CitCom.AI

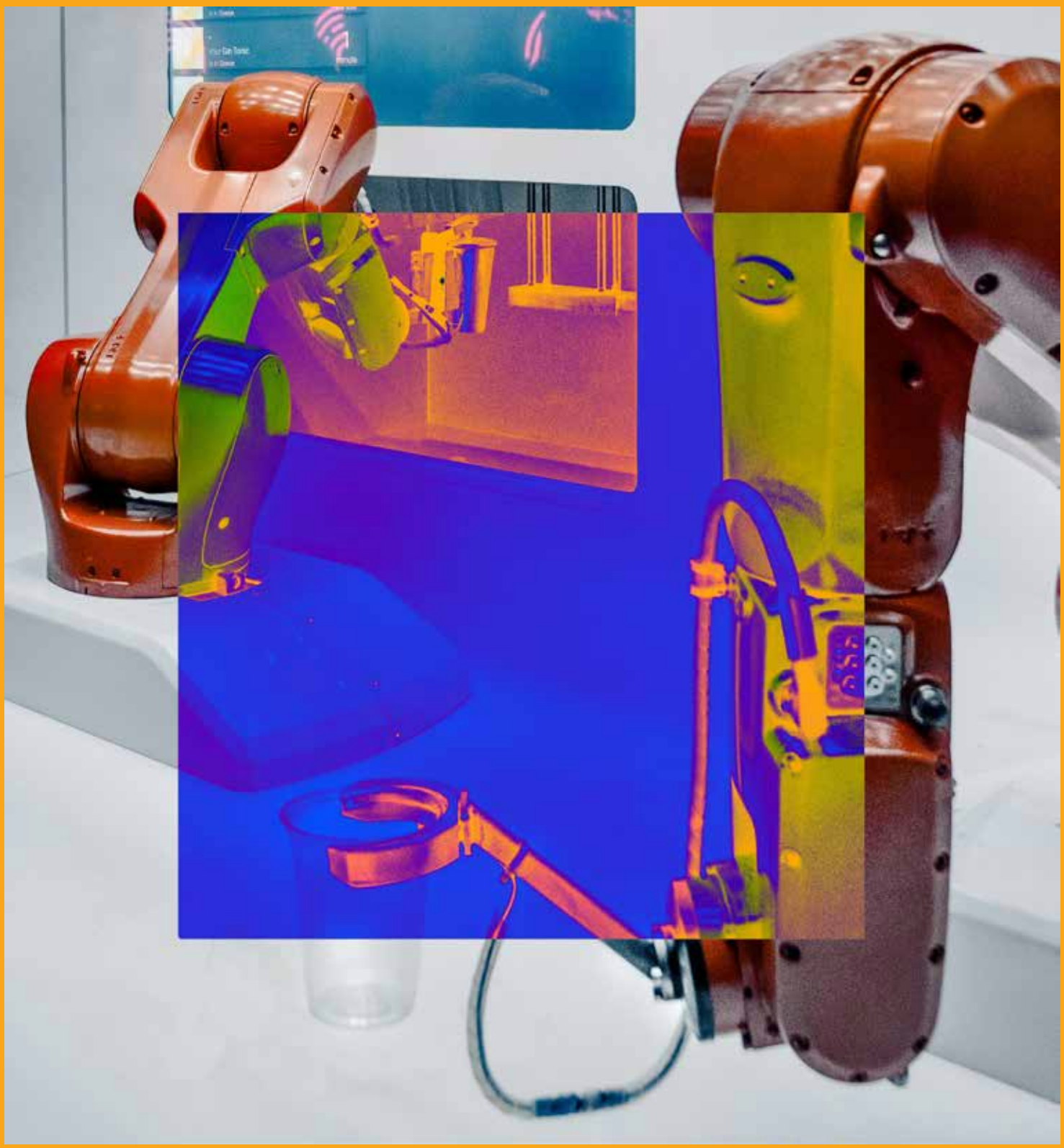
Market report

Version 1.1

Testing AI
in Smart Cities and
Communities

21.02.24

Mapping of the current EU context for the AI testing and experimentation facility (TEF) in support of smart and sustainable cities and communities.



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T5.1: Market report

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Contributors

Section	Name	Organisation
Coordination	Sophie Meszaros	imec-SMIT, VUB
	Laurens Vandercruysse	imec-SMIT, VUB
European Context	Sophie Meszaros	imec-SMIT, VUB
	Laurens Vandercruysse	imec-SMIT, VUB
European Cities and Communities	Alberto Celani	Politecnico di Milano
	Martine Dellanoy	Digital Flanders
	Agnieszka Wendland	WUT
	Rasmus Reeh	DTU
European AI Industry	Lydia Montandon	Fiware Foundation
	Bernat Adrià	Las Naves
	Mar Ferrer	Las Naves
North Node	Sophie Meszaros	imec-SMIT, VUB
	Laurens Vandercruysse	imec-SMIT, VUB
	Thomas Thue Sørensen	CDK
	Peter Mombartz Brændgaard	CDK
	Søren Bernt Lindegaard	CDK
	Petra Dalunde	Rise
Central Node	Eridona Selita	Imec
	Gwenaelle Berthier	SystemX
	Pascal Lhoas	LIST
South Node	Bernat Adrià	Las Naves

	Mar Ferrer	Las Naves
	Rafael Magdalena	UVAL
	Adrian Salcedo	UVAL
	Andrea Bonetti	UVAL

Review Process

Name	Organisation	Date of Review
Thomas De Meester	Imec	30/11/2023
Laurence Johannsen	LIST	01/12/2023
Raimon Calabuig Moreno	UPV	03/11/2023

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Abbreviations

AI	Artificial Intelligence
AI Act	Artificial Intelligence Act Proposal
AIaaA	Artificial Intelligence as a Service
API	Application Programming Interface
AQI	Air Quality Index
AV	Autonomous Vehicle
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
BEVs	Battery Electric Vehicles
BMS	Building Management Systems
CAM	Connected and Automated Mobility
CAVs	Connected and Automated Vehicles
CCAM	Connected, Cooperative and Automated Mobility
CEF	Connecting Europe Facility
CitCom.ai TEF	Cities and Communities AI Testing and Experimentation Facility
CPO	Charging Point Operators
CSR	Corporate Social Responsibility
DEP	Digital Europe Programme
DL	Deep Learning
DigiNEB	Digital Solutions for the New European Bauhaus
DIGITAL	The Digital Europe Programme
DMA	Digital Markets Act
DMI	Meteorological Institute of Denmark

DoA	Description of Action
DS4SSCC	Data Space for Smart and Sustainable Cities and Communities
DSA	Digital Services Act
DMOs	Destination Management Organisations
DSO	Distribution System Operator
DT4Regions	Digital Transformation for Regions
DUET	Digital Urban European Twins
e-IDAS	Electronic Identification, Authentication, and Trust Services
EC	European Commission
ECO	European Cybersecurity Organisation
EDICs	European Digital Infrastructure Consortiums
EDIHs	European Digital Innovation Hubs
EEN	Enterprise Europe Network
EIC	European Industrial Clusters
EIF4SCC	European Interoperability Framework for Smart Cities and Communities
ENAC	Aviation Authority in Italy
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSOG	European Network of Transmission System Operators for Gas
ERDF	European Regional Development Fund
ESPON	European Observation Network for Territorial Development and Cohesion
EU	European Union
EU ETS	European Union Emissions Trading System
FCEVs	Fuel Cell Electric Vehicles

FM	Facilities Management
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GTFS	General Transit Fee Specification
GEUS	Geographical Survey of Denmark and Greenland
IAM	Identity and Access Management
ICT	Information and Communication Technology
ICE	Internal Combustion Engine
IFM	Integrated Facilities Management
IoT	Internet of Things
IP	Internet Protocol
LDT	Local Digital Twin
MaaS	Mobility-as-a-Service
MIMs	Minimal Interoperability Mechanisms
MIMs Plus	European Minimal Interoperability Mechanisms
ML	Machine Learning
NEB	New European Bauhaus
NLP	Natural Language Processing
NIS2 Directive	Network and Information Security 2 Directive
ODD	Operational Domain Design
PFA	Automobile Platform
PHEVs	Plug-in Hybrid Electric Vehicles
RISE	Research Institutes of Sweden
SDO	Standards Developing Organisation
SMEs	Small and Medium-sized Enterprises

SSCC	Smart and Sustainable Cities and Communities
TCO	Total Cost of Ownership
TEF	Testing and Experimentation Facility
TSCAI	The Smart City Association Italy
TSO	Transmission System Operator
VC	Venture Capital
ViPV	Vehicle-Integrated Photovoltaic Technologies
VRUs	Vulnerable Road Users
VTC	Passenger Car with Driver
VOCs	Volatile Organic Compounds
WHO	World Health Organisation
WIN	Water Innovation Network
XAI	Explainable AI
xEVs	Electric Vehicles
XR	Extended Reality

Table 1. Abbreviations

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Executive summary

This market analysis conducted by the CitCom.ai consortium maps the current European Union (EU) context for the artificial intelligence (AI) testing and experimentation facility (TEF) in support of smart and sustainable cities and communities. The purpose of this AI TEF is to enhance AI innovation in the EU by providing a testing environment that closely resembles real-world settings. The main objective is to accelerate the digital transformation of urban areas throughout the EU by allowing the testing and improvement of new systems. The insights provided in this market research are derived from scholarly literature, grey literature sourced from reputable international organisations, and reports from past (EU-funded) projects in the field of AI and/or smart cities and communities.

First, the relevant legislative initiatives, funding programmes, and past projects, are examined in order to foster an understanding of the regulatory and policy landscape in the EU. Regulatory initiatives are classified into six categories: Identity and access, privacy and security, platforms, interoperability, data, and AI. Further, the Digital Europe Programme (DEP), Horizon Europe, and other financing mechanisms that promote digital transformation, AI, and smart cities initiatives, are highlighted and put into context. Moreover, several European projects enhancing interoperability, knowledge sharing, and setting-up/ strengthening digital infrastructure are also profiled, offering a comprehensive state-of-play.

Second, European cities and communities as a stakeholder group in the AI TEF are focused on. European cities and communities exhibit great variation in digital maturity, both across and within them. Metropolitan regions of greater size often demonstrate more diligent strategic planning and (a better level of) integrated data-driven public services. Additionally, departments that are more technically oriented tend to achieve higher scores in terms of adopting new technologies compared to departments that are less technical. In particular, challenges with regard to a lack of skills, limited resources, the presence of data silos, and difficulties navigating various leadership levels are noted. To address these, the analysis puts forth recommendations like boosting skills transfer, nurturing entrepreneurial ecosystems, and employing procurement intelligently.

Third, the report focuses on the EU AI industry. This section provides an overview of the current AI innovators in the field. The EU had around 5 776 players in the AI industry in 2020. The worldwide AI industry is projected to expand from $450 billion in sales in 2022 to over $2.6 trillion by 2032, based on market size estimations. According to one estimate, AI investment in Europe is projected to increase by 29.6% per annum from 2021 to 2026, reaching over $70 billion in 2026. Germany and France have the highest

number of AI businesses among the member states, followed by Spain, Italy, the Netherlands, and Sweden, which also make significant contributions. Typical areas of focus include natural language processing, computer vision, machine learning (ML), robotics and automation, connected cars, and AI services. While specialisation tends to vary between member states, the largest EU clusters involve AI services and autonomous robotics applications. The primary obstacles encountered by AI innovators include limited access to data, insufficient proficiency in navigating a complex legal environment, inadequate computing resources, lack of cross-domain integration, issues in scaling solutions, and concerns regarding privacy and security.

Last, special attention was paid to the three CitCom.ai application domains – power (Nordic region), mobility (central region), and connectivity (south region) – by defining prominent subthemes, including specific related challenges and opportunities, and contextualising regional supernodes through past and ongoing use cases. The Nordic supernode 'POWER' focuses on energy, environmental solutions, and cybersecurity within the energy sector. The main challenges applicable to these domains revolve around lack of data access, limited data quality, interoperability issues, and data protection concerns. Dedicated AI systems could aid in safely and securely managing traffic to minimise environmental impact, and rolling out predictive and preventive maintenance for large scale heat pumps. The primary focal point of the central supernode 'MOVE' is urban transportation, specifically emphasising smart urban mobility, electromobility, and autonomous driving. Specific challenges include high data volumes, lack of appropriate infrastructure, reaching a sufficiently high level of sufficient sensor accuracy and reliability, as well as uncertainties around regulations and business models. The main opportunities stem from improved traffic flows and reduced emissions. The southern supernode 'CONNECT' focuses on the management of (noise) pollution, urban development, water management, integrated facility management, drone deliveries, and tourism. Related challenges span data quality and intricacy issues, lack of data platform interoperability, skills gaps, and regulatory and governance complexity. Opportunities include optimised resource usage and enhanced sustainability through AI applications in areas like climate impacts.

In short, this market analysis report mapped the current landscape, and identified actors, trends, and challenges to guide the AI TEF’s development and impact. Regular updates will be important to capture emerging developments within this dynamic field.

Scope of the market analysis

CitCom.ai's mission is to build a lasting testing and experimentation facility (TEF) for AI in support of the EU's global position in digitalization of cities and communities. Expanding the existing infrastructure and expertise throughout the Union, CitCom.ai will provide real-life conditions for testing and experimentation with AI and robotics solutions in the domain of cities and communities, to speed up the transition towards a greener and more digital Europe. The foundation of this ambition is the CitCom.ai Market Analysis, a joint effort of European organisations to map the current status of the European AI market. The guiding principle of this work is to map the European context by concretizing the regulatory environment, funding instruments, state of existing European AI market, and potential European end-users (both communities and organisations). Special attention is paid to the application domains 'POWER', 'MOVE', and 'CONNECT' by defining respective prominent subthemes and contextualization through use-cases. These domains are assessed on a regional basis, called the supernodes. The Nordic super node covers Denmark, Sweden, and Finland and presents the 'POWER' domain. The Central super node covers Belgium, France, Luxembourg, and the Netherlands and outlines the 'MOVE' domain. The South super node covers Spain, Italy, Poland, and Germany and studies the 'CONNECT' domain. Figure 1 displays stakeholders around CitCom.ai based on the Platform Innovation Kit.

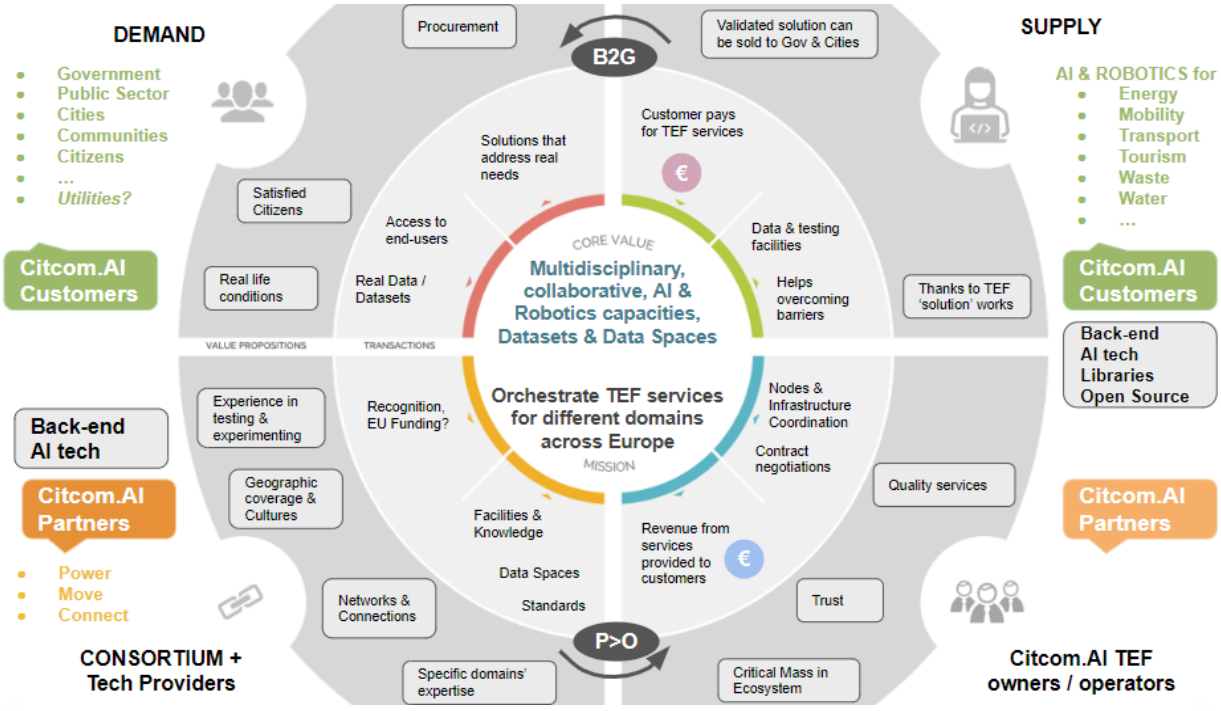

Figure 1. CitCom.ai stakeholders based on the Platform Innovation Kit

While this document serves to inform European stakeholders of the smart and sustainable cities and communities AI domain, it also provides intelligence to CitCom.ai to identify required services, its customers, relevant technologies, marketing, and communication strategies, and to contribute to the building of its infrastructure.

Value Proposition: CitCom.ai offers the possibility to test and experiment innovative AI services in close to real conditions for cities and communities. When services prove to be safe, ethical, efficient and useful, this will boost the adoption of those services by the public sector, not only locally but globally and generate new business for AI innovators.

Table 2. CitCom.ai value proposition.

Methodologically, this study was conducted by way of document analysis. Reviewed documents can be split into three main categories:

1. Academic literature such as peer-reviewed journal articles, books, and conference papers;
2. Gray literature such as policy studies, publications, strategy documents, and working documents from prominent (inter)national organisations;
3. Information on and from past EU-funded projects in the realm of smart cities and communities.

This study commences with an overview of the EU context in terms of regulation, funding, and strategy. Next, we examine the dynamics of two main groups: European cities and communities, and the European AI industry. AI innovators engage in the development, testing, and commercialization of AI solutions, with the aim of tackling various difficulties within the realm of smart cities and communities. Finally, the application domains ‘POWER’, ‘MOVE’, and ‘CONNECT’ are analysed.

Following the focus of the CitCom.ai project together with the Digital Europe Program, this report is structured as follows:

1. **European context: legislation and projects**
   An overview of regulatory initiatives that will influence the market, the relevant landscape of key projects and key organisations that work to build up the European AI-innovation market.
2. **European cities and communities**
   As all AI-services tested and experimented upon in CitCom.ai should serve cities and communities, the market analysis positions cities and communities as the demand side. This section looks at the public sector, and relevant private sector markets that are central to developing EU smart cities ambitions.

3. **European AI industry**
   In the context of CitCom.ai, the term customers has been used to describe the organisations expected to use and buy TEF services. In the Description of Action (DoA), the notion of “customer” includes: “Innovative companies (start-ups, SMEs and large companies), Research Centres and Public Sector”. Hence, this section looks at large and small companies that are either AI innovators or investors.
4. **Supernode domains**
   a. The Nordic super node: ‘POWER’
   b. The Central super node: ‘MOVE’
   c. The South super node: ‘CONNECT’

European context: legislation and projects

The European Commission's (EC) "A Europe Fit for the Digital Age" strategy, as one of six priorities identified in the Commission's work programme, provides the overall framework for the European Union's (EU) efforts relating to Europe's digital transformation [1] . Flowing from this strategy, the "Shaping Europe's Digital Future" plan lists three priority areas for action throughout the 2020-2025 timeframe, as detailed in the EC's official 2020 communication [2] . These areas are: "Technology that works for people," "A fair and competitive digital economy," and "An open, democratic and sustainable society"[3]. To help realise these broad EU digital policy objectives and ambitions, the DEP (2021-2027) was established to provide the necessary financing[4] . Specifically, strategic funding of 7.5 billion euros is to target "five key capacity areas: Supercomputing, AI, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society" [5].

Together, the described strategy, plan, activities, and funds, also support the EU's vision for smart and sustainable cities and communities. The EU's Smart Cities Strategy, Urban Agenda, Research & Innovation initiatives, and Horizon Europe's Smart and Climate-Neutral Cities mission programme use digital technologies and data to improve resource efficiency, reduce environmental impact, and solve urban challenges for higher living standards in human-centric smart cities and communities[678]. As such, the smart and sustainable cities and communities vision combines human-centricity, sustainability, digital transformation, and green growth objectives.

The EC believes that long-term human-centric development of smart city transformations requires accessible data (platforms)[9], and widespread experimentation and deployment of smart city solutions developed by a competitive market (including

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1 https://eur-lex.europa.eu/resource.html?uri=cellar%3Af1ebd6bf-a0d3-11ea-9d2d-01aa75ed71a1.0006.02/DOC_2&format=PDF

2 https://www.europarl.europa.eu/legislative-train/theme-a-europe-fit-for-the-digital-age/file-digital-age-strategy

3 https://commission.europa.eu/system/files/2020-02/communication-shaping-europes-digital-future-feb2020_en_4.pdf

4 https://digital-strategy.ec.europa.eu/en/activities/digital-programme

5 https://digital-strategy.ec.europa.eu/en/activities/digital-programme

6 https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en

7 https://www.eumonitor.eu/9353000/1/j4nvirkkkr58fyw_j9vvik7m1c3gyxp/vjlp5mcvyjzp

8 https://ec.europa.eu/regional_policy/sources/policy/themes/urban-development/agenda/pact-of-amsterdam.pdf

9 https://digital-strategy.ec.europa.eu/en/policies/smart-cities-and-communities

meaningful participation by SMEs and startups) on the basis of needs and common challenges[10]. Furthermore, to advance EU shared goals, networking, information sharing, and policy coordination are crucial to be able to replicate and scale up successful solutions throughout the EU (Living-in.EU, 2019). In the end, smart and sustainable cities and communities are to benefit from advancing innovation, inclusion, and economic competitiveness in a sustainable and future-proof manner. The CitCom.ai TEF constitutes a central lever to the smart and sustainable cities and communities' transition.

Legislative Context

What follows is an overview of the legislative context into which the CitCom.ai TEF is introduced. For the purposes of this report, European Commission legislative initiatives were clustered into six general themes: (i) Identity and access, (ii) Privacy and security, (iii) Platforms, (iv) Interoperability, (v) Data, and (vi) AI.

- Identity and Access

Identity and access are central enablers for the digital transformation of Europe. A trusted, accessible, and inclusive digital identity framework that respects fundamental rights needs to be established[11]. This should position the EU as a global leader in digital identity and promote the adoption of digital identity solutions across the region. This framework needs to offer a secure, user-friendly and privacy-preserving access that can be used across borders and various sectors[12] [13]. The digital identity will foster trust in online services, facilitate the provision of digital public services, and drive the human-centric data economy[14][15][16].

The following sections provide more detailed information on two prime pillars of the EU identity and access space, namely the Single Digital Gateway Regulation and the e-IDAS2 Proposal.

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[10] https://research-and-innovation.ec.europa.eu/system/files/2023-07/swd_2023_277_f1.pdf

[11] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0281

[12] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0281

[13] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-digital-identity_en

[14] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0281

[15] https://commission.europa.eu/system/files/2020-02/communication-shaping-europes-digital-future-feb2020_en_4.pdf

[16] https://eur-lex.europa.eu/eli/reg/2018/1724/oj

Single Digital Gateway Regulation[17]

Through a centralised digital portal, the Single Digital Gateway Regulation seeks to provide EU citizens and enterprises with borderless access to information and services. It mandates the provision of exhaustive and up-to-date information on a variety of subjects to make it simpler for citizens and businesses to locate the information they require. The ultimate objective is to create a more integrated and interconnected digital landscape in Europe, with enhanced accessibility and fewer barriers for cross-border access to information and public services.

Electronic Identification, Authentication, and Trust Services 2 Proposal[18]

The Electronic Identification, Authentication, and Trust Services (e-IDAS) 2 Proposal aims to broaden the extent of trust services under the EU's e-IDAS framework in order to enhance digital transactions and foster trust. It introduces the concepts of digital identity wallets and a European Digital Identity to give individuals greater authority over their digital identities while maintaining the highest standards of security and privacy. The overarching objective is to promote the adoption of electronic identification, authentication, and trust services throughout the EU by providing individuals and businesses with secure, interoperable, and trustworthy digital identity solutions.

- Privacy and Security

Establishing a trustworthy and resilient digital environment depends crucially on privacy and (cyber)security. These are hallmarks of a human-centred approach to technology, placing fundamental rights and freedoms at its core, which ensures citizens' rights are protected and data-driven innovation is supported by trust[19]. The EU underlines its ambitions in this regard by way of premier privacy and data protection regulations, and initiatives setting stringent cybersecurity standards and certification mechanisms.

Below, the General Data Protection Regulation (GDPR), the proposal for an ePrivacy Regulation, the Cybersecurity Act, and the NIS2-Directive, are discussed consecutively.

General Data Protection Regulation [20]*(GDPR)*

The GDPR aims to ensure that personal data is collected and processed in accordance with strict principles, as well as to clarify organisational responsibilities and

[17] https://eur-lex.europa.eu/eli/reg/2018/1724/oj

[18] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0281

[19] https://commission.europa.eu/system/files/2020-02/communication-shaping-europes-digital-future-feb2020_en_4.pdf

[20] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2016.119.01.0001.01.ENG&toc=OJ:L:2016:119:TOC

accountability. Importantly, it strengthens individual data protection rights by expanding and establishing rights such as the right to access, rectify, and delete personal data, as well as the right to object to specific categories of processing. The objective is to strengthen and unify data protection across the EU, while facilitating the unrestricted movement of data.

ePrivacy Regulation Proposal[21]

The proposal intends to establish a robust legal framework to safeguard privacy and confidentiality in electronic communications, supplanting the ePrivacy Directive of 2002. It aims to broaden the scope to include new services and technologies, strengthen consent requirements and user rights, and promote innovation while ensuring fair data processing. The overarching objective is to secure the privacy of consumers of electronic communications, bringing it in line with GDPR.

Cybersecurity Act [22]

The Cybersecurity Act seeks to strengthen cybersecurity in the EU by establishing a European cybersecurity certification framework to increase consumer confidence in digital products and services via a common set of cybersecurity standards. In addition, it expands ENISA's mandate and authority to develop and manage EU-wide certification schemes and to facilitate cooperation among member states in response to cyber threats. Through a harmonised certification approach, the goal is to increase cyber resilience, cultivate trust, and facilitate the digital single market.

Network and Information Security 2 Directive[23]

The NIS2 Directive aims to strengthen cybersecurity and resilience throughout the EU by expanding the scope of NIS1 to include more sectors, updating security requirements, enhancing incident reporting and cross-border cooperation, granting authorities more powers to monitor and enforce compliance, and promoting cybersecurity certification. Through a harmonised regulatory framework for cybersecurity, the goal is to safeguard essential services and digital services, cultivate trust, and foster harmonisation.

- Platforms

Platforms are playing, and will likely continue to play an important (intermediary) role in the digital landscape. The EU's vision on these actors comprises several components:

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017PC0010

[22] https://eur-lex.europa.eu/eli/reg/2019/881/oj

[23] https://eur-lex.europa.eu/eli/dir/2022/2555/oj

Safeguarding access and competition, Ensuring safety and accountability, Protection of fundamental rights and freedoms, and (Renewed) European competitiveness[24][25].

In essence, mitigating the undue market power of current large digital platforms has become a priority since the (potential) side effects on competition, fundamental rights and freedoms, even democracy, became apparent[26][27]. Checks and balances are primordial to foster an equitable, open, and competitive digital space. Moreover, ensuring effective oversight and fostering an ecosystem of digital platforms forged on European values are essential to make the EU a global technology leader[28] .

There are two main platform regulations at EU level which will be detailed in what comes next: the Digital Services Act (DSA), and the Digital Markets Act (DMA).

Digital Services Act[29]

The Digital Services Act seeks to establish harmonised EU-wide standards for digital services that address issues such as unlawful content and disinformation, while preserving fundamental rights and innovation. It differentiates online platforms from other services based on their broader information dissemination, imposes new obligations on very large platforms to mitigate risks, and establishes independent supervision to monitor compliance. The overall objective for digital platforms in the EU is to strike a balance between innovation and economic benefits, on the one hand, and safety, security, and fundamental rights, on the other hand.

Digital Markets Act[30]

The Digital Markets Act aims to guarantee equitable and competitive digital markets in the EU by establishing regulations that target large "gatekeeper" platforms. There is a list of dos and don'ts for gatekeepers designed to prevent them from exploiting their dominant position and suppressing competition. Noncompliance could result in penalties or even the dissolution of businesses, with the ultimate objective of promoting innovation, fair prices, high-quality user options, and economic opportunities while regulating risks.

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[24] https://eur-lex.europa.eu/eli/reg/2022/2065/oj

[25] https://eur-lex.europa.eu/eli/reg/2022/1925/oj

[26] https://eur-lex.europa.eu/eli/reg/2022/2065/oj

[27] https://commission.europa.eu/system/files/2020-02/communication-shaping-europes-digital-future-feb2020_en_4.pdf

[28] https://commission.europa.eu/system/files/2020-02/communication-shaping-europes-digital-future-feb2020_en_4.pdf

[29] https://eur-lex.europa.eu/eli/reg/2022/2065/oj

[30] https://eur-lex.europa.eu/eli/reg/2022/1925/oj

- Interoperability

The EU has undertaken important interoperability initiatives to nurture a more open and integrated digital ecosystem. In such an ecosystem, data, systems, and services collaborate seamlessly across borders and industries, facilitating the free movement of data and services for the benefit of the whole of the EU. Efforts are also specifically intended to promote instituting digital public services in an interoperable manner and to facilitate a more efficient use of data in smart cities and communities[3132]. The end goal is an open and collaborative digital environment in which data and services can readily circulate, fully realising the advantages of data exchange and data-driven innovation.

Next to the more non-committal initiatives and frameworks, the EC has recently proposed the European Interoperability Act, which would provide a legal basis for interoperability as a requirement for public sector actors in certain cases[33]. By promoting interoperability as both a principle and a requirement at various levels, the EU aims to eliminate digital fragmentation in Europe, laying the foundations for an integrated European data space and data economy.

The European Interoperability Framework, the European Interoperability Framework for Smart Cities and Communities (EIF4SCC), and the European Interoperability Act, are discussed in the next sections.

European Interoperability Framework[34]

The European Interoperability Framework provides public administrations with guidance on establishing interoperable digital public services throughout the EU. It delineates four interoperability layers and provides 47 recommendations for enhancing governance, cross-organizational relationships, and streamlining processes. Through the interoperability of IT systems, the framework seeks to improve the efficiency, efficacy, inclusiveness, and cost-effectiveness of transnational public services.

European Interoperability Framework for Smart Cities and Communities[35]

The European Interoperability Framework for Smart Cities and Communities *(EIF4SCC)* provides specialised guidance for establishing seamless collaboration and data exchange between diverse systems and organisations within smart cities. It identifies cultural, legal, technical, semantic, and organisational interoperability layers and suggests 30 recommendations to actualize the full potential of smart city technologies

[31] https://commission.europa.eu/system/files/2022-11/other_staff_working_paper_en_v2_p1_2249550.pdf

[32] https://ec.europa.eu/isa2/eif_en/

[33] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0720

[34] https://ec.europa.eu/isa2/eif_en/

[35] https://commission.europa.eu/system/files/2022-11/other_staff_working_paper_en_v2_p1_2249550.pdf

throughout the EU. On the whole, the framework promotes efficiency, sustainability, innovation, and an integrated digital ecosystem.

European Interoperability Act Proposal[36]

The European Interoperability Act Proposal seeks to improve interoperability throughout the EU by requiring member states to adopt common standards, establish aligned national frameworks, utilise the Interoperability Cartography, and establish an observatory to track progress. The proposed Act provides a legal framework for addressing the fragmentation of digital services, fostering a functional digital single market, and implementing interoperability frameworks to reap the complete benefits of digitization.

- Data

By fostering ethical data exchange and reuse across sectors, the EU's data strategy seeks to establish a trustworthy, human-centric data economy in which European values and principles are to be central tenets. Since data-driven innovation and disruptive technologies, such as AI, need increased data access, another objective of the data strategy is the creation of shared European data spaces across the private and public sectors.

In short, the data strategy seeks to promote trustworthy data-driven innovation and boost European industry competitiveness, while levelling the data single market playing field for enterprises of all sizes, in a context which respects individual's fundamental rights and freedoms[37].

In what follows, the Data Governance Act, the Data Act Proposal, the Open Data Directive, and the common European data spaces initiative, will be discussed.

Data Governance Act[38]

The Data Governance Act proposes rules and guidelines for sharing and repurposing data within the EU in order to promote a trusted and ethical data economy that makes use of the full innovation-enabling potential of data. It aims to facilitate the sharing of data between the private and public sectors, enable the reuse of protected public data, and eventually establish (sector-specific) data spaces. Moreover, the Act embraces an ethical data altruism model, includes a role-definition of trusted data intermediation services, and sets up a European Data Innovation Board. The Act explicitly seeks to

[36] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0720

[37] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0066&from=EN

[38] https://eur-lex.europa.eu/eli/reg/2022/868/oj

strike a due balance between economic opportunities and preservation of individual's fundamental rights and freedoms.

Data Act Proposal[39]

The Data Act aims to facilitate data sharing and access within the EU by obligating public and private sectors to share certain data, putting limits on contracting freedoms with regard to data access and sharing licensing, granting users improved access to data generated by connected devices, and strengthening the data portability framework. The Proposal aims to safeguard fundamental rights to shape a fair, secure, and transparent data-driven economy, but still unlock the value of data for the benefit of society.

Open Data Directive[40]

The EU's Open Data Directive demands member states to make specific kinds of public sector information available as open as possible by default (including via suitable API's), establishes uniform standards for making public data available for reuse, and stipulates measures to facilitate data discoverability. The objectives of the directive are to foster a single market for reuse with a level-playing field in order to unleash the value of public data to power innovation, economic growth, transparency, and policymaking.

Data spaces[41]

Data spaces aim to foster data sharing and use within specific economic sectors through stakeholder collaboration, common (data governance) frameworks, wide and fair accessibility, and appropriate infrastructure. Data spaces are to be environments fully respecting key EU principles and fundamental rights, driving EU competitiveness and sustainability through addressing data fragmentation.

- Artificial intelligence

The EU endeavours to foster the development and use of AI that is human-centric and sustainable. Key considerations in this respect include data integrity, openness, transparency, accountability, and human monitoring[42]. This European AI is to bolster innovative capabilities across all sectors of the economy and enhance global competitiveness of the EU's single market, while upholding fundamental rights as well as strictly abiding by core Union principles.

[39] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A68%3AFIN

[40] https://eur-lex.europa.eu/eli/dir/2019/1024/oj

[41] https://data.consilium.europa.eu/doc/document/ST-6532-2022-INIT/en/pdf

[42] https://commission.europa.eu/system/files/2020-02/commission-white-paper-artificial-intelligence-feb2020_en.pdf

With the proposed European-wide risk-based regulatory framework, the Commission expects to prevent fragmentation across the EU and put specific emphasis on applications that offer high levels of risk[43]. Moreover, fine-tuning of existing regulation on product safety (e.g. with respect to cybersecurity vulnerabilities and human autonomy) imposes itself to guarantee individuals' access to compensation in case of harm and to offer legal certainty for organisations [44].

In short, the EU seeks to establish an ecosystem of excellence and trust with the intention of assuming a leading role in the development of ethical and human-centred AI[45].

Next, we will discuss the Artificial Intelligence Act Proposal as well as the Proposal for an Artificial Intelligence Liability Directive.

Artificial Intelligence Act Proposal[46]

The AI Act Proposal establishes different rules and requirements for AI systems based on their risk levels, ranging from unacceptable to minimal, to ensure they adhere to principles of ethics, lawfulness, and fundamental rights protection within the EU. Some AI applications, those carrying unacceptable risk (e.g., social scoring), are subject to an outright ban in the EU, while others are to adhere by stringent conformity assessments, registration, transparency and oversight mechanisms, depending on the level of risk that they pose. Emerging obligations largely fall on providers (and users) of said AI systems. Specific attention is granted to SMEs, for example with regard to access to AI regulatory sandboxes, in order to safeguard competition, which should all add to fostering trust, balancing economic opportunities with ethical and safety needs.

Artificial Intelligence Liability Directive Proposal[47]

The proposal for the AI Liability Directive intends to provide a uniformity in liability regulations at the national level pertaining to civil law claims that arise as a result of AI systems' output. The primary objective of this proposal is to guarantee equitable protection for individuals who have suffered harm due to AI-related causes to guarantee continued and sustainable trust in the (use of) technology. Specific measures include the possibility for claimants to request access to documentation pertaining to AI systems with high-risk characteristics via the courts, and a presumption (under certain conditions) that establishes a causal connection between the defendant's negligence and the (false) (non-)output of the AI system. This proposal for a Directive is supposed

[43] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0206

[44] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0064

[45] https://commission.europa.eu/system/files/2020-02/commission-white-paper-artificial-intelligence-feb2020_en.pdf

[46] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0206

[47] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC049

to offer the minimum rules to be implemented across the EU, while individual member states are allowed to maintain or introduce more stringent legislation.

Takeaways

What follows is a schematic overview of the above sections on EU legislative initiatives on Identity and access, Privacy and security, Platforms, Interoperability, Data, and AI.

Theme & Rationale	EU Initiative	Content
Identity and Access - Establish secure and user-friendly digital IDs for EU citizens/businesses in line with fundamental rights - Promote adoption of digital ID solutions	Single Digital Gateway Regulation *2018*	- Centralised EU gateway for information and services - Multilingual interface - Interoperability between national systems - eIDAS integration for electronic identification - Cross-border accessibility
	eIDAS2 Proposal *TBD*	- Expand eIDAS-scope to more trust services - Enhance cross-border interoperability - Introduce digital identity wallets and European Digital Identity concepts - Emphasise security, privacy, consent
Privacy and Security - Adopt human-centric, fundamental rights-based approach to technology - Ensure secure, safe, and trustworthy environment enabling innovation	General Data Protection Regulation *2016*	- Establish robust, uniform EU data protection standards - Promote accountability and individual data subject rights - Encourage privacy-centric innovation
	ePrivacy Regulation Proposal *TBD*	- Harmonise communications sector (and OTT) rules across EU - Emphasise user consent over data
	Cybersecurity Act *2019*	- Establish EU cybersecurity certification framework - Enhance ENISA's role to develop harmonised certification schemes - Enhance cyber incident response
	NIS2 Directive *2023*	- Expand security requirements to more sectors - Improve incident reporting obligations - Promote cyber certification adoption

Theme & Rationale	EU Initiative	Content
		- Contribute to safe digital environment
Platforms - Ensure accountability and safety of online services - Promote fair competition and transparency	Digital Services Act *2022*	- Increase accountability of very large online platforms - Introduce oversight mechanisms to mitigate risks - Harmonise rules across EU digital single market
	Digital Markets Act *2022*	- Set requirements for/ prevent market abuse by large "gatekeeper" platforms - Maintain competitive and innovative digital market
Interoperability - Guide implementation of interoperable digital public services - Move from guidance to obligation	European Interoperability Framework 2 (EIF2) *NA*	- Provides 47 recommendations for interoperable digital public services - Outlines 4 layers of interoperability: legal, organisational, semantic, and technical
	European Interoperability Framework for Smart Cities and Communities *NA*	- Focuses on interoperability needs for smart cities - Cultural, legal, technical, semantic, and organisational interoperability layers - Recommends 30 actions to actualize the EU smart city potential
	European Interoperability Act *TBD*	- Mandates use of common standards and frameworks - Requires national interoperability frameworks - Establishes interoperability observatory and enforcement
Data - Establish human-centric and fundamental rights-based EU data economy - Improve data access to drive innovation	Data Governance Act *2022*	- Establish EU data sharing/governance rules to move towards data spaces - Build trust for data sharing through e.g. data intermediaries - Set up European Data Innovation Board
	Data Act *2023 (expected)*	- Facilitate data access between businesses, government, and individuals

Theme & Rationale	EU Initiative	Content
		- Increase public sector data openness - Reduce data lock-in effects and unfair data sharing practises
	Open Data Directive *2019*	- Mandate public sector data availability as open as possible by default - Establish harmonised standards for making public sector data available
	Data Spaces *NA*	- (Sectoral) ecosystems for data sharing - Emphasise stakeholder collaboration, common (data governance) frameworks, wide and fair accessibility, and suitable infrastructure - Adhere to EU (data) principles
Artificial Intelligence - Lead the way in development of human-centric and sustainable AI - Risk-based regulatory framework to safeguard Union values and trust	Artificial Intelligence Act *TBD*	- Establish risk-based regulatory framework - Ban certain AI systems - Set up conformity assessments, registration, transparency and oversight mechanisms
	AI Liability Directive *TBD*	- Establish EU-wide uniformity in minimum civil law AI-liability rules - Facilitate court-ordered access to AI documentation - Mandate conditional reversal burden of proof for fault

Table 3. Overview of relevant EU legislative initiatives for CitCom.ai

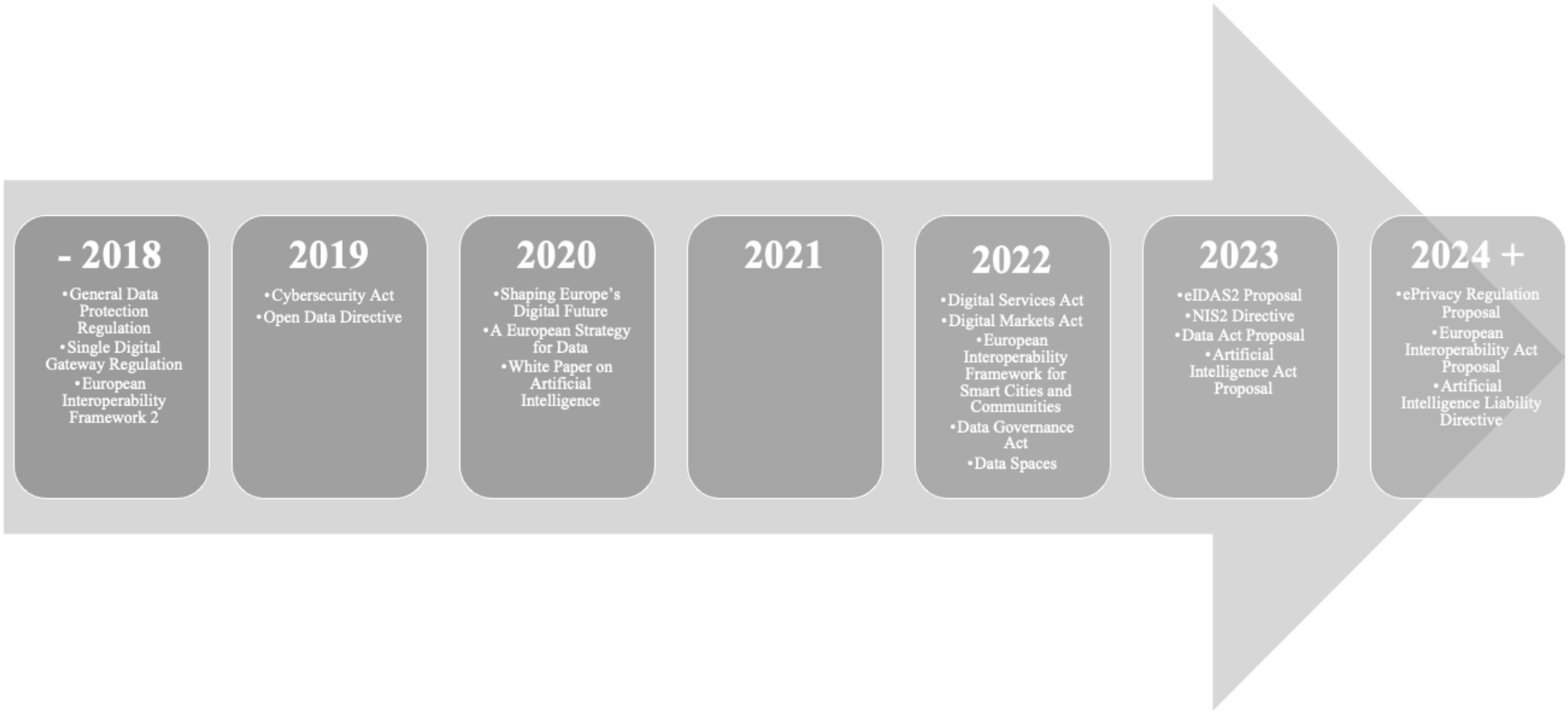

Figure 2. An overview of European legislation's timeline

Funding Context

This section provides an outline of several financing programmes available within the EU that are to bolster digital and smart cities as well as AI efforts. The scope of the programmes varies from the implementation of digital infrastructure to research and innovation endeavours. Overall, the objective of the financing is to enhance digital transformation, sustainability, and competitiveness in European cities, regions, and economies. Programmes cater to a more or lesser extent to one or several of four themes: (i) Development of smart cities and communities, (ii) Advancement of AI, (iii) Boosting digital infrastructure and platforms, and (iv) Promoting SME's. In what follows, primary financing mechanisms are presented.

- The Digital Europe Programme (DIGITAL)[48]

  Size: €7.6 billion

The primary objective of the DEP is to expedite the digital transformation of Europe by providing financial support for pertinent projects, including those focusing on smart cities and AI. Challenges such as EU infrastructure gaps, and digital transformation management are specifically focused on. The allocated budget of €9.2 billion will be used to facilitate the advancement of crucial technologies such as AI, cybersecurity, and supercomputing. Additionally, it will be employed to foster the acquisition of digital skills and encourage the usage of (interoperable) digital technologies. The programme designates a budget of €2.1 billion particularly aimed at promoting the development of common European data spaces and the support of AI, with a particular emphasis on ethical aspects of AI. Furthermore, DIGITAL mandated the set-up of a network of European Digital Innovation Hubs (EDIHs) across the Union. These EDIHs are to focus specifically on technological capacity building and service provision to the public sector as well as to start-ups, SME's, and mid-caps. In addition, intra-EU knowledge sharing, and business model innovation are sought to be achieved through the EDIH-network.

- Horizon Europe [49]

  Size: €94.1 billion

Horizon Europe contributes a substantial sum of €94.1 billion towards the financing of research and innovation endeavours aimed at boosting the EU technological basis as well as strengthening the scientific foundation of the Union. This is done through,

[48] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0694
[49] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0695

among others, propelling the development of smart cities and AI. A dedicated budget of €13.6 billion has been earmarked just for initiatives pertaining to 'Digital, Industry and Space', including AI research. Horizon Europe also seeks to provide financial assistance specifically for crucial technologies that align with strategic initiatives such as the European Green Deal and Digital Agenda. In short, the overall objective of the programme is to foster scientific advancements, address global challenges, stimulate innovation and economic progress, and facilitate job creation.

As a part of Horizon Europe, the European Innovation Council (EIC) was established. The EIC possesses a budget of €8.8 billion for the period of 2021-2027. Its primary focus is on breakthrough/ disruptive innovations that have the potential to create new markets. Following its 7 foundational principles, including efficiency and accountability, the EIC is to allocate at least 70% of its financial resources to startups and SMEs. Applicants can select one of three funding types that most closely fits their needs: the EIC Accelerator, blended financial support for start-ups and SMEs producing market-creating innovation; the EIC Pathfinder, grants for high-risk high-reward breakthrough (fundamental) research; and the EIC Transition, funding facilitating innovations' commercialization processes [50].

- InvestEU[51]

  Size: €26.2 billion budget guarantee

The InvestEU programme comprises a guaranteed amount of €26.2 billion with the aim of facilitating the mobilisation of supplementary investments from both private and public sectors (amounting to €372 billion) "to improve the competitiveness and socio-economic convergence and cohesion of the Union, including in the fields of innovation and digitization" in response to the COVID-19 pandemic[52]. These investments will be demand-driven and specifically directed towards the attainment of strategic goals outlined by the EU, such as the advancement of digital cities, sustainable urban transportation, and AI. Particular attention is paid to safeguarding access to (blended) funding for SME's and start-ups. To attain the aims of the Regulation, InvestEU establishes an InvestEU Advisory Hub which is to function as a central access point for information for potential investment subjects and the related Portal that offers accessible information on projects to investors.

[50] https://eic.ec.europa.eu/index_en
[51] https://eur-lex.europa.eu/eli/reg/2021/523/oj
[52] https://eur-lex.europa.eu/eli/reg/2021/523/oj

- Single Market Programme[53]

  Size: €4.2 billion

The primary objectives of the €4.2 billion programme are: (i) to improve the efficiency of the internal market by focusing on the resolution of barriers, the enhancement of Union law enforcement, the strengthening of market monitoring, and the advancement of governance mechanisms that prioritise the needs of users; (ii) to enhance the competitive edge and long-term viability of SMEs via, among others, the use of digital technologies; (iii) to strengthen the internal market by means of standardisation procedures; (iv) to foster 360° consumer protection; and, (v) to boost the quality of EU statistics. In short, the provision of funds through the programme exemplifies the EU's dedication to bolstering the single market, its digital dimension in particular, and improving its competitiveness.

- Connecting Europe Facility[54]

  Size: €33.7 billion

The Connecting Europe Facility (CEF) focuses on promoting the expansion of trans-European networks in the areas of transportation, (renewable) energy, and digital infrastructure. Especially, digital investments made by CEF in broadband networks, 5G technology, and service infrastructure have the potential to enable the implementation of smart city solutions and the use of AI applications. Combining grants, blended finance, and focused procurement, the CEF addresses infrastructural fragmentation and bottlenecks.

- European Regional Development Fund (ERDF)[55]

  Size: €226 billion[56]

The €226 billion European Regional Development Fund (ERDF), which is part of the European Structural and Investment Funds (ESIFs), seeks to enhance EU cohesion via the provision of financial support for projects making Europe “more competitive and smarter”, “greener”, “more connected”, “more social and inclusive”, and “closer to

[53] https://eur-lex.europa.eu/eli/reg/2021/690/oj

[54] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1153

[55] https://eur-lex.europa.eu/eli/reg/2021/1058/oj

[56] https://www.europarl.europa.eu/factsheets/en/sheet/95/european-regional-development-fund-erdf-#:~:text=Budget%20and%20financial%20rules,was%20allocated%20to%20the%20ERDF.

citizens”[5758] . The ERDF specifically focuses on, among others: infrastructure, accessibility, SME’s, and networking and communication. Management of the financial resources under the ERDF is shared between the EU and the various member states for example in the Interreg programme which is to allocate €10 billion to foster intra-Union cooperation[59]. Furthermore, through the Cohesion Fund, special attention is placed on EU regions that are comparatively less well-developed.

- Recovery and Resilience Facility [60]

  Size: €312.5 billion (non-repayable) and €360 billion (repayable)

The Facility is part of the efforts to counter the impact of the COVID-19 pandemic. The primary objective of the Recovery and Resilience Facility budget is to foster the development of robust EU economies by providing assistance to facilitate the green and digital transformations. A minimum of 20% of the recovery plans are to be allocated towards digital initiatives as a means to enhance competitiveness and promote sustainability.

- Just Transition Fund[61]

  Size: €17.5 billion.

Regulation (EU) 2021/1056 created the Just Transition Fund, which aims to address the socioeconomic consequences arising from attainment of EU energy and climate goals by 2030 and achieving climate neutrality by 2050. Specifically, the fund seeks to alleviate the burden on those employed in businesses reliant on fossil fuels or carbon-intensive sectors, as well as disadvantaged communities affected by this transition. Assistance is delivered via targeted investments that provide fresh employment prospects and foster economic advancement. Engagement of small and medium-sized enterprises (SMEs) is actively sought by implementing various strategies. These strategies include offering training and reskilling opportunities for workers, fostering the growth of new economic activities and business models, and facilitating the expansion of existing ones, for a successful transition towards sustainable and environmentally-friendly practices.

[57] https://ec.europa.eu/regional_policy/funding/erdf_en

[58] https://eur-lex.europa.eu/eli/reg/2021/1058/oj

[59] https://interreg.eu/about-interreg/

[60] https://eur-lex.europa.eu/eli/reg/2021/241/oj

[61] http://data.europa.eu/eli/reg/2021/1056/oj

- Innovation Fund[62]

  Size: ca. €40 billion (2020-2030).

The primary objective of the Innovation Fund is to provide financial assistance for the implementation of novel low-carbon technologies and processes. The Fund is financed by profits generated by auctioning 530 million permits under the European Union Emissions Trading System (EU ETS). It provides financial assistance for large-scale projects via the provision of grants or the use of novel financial mechanisms. Projects that meet the criteria for eligibility primarily emphasise novel approaches in energy-intensive sectors, carbon capture and storage technologies, renewable energy sources, and energy storage systems. The Fund endeavours to foster synergistic relationships with other financial programmes within the EU and aligns its efforts with the objectives of the European Green Deal.

- LIFE programme[63]

  Size: €5.4 billion

The LIFE Programme was instituted by Regulation (EU) 2021/783, with the overarching aim of facilitating the transition towards an economy that is "sustainable, circular, energy-efficient, renewable energy-based, climate-neutral and - resilient." Its primary objective is to tackle environmental and climatic action concerns via the provision of financial support for the advancement and widespread adoption of new technologies, methodologies, and approaches. Projects that possess a high leverage impact and demonstrate potential for transferability and replicability should be given priority. Projects are executed by means of conventional grants or other financial instruments.

- Takeaways

What follows is a schematic overview of the above sections on the various EU funding mechanisms.

Programme/ Facility	**Size**	**Main Objectives Related to Digital Transformation**
The Digital Europe Programme (DIGITAL)	€7.6 billion	- Expedite digital transformation of Europe - Promote development of AI, cybersecurity, and supercomputing - Foster skills, and technology adoption

[62] https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund/what-innovation-fund_en

[63] http://data.europa.eu/eli/reg/2021/783/oj

Programme/ Facility	Size	Main Objectives Related to Digital Transformation
		- Set up data spaces and network of EDIHs
Horizon Europe	€94.1 billion	- Strengthen EU technological and scientific foundation - Fund AI research with €13.6 billion budget - Establish EIC
InvestEU	€26.2 billion (guarantee)	- Mobilise investments to improve EU competitiveness and digitization - Support access to funding for SMEs and start-ups - InvestEU Advisory Hub and Portal
Single Market Programme	€4.2 billion	- Improve internal market efficiency - Strengthen digital single market and competitiveness
Connecting Europe Facility	€33.7 billion	- Promote trans-European networks in transport, energy and digital infrastructure - Address infrastructural fragmentation and bottlenecks
European Regional Development Fund	€226 billion	- Enhance EU cohesion through funding - Focus on infrastructure, accessibility, SME's, and networking and communication
Recovery and Resilience Facility	€312.5 billion (non-repayable) €360 billion (repayable)	- Response to COVID-19 pandemic - Foster green and digital transitions of EU economies - Allocate at least 20% of recovery plans to digital initiatives
Just Transition Mechanism	€17.5 billion	- Address socioeconomic consequences of achieving climate neutrality by 2050 - Focus on disadvantaged communities and workers in carbon/fossil fuel-intensive sectors
Innovation Fund	ca. €40 billion (2020-2030)	- Implement novel low-carbon technologies and processes - Focus on energy-intensive sectors, carbon capture and storage technologies, renewable energy sources, and energy storage systems - Financed by EU ETS
LIFE programme	€5.4 billion	- Tackle environmental and climatic action concerns

Programme/ Facility	Size	Main Objectives Related to Digital Transformation
		- Move towards “sustainable, circular, energy-efficient, renewable energy-based, climate-neutral and - resilient economy” - Priority for high-leverage impact and transferable and replicable projects

Table 4. Overview of relevant EU funding mechanisms for CitCom.ai

Digital transformation of Europe: Perspective of cities, and communities

Challenges

This section provides an analysis of the challenges of digital innovation transforming the public sector, its services and policies while considering the European socio-economic, cultural, and environmental diversity across cities, localities, regions, and communities. The European Parliamentary Research Service (2023) defined six macro-challenges: 1) Privacy, surveillance, cybersecurity, and safety aspects 2) Financial (or other) burden for authorities and service providers 3) Data loss, inaccuracy lack of reliability and interoperability issues 4) Economic damage and inequalities 5) Digital inequality and exclusion 6) Lack of trust or approval in the service and/or service provider. These challenges together with CitCom.ai’s defined barriers are loosely regrouped in the following four aspects: ethical considerations, regulatory frameworks, availability of resources, and public acceptance. Europe’s Digital Decade addresses these aspects by providing cities, communities, and regions with legislation pertaining to data, technology, and infrastructure. These laws are translated into funding programmes that are organised in tenders, grants, and other means to provide the expertise and the financial support to communities to align with Europe’s digital agenda. Such exercises are also used to gain insights into the current bottlenecks of AI services of European communities.

The European Observation Network for Territorial Development and Cohesion (ESPON) published several reports/analysis that detail some of the concrete challenges of communities in this context like, Regional strategies for sustainable and inclusive territorial development – Regional interplay and EU dialogue[64], ‘Potentials of big data for integrated territorial policy development in the European growth corridors (big data)’[65] , ‘Territorial Trends in Technological Transformations’[66] and most recently the ‘Digital

[64] https://www.espon.eu/ressi

[65] https://www.espon.eu/big-data-corridors

[66] https://www.espon.eu/transregecon

Innovation in Governance and Public Service Provision'[67] . These publications concretize the described challenges:

- Ethical considerations

AI systems can inadvertently perpetuate biases and discrimination if not designed and trained on appropriate datasets. European cities need to ensure that AI services are fair, transparent, and accountable. This involves addressing issues like handling personal data, algorithmic bias, explainability, and the potential impact on marginalised communities. Developing ethical guidelines and frameworks for AI deployment is essential to mitigate these challenges.

- Regulatory frameworks

European cities need to navigate complex legal landscapes to ensure compliance with existing regulations. The cities also need access to a broad variety of innovative SMEs that can provide compliant, smart and robust digital solutions, who in their turn then need support to be able to adjust and adapt to the new regulatory European landscape. AI services may fall under various regulatory frameworks, such as data protection, consumer protection, and competition laws. The recent launch of five different acts (data act, data governance act, digital services act, digital markets act, AI act) provides guidance for European digital transformations, and accordingly, communities should adapt those to their local environments. However, given the generality of the regulations, communities are charged with the task of evaluating their respective digital states and customising them. On top of the acts to shape digital transformations, communities are also in need of digital solutions that mitigate the effects of climate change and thereby align with the Green Deal.

- Availability of technical/financial resources and expertise

Given their position, regional and local actors have tacit knowledge regarding their respective areas. With efficient coordination and cooperation, they are well positioned to help the even digital development of European cities and communities by knowledge sharing. However, they may not have the institutional capacity to do so. As it is challenging to address each community individually, instead, Europe supports knowledge sharing (through, for instance, the European Digital Innovation Hubs (EDIHs)) across its regions in a coordinated manner and continues working towards sustainably strengthening this coordination. This includes having those with tacit knowledge contribute to the definition of funds and resources, as well as creating efficient communication about funds and other resources to cities, regions, and communities. Furthermore, technical challenges, such as data quality, interoperability,

[67] https://www.espon.eu/DIGISER

and scalability need to be addressed. European cities must ensure that the data used for training AI models is accurate, reliable, unbiased and representative. Interoperability between different AI systems and platforms is essential for seamless integration and collaboration. Additionally, scalability is crucial to handle the increasing demand for AI services and accommodate future growth.

- Public acceptance

Trust in technology is influenced by risks and uncertainties that are associated with a technology (Li et al., 2008). This has a direct impact on the acceptance of technology (Mcknight et al., 2011). In the case of AI-driven services it was demonstrated that it has the potential to create polarisation by low skill job replacement and creating elite jobs [68]. European communities need to engage with their citizens and address concerns related to job displacement, privacy, and the potential misuse of AI technologies by co-creating positive and engaging perspectives. Building trust and ensuring transparency in AI systems' decision-making processes is vital to gain public acceptance and support[69]. The use of Explainable AI (XAI) techniques, which transform an algorithm from a "black box" into an explainable tool, is recommended to allow users to understand the behaviour of the algorithm, improving transparency and increasing public acceptance.

European initiatives/ projects focusing on data, technology and infrastructure

The described challenges are addressed across four themes (government, skills, infrastructure, and business)[70] by European projects, initiatives and movements that are funded by different European funding programmes and/or are endorsed by European institutions. The projects, initiatives, and movements are established to respond to the challenges and to realise the solutions that are described in legislations and funding programs as well as to elaborate on the needs and requirements of cities, regions and communities. These include:

- Capacity building
- Cross-border collaboration
- Data availability/access/quality
- Knowledge-sharing
- Governance schemes
- Risks
- Stakeholder mapping
- Sustainability
- Social inclusion (incl. digital skills/literacy)

[68] https://www.espon.eu/transregecon

[69] https://doi.org/10.1145/1985347.1985353

[70] https://digital-strategy.ec.europa.eu/en/library/digital-europe-programmes-multiannual-work-programme-2021-2022

- Technical challenges

- European Digital Innovation Hubs (EDIHs)

European Digital Innovation Hubs (EDIHs) are DEP-funded one-stop shops with a regional presence established to support companies and public sector organisations to respond to digital challenges and become more competitive. EDIHs assist businesses in adopting digital technologies to improve business/production processes, products, or services by: offering access to technical skills and testing, as well as the ability to 'test before you invest', providing innovation services, such as finance guidance, training, and skills development that are relevant to digital transformation. The first 136 EDIHs were operational by January 2023. The EDIHs will be supported by the Digital Transformation Agency, currently in a build-up phase. All hubs are part of the EDIH network to boost networking, cooperation, and knowledge transfer activities between EDIH, SME and mid-caps, investors, the public sector and the other relevant stakeholders and initiatives. Many EDIHs comprise organisations affiliated with the Enterprise Europe Network (EEN) or European Industrial Clusters (EIC). Hence, to provide a seamless service to SMEs within local and regional ecosystems, EDIHs should connect with other networks such as EEN, EIC, and Start-up Europe.

- European Digital Infrastructure Consortiums (EDICs)[71]

In order to facilitate cross-border digital initiatives among EU member states, the European Digital Infrastructure Consortium (EDIC) was established as a legal framework. EDICs seek to coordinate multifaceted initiatives that advance Digital Decade priorities by pooling resources from the EU, member states, and private organizations through the establishment of legal entities by groups of at least three member states. Transnational collaborations have the potential to bolster competitiveness via technological advancements and innovation, and mitigate strategic vulnerabilities in digital infrastructures. The establishment of common governance structures additionally facilitates the streamlining of interactions among the national authorities that are involved. EDICs are required to make a positive contribution towards the realization of the Digital Decade's goals, which may include enhancing cybersecurity resilience and competitiveness throughout the EU, optimizing the advantages of emerging technologies, or increasing connectivity. For the benefit of all EU citizens and businesses, however, with a particular emphasis on SMEs, they advocate for a sustainable and inclusive digital transformation of the economy and society.

[71] https://digital-strategy.ec.europa.eu/en/policies/edic#:~:text=European%20Digital%20Infrastructure%20Consortium%20is,Decade%20general%20objectives%20and%20targets

- Digital Solutions for the New European Bauhaus[72]

  Relevance:
  - Alignment with NEB principles
  - Community/ Stakeholder engagement

The New European Bauhaus (NEB) was launched in 2021, as the European interdisciplinary movement to realise the European Green Deal. It promotes sustainability with good design, that needs less carbon and that is inclusive and affordable for all, while respecting the diversity that we have in Europe and beyond. In this context, the movement launched the DigiNeb.EU Project in 2022[73] to connect stakeholders of digital and the NEB community. DigiNEB provides training courses, digital toolkits (a catalogue of technologies) and an observatory of 500+ EU-funded initiatives. They address the profiles listed below, and also offer them the opportunity to partake in technical working groups for knowledge sharing.

- Architects, Designers, Engineers, and other professionals belonging to the NEB community
- Construction industry suppliers & other relevant industry players (e.g., start-ups, SMEs, associations in the building, mobility & health sectors, and SDOs).
- Researchers and academics
- Digital technology companies, associations and initiatives
- Policymakers (including Green Deal-related)
- National & regional authorities, mayors (including urban planners) and cities
- Civil society organisations and citizens

- Living-in.EU Movement[74]

  Relevance:
- Community/Stakeholder engagement
- MIMs Plus development
- Legal/Finance/Monitoring and measuring/ capacity building expertise for smart communities

In 2019, European organisations together with the European Commission (Eurocities, European Regions and Innovation Networks, The Council of European Municipalities and Regions, Open and Agile Smart Cities, European Network of Living Labs, European Committee of Regions) launched the Living-in.EU movement, each bringing their

[72] https://digineb.eu/

[73] https://new-european-bauhaus.europa.eu/system/files/2023-01/CP-003%20-%20Report%20from%20the%20Commission%20%28EN%29%20Part%201.pdf

[74] https://living-in.eu/

respective expertise to help cities, regions, and communities in their digital transformation. The movement is a platform for regional and local public actors to learn and share their knowledge regarding the following topics: legal, finance, capacity building, monitoring and measuring, and technology. Within this context smart communities can learn about European smart city projects (e.g., data spaces blueprint, local digital twin toolbox) that are created to help all European stakeholders. It is also the space where the Minimal Interoperability Mechanisms (MIMs Plus) are developed to foster a European market and digital transformation without leaving anyone behind. The MIMs define the minimum requirements to be interoperable across different topics[75]. The movement is sustained by projects funded under the Digital Europe Programme, Horizon Europe, or other European funds that look at all-round technical solutions for data, technology, infrastructure as well as social inclusion: Data Space for Smart and Sustainable Cities and Communities, DT4Regions, Communicity, and the Local Digital Twin Tool Box.

- Data Space for Smart and Sustainable Cities and Communities (DS4SSCC)[76]
  Relevance:
  - Data Space reference architecture for smart communities
  - Interoperability (MIMs development)
  - Community/Stakeholder engagement

This preparatory action raised a community of 162 individuals to co-develop a data space blueprint that caters to the diversity of Europe. The members of this community are from local or regional authorities and other organisations that work on the legal, technical or business aspects of digital transformation. This action has identified the relevant stakeholders, the roles they can hold in the data space ecosystem, the types of agreements they can have and technologies that can support those. It also provided a list of technical specifications available to create the respective building blocks and looked at the most sought-after datasets by cities and communities that they aligned with the high-priority data sets list created by the EC.

The DS4SSCC is a cross-sectoral, cross-domain data space initiative that was launched together with several data spaces such as the Green Deal Data Space, PrepDSpace4Mobility, DATES project European Data Space for Tourism, Tourism Data Space – Data Space for tourism website, Data Space for Skills: DS4Skills, Omega-X – Energy Data Space.

[75] https://living-in.eu/group/commitments/mims-plus-version-6-final

[76] https://www.ds4sscc.eu/

- Digital Transformation for Regions[77]
  Relevance:
  - Market analysis

This project concluded in 2023 and created a European Platform for Regions to enable AI and Big Data collective solutions. Its goal is to enhance public administration efficiency and effectiveness in user-centric services. Within this context, public administrations were engaged in defining the platform services and can benefit from dedicated capacity building and mutual learning activities. This project identified that regions are interested in the work fields of digital identity, digitization of internal processes, cybersecurity, data space, telemedicine, digital twins, transport, and tourism. The challenges are related to the design and delivery of digital public services, as well as the digitalization and de-bureaucratisation of public services and consolidation of internal administrative processes. Other priorities for European cities and regions in terms of challenges are also to make local government more open and transparent, use data platforms to promote the development of smart cities and enable new digital government practises. The project also found barriers like budgetary issues, access to large amounts of data, and lack of data literacy. Communities also struggle to break the silo culture to benefit from more data standards, to create capacities for appropriate governance and procurement processes. The project concluded that their stakeholders are interested in knowledge exchange between regions with regard to AI and Big Data challenges and related solutions (digital policies, open calls, digital inclusion, smart city trials, strategic implementation of digital projects, data centres and data sharing, transformation of data gathering processes and management capacity, digital transformation of the regional council, updating bureaucratic procedures, exploitation and dissemination of existing work on the digital twins, co-creation of platforms and services, development of strategic use cases (economic forecast, environmental transition)); cross-border collaboration; raising awareness, transparency and the values and benefits (public authorities, private sector, citizens) of AI and big data applications for public services; practical training activities for civil servants / public administrations in the area of AI and Big Data.

[77] https://dt4regions.eu/

- Communicity/OrganiCity/Synchronicity[78]

  Relevance:
  - Ethics regarding AI and XR
  - Understanding of minorities and vulnerable communities

CommuniCity is a citizen-centred project focusing on marginalised communities to boost inclusion. It brings together companies, organisations, associations, tech providers, and citizens to develop solutions to overcome digital and urban challenges. In doing so, it launches 100 pilots that use technologies to boost the inclusion of the elderly, the unemployed, the disabled, the low-literate citizens, and the ones with language barriers as well as providing accessible healthcare information. CommuniCity represents a continuation of the H2020 OrganiCity and SynchroniCity projects.

- Local Digital Twin Toolbox

  Relevance:
  - Market study
  - Interoperability (MIMs development)

As described in the Digital Europe Work Programme 2021-2022, the Local Digital Twin (LDT) Toolbox defines the minimum conditions to qualify as a LDT, generic solutions, building blocks, reusable tools, reference architectures, open standards and technical specifications for the most common use cases. As such, it also helps the deployment of MIMs-compliant solutions. Responding to the NEB, the toolbox also looks at citizen engagement (e.g. Virtual Reality), to use of LDT for participatory urban planning creating innovative and aesthetic living spaces. Across these activities, the toolbox maps EU-based technology providers (corporates, SMEs, developers, etc.) that are active in the development and/or deployment of components of (local) digital twins and proposes a plan to prepare for the large-scale roll-out of LDTs across the EU in the coming years (European Commission, 2021).

- Gaia-X[79]

  Relevance:
  - Community/Stakeholder Engagement
  - Use case/deployment experience

Gaia-X aims to advance the European data economy by defining the specification of an architecture that can support a federated data economy (components, standards, API specifications, data models and design principles), creating open-source tools that can

[78] https://communicity-project.eu

[79] https://gaia-x.eu/who-we-are/hubs/

implement the architectural components, and providing certification. In doing so, Gaia-X also provided federated services for the creation and maintenance of data spaces, specifically for identity and trust management, sovereign data exchange, federated catalogue and compliance. This ecosystem creates a field which is not centrally owned nor is it state-owned, instead it distributes ownership across its participants[80]. Much of this work has been realised via the Gaia-X Hubs where actual cases have been developed. A hub is a central point for regional stakeholders, and it is tightly connected to local governments through the ministry devoted to the Digital Transformation programmes. In this way they have a fast track to propose solutions in line with the strategic political initiatives and aligned with the Gaia-X endeavour of the Association and of all other European hubs. As such, Gaia-X created a community of smart cities and regions[81] .

- Scalable Cities

  Relevance:
  - Communities/Stakeholder engagement
  - Action grant: financial support to replicate already proven measures
  - Capacity building in public administration

Scalable Cities stands for 120 cities engaging in 18 Smart Cities and Communities initiatives financed by Horizon 2020 with around EUR 345 million. They implement approximately 550 demonstrations of technical and social innovations in the fields of transportation and logistics, buildings, urban data and ICT infrastructure, citizen participation, and urban governance in collaboration with university, business, organisations, and consultants. Scalable cities incorporate the following efforts[82] :

- The City Coordinators Group brings together cities to share knowledge, facilitate collaboration and lead advocacy actions.
- The Peer-to-Peer Learning programme is offered to cities to build capacity in public administrations.
- The Action Grant offers financial support to replicate already proven measures.
- The Task Groups bring together practitioners to work on issues related to smart cities.
- The Experts Group offers technical advice to support the work of Scalable Cities.

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80 https://www.data-infrastructure.eu/GAIAX/Redaktion/EN/Publications/gaia-x-technical-architecture.pdf?__blob=publicationFile&v=5

81 https://gaia-x.eu/

82 https://smart-cities-marketplace.ec.europa.eu/scalable-cities#:~:text=The%20role%20of%20Scalable%20Cities,and%20lead%20to%20measurable%20outcomes

- NetZeroCities[83]

  Relevance:
  - Community/Stakeholder engagement
  - Sustainability goals

NetZeroCities aids cities to overcome the structural, institutional and cultural barriers in their journey to achieve climate neutrality by 2030. Tools, resources, and knowledge are developed and integrated into a one-stop platform available via an online portal to all cities. Services are made available to communities that participate in the EU's Mission "100 Climate-Neutral and Smart Cities by 2030.".NetZeroCities will also operate a twinning programme to facilitate peer-learning and will support a series of pilots to assist drive quick learning about how to attain carbon neutrality at the city scale.

- DUET [84]

  Relevance:
  - Data-driven decision-making
  - Understanding of minorities and vulnerable communities
  - Interoperability (MIMs development)

What can a future city look like? City planners can test their ideas using a 3D interface to create a digital city replica or Digital Twin. Advanced city data and computer models can help city officials manage resources, enhance economic development, reduce ecological footprints and improve the quality of life for citizens. The EU-funded DUET project is leveraging the advanced capabilities of cloud and high-performance computing to evolve the traditional public policymaking cycle using large open-data sources. The use of digital twins will make it easier for city managers to predict policy impacts, react to events and ensure long-term policy decisions are more effective and trusted. Tested in Flanders, Athens and Pilsen, DUET creates an advanced Local Digital Twin open and scalable (federated) digital prototype where all stakeholders (policy makers, local businesses, citizens and organisations can profit from.

[83] https://netzerocities.eu/

[84] https://www.digitalurbantwins.com/

- DRural[85]

  Relevance:
  - Inclusion of rural areas
  - Service definitions for rural areas
  - Interoperability (MIMs development)

DRural was funded by the Horizon 2020 research and innovation programme to cater to rural areas. Although these areas host 20% of Europe's population they tend to have a below-average European GDP. To boost these areas, DRural co-develops a digital marketplace of services for people living in rural areas to ultimately improve the quality of life.

- AI4Europe & AI on Demand Platform[86]

  Relevance:
  - Adoption of AI in Europe
  - Excellence of AI and AI-based robotics SMEs

The AI-on-Demand Platform (AIoD) is a community-driven channel designed to empower European research and innovation in AI, while ensuring the European seal of quality, trustworthiness and explainability. AIoD facilitates knowledge sharing, research experimentation and development of state-of-the-art solutions and technologies related with AI and AI-based robotics. AIoD is an open and easily accessible environment for the AI community, including AI researchers from academia and industry, students, SMEs, Tech providers and EU-funded projects, Digital Innovation Hubs and other EU bodies, who can use AIoD by contributing with AI-related knowledge, assets, services or tools, making use of the numerous resources available, including educational courses, learning about the potential and opportunities of AI applications, Engage with other peers and experts.

[85] https://drural.eu/

[86] https://www.ai4europe.eu/

- Takeaways

What follows is a schematic overview of the above sections on the various European initiatives and projects.

Initiative/Project	Main Focus	Activities/Objectives
European Digital Innovation Hubs (EDIHs)	Digital challenges, competitiveness	- Access to technical skills - Test before you invest - Innovation services - Boost networking, cooperation, and knowledge transfer
European Digital Infrastructure Consortiums (EDICs)	Cross-border digital initiatives	- Establish legal entities by at least three member states - Contribute to Digital Decade goals
Digital Solutions for the New European Bauhaus	Sustainability, inclusivity	- Training, digital toolkits, observatory - Stakeholder engagement
Living-in.EU Movement	Digital transformation support	- Platform for regional and local public actors to share knowledge - Minimal Interoperability Mechanisms (MIMs Plus)
Data Space for Smart and Sustainable Cities and Communities (DS4SSCC)	Cross-sectoral cross-domain data space	- Co-develop data space blueprint - High-priority data sets - Stakeholder engagement
Digital Transformation for Regions	AI and Big Data solutions	- Enhance public administration efficiency and effectiveness in user-centric services - Capacity building, mutual learning
CommuniCity/OrganiCity/Synchronicity	Citizen-centered solutions, inclusion	- Focus on marginalized communities - 100 pilots using technology for inclusion
Local Digital Twin Toolbox	Local Digital Twin development	- Definition of minimum conditions for Local Digital Twin elements - Foster deployment of MIMs-compliant solutions
Gaia-X	Federated data economy	- Architecture specification and open-source tools - Creation of federated services for data spaces
Scalable Cities	Smart Cities and Communities demonstration of innovations	- 550 demonstrations - Action grants for proven measures - Peer-to-peer learning

Initiative/Project	Main Focus	Activities/Objectives
NetZeroCities	Climate neutrality support	- Help achieve climate neutrality by 2030 - One-stop platform for tools, resources, and knowledge
DUET	Digital Twin using open data	- Create advanced LDT open and scalable prototype - Leverage cloud and high-performance computing to impact policy cycle
DRural	Digital marketplace for rural areas	- Improving quality of life in rural areas - Development of digital marketplace for rural areas
AI4Europe & AI on Demand Platform	AI research and innovation	- Platform for knowledge sharing - Empowerment of European AI research and innovation

Table 5. Overview of relevant EU European initiatives and projects for CitCom.ai

European cities and communities

The definition of a smart city and the name of the concept has gradually been broadened in Europe from “a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business”[87] over a sustainable smart city focusing on the longer term and also taking into account the economic, social, environmental and cultural aspects[88] to sustainable and smart cities and communities, with the “community” dimension including inhabitants, businesses, visitors, organisations and administrators[89] while Living-in.eu also includes cities and “communities” of all sizes[90]. This entails an additional complexity in thematic focus and in stakeholders. It is hence no longer sufficient to just focus on the application of digital technology in urban areas.

The following sections will present relevant stakeholder groups, provide information on the strategic focus of local, regional governments and agencies, look into their digital maturity, and outline purchasing and current challenges in AI and robotics integration. This analysis will be the basis for a series of conclusions and recommendations to guide the service development.

Stakeholders

Territory matters: cities and communities are an important layer for Europe in driving the sustainable development of the EU, as they are the level closest to citizens and firms; moreover, space-specific characteristics drive the competitiveness of local areas.[91] They act as engines of the new economy, as places of connectivity, creativity and innovation and centres of services.[92] City authorities are increasingly experimenting and piloting AI in combination with other tools like IoT, 5G and Big Data, this is however a slow process to arrive at the needed impact level[93].

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87 https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en

88 https://unece.org/housing/smart-sustainable-cities#:~:text=A%20smart%20sustainable%20city%20is,as%20well%20as%20cultural%20aspects

89 https://digital-strategy.ec.europa.eu/en/policies/smart-cities-and-communities

90 https://living-in.eu/declaration

91 https://journals.sagepub.com/doi/10.1080/0042098022000027022

92 https://ec.europa.eu/regional_policy/sources/studies/citiesoftomorrow/citiesoftomorrow_final.pdf

93 https://eurocities.eu/wp-content/uploads/2020/08/Eurocities-statement-on-AI.pdf

Key stakeholders to the smart and sustainable cities and communities concept are situated within the public sector and not limited to local authorities. The public sector is defined as the national, regional and local governments plus institutional units controlled (and financed) by government units[94] . Following categories are all within the public sector domain.

Public sector organisations

Generally speaking, the public sector is composed of three types of organisations: Core government, agencies and public enterprises or corporations. Core governments have a defined territorial authority. These include all structural parts of the government like departments, ministries, or branches. They are accountable and report directly to the central authority[95]. Agencies are public organisations that deliver public programmes, goods or services. They may be a separate legal entity and operate with a partial degree of independence[96]. Government authorities in EU countries also manage public services directly and indirectly through the creation of public corporations or enterprises in which they participate totally or partially (in some cases with other organisations)[97]. The public services they render may relate to their own activities or be passed down from other levels of governments[98].

Within our scope we will include the local level, the regional level and the agencies. Public corporations or enterprises are a very particular type of entity for which additional research is needed, consequently these are out of scope for this market analysis.

Communities

For the development of smart cities and communities, it is important to not solely count on local authorities to implement innovative urban projects. A key role in the creation of an open information society, which is the basis for the development of smart cities, is also played by business - especially so-called high-tech companies -, universities and community organisations. The implementation of the function of corporate social responsibility (CSR) or social responsibility of science allows, in cooperation with citizens, to create a sustainable smart city ecosystem. Such a development model is ensured not only by infrastructural investments, but, above all, the development of smart cities stimulated by social participation. What follows is a list of possible actors which, through merging and vaguening of roles, might account for part of the future demand in the smart cities and communities realm:

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[94] https://unstats.un.org/unsd/nationalaccount/aeg/papers/m4Delineation.PDF

[95] https://www.theiia.org/en/content/guidance/mandatory/standards/public-sector-definition/

[96] https://www.theiia.org/en/content/guidance/mandatory/standards/public-sector-definition/

[97] https://doi.org/10.1111/1467-9302.00328

[98] https://doi.org/10.1111/1467-9302.00328

- Industry through corporate social responsibility efforts

The use of CSR is an important element of cooperation between business, local/ regional government and its citizens, but the purely business role of start-ups (especially high-tech) should also be recognised. The formation of a "critical mass" of innovation at the interface of business and academia. In that way, technology start-ups allow for comprehensive development of the smart city.

- Academia through practical research

Universities - both technological and applied social sciences - play an equally important role in smart city development. A key issue is the interdisciplinary cooperation of scientists from different fields and, analogous to business, the social responsibility of science.

- Civil society through participation and cooperation

The process of social participation not only means the social gathering of data and their subsequent transformation into useful information and knowledge, but – predominantly – the process of social activation leading to the conscious use of social engagement and ICT, AI and geoinformation technology to shape an open information society. For example, the exploitation of a (smart) city's social networking and collective awareness can lead to improvements in citizens' daily lives and assist the city's crowd-wise policy and decision-making [99].

Top-down vs. bottom-up Engagement

Social participation is the process by which citizens actively participate in issues that are important to them; they share their experiences or views to work out a common development vision and action plan. What is crucial in social participation is that citizens participate in decisions being made by the authorities. One of the tools used to characterise and valorize the process of social participation in implementing public services is a ladder of citizen participation. This concept distinguishes eight levels of participation.[100] The first two rungs are Manipulation (1) and Therapy (2), effectively meaning that public authorities make decisions on their own, without informing the public. The next three rungs of the ladder signify token actions: authorities make decisions on their own, but inform the public of decisions that have already been made. Co-decision-making is at the highest level of the ladder: prior to making a decision, public authorities cooperate with social partners or transfer decision-making ability to groups or social partners. According to the research, "Further up the ladder are levels of citizen power with increasing degrees of decision-making clout. Citizens can enter into a

[99] https://doi.org/10.1007/s13132-016-0370-z; https://doi.org/10.1016/j.landusepol.2021.105614
[100] https://doi.org/10.1080/01944366908977225

(6) Partnership that enables them to negotiate and engage in trade-offs with traditional power holders. At the topmost rungs, (7) Delegated Power and (8) Citizen Control have-not citizens obtain the majority of decision-making seats, or full managerial power." For the creation of an open information society in the smart city, it is important not only that the level of public participation on the Arnstein "ladder" is as high as possible, but also that a significant part of the city's activity is stimulated by a bottom-up approach, in which citizens influence the actions of the authorities.

Living Labs

An important role in the creation of smart cities is to stimulate the development of an ecosystem of cooperation between innovative companies and scientific units. The formation of technology start-ups is important for the development of smart cities. The ecosystem that supports the development and incubation of such entrepreneurship is Living Labs. Living Labs created through cooperation between universities (especially technical universities) and companies from the socio-economic environment stimulate not only the development of entrepreneurship, but also the development of the information society. Living Lab can be understood (depending on the context) as:

- a method to study behaviour in natural settings;
- an environment to observe "natural" reactions and (human-technology) interaction;
- an environment to engage relevant actors in co-creation and open innovation.

Today, the term Living Lab is understood as:

- Open innovation networks: "Living labs are networks that can help [companies] create innovations that have a superior match with user needs and can be upscaled promptly to the global market."[101]
- Regulatory sandboxes: "Living Labs are test spaces limited in time and space, in which innovative technologies or business models are tested under real conditions, which make use of legal leeway and which are linked to an interest in regulatory insights."[102]
- Platforms for transformative, transdisciplinary research: "Living Labs are social contexts in societal reality in which scientists and practitioners can shape and at the same time investigate transformation in transdisciplinary cooperation."[103]

[101] http://doi.org/10.22215/timreview/602

[102] https://www.bmwk.de/Redaktion/EN/Publikationen/Digitale-Welt/handbook-regulatory-sandboxes.pdf?__blob=publicationFile&v=1

[103] https://doi.org/10.14512/gaia.24.1.7

The main activities in Living Labs deal with issues such as networking, research, and training. Living Labs are where innovations for smart cities are created in collaboration between academia, industry and city government with a human-centred approach.

Local, regional governments and agencies

Way of working and strategic focus

The local and regional governments are the level closest to the citizens and communities. Urban areas are inhabited by 39,3 % of Europeans, while 31,6% live in towns and suburbs and the remaining 29,1% in rural areas[104].

The focus of the public sector is on the common good. In order to bring this about they develop policies, deliver public services and manage the public domain. Figure 3 shows the policy cycle[105].

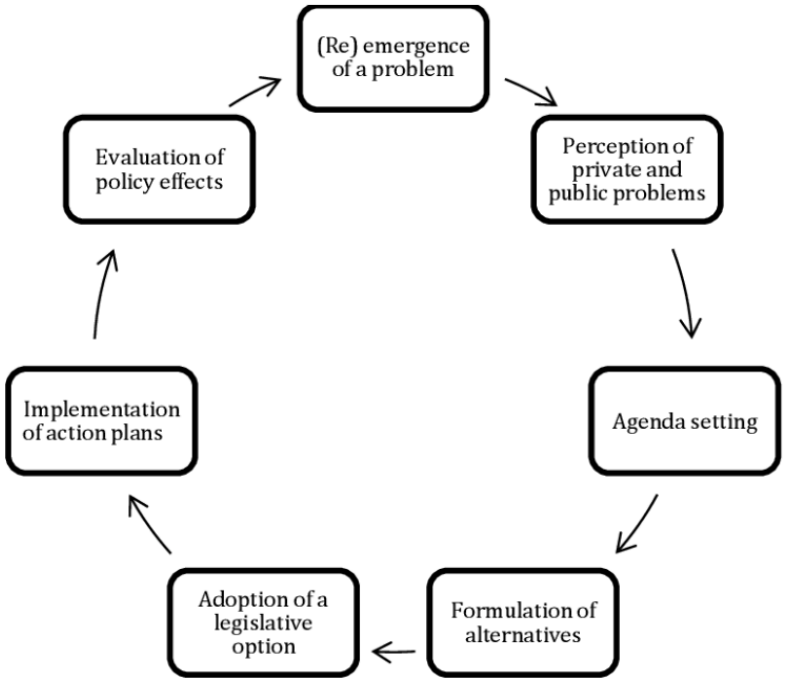


Figure 3. The policy cycle

In high-income countries the public sector contributes to between 20% to 30% of GDP, with the highest shares in Scandinavia[106]. There is a growing interest in this spending which is increasingly monitored through financial reports, supplemented with reports on social benefits and public value[107]. Innovation should be a core activity of the public

[104] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20200207-1

[105] https://doi.org/10.2307/j.ctt9qgz7q

[106] https://doi.org/10.1016/j.respol.2018.12.001

[107] https://doi.org/10.2139/ssrn.3140932

sector as it offers potential "*to improve performance and increase public value; respond to the expectations of citizens and adapt to the needs of users; increase service efficiency and minimise costs*[108]*."* However, the degree of innovation is highly dependent on the strategic management of innovation, its governance, the source and method of attaining ideas of innovation, the culture, the personal characteristics of individual bureaucrats and the capabilities and tools to support it[109]. Pressure to innovate might be present in function of public demand for new or improved services to budgetary constraints. The type of innovation and the magnitude will depend on if they are initiated by the elected arm or the public service, the first being larger and more externally focused and the later smaller and more focused on the way of working[110].

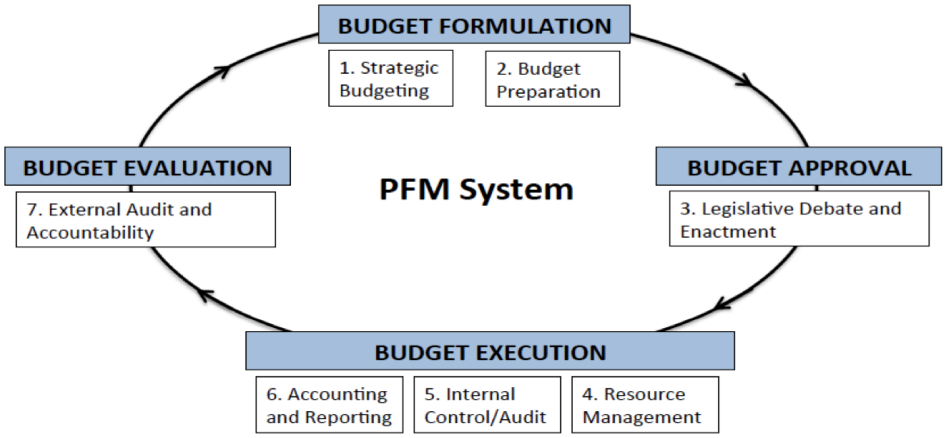


Figure 4. Visualisation governments' public financial resources management

Public procurement is the end result of a process after identifying needs, prioritising requests, determining criteria and budgeting as presented in Figure 4. There are competing alternatives for directly procuring products or services for smart cities and communities. They might for example first attempt non technological solutions, be interested in service contracts, decide to create the solution on their own, reuse a solution from another city or make use of external help (consultants or open source community) for a limited time period to create or adapt an existing solution. The last is often the case when they feel a standard solution might not be a good fit or they have a complex legacy of systems they need to integrate with.

108 http://www.sba.oakland.edu/FACULTY/MATHIESON/MIS524/RESOURCES/READINGS/INNOVATION/INNOVATION_IN_THE_PUBLIC_SECTOR.PDF

109 https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Public-Sector/dttl-ps-public-innovators-playbook-08082013.pdf

110 https://doi.org/10.1016/j.respol.2018.12.001

Budgets allocated to ICT by cities and localities ranged from 10 to 106 euro per inhabitant per year in 2022[111], Amsterdam estimated that one third of their expenditures went towards ICT[112]. While procurement is the official instrument for public purchasing, many cities are also engaged in development efforts where AI finds its way into the municipalities through partnerships and innovation projects. Partnerships provide a way for cities to test new technology, often with external funding, in real life settings before investing. To companies, innovation projects provide opportunities to learn about factual conditions and use cases. It is also a way for companies to penetrate into the public market.

For national governments and the EU, funding projects is a way to stimulate certain activities. One example is the Danish national government effort to stimulate the uptake of AI in the public sector. Since 2019 15 AI 'Signature Projects' have been funded each year.[113] 20 of these projects are conducted at regional level within Health, while other 20 are conducted at municipal level focusing on service delivery within administration, employment, climate plans, nursing, and health. The majority of these projects have stopped short of full implementation.[114]

AI and robotics are two technologies that are trending. Many governments are eager to learn about and experiment with these to tap into the potential these offer in improving policy making processes, public service delivery and the internal management of public services[115]. Findings from the review of a sample of 250 cases across the EU, which can be found in Figure 5, show that AI is used mainly to support improving public service delivery, followed by enhancing internal management and only in a limited number assist directly or indirectly policy decision-making[116]. The analysis suggests that different types of AI technologies and applications are used in different governance functions, highlighting the need for further in-depth investigation to better understand

111 https://mxi.nl/kennis/628/ict-kosten-gemeenten-stijgen-in-2022-met-10-euro-naar-106-euro-per-inwoner#:~:text=euro%20per%20inwoner-,ICT%2Dkosten%20gemeenten%20stijgen%20in%202022%20met%2010,naar%20106%20euro%20per%20inwoner&text=In%202022%20zijn%20de%20ICT,vacatures%20ingevuld%20door%20ingehuurd%20personeel

112 https://www.parool.nl/amsterdam/amsterdam-geeft-164-miljoen-euro-meer-uit-dan-gedacht-vooral-ict-vraagt-veel-geld~b93055fc

113 https://en.digst.dk/digital-transformation/national-uptake-fund-for-new-technologies/

114 https://digst.dk/media/28384/status-paa-signaturprojekterne-2022.pdf

115 https://doi.org/10.1016/j.giq.2022.101714

116 https://doi.org/10.1016/j.giq.2022.101714

the role and impact of use in what is being defined as the governance "of, with and by AI"[117].

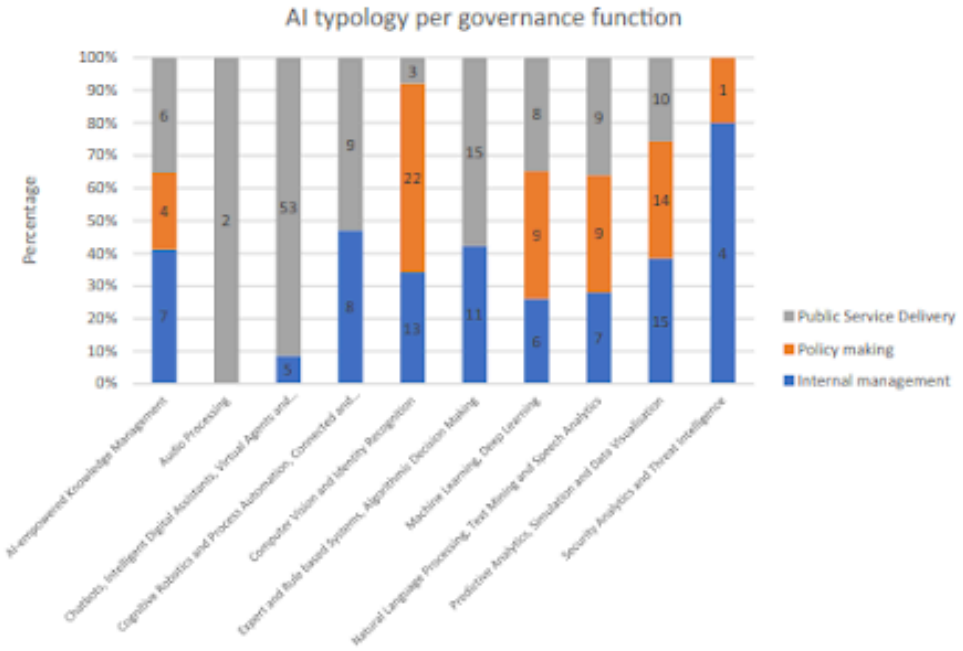


Fig. 3. AI typology per governance function.

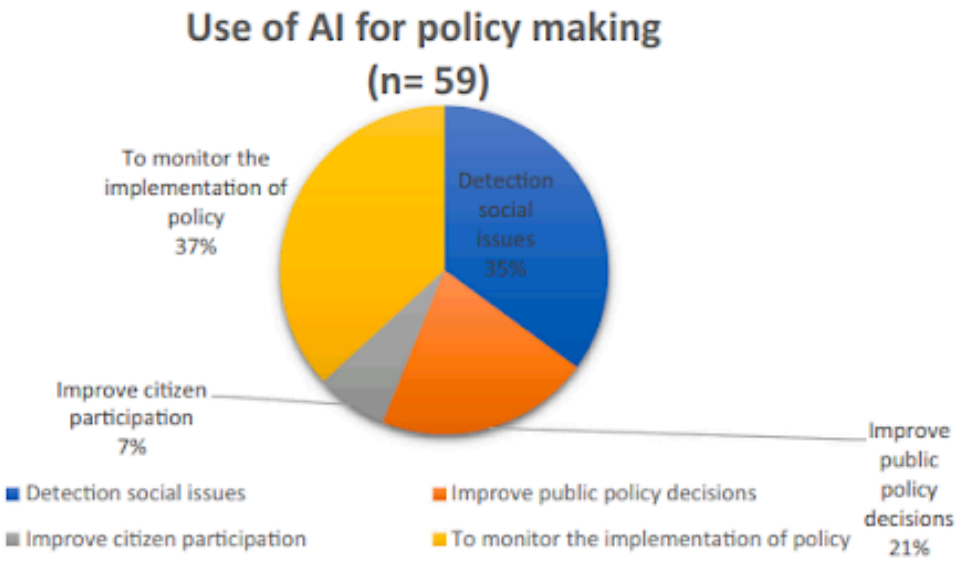


Fig. 4. Use of AI for policy making.

Figure 5. AI Typology and AI-use for policy making

[117] https://doi.org/10.1016/j.giq.2022.101714

Public Sector Tech Watch and CitCom.ai

European cities and communities have started to use AI. The EU Commission (DG DIGIT) and JRC support the collection of these use cases in order to promote and share knowledge of public sector innovation. The collection is available as the Public Sector Tech Watch database[118] and provides a perspective of what AI is being used and purchased by the public organisations in EU.

Figure A.1 shows the number of public sector AI projects in the EU per year, based on Public Sector Tech Watch database. The database represents historic cases. Although the database is continuously updated, it seems that use cases from 2022 onwards (perhaps even 2021) are underrepresented.

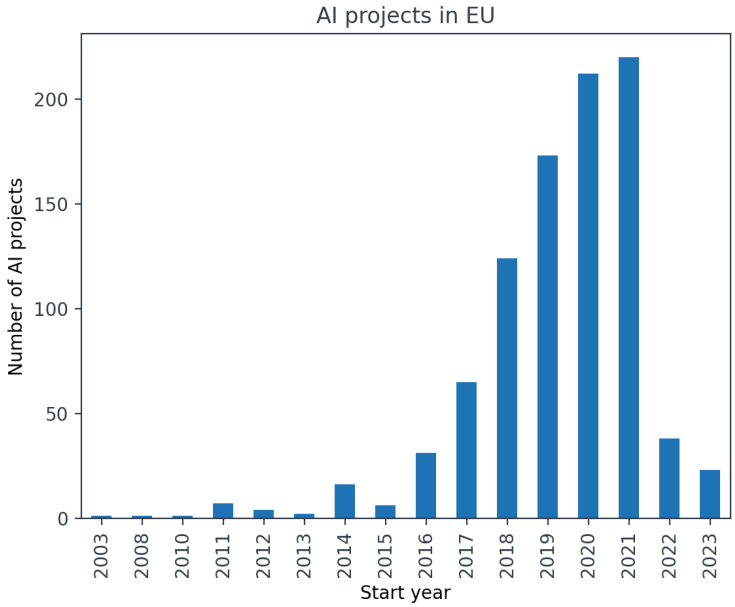


Figure A.1. Number of public sector AI projects in the EU per year.

Figure A.2 displays the distribution of AI projects over the different levels of government. The Public Sector Tech Watch includes 1107 cases of AI and Blockchain, of which 924 cases of AI. Opening up the database we note that national governments are home to approximately half of the use cases (in sum 448[119]), whereas cases in cities and communities amount to 365 in total.

[118] https://joinup.ec.europa.eu/collection/public-sector-tech-watch/cases. Data is continuously updated. The following presentation of insights from the database is based on a download dated 25 oct 2023.

[119] The labelling in the database are not in full consistent but kept in place. In time of writing we have not been able to access metadata. The 448 cases consist of the 422 cases in 'Central-Government' and the 26 in 'Governmental'.

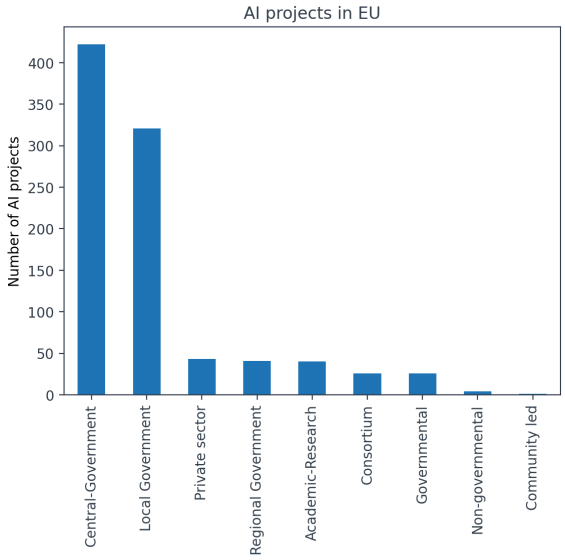


Figure A.2. Distribution of AI projects over the different levels of government.

Figure A.3 shows the number of AI projects per EU member state. The cities in the Netherlands are the most frequent users of AI, followed by cities in Italy, Germany, Norway, and Denmark. In the lower end, only one use case from each of the member states Austria, Bulgaria, Czechia, Greece and Slovenia have been reported to the database.

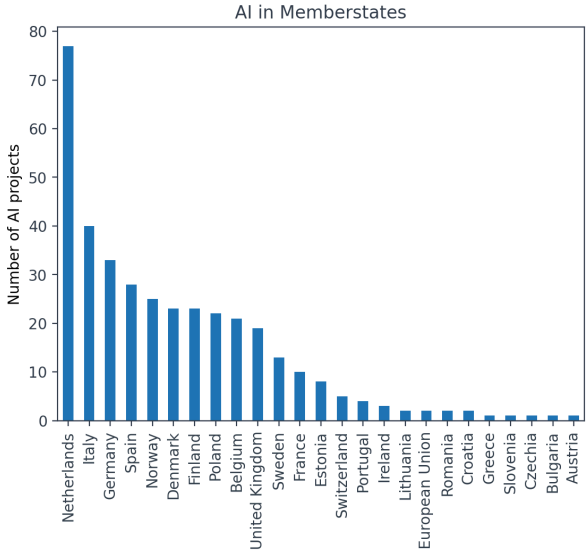


Figure A.3. Number of AI projects per EU member state.

Figure A.4 shows the domains in which AI projects are employed in the EU. It can be discerned that the most frequent AI introduced in EU cities are General public services, Economic affairs and Health, followed by Public order and safety, and Social protection. Looking deeper into the domains, Transport comes out as the domain with the highest number of introduced cases followed by Legislative, Financial and Fiscal affairs.

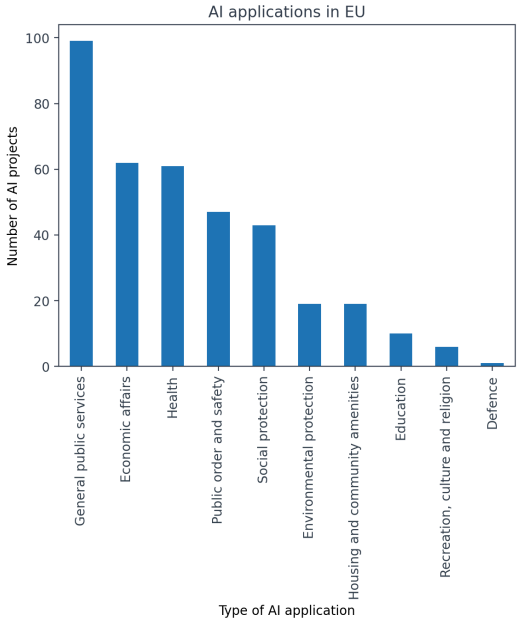


Figure A.4. Domains in which AI projects are employed in the EU.

The main types of AI projects introduced in the EU are ML, NLP, Computer Vision and Planning and Scheduling. At a significant lower level, these four types are followed by different types of automation; Automated reasoning (22), Robotics and Automation (17), Connected and automated vehicles (CAVs) (4). Together, they represent approximately 10 percent of all cases of cities and communities and suggest at least an interest in implementing AI systems in full.

In general, the analyses reflect a demand from cities and communities for general AI applications. For CitCom.ai and the initial focus areas of Power (Northern Super node), Move (Central Super node) and Connect (Southern Super node) this market insight should be considered and investigated. The exception is the central node's focus on transport related AI where a significant proportion of use cases is seen.

From an EU wide geographical perspective the member states that are represented in CitCom.ai are all positioned in the top when looking at introduced AI. The south-eastern member states have a much lower introduction of AI nor are they represented in CitCom.ai.

Digital Maturity

Digital maturity of local, regional governments and agencies was the focus of the Digiser project. Concretely, digital capacities are analysed as digital maturity and calculated into an index of the general ability of municipalities and public administrations to embrace and adopt new technologies. Several notable takeaways emerge from the Digiser results.

First, it was found that, in terms of size, cities with large public authorities tend to benefit from economies of scale, and when addressing the challenges related to institutional capacity, particularly those concerning skills and capabilities, larger public authorities (population size exceeding 500,000) exhibit greater proficiency. Notably, over 65% of these larger public authorities have published strategies for digital innovation. In contrast, approximately 50% of smaller public authorities, with populations ranging from 50,000 to 100,000, have undertaken similar measures[120].

Moreover, the degree of service integration is notably higher in larger public authorities, (population exceeding 250,000)[121]. This trend becomes evident when considering data management capabilities, as larger cities with a resident population exceeding 250,000 consistently exhibit greater performance in this regard. A similar pattern emerges concerning public authority types: parishes and wards, typically characterised by lower population and GDP-per-capita figures, tend to score lower on data management capacity compared to their larger counterparts, such as municipalities, metropolitan areas, counties, and provinces. In addition, data pertaining to GDP per capita reveals that wealthier public authorities generally exhibit higher levels of proficiency in data management, albeit within a narrower range. Notably, there is a significant decline in data management scores for cities with GDP-per-capita figures under 10,000 EUR[122].

Zooming in on the Digiser index of digital capacities, i.e. digital maturity, which is composed of three main subsections: digitization, innovative technologies, and advanced methods, we derive several insights. A first insight finds a variation across Europe. The highest levels on the maturity index are in general found in western Europe, whereas the Eastern parts are dominated by lower observed digital maturity. A second insight required diving into the subsections of the index. Specifically, differences between levels of the three subsections are noted. Most cities have started a digitization process where they are digitising current processes and in some cases also transforming these with use of digital technologies. However, the ability to adopt innovative technologies is more limited than just using digital technologies. This is

[120] https://www.espon.eu/DIGISER

[121] https://www.espon.eu/DIGISER

[122] https://www.espon.eu/DIGISER

important as it is exactly the ability of public institutions that is identified as a potential driver for innovation within the EU. Exactly this becomes visible in Figure 6 below, displaying the digital maturity overview, based on a reference sample. The element of innovative technologies (such as AI, blockchain etc.) is shown to score lower on average than the other two elements, with 0.28 compared to the other two elements with scores of 0.50 and 0.60.

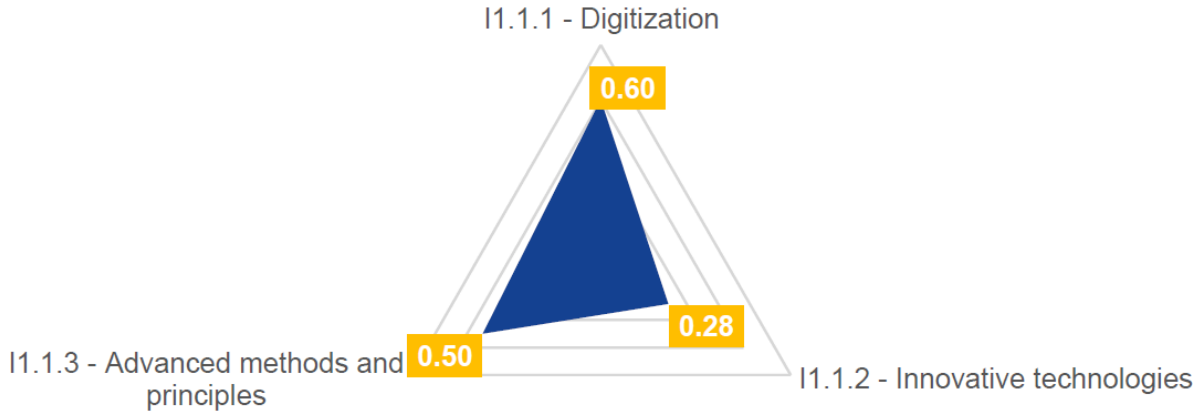
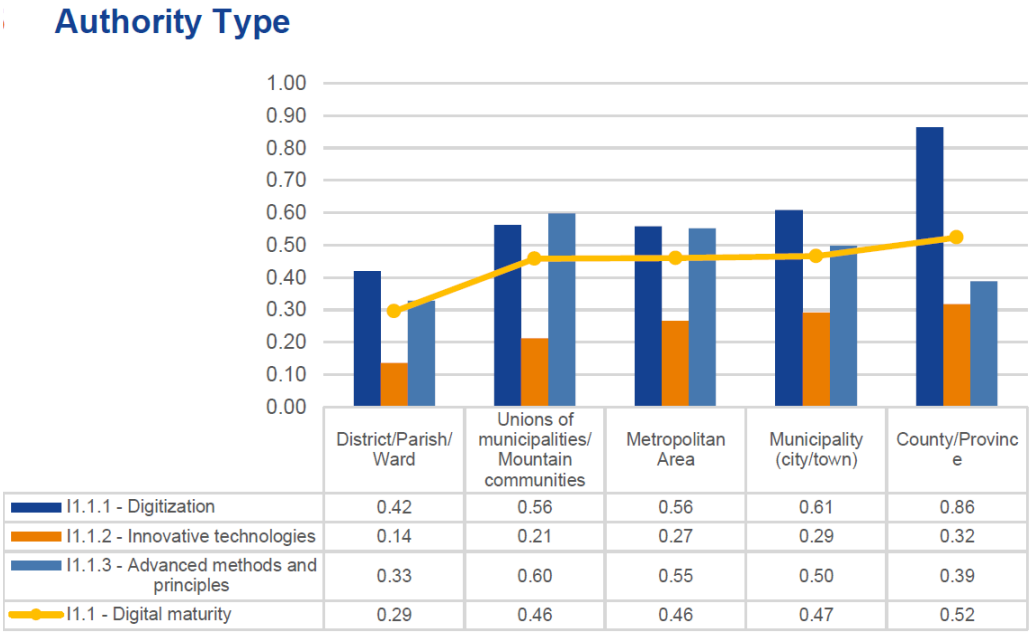


Figure 6. Digital maturity overview

When exploring the digital maturity level a bit more in depth, digging into different clusters for measurement, sorted by population size, GDP per capita, and authority type, the tendency of the lower scoring element of innovative technologies (shown in orange in Figure 7 focusing on authority type) becomes evident.



	District/Parish/ Ward	Unions of municipalities/ Mountain communities	Metropolitan Area	Municipality (city/town)	County/Province
I1.1.1 - Digitization	0.42	0.56	0.56	0.61	0.86
I1.1.2 - Innovative technologies	0.14	0.21	0.27	0.29	0.32
I1.1.3 - Advanced methods and principles	0.33	0.60	0.55	0.50	0.39
I1.1 - Digital maturity	0.29	0.46	0.46	0.47	0.52

Figure 7. Digital maturity by authority type

Challenges

It can be discerned that some of the main challenges underlying limited digital maturity and capacity point towards lack of access to data and lack of technical know-how in public authorities. Among these challenges, a prominent concern is to free data from silos, fostering a transition toward versatile services that align with the diverse needs of the public authorities[123]. Moreover, data-sharing initiatives between various governmental levels often remain limited in scope. Even amid growing public distrust in institutions, the utilisation of transparency measures remains suboptimal due to a myriad of factors[124]. Many cities have adopted data platforms, although the quality of these platforms tends to be lower in municipalities with populations under one million, again pointing to economies of scale.

Another noteworthy challenge arises from the lack of a central coordinating entity and the notable disparities in technical expertise and maturity levels across different municipal departments. Certain departments, such as those dealing with construction, water management, and transportation, may demonstrate a high degree of digital maturity, while others, particularly in the social and cultural domains, may lag significantly behind. Consequently, numerous administrative processes between departments remain non-digitized, impeding the delivery of digital services to citizens[125].

It can be concluded that digital maturity of local, regional governments and agencies varies widely in the EU Metropolitan areas with abundant resources demonstrate a higher level of strategic planning, cohesive services, and decision-making based on data analysis. Nevertheless, even the most technologically advanced governments and agencies have challenges when it comes to using breakthrough technology in a systematic manner. Furthermore, similar factors promote or hinder the progress of digital government capabilities whatever the starting point. Data silos hinder the efficient utilisation of data across different departments and a lack of coordination inside and among authorities renders efforts less effective than they could be.

In a society that is more and more influenced and enabled by digital technology, it is important to facilitate the required cooperation on a European scale. Although diversity is one of Europe's strengths, it can also be our weakness. Innovative solutions can't be implemented across countries because of differences in legislation, technological readiness, financial priorities, means, and so forth. Therefore, it is necessary to find a common ground that enhances our ability to elaborate and upscale digital solutions and

[123] https://living-in.eu/

[124] https://www.espon.eu/DIGISER

[125] https://www.espon.eu/DIGISER

align these in terms of technology (e.g., interoperability), information (e.g., ontology), and public values (e.g., principles and ethics)[126].

Challenges and opportunities in information technology, ML and AI have found their way on the political agenda. But governments and businesses are still organised in silos, trapped in complex and big organisations that lack the proper means to interact effectively and efficiently. They fail to benefit from new possibilities, while also safeguarding public and people's interests[127].

Skills and capacities have a broad impact in the service provision. The abilities, working conditions, resources and motivation of public servants are key to ensure the efficiency of public services. Ideally this issue needs to be solved within the organisation instead of systematically turning to subcontracting. Public authorities need to develop and implement a long-term digital vision and an adaptable framework of actions, namely by ensuring that the city's digital infrastructure design is agile and allows for onboarding of new innovations[128]. A particular challenge if the procuring organisation lacks expertise and competence within the technical field of AI. Another complicating fact is that AI algorithms often operate as "black boxes," making it hard to explain their decision-making or understand their recommendations[129].

Moreover, there is a lack of knowledge among politicians and high level leadership. To work with AI is demanding, knowledge wise as well as resource wise, since it is a new and complex technology. When the leadership, both political and administrational, are hesitating it is hard for any kind of organisation to just go for it. You need to have access to strong leadership that knows where to go and why and that can support the organisation continuously during the way. This may be one of the largest challenges to handle with the public sector.

Also budget processes can be a challenge. When an organisation wants to use AI the way to plan and execute on the budget side needs to change. Developing AI is similar to working with innovation which means it is difficult to predict if and where the outcome/value ends up (if and when you get RoI). To develop or implement AI in an immature organisation often means spending time learning, testing and collaborating to be able to access value. In a public organisation this way of working is unfamiliar and challenging.

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[126] https://living-in.eu/

[127] https://living-in.eu/

[128] https://www.espon.eu/DIGISER

[129] https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/662936/IPOL_BRI(2021)662936_EN.pdf

For cities and regions, various bottlenecks may potentially hamper on the one hand the efficient deployment of AI technologies, while on the other hand also causing AI technologies a heterogeneous impact on economic outcomes at territorial level.

Within the EU, a large proportion of firms belong to the SME class. Small firms may find it hard, and financially unsustainable, because of the substantial role played by overhead costs, to transition to these new technologies.[130] Along the same lines, SMEs may find it hard to dedicate a substantial share of their budget for advanced IC technologies, which would also cause a non-negligible complexification of ICT governance.[131]

On a related topic, SMEs typically differ from larger companies also in terms of managerial practices. Larger firms may find it easier to reach out to frontier AI technologies, due to their structured approach to innovation.[132]

At the same time, the structure of European business may enhance the adoption of AI along many dimensions. For one thing, recent evidence points at a stronger attitude towards long run orientation in family-owned business.[133] Moreover, smaller firms may also more easily identify the potential embedded in AI technologies through a more resilient hierarchical structure.[134] While the lack of resources affecting SMEs compared to their larger counterparts cannot be denied, small firms may actually compensate for this gap through a more cooperative approach.[135] Lastly, smaller firms may also benefit serendipitously from the adoption of frontier technologies, in a way that larger firms may find impossible to achieve due to more formal and rigid practices. [136]

Moving to the likely heterogeneous impact that the adoption of AI technologies may exert on regional and urban economic performance, while evidence is to date very scant, recent work does hint at a spatially uneven distribution of – more broadly speaking – Industry 4.0 technologies in European territories, with a consequently heterogeneous impact on economic performance.[137]

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[130] https://www.jstor.org/stable/40239907
[131] https://doi.org/10.1057/palgrave.ejis.3000430
[132] https://doi.org/10.1287/mnsc.2016.2492
[133] https://doi.org/10.1080/0898562100372621 8
[134] https://doi.org/10.1007/s11187-012-9453-9
[135] https://doi.org/10.1111/j.1540-627X.2009.00286.x
[136] https://doi.org/10.1080/10630732.2022.2035886
[137] https://doi.org/10.1016/j.techfore.2021.121164

From an aggregate perspective, specific attention must be paid to the role of potential bottlenecks to AI adoption from the angle of public procurement.[138] In the European context, this is particularly relevant, as testified by the vast diffusion of this practice in an institutional context where collective actors play a predominant role. For instance, within the EU, 92,247[139] municipalities and regional authorities allocate nearly 14% of the total of the gross domestic product (GDP) in the EU[140] towards procuring services and products, and share responsibilities towards citizens in domains such as health, social care, housing, employment, environmental, emergency service etc.

To create a level playing field for businesses across Europe, EU law sets out minimum harmonised public procurement rules. These rules govern the way public authorities and certain public utility operators purchase goods, works and services. They are transposed into national legislation and apply to tenders whose monetary value exceeds specific thresholds. For tenders of lower value, national rules apply. Nevertheless, these national rules must also comply with general principles of EU law.[141]

Publicly procured service contracts are attractive to private firms as they provide predictable and secure sources of funding during a fixed period. However, procurement procedures tend to favour large firms: by 71% according to PWC reflecting the tendering capacity of these firms and the excessive risk aversion built into selection criteria.[142] This established dichotomy between large firms and SMEs and the success in public procurement tend to overlook differences between SMEs and treat SMEs (see also the points raised above on the role of firm size in co-determining the effective adoption of AI in EU territories). Based on empirical evidence researchers find a more nuanced correlation of firm size and tendering success, where medium sized companies share many of the same procurement capabilities as large firms.[143]

Procuring AI in the public sector has been challenging for a long time but recently the EU Commission has done a lot of work to overcome them. A collaboration resource

[138] Public procurement refers to the process by which public authorities, such as government departments or local authorities, purchase work, goods or services from companies.

[139] https://www.oecd.org/regional/EU-Local-government-key-data.pdf

[140] https://www.oecd-ilibrary.org/sites/18dc0c2d-en/index.html?itemId=/content/component/18dc0c2d-en; https://www.espon.eu/DIGISER

[141] https://single-market-economy.ec.europa.eu/single-market/public-procurement_en

[142] http://dx.doi.org/10.1108/JSBED-03-2017-0114

[143] http://dx.doi.org/10.1108/JSBED-03-2017-0114

“Support public buyers in procuring AI-enabled solutions that are trustworthy, fair and secure” has been launched where experiences, knowledge and tools are shared[144].

One example that can be found here is the City Council of Barcelona has published a Protocol to introduce AI into all municipal services, with guarantees[145].

This document sets the mechanisms for safeguarding the rights associated with each stage of the tendering and implementation of an algorithmic system by the Barcelona City Council, and establishes the governance and supervision bodies that will ensure that the impact of AI is in line with ethical principles[146]. More in detail, public procurement typically begins with a risk classification that helps the procuring organisation to properly sort offerings. Behind this first stage is the idea that contractors should adhere to these same criteria, by implementing the algorithmic system in question under the terms and conditions on data quality, data rights, algorithmic quality, transparency, data protection, development and operations, risk management, inspections and expenses.

Conclusion

European cities and communities present a complex landscape for the adoption of AI technologies. Local and regional governments, being the level of government closest to citizens, have a responsibility to establish policies and deliver services that promote quality of life. However, there is substantial variation throughout the EU in terms of strategic emphasis, digital maturity, and skills and resources available. As a result, AI is currently not meeting its potential in improving decision-making processes due to a perceived uncertainty and the sensitivity of this core public sector function[147]. Increased framing and temporal strategies can support a more impactful and thought-out introduction[148].

Digital maturity varies significantly across cities and communities in the EU, with bigger metropolitan regions displaying greater strategic planning and integrated data-driven services. Even the most sophisticated, however, lag in the methodical adoption of

144 https://public-buyers-community.ec.europa.eu/communities/procurement-ai/resources?field_theme_target_id%5B%5D=8

145 https://public-buyers-community.ec.europa.eu/communities/procurement-ai/resources/protocol-introduce-artificial-intelligence-all-municipal.

146 https://doi.org/10.1007/s13132-012-0084-9

147 https://doi.org/10.1007/s00146-021-01263-4

148 https://doi.org/10.1007/s00146-021-01263-4

modern technology. Differences occur not just across municipalities, but also within them, as certain technical departments score better than others. This siloed approach fragments resources and prevents coherent long-term digital visioning.

Skills and capacities also have an impact on service delivery. To be effective, public sector employees must have a wide range of skills, as well as adequate working circumstances and motivation. However, general skills in technical sectors such as AI remain low. Leadership is often uninformed about AI's requirements, both cognitively and in terms of resource management requirements. Budgeting systems must also develop to handle the unpredictability of innovation against standard project accountability.

Procuring innovative technologies poses additional difficulties. As an emerging field with opaque algorithms, public purchasers struggle with AI's complexity. When compared to established large-scale contractors, startups and SMEs face financial impediments to tendering. Experimenting with AI through collaborations offers a low-risk testing path prior to big investment. National and EU project financing intended to boost specific activities. However, pilot programmes often do not result in full deployment.

From the above overview, also several recommendations emerge:

- Digital maturity across the Union should be increased: facilitating technology transfer through multilevel networking, and living labs which nurture entrepreneurial ecosystems that incubate public sector relevant solutions, can aid in that regard.
- Skills and capacity should be developed further: Development should target leadership as well as (technical) public sector staff, and collaboration across levels of government and with innovation partners should be taken advantage of to spread knowledge while pooling scarce skills and investment.
- Public procurement should be employed intelligently: Budget allocation must balance accountability with agility to foster learning, and care should be taken to better involve SMEs and start-ups through e.g. aggregating procurement demand at regional or national levels. In any case, it would be beneficial to put the emphasis on procurement of long term solutions rather than continue in the piloting phase.

European AI industry

On the supply side, AI innovators are interested in developing AI-related/driven capabilities, products and services to be used in the context of smart cities and communities. AI innovators that are 'TEF customers' are expected to eventually become service providers for cities and communities. The following sections provide estimations of the European and global AI market size, give an overview of the landscape of EU AI innovators, outlines challenges for AI innovators in the smart cities and communities context, presents market trends and needs, performs an analysis of CitCom.ai competitors, and, finally, offers some conclusive overarching remarks.

AI market size estimations

This section zooms in on the European and global AI market size. Interestingly, analysts rarely coincide in terms of figures and market definition (what exactly is measured), but they give an idea / indicator of the market dimension and trends for the future.

Information found related to AI business and evolution provide figures around 1) the number of AI-related players in Europe, 2) the size in terms of revenue worldwide and in Europe, 3) investments in AI in different regions, and 4) estimations of the AI market for the Public Sector in Europe.

First, the AI Watch Index 2021 indicates that there were around 5776 AI economic players in EU28 in 2020 including research institutes, firms and governmental institutions[149]. From this number of AI firms, the JRC report identifies three types of AI firms: "those with a core business in AI that do not patent, those that only file AI-related patent applications, and those with a core business in AI and filing patent applications"[150]. The authors identify in Europe 43 firms (0.7% of all EU AI firms) have a core business in AI and file AI-related patent applications. Taking a broader view, the AI and Blockchain for the future of Europe study[151], which is based on the Crunchbase database information and in which are registered SMEs that have previously received funding. This study refers to 950 AI SMEs in EU27.

Second, as shown figure 8, Precedence Research's report published in June 2023, "The global AI market size was valued at USD 454.12 billion in 2022 and is expected to hit around USD 2,575.16 billion by 2032, progressing with a CAGR of 19% from 2023 to

[149] https://publications.jrc.ec.europa.eu/repository/handle/JRC129174

[150] https://publications.jrc.ec.europa.eu/repository/handle/JRC128744

[151] https://www.eib.org/attachments/thematic/artificial_intelligence_blockchain_and_the_future_of_europe_report_en.pdf

2032”[152], which already represents substantial growth. The value of the AI market in Europe provided by Precedence Research for 2022 is about 25% of the Global market size. Consequently, the AI Market Revenue is expected to reach US$ 712.61 billion in 2032[153], from US$ 137.06 billion in 2023.

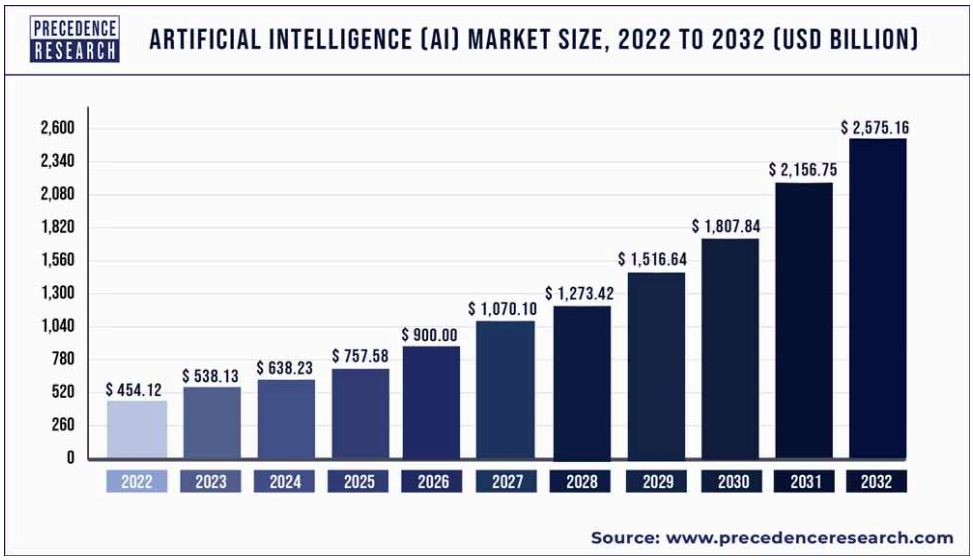


Figure 8. AI market size

Third, global investment data from Pitchbook reports that AI startups collected more than $115 billion in 2021, increasing investment 87.2 % year over year[154]. Another indicator of the size of the market currently and in the future is the investment in AI, in Europe and for sectors, if possible, applied to the Cities and Communities segment. The OECD.AI Policy Observatory database provides live data showing “timely trends about where, how and at what rate AI is being developed and used and in which sectors”[155]. As can be seen in Figure 9 representing Venture Capital (VC) investments in AI per industry in EU27[156], the data extracted, selecting the EU27 as country and industries relating to those considered in the CitCom.ai project, indicates a cumulative total from 2012 to 2023 of approximately $US 51.000 millions (51 billion).

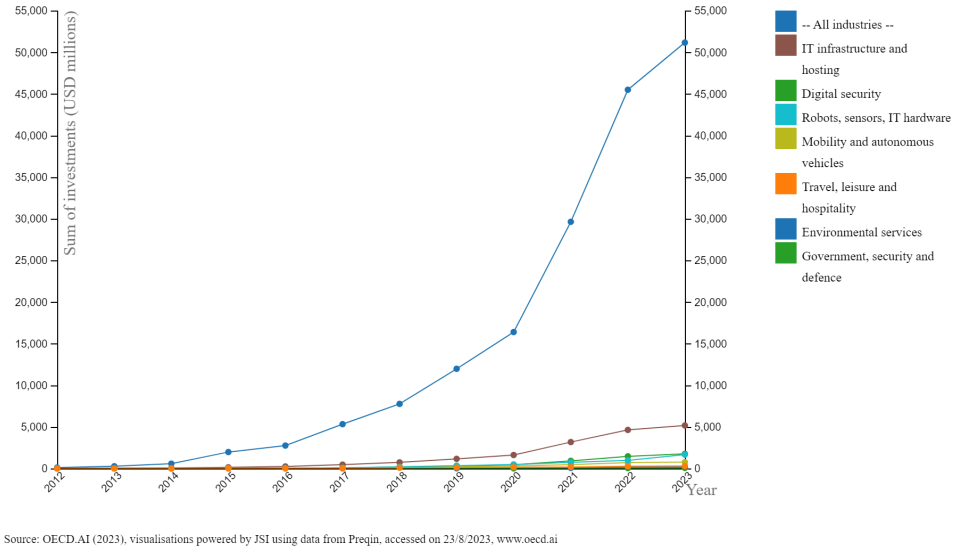
[152] https://www.precedenceresearch.com/artificial-intelligence-market

[153] https://www.precedenceresearch.com/artificial-intelligence-market

[154] https://pitchbook.com/news/reports/2021-annual-artificial-intelligence-machine-learning-report

[155] https://oecd.ai/en/data?selectedArea=investments-in-ai-and-data&selectedVisualization=vc-investments-in-ai-by-country-and-industry

[156] https://oecd.ai/en/data?selectedArea=investments-in-ai-and-data&selectedVisualization=vc-investments-in-ai-by-country-and-industry



Source: OECD.AI (2023), visualisations powered by JSI using data from Preqin, accessed on 23/8/2023, www.oecd.ai

Figure 9. VC investments in AI per industry in EU27

From the cumulative investment of VC in AI in different industries it is possible to infer which sectors related to CitCom.ai receive more investment. If compared to the total investment in Europe, it can be estimated that the proportion of funding for Mobility & Travel (MOVE), Energy (POWER) and industries that support digital development (CONNECT) represent a percentage of roughly 10-15%, meaning USD 5-7.5 billion. Based on information provided by EUROSTAT, Spintan and Intan-Invest, Europe invested over €15.9 billion in 2020 in the development and adoption of AI[157]. This figure includes both the private sector, which invested EUR 10.7 billion in the development and adoption of AI (67%) and the public sector, with an investment of EUR 5.2 billion (33%).

Of course, most relevant for CitCom.ai is what is expected to happen in the future. The JRC's AI Watch Report 2021, a target of €22 billion by 2030 was estimated[158]. Figures revised in JRC's publication "Estimating AI investments in the European Union", authors indicate that if the levels of growth between 2018 and 2020 are maintained, AI investments will surpass EUR 30 billion by 2025[159]. This figure is still half the one estimated by IDC[160]. According to IDC, "AI spending in Europe will post a compound annual growth rate (CAGR) of 29.6% between 2021 and 2026, compared with the

[157] https://publications.jrc.ec.europa.eu/repository/handle/JRC129174

[158] https://publications.jrc.ec.europa.eu/repository/handle/JRC128744

[159] https://publications.jrc.ec.europa.eu/repository/handle/JRC129174

[160] https://www.idc.com/getdoc.jsp?containerId=prEUR250505223#:~:text=AI%20spending%20in%20Europe%20will,then%20%2470%20%20billion%20in%202026

worldwide CAGR of 27.0%. Growth in Europe is being driven by Western and Central and Eastern Europe, with spending expected to reach more than $70 billion in 2026."[161]

Fourth, we attempted to provide some estimations for the AI market for the public sector in the EU specifically. According to Jason Shueh in a blog published in GovReport, "...AI is likely to be a necessity to manage government's ever-evolving service needs"[162]. However, data and statistics that would allow to determine the size of the market for AI in the public sector in Europe is scarce, especially for Cities and Communities. As can be observed in the OECD.AI Policy Observatory, which is the only source found at this stage that provide sectoral data, Industry categories do not cover clearly the public sector "The industry categorisation is based on grouping 228 Preqin industry labels into 20 broader categories[163].

Characteristics of companies

According to the AI watch Index 2021[164], the majority of AI players are firms, with the presence of Research Institute representing only 6%. The Government plays a minor role. The analysis is not detailed enough to identify the size of the players or the intensity of AI engagement, for example in research activities.

Size of AI supply companies (startup, SME, large companies)

According to the EC[165] SMEs represent 99% of the businesses. One supposition could be that it is an indicator that this proportion is similar among AI companies. However, this seems to be in contradiction with what is happening in other regions of the world where prominent players in AI include large companies.[166]

Another aspect to consider is that AI technologies and services are emerging, they are often developed by start-ups and, as mentioned in Pitchbook blog post "Why Europe struggles to scale its.," it is difficult for deep-tech to scale-up[167]. Therefore, it can be expected that many supply companies will be relatively small, (i.e. less than 250

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161 https://www.idc.com/getdoc.jsp?containerId=prEUR250505223#:~:text=AI%20spending%20in%20Europe%20will,then%20%2470%20%20billion%20in%202026

162 https://www.govreport.org/ten-ai-government-tech-startups-to-watch-in-2022/

163 https://oecd.ai/en/data?selectedArea=investments-in-ai-and-data&selectedVisualization=vc-investments-in-ai-by-country-and-industry

164 https://publications.jrc.ec.europa.eu/repository/handle/JRC128744

165 https://single-market-economy.ec.europa.eu/smes_en

166 https://www.precedenceresearch.com/artificial-intelligence-market

167 https://pitchbook.com/news/articles/europe-deep-tech-vc

employees). Interestingly, the author refers to Europe's cultural aversion to risk when investing in deep-tech (including AI) start-ups, which supports the hypothesis that most AI companies in Europe are still small.

Geographical distribution of AI players in Europe

It may be relevant to identify the member states where most players are present, and define a different approach to the deployment of TEF services depending on the size of the local market. Figure 10, extracted from the JRC's TES Analysis of AI Worldwide Ecosystem in 2009-2018 shows that Germany and France are the countries in which there are more AI-related actors, followed by Spain and Italy (South Node), and the Netherlands and Sweden (North/central node)[168].

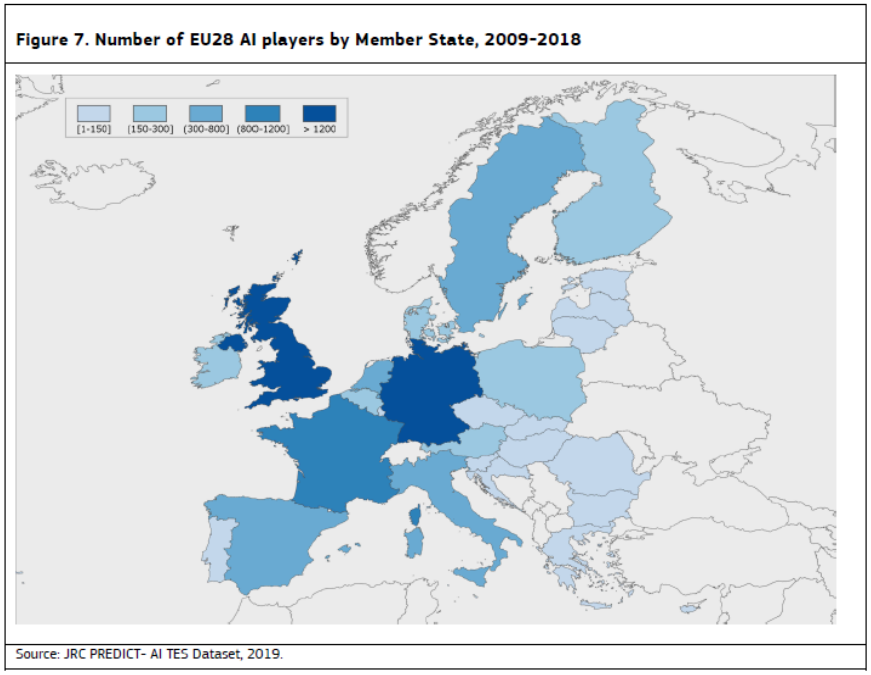

Figure 10. Number of AI SMEs per EU27 member state (heatmap)

In the report on 'AI, Blockchain and the future of Europe' a representation of the number of SMEs per country in Europe is provided by Figure 11, which helps to identify the number of AI SMEs in April 2020[169].

[168] https://publications.jrc.ec.europa.eu/repository/handle/JRC120106

[169] https://www.eib.org/attachments/thematic/artificial_intelligence_blockchain_and_the_future_of_europe_report_en.pdf

Figure 52: Total number of AI and blockchain SMEs per EU27 country, April 2020[219]

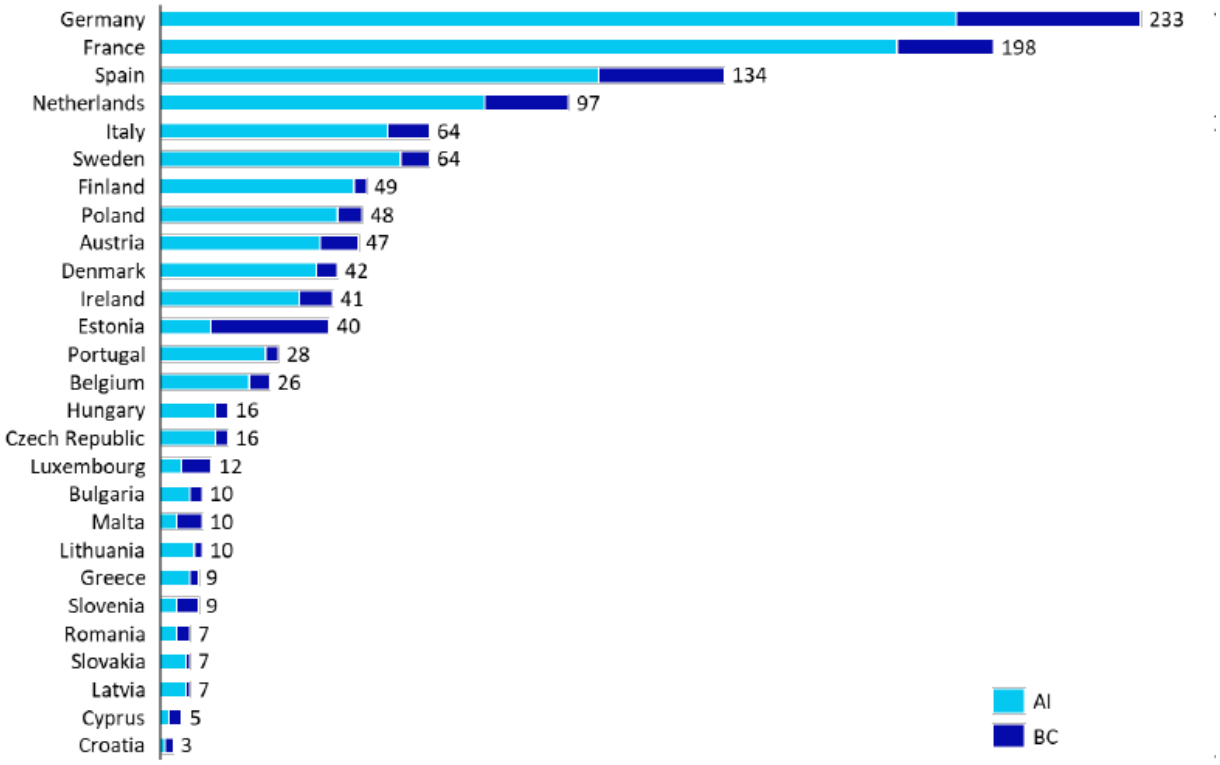

Figure 11. Number of AI SMEs per EU27 member state (overview)

In this report, the authors identify among 40% of AI companies in Europe, ten cities with the most AI SMEs. Although figures do not separate AI from blockchain SMEs, this information coincides with the data provided by the JRC report and is relevant for CitCom.ai, as it may be convenient to focus market research and communication efforts on those geographies: "Paris and Berlin are the largest hubs for AI and blockchain in the EU27, followed by Amsterdam, Barcelona and Madrid with over 40 AI and blockchain SMEs each"[170]. While SMEs are scattered around smaller AI centres, capitals tend to host the majority of a country's SMEs.

Thematic AI areas of activity

The JRC report identifies six non-exclusive thematic key areas within a global view on the AI landscape in 2009-2018[171] and details in which EU players are active: 1) Natural language processing (NLP), 2) Computer vision, 3) ML, 4) Robotics and Automation, 5)

170 https://www.eib.org/attachments/thematic/artificial_intelligence_blockchain_and_the_future_of_europe_report_en.pdf

171 https://publications.jrc.ec.europa.eu/repository/handle/JRC128744

CAVs and 6) AI Services. In their report on 'AI and the future of Europe',[172] the authors add a 7th area, AI Processing units, which relates to the hardware devices optimised for using AI technology. "The increased need for AI processing units is driven by several factors, most importantly the development of smart cities." (with a total market size of $91 billion in 2025).

The JRC report highlights two thematic areas in which the EU is especially strong; AI Services, i.e. services between firms (B2B) or to the end-consumers (B2C) and Autonomous Robotics, with a high impact in health, logistics or manufacturing, among others. However, some specific countries may be stronger in areas that are more related to CitCom.ai domains (energy, transport and connectivity), such as for example Germany, Sweden and Belgium high activity in CAVs.

The report identifies Robotic start-ups as a growing market, with new companies being founded every year and "an annual increase of around 10% of the cumulative number of start-ups from 2003 to 2015."[173] However, robotics are usually applied to other industries than the public sector. So, CitCom.ai's main targets (smart cities and the public sector) are rarely mentioned as an area of robotics application, although the TEF is supposed to cover both AI and Robotics.

Challenges for smart city AI innovators

CitCom.ai plays a crucial role in supporting AI innovators in the smart city domain by offering a range of services to bridge existing gaps.

One of the first gaps identified is the lack of cross-domain integration, allowing innovators to harness data and technologies from various sectors. An interconnected approach is likely to empower innovators to develop comprehensive AI solutions that can address multifaceted urban challenges effectively[174].

Another gap relates to the insufficient expert guidance in navigating the complex regulatory landscape, ensuring that innovators can meet safety, privacy, and ethical standards. This support is invaluable for AI companies looking to develop solutions that comply with legal requirements while also fostering trust among citizens and stakeholders[175].

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[172] https://www.eib.org/attachments/thematic/artificial_intelligence_blockchain_and_the_future_of_europe_report_en.pdf

[173] https://publications.jrc.ec.europa.eu/repository/handle/JRC128744

[174] https://www.azoai.com/article/Smart-Cities-in-the-Era-of-AI-Challenges-and-Opportunities.aspx

[175] https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/662937/IPOL_BRI%282021%29662937_EN.pdf

Moreover, a dedicated platform for prototyping and demonstrations, enabling innovators to test and refine their AI solutions in real-world urban environments is missing on the market. There is a need for assistance services for the development of viable business models, helping innovators turn their AI concepts into practical, sustainable offerings[176].

CitCom.aims to fill these gaps and also to tackle other challenges for AI innovators. Among the challenges, some of them consist of[177]:

- Data quality, quantity, and availability: access to comprehensive, accurate, and real-time data is essential for training AI models. Data may be fragmented, outdated, or incomplete, especially due to complex and not always well interconnected monitoring systems.
- Computational resources: deep learning (DL) models can be computationally intensive and require substantial computational resources.
- Real-time processing: AI models must be capable of handling and processing data in near real-time to be effective for decision-making.
- Model interpretability and transparency: ensuring that AI models are interpretable, and their predictions are explainable, is important for building trust among stakeholders.
- Scalability of the solutions: deploying AI solutions at larger scales can be logistically challenging and may require substantial infrastructure investments.
- Data privacy[178] and security: protecting sensitive environmental data and ensuring data privacy are important considerations.
- Community engagement: involvement with local communities, environmental organisations, and regulatory bodies is crucial for gaining support and acceptance.

What follows is a deep-dive into selected sectors with a specific view of challenges that are present in those contexts.

First, smart city and community AI innovators in the mobility and transportation sector may face Business to Government (B2G) market failures due to challenges related to data access and integration[179]. Governments often hold crucial transportation-related data (e.g., traffic patterns, infrastructure data) necessary for AI innovation in this sector. However, data sharing may be restricted due to privacy concerns, data ownership

[176] https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/662937/IPOL_BRI%282021%29662937_EN.pdf
[177] https://dataconomy.com/2023/07/06/challenges-in-artificial-intelligence/
[178] https://eurocities.eu/latest/cities-discuss-regulation-of-ai-and-its-many-challenges/
[179] https://joint-research-centre.ec.europa.eu/system/files/2020-02/jrc119947.pdf

issues, or a lack of standardised data formats. Inadequate regulatory frameworks for autonomous vehicles (AV) and mobility-as-a-service (MaaS) solutions can also hinder innovation and collaboration between innovators and government entities.

Second, AI innovators for the smart city and community domain focused on energy management and sustainability solutions may encounter market failures due to regulatory hurdles and fragmented energy markets. Integration of renewable energy sources and efficient resource management relies on data access and cooperation with government agencies overseeing utilities and environmental policies. Complex regulations, inconsistent incentives, and a lack of standardised protocols for connecting AI systems to the grid can create barriers to entry and collaboration. Moreover, the long-term nature of sustainability projects may deter private-sector investments without government support or clear policy frameworks[180].

Third, innovators in the public safety and security sector of smart city and community AI may experience market failures because of data sensitivity and regulatory constraints. Access to public safety data, such as crime statistics or emergency response information, is often subject to strict privacy and security requirements. Ensuring that AI systems can access and process this data while adhering to legal and ethical guidelines is a significant challenge. B2G collaborations here require robust privacy-preserving technologies and agreements to address concerns about surveillance and data misuse[181].

Main trends and needs in AI innovation

This section identifies the trends in AI innovation and needs of AI innovators. Interestingly, “Generative AI is dominating discussions on AI, having increased productivity for developers and knowledge workers in very real ways, using systems like ChatGPT ….”[182]. According to Precedence Research, the largest market share in 2022 is occupied by the DL segment, which revenue is expected to grow from USD 166 billion to 948 in 2032. “The rising technological advancements in the field of DL is expected to overcome the challenges associated with the high volumes of data.”[183] As can be seen in Figure 12, this segment is followed by ML, which is used in applications such as hypothesis generation, clustering, altering, tagging, clustering, filtering,

[180] https://www.sciencedirect.com/science/article/abs/pii/S0959652621000548

[181] https://www.deloitte.com/global/en/Industries/government-public/perspectives/urban-future-with-a-purpose/surveillance-and-predictive-policing-through-ai.html

[182] https://www.gartner.com/en/articles/what-s-new-in-artificial-intelligence-from-the-2023-gartner-hype-cycle

[183] https://www.precedenceresearch.com/artificial-intelligence-market

visualisation, and navigation promotes the development of the cognitive solutions. NLP and Machine Vision are the other trends.

Global Artificial Intelligence (AI) Market Revenue, By Technology, 2022-2032(US$ Billion)

Technology	2022	2023	2027	2032
Deep Learning	165.98	196.83	392.57	948.24
Machine Learning	122.59	145.43	290.57	703.50
NLP	91.33	108.31	215.94	521.48
Machine Vision	74.22	87.57	171.01	401.95

Figure 12. AI market revenue per sector

In terms of testing systems specifically, AI innovators have several needs. One of the main conclusions of the JRC AI for the Public Sector is "experiment first, scale-up later."[184] Use cases and experiences recommend "The 'test before invest' approach, as promoted by the European Digital Innovation Hubs, is the most promising way ahead, allowing mutual learning and scaling up of promising solutions."[185] Based on examples around the use of data and public sector regulations involving ethical and legal issues, the authors mention the need for simulations, experimentation spaces, joint experimentation allowing several industrial actors to participate, including SMEs. They also refer to living labs and sandboxes, and a particular requirement for standards.

In the Pierre Audoin Consultants (PAC) inBrief Analysis "Towards AI-based Digital Government & Smart Cities", the authors suggest to overcome the challenges of the public sector by applying a service design methodology that implies testing in close cooperation with users.
This is a common approach in the field of digital government and smart cities. Service design methodology typically involves a user-centred approach where government agencies and smart city planners actively engage with citizens and stakeholders to co-create and refine services and solutions. This approach can help address the challenges of the public sector by:

- Improving User Experience: By involving users from the beginning, services can be designed to be more user-friendly and tailored to their specific needs.
- Enhancing Efficiency: User feedback can identify inefficiencies and bottlenecks in processes, leading to streamlined and more effective government services.
- Increasing Trust: Involving citizens in the design process can build trust and transparency, as it demonstrates a commitment to meeting their needs and addressing concerns.

[184] https://publications.jrc.ec.europa.eu/repository/handle/JRC133826

[185] https://publications.jrc.ec.europa.eu/repository/handle/JRC133826

- Ensuring Relevance: As technology and society evolve, ongoing user involvement can help ensure that government services and smart city initiatives remain relevant and responsive to changing circumstances.

Competitors offering TEF services

In principle, the CitCom.ai TEF is unique, due to the large range of disciplines, geographical coverage across Europe and the variety of services it will offer to AI innovators for Smart Cities and Communities. However, the following organisations offer TEF related / similar services and can become possible competitors of CitCom.ai. Their activities and achievements will be closely followed by the project to ensure that CitCom.ai value proposition remains a differentiator.

- RTOs - 350 RTOs in 32 countries offer services to SMEs across Europe, heavily involved in the Horizon Europe programme, with at least one RTO participating in every second project.[186]
- xTEF - In some cases CitCom.ai will be competing with other TEFs. Existing TEFs are Health TEF, Agrifood TEF and AI-Matters. TEFs foreseen may include Energy and public sector.
- AI4Cities, a project that uses AI to accelerate the transition of cities to carbon neutrality. It focuses on six domains: mobility, energy, building, climate change adaptation, circular economy, and citizen participation.
- AI4EU, a project that builds a European AI on-demand platform and ecosystem.[187] It supports the development and experimentation of AI solutions across various sectors, such as health, media, agriculture, robotics, and manufacturing.[188]
- AI4Copernicus, a project that leverages the Copernicus Earth Observation Programme and the European AI on-demand platform to offer AI solutions for environmental and societal challenges. It covers several domains such as energy, security, health, and agriculture.

Conclusion

This part of the market analysis report provided answers about the supply side of the TEF ecosystem, defined as AI innovators. The European AI industry, which provides a wide range of capabilities, products, and services, is critical in driving innovation for

[186] https://joint-research-centre.ec.europa.eu/system/files/2015-12/JRC97781.pdf; https://www.earto.eu/about-earto/; https://www.earto.eu/wp-content/uploads/EARTO-Annual-Report-2022-Final.pdf

[187] https://aiexp.ai4europe.eu/

[188] https://www.ai4europe.eu/development

smart cities and communities. Understanding the landscape of AI innovators is crucial for assessing the possible impact of their contributions.

Presented market size figure estimations are large, both in terms of current revenue, expected growth and investments. However, it must be noted that figures for Europe, and the public sector specifically, represent a small proportion of the total numbers. Nonetheless, the AI & Robotics suppliers and innovators market is growing very fast.

Geographically, Germany and France have the most AI-related actors, with Spain, Italy, the Netherlands, and Sweden all making major contributions. Paris and Berlin have emerged as significant AI and blockchain centres in the EU27. NLP, Computer Vision, ML, Robotics and Automation, CAV), and AI Services are among the thematic areas of AI activity in Europe. While the EU is particularly strong in AI Services and Autonomous Robotics, emphases and strengths can differ per member state.

AI innovators in the smart city and communities domain in the EU face a slew of challenges, including: Lack of access to high-quality, real-time data, lack of computational resources (for example for real-time processing), difficulties in model interpretability, limited scalability, and data privacy and security. CitCom.ai will play a critical role in assisting AI innovators for smart cities and communities by addressing outlined obstacles, offering a dedicated platform and forum, and encouraging cross-domain integration.

As CitCom.ai progresses, it is necessary to stay updated and keep an eye on indicators that can orient service providers towards the characteristics and needs of the market. Several watch services and observatories with live data and updated information are available and it is recommended to keep actualising the information of this document.

EC - Joint Research Center AI Watch	https://ai-watch.ec.europa.eu/ai-watch-index-2021_en
OECD AI Policy Observatory	https://oecd.ai/en/
AI Standard Hub	https://aistandardshub.org/
AI on demand	https://aiexp.ai4europe.eu/
AI4EU	https://www.ai4europe.eu/
EUROSTATS	https://ec.europa.eu/eurostat/statistics-explained

Table 6. AI watch services and observatories

Supernode domains

CitCom.ai put forward three regions to cater for specific innovation themes. Each region is led by a supernode. A super node is composed of a node, which leads the overall work of the region (super-node), and sub-nodes, that complement the service offering of the super node in a certain theme. As such, the following sections analyse the market of the themes and sub-themes of the respective super nodes, the grouping of the super nodes is given in Table 7.

Super Node Theme	Super Node	Sub-nodes
POWER/Nordic Node	Denmark	Finland
		Sweden
MOVE/ Central Node	Belgium	France
		Luxembourg
		The Netherlands
CONNECT/ Southern Node	Spain	Germany
		Italy
		Poland

Table 7. Grouping of the super nodes

The Nordic super node: 'POWER'

Definition

Power in the energy sector encompasses diverse sources like gas, wind, solar, hydro, nuclear, solid fossil fuels, oil, petroleum, and biomass. The market structure involves Transmission System Operators (TSOs), Distribution System Operators (DSOs), and the supply layer. TSOs prioritise secure grid operation, but their digitalization varies across the EU. DSOs in district heating have a more diverse structure.

Monopolies like TSOs and DSOs, risk-averse for stability, prioritise energy supply over innovation. Frontiers for energy companies include sustainable production, storage, conversion, sector coupling, and prosumers. Simultaneously, environmental monitoring measures natural and human-induced factors, shifting towards high-frequency, localised monitoring for informed populations, national goals, and legislative and media focus. It involves continuous observations, data harmonisation, low-cost hardware, wireless networking, data visualisation, standardised interfaces, and renewable energy technologies.

The shift towards digitalization emphasises the growing importance of cybersecurity in energy systems. Critical infrastructure like power grids demands robust measures to prevent cyber-attacks and ensure stability. Developers use threat assessment, penetration testing, advising on cybersecurity frameworks, real-time monitoring, incident response planning, and AI system security assessments.

In the broader context, ending fossil fuel dependency is a top European priority, requiring significant electrification investments. Integration of fluctuating energy sources emphasises interoperability and secure communication. Nordic communities lead in integrating renewables and leverage quantum excellence centres for infrastructure optimization and enhanced cybersecurity. In essence, power in the energy sector intertwines diverse sources, sustainability, and secure, innovative systems.

Stakeholders

Smart city applications in the POWER domain relate to a variety of stakeholders such as authorities, citizens, businesses, public NGOs, academia, media, and others. Their role can be multiple as they can perform the following activities: gathering, processing data, build public/private infrastructure, govern, provide technologies. These can be divided into three groups: EU Governments and Members State governmental organisations, industrial companies and research and organisations, and citizen, NGO and end users.

- ***EU Governments and State Members governmental organisations.*** This group defines strategies, policies and legislation, security standards and recommendations as well as directions of further research, development, and production in the area of cybersecurity of the energy sector[189]. This is done by dedicated EU committees and other organisations such as ENISA, EE-ISAC, ERNCIP, the European Network of Transmission System Operators for Electricity (ENTSO-E), the European Network of Transmission System Operators for Gas (ENTSOG), the European Cybersecurity Organization (ECSO), CCE, the Union of the Electricity Industry (Eurelectric) and many others. They work together and to take organisational and financial decisions. Necessity of this is advised by the current market and political situation in the world. Besides this, this stakeholder

[189] [https://energy.ec.europa.eu/system/files/2017-03/eecsp_report_final_0.pdf] [https://energy.ec.europa.eu/system/files/2021-04/nccs_report_network_code_on_cybersecurity_0.pdf[

group stands for financing of big international EU cross-countries projects. [190] The document [191] describes all Smart Cities and Communities projects in the EU.

In the context of cybersecurity, funding for EU cybersecurity initiatives has increased in the 2021-2027 programming period through a mix of instruments such as the DEP, Horizon Europe, the European Defence Fund, and the EU Recovery and Resilience Facility. The EU objective is to reach up to €4.5 billion of combined investment. Notably to go to SMEs under the recently established Cybersecurity Competence Centre and Network of Coordination Centres [192].

- ***Industrial Companies and research and organisations.*** The second group implements solutions and services based on the framework and regulations defined above. This group consists of a wide range of private and state companies as well as research organisations, including the workforce engaged in the EU committees and national/ international projects introduced by the first group. Stakeholders from this group deliver all kinds of technical solutions and research activities to meet current market and EU cybersecurity related requirements. This group stands for soft and hardware solutions across the whole Smart Cities infrastructure.

  In the energy market the companies such as Accenture, IBM Corporation, General Electric, Vestas, Mitsubishi Power, Hitachi Energy Ltd, Nordex, Ansaldo Energia, Baker Hughes, and Elliot Ebara, DNV could be mentioned in this respect. These players have adopted various strategies to increase their market penetration and strengthen their position.

- ***Citizen, NGO and end users.*** The last group receives and consumes solutions, services and products delivered by the two previous groups. Citizens are the actors with whom Smart Cities operators interact most, irrespective of the communities' maturity level. Thus, they can influence the first and second groups of stakeholders by setting new demands and expressing their opinions. Recently, the role of the citizen evolved from a passive consumer to an active participant in the transition as, for instance, the initiator of new, local, energy initiatives, becoming a member of such an initiative or by changing from consumer to prosumer. In line with this notion, multiple EU projects involved citizens as

[190] https://energy.ec.europa.eu/system/files/2019-04/swd2019_1240_final_0.pdf; https://energy.ec.europa.eu/system/files/2022-10/pulication%20on%20digitalisation%20in%20cities.pdf

[191] https://pocityf.eu/wp-content/uploads/2020/09/POCITYF-864400_D11.12_Cyber-Data-Security-Management-Plans.pdf

[192] https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)689333

co-innovators and designers[193]. Energy communities contribute to increased citizen participation and acceptance of renewable energy projects. They are also recognised as a fertile ground for social innovation. Gamification strategies are promoted within co-created citizen science projects on which most of the decisions of the project are captured by the community.

Arguably, POWER stakeholders could also be presented as two distinctive groups: direct and indirect stakeholders[194]. Direct stakeholders are citizens, city authorities, government managers of infrastructure, building and service delivery, and local enterprises. Indirect stakeholders are technology and application providers, system integrators, infrastructure service providers and operators. Citizens are the most direct beneficiaries of smart city services. Urban authorities and managers of city governments are the main actors in building smart cities and delivering services to citizens. Local enterprises in a smart city can benefit directly from creating new profits by leveraging smart city infrastructure. Indirect stakeholders provide city-related technologies and infrastructure services in the process of creating value-added outputs and products of a smart city.

All stakeholders have complex bidirectional relations. Issues of politics, bureaucracy, liability, and other non-technical factors challenge the implementation of technical solutions, even when the technologies are considered ready to use. Thus, possessing legacy requirements by stakeholders is regarded as a constraint to cybersecurity solutions providers. On the other hand, key cybersecurity enablers identified by technology providers are used to develop new regulations on cybersecurity data privacy and standards. Governments and companies need to work together to manage the increased complexity of threats to the POWER domain. Digital resilience needs to be integrated into technology research and development, policy and market frameworks[195].

Subthemes

- Energy

Definitions

Even within the TEF, the term “energy” is rather broad and covers a wide variety of energy sources[196] used for electricity, heating, and cooling among others. Thus, any

[193] https://energy.ec.europa.eu/system/files/2022-10/pulication%20on%20digitalisation%20in%20cities.pdf

[194] https://ideas.repec.org/a/gam/jsusta/v10y2018i8p2606-d159871.html

[195]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj2ubOnzsqBAxVuh_0HHQZeCO0QFnoECAkQAQ&url=https%3A%2F%2Fwww.enisa.europa.eu%2Fpublications%2Fsmart-cities-architecture-model%2F%40%40download%2FfullReport&usg=AOvVaw07dNybFXFQaXRGLimMpba8&opi=899784498

[196] https://energy.ec.europa.eu/energy-explained/energy-infrastructure-eu_en

solution providers that solve problems of energy efficiency in buildings and cities across the different energy sources, would be relevant for the TEF. Some of the main energy sources are:

- Gas
- Wind - Kinetic energy converted to electricity
- Solar - Radiation for heat and electricity
- Hydro - Potential and kinetic energy to generate electricity
- Nuclear - Thermal energy to produce heat
- Solid fossil fuels - Coal to produce heat and electricity
- Oil and petroleum
- Biomass

From a high-level perspective, as displayed in Figure 13, the supply side of the electricity/gas market consists of three layers, the Transmission System Operator (TSO) layer and the Distribution System Operator (DSO) layer, and the supply layer[197]. The primary responsibility of the TSOs is to ensure secure and optimal real-time operation of the grid. The digitalization of the TSOs differs across the EU. In some countries like Denmark, Finland and Portugal, Data Hubs have been developed to collect data and facilitate communication between grid operators (DSOs).

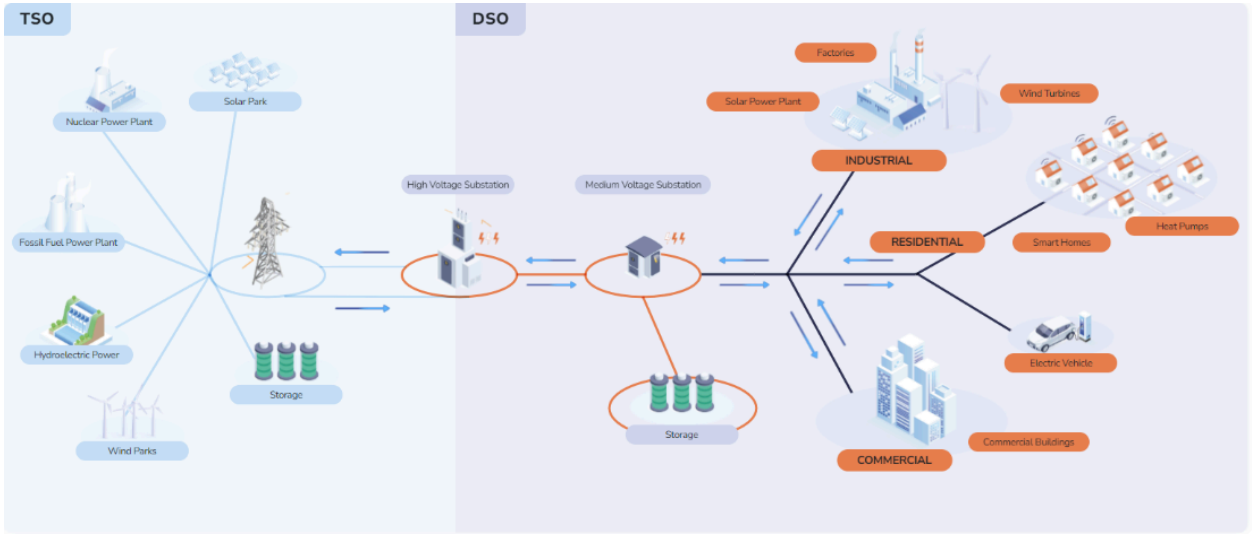

Figure 13. Different layers and roles of supply side of the electricity/gas market

The district heating sector, i.e. the DSOs, is somewhat more diverse and without the centralised structure provided by TSOs in the gas and electricity sectors. Instead, the sector consists of decoupled networks and suppliers providing heating to specific geographical areas. The market in the EU is characterised by most countries having

[197] https://www.eudsoentity.eu/dsos-in-the-energy-transition

less than 10 suppliers controlling more than 70% of the market and an almost even split between having local suppliers versus international suppliers[198] .

These monopolies, i.e. the TSOs and DSOs, are often very risk averse, as their primary objective is delivering a stable supply of energy. They have little incentive to improve or diversify their products and services, as they are legally bound to a specific area, where all inhabitants are forced to be customers. Their main growth potential is through lowering their own expenses. Energy companies' expenses are forecasted to grow exponentially as green energy sources are growing. In many cases, these energy companies are financially responsible for any instability in the energy grid. On top of the financial pressure, both political and social pressure encourage companies to invest in more sustainable and technologically advanced infrastructure. Current frontiers within the energy domain for the further development of energy companies include: scaling of sustainable energy production, storage and conversion of energy[199] , sector coupling, and prosumers[200] .

Challenges

From the perspective of implementing AI solutions in the energy sector, there are several challenges that need to be overcome.

First, the quality of data is often a concern to AI-providers – the two main issues are resolution and delay. The resolution on whether it is daily, hourly or quarter-hourly measurements impacts the precision of the data analysis. There can also be a lack of data, or lack of data of sufficient quality. An example would be an apartment complex in which there are only district heating metres for the entirety of the building – and not for the individual apartment. In this case, the AI-providers are lacking IoT-metering in the systems to perform the necessary analysis for a given service.

Second, the timeliness of the data is an even greater concern, as data is often one day or more late in energy consumption data. This highly impacts the accuracy in forecasts used for different digital tools – and thus impedes the quality of those tools. The more delayed the data are, there is a higher need for forecasted data, and thus the tools are dependent on the forecasting quality. An example would be utilising district heating consumption data for forecasting future demand and improving temperature optimization at district heating centrals – here, data is a day delayed, and the forecast needs to be corrected for this.

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[198] https://doi.org/10.2833/962525

[199] https://energy.ec.europa.eu/topics/research-and-technology/energy-storage/recommendations-energy-storage_en

[200] https://www.eea.europa.eu/publications/the-role-of-prosumers-of

Third, lack of data access presents an obstacle. Because of proprietary metering systems – the AI-providers can struggle to receive data from existing metering systems due to proprietary systems from suppliers, who do not necessarily open up for a third party to receive data. This is in a scenario, where the AI-provider as an example has obtained consent from the building owners to receive the raw data. This will lead to a more troublesome process of receiving metering data from the utility – or the AI-providers having to set up their own metering system for the specific building. This leads to a more general issue for the AI-provider: lack of easy access to unified data. This is one of the main pushes for setting data free in the utility sectors as this will define a unified and easy way to obtain data from utilities – given you have the right permissions.

Fourth, ensuring lawful use of data can be challenging. AI-providers rely on high precision of the data received, and due to GDPR concerns, it is a challenge to facilitate raw data to companies. This can be done with the following 4 methods, and each solution spawns entirely new challenges for the AI-providers:

- **Consent from data owners.** This is a long and tiresome process to receive consent from data owners – especially if there is a need for a large quantity of metering devices to be worked on, as an example, if all buildings in the Triangle Region of Denmark is needed, it becomes practically impossible.

- **Advanced techniques for anonymization.** This method relies on data intermediaries – or the utility itself, to perform the necessary anonymization techniques to comply with GDPR concerns. This is a balance between the level of anonymization and the usability of the data, as with more aggregation of the data, the less useful it becomes for companies. Advanced techniques for producing synthetic data could help the AI-providers to test their solutions closer to reality, but highly depends on the intelligence of the anonymization methods.

- **Middle-man service from a trusted organisation.** This method relies on the AI-provider to deliver their algorithm to a trusted entity, who runs the algorithm on the desired raw data and sends back the results for the AI-provider to evaluate. This requires the AI-provider to trust the entity to handle the core engine of their business, and they will often be hesitant to do so.

- **Secure analytic environment from trusted organisations.** This method relies on a trusted organisation to provide a secure environment, in which AI-providers can interact with data, but never see actual raw data – only

results. This requires advanced checks on the algorithms to make sure that the actions performed manipulate the data enough to eliminate GDPR-concerns before results are extracted. As in the middle-man service, the AI-provider needs to trust this environment.

Last, the incentives for developing and testing AI-solutions might not always be present for AI innovators. On the business side for the AI-providers, there are considerations for how their limited time, money and resources are spent, and a need to ensure a possible business after testing their AI-solutions.

a. Engaging with the customer in the product development phase
b. Ensuring customers interest in the results from the testing facility

The test sites in CitCom.ai are aimed at AI-providers to test out their algorithms, services and whatnot to enhance their product. However, what to test, and what to improve on the products can be a costly affair, and there is often a need to align it with the strategic interests of a potential customer. On top of this, for the AI-provider to invest time and money into testing their algorithms, there is often a need for customers to follow the results in order to bridge the gap from tests to a commercial product. An example here is performing dynamic rating of transformer stations in the electricity system. Here, a lot of great algorithms can be developed with data from the utilities, but which issues to address could require insights from the utility – is it a forecast of the critical temperature on the station? Is it the phase imbalance implications? Is it voltage regulation issues? The strategic insight from the customers – and interest in the outcomes from the test facility, would increase the interest of AI-providers to invest time, money and resources in developing their products in this specific setting of CitCom.ai.

Opportunities

AI offers several interesting avenues for harvesting opportunities in the energy domain. First, aid in becoming self-sufficient in terms of energy provision. The war in Ukraine has shown the vulnerability of not having a self-sufficient energy system in the EU, but rather depending on the import of energy sources from other parts of the world. Second, AI can make our energy grids more resilient, a necessity. Europe has been experiencing large scale droughts, which significantly reduce the energy produced by hydroelectric power plants. Moreover, the buildings in the EU are to a large degree old and inefficient. In 2021 about 35 % of buildings are more than 50 years old and upwards of 75% are deemed energy inefficient[201]. Consequently, the energy grids are very loaded and within district heating, it is a very significant problem as in many countries the weighted average specific heat consumption is higher than the suitable threshold for the most

[201] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

modern systems[202]. Last, the generation of renewable energy is much less controlled than the one from fossil fuels. A central challenge for the green transition is the ability to stabilise the fluctuating output of green power production. When the share of renewable energy is greater than 74% the flexibility requirements of the grid increases significantly[203].

- Environmental Solutions

Definition

Environmental monitoring can be defined as the measuring and comparison of factors occurring naturally in the air, ground and water or that arise in these modalities as a result of some human intervention. For example, climate, water- and soil-pollution, noise, biodiversity and plant/animal welfare, airborne particulate matter and gasses.

Environmental monitoring historically has been the domain of specialised agencies with deep domain knowledge who apply a set of narrow and costly tools to collect information on a sporadic basis.

In the context of city-living and modern communities, the demand for localised high-frequency environmental information and insights has increased, largely due to a more well-informed population, national goal-setting and emissions targets, legislation, and media and political focus on the climate, environmental scandals, and other newsworthy events. This requires a change in focus for both the environmental technology provider and consumer, and signifies a shift away from “traditional” information-gathering efforts. The main elements of a modern, and future-proof, environmental monitoring intervention are; continuous monitoring, high-frequency observations, data harmonisation across sampling devices, low-cost and low-power hardware, wireless networking capabilities, data visualisation and content-management platforms, standardised interfaces, the application of new battery and renewable energy technologies, the deployment of “off-the-shelf” multi-modal sensing devices[204]. Environmental monitoring technologies can be roughly divided up into remote, e.g. satellite imagery, and local, e.g. sensing devices. The scale of remote monitoring is typically greater than local and is familiar to us in the form of weather forecasts, and a thorough weather (or pollution) forecast would of course include both local and remote sensor data.

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[202] https://doi.org/10.2833/962525

[203] https://energy.ec.europa.eu/topics/research-and-technology/energy-storage/recommendations-energy-storage_en

[204] https://www.mdpi.com/1424-8220/20/11/3113

Challenges

The main challenges in environmental monitoring in Smart Cities are mostly related to closing the gap between generating measurements and actionable insight.

First, there is a lack of standardizations which makes interoperability challenging. Technical interoperability at the power and network level is largely solved, and standardised data formats are numerous, which is both ironic and illustrative of the lack of enforcement of data standards. Where standardisation is lacking is primarily in the semantic domain[205], which makes the usefulness of sensor networks first apparent after an exercise in interface-building, data mapping and enrichment, in order to harmonise the data so that it may be queried and correlated.

Second, generating environmental insights requires domain knowledge. Outdoor environmental monitoring is highly complex and context-specific, and significant knowledge is required to extract knowledge from numerical data. High-level mappings, such as Air Quality Index (AQI), or red-amber-green pollen counts are typically used to communicate environmental data to the public. An effort is to be made in developing compelling and informative visualisations that allow better decision-making[206]. Forecasting, prediction and simulation all require an understanding (and a data representation) of the driving factors for environmental change, which may be closely related to human actions. Furthermore, understanding what type of monitoring is required in a certain context may not be readily apparent to city planners, procurement or other city-management units.

Third, access to validating and supporting data to prove correlations is limited and/or costly. For a City or Community without a continuous traffic-monitoring infrastructure, options to report their emissions load are limited - extrapolating sporadic counts and using a rough numeric calculator such as COPERT[207] to estimate emissions-per-road-segment-per-day. Another option is to purchase data from mobility providers such as taxis and buses, or from GPS operators, both of which are costly and only a partial representation of the overall activity. This is also true for other relevant data sources, power and water consumption, waste management and recycling, municipal data etc.

Repeated and consistent access to data is an important challenge in almost every aspect of Smart City & Community development. Access to data encompasses three types of effort;

- Access to live, real-time data from local monitoring devices

[205] https://doi.org/10.1002/ett.3902

[206] http://dx.doi.org/10.1016/j.envsoft.2016.09.004

[207] https://www.emisia.com/utilities/copert/

- Access to aggregated “big” environmental datasets
- Access to adjacent datasets describing driving factors (e.g. traffic, power consumption).

Private actors may also wish to limit the exposure of their own data for business reasons. Work is currently underway to consolidate and standardise access to environmental data through the EU’s GreenData4All initiative.[208]

Other challenges may relate more to the deployment of sensor networks, such as:

- Optimal setup and deployment of IoT devices is poorly understood.
- Lack of technical knowledge to sufficiently handle deployment and operations.
- Building real-time, continuous integrations to e.g. city-management platforms requires more maturity in interfaces
- High-accuracy monitoring is still being done manually in 50% of cases.

From the perspective of the AI innovator, device manufacturer or data provisioning unit, the same challenges arise, namely interoperability and standardisation.

First, understanding the demand for interoperability. Which interfaces should a device manufacturer provision in order to preempt development time being spent on custom integrations with municipal systems? The environmental data landscape is heterogenous and is likely to remain so until the widespread adoption of data modelling standards. This means, to supply smaller cities and communities with AI tools, technology suppliers should focus on delivering integrations (or partnering with integrators) to promote the uptake of new data-driven methods. It may not be enough to passively supply an API with low-quality documentation. Integrating AI applications with existing tools is challenging due to the width and scope of these tools – in Denmark there are over 350 different software systems used in municipal operations.

Second, a crowded marketplace of similar devices and services. To sell AI-based solutions around the environment to cities and communities, one key factor is the ability to demonstrate a service or product. There is often a knowledge gap between providers and end-users of AI technology which can result in a mismatch between the problem and solution. Demonstrations are therefore important communicative tools in showing the applicability of AI to urban problems.AI should be designed so that humans can understand its decision-making process, and must be designed to minimise bias and promote inclusion. If municipalities are to draw conclusions based on these systems,

208 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13170-GreenData4All-updated-rules-on-geospatial-environmental-data-and-access-to-environmental-information_en

this should be addressed or they will not use it. It is vital to create trust between the user and the AI provider's products and services.
Other supply-side challenges could be:

- Quality of software documentation, code and examples.
- Understanding applicability of AI in environmental monitoring.
- Reducing operational complexity – move toward plug-and-play.

Opportunities

Current trends, or those gaining traction, in the field of environmental monitoring are;

- Social – Increased public awareness around climate and environmental impact.
- Legal – Demand for data-based reporting of climate impact.
- Data – Data-driven decision-making, simulation of scenarios.
- AI and ML – potential to calculate mitigation and optimization on environmental data.
- Hardware – edge-, fog- and cloud-computing, long-life battery technology, sparse networking, low cost IoT devices.

The main drivers for the growth in the market are:

- Increased regulation around factual reporting for businesses, cities, and authorities regarding emissions and other environmental pollutants.
- Cost of electronic devices, data storage and processing becoming lower and therefore allowing a higher number of deployments for a given investment.
- Reduction in complexity of managing a distributed IoT network.
- Digitization of adjacent phenomena that have an environmental impact, e.g., traffic activity, building and space occupancy, energy consumption.
- Increase in political focus on environmental factors, including the setting of ambitious climate goals.
- Social awareness of climate factors and public demand for high-quality information.

- Cybersecurity

Definition

The cybersecurity in energy systems in cities is growing rapidly due shifting trends, expectations, and behaviour in the energy market owing to the numerous advantages provided by the digitalization of energy & utility services. The rise in need and requirement to keep information, data, and devices secure in the energy sector fuels the cybersecurity in the energy market. Cybersecurity in the energy sector is of utmost

importance because of the critical nature of the infrastructure, including power grids, pipelines, and other energy systems. Cyber-attacks can cause significant damage to these systems, leading to prolonged power outages, environmental hazards, and loss of life.

Challenges

The main challenges in the cybersecurity for Smart Communities are: [209]

- data,
- sensors and actuators,
- communication systems (short and medium range networks etc),
- software and hardware systems, including processing and storage components (Cloud-based servers)

Challenges related to data is one of the most severe and includes:

- limited use of existing data and insufficient data for quantitative and qualitative analysis; limited access to data as data ownership is not clear;
- limited data sharing, insufficient data interoperability;
- necessity to secure smart data (citizens', health, transport, utility, urban, weather, criminal, housing, telecom, finance). [210]

The challenges and risks could be classified as:

1. Supply chain and vendors attacks challenge;
2. Incomplete integration of systems and expanded & interconnected attack surface;
3. Ransomware attacks & Incident response;
4. Identity and access management (IAM) inefficiencies;
5. Mobile devices phishing;
6. Combined legacy systems with new technologies/ internet of things devices;
7. Skill shortages;
8. Resource constraints: Smaller utilities and cities may have limited resources to invest in comprehensive cybersecurity solutions;
9. Economic challenge since vendors face little cybersecurity demand from buyers.

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[209] https://www.mdpi.com/2624-6511/6/1/8;
https://energy.ec.europa.eu/system/files/2022-10/pulication%20on%20digitalisation%20in%20cities.pdf;
https://guidehouse.com/insights/advanced-solutions/2022/the-energy-sectors-cybersecurity-challenges;
https://www.sciencedirect.com/science/article/pii/S2210670718316883;
https://energy.ec.europa.eu/system/files/2019-04/swd2019_1240_final_0.pdf

[210] Based on the literature study [https://www.cisa.gov/sites/default/files/2023-04/cybersecurity-best-practices-for-smart-cities_508.pdf, https://explore.avertium.com/resource/top-5-cyber-threats-in-energy-sector and https://guidehouse.com/insights/advanced-solutions/2022/the-energy-sectors-cybersecurity-challenges, http://people.se.cmich.edu/liao1q/papers/giq.pdf],

Domain-specific challenges of Smart City applications[211] such as Smart health, Smart buildings, Smart transportation, Smart Grids and Smart Homes share the following cybersecurity challenges and risks:

Sensitive data and privacy leakage:

- change or repeated messages incl. smart metres;
- denial of service;
- suspend message;
- fake information distribution;
- forgery of identity, eavesdropping;
- hardware manipulation;
- delay, block and distort of messages;
- eavesdropping.

Demand and supply mechanism for cybersecurity is presented based on results presented in a report. [212]

Opportunities

Opportunities in the market are five-fold:

1. IoT Security: With the proliferation of IoT devices in urban energy systems, vendors are developing specialised solutions to secure these endpoints and manage the risks associated with IoT.
2. AI and ML: Vendors are integrating AI and ML capabilities into their cybersecurity products to enhance threat detection and response in real-time.
3. Zero Trust Security: The adoption of the zero-trust security model is on the rise, focusing on continuous authentication and monitoring to protect energy systems in cities.
4. Cloud-Based Security: Cloud-based security solutions are gaining popularity, allowing energy providers to scale their cybersecurity measures as needed and benefit from centralised threat intelligence.
5. Cybersecurity as a Service: Managed security services and cybersecurity as a service (CaaS) offerings are emerging, providing cost-effective options for cities with resource constraints. [213]

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[211] see [https://www.sciencedirect.com/science/article/pii/S2210670718316883, Sustain. Cities Soc., vol. 50, p. 101660, Oct. 2019, doi: 10.1016/J.SCS.2019.101660, https://www.researchgate.net/publication/354348110_Smart_city_and_cyber-security_technologies_used_leading_challenges_and_future_recommendations]

[212] https://energy.ec.europa.eu/system/files/2022-10/pulication%20on%20digitalisation%20in%20cities.pdf

[213] https://energy.ec.europa.eu/publications/study-evaluation-risks-cyber-incidents-and-costs-preventing-cyber-incidents-energy-sector_en

Regional insights/ Use cases

- Cyber security for energy devices connected to internet

Description

Today, cyber attacks pose a concrete threat to our electricity system. At the same time, the electricity system is undergoing a major change with more actors and more weather-dependent production in the electricity mix. Flexible energy products such as solar cells, electric cars, large batteries and heat pumps are needed to create a balance between used electricity and produced electricity. This electrical system and electricity market is dependent on digital systems to function well. When products in the electrical system are digitised and connected, households and condominium associations can be paid for regulating electricity use, storing energy and supplying electricity to the electricity system. Thus contributing to balance in the electricity system. This flexibility brings many benefits such as improved energy efficiency, increased control over energy use, reduced costs for households, reduced power peaks in the system and thereby better utilisation of the electricity system.

However, as soon as the energy products are connected to the internet, they create a possible pathway for cyber attacks against the power system. Energy companies and network owners have procedures for managing cyber attacks directed to their facilities, but, on the other hand, the electricity *users* cannot be expected to have equally good cyber security. That can lead to problems for the individual user, but also the entire electrical system, that can be disrupted in one coordinated attack. This issue has been stressed by Research Institutes of Sweden (RISE) in different contexts.[214] RISE has investigated the impact on the electrical system of potential attacks and the cyber security of connected heat pumps.

Lessons learned

- The combination of lack of updates and the exposure against the Internet creates risks for cyber attacks on heat pumps. RISE hasn't seen any signs that heat pumps differ from other connected products when it comes to this.
- RISE has found that the connected heat pumps in Sweden now together constitute a large enough amount to be able to cause disruption to the power system in a synchronised attack against many heat pumps. The situation is similar for other connected energy products.
- To protect the electricity system are, among other things, protection mechanisms in the electricity system, safe and systematic updates for products and services, good password management, as well as correct and accessible information to the users, needed. A stronger systematic cyber security work is needed in the

[214] https://www.ri.se/sv/centrum-for-cybersakerhet/var-forskning/rise-video-cybersakerhet-i-framtidens-energisystem

energy industry at all levels because the risks with connected energy products are so large. All actors have a responsibility; authorities and decision makers, suppliers and installers and not least the individual user.[215]

- Dynamic rating of transformers

Description

In the Triangle Area of Jutland in Denmark, data from the DSO grid of TREFOR has been used to investigate the possibility of performing dynamic rating of low-voltage transformer stations. IoT measurements for power quality and temperatures for every second have been installed on 0,4/10 kV transformers. AI-techniques like time-series analysis and machine-learning are applied on the data to receive proper forecasts 24-hours ahead of the critical temperature for the transformers. The critical temperature allows an indication on the health state of the transformers – allowing DSOs to go above rated capacity in shorter periods without heating the transformer beyond a critical state. In the project, Digital Energy Hub[216], SMEs could work with the data and develop new digital services, which would lead to new tools being able to be deployed in the DSO-grid.

Lessons learned

Pseudonymization and anonymization techniques on the initial data linking transformer data, weather data and consumption data to mask GDPR-sensitive data for the companies to work with it is highly relevant in future, when data is facilitated to companies.

Development of new digital services for advanced issues in the energy system often requires ecosystems of companies working together. In this example, three services are joined together to fulfil the needs:

- Data-as-a-service: IoT-metering is performed by Linc Technologies
- Hosting and data streaming: CDK receives the data from Linc Technologies and streams it between the actors (AI-company and utility)
- AI-as-a-service: AI-nergy performs a forecasting service based on the data and delivers it back to CDK.

Here, it would be valid to test multiple technologies in the DSO-grid in CitCom.ai, but also investigate ecosystems of microservices.

[215] https://www.ri.se/sites/default/files/2023-04/CfCs_Rapport_Cyberhot-mot-elsystemet.pdf
[216] https://www.digitalenergyhub.com/en/sprints/sprint-1/

- Temperature optimization of district heating centrals

Description

In a variety of locations, an AI-company like ENFOR has successfully delivered data-driven temperature optimization of district heating centrals – an example of this is the Heatman[217] project. Here, TREFOR-, Brønderslev-, and Fredericia district heating have deployed this forecasting services into their SCADA-system. The forecast is based on consumption data, and it ensures that the hydraulics of the district heating can be optimised to deliver optimal temperatures and pressure set-points in the grid – this will lead to lower heat losses and can improve bottlenecks in the grid. The AI-techniques involved are time-series analysis and machine-learning.

Lessons learned

Optimization of district heating grid by including consumption data in data-driven approaches holds great potential in utilising flexibility in the grid and reducing costs. In the project, a common infrastructure to connect to the OT-layer of the utilities (SCADA-systems) were developed, and solution providers could connect in a unified manner, which could increase the competition on these services for the benefits of the utility companies.

In CitCom.ai, this infrastructure is highly valid in order to have multiple AI-solution providers test out algorithms to optimise the district heating system – whether it is temperature optimization, pressure optimization, or something entirely different.

- Intelligent heat pump control

Description

In the project, Flexible Energy Denmark[218], the AI-provider, Neogrid Technologies, was operating a Living Lab in Aalborg, in which residential heat pumps were intelligently controlled to optimise the comfort and heat costs of the occupants. Based on time-series analysis and reinforced learning models, consumption data are used to create a thermodynamic model of the households, which determines the flexibility of said household by how much the indoor temperature can be varied in order to optimise heat pump operation. The heat pump utilises this flexibility to primarily ensure the comfort of the household owner and secondarily, reduce costs by utilising market prices for electricity (spot prices, ancillary service prices, local demands, etc.). Neogrid Technologies also does this with aggregated portfolios of households to operate these as virtual power plants in the electricity market.

[217] https://heatman.dk/
[218] https://neogrid.dk/projekter/fed-flexible-energy-denmark/

Lessons learned
In the FED-project, a series of Living Labs were operating to test out different solutions in grids. In the Aalborg case, Neogrid Technologies have done all of the necessary steps: instalment of IoT-metering devices to achieve consumption data, hosting data and providing AI-services to the residents.

The inspiration here for the CitCom.ai is the Living Labs, which shows a real-life demonstration of the tools – here, a more unified way of testing AI-solutions could be issued, allowing Neogrid Technologies to purely focus on AI-services rather than performing all of the tasks involved – and for the CitCom.ai project to test several AI-solution providers, for example Danfoss LeanHeat solutions.

- Load profiling in the DSO-grid for future tariffs

Description
In the project, EnergyLab Nordhavn[219], several utility sectors were investigated – one of them being the electricity supply, moreover the DSO's. Here, large quantities of consumption data in the Copenhagen Area from the utility company Radius-Cerius were investigated by DTU Wind for interesting patterns. Here, online load profiling and clustering techniques were used to determine how the demand in the DSO-grid could be classified. This provides the utility company with a better insight on what the peak loads are, and how different customer groups stress the grid. One use could be to increase accuracy in tariffs – based on customer groups and the temporal aspect.

Lessons learned
The inspiration here is to deploy other techniques – than the forecasting services, to determine interesting patterns in data. Moreover, this also discloses another angle into which kind of products could be developed due to data-insights – in this situation, a better data-driven foundation to set variable tariffs in the DSO-grid in order to incentivize customers for the use of their flexibility for cost reductions.

- Predictive and preventive maintenance for large-scale heat pumps

Description
In the project, SVAF[220], a large-scale heat pump was commissioned in the district heating system of Greater Copenhagen. This heat pump is a hybrid-heat pump, which can both harness its source energy from seawater and sewage water – both important heat sources for large-scale heat pumps, but also provides technical challenges in the

[219] http://www.energylabnordhavn.com/uploads/3/9/5/5/39555879/d.6.1.2b_v2.pdf
[220] https://www.hofor.dk/baeredygtige-byer/udviklingsprojekter/fremsynet-fjernvarme/store-varmepumper-fjernvarme/

heat exchangers at the source-side. In brief, the heat exchanger will be contaminated over time – especially by the sewage water, which over time will issue biofilm in the heat exchangers and reduce the efficiency of the exchanger – and the overall efficiency of the heat pump. To combat this – and other operation challenges of a large-scale heat pump, a Digital Twin was developed with anomaly detection as the focus point. Here, normal conditions for the heat pump were learned by the models and thus unconventional behaviour could be detected. Here, it could be used to decide when to clean the heat exchangers to remain at a high efficiency. The AI-provider, Technological Institute, developed a tool to detect the health of the heat pump, for the utility company HOFOR to use on this and future heat pumps.

Lessons learned

The focus here is on Digital Twins and the applicability of those. Here, a digital doctor was able to detect normal steady-state conditions of the heat pump, and issue alarms, if anomalies were detected. In CitCom.ai, the use of digital twins can lead to new products – like here, in predictive and preventive maintenance, but also other optimizations in the operation of DER's.

The Central super node: 'MOVE'

Definition

MOVE represents one of the three application domains of the CitCom.ai project. In particular, MOVE is intended for more efficient and greener transportation linked to logistics and mobility in cities and communities. Each node within the MOVE central supernode has its own sub-theme, but all share a similar need and challenge to develop and increase AI-system maturity for more secure and sustainable mobility in cities and communities, leveraging digital technologies such as AI, IoT, cloud computing, big data analytics, and others. Beyond sustainability, the key principles include quality of life, safety, security, accessibility and reduction of climate-related issues (e.g., CO2) in the urban area.

Considering that cities are dynamic urban ecosystems with evolving physical, socio-cultural, and technological infrastructures facilitating, regulating, and often constraining the free movement of its citizens in crucial ways; how urban mobility is managed can both sustain and transform a city's socio-economic and cultural capital[221]. The algorithmic and data-centric infrastructure introduced in the urban setting has set the path for a lot of opportunities as well as challenges. Urban AI, constituting inter-related urban technologies, big data, computational systems and AI in urban

[221] https://doi.org/10.1007/s00146-022-01502-2

spheres centres around so-called “smart cities” aims to reimagine, reframe and remake cities[222].

To be able to achieve that, the MOVE supernode aims to foster a collaborative ecosystem among different stakeholders in the transportation domain, such as local governments, research institutions, industry players, AI innovators, NGOs, civil society organisations, and citizens. Through enabling access to data and infrastructure for AI experimentation and testing in real-life conditions, MOVE will accelerate the digital transformation of transportation in cities and communities, leverage the smart city concept and support innovative companies including SMEs to use AI confidently and to stand at the forefront of innovation.

The central MOVE supernode of the CitCom.ai project focuses on challenges related to transport, more specifically of mobility and logistics in cities and communities of Belgium, The Netherlands, Luxembourg and France. Moreover, the application domain MOVE covers three crucial sub-themes that address the different aspects of transportation planning and management in the urban setting as:

1. Urban mobility algorithms and smart intersections
2. Electromobility
3. Autonomous driving

Each sub-theme focuses on specific AI capabilities that can provide innovative and secure solutions in transportation such as predicting pedestrian flow, smart and intelligent intersections which aid road safety concerns, advanced and connected charging infrastructures and autonomous urban transport that aim to enhance the security and quality of life for citizens. The overarching goal of each sub-theme is to support communities and cities not only in their digital transition effort that aims to enhance the livability of their citizens, but also making sure that the state-of-the-art technologies are being exploited to address their key challenges.

This following section encompasses a detailed stakeholder mapping, including needs and challenges, which is then followed by a description of the sub-themes and their respective challenges and opportunities. The last part of the section will focus on specific regional use-cases, and associated lessons learned within scope of the supernode.

[222] https://www.researchgate.net/publication/336325967_Reframing_reimagining_and_remaking_smart_cities

Stakeholders

Urbanisation, emerging digital technologies and changing consumer and employee expectations have unlocked new potentials for modes of transportation and mobility experiences. This has set the stage for a new mobility ecosystem, with a growing number of urban mobility players, mainly in the applications and development related to digital technologies and particularly to AI applications.

The EU ecosystem in AI development and deployment includes academic research in key areas, a vibrant start-up environment, a well-established and advanced technology market, cutting-edge academic and research centres, national government initiatives and others. Unlike simpler cooperative agreements between two parties, ecosystems involve a complex constellation of players:

- ***Public institutions****,* being governmental authorities at a local, regional, or federal level (e.g., cities) that play the role of an intervener, with the dual goals of improving mobility services and pushing policy agendas (e.g., Belgian Government, City of Mechelen, City of Brussels and others), some of them joining the 100 cities targeting climate neutrality in 2030 (City of Differdange in Luxembourg, Cities of Paris or Lyon in France[223], etc). In most cases, these organisations lack and struggle with having the right resources (e.g., talent, knowledge etc) in place to align with the pace of digitalization within the mobility domain. Beyond that, certain national programs are dedicated to meeting challenges linked to automated transportation: for imagining reliable AI for critical systems (confiance.ai), or to develop a platform for evaluating and validating the security and safety of the automated public transport vehicle (PRISSMA, Research and Investment Platform for the Safety and Security of Autonomous Mobility).

- ***Citizens*** can be represented by associations that aim to voice the interests of the public in mobility topics and setting pressure on policies which do not meet their requirements such as Fietersbond in the Flemish Region. Being a charity organisation, it remains challenging for them to secure funding for their citizen-oriented projects which in this digital era have additional implementation costs. When citizens structured organisations are lacking, the trends is more and more to actively involve citizens participation in the mobility plans (f.i. in the city of Luxembourg with the 'Mobilitéitsplang fir Muer[224]').

223 https://labo.societenumerique.gouv.fr/en/articles/nine-french-cities-among-100-smart-and-climatically-neutral-cities-selected-by-the-european-commission/

224 https://www.vdl.lu/en/getting-around/notre-plan-de-mobilite-pour-demain/citizen-participation

- ***NGOs and interest groups***, being non-profit and umbrella organisations that level the playing field (e.g., United Nations, IRU, ICLEI Europe and others). Some of these organisations are national initiatives federating the more dynamic actors (e.g., Stroum Beweegt[225] in Luxembourg). Their needs revolve around providing the right guidance with the most up-to-date information and tools to the organisations that are part of their group. However, it is challenging for them to foster the sustainable, trustworthy partnership that is necessary to attain performant, fast, safe and secured data exchange. Some sectors are already well organised through numerous stakeholders and are active people, like the PFA (French Automotive Platform[226]) is the collective interest organisation and unique platform for the automotive sector whose mission is to consolidate and develop the 4,000 companies, industrial players in the automotive and road transport sectors in France, based on a vision clarity of the major challenges of the sector in terms of innovation, regulations, norms and standards, industrial competitiveness, skills and jobs. For transport, there are ecosystems that support research and innovation activities aimed at developing safe and sustainable road transport through automation and standardisation (e.g., STRMTG[227], CCAM[228], NextMOVE[229], etc.). In addition, the French Society of Automotive Engineers (SIA[230]) brings together all the specialists and enthusiasts of the automotive industry and its technologies into an association since 1927. SIA aims to promote the development and sharing of knowledge among engineers, executives and technicians from French companies and large groups present in France, in the field of automobiles and the mobility of the future.

- ***Mobility service providers*** are traditional transport operators (e.g., PT, taxi etc) and emerging new mobility service providers (e.g., on-demand mobility, micro-mobility, car-sharing, autonomous robot taxis such as Waymo, Cruise, Tier Mobility, Lime, Dott, etc.). While traditional mobility service providers are rapidly trying to incorporate and adjust to the new technologies, or complementing their

[225] https://stroumbeweegt.lu/en/homepage/

[226] https://pfa-auto.fr/; https://pfa-auto.fr/recherche-et-developpement/

[227] STRMTG - The Technical Service for Ski Lifts and Guided Transport or STRMTG is a nationally competent service attached to the General Directorate of Infrastructure, Transport and Mobility (DGITM) of the Ministry of Ecological Transition, the ministry responsible for Transport.

[228] European partnership “Connected, Cooperative & Automated Mobility”

[229] NextMove leads and represents the French "Mobility Valley", one of Europe's leading Automotive & Mobility innovation ecosystems, covering the entire value chain where sustainable mobility solutions are invented, developed, tested and industrialised. From research to industry and services, NextMove federates the main players in Normandy & Paris regions to boost their competitiveness and provide support for transitions.

[230] https://www.sia.fr/?lng=en

transport offer (e.g., Flex[231], the biggest car sharing operator in Luxembourg has been launched by CFL, the national railway operator), new mobility providers overtook quite a large portion of the market. The optimisation of new mobility providers, for instance e-scooters, or car-pooling services require regulatory operations to, a) assess their take in the public space, b) define specific terms and conditions, c) enable multimodality and foster a sustainable end-to-end journey. As such, building trust and fostering data sharing across partners remains a priority.

- ***Startups, SMEs, and large companies,*** are technology providers and/or suppliers such as OEMs (original equipment manufacturers), or software providers that offer innovative user-centric AI services or products in the sector of urban mobility on a for-profit basis. Examples include OTIV, Skipit, Nvidia, Panasonic, Telenet, Be-mobile and others. Being in the role of AI innovator, these technology providers need to ensure they bring the latest technological innovations in the market and contribute to pioneering solutions. As such, they need to confront data scarcity, regulatory burdens and lack of real-world algorithm validation.

- ***Incubators and accelerators*** are organisations that help other organisations by accelerating their transition to become more digital and innovative through new technologies including AI (e.g., Plug & Play, Agoria & Sirris). These “umbrella” entities ensure their members have a smoother transition to the digital transformation also in the field of mobility. Their members struggle having their solutions tested and validated with real-time data, as access to such data and as well as aligning with the EU technical regulations and legislation are challenging.

- ***Knowledge institutes and supporting organisations*** are umbrella organisations that play the role of intermediaries and assist in the ecosystem development by enabling synergies and sharing best practices with their members (e.g., Eurocities[232], CIVITAS[233] Initiative, Polis Network[234], and others). Same as incubators and accelerators, these organisations inform members about new regulatory frameworks, technical implementation guidelines and encourage a faster uptake of AI technologies for cities and communities products. Still, these efforts are met with the lack of resources, in terms of skills,

[231] https://www.flex.lu/fr/accueil/
[232] https://eurocities.eu/
[233] https://civitas.eu/
[234] https://www.polisnetwork.eu/

tools, and finances. A relevant example includes ERTICO- ITS Europe[235], which is a public-private partnership, aims to develop, promote, and connect Intelligent Transport Systems and Services (ITS) through various activities.

- ***Academic, research and transfer centres*** (e.g., imec, Institutes for Technological Research, such as IRT SystemX, public industrial and commercial institutions, such as LNE : National metrology and testing laboratory, LIST : Luxembourg Institute of Science and Technologies; etc.) are entities that conduct pioneering and in-depth research about the application of AI in the urban mobility sector and ensure to transfer knowledge to other relevant organisations. Their mobility innovations are usually lab-tested, hence, they have not been validated by real testing and experimentation facilities where their algorithms could be further trained and modified in the real environment.

Subthemes

- Urban Mobility

Definition

As cities become more populated and interconnected, the task of managing them becomes increasingly difficult. Traditional methods of urban planning, which often rely on manual data collection and analysis, are ill-equipped to handle this complexity. Urban AI with its ability to process vast amounts of data and to make predictions based on patterns, offers a solution to this problem. For instance, the need to install additional sensors to generate data enables cities with the chance to optimise their infrastructure throughout the continual collection of relevant data. Combining it with the potential to make monitoring systems more comprehensive and effective with the help of AI, could make urban mobility planning and management processes more efficient and more evidence-based. In addition, this allows the technical infrastructure to be operated for longer before it needs to be replaced. As of today, a wide range of applications are already being used to help communities improve their mobility services provided to their populations. Think of the AI based Passenger Management System[236] that updates passengers with smart applications using various transport mediums with real-time data on roadblocks, occupancy rate, delays, and breakdowns. These listed examples enable traffic managers to make informed decisions while designing transportation routes and timings therefore resolving the city congestion, and furthermore allows individuals to better optimise their travel plan.

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[235] https://ertico.com/

[236] https://www.trinitymobility.com/blog/ai-applications-smart-cities#:~:text=An%20AI%20based%20Passenger%20Management,timings%2C%20resolving%20the%20city%20congestion

Specifically, connected and smart intersections, which intelligently adapt their traffic lights depending on the conditions of the surrounding environment and the road users involved, are a great example of urban mobility technological advancements. Smart intersections themselves fall under the umbrella of urban mobility algorithms and help improve the safety, efficiency and sustainability of urban transport, leading to a more intelligent and connected urban environment. But, what is more concretely a smart intersection? It is a road intersection that is more intelligent and self-reliant enabled by the use of technologies such as IoT, Video Analytics, AI/DL and Edge Computing. The combination of AI with internet protocol (IP) based video analytics makes it possible to leverage visual analysis in a very targeted manner and perform analysis on traffic flow assessment and obtain insights into road user behaviour. These technologies are used to differentiate and count different road users, such as cars, trucks, buses and vulnerable road users (VRUs), adjust timing for each of the road users involved in the intersection, fine-tune traffic signals,[237] etc. In addition, ML inference models are trained to identify different events such as jaywalking, near misses between road users, crashes, unpredictable objects on road and many others. An example of such technology is the Cisco Integrated Edge Video Analytics used to identify and assess traffic counts in Melbourne, Figure 14 presents the idea.

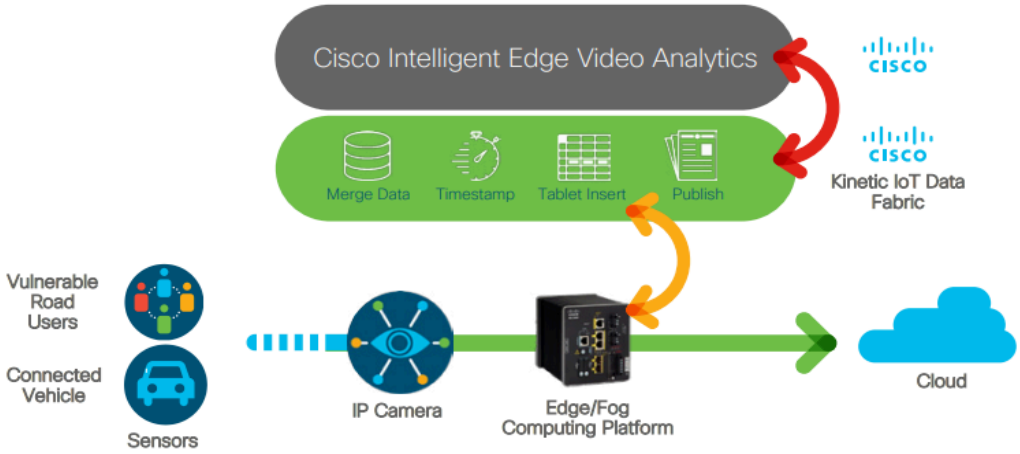

Figure 14. Cisco Integrated Edge Video Analytics high level overview of the platform

A similar and local implementation of such technologies in the EU is the Mobilidata programme[238] running in Flanders, where 250 traffic intersections will become intelligent by 2024. Through the combination of digital technologies, priority is enabled for the emergency vehicles, public transport and VRUs in those intersections.

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237 https://eng.unimelb.edu.au/__data/assets/pdf_file/0004/3280342/Cisco-Smart-Intersections-IoT-insights-using-Video-Analytics-and-AI.pdf

238 https://www.mobilidata.be/en

Challenges

There are several benefits of integrating AI and IoT technologies in smart intersections in particular and urban mobility in general. However, the integration of AI in smart cities is not without a wide number of challenges and limitations.[239] Taking into account that AI systems rely heavily on large amounts of data to function effectively, this data often includes sensitive information about individuals/communities, raising concerns about privacy and security, ethics, transparency, standardisation and others. The most prominent challenges are listed in what follows.

First, data heterogeneity is an issue. A lack of standardisation across Urban AI, heterogeneous IoT devices and their communication protocols often results in compatibility issues, thus demanding the standardisation of IoT protocols and interfaces for effective device integration and efficient data communication. Therefore, there is a need for standardised regulations regarding the use of Urban AI to safeguard privacy, government/corporate surveillance, and commercial exploitation.

Second, the large data volumes that are common in this particular context pose a challenge. The large volumes of data generated by IoT devices demand powerful computing resources and storage capabilities, hence elevating the need for data centres, data spaces and cloud computing infrastructure[240].

Third, suitable data security and data protection measures constitute prerequisites for project implementation. Data security is crucial in smart intersections due to the risk of cyber-attacks and data breaches, necessitating robust security measures. Continuous surveillance can also lead to privacy issues. Appropriate data governance protocols must be in place to ensure data privacy and accuracy. This should include proper policies and regulations to address data anonymization, consent, and access rights to gain public trust and widespread adoption. Balancing the benefits of AI with privacy and ethical considerations is vital for widespread acceptance and adoption of sustainable smart mobility solutions.[241] Furthermore, addressing ethical concerns, such as bias introduced by computational algorithms, may lead to discriminatory outcomes (for example, unfair treatment of certain groups), which is undesirable for equity and diversity in societies.[242]

Fourth, ensuring appropriate levels of transparency can be challenging. As AI becomes more involved in decision-making processes, it is crucial that these processes are transparent and that the AI systems can be held accountable for their decisions. There

[239] https://www.techopedia.com/the-intersection-of-ai-and-iot-how-smart-cities-are-transforming-urban-living

[240] https://link.springer.com/chapter/10.1007/978-981-15-8983-6_41

[241] https://medium.com/next-gear-ventures/hurdles-for-ai-in-smart-mobility-challenge-accepted-f2929e4e3c4

[242] https://link.springer.com/article/10.1007/s43681-022-00138-8

are limited means to allows individuals to control the confidentiality of their own urban mobility data; lapses in urban mobility and mobile phone location data inadvertently allows re-identification of people's whereabouts without their explicit knowledge[243], while more recent examples of surveillance on Strava, a social network for athletes[244] demonstrate how digital privacy is easily compromised.

Last, a lack of data is detrimental to the development of urban mobility AI systems. One of the basic technical requirements for developing AI systems in urban mobility is that there must be sufficient data available for the system to solve the societal problem[245]. Many applications of AI systems require the integration of data from a variety of sources. For algorithms to be able to draw accurate inferences, there should be access to a large quantity of structured, labelled data in a machine readable format (this is the technical definition of 'data quality'). Particularly for societal applications such as solving urban mobility challenges, the algorithms also require highly representative (training) data, for example in terms of the social groups and city districts it covers.

Opportunities

While there are significant issues to be addressed, particularly around data privacy and governance, the potential benefits of AI in urban mobility are tremendous. From democratising the planning process to creating more sustainable and innovative cities, AI has the potential to transform the way we design and manage the way we commute.

There are vast opportunities with regard to AI-powered Mobility Assistance. The future of urban mobility will undoubtedly be a hybrid of automated and assisted driving considering the speed of adoption of digital technologies in cities. This also means the feature of seamless integration between vehicles and the surrounding infrastructure. Cities will use more and more intelligent video analytics to provide real-time assistance to drivers and passengers. They can also enable seamless communication between vehicles and the surrounding urban infrastructure[246].

AI promises to make roads smarter and faster at the same time. The integration of intelligent video analytics into their infrastructure and AI in the vehicles allows cities to improve their road safety and make judgments and decisions based on real-time data, historical data, trends, and long-term patterns. Identifying infrastructure bottlenecks and correcting inefficiencies through data-driven spatial planning, for example, helps to

[243] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0140589

[244] https://www.tandfonline.com/doi/abs/10.1080/2159676X.2020.1836514

[245] https://www.we-do-change.org/fileadmin/downloads/GIZ2020_AI_urban_development.pdf?_=1610115274

[246] https://vinotion.com/vidigest/how-intelligent-video-analytics-can-help-solve-some-of-the-worlds-biggest-urban-mobility-challenges/

reduce the likelihood of accidents or congestion and allows us to inform road users, about upcoming traffic situations, in time.[247]

Moreover, using AI-powered traffic management, smart cities can get on top of keeping the streets flowing. By crunching massive amounts of real-time data, the algorithms can accurately predict congestion and identify potential bottlenecks in advance. Armed with this knowledge, cities and communities can optimise signal timings, reroute traffic, and suggest alternate routes to drivers, helping them avoid gridlock and arrive at their destinations without being massively annoyed[248].

- Electromobility

Definition

The European Commission's Green Deal[249] is paving the way toward a climate neutral Europe and this includes the transport sector that is responsible for around 25% of the total EU greenhouse gas emissions. The target adopted by the EC Council for reducing CO2 emissions of new cars and vans compared to the 2021 levels has been set to 55% in 2030 and to zero emissions for new cars in 2035. Even if other solutions, like Fuel Cell Electric Vehicles powered by hydrogen are still considered, the electrification of the cars, and more generally electromobility, is seen as the best choice to attain these targets.

In 'Why Electromobility and what is it ?'[250] Electromobility is defined as a road transport system based on vehicles that are propelled by electricity. Some road vehicles are equipped with technologies that make them capable of producing their own electricity (e.g. hybrid electric vehicles). Others utilise energy supplied by a source of electricity outside the vehicle – usually the electric grid.

High level challenges on electric vehicles (xEV's) can mostly be differentiated:

- (P)HEV's (Plug-in Hybrid Electric Vehicles) are facing different challenges that are related to the scenario of usage (heavily impacting the proportion of the distance that will be covered with electricity), the complexity of the technology or the reality of the ecological benefits.
- FCEV's (Fuel Cell Electric Vehicles) are facing very different challenges related to hydrogen station's availability or cost and impact of the production of

[247] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0140589

[248] https://www.rst.software/blog/9-use-cases-of-ai-in-urban-mobility-that-can-power-smart-cities

[249] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

[250] https://scholar.google.se/scholar?hl=sv&as_sdt=0,5&cluster=5402635595743840272

Hydrogen which vary widely depending on the technology used to produce it (the 'colour' of Hydrogen[251]).

- BEV's (Battery Electric Vehicles) are mostly facing challenges on the charging station capabilities (home, work, travel) and the speed of charging infrastructure deployment, cost or consumer adoption. Some behavioural changes may also be needed from people driving electric cars. In CitCom.ai, our main focus is on this segment of the market and these challenges.

Challenges

The SCALE[252] An EU-Funded project issued a report giving us better insight on the main challenges of Electromobility.

There are several challenges concerning consumer adoption and acceptability, basically social factors, impeding uptake of electromobility. Figure 15 shows that mainly price, (perceived) lack of range of the EVs, and lack of charging opportunities influence scaling of electromobility.

Figure 4: Barriers toward buying an EV. Iceland, N=519. Finland, N=647. Denmark, N=506. Sweden, N=567. Norway, N=391.

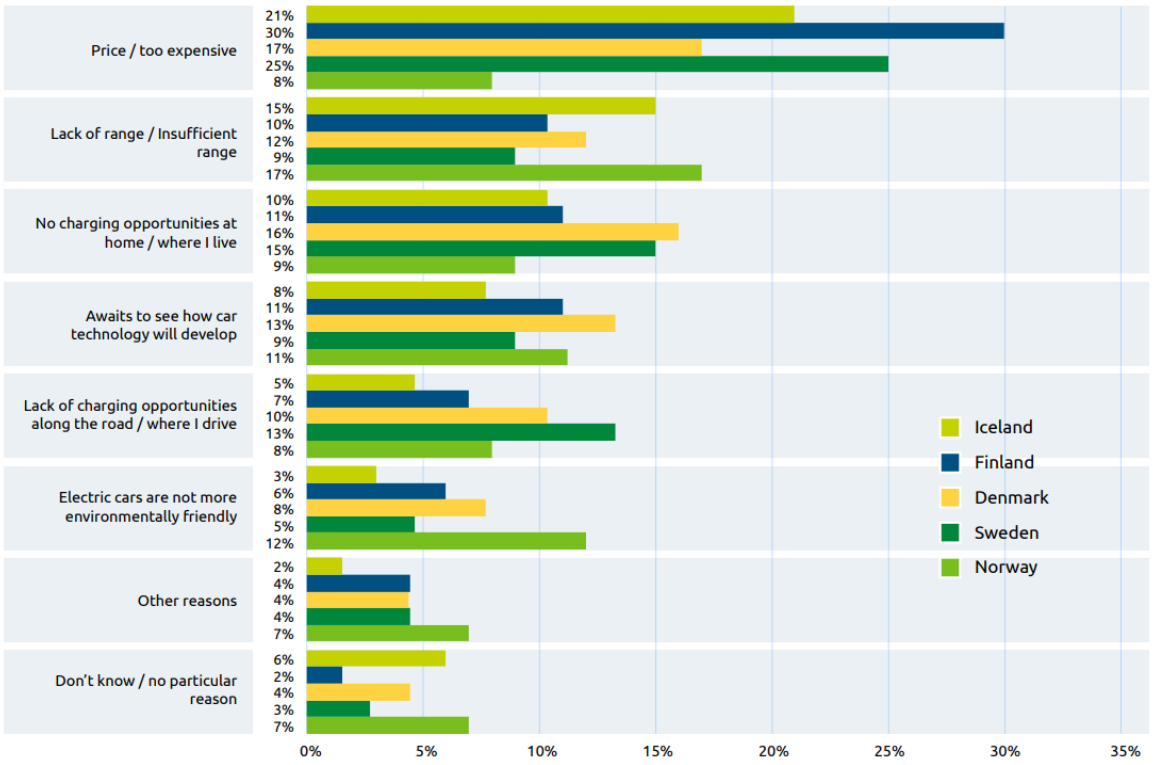

Figure 15. Barriers to adoption of EVs.

[251] https://doi.org/10.1016/j.ijhydene.2022.02.094

[252] https://scale-horizon.eu/

First, the cost of an electric vehicle is an impediment to adoption. As of 2023, the cost of xEV's is seen as higher than the ICE (Internal Combustion Engine) one's. The initial price of an electric car compared to a fossil based car of the same segment is effectively higher. But if we take the Total Cost of Ownership (TCO) into account, the higher cost of EV may be recovered in as little as 5 years[253]. In some countries, this initial higher price of the electric vehicle is lowered by incentives (€9.000 for a purchase price up to €40.000 in Germany), or lowered taxes (as far as no taxes at all in Norway). France, UK, Spain and Italy also have strong incentives for buying EV's. The trend there is to go for lower initial prices with a lot of OEM's having sub 25k€ EV in their short term plans.

Second, there is the challenge in terms of producing sufficient electricity and getting to necessary grid capacity. The evolution toward electrification, not only in the mobility sector, is putting pressure on the energy providers and the grid. European power demand will increase by 40 percent until 2050, from 3.500 TWh in 2020 to 4.900 TWh[254]. Even if smart grid management or dynamic tariffication (f.i. for residential consumers) will be helpful to reduce peak demand and make a better usage of the available capacities this increase of demand will remain challenging.

Third, rolling out charging station infrastructure is another challenge. The European Network of Transmission System Operators of Electricity (ENTSO-E) estimates that, in Europe 70 to 85% of EV users will count on private charger (at home, office)[255]. That means that a quarter of the EV users will be totally dependent on chargers from the Charging Point Operators (CPO) while the rest will still need it sporadically (for holidays, longer trips, etc). Deploying the adequate infrastructure of charger in term of number (1 for 10 vehicle being considered as a sweet spot), capacity (from slow 11kw charging in 6-8 hours to ultrafast 350kw charging in 3-8 minutes), pricing strategy (including incentive to charge at the best moment for the grid), is a complex challenge where AI could have an impact.

Opportunities

AI also offers opportunities for electromobility, notably aiding in increasing the flexibility of the electricity grid and forcing breakthroughs in the context of using BEV's batteries as storage.

First, electricity can be produced with many different technologies and sources coming from renewable energy (sun, wind, water, etc), CO2 neutral (e.g. nuclear) or even fossil

[253] https://doi.org/10.1016/j.enpol.2021.112564

[254] https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/epng/pdfs/transformation_of_europes_power_system.ashx

[255] https://www.entsoe.eu/2021/04/02/electric-vehicle-integration-into-power-grids/

(e.g. gas). The demand can also be partially adapted (delaying the start or home appliance, shifting the energy hungry processes in the industry, etc). If it complexifies the work of the grid operators, it also opens a large area of new possibilities for innovative solutions to target the CO2++ neutrality. As an example, The Danube InGrid project between Hungary and Slovakia is designed to enhance cross-border coordination of electricity network management, with a focus on smartening data collection and exchange

Second, the possibility to take energy from the BEV to send it back to home (V2H) or even the grid (V2G) is a real opportunity as confirmed by some studies[256]. The SCALE project[257] has been funded by the EU to investigate these possibilities. Their report on consumer behaviour (D1.1) confirms that most of the people (82% of Dutch EV drivers, f.i.) are willing to smart charge (or unload). Despite some open questions that still need to be solved, i.e.. on the impact of the car battery, there is a real potential considering that an average battery capacity car (50 KwH) can provide two or three days of electricity for an average four person family (4.500 KwH a year).

- Automated driving

Definition

Connected and Automated Mobility (CAM) refers to autonomous/connected vehicles or self-driving cars (vehicles that can guide themselves without human intervention). EU countries, industry and the Commission collaborate to achieve the EU's ambitious vision for CAM across the EU, taking into consideration public authorities, citizens, cities and industry interests.

In 2021, SAE International clarified the J3016 “Levels of Driving Automation” standards. The SAE J3016 defines six levels of driving automation, from SAE Level Zero (no automation) to SAE Level 5 (full vehicle autonomy in all conditions). It serves as the industry’s most-cited reference for automated-vehicle (AV) capabilities.

To dig into the operational mode[258], the levels of automation in the French regulatory framework distinguish the capabilities of a driving delegation system to complete manoeuvres initiated in automated mode in complete safety. It ranges between: 1) an automated driving system, exercising dynamic control of the vehicle; 2) a vehicle partially automated, making a takeover request to respond to certain traffic hazards or malfunctions during a manoeuvre; 3) a highly automated vehicle, responding to any traffic hazard or malfunction; and 4) a fully automated vehicle, responding to any traffic hazard or breakdown.

[256] https://doi.org/10.1016/j.esr.2022.101001

[257] https://scale-horizon.eu/use-cases/

[258] https://www.ecologie.gouv.fr/sites/default/files/05-Mobilite_routiere_automatisee_definitions_reglementaires.pdf

Challenges

According to Automated Vehicles: joint report (2022)[259], the introduction of automated vehicles will have profound legal consequences. It requires new regulatory schemes and new actors (with new responsibilities and liabilities). The authors therefore recommend primary legislation - a new Automated Vehicles Act - to regulate automated vehicles on roads or other public places in Great Britain.

With the evolution of digital technologies (see [260]), such as robotics, internet of things, AI, high-performance computers and powerful communication networks, vehicles in general, and cars in particular, are quickly changing. Therefore policies and legislation relating to digital technology, including cybersecurity, liability, data use, privacy and radio spectrum/connectivity are of increasing relevance to the transport sector. These aspects need coordination at the European level in order to ensure that a vehicle may remain connected when crossing borders.

To explore the details of automated vehicles, and to achieve a high-level during automation (see [261]), specific challenges are included in what follows.

First, there is a challenge in ensuring sufficient sensor accuracy and reliability. Automated driving systems rely on sensors to detect objects in the environment and accurately assess their location. As such, it is essential for the sensors used in these systems to be highly accurate and reliable. In addition, sensors must be able to operate effectively in various environmental conditions. That includes different lighting and weather conditions, such as rain or snow.

Second, as self-driving cars become a reality, new legal and social frameworks must be developed to accommodate this new form of transportation. Existing laws and regulations may need to be updated to account for AV, and new ones must be developed. This includes liability issues, data privacy, and cybersecurity concerns. Social acceptance of self-driving cars must also be considered to ensure widespread adoption.

Third, automakers cannot achieve high-level driving automation alone. Collaboration with suppliers, technology companies, and infrastructure providers is essential to meet the unique challenges that self-driving cars present. This means sharing data, expertise, and resources to develop a cohesive and effective solution. Collaboration could also help accelerate the development process.

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[259] https://www.lawcom.gov.uk/document/automated-vehicles-final-report/

[260] https://digital-strategy.ec.europa.eu/en/policies/connected-and-automated-mobility

[261] https://datamyte.com/autonomous-vehicle-challenges/

Next, to achieve full driving automation, self-driving cars must collect vast amounts of data, including sensory data from the vehicle's surroundings and detailed information on the driving experience. This data must be collected, processed, and analysed in real-time so that the vehicle can make split-second decisions accurately. Data management and analytics will be critical in the development of self-driving cars.

Fifth, as more sophisticated technology is introduced, the risk of cyber-attacks increases. Hackers can potentially take over control of AV and cause harm. Therefore, vehicle cybersecurity must be a priority during the development of self-driving vehicles. This includes measures that detect and respond to cyber threats and prevention methods.

Furthermore, as more vehicle control becomes automated, also the relationship between the driver and the vehicle will change. Drivers must understand the vehicle's capabilities and limitations and know when to take control. Through alert systems and human-machine interfaces, effective communication between drivers and the vehicle is vital for achieving high-level driving automation.

Last, to achieve full driving automation, upgrades to infrastructure are essential. This includes new road markings, signs, and signals recognizable to autonomous vehicles. Communication between infrastructure and self-driving cars will help reduce the risk of accidents, and the development of charging infrastructure and rest stops will be required. Upgrading infrastructure to support self-driving cars will require significant time and money.

Opportunities

The ACEA position paper [2020][262] outlines some opportunities offered by AI when applied to vehicles. We will go through them one by one below.

First, AI technology can contribute to increasing the level of safety for vehicles, drivers, and roads; fully in line with road safety targets such as the 'Vision Zero' ambitions of the EC.

Second, AI technology applications, in the case of Connected, Cooperative & Automated Mobility (CCAM), can further optimise movements or decisions, maximising efficiency in terms of time and fuel or power consumption.

Third, preventive maintenance through continuous data analysis will reduce unanticipated failures and help achieve a closer relationship with customers. AI can reduce in-vehicle cost as well as the cost of ownership through predictive maintenance.

[262] https://www.acea.auto/publication/position-paper-essential-uses/

Fourth, a potential AI benefit relates to the mitigation of human bias, allowing for greater objectivity. For example, in manufacturing-production processes AI allows for more effective quality checks / monitoring.

Fifth, AI applications will ultimately lead to safer journeys, more efficient travelling and more relaxing and satisfying driving. Moreover, infotainment systems can offer products and services to the driver, based on the raw data.

Finally, AI can help accelerate the development of new products, for example by avoiding the need for 1:1 scale prototypes to be built, making verification tests digital and learning better and faster from data. AI allows for capturing the key features of new products in the design process, hence reducing the time to market.

Regional insights/ Use cases

- Automated parking control system

Description

An illustrative Urban AI use case to be examined within this report is the automated parking control system[263] in the city of Amsterdam. In many European cities including Amsterdam, there are a limited number of cars allowed to park in the city to make the urban areas more liveable and accessible, especially for pedestrians and cyclists. Here, the municipality enforces the use of approved parking permits by owners of cars and any parking fines to be levied if they have not been paid via a parking metre or mobile app. The city has begun enforcing such parking measures automatically using municipal "scan cars" equipped with video cameras, to process licence plates and conduct background checks on the drivers using automated image scanning and an AI-based identification service. The City of Amsterdam is currently using this service with over 150,000 parking spaces in the city streets.

As part of the parking control service, the scan cars drive through Amsterdam using object recognition software to scan and identify licence plates of nearby cars they encounter. The licence plate numbers are validated through a National Parking Register to ensure the cars are allowed to park in certain areas of the city. If no valid permit or payment has been determined for certain parked cars the case is sent to a human inspector for further processing. In the final step, parking inspectors assess the scanned images to verify if licence plates are correctly recognized or if cars are parked temporarily for special situations like loading/unloading or stationary cars in front of traffic lights. Based on the remote assessment, the inspectors can decide whether to conduct an on-site visit to verify the situation before parking tickets are issued. Hence,

[263] https://algoritmeregister.amsterdam.nl/en/automated-parking-control/

the parking control system uses a hybrid approach to automated AI-based scanning and verification with the assistance of experienced human operators.

Lessons learned

Now for all its safeguards such an Urban AI system may pose a range of risks to citizens including that of privacy, wrongful identification, and inadvertent neighbourhood profiling. The video cameras may not simply scan and identify licence plates but also other kinds of visual features in the environment including private data such as details of people and their cars or homes while driving in the city. In some cases, wrongfully identified licence plates may incriminate drivers who have legitimate parking permits. To mediate these concerns, clearly the municipal authorities in the City of Amsterdam are working on providing mechanisms for transparency, auditability, and accountability for such automating parking control systems to city residents. This would enable residents and visitors to the city to better understand the nature of risks such systems may introduce, what rights they have for due recourse, and how the system handles its overall services and policies in a responsible and trustworthy manner.

- SAM Project

Description

The SAM[264] project is the best illustration of mobility use cases in France; Results are not yet available. The French government has chosen the SAM[265] consortium gathered around the Automobile Platform (PFA) to launch a large-scale experimentation program for AV and make France a land of development, implementation and deployment of driving and autonomous mobility. In short, this project considers more than €100 million, and concerns nearly 50 Vehicles, 11 Territories. This project targets six categories of AV use cases: autonomous driving, valet parking, VTC (Passenger car with driver), new collective or shared mobility services, public transport, last mile delivery.

Scope

The SAM project defines several evaluation domains:

- Safety and scope of employment: What are the relevant scenarios for security validation? What is the ODD (Operational Domain Design) achievable by the system vehicle/infrastructure?
    - Example: a private vehicle offering an L3 highway driver type functionality defines in its ODD that driving is only possible on the highway, during the day, and with good horizontal signage. Outside of these conditions the system is not able to perform the associated function.

[264] https://www.sam-evra.fr

[265] https://www.sam-evra.fr

- Acceptability: How is the service received by its users? and other road users?
- Behaviour: What are the behaviours of service users and other road users and their impact on road safety?
- Environment: What are the environmental characteristics of AV? What are the environmental consequences of setting up the service?
- Traffic: How AV fits into traffic real state?
- Service performance: How does the experienced and of the target service work?
- Economic and societal: What is the impact of the service on the demand for journeys? What are the societal costs and benefits of the deployed service ? How is the deployment of the VA organised? at the local and national level? What are the expected costs and revenues for VA service?

- Local Digital Twins for Energy

Description

The use case focuses on cities' and communities' challenges to support electromobility and the impact on energy investment needs. In that sense, the use case aims at delivering a visual and interactive tool to support city decisions on the location of chargers, their associated demand, and how this energy demand can be compensated by smart investments in photovoltaic. Such a tool combines electromobility network and demand data, mobility data, building data, weather data, and energy telemetries in order to model both demand and supply and understand the impact of different scenarios in terms of the energy balance. The tool is intended for city and community managers.

- Vehicle-Integrated photovoltaic

Description

The electrification of the transportation sector is becoming mainstream. In particular for buses, transportation agencies are in the deployment phase of electric (battery-enabled or fuel-cell) passenger buses for specific lines and itineraries. However, the high impact of factors like driver behaviour, driving context, and meteorological conditions on battery range poses a challenge for fleet managers to decide on concrete strategies for electrification transition without impacting the duty cycle of buses. In that sense, the incorporation of Vehicle Integrated Photovoltaic Technologies (ViPV) can assist in managing those challenges by reducing the high variability of range with an external source of energy. This use case intends to deploy a tool by which transport operators could assess the benefits of a certain PV investment together with the impact on the duty cycles of the different lines, itineraries, or the entire network. In terms of data, the tool will make use of General Transit Feed Specification (GTFS) for a line or the entire network and quantify, through models, the solar irradiation under realistic conditions. The output of the model is used, together with other economic factors, to compute a comprehensive and visual assessment.

- Battery-enabled EV chargers assessment

Description
When cities and communities decide to invest in EV charging, either through CPOs or directly in self-managed charging infrastructure, the performance of the chargers under real conditions would need to be assessed. The intention of this use case is to provide an assessment service that evaluates the performance of the EV chargers under controlled conditions in well-modelled distribution networks and in a Hardware-in-the-loop infrastructure. The data generated by the service will mainly consist of highly-sampled time series of relevant signals and a number of models will be implemented to detect potential anomalies and particular situations to be highlighted in the assessment.

- Optimization of EV charging networks

Description
Maximising the chargers' occupancy is key for cities, communities, and CPOs aiming on smart investing in electromobility transition. In that sense, it is crucial to understand the underlying reasons pushing occupancy up. Exploring data correlations from existing charging transactions stands as a useful strategy to extract potential features that charging network planners could quantify in order to have an accurate prediction of the expected occupancy of a charger and, on top of that, a recommendation of an optimal deployment considering multiple constraints. The tool intends to provide stakeholders with an interactive interface to quantitatively assess the expected occupancy of chargers given a location, some metadata, and its context. The data used for this use case is primarily chargers occupancy time-series, map layers, parking occupancy and meteorological data, among others.

- EV-related emissions

Description
xEV's are certainly not carbon-free. On top of the emissions related to its manufacturing process, including battery production, during the rest of the life cycle, emissions will be related to the source of electricity at each charging session. Therefore, it is crucial both for individual drivers and fleet managers to have instruments to control its emissions as ICE-vehicle drivers do. In order to do so, energy generation data as well as EV charging transactions need to be exploited. The use-case intends to deliver a tool for drivers and fleet managers that quantifies, at each trip the amount of emissions. Additionally, recommendations can be provided to end-users on how to flexibilize their charging demands in order to minimise their emissions.

The South super node: ‘CONNECT’

Definition

CONNECT is one of the three essential concepts of the CitCom.ai project. CONNECT refers to the need to link citizens, infrastructures, AI and robotics services securely in cities and communities. By using digital technologies such as IoT, cloud computing, big data analytics, and AI, CONNECT seeks to improve the quality of life, the efficiency of resource use, and the environmental sustainability of urban areas.

The theme CONNECT covers six sub themes that address different aspects of urban improvement planning: 1. pollution, greenhouse gas emissions and noise management; 2. urban development management; 3. water and wastewater management; 4. integrated facility management; 5. drone delivery management; and 6. tourism management. Each sub theme focuses on specific AI capabilities that can provide innovative solutions for the challenges and opportunities faced by cities and communities.

The southern supernode of the CitCom.ai project focuses on CONNECT, and includes partners from Spain, Italy, Poland and Germany. This analysis includes a stakeholder overview, a description of the subthemes, and regional insights. The stakeholder overview identifies and describes the main actors involved, which can be classified into four types: public sector, private sector, civil society, and research and academia. Each type of stakeholder has different needs and challenges that need to be addressed by the AI TEF. The subtheme sections define and explain six specific focal areas. They also provide examples of existing or potential AI solutions that illustrate how they can address the needs and challenges of different stakeholders. The regional insights section showcases use-cases, and lessons learned from the implementation of AI solutions.

CONNECT aims to foster a collaborative ecosystem among different stakeholders in the smart and sustainable cities and communities domain. The southern superhub will provide a variety of data sources to support the development and testing of AI solutions for the subthemes. By providing access to data and infrastructure for AI experimentation and testing in real-life conditions, CONNECT hopes to accelerate the digital transformation of cities and communities in Europe and beyond.

Stakeholders

The stakeholders within the CONNECT domain of CitCom.ai comprise four stakeholder groups, aligned with the quadruple helix model: Public sector, private sector, civil society, and research and academia.

- ***Public Sector.*** In Spain, the public sector is represented by the RECI (Spanish network of Smart Cities), a network that includes key cities like Valencia. In Italy, individual municipalities have established their own path towards digitalization and a sustainable transition, despite the fact that there are associations for municipalities such as the ANCI (National Association of Italian Municipalities) or the Rete dei Comuni Sostenibili. Meanwhile, the capital city authorities in Warsaw lead over 80 projects related to the implementation of the smart city idea. For tourism, some potential stakeholders are the regional ministry of tourism, port authorities, the train national company (RENFE), valencian airports, Visit Valencia, and the Chamber of Commerce of Valencia. In the fields of water, noise and air pollution, some stakeholders are local, regional and national security forces and environmental public institutions (CEAM, VAERSA, SEPRONA, etc).

- ***Private sector.*** Within the private sector, some stakeholders involved are: AI-ML innovation companies, cybersecurity companies, law firms, tourism operators, facility management companies, utility companies, waste management companies (Fovasa), startups (Startup Valencia), accelerators (Col·lab, Lanzadera, Innsomnia), and associations such as City Vision, which provides the content and event platform to facilitate the exchange of experiences, needs and solutions for the smart transformation of territories; Mindicity, that is an urban intelligent platform by TIM; and, The Smart City Association Italy (TSCAI), which supports cities and their partners in the process of building a sustainable growth programme. The Italian smart city market, valued at 900 million euros in 2022 (+23% over 2021), witnesses collaborations between local governments and some of these associations. Milano Smart City Alliance, which is specifically focused on contributing to the realisation of a smart city by creating the conditions for the development of attractive projects that generate tangible benefits for the territory in terms of innovation and sustainability, constitutes the best example of an organisation focused on the improvement of a single city. Private entities in Warsaw actively participate in various smart city projects.

- ***Civil society.*** Civil society stakeholders play pivotal roles in shaping smart city initiatives. In Spain, this includes civic or consumer associations like FAAVV, environmental groups and NGOs, educational foundations, etc. Cooperation between universities and city residents not only allows for the implementation of the mission of social responsibility of science, but also helps shape an open information society. For example, in Warsaw the platform Digital Agora[266] is intended to enable the smart city community to express their own opinions on the

[266] https://doi.org/10.1016/j.landusepol.2021.105614

city's development, submit proposals and discuss concepts submitted by the city authorities and various interest groups.

- ***Research & Academia.*** Research and academia contribute expertise in environmental sciences, AI, data analysis, urban planning, and more. They are essential for developing and validating AI models and innovative solutions for urban challenges. Universities and academic centres, such as WUT in Warsaw, UV and UPV in Valencia, Politecnico di Milano, but also other public and private universities and research institutes, contribute significantly to smart city projects. The Smart City Observatory, belonging to the Politecnico di Milano School of Management, serves as a prominent entity within the research and academia sector.

In summary, the CONNECT domain brings together stakeholders from the public sector, private sector, civil society, and research and academia. Each group has its unique role, challenges, and needs, all contributing to the advancement of sustainable urban development.

Subthemes

- Pollution, greenhouse gas emissions and noise management

Definition

Pollution is the introduction of harmful substances into the environment that can cause various diseases and cancer. Greenhouse gases trap heat in the atmosphere and cause global warming, which can alter the climate and increase the exposure to health risks. Noise is the unwanted sound that can disturb the quality of life and cause stress, hearing loss, and cardiovascular effects. These problems can be reduced by implementing regulations, improving planning and technology, and promoting awareness and education.[267]

Pollution, greenhouse gases and noise are environmental problems that affect human health and well-being, especially air and noise pollution have become major problems in cities. Although emissions have declined in the last two decades, resulting in better air quality, air pollution remains the largest environmental health risk in Europe[268]. Exposure to fine particulate matter and nitrogen dioxide levels above the World Health Organization (WHO) recommendations cause an estimated 238,000 and 49,000 premature deaths, respectively, in 2020. These pollutants are linked to asthma, heart

[267] https://www.frontiersin.org/articles/10.3389/fpubh.2020.00014/full

[268] https://www.eea.europa.eu//publications/air-quality-in-europe-2022

disease and stroke[269]. Noise pollution is also causing premature deaths. According to WHO, it is one of the most dangerous environmental threats to health and is responsible for 12,000 premature deaths and 48,000 new cases of ischaemic heart disease every year[270]. Furthermore, air pollution includes greenhouse gases such as carbon dioxide. Greenhouse gases causes the climate to warm and air pollution can also accentuate this warming, there is a correlation between climate change and air pollution.

Challenges

Challenges related to the demand side of AI for pollution management are associated with the perspective and readiness of governments, organisations, and communities to embrace AI-based solutions for addressing pollution. These challenges can significantly impact the adoption and effectiveness of such technologies.

First, there are cost and funding constraints as the implementation, continuous operation and maintenance of AI-powered pollution monitoring and control systems can be expensive, which can deter some organisations from investing in them.

Second, there is a lack of awareness and education which leads to limited understanding of the capabilities and benefits of AI in the context of pollution monitoring and control systems may require raising awareness and providing education about AI's advantages.

Third, interdisciplinary collaboration which is necessary in this context can come with considerable hurdles. Specifically, achieving collaboration between experts in environmental science, engineering, data science, and policy can be challenging.

Next, there are challenges related to data quality and availability. For example, high quality pollution data can be limited, making it challenging to develop accurate AI models.

Last, there is a need to take into account the local context and foster community engagement. The challenge is to find requirements of solutions tailored to the local context and engagement with the community regarding pollution concerns.

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269 https://www.eea.europa.eu/en/topics/in-depth/air-pollution?activeAccordion=4268d9b2-6e3b-409b-8b2a-b624c120090d

270 https://www.eea.europa.eu/articles/noise-pollution-is-a-major

AI innovators working on pollution management also face various challenges on the supply side, which relate to the development, implementation, and deployment of AI-based solutions. These challenges encompass technical, logistical, and operational aspects[271].

Again, there are prominent cost considerations. The richer the location, the better the access to air pollution monitoring systems and the higher the level of health care. Ensuring that AI-based solutions are cost-effective and accessible to regions or communities with limited resources is a challenge.

Also dealing with model complexity and ensuring accuracy can be challenging. Complex and nonlinear relationships between various factors (emissions, weather, geographical data) can complicate the building of accurate AI models for urban air pollution monitoring. Moreover, integrating data from various sources (including satellite imagery, ground-based sensors, weather forecasts) can be complex.

Finally, there are limitations of different air pollution monitoring technologies with stationary networks. Concretely, monitoring networks based on cheap sensors have been developed in many cities; however, the problem of the reliability of the data obtained from cheap sensors is also questionable.

Opportunities

AI-powered sensors and data analysis can help track air and noise quality and pollutant levels in different locations. This information can guide regulatory measures and alert people to high pollution periods. AI can also help track emissions from various sources, enabling better regulatory compliance and accountability in reducing carbon footprints. Some examples in air pollution and noise management are[272]:

- Air quality monitoring and early warning systems: AI-powered sensors that detect pollutants and provide alerts and warnings when air quality deteriorates. Data analysis to identify pollution sources, trends, and correlations.
- Predictive modelling and air quality forecasting: accurate forecasts by analysing historical data, weather conditions, and emissions data help authorities for decision-making.
- Pollution source identification: AI can distinguish between industrial emissions, vehicular pollution, natural sources, and more.
- Data-driven policies: insights into the effectiveness of pollution control measures, correlation with public health.

[271] https://www.mdpi.com/2504-2289/6/3/75

[272] https://www.mdpi.com/2075-5309/13/8/2061

- Public awareness: AI-powered platforms can provide the public with real-time air quality information and pollution sources, raising awareness and encouraging them to take action.
- AI acoustic sensors: detecting noise levels and sources allows cities to implement measures and regulations. They also can incorporate light signals to deter and reinforce regulation.
- Traffic flow optimization[273]: minimising noise and pollution in urban areas
- Noise cancellation technologies: AI-driven noise cancellation can help reduce noise pollution by actively countering unwanted sounds in specific environments.

- Urban development management

Definition

Urban development management is the process of planning, designing, implementing and evaluating urban development projects and policies that aim to improve the quality of life, sustainability and resilience of urban areas.

Emissions (considering the neutrality concept from the Climate Mission kit, scope 1 + 2 + waste) come fundamentally from 4 main sources: mobility and transportation, heating/cooling and energy consumption in buildings, electricity generation, and waste management. Urban development management using AI allows for solutions that are expected to be the major driver to make cities and communities climate neutral.

Challenges

Urban development management is witnessing transformation through AI solutions, addressing complex challenges and striving for climate-neutral cities. This overview delves into the key challenges on the demand side of AI solutions in this domain. The challenges are:

- Data Integration Complexity: Integrating diverse urban data sources, including historical energy data, citizen behaviour parameters, and environmental monitoring, is a primary challenge. Streamlining this data integration is critical for AI solutions to function effectively.
- Behavioral Parameter Analysis: Understanding and predicting citizen behaviour related to energy consumption and mobility is intricate. AI solutions must grapple with the complexity of influencing factors to model and predict behaviour accurately.
- Policy Impact Assessment: Assessing the impact of urban policies, such as energy refurbishment, demands robust AI-driven simulation algorithms. These

[273] https://www.isarsoft.com/article/ai-in-traffic-management

algorithms must consider multiple dimensions, including historical data and architectural interventions.
- Specific, specialised digital skills and technological capacity: Securing IT experts with the requisite skills is vital for tasks like data creation, algorithm design, and digital infrastructure setup, especially challenging for public city administrations.
- Conscientiousness and engagement of citizens: Digital literacy is pivotal for citizen engagement in smart cities, enabling informed participation, risk awareness, and the realisation of benefits while ensuring inclusive decision-making models that prioritise citizens' well-being.

Innovative solution providers in the urban development domain also face a unique set of challenges and requirements when attempting to introduce their AI-driven products and services to cities and communities. Indeed, there are several preconditions necessary to secure the expected benefits of AI. They are presented below[274]:

- Data: To harness AI for urban development, ample high-quality data across multiple domains is essential, whether privately or publicly sourced, and supported by robust data management systems and skilled personnel.
- Digital infrastructure: Effective urban AI development hinges on robust IT infrastructure and computing power that prioritise interoperability and big-data analytics to harmonise systems.
- Legal framework: A suitable legal framework is essential to address privacy, liability, and regulatory challenges posed by the digital economy's impact on urban governance, striking a balance between citizen protection and innovation promotion.
- Partnerships: Smart city initiatives require diverse partnerships involving private sector entities, urban planners, citizens, and various sectors to address complex challenges through innovative collaboration models like public-private partnerships and multi-level governance.
- Governance: A robust governance system for smart cities should feature multi sectoral integration, multi-level governance, and a human-centric approach to AI, fostering innovation and societal acceptance. Adequate planning, leadership, funding, and ongoing evaluation are crucial elements for successful implementation.

Then, AI innovators in urban solutions must address these challenges, meet specific needs, and overcome barriers to successfully introduce their AI-driven products to cities and communities. Building strong partnerships and collaborative relationships with urban stakeholders is key to driving adoption.

[274] https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690882/IPOL_STU(2021)690882_EN.pdf

Opportunities

But AI solutions are also reshaping urban development management by addressing these challenges. Some examples of the key trends are:

- Predictive Energy Demand Analysis: AI solutions are increasingly focused on predicting residential energy demand at the city level, aiding urban planners in data-driven energy management decisions.
- Renewable Energy Generation Prediction: AI-driven solutions predict renewable energy generation, enabling cities to optimise clean energy integration.
- Energy Improvement Potential Assessment: AI solutions indicate the potential for energy improvement through building refurbishment at the city level, prioritising energy-efficient renovations.
- Impact on Citizens: AI solutions assess the impact of urban renovations on citizens, evaluating changes in living conditions and environmental quality.
- Spatial Big Data for Sustainable Building Management: Leveraging spatial big data, AI optimises sustainable building management, considering factors like building shapes, demographics, and energy consumption.
- Mobility and Traffic Management: AI-driven traffic management systems, autonomous vehicles, and mobility analytics. These services range from traffic prediction and route optimization to the development of autonomous transport solutions.
- Urban Planning and Design: Urban planning firms and architectural companies are increasingly embracing AI.Their services include land-use analysis, urban simulation, and recommendations for sustainable urban design.
- Public Safety and Security: Security technology companies focus on enhancing public safety with services such as predictive policing, emergency response optimization, and surveillance analytics.

As cities, such as Valencia, aim for climate neutrality, AI's role in policy assessment and urban transformation is set for significant growth and impact. These solutions empower cities to become more efficient, sustainable, and responsive to the evolving needs of their residents.

- Water and water-waste management

Definition

Water and water-waste management is a multifaceted domain intricately involved in the comprehensive and sustainable management of water resources and waste within urban and community contexts. This encompassing field integrates diverse strategies, technologies, and practices, encompassing everything from sourcing and treating water to systematic distribution and responsible wastewater management. It addresses critical

challenges related to water availability, quality, and sustainability, particularly relevant in many Southern EU cities. Guided by insights from projects like Gonexus[275], this domain leverages advanced AI approaches to enhance water infrastructure management, empowering decision-makers and automated systems for effective resource allocation. Moreover, it emphasises the importance of low-latency actuation mechanisms for rapid responses in critical situations. This domain fosters innovation and research for tailored solutions to urban water management challenges, playing a pivotal role in advancing environmental sustainability and urban resilience.

Challenges

The domain of water and wastewater management faces several complex challenges and trends that shape the market for AI solutions. These challenges and trends define the boundaries and characteristics of the market, encompassing products, services, target customers, geographic scope, demand and supply mechanisms, and market size and growth potential. These are some challenges:

- Complex Urban Water Issues: Many southern EU cities grapple with critical water issues, including water scarcity, wastewater treatment, and the need for sustainable water management. These complexities necessitate innovative AI solutions to address the multifaceted challenges.
- EU Green Deal Expectations: The EU Green Deal sets ambitious sustainability goals for member states, placing pressure on cities and communities to adopt eco-friendly practices. AI solutions must align with these expectations to drive environmental sustainability in water management.
- Infrastructure Optimization: Water infrastructure management requires optimization to ensure efficient resource utilisation. AI plays a crucial role in enhancing decision-making processes, especially in scenarios requiring low-latency actuation mechanisms during critical situations.

On the supply side, the AI innovators in water and wastewater management encounter challenges related to data accessibility, regulatory compliance, market education, and customization. Concurrently, they must navigate barriers related to budget constraints, resistance to change, data security, and technical complexity. Access to diverse and high-quality datasets, including real-time water quality and infrastructure data, is crucial for AI model development. The complex and varying regulatory landscape poses hurdles as water regulations and standards differ across regions. Educating cities and communities about AI's potential in water management is essential, given that many may be unfamiliar with these technologies. Additionally, the need for customization arises, as each locality has unique water management challenges demanding tailored AI solutions.

[275] https://gonexus.eu/

Opportunities

The intersection of technology and water management is giving rise to a spectrum of key trends that not only address existing issues but also pave the way for smarter, more resilient cities. Here some examples:

- AI-Driven Pump Optimization: AI solutions are trending towards optimising wastewater pump operations. These technologies enable real-time monitoring and adjustment of pump systems, reducing energy consumption and operational costs.
- Behaviour Change Campaigns: AI is increasingly employed to support behaviour change campaigns related to water consumption. These campaigns leverage data-driven insights to encourage responsible water usage among consumers.
- Waste Recycling Management: The management of waste recycling infrastructure is a growing concern. AI solutions are trending towards automating waste sorting processes, enhancing recycling efficiency, and reducing environmental impact.
- Environmental Infrastructure in Urban Ports: Urban ports are vital hubs with complex environmental water infrastructure. AI solutions are emerging to monitor and manage water quality, ensuring the sustainability of these critical areas.

To assess specific problems in real-life water systems there are different AI solutions, some examples are described in a white paper of the IWA Digital Water Programme[276]:

- Real-time Detection of Pipe Bursts in Water Distribution Networks
- Automated Asset Condition Assessment using AI and Computer Vision
- Predictive Wastewater Treatment Plant Control
- Smart Alarms for Proactive Wastewater Network Management
- Real-Time Forecasting of Sea Currents
- Bayesian Networks for Proactive Asset Management
- Computer Vision for Opportunistic Rainfall Monitoring

The emphasis was placed on showcasing practical solutions, as opposed to mere technologies, which were created to tackle genuine challenges in real-world water systems. Despite the limited number of instances presented, it is evident that AI-driven solutions have substantial potential in the water sector. These solutions demonstrate their efficacy in addressing authentic issues within these systems while delivering tangible advantages.

[276] https://iwa-network.org/wp-content/uploads/2020/08/IWA_2020_Artificial_Intelligence_SCREEN.pdf

- Integrated facility management

Definition

Integrated facilities management (IFM) is a comprehensive method of facilities management (FM) that consolidates the administration of all the systems and processes in an organisation - and usually also the service providers - under a single technology-based platform that is outsourced[277].

IFM can increase operational efficiencies, drive savings, and leverage program data across a business to better meet organisational goals. It's an approach that can:

- Streamline operational processes
- Better control operating costs
- Improve overall communication and collaboration
- Enhance the use of technology to leverage actionable insights

In short, IFM increases organisational agility and can help move businesses to a more robust strategic footing[278].

Actually the trend of general contracting all the service of FM is the leading one, grouping under the same contract all the delivery of services for the same client. The company that delivers the services is a one stop shop for the client, even if not all the services are delivered by the same company. The performance control is performance-based and not prescriptive, i.e. it is not considered in the contract the possibility in which the client tells exactly to the provider the operational activities it should perform in order to get the service delivered but deals with the provider and agrees to a system of shared controls and performance indicators.

Challenges

Challenges are linked to the data paradox effects in the neighbourhood, firstly, the huge quantity of data generated by multiple sources and multiple data owners is the most important management issue to be tackled, i.e. different Facility Management companies implies different contracts. Building management systems (BMS) generate data, most frequently owned by different players - building managers, asset managers, developers, communities, FM companies, utilities companies, special service providers, etc -, and the ownership of data if it is not clear and the need of data usage for the purpose of management of the neighbourhood is a crucial topic. Moreover, different platforms and systems implemented by different owners, responding to different areas[279]

[277] https://www.enternest.com/blog/what-is-integrated-facilities-management

[278] https://www.enternest.com/

[279] https://re.public.polimi.it/handle/11311/1034387

activities are in many cases not intended to be created to generate clean and usable databases.

Opportunities

In the realm of urban innovation, smart contracts emerge as a pivotal trend, where the support of AI plays a crucial role. A notable innovation in the management of the built environment is the definition of public areas' usage by the general public and city users. However, at the neighbourhood level, barriers to this innovation often arise due to bureaucratic hurdles and internal procedures dictated by a multi-player system. This system acts as leaders of silo-like structures in the FM at the neighbourhood level, where functions are distinctly separated, and roles are confined to a narrow circle of highly specialised activities.

Smart contracts, as part of the positive effects of Integrated Facility Management, serve as a solution. Integrated FM becomes an enabler of smart contract operativity, allowing users to pay only for the effective usage of services and facilities. This introduces a pay-per-use model that extends to various services and multi-square metre areas within the city.

The potential of Integrated Facility Management goes beyond financial considerations. It can consolidate diverse services under one contract, encompassing services to individuals (such as neighbourhood nurseries and special mobility services), services to businesses (operation-connected services for commercial functions in the neighbourhood), and services to the building and public areas (including gardening, cleaning, pest control, safety, and security).

Moreover, the incorporation of AI into manual activities, following a business process reengineering, emerges as a key strategy to enhance manual and high-risk activities. This shift addresses issues related to manual registration and data collection errors. Additionally, leveraging the learning characteristics of AI systems can positively impact the quality of life for the general public in the neighbourhood.

- Delivery management by drones

Definition

This sub-theme was meant to focus on the management of delivery services by using aerial drones, including the use of AI techniques to optimise flight paths and coordination across multiple drones. Unfortunately, the regulations have made it increasingly difficult to obtain the required permissions from the national aviation authorities. At the end of 2023, for example, obtaining the authorization for a single day

of flight from the aviation authority in Italy (ENAC) required 6+ months and a significant amount of paperwork. Arguably, testing and experimenting with this kind of applications is right now unfeasible within the context of a collaborative project. We put this initiative on hold and plan to revisit the situation after M24.

- Tourism management

Definition

Tourism is a major economic activity in the EU with a significant impact on economic growth, employment, and social development. It is an important source of income and a significant proportion of GDP, particularly for the countries of the Southern arc. In this context, it is easy to imagine that tourism plays a powerful role in the fight against economic decline and unemployment[280].

Smart Tourism can be seen as an offshoot of the Smart City concept. The main idea is to take advantage of the massive use of information technologies of a Smart City and apply this approach to a Smart Destination to achieve resource optimisation, effective and fair governance, sustainability and quality of life.[281]

Challenges

Tourism is the ecosystem most affected by the COVID-19 crisis[282], but today it faces profound challenges of various kinds, not least economic. With the European Green Deal[283], the EU has set a target of being carbon neutral by 2050 and has committed to reducing emissions by at least 55% by 2030. With these goals in mind, there is no doubt that the tourism ecosystem will be an important player in achieving a climate-neutral Europe. From our perspective, the green transition could be enhanced by today's other great challenge: the digital transition[284]. The proliferation of platforms, online payments and social media generate an enormous amount of data that, if properly managed, can successfully address many of the challenges facing tourism. This is where AI comes in, offering many benefits, but also its fair share of problems and drawbacks. Here are some issues to consider[285]:

First, several challenges relate to the data itself. The main challenges in using data for tourism are the well-known challenges of the data itself, the so-called “Vs”: Volume,

[280] https://single-market-economy.ec.europa.eu/sectors/tourism_en

[281] https://www.eea.europa.eu//publications/air-quality-in-europe-2022

[282] https://ec.europa.eu/docsroom/documents/45977

[283] https://www.eea.europa.eu/en/topics/in-depth/air-pollution?activeAccordion=4268d9b2-6e3b-409b-8b2a-b624c120090d

[284] https://ec.europa.eu/docsroom/documents/45977

[285] https://data.europa.eu/doi/10.2873/23880

Velocity, Variety and Veracity. Ensuring all the different Vs requires specialised skills and advanced technologies. To better understand this challenge, we can read about HERIT-DATA[286], which promotes the use of smart and open data to better manage tourism flows in natural and cultural heritage sites. The project aims to identify innovative solutions, supported by new technologies and big data, to reduce the negative impacts of tourism on cultural and natural heritage sites. The main challenges addressed by the project were the lack of openly accessible tourism-related data (i.e. only 30% of such data is publicly available, while 65% is restricted and 5% partially public); the lack of tools and resources, including the lack of sufficient sensors to properly measure the impact of tourism.

Second, there is a heterogeneity inherent to tourism data. Considerable effort is required to standardise and harmonise data, which typically comes from heterogeneous sources and formats. One of the best examples of this challenge is the MyHelsinki Open API project[287]. It is an application programming interface for accessing three databases (one on places, one on events and one on activities) based on a set of queries and filters selected by the user, providing information on places, events and activities related to Helsinki and the surrounding region as open data. As the interface combines data from different sources, the main challenges relate to the need to ensure data quality and standardisation. Significant human resources are required to ensure continuous updating and content checks.

A third challenge concerns technology and power. All smart solutions require an ecosystem of information and communication infrastructures to function. In a fragmented industry such as tourism, which is largely based on micro-enterprises, the significant investments required to create value from data can be particularly difficult to implement. A well-suited use case is represented by the new Smart City Control Room in Florence[288], which uses well-tested and already active tools for traffic control and public lighting, with traffic light synchronisation systems, traffic control using sensors and cameras, mobility control for electricity and car & bike sharing, monitoring of public lighting and its consumption. According to the developers, the most challenging element for the construction of the control room concerns the implementation of a wide range of technological tools for data collection and analysis, such as those related to IoT, ML and big data. Finally, the implementation of the solution requires high-level and multidisciplinary expertise related to each of the domains (e.g. mobility, energy, health and water) under analysis.

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[286] https://interreg-med.eu/

[287] https://www.hel.fi/hel2/tietokeskus/data/dokumentit/6Aika-esitteet/20171116_APIrecommendations_WEB.pdf

[288] https://www.comune.fi.it/comunicati-stampa/firenze-smart-city-la-centrale-di-gestione-e-monitoraggio-trova-casa-accanto

Next, tourist attitudes and digital literacy play a role in AI in the tourism sector. Some travellers might resist interacting with AI systems, preferring the familiarity of human interactions. Adapting to these technologies might be a challenge, especially for older generations or those who lack digital literacy. The research delves into the evolving landscape of accessibility and digital literacy in tourism, with a specific focus on elderly tourists.[289] The research reveals that many elderly tourists have some level of digital literacy, primarily through internet use.[290] It highlights the strong correlation between education and internet usage among elderly respondents. However, a significant disparity arises for elderly tourists with disabilities, who appear to use the internet less frequently. The study also finds that many elderly tourists are unfamiliar with emerging technologies like QR codes and NFC. Moreover, a segment of elderly tourists, particularly those over 80, individuals with limited education, women, people with disabilities, and rural residents, remains entirely excluded from the digital world. This exclusion poses challenges, particularly in terms of access to essential tourist information. The study concludes by emphasising the need to promote digital literacy among seniors and create inclusive, age-friendly spaces, products, and services. It also calls for public policies and strategies to address these issues, aligning with the goal of reducing inequalities and leaving no one behind, as outlined in the 2030 Agenda for Sustainable Development.

Moreover, data privacy and security concerns can complicate things. AI systems in tourism often require access to personal data such as travel preferences, location data, and payment information. Mishandling this data could lead to breaches, identity theft, or unauthorised access. An effective example of this is Aruba Airport, which has introduced the Aruba Happy Flow biometric technology, a facial recognition camera-based travel security system that consists of a series of user-centric self-service touchpoints, from check-in to boarding. Passengers only need to identify themselves at check-in. At this step, their virtual identity is created, allowing passengers to pass through all checkpoints using facial recognition[291]. Aruba Happy Flow combines the public border control process with the private passenger process at the airport. It is the first system of its kind and is designed to speed up, streamline and secure the passenger process. Data protection and privacy issues were a prerequisite for the

289 https://upcommons.upc.edu/bitstream/handle/2117/388446/Art1.10.17411.jacces.v12i2.314.pdf?sequence=1&isAllowed=y

290 https://upcommons.upc.edu/bitstream/handle/2117/388446/Art1.10.17411.jacces.v12i2.314.pdf?sequence=1&isAllowed=y

291 https://govinsider.asia/intl-en/article/annet-steenbergen-how-aruba-is-creating-a-seamless-travel-experience-with-facial-recognition

development of the solution. In fact, the platform adheres to the international principle of 'privacy by design' and complies with the GDPR data protection standards[292].

Last, there is the conundrum on how the human has to work with the AI-systems. Introducing AI into tourism could raise ethical questions, such as whether it is ethical to replace human workers with machines, or how AI should make decisions in morally complex situations. Research also discusses the ethical integration of AI and robotics in the tourism and hospitality industry (TH).[293] It highlights the need for a co-constructive approach involving different stakeholders, including guests, employees and managers, to ensure that AI systems are aligned with human values. The value-sensitive design approach is recommended for this purpose. From a managerial perspective, the article urges TH organisations to actively collaborate with industry partners in designing AI systems to address ethical concerns and avoid the negative impacts of biassed and opaque AI. The framework presented highlights that not using AI and robots also has ethical implications, as automation can create better working conditions for human employees. Failure to adopt automation can hinder productivity, well-being and income. In conclusion, the article emphasises the importance of ethical AI integration in TH and the involvement of all stakeholders for responsible technology implementation.

Opportunities

The opportunities created by digital innovation in tourism destinations can be focused on three pillars[294]. The first is represented by new business opportunities through the implementation of innovative business models and ecosystems, new services exchanged by consumers and producers as peers, and new ways of bringing together supply and demand. From the visitor's point of view, data analytics can provide personalised experiences to tailor their holiday. The development of a public dashboard specifically for tourism users can provide easy-to-use information on services, offers, heatmaps, events, experiences, available infrastructure, sustainability, and safety levels of a specific holiday destination. Last but not least, digitisation can also help local authorities and destination management organisations (DMOs) to reduce the impact of seasonal flows on local resources, infrastructure, transport systems and services, and to integrate arrivals more smoothly and fluidly. This can be particularly important for the development of rural and protected areas such as nature parks. Furthermore, it is possible to apply AI algorithms to measure and track trends, which can be a game changer for sustainable tourism strategies at local, regional, national and EU levels. We

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292 https://wttc.org/Portals/0/Documents/Reports/2019/Security%20and%20Travel%20Facilitation-Seamless%20Travel%20Journey-Emerging%20Model%20Overview%20Findings%20Report-Nov%202019.pdf?ver=2021-02-25-182755-503

293 https://ssrn.com/abstract=4030669

294 https://data.europa.eu/doi/10.2873/23880

can also provide a list of possible AI-driven tools examples as starting points for the development of new tools:

- Recommender tools, according to profiles of uses or cases[295]
- Prediction applied to resource management[296]
- Knowledge discovery from data[297]
- Optimization of management processes and visitor experience[298]

Regional insights/ Use cases

- AI to drive the benefits of green infrastructure in society

Description

The NINFA project, by the company Green Urban Data, allowed the creation, integration and implementation of a new and innovative tool capable of assessing and predicting Green Infrastructure Ecosystem Services automatically from the identification of tree species from high resolution satellite images of Valencia urban area.

The development of NINFA responds to two major difficulties of the classical method of ecosystem services assessment of urban tree cover:

- Impossibility of access to all the information of the urban forest inventory, especially those trees that are not under municipal conservation.
- High allocation of human resources, and therefore economic, for the inventory of trees and their subsequent analysis in the office.

A pilot project was performed in the Mediterranean basin, selecting four plant taxa that maximise the scope and impact of the product in this area, which have been identified from satellite images using new image segmentation algorithms with DL techniques.

Lessons learned

The project focuses on the use of satellite images and AI techniques in order to assess the tree cover of a city (urban forest). Undoubtedly one of the major findings of the project is its replicability, scalability, and the improvement of efficiency in the processes and decision making carried out by public administrations. It facilitates knowledge through an agile, economical and usable tool, democratising the capacity for analysis, dissemination, transparency and planning for public managers.

[295] https://doi.org/10.48550/arXiv.2306.10946; https://doi.org/10.1016/j.eswa.2021.116234
[296] https://doi.org/10.48550/arXiv.2303.01692; https://doi.org/10.48550/arXiv.2206.13274
[297] https://doi.org/10.1007/978-3-030-88389-8_6
[298] https://doi.org/10.1109/CAIT56099.2022.1007223

- Brain4it

Description

Brain4it is an open source platform for developing AI applications for IoT. It works as a network service that allows it to be remotely controlled and programmed using a functional language that facilitates the implementation of expert systems and machine learning applications.

The main objective is to develop a tool to govern the city's sensors and actuators in an intelligent and automated way. It is developed by the City Council with the participation of several employees. It is configured to allow interoperability with other programs and its integration in frameworks of municipal or public management systems.

Lessons learned

It is specially indicated for the management of dynamic environments where flexibility and adaptability are essential requirements. When Brain4it runs in the cloud it works as an Artificial Intelligence as a Service (AIaaS) capable of acting on other platforms and connected devices.

Brain4it supports multiple connectivity protocols, like HTTP, XMPP, MQTT, SMTP, JDBC, to enable communication with sensor/actuator platforms, messaging systems, databases and web services. It also provides libraries for natural language processing, computer vision and predictive data analysis. The processing results can be monitored at real time through dashboard panels. It has proven its value in multiple areas: smart cities, domotics, robotics, IT infrastructure management, mathematics, etc.

- Connecta València: Smart and sustainable tourism territory

Description

The Valencian province installed several intelligent systems and devices in more than 200 municipalities to improve their tourist experience and capture valuable information on tourism, mobility and carbon emissions, aiming to integrate the public transport system.

The project has three main areas of action:

- Reuse all the tourist information available in the different pre-existing sources.
- Obtain new data through the installation of intelligent devices.
- To achieve improvements in the management of tourism, mobility and environmental impact.

It will generate a provincial network of data collection of the tourist impact or big data of the different destinations of the Valencian territory. This will allow them to be more competitive and attractive for tourism by having a greater knowledge of the sharing and

mobility of visitors, and thus be able to offer better experiences to visitors, more sustainable and also appropriate to the demand of the moment. The project will also promote transparent and universal access to public data on services by citizens, visitors, professionals and companies, thus promoting the growth of industry and entrepreneurship, as well as interoperability between different administrations and agents.

Lessons learned

This project is very interesting for our pollution and tourism management subthemes. The regional initiative consists of setting up different sensors, antennas, meteorological stations, and tourist totems, but also implementing softwares and other IT tools to gather and manage the data.

- AI4water

Description

The AI4WATER project proposes to optimise the use of available water resources, mitigate the effects of increasing water scarcity in agriculture and improve food security by creating a digital twin in an irrigation sector in Lleida (Spain). The DT allows to simulate, plan, analyse and improve crop growth, maximising yields and making it more sustainable for agriculture[299].

Lessons learned

The DT models the water flows of the irrigated area using as inputs the water captured from the environment, the water returned to the environment and the information on its different uses (human, industrial and agricultural according to the information obtained from water metres). Other variables that influence the water balance, such as atmospheric variables (temperature, relative humidity and solar radiation), evapotranspiration and surface soil moisture, will also be taken into account.

- The Water Innovation Network (WIN)

Description

WIN is a network of organisations, including water utilities, research institutions, and technology providers, focused on innovation in the water sector. It promotes collaboration and knowledge exchange in areas like AI and water management.

Lessons learned

Insights from WIN can help AI water innovators to keep up to date with the latest trends in the water industry, including industry, case studies and events.

[299] https://cit.upc.edu/ca/portfolio-item/bessons-digitals-per-a-agricultura-de-regadiu/

- Development of a prediction model for the development of the COVID-19

Description

Development of a prediction model for the development of the COVID-19 pandemic (both temporally and spatially). The model using AI tools and multi-agent modelling is generic and can be used for any area. The project assumes that each resident, represented by a digital "agent," moves through the space according to the rules specific to where they live-work, rest, etc. Interactions between agents result in a change in the number of illnesses. The model has been calibrated on real-world data, and also allows for the inclusion of different levels of restrictions like wearing masks, social distancing, working and learning remotely, etc.

Lessons learned

The model was presented at the Ministry of Health and can be used to model any viral or bacterial pandemic.

- Air quality monitoring system using IoT sensors and LoRa system

Description

The system was developed using proprietary sensors developed by WUT and was tested in the municipality of Zuromin. Dozens of sensors deployed in the test area collect multi-source data on methane compounds, sulphur, ammonia, temperature, siel and wind direction, while an AI-based computing system processes the data by interpolating the spatial distribution of air pollutants.

Lessons learned

The system, realised under the ministry's Human Smart City program, can be used for any area.

- Video surveillance system with proprietary AI tools enabling edge computing

Description

Developed a video surveillance system for the area of the WUT main campus using video sensors and proprietary AI tools enabling edge computing. The system uses standard CCTV cameras, but is enhanced with proprietary tools for near real-time processing of image data.

Lessons learned

The system, which is being tested on the WUT campus, makes it possible both to improve the quality of video surveillance (and the level of security) and to support the campus revitalization and space planning process.