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A First Step Towards a "Smart City Brain" for Sustainable Development – Turning the Experiences of Two Cities into Replicable Processes

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Abstract

In this paper, we compare two projects from the cities of Basel and Shenzhen, which are transforming – or in the case of Shenzhen already has – their public transportation from fossil-fuelled to electric vehicles (EVs) only. In so doing, we derive two different processes that could be reused as templates for many other cities in both Switzerland, China or elsewhere. Moreover, to address the far-end goal of actually reaching Sustainable Development Goals (SDGs) within cities, we propose the vision of a sharable platform as a Smart City Brain for Sustainable Development that will allow the collection of data from individual projects, share them within a community and create re-usable visualisations of important KPIs and other indicators. We also extend the existing concept of technological connectivity to include product material data as well in order to support circularity.

1 Introduction

In 2007, humanity passed a milestone threshold. For the first time in human history the amount of people living in urban, as opposed to rural, areas exceeded 50% (Kourtit, Nijkamp, Arribas, 2012) and this number is going to continue to increase in the near future. As a consequence, global cities, out of necessity, have to compete with each other for the best talent by focusing on offering creativeness, innovation and entrepreneurship. In short, municipal leaders need to make their cities more alluring to prospective citizens by being more “livable” than their other urban competitors.

Some of the common attributes of livable cities are the cost and the quality of living, the lack of pollution and efficient resource allocation. Cities are, after all, dynamic systems (Lnenicka et al., 2022) that undergo transformation and adjustments, depending on the grade of innovation capability and willingness to reinvent. As technology has seeped into and begun to dominate virtually every aspect of human life, cities too are also using Information and Communication Technology (ICT) and the Internet of Things (IoT) to improve their efficiency and thereby their liveability to encourage increased citizen participation.

At the same time, there are pressing challenges that are confronting humanity with arguably the most urgent ones being climate change and pollution. Thankfully, when applied at the systemic level, the circular economy can help mitigate both of these two primary challenges. For this reason, some smart cities are now using technology to redirect material flows such as waste and increase the participation of its citizens in the city’s processes. When applied at a pragmatic level, there are also many diverse and innovative activities and projects on the way which will enable cities to achieve the globally shared sustainable development goals SDG's which are nothing short of a paramount universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by the year 2030.

Thus, to explore this urgent issue, this paper will compare, as mentioned, two cities on two divergent continents - Basel in Switzerland and Shenzhen in China. At first glance they may seem to have very little in common. Indeed, some authors even suggest, that Chinese practices cannot be applied to European realities because they have been framed by different problems (Avdiushchenko, Zajac, 2019). Yet, while this argument may appear valid, especially when considering the inequalities within China, our focus is not on the underdeveloped regions of China but rather on one of its urban megacities and the nation’s first Special Economic Zone (SEZ) - the City of Shenzhen. Indeed, to illustrate that the comparative study of these two cities is worthy the fact is that they both have a comparable ratio of their respective populations to their countries’ total population. In addition, both cities are the economic engines for their respective countries' economies. Moreover, both are using technology to address their country’s environmental challenges and to tackle the urgent issue of managing urban waste and other material flows.

Therefore, based on the experiences of these two cities, this paper offers a vision of how these cities’ individual project initiatives can be used for replicable processes for other urban areas. We visualise these with the help of standardised Business Process Modelling Notations (BPMN) that can stipulate the transition from individual projects to replicable processes to generate the necessary impact on a global scale. BPMN serves as a standard notation to design and optimise business processes with the help of well-known Key Performance Indicators (KPIs) (Jüngling et al., 2021). Furthermore, we propose a blueprint for a “Smart City Brain” from a bottom-up process perspective, by using the Konstanz Information Miner (KNIME) analytics platform (n.d.) as a pragmatic platform to collect and visualise the necessary insights and KPIs from the different processes, to be able to envision trends and share them via the KNIME community hub (n.d.). The paper is organised as follows: in the first part, we examine the administrative or governmental framework followed by illustrating the transition to electric vehicles. Then, in the second section, we look at the processes required to add circularity to the smart-city equation.

1.1 Governance, Rules and Regulations Triggering SDGs

Within the interconnectedness of smart cities and the transition to circularity, the underlying administrative framework plays a crucial role. This can be at the federal or central government level, provincial or municipal level. In Switzerland, governance is divided up by the federal government, the cantons and the municipalities or communities. The cantons, as well as the communities, have a significant degree of autonomy with respect to many topics including those related to SDGs. Furthermore, as a direct democracy, the Swiss people have the possibility to vote on laws and constitutional amendments at the federal, cantonal, and municipal levels through the use of specific referendums and initiatives. As a consequence, many long-term processes are initiated by a populist, groundswell political push that can trigger significant transition processes such as the recent voting in the canton Basel, with a metro population of just over half-a-million, declaring a binding goal for the city of Basel, with a population of 175,000 citizens (Wikipedia, n.d.), to make its public transportation system CO2 neutral by 2037. This mandate is actually three years earlier than the target set by the Swiss Federal Government.

Meanwhile, on the other side of the world, there is Shenzhen, a megacity of 17 million people, located in the southern Chinese province of Guangdong. Shenzhen's growth from a small fishing village to a megacity occurred in only 40 years soon after it was declared the very first Special Economic Zone (SEZ) in China in May 1980. This special role attracted investment to Shenzhen, especially from Hong Kong, as these two cities share a border. These investments created opportunities that have since been attracting millions of people to Shenzhen from other parts of China, be it to work in the construction industry for less-educated workers or, for those with a higher education, for careers in one of now many thousands of technology companies. To illustrate its rapid growth in numbers, the city's GDP rose from 0.2 billion RMB in 1979 to 3.24 trillion RMB (US$475 billion) in 2022 (China Daily, 2023). As a SEZ, Shenzhen also enjoys a privileged status within China and has been a testing area for a variety of innovative, far-sighted projects. For example, the Chinese Central Government, a participant in the 2030 Agenda of United Nations, has, as a consequence, established sustainable development as a high priority in its national strategy (Xu et al. 2022).

1.2 The Benefit of Smart Cities

Due to accelerating urbanisation, cities are facing a variety of challenges, as the increase in population requires a higher priority to be placed on resource input and output. Cities are also very complex systems and can be defined as "...an interconnected set of elements that is coherently organised in a way that achieves something" (Meadows, 2008). As Nogueira et al. (2020) state, in cities, social, ecological, and technical systems are deeply intertwined since the parts of one distinct subsystem belong to, and can dynamically affect, the others. To manage these challenges, one solution is the Smart City which integrates its buildings, healthcare services, education, public mobility services, living and environmental aspects, etc., with help of ICT and IoT. It is important to emphasise that a Smart City is a multidisciplinary concept that embodies not only its ICT and IoT infrastructure but also its capacity to manage information and resources to improve the quality of lives of its people. The use of information technology has been considered as a key factor that defines the smartness of a city since it can sense, monitor, control and communicate most of the city's services like transport, electricity, environment control, crime control, social, emergencies and other aspects. (Ramaprasad et al., 2017).

Taking a look at city's transport system, the first generation of solutions focused on design, infrastructure preparedness and construction. The following step was to find a way to reduce resulting traffic congestions, as well as, carbon emissions pollution and to also enhance smart mobility, fuel efficiency, accessibility and safety (Pamučar et al., 2022). Now, as a third step, some smart cities are using electric vehicles as a primary policy strategy tool to finally reduce carbon emissions generated from Internal Combustion Engines (ICEs). We will now turn our focus to specifically how Basel and Shenzhen are managing this significant move to electric vehicles.

2 Transition to Electric Vehicles

Due to its potential to reduce greenhouse gas emissions, if supported by an infrastructure fed by renewable energy, the transition to electric vehicles (EVs) has become a major priority for global governments in the US, Europe and in China. This transition also contributes to efforts to reduce their reliance on imported oil and create new jobs opportunities and business models for the maintenance of EVs and the related infrastructure in the country's urban areas. Different frameworks and regulations, such as the Inflation Reduction Act (2022) in the USA, have created financial incentives for this transition to clean transportation. One of China's approaches to decarbonise its transport system is to offer strategic investments for certain industries or to create SEZs for prototypical implementations. This brings us to some comparative insights into the transition to EVs with the relevant stakeholders currently active in Basel, as well as, the processes of Shenzhen, which has already reached its EV goals in 2019.

2.1 The Public Transportation System in Basel

The city of Basel has a well-developed public transportation infrastructure, which started with trams transversing the city as early as 1895. The operator, called Basler Verkehrs-Betriebe (BVB), has continuously developed the infrastructure and currently has a network of more than 180km which serve more than 300,000 daily passengers. In 2020, BVB started a project for a step-by-step replacement of existing buses with 126 new e-buses by 2027. Naturally, such a transition includes several stakeholders

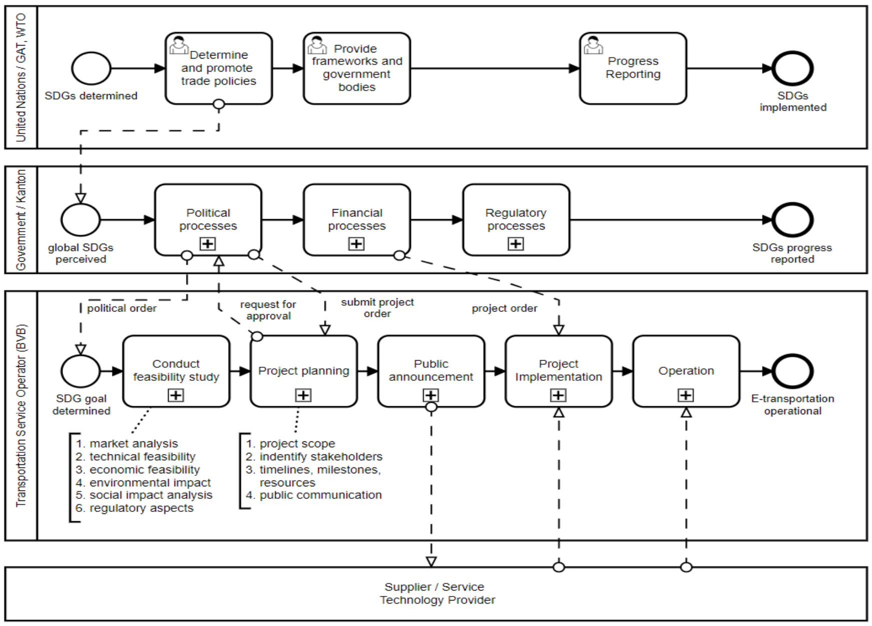

Figure 1: Transition to e-vehicles in Basel

and the process needs to be not only integrated into the global framework of international guidelines but also aligned with the political and governmental authorities of Basel. The city is initiating and sponsoring the transition that is aligned with the goal that Basel should be CO2 neutral by 2027. Figure 1 shows the process of this transition with many different stakeholders and actors involved.

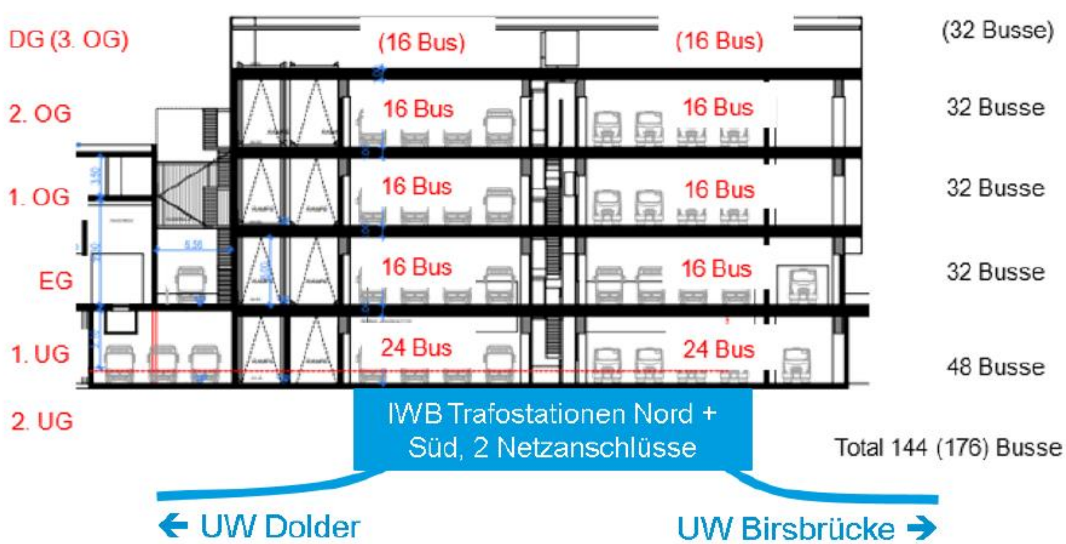

Figure 2: Planned layout of the new building for e-busses with charging infrastructure

As seen in Figure 1, there is some dependency between the canton and BVB through the financial processes where BVB gets orders from canton Basel for the city of Basel which in turn is dependent on these political processes and heavily influenced by the Swiss direct democracy. Moreover, the project has to deal with several other challenges, such as including urban planning requirements for solutions for garages and parking places with appropriate charging infrastructure. These include investment from the local energy provider IWB (Industrielle Werke Basel), the third-party use of buildings, cost inflation and the replacement of legacy systems. To illustrate, Figure 2 shows the planned construction of the new garage rank by BVB.

Overall, the transition to e-buses is the first initiative of its kind and will contribute an annual reduction of 10,000 tons of CO2 equivalents per year in Switzerland. The project can also serve as a template for the transition within other cities according to the report of the Swiss Federal Council (Der Bundesrat, 2021).

2.2 Electrification of Shenzhen’s Infrastructure

As China’s first SEZ, Shenzhen was specifically mandated to begin experimenting with market-based innovations and has, hence, been under less political domination compared to other pilot cities in China. This has led to more openness towards entrepreneurship and business innovation (Li et al., 2015.). However, the Shenzhen miracle of economic development and its resulting offer of jobs has resulted in more than few challenges. For example, the new emerging middle class has been purchasing more and more vehicles as their standard of living has continued to rise. This has led to more road congestion and increased air pollution.

The transition to electric transportation is not exclusively a Shenzhen story. New Energy Vehicles (NEVs) were put into China’s National Key Science and Technology Industrialisation Projects in its 9th Five-Year Planning (FYP) period, lasting from 1996 to 2000. Then, Shenzhen was only part of a larger plan from the central government, going back all the way to 2001, when the government set a budget of US$140 million for EV technologies research and development. Results of that initiative were demonstrated for the first time at the Beijing Summer Olympics in 2008 with 50 EVs and the Shanghai World Expo in 2010 with 120 EVSs. The next national step was a project called “Thousands of Vehicles, Tens of Cities (TVTC)”, which is considered today as the EV move from the laboratory stage to market deployment. These city-based pilots focused on the use of EVs in public transport. (Li et al., 2016). However, despite other cities being involved in the programme, Shenzhen has distinguished itself because it has been, by far, the most successful city in the implementation of EVs with EV totals of 19,000 public buses, 24,000 taxis and approximately 63,000 private ride-hailing vehicles registered in the city as of 2022 (smartcitiesworld.net, 2023, energypartnership.cn, 2023).

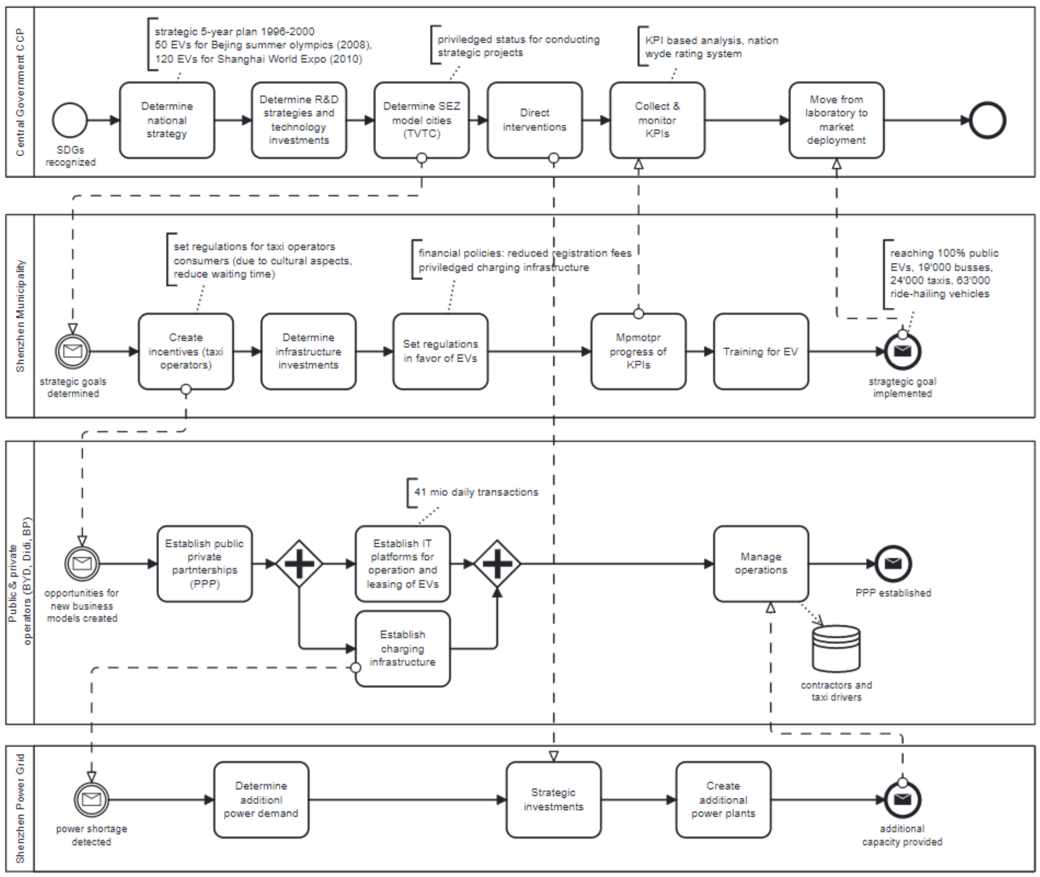

Figure 3: Transition to e-vehicles in Shenzhen, Special Economic Zone in Guangdong, China

Favourable policies and financial support has helped the development of Shenzhen not only as one of the key cities in the sales of New Energy Vehicles (NEVs) but also the city has become the major production hub of these vehicles with BYD Motor Company as one of the largest producers. This has also helped Shenzhen earn much credit in the development of smart and low-carbon cities in China. (Li et al., 2015). However, the transition to NEV also has some downsides, especially considering that most of electricity in China is still generated with fossil fuels. In addition, drought and short supply shortages of renewable energy prompted the government to quadruple the number of new coal plant permits and approve new capacities in 2022. The amount of these new coal power plants is equivalent to all the U.K.'s plants combined (Caixin Global, 27 February 2023).

Just like ICE vehicles rely on a network of gas stations, EVs also require a separate infrastructure. In the case of Shenzhen, this network includes the China Southern Grid Corporation (CSG) which owns Shenzhen Power Supplier Bureau (PBS) as the transmission operator, BYD as the largest EV manufacturer, plus Wuzhoulong Motors buses, as well as, Shenzhen Bus Group as the provider of the majority of bus services for citizens in Shenzhen. Additionally, a state-owned enterprise Potevio Ltd., a Chinese telecommunications hardware manufacturing company, also belongs to the network. Its portfolio includes information and communication technology (ICT) product manufacturing, trade, related-technology research and services. As a licensed operator for EV charging infrastructure, its role was to build charging stations across the city and put them into operation. For e-buses, Potevio is involved in EV purchasing, battery leasing and the charging services. This significant investment required Potevio to get the strong backing in form of subsidies from the central and the municipal governments to ensure a strong financing capability. With this backing, Potevio has a privileged position with banks and can buy cars from the local manufacturers and, in turn, lease these EV bodies and batteries to the Shenzhen Bus Group (Li et al, 2016).

In case of e-taxis, the situation is a little different. The Shenzhen Bus Group and BYD established Shenzhen Pengcheng Ltd. as a new e-taxi fleet operator in 2010. Despite initial losses, the company has now become profitable. Their main task is buying EV bodies and batteries, providing charging services for the e-taxi fleet and renting out taxis to drivers (Li et al, 2016). As this overview illustrates, making the transition from fossil-fuel vehicles to electric ones requires a coordinated effort from across the public sector. According to Steinhilber et al. (2013), six principal instruments are responsible for the transition to a NEV system: 1) regulation and governance, 2) infrastructure investments, 3) R&D incentives, 4) technology, 5) business models and 6) consumer incentives.

However, from the perspective of circular economy principles, two elements are important: longevity and circularity. Longevity, as the name implies, means the length of time a product is used and circularity means the number of times a product is used and re-used (Figge et al., 2018). At this point, electric vehicles do not meet either of these criteria as only a gradual circularity of the cars and their batteries is possible at the moment. Regarding longevity, current estimates put the electric vehicles on par with fossil fuel ones, at only 15-20 years. As these products are basically computers on four wheels, as the first author observed during her four years working in Shenzhen, it remains to be seen if these mass-market EV models can reach this lifespan. The omnipresent ride-hailing Didi vehicles in Shenzhen don’t give a favourable longevity impression. As Alcayaga et al. (2019) state, “...advances in information technologies shorten product lifetimes, generating substantial electronic waste each year.” Looking forward, it is paramount that this same fate does not happen with the manufacturing of electric vehicles.

The success of the local EV producer BYD has brought more competition to the electric car market. Even the just mentioned ride-hailing platform Didi Chuxing is entering the NEVs production race together with state-owned BAIC. In 2019, DiDi even announced a joint venture with BP to build EV charging infrastructure (China Daily, 2 August 2019). However, due to DiDi’s fallout with the Chinese government over its IPO, no new data is currently available. Didi and other ride-hailing companies are also part of the city transport infrastructure as these highly-individualised, convenient trips are affordable and very popular among the city’s middle-class citizens. According to the website “That’s Shenzhen”, Didi has one of the biggest customer platforms in China, covering 493 million annual active riders and 41 million average daily transactions. The exact number of Didi cars is not presently available but in 2021, the company had over 15 million drivers worldwide (Reuters, 2021). The biggest bulk of these would be in China’s cities. In 2020, the company announced that 1 million robotaxis or driver-less vehicles will be available on its platform by 2030 (Reuters, 2020). To understand the significance of ride-hailing EVs and their impact resource usage, it is important to note that Didi is not the only ride-hailing platform in China.

In addition to taxis and buses, Shenzhen enjoys an extensive underground network with the Shenzhen Metro covering 547.42 kilometres with 16 lines, connecting the city’s geographic width of 81.4 kilometres from east to west (Wikipedia, 2023). This metro is supported by local trains that connect districts with major rail hubs, like, for example, from the Pingshan District with Shenzhen North Station. Due to our focus on electric vehicles, this point won’t be explored further in this paper despite its significant role in urban transport. Instead, the paper will continue to consider the circular economy from the standpoint that the production and the use of automobiles has a significant impact on waste and indeed how cities can actually become more liveable.

3 Smart Cities and the Circular Economy

Cities have been identified as a key enabler of the circular economy because, due to ever-increasing urbanisation, material inflows and outflows are correspondingly increasing. According to the International Resource Panel (2018), material consumption in cities will rise to 90 billion tonnes by 2050. In 2010, that number was only at 40 million tonnes and even then we were not able to deal with that amount in an efficient manner. Per definition, the circular economy decouples economic growth from the use of virgin materials. Thus, increased circularity will help cities manage its material flows. Within the circular economy, technical materials are kept in circulation for as long as possible while biodegradable materials biodegrade in nature. Its principles are also based on renewable energy and elimination of toxins (Ellen MacArthur Foundation, 2013). However, we believe that infrastructure is one of the key enablers of circularity (Kierans, Chen, 2022) because only when the required infrastructure is built, can production materials actually flow back to be used again. This begs the question of financing infrastructure changes which a publicly traded company like BYD, for example, might not want to finance. This, private-public partnerships can be very successful and something similar is likely required for any smart or circular city to effectively control its material flows.

As there are a plenitude of material flows within a city like Shenzhen or Basel, the focus of this paper is exclusively on electric vehicles within the city infrastructure. This focus is justified by how the following statistics reveal the significance of vehicles on our urban landscape. In the 10 year-period period 2005-2015, the amount of all cars on the road in China rose by an unprecedented, staggering 415%. Meanwhile in Europe, that growth remained constant at 20%, in United States 11% and globally 44%. In sheer total numbers, the number of vehicles increased in that decade from 0.89 billion to 1.28 billion globally. Around 1.83-1.97 billion vehicle units are expected on the roads by 2030, with China's global share at 20-22% (Salles Martins et al., 2021). As of 2017, there were only 3 million electric vehicles in the global stock, but this is expected to grow to 125 million by 2030, and 530 million by 2040 (Thomson et al., 2020).

As Shenzhen illustrates, a megacity can transition its infrastructure to electric vehicles. In the process, however, resources are used and, at the moment, not entirely considered. For example, assuming that by 2040 electric vehicles achieve a market penetration of 50%, approximately 200 kt of lithium-ion batteries will reach the end of life from an automotive perspective (Thomson et al., 2020). This does not include buses and taxis in Shenzhen, which adds even more lithium-ion batteries to the waste pile. Nor does it consider the amount of metal, plastics, rubber, and textile materials that are also used in a production of thousands of taxis, ride-hailing cars and busses.

These predictions ought to reveal the urgency for the transition to the circular economy. One of the considerations ought to be the increased need for electric energy, which is, as mentioned, still mostly generated from non-renewable sources. In China, the share of coal to the power grid power amounts to 44.8% (Salles Martins et al., 2021) and this proportion is showing no signs of abating as China continues, again as mentioned, to approve new coal plants.

Another circular concern to take into account is the commodity market. The world's major exporter of cobalt, which is primarily used to produce electronics, is Democratic Republic of Congo (DRC) with 69.9% of global reserves and 51.1% of world production. (cobaltinstitute.org, 2023). Yet, details about human rights abuse and environmental issues in the DRC have been widely reported. Overall, 98% of all the cobalt that is mined is as a by-product as it does not have its own ore and depends on copper and nickel mining.

Hence, considering the social and the resource depletion impact of this commodity, it makes no sense to simply throw these materials away at the end of the products' lifecycle, not to mention the financial considerations of dumping such a valuable resource. According to Salles Martins et al. (2021), one battery pack for an automobile is composed of US$1,764 of cobalt, US$1,433 of nickel, US$1,005 of lithium carbonate, and US$536 of graphite. As Thompson et al. (2020) states, the decarbonisation of transportation has clear environmental benefits. Clearly a systemic approach needs to be urgently developed for managing electric motors and batteries. With more and more new disruptive products and innovations with large growth potential coming to the market, these products can rapidly become an ominous environmental issue if circular economy principles have not been designed into the product.

As the Masiero et al., 2016 paper illustrates, different electric vehicle producers are working on different battery solutions. However, these efforts rarely consider circularity in the design phase process. "Design for circularity" should be required as the first step at the conceptual level in order to avoid material losses at the end of the products' lifecycle. As we have seen, an illustration is the enormous change that can take place when a city decides to electrify its infrastructure.

4 Towards a Smart City Brain for the Circular Economy

This paper is, in part, titled "The First Step Towards a "Smart City Brain" for Sustainable Development" to which we now turn our focus. According to ChatGPT: "A smart city brain that enables the circular economy could be a centralised platform that utilises data and technology to manage resources and waste in a closed-loop system. It could use sensors and other technologies to track the flow of resources, waste, and energy in real-time, allowing for efficient and sustainable management. This brain could also use machine learning and artificial intelligence to optimise resource allocation, minimise waste, and predict future needs. Additionally, it could also facilitate collaboration and coordination among stakeholders, such as government agencies, businesses, and residents, to ensure the implementation of circular economy practices throughout the city."

For example, Estermann et al., 2018 are proposing and conceptualising a National Data Infrastructure (NDI). As a result of their literature review, they suggest approaching NDI from four different complementary perspectives, namely Open Data, Big Data, Base Registers and My Data. However, they also mentioned the potential difficulties and a lot of political considerations when advancing the cause of an NDI.

Nevertheless, they answer their research question about the nature of key building blocks of an NDI to not be a monolithic block, nor confined to a single country alone, but to be built upon a distributed architecture which can be inter-connected at an international level. About the way it should be organised, there was a general agreement between all the interview partners that following a step-by-step implementation process and combining bottom-up and top-down elements would be the most likely way to succeed.

BPM Lifecycle	General Outcomes	E-Vehicles	Circular Economy	Diffusion of Innovation
Process Identification	process architecture	regulatory frameworks	redesign for circularity	*prior conditions (problems/needs)*
Process Discovery	as-is-model	case-studies	problem categoization	knowledge
Process Analysis	Insights into weaknesses and their impact	generalization and reuse	defect patterns (time-lag)	persuasion
Process Redesign	to-be-process model	impact analysis	solution design patterns	decision
Process Implementation	executable process model	infrastructure changes	reverse logistics (storage)	implementation
Process Monitoring	conformance and performance insights	environmental KPIs	business KPIs	confirmation

Table 1: Turning innovation experience into replicable processes – drawing analogies

Similar to the process of establishing e-buses in the city of Basel, there were political as well as operational aspects involved in the EV-based implementation of the transportation system. Similarly, in Shenzhen, processes and overall strategies were driven by the central government. The processes in Figure 1 and Figure 3 provide insights into these two different transition projects, with the different activities from the major stakeholders in Switzerland and China. What can be learned from these two cases? What can be generalised, and what could be helpful for other cities to pursue a similar path? Table 1 visualises some of the ideas and a proposed solution approach which is part of the vision of this paper and which comes from the discipline of Business Process Management (BPM) within organisations.

Turing projects into reproducible processes is central to the core idea of this paper. As such, one could try to make analogies between the different application domains and aim toward transferring the best practices from BPM into the best practices of Smart City construction, such as described in the Smart City Transformation Framework (SCTF) from Kumar (2020), which provides help for policy makers, government officials or service providers involved in transitions.

The framework is structured into a planning phase, physical infrastructure development, ICT infrastructure, deploying smart solutions and providing valuable insights through a mind-map that describes the Smart City. But the BPM approach with different life cycles from process identification up to process monitoring, and the expected outcomes of each of these phases, describes an organisation in much more detail. There are even standardised frameworks such as the process classification framework from APQC, which provides templates in organisations, that is even much more structured. BPM and optimisation, including lean manufacturing, is well established and provides optimised template processes which are implemented in Enterprise Resource Planning (ERP) systems. However, the processes of how cities could optimally achieve the transition to EVs or implement circular economy principles are not available.

There are already valuable data and KPIs related to SDG at a country level where country comparisons for mutual learning are already possible. According to this data (SDG Indicators Database, n.d.), the mean annual population-weighted average mean concentration of fine suspended particles of less than 2.5 microns in diameter (PM2.5) in China in 2019 was 38.5 micrograms per cubic metre and in Switzerland 10.2 for the same time period. Both values are one of the measured KPIs for SDG11 (sustainable cities and communities) and are above the maximum level for safety set by WHO of 10 micrograms/m^3. For SDG12 (responsible consumption and production), the domestic material consumption in China increased from 9.5 metric tons per capita in 2000 to 22.9 metric tons per capita in 2019, while it decreased from 10.0 metric tons per capita in 2000 to 8.9 metric tons per capita in 2019 in Switzerland.

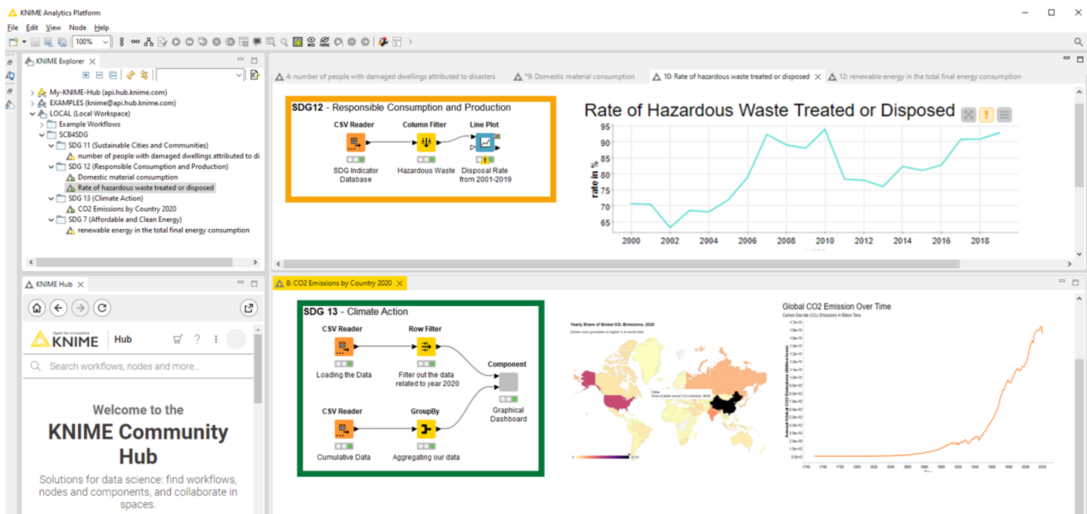

Figure 4: Preview of a SCB4SDGs sharing platform with workflows for SDG12 and SDG13

With the help of the KNIME analytics platform (n.d.), shared workflows can be created, as shown in Figure 4. The upper right sub-window points out the rate of hazardous waste treated or disposed in China, which increased from 70.7% in 2000 to 92.8% in 2019. In the lower right hand sub-window, the workflow "CO2 Emissions by Country 2020" was downloaded from the KNIME Community Hub (n.d.) and can be embedded into local workspaces.

However, the most telling data for our vision and thus also the second part of our paper's title "Turning the Experiences of Two Cities into Replicable Processes", is the aggregated data for the SDG country profiles. The intention is to create a Smart City Brain for individual cities' SDGs, where the different stakeholders and organisations could share their data that can be aggregated into standardised SDGs in order to create the necessary KPIs for the proposed control phase.

These local KPIs could create more incentives since local changes can create local insights. And, when local progress can be monitored and also create more positive feedback loops, passive participants in a "powerless" global society could be turned into active, local contributors for SDGs. The workflows of the cities could then be shared in a community hub and then be duplicated to turn local city-insights into sharable, replicable resources for many other urban communities.

5 Outlook and Conclusion

In this paper, we have used the transition in the cities Basel and Shenzhen and their EV initiatives towards a Smart City model to compare their approaches and extract their respective learnings. The goal is to extract the "Smart City Brain", a replicable model that can be used by other cities around the world as their blueprint and, depending on their local conditions adjusted accordingly. We compared two cities that, from a geographical point of view, are on the different side of the world, in Switzerland and China. However, they share common ground as Shenzhen has already transitioned to an electric transport infrastructure and Basel is in the process of making this change. We argued that the lessons from their transitions can also be used to implement the circular economy because electrification of the infrastructure does require a large amount of virgin raw materials. If these EV vehicles are actually redesigned for circularity, they can be returned to original producers and reused for future products. As a result, cities would inevitably face less waste and pollution, increase the quality of living for its citizens and save invaluable virgin resources.

6 Limitations and Future Recommendations

As the paper title indicates, this is a first step towards a Smart City Brain with a goal of identifying commonalities that can make future transitions easier. We focused on the electrification of the city infrastructure because Shenzhen has more experience and Basel can learn from it, as can eventually other cities. It remains to be explored, in future papers, how a redesign for circularity will impact the material and information flows of a smart city.

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