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Smart solutions for climate mitigation – risks, potentials and strategies

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Content

Introduction

The “**smart city”** is a vision and concept for cities of the future. Guided by this broader image, municipalities in the Baltics and Germany are increasingly developing and piloting, and eventually aim to scale up smart solutions. These solutions seek to modernize, transform and connect existing technical and social infrastructure, and related services as well as improve local governance mechanisms. Objectives vary, but often focus on the quality and well-being of individuals and communities, protecting the climate and environment, and promoting the local economy.

A core intended outcome of smart solutions is **efficiency gains**, particularly in the mobility and energy sectors[1]. Efficiency is a sustainability strategy that aims to minimize resource use per product / service. In the mobility sector, efficiency gains are intended to be generated through solutions such as shared mobility (e.g. car- and bike-sharing), vehicle automation and intelligent traffic management systems (Seebauer 2018: 311; Ghosh 2020: 2; Pakusch et.al 2018: 1-2; Mohammadian 2020: 1; Pangbourne 2018: 1-2; Taibet et. al 2018: 765-796). In the energy sector, efficiency gains are hoped to be reached through e.g. smart grids, vehicle-to-grid charging stations enabled by mobile payment systems, energy monitoring and evaluation via “gamification”, urban energy saving sensors such as lamp posts, and system and control units to integrate renewable energies into grids (Bidar et.al 2011: 4927; Strengers 2013: 173; European Commission 2014; Lane et.al 2008: 1).

However, research on the climate effects of digital solutions indicates that **rebound effects** and **burden shifting** may counter these efficiency gains, when not addressed. Rebound effects refer to “a behavioural change that partly or completely offsets expected savings from technological improvements or other measures that seek to lower energy use or GHG emissions” (Walnum et.al 2014: 9511). An example is energy consumption – if energy

[1] Other objectives are e.g. set up more inclusive public services and to support the local economy.

efficiency gains lead to lower energy prices they may induce further energy demand. If the efficiency gains are not only compensated but lead to higher energy demand or emissions the effect is called “backfire”.

Increased efficiency can also be compensated trough growing consumption, using the efficiency savings: examples are the purchase of more powerful (and potentially more energy-intensive) digital technologies, increased bandwidth (from 2G to 5G over a period of ca. 10 years), more devices (from single computer to laptop-smartphone-smartwatch combo) and increased mobility (from wired devices to completely wireless ecosystems).

Burden shifting involves “the transfer of environmental impacts between environmental compartments or supply chain stages, which may happen when pushing for resource efficiency” (Corrado et.al 2017: 56). An example are sensors used in smart solutions – while they may lead to climate benefits in the use phase of a smart solution, the sensors need to be produced and the production is associated with climate pressure; thus the climate burden shifts from the use phase to the production phase. The production of the digital devices such as smartphones and computers is responsible for a large share of the emissions from the digital service sector.

Currently, these risks are **rarely explicitly discussed** in connection with smart solutions, as attention rests primarily on their positive aspects for climate protection. As a result, stakeholders responsible for designing and managing smart solutions are often not aware of these risks. In this policy guideline, we argue that municipalities can address potential risks in all phases of a smart solution, building on existing municipal processes – from planning, procurement and implementation, to monitoring and evaluation. One core aspect is systematic monitoring and evaluation, as it helps understanding the effects.

This guideline intends to:

- Provide a brief introduction to rebound effects and burden shifting in the context of smart solutions as well as municipal strategies to mitigate these (chapter 1)
- Highlight Baltic and German experience in monitoring and evaluation as one core strategy to address risks (chapter 2)

1 Background on Rebound Effects, Burden Shifting and Municipal Strategies

1.1 Rebound effects

Figure 1: Examples of Rebound Effects in Smart Cities

Source: Studio Grafico, Marina Piselli.

In recent years, the challenge of rebound effects became a core focus of efficiency and climate mitigation policies and strategies. In general, there are **three different types of rebound effects** – direct, indirect, and economy-wide effects (Gossart 2015: 435-445; Pakusch 2018: 3; Seebauer 2018: 312; Sorrell et.al 2007: 637; Viviano et.al 2018: 4). **Direct** rebound effects occur when products or services become less costly due to efficiency gains and as a result of this price change, individual consumption increases (Sorrell 2007: V). For example, smart mobility solutions such as autonomous driving, an increase in electric vehicle use and MaaS services may increase the overall efficiency of transport, as energy and cars are more efficiently used. However, this could lead to higher annual distances travelled when the relative price per km decreases and consumption of these services increases. **Indirect** rebound effects occur when individual cost savings from efficiency gains are used for consuming other goods and services. The consumption of these goods and services causes higher energy and resource demand. For example, net-cost savings in terms of money and time freed up by smart city-related services could lead to increased consumption in other activities, e.g. flights. **Economy-wide rebound effects** refer to the aggregate of direct and indirect rebound effects.

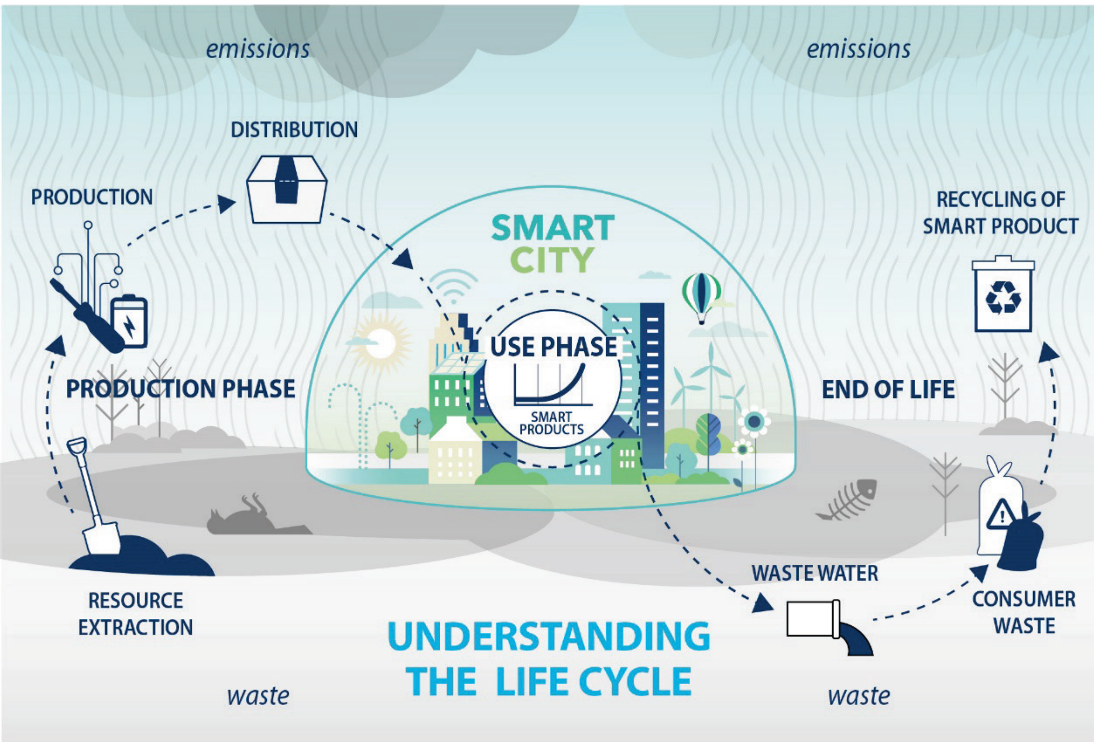
In municipalities, these rebound effects may occur in all smart city projects that aim to increase the efficiency of a product or service. These include e.g. the transport sector and individual mobility, the energy sector (buildings, districts, and city-wide energy system), waste management and water supply.

Rebound effects are **primarily caused** by economic and psychological factors (Semmling et al. 2016: 7 – 8). Economic factors relate to the purchasing costs of a service or product; if these costs are lower due to efficiency measures, incentives for additional purchase may arise. Psychological factors comprise of e.g. the consumer perception of costs of services or products – more efficient cars might appear to generate a larger than actual usage cost reduction when consumers neglect the purchasing costs.

There are different **strategies** to counter rebound effects (Semmling et al. 2016; European Commission DG ENV 2011: 98-100; Craglia et.al 2019: 1093). One strategy is fiscal and combines efficiency measures with a tax on resource or energy consumption, which roughly equals the saved costs (Semmling et al. 2016: 22). An example is the introduction of a tax on petroleum that increases with efficiency gains. A related approach is to implement a “bonus-malus scheme”, where “tax proceeds” are used to incentivize for more sustainable choices through rebates and subsidies. A second strategy is to establish a cap-and-trade-system, which establishes resource use budgets. The consumers or producers receive certificates for resource use and can trade certificates. When budgets are exceeded, consumers or producers have to acquire additional certificates. This reduces the incentives for transgressing the budget. A third strategy focuses on communicating, informing consumers about their individual resource consumption (e.g. energy consumption), the impact of their behaviour and lifestyle on resource use and ways to address rebound effects.

1.2 Burden shifting

Figure 2: Understanding the Life Cycle of a Product or Service



Source: Studio Grafico, Marina Piselli.

“Burden shifting” is best understood in relation to the **life cycle** of a product or service. The life cycle comprises all stages of a product or service: from resource extraction of necessary materials, to its production, usage and disposal or recycling. In all these life cycle phases, inputs flow from the environment to the product or service to ensure its functioning. For example, energy is used in all phases to extract, produce, use and discard. At the same time, outputs flow to the environment. For example, emissions occur in the production or through the energy input such as CO_2-emissions. These inputs and outputs are pressures on the environment, which eventually impact its current state. All life cycle phases need to be considered to understand the full environmental pressure emanating from a product or service.

When introducing an innovation such as a new technology, **burdens may shift** between life cycle phases in comparison to the previous technology. This means that, while a new product or service causes less environmental burdens in its use phase compared to its previous form, these gains might be countered by increased burdens in the production and end-of-life phase. For example, an electric bus decreases the environmental impact in the city through reduced emissions to the air, but the environmental impact of production and end-of-life-phase might be equal or higher than for a bus running on petrol. These shifts are often less visible as the description of innovations often focuses primarily on the use phase of a product / service. Another example would be a shifting from one environmental impact, i.e. greenhouse gas emissions, to another one, i.e. biodiversity loss.

In the context of **smart city initiatives**, burden shifting can occur when smart solutions are implemented that reduce the environmental impact within the city. However, the production and recycling of necessary components for the smart solution can cause environmental burdens elsewhere. In this case the overall environmental impact might not be reduced but just “shifted” outside the city. Smart solutions might also contribute to a reduction of carbon emissions, but requiring minerals that might increase the pressure on biodiversity.

One study **investigated and modelled the implementation of smart city solutions** in Copenhagen. The solutions were Greywater Recycling (GRe), Green Roofs (GRo), Smart Windows (SWi), Sensorized Waste Collection (SWC), Pneumatic Waste Collection (PWC), Smart Water Meters (SWM) and Smart Energy Grid (SEG). The main finding was that only SEG could reduce the environmental burden of Copenhagen significantly. All other solutions have limited positive results or even negative overall results (Ipsen et.al 2018: 12). This is due to the fact that the analysed solutions shift “the direct impacts from the urban system to embedded impacts”, which means that the impacts occur outside of the city at the production or recycling stage (Ipsen et.al 2018: 14).

1.3 Municipal strategies

Municipalities that are implementing smart city projects can **mitigate these risks**. A precondition for mitigation is that the city is actively steering the smart city development process and aligns it with climate mitigation and environmental protection. The fact that rebound effects and burden shifting might occur needs to be considered and evaluated in all stages of the smart city development. In order to curb these effects, smart city solutions need to be accompanied by further measures such as price incentives or changes in the physical infrastructure.

On the **strategic and institutional level**, municipalities can integrate risk mitigation in smart city strategies, priorities, related targets and indicators. Furthermore, municipalities may in addition to efficiency measures include other sustainability strategies, such as sufficiency that aims at reducing overall demand. Often a combination of efficiency and sufficiency might help to curb rebound and burden shifting effects.

On the **project implementation level** risk mitigation should be integrated in all project phases of a smart solution – from planning to procurement, monitoring and evaluation as well as communication, upscaling and replication.

In the *planning phase*, the potential of rebound effects or burden shifting should be considered and investigated. If potential effects are identified those should be addressed by additional measures accompanying the implementation of a smart solution.

In the *procurement phase*, the effects of smart technologies in the production and end-of-life phase need to be evaluated. In order to minimize negative effects on the environment the technology with the least impacts should be selected. However, it should be also considered if the implementation is reducing overall environmental effects. If this is not the case, a cancelation of the project needs to be considered.

Monitoring and evaluation of smart city projects is one of the most important measures in order to collect the data for further investigations. Therefore, in the monitoring and evaluation phase, not only the direct effects in the city should be investigated, but also environmental impacts in the production and end-of-life phase should be included for a complete picture. The data collected can inform research on rebound effects and burden shifting, which is currently still limited due to a lack of available data.

In the *communication and replication* phase, not only success factors should be collected and disseminated, but also learnings in regard to potentially occurred negative effects. These conclusions can be considered in future projects and, thereby, minimize the potential that rebound effects or burden shifting is replicated in those projects.

In conclusion, urban planners, city councils and private firms that aim to reduce the environmental impacts in and through cities with smart solutions need to consider the possibility that rebound effects and burden shifting occur. In case that possible rebound effects or burden shifting are identified in the planning stage, the implementation of a smart city project should be accompanied by measures to mitigate those effects. When implemented, smart city projects should be monitored and evaluated in order to quickly identify occurring rebound effects and mitigate those through additional measures.

2 Baltic Experience on Monitoring and Evaluation

2.1 SmartEnCity in Tartu

2.1.1 Smart Zero CO2 cities

"A Smart Zero CO2 City is a resource efficient urban environment where carbon footprint is nearly eliminated, energy demand is kept to a minimum through the use of demand control technologies that save energy and promote raised awareness; energy supply is entirely renewable and clean; and resources are intelligently managed by aware and efficient citizens, as well as both public and private stakeholders."[2]

The smart Zero CO2 City concept was developed as a central element of the theoretical work under the SmartEnCity *lighthouse* project[3]. The need for this concept did arise from the practical interventions in building refurbishment and mobility to give a context for the direction the city is moving when redesigning its services. The concept focuses on the climate impact of the smart city; it can therefore be used for developing smart services for climate neutral cities. Two of the original *lighthouse* cities within SmartEnCity (Sønderborg, DN and Tartu, EE) are aiming to reduce the climate impact of public services in the near future to zero, following the Smart Zero CO2 concept. To achieve the concept's ambition, the *lighthouse* city Tartu focused on building retrofitting (see Figure 3), smart mobility, and emission free public services.

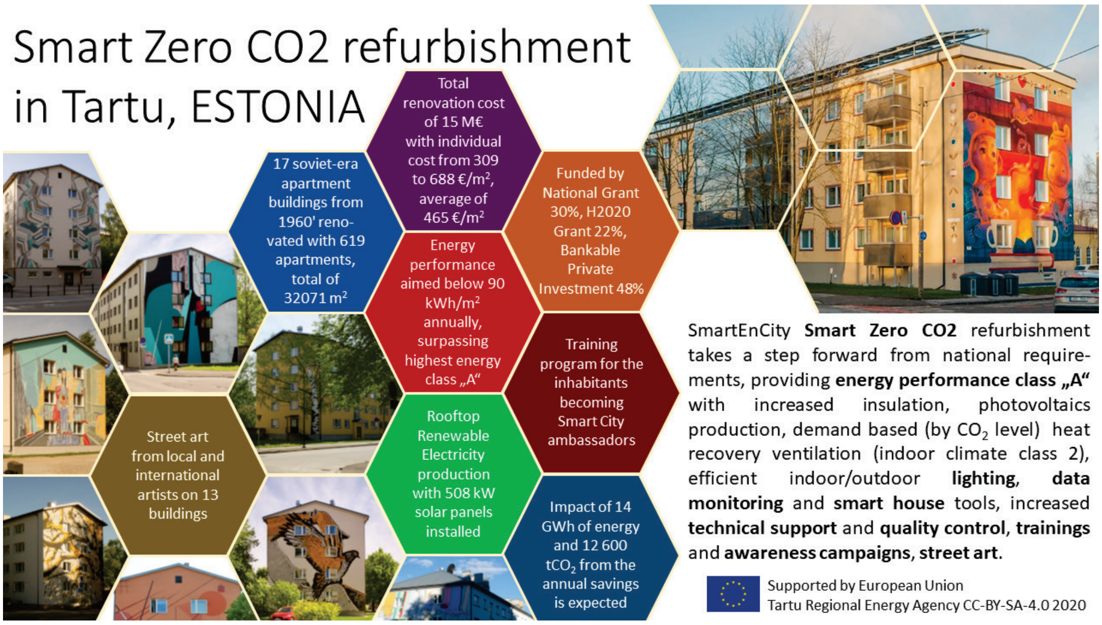
Smart city initiatives in Tartu must be understood against the background of the rapidly developing economy, as with many Central and Eastern European cities. In Tartu, climate friendly smart city development can potentially be fostered by adjusting the direction of the constant urban development initiated by the private sector and doing this can end up in the crossfire of the interest of strong private actors. Because of this, successful smart city initiatives in CEE countries are happening in the "perfect storm situation" where the interests of the administration, public actors (such as the University of Tartu and the Tartu Regional Energy Agency) and private entities are aligned. One of these examples is the building retrofitting program in Tartu (see Figure 3, also chapter 5) that created 17 fully refurbished "smartofkas" (Soviet era housing from 1960') utilizing a national refurbishment grant and at the same time providing a "motivational package" for banks and contractors.

The SmartEnCity project has condensed its experience in a Cities4ZERO methodology to support future follower cities (see e.g.: Urrutia-Aczona et al. 2019). This approach can be used as a framework for creating zero-emission cities in Europe.

[2] SmartEnCity consortium 2020 (unpublished).

[3] See: SmartEnCity project Horizon 2020 grant no. 691883. https://smartencity.eu/

Figure 3: Smart Zero CO2 building retrofitting program in Tartu, EE as part of SmartEnCity project



Source: Tartu Regional Energy Agency (2020).

2.1.2 Evaluating SmartEnCity

In Tartu, in order to enhance the climate impact of the Smart Zero CO2 City, an integrated urban plan is prepared, integrating the climate and energy goals into the urban development context. The plan is prepared using the somewhat modified Sustainable Energy and Climate Action Plan SECAP[4] methodology and will be finalized in the spring of 2021, being currently in the public consultation stage. This will be a step forward from the existing Sustainable Energy Action Plan prepared in 2015, adding climate adaptation elements and setting more ambitious goals for increasing the efficiency of energy consumption and decreasing emissions. The main goals will be the shift towards low-carbon public services and to reduce the Tartu's GHG emissions by 40% in 2030 compared to 2015.

The evaluation of the climate impact of Smart Zero CO2 City is undertaken in cooperation with the local energy agency (TREA) and is using the indicators both developed by SmartEnCity project[5] and by the European Commission. The outcomes of the evaluation are reported to EASME (under European Commission) and to the public. Additionally, the energy agency is helping the city in reporting the outcomes of the full emission inventory (see Figure 2) to the Covenant of Mayors office every four years.

[4] Guidebook 'How to develop a Sustainable Energy and Climate Action Plan (SECAP)'. Bertoldi et al, Publications Office of the European Union 2018.

[5] Deliverable 7.2: KPIs definition. Quijano et al, SmartEnCity 2018.

Figure 4: Main indicators for city emission inventories according to Covenant of Mayors

Sector		CO_2 emissions [t] / CO_2 eq. emissions [t]															
				Fossil fuels								Renewable energies					
		Electricity	Heat/cold	Natural gas	Liquid gas	Heating Oil	Diesel	Gasoline	Lignite	Coal	Other fossil fuels	Plant oil	Biofuel	Other biomass	Solar thermal	Geothermal	Total
BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES																	
Municipal buildings, equipment/facilities		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Tertiary (non municipal) buildings, equipment/facilities		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Residential buildings		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Public lighting		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Industry	Non-ETS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	ETS (not recommended)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Subtotal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TRANSPORT																	
Municipal fleet		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Public transport		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Private and commercial transport		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Subtotal		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OTHER																	
Agriculture, Forestry, Fisheries		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
OTHER NON-ENERGY RELATED																	
Waste management																	**0**
Waste water management																	**0**
Other non-energy related																	**0**
TOTAL		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Source: Covenant of Mayors & Mayors Adapt Offices, Joint Research Centre of the European Commission (2016).

The evaluation of SmartEnCity performance indicators[6] in Tartu has three scopes: refurbished buildings (quality of indoor climate and comfort as well as the energy consumption and related carbon emissions), demo area (technical, environmental, social and economic indicators) and the whole city (technical, environmental, social and economic indicators). In addition, separate evaluations focus urban mobility and citizen engagement. The evaluation is made in cooperation with knowledge partners like the energy agency (TREA) and the local university (University of Tartu) during the 3-year intervention period and during the 2-year follow-up evaluation period. The environmental impact of SmartEnCity interventions in Tartu[7] is evaluated as (bullet points directly quoted from: Hernández et al. 2017):

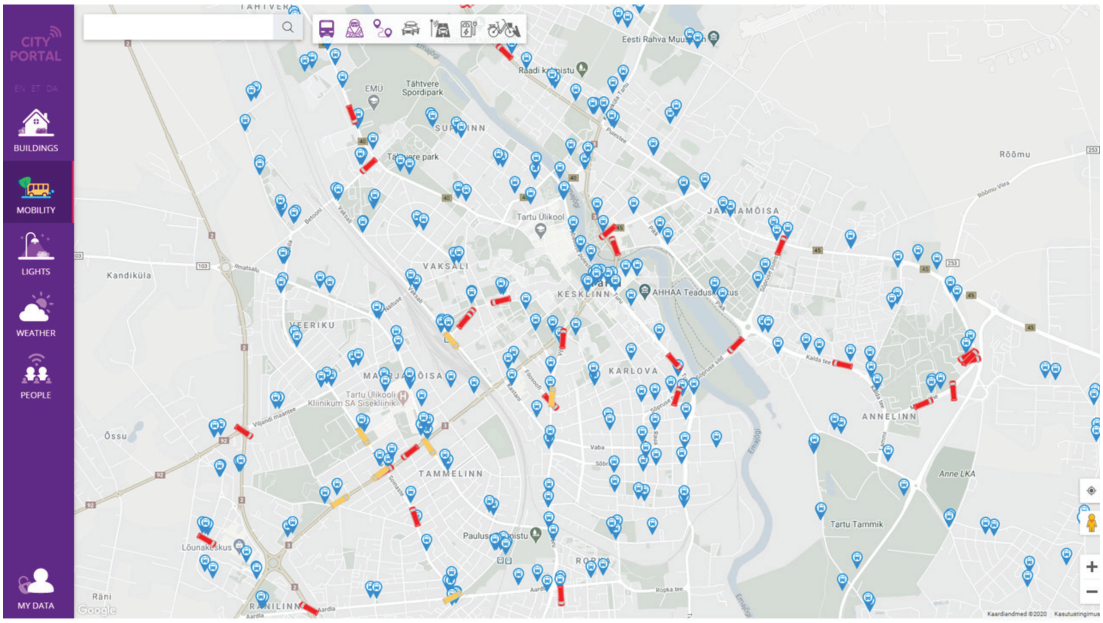
- Energy savings in the city due to district renovation;
- Lower emissions of CO_2 in the city due to district renovation;
- Lower emissions of CO_2 in the city due to sustainable mobility actions;
- Increase in the use of RES in the city due to district renovation;
- Increase the production of RES in the city due to district renovation;
- Number of dwellings/buildings retrofitted due to SmartEnCity project;
- Number of new buildings/dwellings in the city that demand a retrofitting or to include energy efficient measures;
- New sustainable vehicles (EV) in the city due to SmartEnCity project;
- New sustainable vehicles (biogas buses) in the city due to SmartEnCity project;
- Increase of the number of EV charging infrastructures in the city (only public or public & private infrastructure) due to the project;
- Increase in the use of EV charging infrastructures due to the project.

The data for the evaluation is collected and analyzed by the consortium members using existing data sets from national/municipal statistics. Additionally, a new data set from energy monitoring is created to evaluate the energy consumption and production related impact. Energy and environmental monitoring are utilized using the City Portal – a new data collection and visualization tool developed during the project (see Figure 3). The portal is collecting, analyzing and visualizing data on the energy consumption and indoor climate of the refurbished buildings, the energy production of installed PV-panels, the location and availability of city busses, vacancy of city bike lots etc. The information is accessible for all citizens. The data is aggregated in conformity with the GDPR regulations for protecting the privacy of citizens.

[6] Deliverable 7.8: Integrated Infrastructures action monitoring program. Hernández et al, SmartEnCity 2017

[7] Deliverable 7.4: City impact evaluation procedure. Quijano et al, SmartEnCity 2017

Figure 5: Tartu City Portal user interface showing realtime city bus information



Source: Tartu City Portal (2020).

The most significant outcome of smart city initiatives in Tartu has been the increasing interest for environmental innovation within the municipality, among decision makers, service providers and others. Direct outcomes include:

- The district cooling network in the city centre started in 2016 and is in development;
- A low-carbon smart bicycle sharing service (city bike) started in 2019;
- The municipality switched to low-carbon public transportation in 2020;
- 17 refurbished apartment buildings with integrated electricity production (PV) panels were finished in 2020;
- The municipality will switch to green electricity in 2021.

The smart city activities in Tartu have been coordinated by a multidisciplinary team of experts and knowledge partners – the team covers different topics such as energy efficiency, renewable energy production, mobility, urban planning, information technologies, public governance, communication etc. This wide cooperation model which also involves the service providers, technical designers and building contractors has helped to be ready for the unknown – for many uncertainties of the first large scale smart city project in Estonia.

2.2 Smart Urban Greenhouse Management in Riga

In Riga, a smart city project at the municipal enterprise “Getliņi EKO”, the largest municipal solid waste landfill of the Baltic States, has been recently implemented. It is a modern and safe waste recycling centre, recognized as one of the most innovative landfills in Europe. It features a monitoring system which intends to improve the performance of the landfill.

Energy efficiency and environmental sustainability are the main aims of the “Getliņi EKO”. Besides the traditional functions of a landfill, “Getliņi EKO” is engaged in the production of biogas from biodegradable waste. The landfill gas produced in the cells[8] is transferred to the

[8] In the landfill the waste is placed in closed capsules (cells) for biodegradation.

“Getliņi EKO” power unit, then burned in six internal combustion engines and converted into energy – electricity and heat as by-product. While the electricity is being sold to the grid, the excess heat is used to warm the urban greenhouses of the “Getliņi EKO” where more than a hectare of tomatoes, cucumbers and potted flowers are grown.

“Getliņi EKO” established the first greenhouse in the world that introduced 100% LED lighting for vegetable farming in 2017. During the first years of operation, “Getliņi EKO” concluded that they cannot optimize the overall performance if they do not properly measure, monitor, and evaluate their environmental impact. Specifically, “Getliņi EKO” realised that it was not enough to measure the temperature solely in the centre of the greenhouse with the existing central climate sensor, as such an approach does not provide all the information needed to optimize the production processes, energy efficiency and other impacts on the environment. Every degree and gram matters when it comes to optimizing the growth of vegetables and this is where reliable environmental monitoring comes in.

In order to continue to lead the way in technological innovation in the “Getliņi EKO” urban greenhouses, a smart monitoring system was set up in 2018, which aims to optimize resource use. The monitoring system includes different remote/wireless sensors that transfer the data to one dashboard/data processing centre.

Thermo sensors measure the temperature on different levels of the plants – top, middle, and bottom, as often the lower levels may have the optimal temperature while the top of the plants are overheating. Based on these measurements, the thermal energy supply and the ventilation is managed by automatic operation of windows and shading in the greenhouses.

Scale sensors are used for measuring the weight of the plants, the supply of the nutrients, the water supply and the drainage. This allows to calculate the biomass increase; also, the supply of nutrients and water to the plants can be automatically regulated.

“Getliņi EKO” implemented the smart monitoring solution in their vegetable greenhouses after realizing that the yield increase with LED lights alone did not meet the expectations. With the smart monitoring in place, “Getliņi EKO” improved their yearly yields by over 20% while the yearly thermal energy consumption was reduced by 8% on average. Other key benefits include gathering real-time data and accumulating historical data, being essential for further improvements.

2.3 The Stormwater Management in Vilnius

Sustainable stormwater management is beneficial to ensure local ecosystem stability (maintained groundwater level), protecting areas from flooding, saving groundwater and surface water from pollution (rainwater treatment), creating places for relaxation and fostering biodiversity. The collection of surface runoff water is an especially important activity in Vilnius City. A central part of the city is located in a deep and wide (~ 5 km) Neris River Valley. Furthermore, it can be classified as a territory of high precipitation by exceeding the limit of > 400 mm/year (Rural Solutions, 2015). According to Statistics Lithuania (2019), the annual precipitation rate in Vilnius City was 536 mm/year in 2019 and the average of 5 years was 651 mm/year (2015 – 2019). Comparing the national data from eight Lithuanian cities, Vilnius is at the fifth place in terms of annual precipitation rate (lowest – Varėna 489 mm/year, highest – Klaipėda 826 mm/year) (Statistics Lithuania, 2019). The experience of the last few years has shown that precipitation extremities become more intensive causing water to flush down the hills into the City center.

“Grinda” is the primary contractor in providing city utility and maintenance services. The company is owned by Vilnius city municipality. In 2017, Grinda began the project “Management Of Surface Wastewater Systems In Vilnius”. The project includes the reconstruction and building of rainwater collectors and water treatment facilities in six different locations and the inventory of Vilnius City rainwater networks (inventorisation of approximately 500 km of piping) (see interactive map – ArcGIS - Grinda PN isleistuvai). Accounting the inventory is useful for hydraulic and hydrological modelling implementation, which will allow a more accurate system capacity assessment in the city. Two specific examples for sustainable water management sub-projects are Geležinis Vilkas and T. Narbutas streets cases.

The case of Geležinis Vilkas street reconstruction is related to the reconstruction of the surface wastewater collector, the installation of management tools and monitoring systems in Geležinis Vilkas street and Šeškinė complex. Currently, stormwater from a large basin flows into a 2.0 m x 1.8 m collector and into the Neris River. However, the existing stormwater system (collector) is not capable to handle the water flow (about 30 m3/s) emerging from new developed areas. As a result of the project, one part of rainwater flow will be redistributed into a rainwater storage facility (9 m3/s) and another accumulated in the pond. These solutions will not only increase the city's capacities in stormwater management and reduce risk of floods, but also contribute to enhancement of biodiversity and recovery of ecosystems.

The main goal of T. Narbutas street reconstruction “project was to resolve the issue of accumulation of precipitation water” (SWECO, 2021). This traffic-intensive street is located in the central part of the city and has an important junction with four living districts. However, previous stormwater networks (built in 1966) were incapable to handle the amount of precipitation, which resulted in floods during rainy days and seasons. Several solutions were implemented during the project. For a reconstruction of the networks, the micro-tunnelling method was applied as a technique to install an underground pipeline through a bore created by a shield type driven machine from a starting pit (Hoang et. al, 2019). “Installation of a new surface runoff collector pipe [(technical term DN/OD1600mm)], with the re-connection of existing networks, and the construction of a modern wastewater treatment plant” were also important activities of the project (SWECO, 2021). Regarding complexity and scale, it was the largest project in Lithuania as well as the first municipal project where the methodology for building information modelling was applied. As a consequence, T. Narbutas street project was nominated as the best building information modelling project of 2019.

During the monitoring and evaluation phase of the project, Grinda cooperates with the Environmental Projects Management Agency under the Ministry of Environment of the Republic of Lithuania (EPMA). To achieve the project’s goals, employees of “Grinda” are responsible for the management of infrastructure construction processes; technical and strategic solutions are discussed in Grinda engineering work groups.

There are two main indicators for project monitoring; these are(1) the inventory of the surface wastewater sewer (in km) and (2) rainwater drainage area from which infrastructure for the treatment of collected surface water has been installed or reconstructed (ha). The control of monitoring indicators is performed by the Environmental Projects Management Agency (EPMA) according to data declared by Grinda. After the implementation of a project activity, the actual verification of the project activity on the site is performed. Several times a year, the project progress is presented to the management of EPMA and the board of Grinda. The actual monitoring results are updated and declared to EPMA every 2-3 months. Accordingly, EPMA assesses, provides comments and recommendations. It is necessary to point out that both projects are directly related to the General City Plan and Special plans of Vilnius City and provide essential solutions contributing to the implementation of these planning documents.

According to Grinda's project experience, recommendations for municipalities are:

1. Municipalities should directly cooperate with the public and private sector outside of Lithuania / their respective country in order to find the latest technological solutions and be aware of good practice. Application and implementation of good practice ensure to maximize benefit on the municipal level.

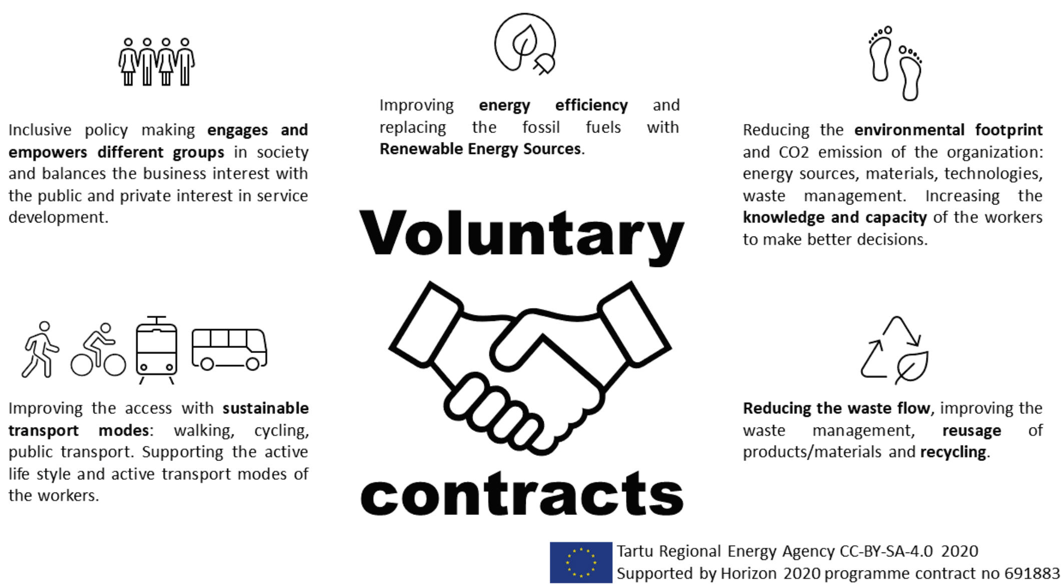
2. The city government should analyze decisions from different perspectives and set long-term strategic goals for climate change mitigation. Monitoring & evaluation of such projects, which contribute to the strategies, should be constantly undertaken to assess the achievability of the indicators set for the evaluation of the project and indicate the challenges when the indicators are not fulfilled.

3 Conclusions

Smart city technologies have a carbon impact that can add to the existing footprint of the city due the rebound effect and burden shifting, if not addressed during the implementation. Because of this, impact monitoring and evaluation are the crucial elements of smart city initiatives. Due the digital nature of many smart city interventions, monitoring can be a natural element of the smart city model, harvesting the data without interrupting the information flow and requiring separate effort. This automated data collection has many advantages but also some challenges, most importantly on providing the quality and privacy. While monitoring can be easily outsourced, the evaluation (together with the foresight and benchmarking) should be the responsibility of the public administration coordinating the smart city initiative. For example lighthouse city Tartu is using the base line inventory and emission inventory (BLI and EMI) approach suggested by Covent of Mayors as part of the Sustainable Energy (and Climate) Action Plan methodology in the framework of Smart Zero CO2 City concept. Initiatives like Cities4ZERO and similar[9] can be used for creating ambitious framework for new cities setting their goals.

Mere monitoring and evaluation may still not be sufficient for reducing the footprint of the city as the municipal services are usually not the major component of the carbon footprint. For achieving the climate neutral city a more advanced cooperation model (see the example from Tartu in Fig. 4) is required that will properly address the climate impact also in private sector. Sharing the responsibilities for climate neutrality in different partnership models is the upcoming challenge for smart city initiatives in Europe.

Figure 6: Voluntary contracts model suggested for community wide climate cooperation in the City of Tartu.



Source: Tartu Regional Energy Agency (2020).

[9] 100 Climate-Neutral Cities by 2030 - by and for the Citizens. European Commission 2020.

In large scale urban retrofitting projects, a financial rebound effect is noticeable for increasing the prizes for the renovation works and potentially for the living costs of inhabitants, making the transition unfair for more vulnerable social groups.

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