Building Cities of the Future: Siemens AG

Most of the world's population lives in urban areas. The urban population's share in the global population keeps growing and is projected to reach 68.4 % globally and up to 83 % in upper-middle-income countries by 2050 (United Nations Department of Economic and Social Affairs, 2019).

A city is a complex structure that must deliver essential services, such as electricity, water, waste management, and transportation, while also ensuring access to information networks, healthcare, environmental monitoring, and emergency services. As urban populations grow, cities must expand to meet increasing demands.

To achieve sustainable growth, cities need to manage limited resources like land, funding, and workforce efficiently. Leveraging data, tools, and innovative approaches is essential, with the concept of smart cities offering a strategic framework for addressing these challenges.

There are various vendors involved in the development and implementation of smart city solutions. This essay focuses on Siemens AG, a large technological conglomerate offering services across industries such as aerospace, automotive, and the chemical sector, which is also a key player in research and development for smart cities (Siemens AG, 2024).

This essay will explore how Siemens' smart city initiatives exemplify innovative approaches to urban challenges while addressing the associated controversies and implications of smart cities.

What Is a Smart City?

While there isn't one universally accepted definition for the term, smart cities can be described as "urban settlements that make a conscious effort to capitalize on the new Information and Communications Technology (ICT) landscape in a strategic way, seeking to achieve prosperity, effectiveness and competitiveness on multiple socio-economic levels" (Angelidou, 2014).

Smart cities capitalize on various kinds of modern technology:

- Internet of Things (IoT) integrates a network of various sensors that enable real-time data collection and analysis to optimize parking management, waste collection, lighting controls, and environmental monitoring systems (Janani *et al.*, 2021);
- Cloud and edge computing allows performing data analysis closer to the end devices, thus improving the system efficiency and reducing the response time (Gheisari, Wang and Chen, 2020);
- Big data in combination with artificial intelligence allows for processing large quantities of heterogenous data and recognizing patterns applicable for scenarios like predicting disasters (Jung *et al.*, 2020).

By employing these and other technologies, smart cities aim to improve efficiency, accessibility, and adaptability to the usage scenarios and the environmental factors. Simultaneously, they strive for sustainability and carbon neutrality.

Smart City Controversies

Smart cities by design collect, process, and store vast amounts of data including sensitive information like healthcare records or personal data tied to government services. These data can be analyzed to reveal meaningful patterns and citizens' habits and interests, which raises the privacy and security concerns that significantly impact the public perception of smart cities, diminishing their appeal and discouraging citizens' participation. Conversely, fostering a sense of safety and trust through robust privacy and security measures can encourage greater citizen involvement and active participation. By addressing these concerns effectively, smart cities can create an environment where individuals feel secure and are more likely to contribute to the community (Panahi Rizi and Hosseini Seno, 2022).

One way to approach this issue is to incorporate the protection measures in the design of the system: minimize the data intake, encrypt data when it is transferred and stored, anonymize the data, and implement security audits. Apart from that, some jurisdictions enforce the implementation of different data protection regulations, like GDPR in the European Union. Frameworks like GDPR require that end users must be informed about the data collection, its purposes, and that the data must be removed upon request ('Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (Text with EEA relevance)', 2016; Panahi Rizi and Hosseini Seno, 2022).

Furthermore, the implementation of a smart city might require deep integration of systems that manage critical infrastructure, and the sheer number of appliances and services required to manage a city effectively presents challenges, particularly regarding the expenses associated with introducing and maintaining the necessary infrastructure (Kummitha, 2018). Addressing this issue is possible by implementing a smart city according to common design principles with application of openly available standards thus allowing for replacing individual modules of the solution and preventing vendor-lock (Hernández *et al.*, 2019).

Finally, the ability of smart cities to deliver on one of their key promises — sustainability — is also questionable; some researchers find that the “smartness” of a city does not necessarily correlate with metrics such as CO2 emissions. (Yigitcanlar and Kamruzzaman, 2018). On the contrary, other researches show that introducing smart city technology can reduce the environmental pollution of a city by allowing to use data-based approach in upgrading the production lines and optimizing the resource flow in a city (Chu, Cheng and Yu, 2021). However, it might be important to include indirect energy consumption and emissions of the data centers powering the computation necessary for a smart city to function. The data centers worldwide are responsible for large amounts of greenhouse gas emissions (Lannelongue, Grealey and Inouye, 2021), which can potentially offset any benefits brought by smart cities.

Siemens AG: Case Study

Siemens AG offers services spanning from planning and conceptualization to the implementation of smart city systems and infrastructure. The company provides solutions like IoT infrastructure, energy grid automation, and smart building services to support smart city development (Siemens AG, 2023).

Designing a Smart City: the Siemens Way

Siemens recommends a project-based approach for smart city planning, emphasizing the need for preliminary research, goal setting, and understanding the city’s technological landscape and partner network. Existing solutions from other cities must be evaluated, and input from stakeholders — government officials, businesses, and residents — included to ensure the project delivers value to end users (Elbracht and Farah, 2022, p. 15).

As a smart city is a complex solution consisting of a lot of smaller components, it is suggested to prioritize them using frameworks like priority matrix and implement in waves, starting with smaller individual initiatives that can act as cornerstones for the future more complex and expensive solutions as presented in the Figure 1 (Elbracht and Farah, 2022, p. 21).

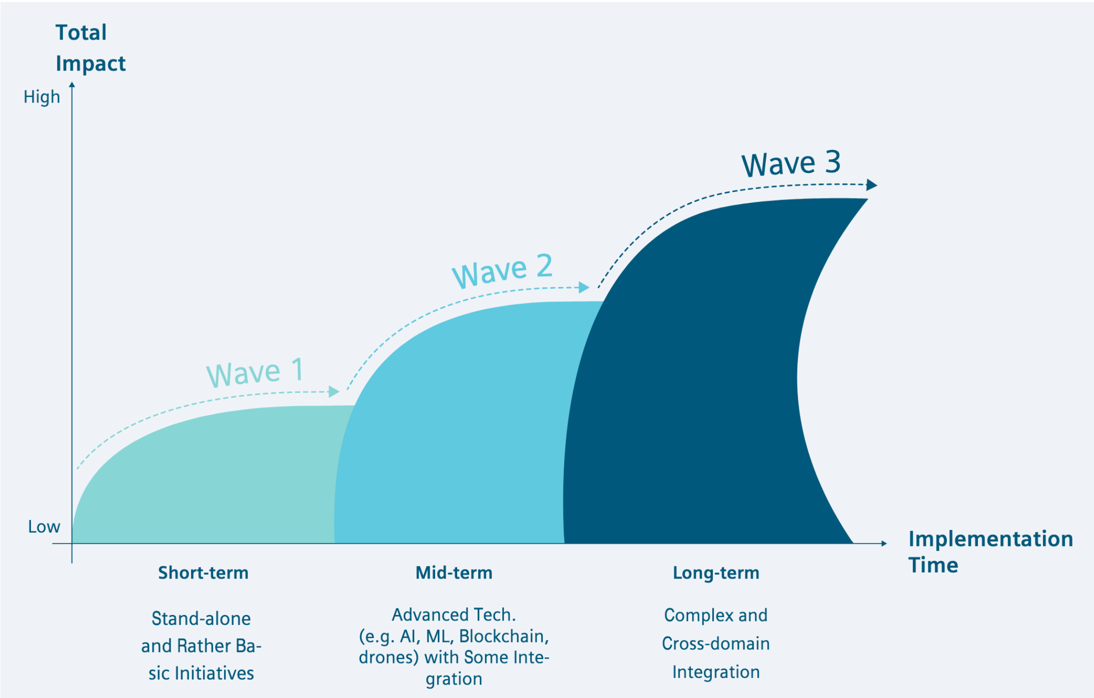

Figure 1: The execution roadmap (Elbracht and Farah, 2022, p. 21)

The agile strategy allows for reflection, adjustments of the approaches, and realignment as needed (Elbracht and Farah, 2022). This demonstrates the company's thorough approach to designing and supporting smart city solutions, as it allows for flexibility and adaptability in addressing evolving challenges, integrating stakeholder feedback, and ensuring the project remains aligned with its goals and the needs of the community.

From Blueprint to Urban Reality

Siemens does not only consult on the planning of smart city solutions, but also actively contributes to the projects such as The Red Sea Project in Saudi Arabia and is currently developing the Siemensstadt Square district in Germany. This essay will focus on yet another project: the Aspern Smart City Research (ASCR) in Austria, which serves as a model town for testing various smart city solutions and approaches.

ASCR is a project launched in 2013 by Siemens in collaboration with the city of Vienna and its municipal service providers (Aspern Smart City Research GmbH & Co KG, no date a). Figure 2 presents the diverse set of the research areas and solutions implemented as a part of the project. In its planning and implementation, the project follows on the guidelines Siemens proposes for other projects: the projects target different stakeholders and aim to understand what factors boost the adoption of the solutions.

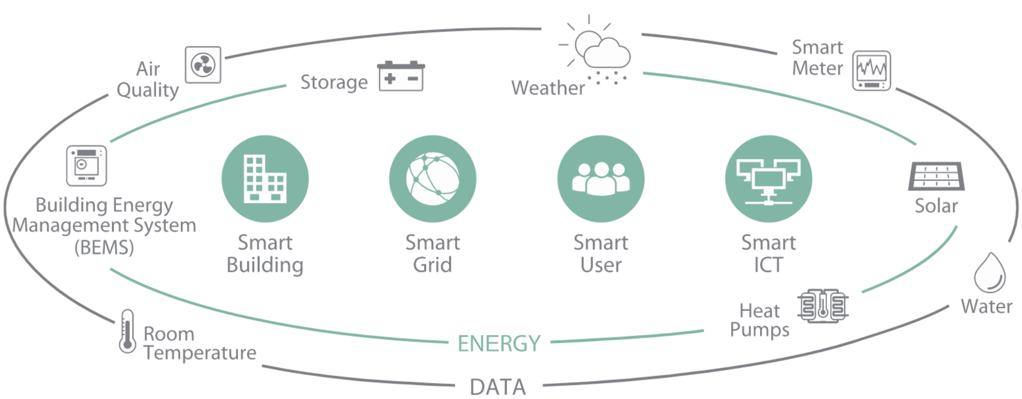

Figure 2: Overview of ASCR's research areas and their components (Aspern Smart City Research GmbH & Co KG, no date b, p. 21)

The four core research areas (Smart Building, Smart Grid, Smart User, and Smart ICT) in ASCR intersect significantly. For example, ICT solutions collect data from lower-level electrical grids near consumers, analyze it on cloud or edge platforms, and adjust grid parameters to meet demand, optimizing e-car charging to minimize grid impact. End users receive data to adjust habits and reduce energy consumption (Aspern Smart City Research GmbH & Co KG, no date b, p. 48). Data analysis from ASCR residential buildings demonstrates that these strategies reduce greenhouse gas emissions, lower reliance on external electricity providers, and cut electricity costs for users (Liedy, 2021, p. 52).

Underfloor temperature control and "Grätzl" (neighborhood) heating exemplify efforts to reduce energy use and waste. In residential buildings, temperatures were lowered by 1.5–2 ºC using underground heat storage and groundwater to dissipate excess energy. The "Grätzl" heating system repurposes excess heat from a data center to meet 70 % of the heating needs of a nearby Floridsdorf hospital, reducing CO2 emissions by approximately 4000 tons (Aspern Smart City Research GmbH & Co KG, no date b, p. 66). These projects showcase how data-driven decisions based on smart city infrastructure can enhance sustainability and mitigate the environmental impact of energy-intensive data centers.

The project's investigation into the realm of smart buildings led to the development of software solutions aimed at optimizing building maintenance and usage. By collecting extensive data on building operations and leveraging artificial intelligence to detect patterns, predictive maintenance becomes feasible, as illustrated in Figure 3. Additionally, digital twin technology enables modeling of a building's parameters under various scenarios, offering insights into energy efficiency and operational adjustments. ASCR agrees that the use of open standards is crucial for implementing Building Information Modeling (BIM) (Aspern Smart City Research GmbH & Co KG, no date b, p. 84). As already mentioned, the use of open standards facilitates easier updates and integration of new technologies, and prevents vendor lock-in.

Figure 3: Analysis of the data collected by smart buildings enables predictive maintenance (Aspern Smart City Research GmbH & Co KG, no date b, p. 81)

ASCR employs numerous sensors, raising privacy concerns as they collect vast amounts of personally identifiable data, including residents' habits. Early stages of the project investigated privacy-preserving techniques to address these issues. First, explicit consent is required for data collection and processing, with the ability to withdraw consent under Austrian law. Additionally, the API endpoints of the smart city are publicly listed but protected by firewalls to restrict access to authorized users and services. Lastly, strategies such as anonymization, data aggregation by criteria like time, building, or household, distortion with noise patterns, and homomorphic encryption (allowing data to be processed without decryption) were explored as potential safeguards (Dhungana *et al.*, 2015).

ASCR demonstrates the application of the abovementioned agile approach, including on large scale. The outcomes of each sub-project are analyzed to decide on the experiments' success and possibilities for improvement or future implementation. The project is completed in several steps, each with its foci and set of subprojects and hypotheses to work on. For example, the next stage of the project planned to end in 2028 will have a focus on retrofitting the old buildings to use renewable energy, investigate how the planning stage of a new building or a district can benefit from the findings of the previous stages, and how it is possible to further improve e-mobility solutions (Aspern Smart City Research GmbH & Co KG, no date b, p. 98). Close collaboration with the stakeholders such as Vienna municipal services and focus on the relevant problems ensures the research is demanded and the developed solutions are likely to be applied not only in Aspern, but also in nearby Vienna.

The inclusion of the older buildings in the research objectives is also crucial, as currently the research has been mostly conducted in the structures specifically built for the ASCR project, and the smart city initiatives are hardly viable if they do not include the existing infrastructure. Besides, the findings of this research can potentially help with implementation of smart cities in another regions, including the developing world.

Conclusion

The concept of smart cities, exemplified by Siemens' initiatives, illustrates the potential of smart city technology in urban environments. By combining innovation with privacy-conscious practices, smart cities address critical challenges, including energy efficiency and environmental sustainability. Projects like ASCR demonstrate the importance of stakeholder collaboration and adherence to open standards, providing a scalable model for future urban development. These efforts lay a foundation for cities worldwide to achieve sustainable and adaptable growth.

References

Angelidou, M. (2014) ‘Smart city policies: A spatial approach’, *Cities*, 41, pp. S3–S11. Available at: https://doi.org/10.1016/j.cities.2014.06.007.

Aspern Smart City Research GmbH & Co KG (no date a) ‘About ASCR’, *Aspern Smart City Research*. Available at: https://www.ascr.at/en/about-ascr/ (Accessed: 24 January 2025).

Aspern Smart City Research GmbH & Co KG (no date b) *ASCR 2023 — Final Report*. Aspern Smart City Research GmbH & Co KG. Available at: https://www.ascr.at/wp-content/uploads/2024/05/AB-ascr-190x260mm-2023-en-RZ-web-1.pdf (Accessed: 20 January 2025).

Chu, Z., Cheng, M. and Yu, N.N. (2021) ‘A smart city is a less polluted city’, *Technological Forecasting and Social Change*, 172, p. 121037. Available at: https://doi.org/10.1016/j.techfore.2021.121037.

Dhungana, D. *et al.* (2015) ‘Aspern smart ICT: Data analytics and privacy challenges in a smart city’, in *2015 IEEE 2nd World Forum on Internet of Things (WF-IoT)*. *2015 IEEE 2nd World Forum on Internet of Things (WF-IoT)*, pp. 447–452. Available at: https://doi.org/10.1109/WF-IoT.2015.7389096.

Elbracht, O. and Farah, F. (2022) *From City Theory to Smart Tech Reality*. Siemens AG. Available at: https://www.siemens-advanta.com/whitepapers/smart-tech-reality (Accessed: 18 November 2024).

Gheisari, M., Wang, G. and Chen, S. (2020) ‘An Edge Computing-enhanced Internet of Things Framework for Privacy-preserving in Smart City’, *Computers & Electrical*

Engineering, 81, p. 106504. Available at: https://doi.org/10.1016/j.compeleceng.2019.106504.

Hernández, J.L. *et al.* (2019) 'An interoperable Open Specifications Framework for Smart City urban platforms', in *2019 Global IoT Summit (GIoTS)*. *2019 Global IoT Summit (GIoTS)*, pp. 1–7. Available at: https://doi.org/10.1109/GIOTS.2019.8766396.

Janani, R. *et al.* (2021) 'IoT in smart cities: A contemporary survey', *Global Transitions Proceedings*, 2(2), pp. 187–193. Available at: https://doi.org/10.1016/j.gltp.2021.08.069.

Jung, D. *et al.* (2020) 'Conceptual Framework of an Intelligent Decision Support System for Smart City Disaster Management', *Applied Sciences*, 10(2), p. 666. Available at: https://doi.org/10.3390/app10020666.

Kummitha, R.K.R. (2018) 'Entrepreneurial urbanism and technological panacea: Why Smart City planning needs to go beyond corporate visioning?', *Technological Forecasting and Social Change*, 137, pp. 330–339. Available at: https://doi.org/10.1016/j.techfore.2018.07.010.

Lannelongue, L., Grealey, J. and Inouye, M. (2021) 'Green Algorithms: Quantifying the Carbon Footprint of Computation', *Advanced Science*, 8(12), p. 2100707. Available at: https://doi.org/10.1002/advs.202100707.

Liedy, R. (2021) *Measuring the Sustainability of Energy Community Business Models. A Simulation-Based Analysis of an Energy Community in Smart City Aspern*. Master of Science Thesis. University of Applied Sciences Technikum Wien. Available at: https://resolver.obvsg.at/urn:nbn:at:at-ftw:1-65031 (Accessed: 25 January 2025).

Panahi Rizi, M.H. and Hosseini Seno, S.A. (2022) 'A systematic review of technologies and solutions to improve security and privacy protection of citizens in the smart city', *Internet of Things*, 20, p. 100584. Available at: https://doi.org/10.1016/j.iot.2022.100584.

'Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (Text with EEA relevance)' (2016). EUR-Lex. Available at: https://eur-lex.europa.eu/eli/reg/2016/679/oj/eng (Accessed: 19 January 2025).

Siemens AG (2023) *Livable City Districts*. Available at: https://assets.new.siemens.com/siemens/assets/api/uuid:198241a1-a50c-49b0-94bb-9da370de6d2f/Smart-Campus-CityDistrict-iPDF-EN.pdf (Accessed: 18 November 2024).

Siemens AG (2024) *Siemens global Website*, *siemens.com Global Website*. Available at: https://www.siemens.com/global/en.html (Accessed: 21 November 2024).

United Nations Department of Economic and Social Affairs (2019) *World Urbanization Prospects: The 2018 Revision*. United Nations.

Yigitcanlar, T. and Kamruzzaman, Md. (2018) 'Does smart city policy lead to sustainability of cities?', *Land Use Policy*, 73, pp. 49–58. Available at: https://doi.org/10.1016/j.landusepol.2018.01.034.