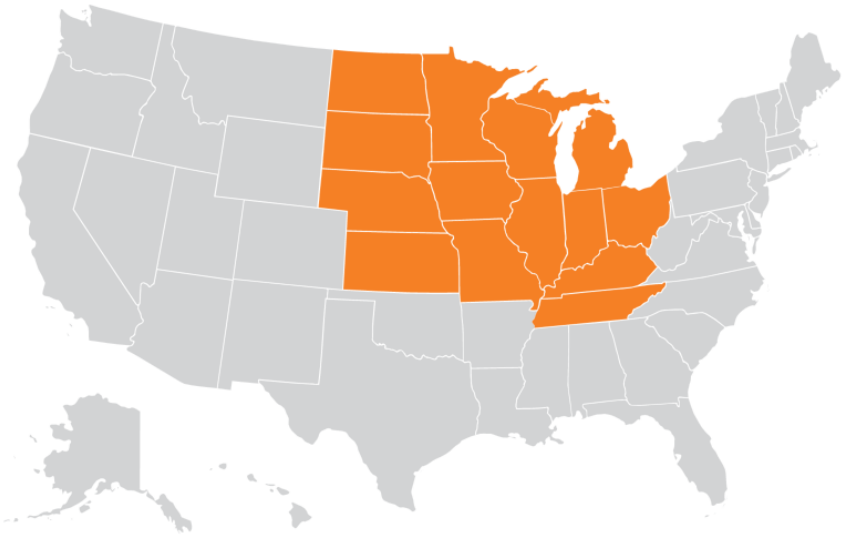
# Connect with the Midwest

## '*Smart City*' trends and opportunities for collaboration



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## Abstract

Smart City definitions and priorities vary among individuals and stakeholders, but one thing is clear: the urban function is modernized in both the Netherlands and the Midwest region of the United States of America.

Starting from the clustering of the *Netherlands Smart City Embassy*, this paper lays out developments related to information technology, mobility & transportation, resilience, energy & water, the built environment, and food. This inventory of developments in the Midwest shows that more is happening than this region of the United States is commonly given credit for, ranging from 5G-connectivity in Indianapolis to infrastructure resilience in Minneapolis and from mobility innovation in Columbus to sustainability in Chicago's built environment.

Many cities in the Midwest aspire to become a truly 'Smart City'. This proposition paper argues there are ample opportunities for cooperation in the 'Smart City' sphere at the mutual benefit of the Netherlands and the Midwest. The table on pp. 16-18 outlines some of these opportunities.

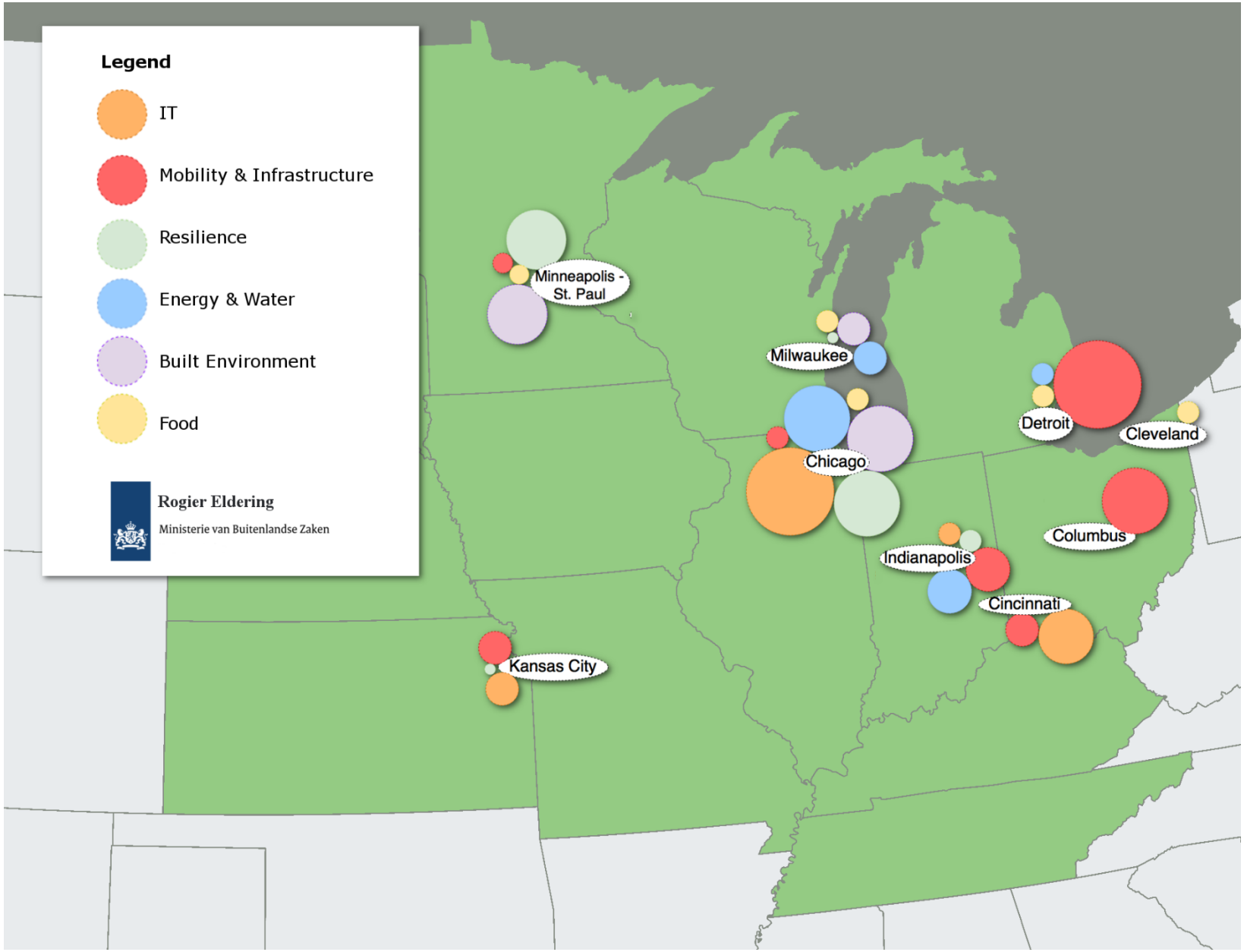


## Samenvatting

Definities en prioriteiten rondom 'Smart City' lopen wijd uiteen, maar één ding staat vast: stedelijke functies worden 'verslimd' in zowel Nederland als het Middenwesten van de Verenigde Staten van Amerika (de '*Midwest*').

Dit *proposition paper* brengt ontwikkelingen in kaart rondom informatietechnologie, mobiliteit & transport, (klimaat-)adaptatie, energie & water, de bebouwde omgeving, en voedsel. Deze clustering is gebaseerd op de structuur van de *Smart City Embassy*. Op basis van deze ontwikkelingen kan worden geconcludeerd dat interessante ontwikkelingen plaatsvinden in deze regio, uiteenlopend van 5G-connectiviteit in Indianapolis tot klimaatadaptieve infrastructuur in Minneapolis en van mobiliteitsinnovatie in Columbus tot duurzame bebouwing in Chicago.

Veel steden in de Midwest hebben de ambitie om volwaardige Smart Cities te worden. Samenwerking in dit domein is dus in het belang van Nederland en de Midwest. De tabel op p. 16-18 vat enkele kansen samen.


Legend
IT
Mobility & Infrastructure
Resilience
Energy & Water
Built Environment
Food
Rogier Eldering
Ministerie van Buitenlandse Zaken
Minneapolis - St. Paul
Milwaukee
Chicago
Detroit
Cleveland
Columbus
Indianapolis
Cincinnati
Kansas City

# Contents

# 1. Introduction

The future will largely take shape in cities. Half of the global population lives in cities and that share is rising. Both challenges and opportunities are amplified in the urban domain due to high concentrations of social and economic capital. Many of these challenges and opportunities relate to digital transformation; others relate to smart urban planning and design.

The 'Smart City' has become a focal point for collaboration and exchange of best practices, with elements of inter-city competition. One major priority is to develop replicable and scalable solutions that use advanced technologies, which arguably requires a standards-based approach. For example, the *Global City Teams Challenge* (GCTC) was launched to encourage collaboration and develop such standards [1]. The GCTC has incubated over 160 project teams with participation from over 150 cities and 400 municipal governments, nonprofit organizations, research institutes, and private corporations across the world. The *National Institute of Standards and Technology* (NIST), part of the U.S. Department of Commerce, convenes the challenge.

*The United States and the Netherlands share an interest in the Smart City – both in policy and in practice.*

In the Netherlands, a roadmap for city-to-city collaboration was presented to the Dutch Prime Minister early 2017. This document was collectively drafted by a large share of Dutch cities [2], a collaborative process that Smart City stakeholders in the Midwest are interested in learning about. The strategy is the subject of ongoing substantiation and the follow-up will include a negotiated approach to international Smart City dialogues. To showcase various projects, a national public-private partnership also launched an online platform: the *Smart City Embassy* [3].

In the U.S., the White House launched a Smart Cities Initiative "to help communities tackle local challenges and improve city services" in 2015 – including over $160 million in proposed investments. More recently, the Trump Administration announced an infrastructure plan to support $1 trillion in private and public investment in physical infrastructure as well as broadband [4]. Whether this includes another push for Smart City developments will become clear as the details of this plan are announced.

*The 'Midwest' extends from North Dakota to Tennessee and from Kansas to Ohio.*

This area of fourteen states is the equivalent of the land cover between Glasgow, Barcelona, Thessaloniki and Warsaw – and the size of its population and economy exceed Germany's. The region known as the 'Rust Belt' is largely located within the Midwest and arguably leading the revival of the U.S. manufacturing industry. This process is driven largely by new technology and accommodated by the abundance of domestic energy and human capital. The focus of this document is on the states that surround the Great Lakes.

## *The innovation drive in the Midwest is demonstrated by some of its cities' performance in national Smart City challenges.*

Inter-city challenges have become a way to allocate (federal) funding for tech and innovation. From the *U.S. 2016 Smart City Challenge* [5], Midwestern city Columbus, Ohio emerged as winner. Columbus received a federal grant amounting to $40 million, which was later supplemented to $500 million in public-private funding [6]. The seven finalists also included Kansas City, Missouri. Indianapolis/Marion County, Indiana was among the first five cities to win a *Smart Cities Council Readiness Challenge Grant* [7]. A coalition of leading companies, awarded this grant to stimulate continued innovation in the areas of water, energy and mobility.

Winning project proposals emphasize the potential of advanced technologies for social inclusion. This includes diminishing the digital divide between numerous sociological groups, which persists even though home access to the internet is widespread across the Midwest [8]. In addition, mobility tends to be seen as a cross-cutting issue related to access to education, employment and health services alike.

## *This proposition document maps out 'Smart City'-related trends to identify opportunities for cooperation in the Midwest.*

This proposition document is the product of research done between March and August 2017 and it does not pertain to be complete. It focuses on trends and opportunities that link to the strengths of the economy of the Netherlands, particularly technology and best practices related to Smart City. Therefore, the clustering of developments takes the structure of the *NL Smart City Embassy* as a starting point. Food is identified as an additional cluster, resulting in the following six clusters:

- Information technology (pp. 8-10);
- Mobility & Transport (pp. 11-13);
- Resilience (p. 14);
- Energy & Water (pp. 15-16);
- Built environment (pp. 17-18);
- Food (p. 18).

Those who are interested in opportunities for collaboration related to a specific cluster or theme are advised to look at the overview table (pp. 19-21). The selected opportunities were deduced from key developments in the Midwest. Said developments are described in more detail in chapter 2, which also highlights urban examples to complement the general narrative.

# 2. Developments

The following section discusses key developments related to information technology across the Midwest (section 2.1) and their ramifications for various domains in the Smart City (section 2.2 through 2.7).

## 2.1 Information technology

*Democratization of data and increasing connectivity provide a level-playing field for analytics. With accelerated innovation concentrated in urban hubs, the Midwest is not "flyover country" any longer to the tech industry.*

### Open data & Analytics

The open-data movement provides tools to develop smart solutions for livable cities. The Midwest was selected as a pilot region within the context of the *Code for America Brigade*, a non-partisan network organization that promotes the use of technology and open data for transparent, participatory, and effective governance [1]. Numerous data portals can be accessed by anyone to retrieve information on public services and socio-economics in the Midwest [2-5].

- *Data Driven Detroit* (D3) comprises data on socio-economics, land-use, and health and safety, used in e.g. the *Detroit Sustainability Indicators Project*.
- *Cincinnati's Open Data Portal* comprises data on five priority goals: public safety, economic growth, community well-being, innovative governance and fiscal sustainability.
- Chicago's *Open Data Portal* integrates more than 600 machine-readable datasets, ranging from restaurant inspection reports to reported crime.
- *Plenario*, developed by a renowned university in Chicago, integrates disparate data portals from large cities within and beyond the U.S. to provide access to multiple datasets across time and space.

Even though many civic applications and visualizations are developed in cities that champion open data, the lack of 'human readibility' can inhibit public engagement. To overcome this obstacle, Cincinnati built an online 'dashboard' – i.e. *CincyInsights* – that presents data on public safety, street sweeping, snow removal and more in visually appealing ways [6]. *OpenGrid* is an open source platform, developed in Chicago, to provide both real-time and historical insights. As data is ingested in *OpenGrid*, which is also supported by *Plenario*, it is indexed by location and time. Queries will thus show the available data for any specified area. To take this one step further, the *SmartData Platform* allows for predictive analytics for use within cities [7,8].

Established applications of analytics include health and safety. For example, *CivicScape*'s predictive policing software is used by police forces in Chicago and other populous cities in the U.S. [9]. The company tailors its services to urban data sets but the basic code is open source. Another example is the City of Chicago's *Food Inspection Forecasting* program, which uses predictive algorithms to intensify inspections in places where critical violations of food safety regulations are most likely to occur [10]. Cincinnati has taken a data-driven approach to tackling child mortality since 2007, singling out quantifiable risk factors and at-risk communities [11].

## Internet of Things

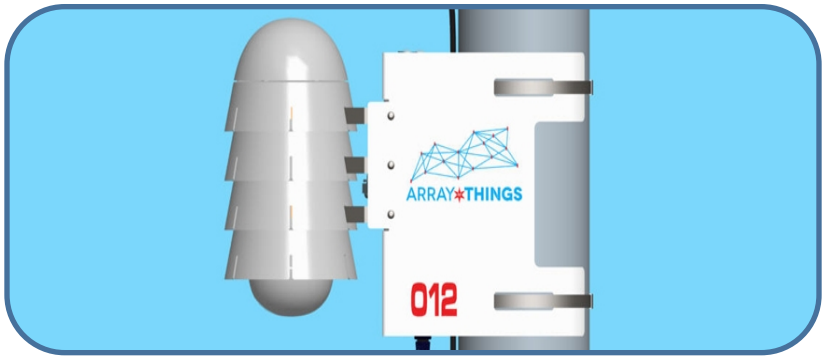
Corporate activity in the Internet of Things (IoT) domain is intensifying in the Midwest. The *Illinois Technology Association IoT Council* inventoried over 130 IoT-companies that were either headquartered in the Midwest or had a significant employee population and customer base in the region [12]. The report, released in June 2017, also highlighted a significant increase compared to the previous year. Connectivity appears to be a growing part of the economy.

Urban applications of IoT technology include Smart Mobility, infrastructure monitoring, and smart grids that facilitate dynamic energy pricing (pp. 11-12; 15-16). Such applications often rely wireless sensor networks. Sensor technology is increasingly integrated into vehicles, mobile devices and other objects. In Louisville, Kentucky, for example, 500 smart inhalers were distributed among asthmatic residents in 2012, to record geo-coded data and map hotspots of emergency asthma attacks [13]. To compare these with trends in air quality, the city is now planning to deploy air-quality sensors mounted on bikes.

An example of an IoT-enabled sensor network that primarily pushes frontiers in science through gathering data on the physical environment is the Array of Things project in Chicago (see picture on the right) [14]. It entails a network that will consist of 500 boxes equipped with sensors, cameras and microphones. Twelve of these have been installed to record temperature, light intensity, air pressure and chemical quality, noise and traffic intensity – data for anyone to analyze and use.

The presence of such networks has considerable potential to understand how human wellbeing is related to the urban environment and even to 'nudge' human behavior.

Public lighting and information services comprise other applications of IoT-technology in cities. The '*Smart Corridor*' project in Kansas City – the first city to be covered with the Google Fiber network in 2012 – entails public Wi-Fi and IoT technology coverage in over 50 city blocks [15]. This already includes 125 connected traffic lights and 25 interactive kiosks for public information services and emergency alerts, but it may be expanded to include sensors and integrated LED-lights. Sensor-data is channeled to an open data portal and a map that visualizes e.g. traffic flow and the availability of car-sharing services.




Broadband access is key to leveraging the applications of IoT-connectivity in a smart city. For example, the city of Indianapolis as an AT&T pilot for its 5G-network to test a new generation of wireless network technology. Potential application domains of extended broadband include a recently started large-scale program to install new streetlights after a 23-year moratorium [16]. The city of

Cincinnati is working with partners to roll-out a 5G network soon [17].

### Cyber security

For a Smart City to be successful, it must be data-secure. Awareness of cyber security increases across the Midwest, as illustrated by the emergence of a partnership organization that aims to connect the region's cyber ecosystem and inspire the next generation of cyber professionals (i.e. the *Midwest Cyber Center*) [18].

Cyber security priorities vary across the region depending on the level of connectivity. The State of Illinois is among the most ambitious. Their cybersecurity strategy was recently announced in the context of the emergent "smart state" and the risks that cyber-attacks may pose to critical infrastructure, the economy and citizens' privacy [19]. Specifically, a federally funded collaboration between universities, national labs and private industry is aimed at bolstering the security and reliability of power grids that become increasingly digitally connected (i.e. *Cyber Resilient Energy Delivery Consortium,* see also section 2.5) [20].

### Innovation hubs

In many cities, the growth of the (information) technology industry is the product of both public efforts and corporate activity. Tech giants such as *Amazon*, *Microsoft* and *AT&T* are expanding their services in the Midwest. At the same time, economic development and start-up acceleration in the tech-industry is prioritized across the region.

As a result of such combined efforts, Chicago has become one of the most significant tech-towns in the United States. For example, *UI Labs* is a Chicago-based non-profit organization that runs *City Digital* – a program dedicated to unlocking data-driven innovation in the urban environment [21]. UI Labs develops projects in partnership with organizations in industry, academia, and civil society – both within and (far) beyond Chicago. Even though the organization runs entirely on corporate investments, they work closely with municipal governments to create the space for demonstration projects in the area of energy management, physical infrastructure, mobility, and utilities.

Beyond Chicago, new tech incubators, accelerators and early-stage investors are finding their way to Detroit, Columbus, Madison, Cincinnati, Kansas City and Indianapolis [22]. For example, two brand-new innovation hubs are currently being developed in Indianapolis, Indiana [23,24]. *16 Tech* will consist of labs and office space (~240,000 $m^2$) for start-ups and other companies that push frontiers in the areas of tech, urban living, and advanced manufacturing. Further, *IoT Lab-Fishers* will provide co-working space (~2,270 $m^2$) along with programming and resources for cloud analytics and edge hardware development.

## 2.2 Mobility & Transport

*The Midwest was the motor of the American automotive industry during its golden days and has since transitioned to advanced manufacturing. Almost 70% of total U.S. light vehicle production can be traced to the Midwest today, with half of the top 100 suppliers based in the state of Michigan. The high concentration of automotive OEMs and top-tier research institutes provides a unique environment for re-inventing mobility.*

### Advanced manufacturing

Advanced manufacturing is at the heart of the Mobility & Transport sectors in the Midwest. The density of top-tier universities and R&D centers specialized in all aspects of vehicle manufacturing is particularly high in the state of Michigan. Focal areas range from industrial automation to crash safety design.

The manufacturing of lightweight materials is of increasing importance to automotive and transportation sectors alike. Use of such materials (e.g. aluminum and composites) can improve energy efficiency and provides opportunities to redesign vehicle components and further reduce costs. Headquartered in Detroit, the *American Lightweight Materials Manufacturing Innovation Institute* (i.e. LIFT technology) brings together public and private partners from the states of Michigan, Ohio, Indiana, Kentucky and Tennessee [1]. Automation is transforming manufacturing processes, with widespread deployment of robotics in the automotive sector. Automation (research) hubs can be found in e.g. Chicago, Detroit, and Minneapolis.

### Connectivity & Automation

Smart Mobility is gaining traction in the Midwest, driven in part by the desire to diminish casualties and to reduce productive hours lost in traffic. Whether one is interested in Intelligent Transportation Systems, technologies for connected driving, or automation – the Midwest has it all.

The ongoing development of web-based technologies finds its way into ever more automotive applications, including safety protection systems through the communication between vehicles (V2V) or between vehicles and the roadside infrastructure and the cloud (V2I and V2X). For example, 'smart corridors' – i.e. parts of highways equipped with communication technology – cut across the states of Michigan, Ohio and to some extent Illinois. The soon-to-be largest application of V2I technology extends over a length of approximately 195 km in the metropolitan area of Detroit [2].

The equipment of infrastructure with web-based technology can also facilitate real-time monitoring of weathering in roadways and bridges, which has implications for maintenance and renovation. A team of engineers from Washington University in St. Louis is turning to cloud computing to develop smart monitoring solutions that can predict infrastructure failures and prioritize areas for emergency response. They deployed a network of wireless, smart sensor networks for real-time structural health monitoring of Michigan's *Mackinac Bridge* [3]. Integrated infrastructure monitoring is not (yet) deployed on an extensive scale in the Midwest, but

the city of Cincinnati adopted a vehicle-based monitoring system in 2015, which entailed the equipment of vans with lasers and sensors in 2015 to scan the road surface for cracking, raveling and potholes [4].


The Midwest is home to numerous testbeds for connected and autonomous driving. For example, *Mcity* is a unique testing facility for connected and automated driving technologies in simulated (sub-)urban environments [5]. It covers about 65,000 $m^2$ of (road) infrastructure, equipped with intersections, traffic signs and streetlights and lined by simulated buildings (see picture above). Visitors will soon be able to use on-site driverless shuttle services. The *American Center for Mobility*, currently under construction, is twenty times more extensive and will allow for testing of new technologies applied to common (non-) civilian vehicle activities (e.g. parking and fueling) and logistics [6].

### Green mobility

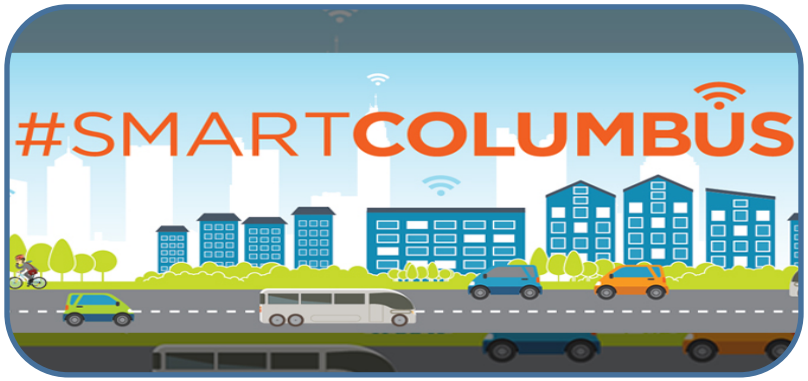
'Green mobility' represents an increasing share of the Midwest's economy, particularly in R&D and manufacturing. Advocacy groups consider Michigan leading in this regard, with nearly 28,000 jobs split between electric and hybrid vehicles [7]. On the corporate side, the state's car battery innovation is centered in manufacturing hubs such as *LG Chem* and *General Motors*. On the research side, University of Michigan's *Center for Electric Drive Transportation* is focused on the optimization of electric and hybrid system design, component design and operation control – in close partnership with major corporations [8]. Even though energy storage solutions development in the Midwest is arguably rooted in the automotive industry, other applications of storage innovation are emerging (e.g. grid modernization, see pp. 15-16).

The Midwest is home to some populous metropolitan areas that are experiencing exceptional electric vehicle uptake. Researchers from the DC-based *International Council on Clean Transportation* identified Detroit (+283%), Kansas City (+130%), and Minneapolis (+107%) based on sales data between 2015 and 2016 [9,10]. Beyond local hubs, the overall uptake of electric and hybrid vehicles in the Midwest remains significantly lower than the U.S. average, due to a general lack of purchasing options and charging infrastructure [11]. Opportunities for continued electric vehicle adoption remain in areas where the charging infrastructure is extensive. For example, since a utility company installed more than 1,000 public charging stations in Kansas City, Missouri, this city's charging infrastructure density is among the nation's highest.

The *American Public Transportation Association* lists numerous cities in the Midwest that electrified parts of their public transport in 2016 [12]. In particular, Minneapolis and St. Paul in Minnesota and Indianapolis in

Indiana have large shares of electric and hybrid buses in their fleet, largely powered by local solar and geothermal energy systems. In the case of Indianapolis, this is part of an ongoing restructuring effort of their transportation system, which was once ranked the worst in the country.

Compared to electric and hybrid mobility, the extent of hydrogen fuel-cell technology research and application remains limited in the Midwest. Highest levels of activity can be found in Ohio. The *Renewable Hydrogen Fuel Cell Collaborative*, based in Columbus, is an academic center dedicated to establishing the Midwest as a national leader in the adoption of hydrogen fuel cell-powered vehicles. Further, the *Ohio Fuell Cell Coalition* focuses on economic development to achieve the same goal [13-15].




## Mobility as a service

With increasing levels of connectivity and automation comes a need to take an integrated approach to mobility. This includes considering how one mode of transportation relates to another, the user experience and various aspects of social inclusion. Increasingly, policymakers and urban planners in the Midwest draw inspiration from policy and practices in e.g. the Netherlands.

While ride-sharing applications have become commonplace across the Midwest, shared car ownership programs in the more populous cities are relatively new. These include Madison (*Community Car*), Cleveland (*CityWheels*), and Minneapolis-St. Paul (e.g. *Car2Go*). Indianapolis offers all-electric car-sharing services (*BlueIndy*), with 200 charging stations and a planned fleet of 500 cars [16]. The rise in demand for car-sharing services is expected to continue.

Cycling is gaining popularity in cities like Chicago, Detroit and Indianapolis, although primarily for recreational purposes. Bike-sharing programs have already been implemented in all of those cities, where Chicago has the most extensive one (consisting of 5800 bikes and 580 solar-powered bike stations) [17]. Moreover, some cities are taking steps to increase the appeal of cycling through urban planning. For example, the city of Madison in Wisconsin referenced Amsterdam as a source of inspiration in their report on improving "bikeability"[18].

From the perspective of mobility as a service, interesting developments are unfolding in Columbus. After winning the 2016 U.S. Smart City Challenge, partners in the *Smart Columbus* project have been working to stimulate shared car-ownership, increase connectivity to improve safety and reduce congestion, and rely on high levels of automation to increase public participation of the elderly and disabled [19]. Many other medium-sized cities in the Midwest are faced with societal challenges similar to the ones Columbus put at the center of their proposal. Columbus will likely become a showcase for state-of-the-art technologies and best practices in the next few years.

## 2.3 Resilience

*Far away from the moderating effects of the ocean, the Midwest's infrastructure was designed to withstand extreme weather. Since metropolitan areas suffer from heat waves and flash floods more frequently than before, smart urban design is gaining traction. Information technology facilitates weather preparedness and timely response to extreme events.*

### Green infrastructure

Green roofs have the proven potential to improve air quality and combat urban heat and flooding. In the Midwest, Chicago has the largest number of green roofs due to long-standing policies to promote quality of life in the built environment [1]. In addition to resilience, green roofs may have an esthetic component (see picture on the right for an example of *SemperGreen*'s work in Lansing, Michigan). Advanced designs with sluices and valves for controlled water release are not common.

Other types of green infrastructure that gain traction to increase resilience include storm water basins, pavement innovation, and sewage upgrades [2]. Specifically, pavement innovation is successfully deployed in cities like Minneapolis-St. Paul and Chicago to allow water to infiltrate between paver units or through porous material itself and to reduce the urban heat island effect through using high-albedo material [3]. In a capital-intensive plan, Toledo, Ohio, has committed to diminishing sewage overflows by 2020; while in Minneapolis-St. Paul, Minnesota, storm water is largely discharged separately thanks to extensive sewer separation over the past two decades [4-6]. In Chicago, IoT-enabled sensors are deployed for impact studies in the context of the *Smart Green Infrastructure Monitoring Program* [7], a flagship pilot project by *UI Labs* (see p. 10).

### Emergency response

Information technology can facilitate timely response to minimize socio-economic impacts of emergencies, including heat waves and flashfloods. For example, a nonprofit headquartered in Chicago, *RainReady*, deploys e.g. smart meters, rain sensors, and leak detection to strengthen an array of green infrastructure and landscaping solutions [8]. In partnership with others, this non-profit empowers communities in Illinois to manage floods and droughts. In the Greater Cincinnati area, an online mapping system relies on open data to increase situational awareness in times of regional disaster [9]. Once details of the incident are entered, the system adds residential and infrastructural layers to the map along with real-time data (e.g. weather, traffic, social media).

## 2.4 Energy, Water & Waste

*Grid modernization is an emergent priority across the Midwest, thanks in part to the rise of renewable power. Smart meters enable flexible pricing to reduce temporal differences in demand and increase efficiency, both for electricity and water use. Meanwhile, energy innovation creates room for new stakeholders and alliances.*

### Energy diversification

Shares of renewable energy in total capacity are growing in the context of economic trends and regional policy developments. Conditions in the Midwest are favorable to wind turbine development – with the states of Iowa, Kansas, Illinois and Minnesota in the top-10 for installed capacity [1]. Solar power is gaining ground, but current capacity far exceeds potential capacity in all cities but Indianapolis [2,3]. Biomass and ethanol comprise a significant source in rural areas in particular, fueled by the agricultural sector. Notably, nuclear technology is a significant source of power in this region.

State policy on energy diversification is often geared towards promoting employment and job growth, such as the 2016 *Future Energy Jobs Act* in Illinois [4]. Other notable recent energy policy developments occurred in the states of Ohio, Michigan and Iowa – all under the leadership of Republican governors. Moreover, these are among the eight states in the Midwest that agreed upon a *Renewable Portfolio Standard* [5]. Such standard stipulates a threshold for electric generation capacity from renewable resources to bind investor-owned utilities, municipalities and/or electric cooperatives. Some states' ambitions are striking compared to the Netherlands' goal of 16% renewable energy in 2023. To illustrate, Illinois' Renewable Portfolio Standard is 25% in 2025 (compared to 7% capacity in 2016) and Ohio's is 25% in 2026 (compared to 3% capacity in 2016) [6,7]. Further, the state of Minnesota already exceeded their 2025 goal at 28% capacity in 2016 and a bipartisan plan proposes raising it to 50% in 2030.

### Modernizing electricity infrastructure

Large parts of electricity grids are above ground in the Midwest and grid modernization is an emergent priority. Extreme weather events resulted in large regional power outages and economic damage to grids in recent years. Increasing sense of urgency to make grids more robust created room for innovation. For example, extensive rolling-out of smart grids as part of a ten-year, $3.2 billion plan to make Illinois' electricity supply more sophisticated. This included the establishment of an evergreen venture capital firm (i.e. *Energy Foundry*) that supports onboarding for a federally-funded collaborative on smart grid business development (i.e. *Smart Grid Cluster*) [8,9]. Illinois ranked 2$^{nd}$ in the national 2016 *Grid Modernization Index* as a result, but Michigan and Minnesota are catching up [10].

Leveraging information technology in the process of grid modernization could not only automate response to failures and disturbance of the grid, but also provides opportunities for demand-side management. Flexible electricity rates – coupled with increased insight and control – can shift electricity demand to off-peak periods and may result in overall lower levels of consumption. If

hooked up to local generation capacity and batteries, the smart grid may also improve the reliability of renewable energy supply. All of this requires a combination of hardware (e.g. smart meters, advanced control systems and communication networks), software (e.g. peer-to-peer transaction platforms) and multi-directionality (so customers can offload 'excess' energy to the grid) [11].

The Midwest has seen rapid expansion of 'Advanced Metering Infrastructure', i.e. smart electric meters in homes, offices and industrial buildings. The number of smart meters in the Midwest reportedly increased by a factor of four within five years (2.2 million in 2010; 10.2 million in 2015) [12]. Almost one-third of the total was 'smart' in 2015, but the differences between the states are large – with Illinois and Michigan leading the way and Iowa on the other end of the spectrum.

Some microgrid projects incorporate local energy generation and storage facilities to ensure maximum resilience. These include the village of Minster, Ohio (7 MW storage capacity hooked up to a network of solar panels). The extent of such projects remains small and most are operated by universities or (semi-)public entities. Increasingly, utility companies are seeking (co-)ownership, for example *Indianapolis Power & Light* (20 MW project at Harding Street Station) and *Comed* (10 MW project in Chicago's Bronzeville neighborhood).

### Pipeline infrastructure

Substantial investments in pipeline infrastructure can be anticipated as part of the federal infrastructure plan (see p. 6). Regarding drinking water infrastructure, water quality problems associated with corroded pipelines created a sense of urgency in e.g. Flint, Michigan. The *American Society for Civil Engineers* estimated the rate of water main breaks at 240,000/y in 2017, since many assets are approaching the end of their usable life [13]. Water main breaks and leaky pipes cost billions of dollars a year in water leakage, damage to surrounding areas and property, public health and safety issues, and lost economic activity. Redevelopment of pipeline infrastructure provides opportunities to leverage IoT-technology for timely detection of leaks to improve efficiency and water quality.

U.S. water utilities expect to invest $8.3 billion in smart infrastructure over the next ten years, as concluded in a nation-wide survey of 340 water utilities by DC-based smart infrastructure market intelligence firm *Northeast Group* [14]. Interesting developments are unfolding in the city of Indianapolis. Starting with the *Riverside Watershed Environmental Living Lab for Sustainability* project, efforts to equip this city's drinking water infrastructure with IoT-enabled sensors for smart monitoring and asset management started in 2013 [15]. To this end, *Global Water Technologies* and *IUPUI University* collaborated closely with utilities and the municipality. To encourage continued innovation in this context, Indianapolis was recently awarded a *Smart City Council Readiness Grant* (see p. 7).

The *Smart Sewers* initiative in Cincinnati aims to reduce combined sewage overflows through real-time monitoring and control to use the system's capacity optimally [16]. It relies on sensors to measure flow levels and gates and valves to direct the flows between interceptor sewers, storage tanks, and treatment facilities. Capital-intensive expansion of the grey infrastructure is thus avoided.

## 2.5 Built environment

*Smart building technology is gaining traction in the Midwest, with Chicago and Minneapolis-St. Paul leading the way. Smart technology can help to conserve resources and streamline the building's operations. Innovation in the built environment thus has cross-overs with energy, water and waste (see also section 2.4).*

### Market concentration

In the Midwest, the market growth for innovation in the built environment is concentrated in a few hubs. The *U.S. Green Building Council* ranked Illinois third for number of LEED-certified buildings (*Leadership in Energy and Environmental Design*) per capita [1]. More specifically, the City of Chicago has more 'green' office buildings than anywhere in United States, according to a 2017 ranking by *CBRE Group* and *Maastricht University* [2]. In previous years, Minneapolis repeatedly topped the rankings.

### Efficiency benchmarking

Even though energy and water prices are relatively low in the Midwest, increasing cost awareness is among the factors driving innovation in the built environment (see also pp. 15-16 on advanced metering infrastructure). For households that spend a large share of their disposable income on utilities, there is a lot to be gained by energy conservation and efficiency. Meanwhile, corporate practices are changing. In Chicago, for example, a pilot program run by a NGO, consultancy and a utility company combines smart metering, self-imposed conservation targets, and financial incentives for building operators to make energy efficient choices [3].

Beyond cost reduction, corporate energy efficiency is encouraged with 'informal' incentives. These include reporting obligations and opportunities for positive public outreach. For example, the city of Chicago requires periodic reporting of energy data for large buildings, which cover merely 1% of the built environment yet represent 20% of the city's consumption [4]. These data are published on Chicago's *Open Data Portal* (see p. 8). Further, more than 60 office buildings committed to a 20% reduction of $CO_2$ emissions within five years as part of Chicago's *Retrofit Energy Challenge* [5].

### Design

A major trend in the built environment is functional design to minimize ecological impact. This may include rainwater capturing, on-site wastewater recycling and composting, lots of green space and built-in renewable energy generation capacity. Such buildings can be found in rising numbers in the city of Chicago, which has a rich tradition of architecture, design and urban planning. For example, *Moss Design* utilizes recycled materials and minimizes the environmental footprint of their projects through optimal use of e.g. natural light and passive cooling [6]. In Minneapolis-St. Paul, the *Ford Twin Cities Assembly Plant* will become a mixed-use neighborhood with cutting-edge technologies [7]. The plan outlines design standards related to vegetation and landscaping, lighting, solar energy, roofing and parking.

### Remote control

Another trend is the use of IoT technology to streamline heating, ventilation, air conditioning, lighting and other systems. This trend has only just started to penetrate the market in the Midwest. Successful pilots include the office building of the *National Resources Defense Council* in Chicago [8]. In addition to numerous sustainable design solutions, said building features an advanced lighting system that automatically adjusts to the surrounding light conditions and activity.

## 2.6 Food

*The Midwest provides fertile ground for smart urban farming, thanks to its agricultural tradition coupled with strong agricultural technology clusters.*

Numerous cities in the Midwest are upcoming hubs for urban farming. Among these are Detroit, Cleveland (Ohio), Chicago, Milwaukee (Wisconsin) and Minneapolis (Minnesota) [1-3]. Chicago is home to the world's largest rooftop farm, but vertical farming is gaining ground as well. In addition to a long agricultural tradition, relatively low rent and energy prices may explain the popularity of urban farming in the Midwest. Moreover, the demand for locally produced food is growing.

'Smart agriculture' is gaining ground across Midwest, in both research and practice. Smart farming includes precision farming and the application of robotics. There are research hubs in numerous states; Purdue University in Indiana is the most renowned. *Green Sense Farms* in Chicago is among a few niche companies that are operating on the interface of urban- and smart farming (see picture on the left). The deployment of LED-technology, developed by Netherlands-based *Philips*, enables the production of 1.5 million tons of produce a year in a highly controlled environment and irrespective of the weather [4].

# 3. Opportunities for collaboration

The developments outlined in chapter 2 can be translated into an inventory of opportunities for collaboration. The table below provides a non-exhaustive overview of business opportunities and other potential areas of collaboration.

| Cluster | Theme | Opportunity |
|---|---|---|
| Information Technology | Open data and analytics | • Dutch start-ups could develop Smart City solutions and applications using the new abundance of data in Midwestern cities with Open Data Portals. |
| | Internet of Things | • Emerging IoT hubs such as Chicago and Kansas City may be receptive to Dutch technology – e.g. light-powered sensors – to leverage the full potential of connectivity.<br>• Dutch city officials may be interested in Chicago's *Array of Things* sensor project. In turn, Chicago city officials may be interested in 'nudging' applications of Big Data and smart lighting pilots in e.g. Eindhoven. |
| | Cyber security | • Demand in cyber security expertise is rising in large parts of the Midwest in the context of Smart Mobility and grid modernization. Dutch technological and governance expertise may be valued. |
| | Innovation hubs | • Dutch start-ups may find the resources to scale-up smart city solutions in any of the innovation hubs in the Midwest. |
| Mobility & Transport | Advanced manufacturing | • Dutch companies in the area of automation and robotics will be able to find lots of expertise in the Midwest. |
| | Connectivity and automation | • Dutch developers of V2I and V2X technologies may use the extensive testing facilities in Michigan.<br>• Specific Dutch expertise that may be in demand in the Midwest includes Intelligent Transportation Systems (ITS) and traffic management.<br>• Dutch experts in IoT-enabled structural monitoring of infrastructure such as dikes and highways and developers of advanced technologies (e.g. self-healing concrete) may find opportunities in infrastructure redevelopment in the Midwest. |
| | Green mobility | • Given that the Netherlands is among the frontrunners in electrification of transport (with the share of electric vehicle sales second in the world only to Norway), parts of the Midwest may be receptive to Dutch insights. |
| | Mobility as a service | • Increasing interest in the concept of 'Mobility as a service' across the Midwest, provides the platform to promote the Dutch governance model – e.g. in Columbus, Ohio.<br>• Specific expertise that is in demand in the Midwest includes improving |

| | | |
|---|---|---|
| | | "bikeability" as part of urban planning strategies, with the city of Madison citing Amsterdam as source of inspiration. |
| Resilience | Green infrastructure | • The green-roofs market of Chicago may offer opportunities for Dutch companies that deploy IoT-technology to allow for the controlled discharge of storm water.<br>• Some city and state governments may be interested in learning about Dutch best practices and technologies related to the resilience of infrastructure, particularly in Minneapolis/Minnesota. The U.S. Federal Highway Association the U.S. Dep. of Transportation already work closely with the Netherlands/Rijkswaterstaat.<br>• Companies specialized in pavement innovation (e.g. techniques for permeable/pervious or high albedo pavements) may find opportunities in flood-prone metropolitan areas.<br>• Cities like Chicago may be interested in learning about Dutch experiences with advanced sewer separation to combat urban flooding. |
| | Emergency response | • Cities that frequently face extreme weather will be interested to learn about risk management strategies that are based on 'citizen science' and crowdsourced data. |
| Energy | Energy diversification | • The energy market in the Midwest is dynamic, which may provide space to new stakeholders.<br>• Dutch companies in the renewable energy business may find opportunities in states (e.g. Minnesota; Illinois) and cities (e.g. Chicago, Madison) that set high Renewable Portfolio Standards and other sustainability targets. |
| | Modernizing electricity infrastructure | • The widespread roll-out of smart meters in parts of the Midwest provides opportunities for start-ups to scale up solutions for renewable energy, energy storage solutions and smart (micro-)grids.<br>• Start-ups may apply for financial support in context of the 'Smart Grid Cluster', an Illinois-wide collaborative for business development. |
| Built Environment | | • Dutch architectural design that will be a source of inspiration in the Midwest are functionalist, smart and efficient – such as 'the Edge' office building in Amsterdam and the 'Dutch Windwheel' plan in Rotterdam.<br>• Market opportunities further present themselves in the area of sustainable construction practices and materials, e.g. recycled concrete and energy-smart windows.<br>• In particular, Dutch companies that focus on IoT-enabled sensor-technology in the built environment stand to benefit from market opportunities. |
| Food | | • Opportunities remain at the interface of smart agriculture and urban farming, two notable trends in the Midwest. In addition to smart urban |

| | | |
|---|---|---|
| | | farming, specific subjects of collaboration could include climate-resilient agriculture.<br>• Collaboration between agricultural schools could be intensified. This may include exchange programs between Wageningen University in the Netherlands (ranked the world's best agricultural school in 2017), Purdue University in Indiana and the University of Wisconsin-Madison and the emerging collaboration between the University of Applied Sciences Van Hall Larenstein and the University of Wisconsin. |

## 4. About the Consulate-General in Chicago

Chicago is home to the diplomatic representation of the Kingdom of the Netherlands to the Midwest, which has been around for almost 150 years. Our core business is economic diplomacy, i.e. to identify opportunities for growth and connect potential business partners. Start-up acceleration is an important part of this.

In addition to Smart City, our Economic Affairs team prioritizes the following sectors:

- Smart Mobility
- Water
- Agriculture & Food
- Life Science & Health

Do you have any questions or are you considering to expand your business in the Midwest?
Contact us through chi-ea@minbuza.nl and we will help you get started.

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