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Concept for the harmony of mobility, economy and environment

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Abstract
The harmony of mobility, economy and environment crystallizes in the requirements for the concept of the Smart City. An important component of the overall construct is Smart Mobility and, especially in metropolitan areas, a challenge to all three goals of modern society. This paper shows that mobility alone, by enabling the interconnectedness between the individual goals of a Smart City, plays a central role, which not only has a positive impact on economic power and the environment, but at the same time creates access to other smart services. The design of mobility is also the smart city dimension that, together with building emissions, has the greatest potential for the reduction targets for climate-damaging gases.
Keywords: Mobility, Economy, Environment, Smart City, Sustainability, Smart Living

Introduction

The focus of this paper is on the concatenation of (available) practical and possible smart city applications. Economic activities always include mobility, as well as Smart City solutions always include mobility, economy and environment as basic dimensions.

Since the end of the 1990s, the term smart city has increasingly entered the scientific and urban planning discussion when it comes to the design of cities and metropolitan regions worldwide. In this context, “smart” stands for the linking of the digital and physical worlds in all areas of life of the citizens and users of the city and the urban offer.

The importance of the context of different legitimate aspects in smart city optimization is described in this paper by the possible harmony of **mobility assurance, economic performance and sustainability.** The

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importance of interdisciplinarity in finding solutions is highlighted accordingly.

By definition, the smart city solution is multi-dimensional. Individual smart solutions may well stand in the way of an overall smart concept - analogous to isolated solutions in other optimization contexts.

In preparation for building a consistent concept, therefore, the **chapter 2** will first examine the ***problem of assigning smart solutions to multidimensional smart city solutions.*** This is also important to prevent arbitrary adaptation by copying and imitation without taking into account the different framework factors. Supposedly "smart" alone does not do justice to the required consideration of multidimensionality and the interlocking of smart city components.

The interaction of mobility, economy and environment needs an essential extension, which is captured by **Smart Living** and consequently strongly integrates the dimension Smart Living into the aforementioned. This is exactly where **the third chapter** ***analyzes and evaluates multidimensional smart city approaches using the example of smart living***.

Since people are always economically active in the context of living and working, and the search for a place to live is for the vast majority related to the place of work, making it possible to combine work and living is an important component of Smart Mobility.

The **fourth chapter** ***Bringing Smart City Components Together under Ensuring Smart Mobility*** takes this into account and illustrates the effects of non-smart solutions for urban mobility.

The mapping problem of smart solutions to multidimensional smart city solutions

Classification of the smart city approach

There is no uniform definition of smart cities. Depending on the perspective, there are various approaches to grasping the scope of a smart city strategy. Initially, the use of the resulting option through digitization and better information and communication technology for cities was described as smart. Building on this, initial smart city definitions broke down the options into different fields of work, which can also be seen as dimensions. Initial definitions include the six dimensions of mobility, energy, environment, citizens and quality of life, economy, and administration.

Based on these basic dimensions, Cohen built the smart city wheel to further specify the dimensions: this is based on the dimensions of mobility, environment, administration, economy, citizen, and quality of life. All approaches to explaining the comprehensiveness agree that Smart Mobility is one of the basic dimensions, even if the spectrum of working fields is further developed or refined (see exemplary *Figure 1*).

	Deloitte (2017)	Roland Berger (2017)	A. D. Little (2016)	Swiss SC Survey (2020)
Mobility	X	X	X	X
Safety	X	-	X	X
Energy, Environment	X	X	X	X
Building	X	X	X	X
Living	X	-	-	X
Health	X	X	X	X
Education	X	X	X	X
Finance	X	-	X	-
Tourism, Leisure	X	-	X	-
Retail, Logistics	X	-	-	(X)
Manufacuring	X	-	-	-
Government	X	X	X	X
Communication Services	-	-	X	-

Figure 1: Smart City Fields of Work / Smart City Dimensions

Source: Own illustration based on Deloitte, 2015; Roland Berger, 2017; Baron, Ralf et al. 2016; Energie Schweiz, 2020

Deloitte makes a more refined distinction than the basic dimensions in 11 smart city dimensions. There are different focal points; Roland Berger, for example, focuses on 6 fields of action. Arthur D. Little, on the other hand, distinguishes 10 areas of application as vertical areas (see *Figure 1*).

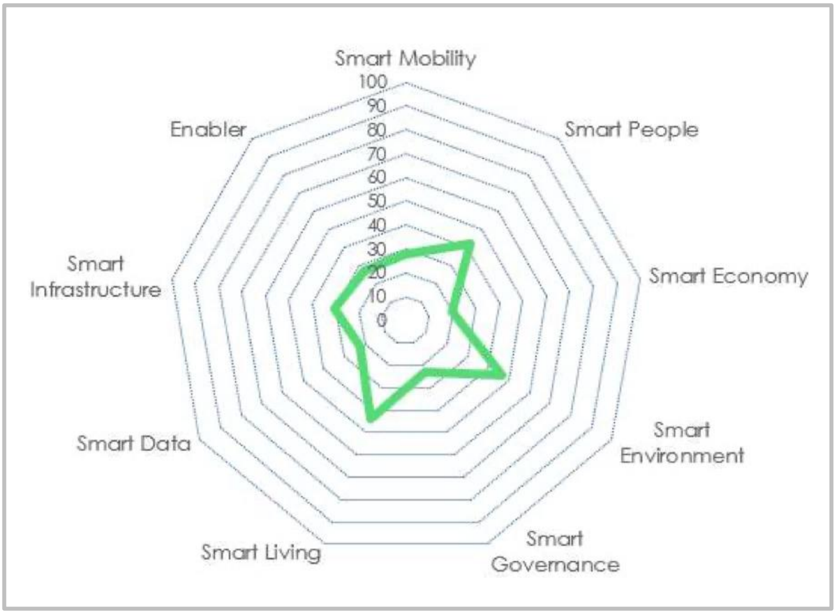

Figure 2: Smart City realizations in practice

Source: Müller, Leicia et. al. 2020, S. 6

For the conceptual framework of this paper, it is important that all attempts to explain the comprehensiveness of a smart city solution explicitly include the area of smart mobility. There is no single definition of what makes a city "smart" or what should be considered a "non-smart" solution.

It also shows that reality is often still far from the ideal, even in the individual dimensions. For example, *Figure 2* shows what the smart city profile of 84 participating cities and municipalities from Switzerland will look like at the end of 2020 (Müller et. al., 2020:2ff).

Technological possibilities

Information and communication networking fundamentally increases the controllability of urban systems and opens up opportunities for point-, time- and price-oriented adjustments of a wide range of services to the individual needs of people in the city. This increases the economic and ecological efficiency of the systems and their long-term design as a whole. The description of the Swiss platform on smart cities is used as a basis (www.smartcity-schweiz.ch), according to which a smart city can be described as one in which

- **New technologies** in the areas of infrastructure, buildings, mobility, etc. are intelligently networked across systems in order to use resources such as energy efficiently and reduce their consumption.
- **New forms of mobility** and their infrastructural requirements for networked services are anticipated, developed and realized.
- Create **space for innovation** and testing of new ideas, behaviors, and solutions.
- **Integrated (urban) planning processes**, such as interlocking mobility concepts with the possibilities and requirements of new technologies.

The **new technologies** also include all improvements around real-time navigation, which is already frequently applied in various forms in individual traffic, but often falls short of the real traffic situation, because a linking of different information sources does not take place sufficiently.

Analysis and evaluation of multidimensional smart city approaches using the example of smart housing

Good approaches can be found in structural urban areas that are organizationally under one leadership, because the partial interests that are otherwise often found stand in the way of an overarching solution.

This explains, among other things, why the city state of Singapore, with its clear decision-making structure, is planning a comprehensive introduction of autonomous vehicles for public transport as well as for freight transport, which extends, for example, for the flow of goods from the port to destinations in the city. In a comparable decision-making situation in Europe, the divided responsibilities with no overarching decision-making institution would take significantly longer to arrive at a Singapore-analog approach.

For this reason, multidimensional solutions always have a good chance of integrative implementation and development if suitable "uniform decision-making structures" for relevant smart city components exist or are established.

Disruptive changes, but also significant change processes, have always been characterized by the fact that it is impossible to estimate what may result from them. What and how results from the **interplay of supply and demand**.

- **Supply**: From a smart city perspective, specific new offers arise that are only made possible by digitization and new technological possibilities.
- **Demand**: **Demand-specific factors**, such as the pressure for new solutions due to demographic change and the changes triggered by sustainability efforts, have an impact on the realization of these - a combination of smart living and smart mobility also offers options for new offerings.

Ultimately, either a commercially viable business model must emerge for private providers, or certain smart city solution components will be enabled through public provision.

Developments in the field of smart living encompass the interconnections shown in the *Figure 3* from smart buildings and urban planning, environment, energy and water, living space and public safety in combination with mobility. It follows virtually from the logic of Smart Living that the dimensions of planning and management, infrastructure and people must be addressed together.

Figure 3: Multidimensional smart city strategy

Source: Cf. Bholey, Mihir, 2017, p. 47

A brief look at smart housing considerations therefore coincides with the basic assessment of smart city challenges. For example, one Smart Housing trend is how to accommodate more people in harmony with the environment in growing cities with limited land. There will therefore be options, especially for low-income citizens, that can go in the direction of **compact small apartments** (*micro compact homes*) all the way to residential cubes.

The solution with **small mobile houses** is an option for metropolitan areas, as it allows permanent housing creation in dense areas.

From a smart city perspective, residential projects aimed at **multi-generational living** as an alternative to earlier large-family homes are also possible in principle without a smart solution.

Another trend is **green living in the city**. This includes facade greening and the nature-affine design of exterior walls and roof surfaces. As an effect of green buildings, energy requirements are lowered, and basic temperature regulation reduces the need for cooling air conditioning units.

From the residents' point of view, the evaluation of living in a smart city will be multidimensional, as *Figure 1* has already shown. In this context, the evaluation dimensions are partly consistent with those from the smart city dimensions, such as safety, mobility (traffic and transport), education, nature (surrounding area and nature). Differences exist, on the other hand, in other criteria – whereby the evaluation and the additional criteria have different weighting depending on the age group or become relevant in the first place. For example, the smart city dimension of health is naturally age-dependent and, due to the positive correlation between age and the need for adequate health care, is more important in the corresponding age groups than various other offerings.

Smart living must therefore always be evaluated in the context of other factors in the housing decision. The different expectations of target groups (e.g., young parents vs. singles) and age groups (e.g., students vs. seniors) leads to different prioritization of e.g.

- **Location of** the place of residence in the city: accessibility, mobility options.
- **Health and educational facilities**: Availability and equipment as well as accessibility.
- **Digitization of** the living facility and linking options with the outside world.
- **Type of dwelling**: design, living concept, sustainability components.
- **Sports and leisure facilities:** comprehensiveness and accessibility.

The list can be extended at will to match the decision criteria shown. It is striking that, except for purely digital elements (digitization of the living facility), accessibility in the sense of an integrative mobility solution is essential for the evaluation result. This shows the strong link between smart living and smart mobility. Even in the case of the type of dwelling with the living concept, the mobility solution may play an important role.

Customer expectations often have a bipolar effect on smart city requirements. For example, the idea of an environmentally friendly, car-free city is difficult to combine with the demand for attractive living in rural areas – which inevitably leads to commuter flows into the city.

Economically interesting is in particular the urban planning objective for the linkage and accessibility of the city's offers for the residents in the different neighborhoods. If it is not possible to ensure a public transport solution at low cost at all times, then there will always have to be individual mobility, unless one wants to accept the economic consequences.

If stores can no longer be reached by customers, there will no longer be any sales in stationary retail. If non-stationary retail can be an adequate substitute, which is not possible in the catering and leisure sectors, for example, then the total number of deliveries to the front door increases. Alternatively, volume bundling can be done in close proximity per household - with the conditions of multi-temperature zone storage and delivery that may need to be met. The design of the handover is a challenge for Smart Living, provided that one wants to avoid a concierge area with a corresponding serviced intermediate storage structure.

There remains the need for the logistical connection of the "non-digitizable services" of a city's offer, which must be solved directly by Smart Mobility solutions.

From an economic perspective, it is important to consider that the abandonment of stationary solutions is usually accompanied by the loss of tax revenues and also makes jobs obsolete, which in turn affects tax revenues and the range of jobs in the surrounding area.

Smart living often relies on app-controlled solution components. In addition to many advantages, these also offer disadvantages, as will be briefly shown below.

Figure 4: Movement profiles through voluntary user statements (here: location sharing when taking photos) Example of movement profiles

Source: Tagesspiegel (o. J.): https://www.tagesspiegel.de/images/tagesspiegel/25657320/2-format43.jpg (retrieved on February 15, 2022)

When not deactivated, large-scale motion profiles are created. An example of the data randomly passed on to third parties by apps that store movement profiles can be condensed is shown in *Figure 4* on the city map of Berlin. From the perspective of urban planning, the data obtained within the terrain is also suitable for avoiding bottlenecks, adjusting capacities, or identifying unattractive areas (without users). This information is already being used by campus universities, for example. However, some universities go further in terms of surveillance-related solutions: for example, Curtin University, Western Australia has installed 1,600 cameras with facial recognition under the official premise of improving student satisfaction and learning. The optimization components that are named echo those of other university examples. It turns out that universities also run the risk of gaining as much information as possible.

Consolidation of smart city components under the assurance of smart mobility

The social discussion regarding modern requirements for mobility has recently often been reduced to a focus on e-mobility and the use of bicycles. The latter is also used by some interest groups not only to represent the legitimate interests of users, but at the same time to slow down, limit or exclude individual vehicle traffic from city centers.

From the EU's perspective, the aim is not to prevent individual transport, but to achieve low-emission mobility (EU, 2016:2). It can be argued here that more emissions are required for the production of the sum of individual vehicles than for shared solutions, as these would be required in significantly lower total numbers.

In principle, a conceptual solution composed purely of public mobility is conceivable if this is politically desired. However, practicability is only given if the justified interests of the majority of the population with regard to mobility are duly taken into account in such a concept.

This is precisely where action is currently needed, as the desire to promote environmentally friendly mobility options is often equated with the need to make supposedly environmentally unfriendly solutions more difficult. This approach falls far short of the goal of a transportation turnaround and can only lead to a deterioration in mobility.

The goal must be to comprehensively incorporate the smart city components into a strategy whose goal can also be a change in transportation. To this end, the expanding mobility options and offers should be made available to citizens in such a way that they are "bundled in a provider-neutral, integrated and cross-modal way" (Perform, 2017:13).

When analyzing large-scale mobility options, the following items should be covered in the minimum version of the transportation transformation strategies:

- environmentally friendly solutions must be accessible to the population;
- the mobility solution must be a realistic option to meet the mobility need;
- a real environmental effect must be given;
- the mobility solution must be in line with the importance of cities and metropolitan areas for their catchment area and the functions covered by them.

If individual transport is to be avoided, then there are various possibilities for alternatives:

a) there is a comprehensive network of stops of the public transport;
b) car sharing and pooling options are available (possibly in networks with a wide-meshed network, or in the case of terminating networks in peripheral areas);
c) bicycles and e-scooters are supplementary to a) and b) or available as a substitute for a);
d) additionally: already well before the city, individual traffic is diverted to public transport by park&ride and similar solutions.

Whoever takes a closer look at the first three points a) to c) recognizes them as obstacles in reality on the way to a consistent strategy. Except in the central network areas of (large) cities and metropolitan areas, the network is never comprehensive in the sense that it allows citizens of all ages to get from a starting point (source) to a destination (sink) in an acceptable amount of time.

The first starting point here is the **sum and locations of the stopping points**: Due to demographic change, there are increasing proportions in the populations of all EU countries whose personal mobility is limited. The possibility to walk to and from stops, as they were planned in the past, is often not given. Another detail is accessibility, but this is not discussed further here.

If there are enough stops, the question of **frequency of their operation** remains. Almost everyone knows from experience stops that are insufficiently frequented. This may be because, as a stop in an industrial area, they are only served at peak times, or the timetable is concentrated on schoolchildren. In both cases, the utilization of the line can be too low when offering a better frequency: only where a sufficient **utilization of the vehicles** is guaranteed is their use worthwhile.

There are various levers for this, which will be considered later. It goes without saying that a consistent mobility strategy must be adjusted.

There is no comprehensive network for local public transport that is so busy in all areas that it offers an adequate environmentally friendly service for all mobility needs. For the evaluation of a strategy, it is therefore of interest to record how many mobility requirements on the part of the population are covered by the targeted solution. A further component of the quality of this strategy should be how many additional alternative routes that can actually be used are also used.

This means that the theoretical calculation for the use of, for example, a new bicycle expressway, which could include possible users for a commuter route, must not be used. It must be examined to what extent these "theoretical users", with this bicycle expressway and its integration into the mobility network, satisfy "real mobility needs" (such as the way to work, shopping in the city, visiting an exhibition in the city, visiting friends outside the city).

From the perspective of the smart city solution, a reduction in flow speed is not a solution component – rather counterproductive, because increased speeds also reduce transfer times and thus dead times from the perspective of infrastructure users and from an economic perspective.

Bottlenecks and subsequent congestion in the system can also result from speed limit 30 sections on busy roads, as vehicles build up and cause more pollution elsewhere. Whether and how the environmental effect in 30-speed sections can be quantified is debatable. Even protagonists admit that the reduction potential is difficult to quantify (Participation process for the Climate Protection Plan, 2016:225).

The sum of the factors on the mobility decision can be systematically expanded, analogously to the development of the Smart City dimensions. It is important that a realistic assessment is made on the basis of the most comprehensive considerations possible, which lead to a consistent strategy for achieving Smart Mobility.

For a large group of users of the prospective smart mobility offer, the option of **transitioning between mobility options** is particularly important. By identifying the current constraints, the reverse conclusion is that there is potential for expanding the user group or the frequency of use. With regard to the mobility network, this results in a wealth of adjusting screws for network densification and fundamental network attractiveness.

For all those whose mobility needs cannot be met by public transport or cycling, the only remaining solution is an individualized one.

This also includes the mobility option b) **Car sharing and pooling**. Car sharing is based on the individualized private use of a vehicle that is made available at suitable delivery points and is suitable for mostly short-term mobility needs. For longer-term use over several hours, classic car rentals are usually less expensive, but often have a location disadvantage if the delivery option is not available.

An important component of the attractiveness of car sharing from a mobility perspective is its availability in short spatial proximity. Limiting factors for the number of users are

- Choice of vehicles at the sites is limited:
  usually only one or a few vehicles are available, and the models that dominate the network are often designed for short distances and small transport volumes.
- Short-term transport problems may not be realized due to the limited availability:
  The application focus is on planned trips, provided that spatial mobility in receiving (picking up) the vehicles is not given.
- Network is too wide meshed:
  the accessibility of the sites for many users is "more difficult" as a result, which can also have an effect on the *free-floating solution,* since not all sites are used equally.
- Usage costs are too high:
  Expensive for longer distances or longer periods of time.
- Total time is extended by handover process:
  Parking facility at destination must be available.

The last point in particular also contradicts the closure of roads to individual traffic.

Shared rides are more attractive the greater the overlap in the distance traveled by individual passengers. In addition, there are the two variants of the modified shared cab, in which a permanent or full-time driver operates a vehicle on an all-day/shift basis, or without it is a modified form of ridesharing, in which the provider is a private individual who picks up one or more people on their planned trip on a route-by-route basis.

From the shared ride, there is a smooth transition to public transport in terms of the size of the flow – and the same is true of the problems in the reliability of shared transport connections. The public transport service should be the cheapest alternative due to the economies of scale – but in practice, as shown repeatedly, it is not always. In order to operate a network permanently, not only the most lucrative (or best-utilized) route sections can be offered.

The context of supply costs, cost recovery and attractiveness is taken up in the following example: Public transport in Germany, for example, is financed to around one third by ticket prices (user-financed approach). With total costs of €27 billion, this corresponds to "only" €9 billion (Bormann, 2010:197). In almost all cities, there is a lack of attractive services.

There is disagreement on the accompanying measures, for which, for example, the participation process on climate protection calls for „simultaneous push measures" to shift traffic (Participation process on climate protection plan, 2016:200). From a smart city perspective, it must be ensured that, since the structural measures for modal shift are taken in advance. This includes the financing issues to be clarified, the investment and infrastructure measures, the interconnection strategy with digital network performance, etc. that are required for smart mobility. To already dismantle existing solutions at the same time contradicts the idea of increasing attractiveness and has a negative impact on the economic performance and attractiveness of metropolitan areas.

Private transport is a component of transport performance in the EU. Road transport accounts for a total of 80% of all EU greenhouse gas emissions from the transport sector. With a share of 25% of all emissions for mobility, this still corresponds to 20% of all relevant EU emissions.

A subset of these emissions is again parking search traffic, which is factually concentrated in highly frequented locations in metropolitan areas and central points. The economic and ecological consequences are significant (APCOA, 2013):

- More than 30% of inner-city traffic is caused by Parking search traffic.
- One third of German drivers are looking for parking spaces in city centers. Looking for a parking space. The resulting distance per city district corresponds to 14 circumnavigations of the earth.
- On average, a car driver needs ten minutes to find a to find a parking space.
- When searching for a parking space, the driver covers 4.5 kilometers.
- On average, vehicles are parked 23 hours a day.
- 1.3 kilograms of CO_2 are emitted on average per car during the search for a parking space are emitted per car.

The extent to which emissions are directly related to gasoline consumption is not the subject of this paper, but the economic impacts caused by congestion and slow-moving traffic, which are often directly related to commuter flows, will be shown with some examples (Keh, 2013):

- **Germany:** 14 billion liters of fuel are consumed annually in traffic congestion and slow-moving traffic (equivalent to 17% of total

German consumption and resulting in additional CO_2 emissions of approx. 35 Million t).

- **USA:** On average, every driver spends around 54 hours a year in traffic jams. In Los Angeles, the figure is 167 hours (Tomtom Traffic Index, 2020).
- **Germany:** The economy loses around 100 billion euros a year due to traffic jams. For example, the annual congestion time during rush hour in Frankfurt am Main is 121 hours (Tomtom Traffic Index, 2020).
- **UK**: 2 billion euros lost annually in economic output due to congestion-related delays in London alone. The congestion time in London is equivalent to 149 hours per annum.

A pure conversion to electric mobility does not solve the gross emission problem of e-vehicles[3] in the overall ecological balance and ignores the economic dimension.

The advantage of considering the entire life cycle is also where the EU comes in, tying e-mobility as a possible component in alternative transport technology – especially in urban areas – to meeting certain conditions (Niestadt–Bjørnåvold, 2019:6):

- Electric vehicles produce fewer emissions throughout their life cycle, from manufacture to operation and disposal.
- That the energy used to manufacture these e-vehicles is at least partially generated from renewable energy.
- Service life, vehicle size and disposal/reuse of the construction components (especially the battery).

Only the criterion of using renewable energies seems to be fulfilled in 2020. E-vehicles are currently not in a dominant position in terms of meeting the environmental criteria.

[3] Currently, the main advantage is only in the use phase of the e-vehicles.

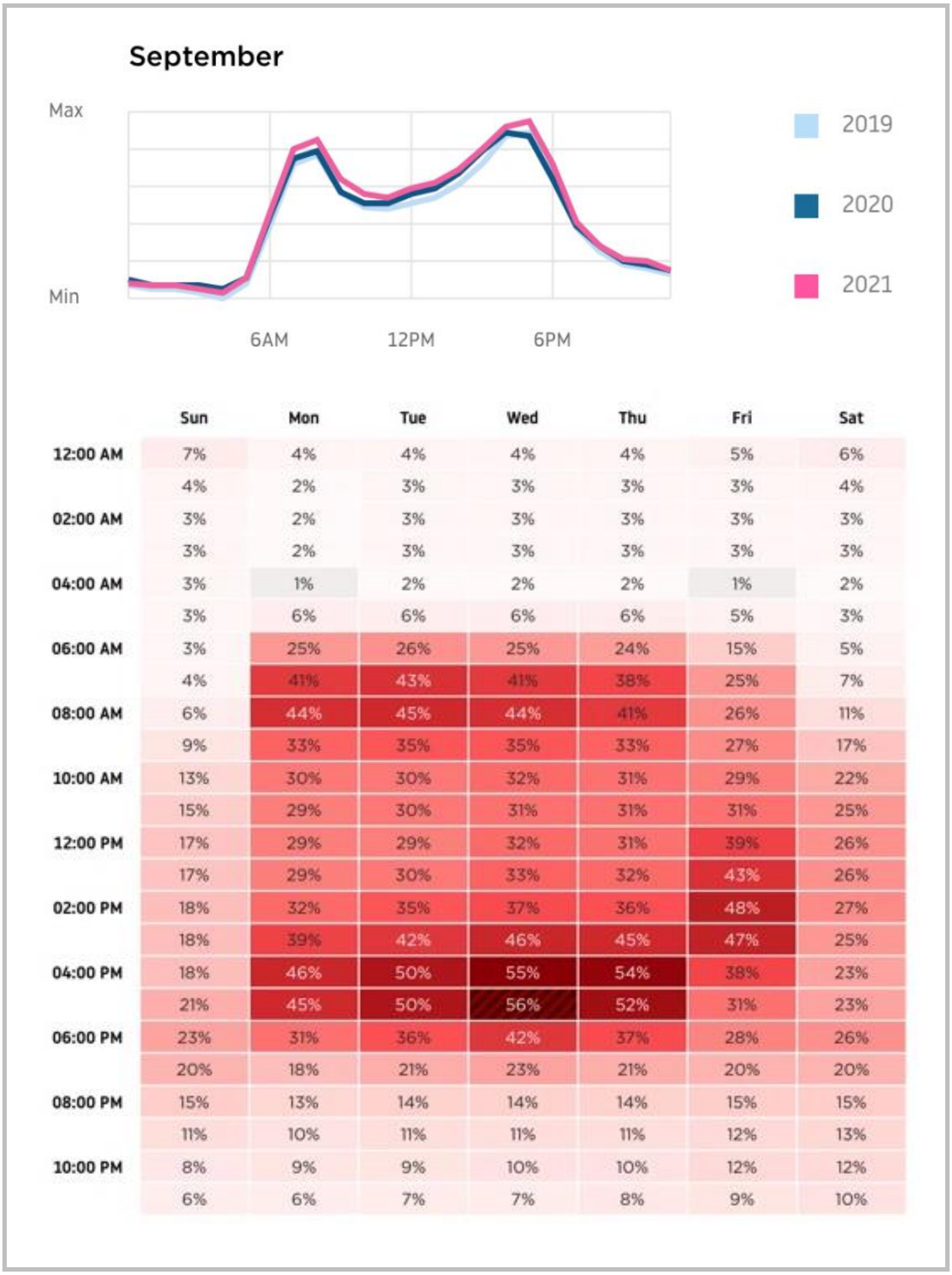

Figure 5: Monthly and weekly traffic congestion (City of Vienna, Austria)

Source: Tomtom Traffic Index (2022)

Every congestion situation underscores the existing range problem of e-vehicles. If one considers the frequently existing congestion profile in metropolitan areas, then the demand for continuity of traffic flow as a smart mobility criterion is also essential for e-vehicles. The congestion profile of Vienna is to be used as an example for the problem in relation to commuter flows (see *Figure 5*). The percentages show the delay compared to an ideal typical travel time.

Congestion situations have a limiting effect on market penetration for long commuting distances and tours, as the presence and duration of the charging process are critical. From the vehicle driver's perspective, a significant risk remains that the available charging points are either occupied at the time of arrival, the charging process is insufficient in time for an adequate range, or the charging point is occupied by non-electric vehicles. This is precisely where the smart use of nodes in mobility networks comes in, where the transition from one mode of transport to the next is simplified and the infrastructure is provided, e.g., for charging e-vehicles, without creating unreliability for the majority of users.

An international research group with the participation of the University of Sopron has been working on the topic of smart city mobility since 2018.

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Székely Csaba 1947-ben született Sopronban. Középiskolai tanulmányait a soproni Széchenyi István Gimnáziumban végezte. A Gödöllői Agrártudományi Egyetemen végzett tanulmányokat, ahol 1969-ben mezőgazdasági mérnöki diplomát szerzett. 1970 januárjában a gödöllői egyetem Mezőgazdaságtudományi Karának Üzemtani Tanszékére került tanársegédnek. 1971-ben a bonni Friedrich Wilhelm Egyetemen folytatott üzemgazdasági tanulmányokat. 1974-ben egyetemi doktorátust szerezett, és adjunktusnak nevezték ki. 1977-ben a giesseni Justus-Liebig Egyetemen végzett kutatómunkát az operációkutatási módszerek területén. Kandidátusi disszertációját 1980 januárjában védte meg.

1980-tól négy éven át mezőgazdasági attaséként dolgozott Bonnban. 1984 októberében egyetemi docensként tért vissza a Gödöllői Agrártudományi Egyetemre. 1985-ben megbízást kapott az Üzemtani Tanszék vezetésére, és ezt a feladatot 20 éven keresztül látta el. 1989-ben egyetemi tanárrá nevezték ki. 1987-ben megalakult az egyetem Gazdaság- és Társadalomtudományi Kara, ahol kezdetben dékánhelyettesként, majd 1990-től két cikluson keresztül dékánként tevékenykedett. A kar munkájának szervezése mellett jelentős szerepet töltött be a PhD képzés megalapozásában, és a tudományos továbbképzésben is.

1996-ban a GATE rektorává választották. A három éves vezetési ciklus alatt feladata elsősorban az akkori időszakban zajló egyetemi integrációs folyamatok Gödöllő számára kedvező alakítása, befolyásolása volt. A partnerekkel közösen végzett munkát siker koronázta, mert az Országgyűlés 1999 márciusában jóváhagyta a Szent István Egyetem megalakulását, Gödöllő székhellyel. Rektori tevékenysége a ciklus lezárásával, 1999. június 30-án fejeződött be.

2000-től nagyobb energiát fordított a kutatási feladatokra, több kutatási programot indított el. Az 1992-ben általa létrehozott Józsefmajori Kísérleti és Tangazdaság fejlesztését tovább folytatta, és az elméleti kutatási eredmények gyakorlatban való megvalósítására törekedett, amelynek alapján elkészítette MTA doktori értekezését. A disszertációt 2005 júniusában védte meg.

2003-tól egyre nagyobb időráfordítással vett részt szülővárosában, Sopronban a Nyugat-magyarországi Egyetem Közgazdaságtudományi Karának oktató munkájában. 2005 márciusában egyetemi tanárrá nevezték ki Sopronban is. 2005 szeptemberében a NYME Közgazdaságtudományi Karán dékánná választották, amely mellett egy ideig a Szent István Egyetem Gazdaság- és Társadalomtudományi Karán is folytatta egyetemi oktatói tevékenységét. Két dékáni ciklus lezárása után 2017-ig a Széchenyi István Gazdálkodási és Szervezéstudományok Doktori Iskola vezetőjeként, illetőleg egyetemi tanárként tevékenykedett. Jelenleg professor emeritus, és aktívan közreműködik a doktori iskola munkájában. 2009 óta tölti be Gazdálkodás folyóirat szerkesztőbizottságának elnöki tisztjét, és ugyanezen évtől fogva a Gazdaság és Társadalom folyóirat főszerkesztője. 2010-ben az FM Agrárgazdasági Tanácsa elnökévé választották, amely feladatot 2017-ig látta el.

Munkásságáért Szent-Györgyi Albert díjat, Pro re Rustica Promovenda kitüntetést, illetőleg Nagyváthy János díjat adományoztak számára. A Giesseni Justus Liebig Egyetem és a Szent István Egyetem honoris causa doktora. A felsőoktatás fejlesztéséért 2014-ben Magyar Érdemérem Tiszti Keresztje kitüntetést kapott. 2019-től a Kismartoni Főiskola tiszteletbeli professzora.