offices break up large, centralized facilities into a network of smaller workplaces that can be located close to customers or to employees' homes.	Technology widely used for interconnection between home and office space	Long-term (gradual increase with immediate start)	Companies, Employees	Sharing Smart Community
	Equity in employment	Increasing equity in employment	Adding transparency and a commitment to equity to the paycheck.	Short term (until 2025)	Companies, State (legal framework)	Sharing Smart Community
			Further implementation of affirmative action measures to limit disadvantages in employment experienced by designated groups in all occupational categories and levels in the workforce.	Mid-term (from 2030 on)	Municipality, Companies, State (legal framework)	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			No payment gaps exist on where you come from or who you are	Long-term (gradual increase with immediate start)	Municipality, Companies, National government	Sharing Smart Community
Mobility and Transport System	**Sufficiency in transport and decrease of passenger car use**	Decrease of total demand for travel (shorter distances, less frequency), Significant changes in mobility behavior	Measures to substantially change user behaviour	Short-term	Municipality, National and regional governance	Sharing Smart Community
			Significant price signals: tolls, parking space management to reduce passenger car use	Short-term	Municipality	Sharing Smart Community
	Multi-modality	Increasingly sgnificant role of public transport and slow modes walking and cycling	Political measures to strengthen multimodality (education, information, communication) Making sustainable mobility participatice and tangible Pilot projects of new mobility	Short-term	National level with influence of country level	Sharing Smart Community
			Changes in physical infrastructure (burden on public spatial planning and infrastructure investment): traffic calming, deceleration, no further road expansion	Short-term/Medium-term	Municipality, National and regional governance	Sharing Smart Community
			Changes in legal conditions: adaptation of Straßenverkehrsordnung (road	Medium-term/Long-term	National level with influence of regional level	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			traffic act) and Personenbeförderungsgesetz (passenger transportation act) to facilitate environmentally friendly and accessible mobility			
			Improving the supply side of environmentally friendly transport modes (pull) (investments from country/state)	Medium-term	State/Country, Mobility provider	Sharing Smart Community
			Adaptation of the pricing scheme (push)	Medium-term	State/Country, Mobility provider	Sharing Smart Community
			Car free city center in Stuttgart (until 2030)	Short-term	Municipality	Sharing Smart Community
		More and more technical options enhance the attractiveness of public transportation (real time informtion, augemented reality, WLAN)	Financial investments	Medium-term	State/Country, Mobility provider	Sharing Smart Community
		Sharing concepts gain more and more importance in urban transport	Privileging sharing concepts (station based and non station bases) on federal (urban) roads (already in place in Germany)	Short-term	National governance	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Giving car sharing providers additional rights at regional or local level	Short-term	Municipality	Sharing Smart Community
			Promotion of information and cooperation exchange between sharing service providers and the environmental network to promote the sharing offer	Short-term	Municipality	Sharing Smart Community
	Autonomous and connected vehicles	Autonomoud driving technology becomes more and more established --> Car- and ride-sharing systems are based on autonomous driving --> Autonomous driving has become completely established within cities by 2050	Technological improvements (higher levels of automation are reached, fostering connectivity)	Mid-term	R&D, private Enterprises (regulatory approaches from EU level)	Sharing Smart Community
			Increase acceptance of autonomous driving among citizens:	Mid-term	All	Sharing Smart Community
			Addressing liability issues	Mid-term	National governance, EU	Sharing Smart Community
			New approach for certifying the safety of automated vehicles	Mid-term	National governance, EU	Sharing Smart Community
			Ensure consistency between national traffic rules and avoid	Mid-term	National governance, EU	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			contradiction with EU vehicle rules			
			Ensuring cybersecurity, data protection and data access	Mid-term	National governance, EU	Sharing Smart Community
			Provision of data infrastructure (5G infrastructure)	Mid-term	Municipality, Service Provider	Sharing Smart Community
			Assess long term effects, anticipate rebound effects, tackle potentially emerging ethical issues	Mid-term	R&D	Sharing Smart Community
			Providing smooth labour market transitions for the affected workers through quality employment and social services, access to training, and social protection	Mid-term	National governance, Enterprises	Sharing Smart Community
	CO2 emission free vehicles	Efficiency increases in vehicle technologies --> New carbon-free propulsion systems like electric drives or fuel cell vehicles	Higher taxes on fossil fuels	Short-term	National governance, EU	Sharing Smart Community
			Blue badge and temporary access restrictions	Short-term	Municipality	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Ambitious update of vehicle efficiency standards (Passenger car to 35-45 g CO2 / km real in 2030)	Short-term	National governance, EU	Sharing Smart Community
			RDE tests to limit the maximum deviation between real consumption and test cycle (f.e 15% deviation)	Short-term	National governance, EU	Sharing Smart Community
			Examination of existing charging iinfrasdtructure and public fundign of charging infrastructure expansion	Short-term	National governance, EU	Sharing Smart Community
			Binding quote for electric vehicles (50% in 2030, 100% in 2035)	Mid-term	National governance	Sharing Smart Community
Energy Systems	**Complete Substitution of fossil fuels**	Restructuring powerplant operation	Rapid phase out of conventional coal power plants	Short-term	R&D, Legislation (National, European)	Sharing Smart Community
			Market shift towards natural gas/Increasing use of gas CHP (natural gas will be used as a bridging technology)	Short-term (until 2030)	R&D, Legislation (National, European)	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Flexible back-up power plants to compensate for fluctuating generation ((1) gas, (2) biogas from waste) Defining political targets/specifications for reserve power plants	Medium-term (from 2030 on)	R&D, Legislation (National, European)	Sharing Smart Community
			Developing electrolysers as flexibility option	Short-term/Medium-term (2025-2030)	R&D, Legislation (National, European)	Sharing Smart Community
			Conversion of back-up power plants to synthetic gas use	Mid-term(Long-term (from 2030 on)	R&D, Legislation (National, European)	Sharing Smart Community
		Use of hydrogen instead of natural gas/synthetic gas	Additional research to clarify overall costs of adapting current gas infrastructure to high hydrogen concentrations	Medium-term	R&D	Sharing Smart Community
			Adjustments in gas transmission and distribution networks in order to make them fit for the transport of hydrogen (additional insulation of pipelines, metering equipment, compressors)	Medium-term/Long-term	Business/Infrastructure operator	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
	Municipal renewable energy potentials completely exploited	Increased use of renewable energies:	Make framework conditions as favorable as possible: reduction of legal hurdles, promotion and provision of financing (eg climate change funds, cooperatives and contracting offers), information and advisory services on renewable energies.	Short-term	Municipality	Sharing Smart Community
		Photovoltaics will contribute with the largest share to electricity genertion in Stuttgart; they will be integrated in buildings roofs and facades or at roads and sealed surfaces such as parks and storage areas	Appropriate guidelines for urban planning and development to minimize area conflict with climate adaptation, green spaces etc.	Short-term	Municipality	Sharing Smart Community
		Wind power (has only a limited potential in Stuttgart)	Changing legal regulations and campaigns targeted towards citizens acceptance	Short-term	Municipality	Sharing Smart Community
		Hydropower (potential in Stuttgart fully exploited)	Renovation of existing plants	Short-term	Municipality	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Biomass (potential is limited in Stuttgart)	Taking into account health concerns due to particulate matter when burning biomass in the city	Short-term	R&D	Sharing Smart Community
	Security of supply and distribution	Storage technologies: short term storage	Decision on the use of the appropriate storage technologies (+ how many) Implementation of storage technologies	Short-term to mid-term	Several	Sharing Smart Community
		Storage technologies: long term storage		Short-term to mid-term	Several	Sharing Smart Community
		Share of back-up CHP increases to ensure supply safety. After a transition period, in which CHP are still operated with fossil natural gas, they are adapted towards the use of synthetic gas or biogas		mid-term to long-term	Several	Sharing Smart Community
		Electricity distribution grids adapted towards load reversal: intelligent net infrastructure (Smart Grid) with integrated smart metering system	Regulation that all electricity consumers will be equipped with smart meters	Short-term	Legislation	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
Heating and Buildings	**Energy conscious use of appliances and reduction of energy demand**	Decreasing heating demand	Information campaigns about influence of natural ventilation (windows) and room temperature on heating demand	Short-term	Municipality and further levels	Sharing Smart Community
		Decrasing electricity demand	Information campaigns about conscious turn on/turn off of electric appliances and avoidance of standby electricity losses	Short-term	Municipality and further levels	Sharing Smart Community
			Conscious choise of technical equipment level of the household ("less is more mentality")	Short-term	Municipality and further levels	Sharing Smart Community
		Adapted operation of the building technology	Training of facility managers, residents	Short-term	Municipality and further levels	Sharing Smart Community
	Sufficiency and new living and building arrangements	Reducing space per person/ increasing number of persons per household New living arrangements	Information campaigns Multi-generation projects or shared housing	Short-term	Municipality and further levels	Sharing Smart Community
	Completely renovated building stock	The renovation rate of buildings is increased from 1.5% to 3% until 2050 (also to enable efficient operation of heat pumps) Insulation measures are accompanied by	Make energy-efficient refurbishment a “lifestyle product” by targeted competitions for innovative ideas.	Short-term	Municipality, Companies	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		mechanical ventilation and heat recovery systems.				
		Gradual building renovation in commercial and industrial sector, as soon as end of lifetime of building envelope or of components has been reached.	Training in adapted operation of the building technology for facility managers	Short-term	Municipality, Companies	Sharing Smart Community
	Efficient and environmental friendly heating	Rapid phase out of conventional coal and oil boilers	Ban on these boiler types	Short-term	Legislation	Sharing Smart Community
		Decreasing gas demand through renovation of buildings and replacement with alternative heating systems (see below) (transition start now, but ongoing development)	Information and counceling services to make alternatives to conventional boilers more visible	Short-term	Municipality	Sharing Smart Community
			Targeted promotion of renewable enrgy, heat pumps, CHP	Short-term	Municipality	Sharing Smart Community
			Set incentives that restrict the expansion of natural gas in the medium term (to offset economic	Medium-term	Municipality	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			aspects and missing planning safety)			
		Conversion of existing gas boilers to cogeneration	Set incentives to support the conversion of existing gas boilers to cogeneration	Medium-term	Municipality	Sharing Smart Community
		Expansion of heating networks	(1) Increasing connection rates in areas with existing infrastructure (2) development of new areas	Short-term/Medium-term	Infrastructure operator, Municipality	Sharing Smart Community
			Financial support of new connections to the heat network (f.e. price guarantees for local heating solutions)	Medium-term	Municipality	Sharing Smart Community
		Transition to climate neutral heat generation fr district heating	Exchange of fuel in 2 steps: 1. coal>natural gas, biomass, industrial waste heat, solarthermie 2. synthetic gas replaces fossil natural gas and waste	Medium-term	Provider	Sharing Smart Community
		Increasing use of heat pumps (targeted replacement of oil and gas fired heating with efficient heat pumps with renovation cycles)	Rapid roll out of hybrid heat pumps	Medium-term	All	Sharing Smart Community
			Continued deployment of heat pumps	Medium-term	All	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Use of synthetic gas in remaing gas boilers (in not completely renovatable buildings without long distance heating)		Long term	Municipality	Sharing Smart Community
		Use of hydrogen instead of natural gas/synthetic gas	Additional research to clarify overall costs of adapting current gas infrastructure to high hydrogen concentrations	Medium-term	R&D	Sharing Smart Community
			Further development/ Gradual increase of stationary fuel cells	Medium-term	R&D, Citizens, All	Sharing Smart Community
			Adjustments in gas transmission and distribution networks in order to make them fit for the transport of hydrogen (additional insulation of pipelines, metering equipment, compressors)	Medium-term/Long-term	Business/Infrastructure operator, Legal framework	Sharing Smart Community
			Injection of regenerative hydrogen into gas system (leads to conversion of the combustion plants)			Sharing Smart Community
Society and Culture	**Sharing culture**	Sharing culture enters into the companies	Facilitating the creation of workplace childcare cooperatives, providing access to shared vehicles, offering job sharing	Gradual increase (start now)	Municipality, Society	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Sharing culture enters commercial spaces	Facilitating the establishment of community-owned commercial spaces	Gradual increase (start now)	Municipality, Society	Sharing Smart Community
		Sharing culture enters neighborhoods	Creating staff positions focused on neighborhood community activities, designing neighborhooods for sharing: walkable spaces, parks, narrow streets	Gradual increase (start now)	Municipality, Society	Sharing Smart Community
		Sharing culture enters food sector	Allowing parks and other public spaces to be used as places for food sharing	Gradual increase (start now)	Municipality, Society	Sharing Smart Community
Consumption and waste management	**Healthy lifestyles, including balanced diet and adequate physical activity**	Locally or regionally and seasonally produced food dominates more and more the market	Farms in buildings in town centres to reduce transportation need, Promotion of products	Long-term	R&D, Legislation (National, European)	Sharing Smart Community
		Meat consumption and food waste are more and more reduced	Appropriate incentive programs or urban support in marketing regional products (strengthening weekly markets)	Short-term	Municipality	Sharing Smart Community
	Cradle to cradle principle for consumption	Increased prevention of the waste generation and promotion of the waste reuse		Gradual increase (start now)	Legislation (National, European)	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
Land use and urban form	**Active neighborhood**	Reduction in need for commuting leads to more dispersed communities	Creating staff positions focused on neighborhood community activities, designing neighborhooods for sharing: walkable spaces, parks, narrow streets		Municipality, Society	Sharing Smart Community
	Sustainable and integrative city center structure.	Sustainable inner development	Fostering inner development prior to greenfield development. Bringing special attention towards minimizing thermal stress and maintaining thermal comfort of inhabitants.	Gradual trend (start now)	Municipality	Sharing Smart Community
		Increasing demand of space for universities and research institutes	No development of new areas, but tapping into the 3rd dimension.	Gradual trend (start now)	Municipality	Sharing Smart Community
		Rising conflict between areas for climate change adaptation and renewabl energies	Appropriate land use planning	Gradual trend (start now)	Municipality	Sharing Smart Community
	Green spaces are accessible within few minutes from each point of the city	Increasing accessability of green spaces	The city of Stuttgart already has a high share of green spaces, which is why the transition does not concentrate on further increases but on the accessibility of the green space by citizens.	Gradual increase (start now)	Municipality	Sharing Smart Community

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
Economy and Employment	**Flexible workplace options based on spatial and digital connectivity**	Satellite offices break up large, centralized facilities into a network of smaller workplaces that can be located close to customers or to employees' homes.	City-wide rollout of affordable childcare and nursery schemes to ensure flexibility of employees	Short-term (untill 2025)	Municipality	Connected Cobweb City
			Digital solutions used for matching job seekers with relevant employment and skills options	Mid-term (from 2030 on)	Municipality	Connected Cobweb City
			Further measures increasing the skills of residents to meet the challenges caused by automation of jobs	Short-term to mid-term	Municipality, Companies	Connected Cobweb City
		Traditional offices will exist in a mixture with co-working spaces, telepresence, hoteling or any combination thereof	Technology widely used for interconnection between home and office space	Long-term (gradual increase with immediate start)	Companies, Employees	Connected Cobweb City
	Digitalized "smart" economy	Increasing digitalization	Generation of legal framework Fostering acceptability and training of employees to increase the skills to meet the challenges caused by automation of jobs	Short-term to mid-term Gradual increase (start now)	Legislation Municipality, Companies	Connected Cobweb City
	Equity in employment	Increasing appreciation of working in the social	Adequate payment	Mid-term	Companies, National government	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		sector (immigrants, health care, elderly care)	Information	Mid-term	Companies, National government, Municipality	Connected Cobweb City
		Increasing equity in employment	New initiatives to deliver reduced spatial inequality in umemployment rates between different city districts and neighborhoods	Short term (until 2025)	Municipality	Connected Cobweb City
			Adding transparency and a commitment to equity to the paycheck.	Short term (until 2025)	Companies, State (legal framework)	Connected Cobweb City
			Further implementation of affirmative action measures to limit disadvantages in employment experienced by designated groups in all occupational categories and levels in the workforce.	Mid-term (from 2030 on)	Municipality, Companies, State (legal framework)	Connected Cobweb City
			No payment gaps exist on where you come from or who you are	Long-term (gradual increase with immediate start)	Municipality, Companies, National government	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
	Fast retail	Ultra-fast delivery	Technology facilitates fast delivery, eg. use of drones Promotion of specialized local stores	Mid-term	Companies Municipality	Connected Cobweb City
Mobility and Transport Systems	**Autonomous and connected vehicles**	Autonomoud driving technology becomes more and more established --> Car- and ride-sharing systems are based on autonomous driving --> Autonomous driving has become completely established within cities by 2050	Technological improvements (higher levels of automation are reached, fostering connectivity)	Mid-term	R&D, private Enterprises (regulatory approaches from EU level)	Connected Cobweb City
			Increase acceptance of autonomous driving among citizens:	Mid-term	All	Connected Cobweb City
			Addressing liability issues	Mid-term	National governance, EU	Connected Cobweb City
			New approach for certifying the safety of automated vehicles	Mid-term	National governance, EU	Connected Cobweb City
			Ensure consistency between national traffic rules and avoid contradiction with EU vehicle rules	Mid-term	National governance, EU	Connected Cobweb City
			Ensuring cybersecurity, data protection and data access	Mid-term	National governance, EU	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Provision of data infrastructure (5G infrastructure)	Mid-term	Municipality, Service Provider	Connected Cobweb City
			Assess long term effects, anticipate rebound effects, tackle potentially emerging ethical issues	Mid-term	R&D	Connected Cobweb City
			Providing smooth labour market transitions for the affected workers through quality employment and social services, access to training, and social protection	Mid-term	National governance, Enterprises	Connected Cobweb City
	Multi-modality	Increasingly sgnificant role of public transport and slow modes walking and cycling	Political measures to strengthen multimodality (education, information, communication) Making sustainable mobility participatice and tangible Pilot projects of new mobility	Short-term	National level with influence of country level	Connected Cobweb City
			Changes in physical infrastructure (burden on public spatial planning and infrastructure investment): traffic calming, deceleration, no further road expansion	Short-term/Medium-term	Municipality, National and regional governance	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Changes in legal conditions: adaptation of road traffic act and passenger transportation act to facilitate environmentally friendly and accessible mobility	Medium-term/Long-term	National level with influence of regional level	Connected Cobweb City
			Improving the supply side of environmentally friendly transport modes (pull) (investments from country/state)	Medium-term	State/Country, Mobility provider	Connected Cobweb City
			Adaptation of the pricing scheme (push)	Medium-term	State/Country, Mobility provider	Connected Cobweb City
		Sharing concepts gain more and more importance in urban transport	Privileging sharing concepts (station based and non station bases) on federal (urban) roads (already in place in Germany)	Short-term	National governance	Connected Cobweb City
			Giving car sharing providers additional rights at regional or local level	Short-term	Municipality	Connected Cobweb City
			Completing all proposed Park&Ride stations to improve transport links to the city	Short-term	Municipality	Connected Cobweb City
			Promotion of information and cooperation exchange between car sharing providers and the	Short-term	Municipality	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			environmental network to promote the sharing offer			
	CO2 emission free vehicles	Efficiency increases in vehicle technologies --> New carbon-free propulsion systems like electric drives or fuel cell vehicles	Higher taxes on fossil fuels	Short-term	National governance, EU	Connected Cobweb City
			Blue badge and temporary access restrictions	Short-term	Municipality	Connected Cobweb City
			Ambitious update of vehicle efficiency standards (Passenger car to 35-45 g CO2 / km real in 2030)	Short-term	National governance, EU	Connected Cobweb City
			RDE tests to limit the maximum deviation between real consumption and test cycle (f.e 15% deviation)	Short-term	National governance, EU	Connected Cobweb City
			Examination of existing charging iinfrasdtructure and public fundign of charging infrastructure expansion	Short-term	National governance, EU	Connected Cobweb City
			Binding quote for electric vehicles (50% in 2030, 100% in 2035)	Mid-term	National governance	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
	Urban connectivity	Increasing digital connectivity	5G connectivity is commercially available	Short-term	Several actors	Connected Cobweb City
			Shared digital infrastructure for public and private	Short-term	Several actors	Connected Cobweb City
			Ultrafast Wi-Fi will be available in public spaces and parks to enable new work opportunities	Mid-term	Several actors	Connected Cobweb City
			Virtual and augmented reality applications will contribute to a reduced ravel demand	Mid-term	Several actors	Connected Cobweb City
			6G trials and a next generation of digital applications for work, entertainment and healthy living	Long-term	Several actors	Connected Cobweb City
			Health and wellbeing are supported by the use of "big data" technologies and artificial intelligence	Long-term	Several actors	Connected Cobweb City
		Increasing spatial connectivity	Completing all proposed Park&Ride stations to improve transport links to the city	Short-term	Municipality, Infrastructure planner	Connected Cobweb City
			Providing rapid connections to the city center, e.g. high speed lanes	Mid-term	Municipality, Infrastructure planner	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Green infrastructures for city links	Mid-term	Municipality, Infrastructure planner	Connected Cobweb City
Energy Systems	**Complete Substitution of fossil fuels**	Restructuring powerplant operation	Rapid phase out of conventional coal power plants	Short-term	R&D, Legislation (National, European)	Connected Cobweb City
			Market shift towards natural gas/Increasing use of gas CHP (natural gas will be used as a bridging technology)	Short-term (until 2030)	R&D, Legislation (National, European)	Connected Cobweb City
			Flexible back-up power plants to compensate for fluctuating generation ((1) gas, (2) biogas from waste) Defining political targets/specifications for reserve power plants	Medium-term (from 2030 on)	R&D, Legislation (National, European)	Connected Cobweb City
			Developing electrolysers as flexibility option	Short-term/Medium-term (2025-2030)	R&D, Legislation (National, European)	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Conversion of back-up power plants to synthetic gas use	Mid-term(Long-term (from 2030 on)	R&D, Legislation (National, European)	Connected Cobweb City
		Use of hydrogen instead of natural gas/synthetic gas	Additional research to clarify overall costs of adapting current gas infrastructure to high hydrogen concentrations	Medium-term	R&D	Connected Cobweb City
			Adjustments in gas transmission and distribution networks in order to make them fit for the transport of hydrogen (additional insulation of pipelines, metering equipment, compressors)	Medium-term/Long-term	Business/Infrastructure operator	Connected Cobweb City
	Municipal renewable energy potentials completely exploited	Increased use of renewable energies:	Make framework conditions as favorable as possible: reduction of legal hurdles, promotion and provision of financing (eg climate change funds, cooperatives and contracting offers), information and advisory services on renewable energies.	Short-term	Municipality	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Photovoltaics will contribute with the largest share to electricity genertion in Stuttgart; they will be integrated in buildings roofs and facades or at roads and sealed surfaces such as parks and storage areas	Appropriate guidelines for urban planning and development to minimize area conflict with climate adaptation, green spaces etc.	Short-term	Municipality	Connected Cobweb City
		Wind power (has only a limited potential in Stuttgart)	Changing legal regulations and campaigns targeted towards citizens acceptance	Short-term	Municipality	Connected Cobweb City
		Hydropower (potential in Stuttgart fully exploited)	Renovation of existing plants	Short-term	Municipality	Connected Cobweb City
		Biomass (potential is limited in Stuttgart)	Taking into account health concerns due to particulate matter when burning biomass in the city	Short-term	R&D	Connected Cobweb City
	Security of supply and distribution	Storage technologies: short term storage	Decision on the use of the appropriate storage technologies (+ how many) Implementation of storage technologies	Short-term to mid-term	Several	Connected Cobweb City
		Storage technologies: long term storage		Short-term to mid-term	Several	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Share of back-up CHP increases to ensure supply safety. After a transition period, in which CHP are still operated with fossil natural gas, they are adapted towards the use of synthetic gas or biogas		mid-term to long-term	Several	Connected Cobweb City
		Electricity distribution grids adapted towards load reversal: intelligent net infrastructure (Smart Grid) with integrated smart metering system	Regulation that all electricity consumers will be equipped with smart meters	Short-term	Legislation	Connected Cobweb City
Heating and Buildings	**Energy conscious use of appliances and reduction of energy demand**	Decreasing heating demand	Information campaigns about influence of natural ventilation (windows) and room temperature on heating demand	Gradual increase (start now)		Connected Cobweb City
		Decrasing electricity demand	Information campaigns conscious turn on/turn off of electric appliances and avoidance of standby electricity losses	Gradual increase (start now)		Connected Cobweb City
			Conscious choise of technical equipment level of the household ("less is more mentality")	Gradual increase (start now)		Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Adapted operation of the building technology	Training of facility managers, residents	Gradual increase (start now)		Connected Cobweb City
		Reducing space per person/ increasing number of persons per household		Gradual increase (start now)		Connected Cobweb City
	Completely renovated building stock	The renovation rate of buildings is increased from 1.5% to 3% until 2050 (also to enable efficient operation of heat pumps) Insulation measures are accompanied by mechanical ventilation and heat recovery systems.	Make energy-efficient refurbishment a “lifestyle product” by targeted competitions for innovative ideas.	Short-term	Municipality, Companies	Connected Cobweb City
		Gradual building renovation in commercial and industrial sector, as soon as end of lifetime of building envelope or of components has been reached.	Training in adapted operation of the building technology for facility managers	Short-term	Municipality, Companies	Connected Cobweb City
	Efficient and environmental friendly heating	Rapid phase out of conventional coal and oil boilers	Ban on these boiler types	Short-term	Legislation	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Decreasing gas demand through renovation of buildings and replacement with alternative heating systems (see below) (transition start now, but ongoing development)	Information and counceling services to make alternatives to conventional boilers more visible	Short-term	Municipality	Connected Cobweb City
			Targeted promotion of renewable enrgy, heat pumps, CHP	Short-term	Municipality	Connected Cobweb City
			Set incentives that restrict the expansion of natural gas in the medium term (to offset economic aspects and missing planning safety)	Medium-term	Municipality	Connected Cobweb City
		Conversion of existing gas boilers to cogeneration	Set incentives to support the conversion of existing gas boilers to cogeneration	Medium-term	Municipality	Connected Cobweb City
		Expansion of heating networks	(1) Increasing connection rates in areas with existing infrastructure (2) development of new areas	Short-term/Medium-term	Infrastructure operator, Municipality	Connected Cobweb City
			Financial support of new connections to the heat network (f.e. price guarantees for local heating solutions)	Medium-term	Municipality	Connected Cobweb City
		Transition to climate neutral heat generation fr district heating	Exchange of fuel in 2 steps: 1. coal>natural gas, biomass, industrial waste heat, solarthermie	Medium-term	Provider	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			2. synthetic gas replaces fossil natural gas and waste			
		Increasing use of heat pumps (targeted replacement of oil and gas fired heating with efficient heat pumps with renovation cycles)	Rapid roll out of hybrid heat pumps	Medium-term	All	Connected Cobweb City
			Continued deployment of heat pumps	Medium-term	All	Connected Cobweb City
		Use of synthetic gas in remaing gas boilers (in not completely renovatable buildings without long distance heating)		Long term	Municipality	Connected Cobweb City
		Use of hydrogen instead of natural gas/synthetic gas	Additional research to clarify overall costs of adapting current gas infrastructure to high hydrogen concentrations	Medium-term	R&D	Connected Cobweb City
			Further development/ Gradual increase of stationary fuel cells	Medium-term	R&D, Citizens, All	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
			Adjustments in gas transmission and distribution networks in order to make them fit for the transport of hydrogen (additional insulation of pipelines, metering equipment, compressors)	Medium-term/Long-term	Business/Infrastructure operator, Legal framework	Connected Cobweb City
			Injection of regenerative hydrogen into gas system (leads to conversion of the combustion plants)			Connected Cobweb City
Society and Culture	**Multicultural society**	Shared ethos of respect and community, increased immigration to support population growth	Set up of inclusive, participatory and transparent governance structures	Gradual trend (start now)	Municipality, State, Citizens, Organisations&Initiatives	Connected Cobweb City
	No compartmention or isolation of society	Increasing trend towards individualistic society	Physical interactions are specifically encouraged through social/green spaces and cultural activities, Regenerating districts happens under the paradigm to prevent societal compartmentation.	Gradual trend (start now)	Municipality, State, Citizens, Organisations&Initiatives	Connected Cobweb City
		Increasing use of virtual reality				Connected Cobweb City
		Increasing risk of isolation				Connected Cobweb City
Consumption and waste management	**Convenient Shopping and Retail**	Online shopping combined with drone delivery services	at company level	Mid-term	Companies, Individuals	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
		Holograms and 3D presentations will allow projections of goods	at company level	Long-term	Companies, Individuals	Connected Cobweb City
		Ultra-fast delivery	at company level	Mid-term	Companies, Individuals	Connected Cobweb City
		Return to more specialization and the local store	Initiatives and municipal programs to support local stores	Mid-term	Companies, Individuals	Connected Cobweb City
Land use and urban form	**Green infrastructure**	Green infrastructure networks evolve and expand	Investments in green infrastrcture demonstration projects in order to increase awareness and support for green infrastructure, Monitoring systems for pilot projects	Short-term	Municipality	Connected Cobweb City
			Knowledge dissemination and awareness raising among planners and decision-makers on the importance of Green Infrastructure benefits for transport	Short-term	Municipality, EU level, National level	Connected Cobweb City
			Green infrastructure is considered in all building standards, planned maintenance projects and capital improvement and master planning processes	Mid-term	Municipality	Connected Cobweb City

Sector/Factor	Final state of the vision	Development and transition steps	Actions	Time Horizon	Actors	City
	Urban density	Evenly distributed population density within built-up area	Urban planning	Short-term	Municipality	Connected Cobweb City