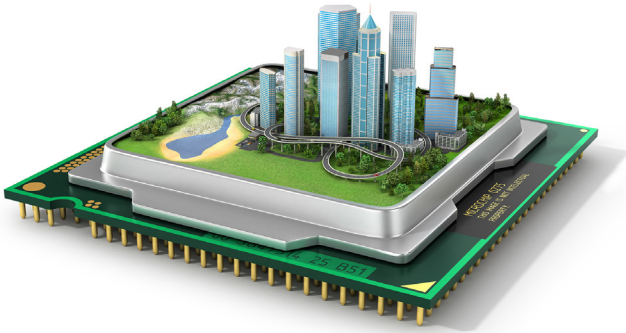


# Smart Cities



The Economic and  
Social Value of Building  
Intelligent Urban Spaces

# Smart Cities

The Economic and  
Social Value of Building  
Intelligent Urban Spaces

KNOWLEDGE @ WHARTON

Philadelphia

© 2016 by Knowledge@Wharton

All rights reserved. No part of this book may be reproduced, in any form or by any means, without written permission from the publisher.

Company and product names mentioned herein are the trademarks or registered trademarks of their respective owners.

Knowledge@Wharton  
The Wharton School  
University of Pennsylvania  
332 Steinberg Hall-Dietrich Hall  
Philadelphia, PA 19104

ISBN: 978-1-61363-078-5

# CONTENTS

About This Report	1
Foreword, by Seeta Hariharan and Vincent Rouaix	2
Chapter 1. The Road to a Smart City	8
Chapter 2. Drivers and Strategies of Smart Cities	15
Chapter 3. From Barcelona to Medellín: Smart Cities That Are Blazing a Path	22
Chapter 4. Building Community Support and Avoiding Pitfalls	32
Chapter 5. Finding Financing for Smart Cities	38
Chapter 6. Smart Solutions for Energy Savings: The “Mini-City” of the University of Pennsylvania	44
Chapter 7. Lessons for Tomorrow’s Smart Cities	47
About Knowledge@Wharton	51
About Tata Consultancy Services	52

## ABOUT THIS REPORT

This report was produced by Knowledge@Wharton, the online research journal of the Wharton School of the University of Pennsylvania, and sponsored by Tata Consultancy Services (TCS), a global IT services, digital, and business solutions company. It was researched and written with the close cooperation of TCS executives, industry experts, and scholars and practitioners affiliated with Wharton.

## FOREWORD

Over the years, the field of technology has given us an awe-inspiring range of advances and improvements. Perhaps one of the most remarkable and impactful innovations so far is the smart-city phenomenon, which brings so many beneficial changes to our lives. This ebook, *Smart Cities: The Economic and Social Value of Building Intelligent Urban Spaces*, is largely inspired by a partnership between the TCS Digital Software and Solutions (DS&S) Group and Gfi Informatique. Early in 2013, TCS started applying its efforts across smart city domains, including water management, transportation, energy management and lighting. Soon, TCS' DS&S Group and Gfi formed a successful partnership to address some of the most significant urban growth challenges that people face today.

Our efforts are now directed at solving a range of economic and social problems through smart city applications. Gfi brought to the table a deep understanding of European markets, well-established relationships within the public sector and an ambitious strategy to improve lives through these smart choices. We will continue to work together to help the smart city influence reach more cities across the globe, aiming to help people regardless of their geography, age, life circumstances or health.

Those of us who share those ambitions, who also want to help people and help the planet, are excited about the smart-city phenomenon. It is possible for business, government, grassroots groups and other stakeholders to work together to make the world more livable through emerging technologies. Smart cities offer the potential to wrap community growth, social and environmental responsibilities

and business and civic community efforts together to transform our working and leisure worlds and to create better lives.

There are many definitions of smart cities, but the best ones always start with the citizens of a community. The primary impetus for smart-city transformations is to engage people toward creating a better quality of life. That is why we see leaders around the globe such as U.S. President Barack Obama, French Prime Minister Manuel Valls, or Indian Prime Minister Narendra Modi embracing smart cities.

Chapter 3 of this ebook describes success stories from Barcelona to Medellín, Colombia. Anyone who travels the world today can see many successful smart city endeavors that have made a real difference. Here are examples from three different cities:

- **Singapore.** Having enough water has long been a national priority in Singapore, since half of its water supplies are imported from neighboring Malaysia. Through astute planning and innovation, Singapore is steadily moving towards greater self-sufficiency in water supply through technologies that enable efficient catchment of rainwater, desalinization plants (treated seawater), and recycling of sewage (treated used water). These initiatives have been so successful that Singapore now plans to export its technologies to emerging economies that are facing water stresses due to climate change, increasing populations from rural to urban migration, and urban development.
- **Columbus, Ohio, United States.** Columbus is the 2016 winner of the U.S. Department of Transportation's Smart City Challenge, which came with an award of \$50 million. The city plans to use this fund to create a transit system that, among other things, will provide self-driving shuttles to link bus services to a retail district and connect citizens to their jobs. Columbus sees benefits that will extend far beyond transportation. This solution also helps the environment. And, the new transit system will also improve health

care in Linden, a neighborhood with an infant mortality rate that is four times the national average, by providing transit services to those who need care the most. Columbus will also collect data to create tools that help vehicles like trucks operate more efficiently. Other apps will help tourists get around and provide residents with better access to services as well as navigation of the modern transportation network.

- **Amsterdam, Netherlands.** Cyclists account for 43% of Amsterdam's city traffic, a testament to the city's commitment to a healthy environment and clean energy. The city is further tackling its pollution problem through the Tree-WiFi. Tree-WiFis are connected devices that look like birdhouses, which are attached to trees and feature sensors that offer free WiFi as well as measure the air pollution level within a 100-meter radius. If pollution is at a reasonable level, the birdhouses illuminate a green light and produce a free WiFi signal. If pollution levels are too high, instead of offering Internet access, these innovative birdhouses offer information on how to improve the air quality. Tree-WiFi is also an example of how a city is engaging its citizens toward a cleaner environment.

Some common challenges driving the smart-city phenomenon include the following:

- **Unprecedented urban migration.** The World Economic Forum estimates that 70% of the world's population will live in urban areas by 2050. As urban migration increases, societal burdens are the result. This is where insights from smart cities can make a difference, through the creation of innovative living and working spaces. As this ebook states, "Those insights are what enhance livability, workability, and sustainability in a city."



- **Exacerbated inefficiencies.** Inefficiencies in any system, whether in transportation, energy, water, or our carbon footprint, are exacerbated due to rapid urbanization. In some major cities, for example, people spend more than two hours a day commuting to work due to a housing crisis, poor roads, and inadequate public transportation. Creating nimble systems for city services is a common feature of any smart city. Instant and responsive pulse checks on citizens' needs will ensure that we are stewards of our own city homes. It's a natural expansion of this positive growth to include needed improvements to underserved areas, paying attention to health issues, especially among the most burdened groups such as the growing aging population and the homeless.
- **Pressure to do more with less.** Taxes are still the major source of revenue for most cities, yet that income does not cover the needs created by shrinking resources and inefficient systems. Today, public officials are under pressure to do more with less to fix inefficiencies and daily challenges in city systems. In Chapter 5, this ebook describes a few innovative finance models, like tapping impact investors. As with every challenge that smart cities address, the capacity to learn, adapt, and innovate also applies to new ways of bringing in income. The growing smart-city industry sets a standard for sharing resources, such that the lessons learned by the alleviation of data territorialism can also apply to efforts for sharing economic resources. It's a new day with possibilities that can unite us and move us into creating a better society.

With these three challenges becoming more pronounced, cities have no alternative but to become intelligent cities. So what are some key steps and considerations for cities to begin their smart city transformation?

- **Visualize.** Start by developing a vision of a citizen's experience in the city. People's experiences help to illustrate the benefits of smart

cities. For example, even someone who is not technologically savvy can appreciate the shorter commute time that is the result of better options in public transportation. Their experiences also underscore the societal impact of their actions. For instance, the use of public transportation improves air quality by reducing emissions.

- **Collaborate.** Collaboration between political and civilian leadership – mayors, city planners and citizens – is key for any smart-city project to be successful. Given the revenue pressures, politics and other challenges, cities and other stakeholders should partner with private firms to jointly fund smart-city programs. Further, transparency in terms of where tax dollars are used will help bring citizens on board. What we have personally seen in the smart-city process is that the benefits spiral into new constellations of more benefits. But it all starts with people. If the technology meets the needs of the citizens, positively impacting the community, then the funding comes more readily and the benefits manifest, meeting more needs of the community, and the cycle goes on. Eventually, the conga line will include everyone and we will all be dancing to the beat.
- **Adopt.** Finally, urban technologies become the enablers to grow smart-city reach. As an example, adopting smart parking technologies will allow citizens to not only quickly and easily find parking but will also help to improve citizens' experiences and reduce a city's carbon footprint. Similarly, smart streetlights that create a "light wave" only when and where it is needed will help to drive energy efficiency. The list of improvements and synergies becomes a true dream-to-reality thrill. New technology enables smart cities to grow and for the magic of that transformation to reach everyone in the community. The second piece to enabling growth, adoption, and resources is for industry associations and consortiums to establish standards. The technology can easily surpass policy, and we could

## Foreword

lose sight of our principles and vision. The standards can keep us all playing well together.

This ebook sets out more helpful steps or considerations for starting the smart-city process in Chapter 7.

It is exciting to be a part of the creative process that yields a future that merges the heart, the economy, and a healthier planet. There's a lot to learn and a lot to gain. We look forward to seeing you all out there in this new world.

Seeta Hariharan  
General Manager and Group Head  
TCS Digital Software & Solutions Group  
[www.tcs.com/digital-software-solutions](http://www.tcs.com/digital-software-solutions)

Vincent Rouaix  
Chairman and CEO  
Gfi Informatique  
[www.gfi.world](http://www.gfi.world)

## CHAPTER 1

# THE ROAD TO A SMART CITY

It's 6:00 a.m. and your connected alarm clock slowly bathes your bedroom with a blue light to simulate sunrise, accompanied by soft music, to gently rouse you. Time to get ready for work. You squint when the window shades automatically open, as your connected home senses the activated alarm. Nearby, the smart thermostat adjusts to your desired daytime temperature, which is cooler than at night. Your smartphone chirps. It's a text from your Internet-enabled coffeemaker, telling you the coffee is ready. A notification from your toaster oven app shows a live video of your breakfast bagel being toasted. All of this happens before you even get out of bed.

After breakfast, you're ready to leave home. You check the city transit app on your smartphone because you're taking the bus today. It shows the driverless shuttle is 10 blocks away, so you have a few more minutes to finish your coffee. Leaving the house, you arrive at the bus stop with some time to spare. As you wait, you browse the digital kiosk for entertainment listings and book two movie tickets for Friday night. Since you logged in to your account, the kiosk recognizes you and knows that you like to try new cuisines so it recommends restaurants near the movie theater suited to your adventurous palate and spending habits. You make reservations at that Ethiopian restaurant you've been meaning to try. With a few taps, your weekend plans are set.

Your electric bus arrives on time. The doors swish open and as you board, sensors in the shuttle detect the city's electronic pass in your smartphone and automatically subtract your fare. It's a virtual card that you also use to pay for many city services besides transportation—such as water and electric bills, highway tolls, and even local taxes. During

the ride, the smart bus is busy capturing data about the passengers' trips. Sensors on the bus pick up unique addresses from mobile devices to track trip patterns. An algorithm weeds out errant signals—those that drop off after the bus pulls away from the stop, showing that they are from people who were near but not on the shuttle. This data will help administrators decide how frequently the route should run or whether larger buses are needed at certain times of the day when there are more riders.

Tomorrow, you'll have to drive to work because you're visiting a client off site. You've been carless for a year now because you enjoy using the city's electric car-sharing program—you pick up a car from a designated station and return it to any station, just as you would a bike. You enjoy driving more now because traffic is less of a problem these days. The enhanced traffic app you downloaded is tied to the city's video surveillance cameras and sensors that monitor the traffic flow in real time for accidents and other delays—and quickly create detours. Using predictive analytics, the city uses this data to anticipate traffic jams as well. That's how you kept your cool when the president visited your city recently and created higher-than-normal congestion; you were able to find an alternate route quite easily.

Back home after a busy day, you approach your house and the door unlocks automatically as it recognizes you. Looking forward to a quiet evening, you ponder the choices for dinner. Instead of rummaging through your fridge wondering what's fresh, you pull out your smartphone to check the fridge app. It has a snapshot of what's inside and also tracks how long the food has been inside. There's a three-day-old BLT sandwich and the lettuce is probably wilted. So you choose the leftover fettucine alfredo, which the fridge reminds you is from last night.

After dinner, it's time to clean up. You toss leftovers and other trash down a suction chute in the kitchen, where it goes through underground pipes to a waste-processing facility. Some of the trash is converted into energy for the regional power grid. Larger trash items are placed in

bins outside the house. Once the bins are three-quarters full, sensors alert waste-disposal trucks that it's time to pick up the trash.

With cleanup done, you're ready to turn in. But the shirt you want to wear tomorrow to your client meeting is soiled. So you throw a load of laundry in the wash—and you can leave it. The connected washer-dryer appliance has laundry-folding capabilities. After washing and drying your clothes, the folding feature uses image recognition to sort through the apparel—shirt, pants, or something else—and deploys robotics to fold them. At 10:00 p.m., you climb into bed knowing that you'll have a freshly laundered and folded shirt to wear in the morning.

This is the enhanced quality of life you enjoy every day—in a smart city.

### **What Are Smart Cities?**

Smart, or intelligent, cities are communities that harness technology to transform physical systems and services in a way that enhances the life of its residents and businesses while making government more efficient. It is more than a mere automation of processes; it links disparate systems and networks to gather and analyze data that is then used to transform whole systems.

While the idea behind smart cities has been around for years, it has acquired a new urgency as more people move into urban centers. Sustainability is becoming an important imperative and technologies have advanced to a point where there can be real-time and meaningful interaction between cities, residents, and businesses.

According to the United States' Smart Cities Council, a smart city is a “system of systems—water, power, transportation, emergency response, and others—with each one affecting all the others.” In recent years, the ability to merge multiple data streams and mine them for critical insights has been refined. Those insights are what enhances livability, workability, and sustainability in a city.

But “smart cities have also a longer meaning as well,” added Gary Hack, professor emeritus of city and regional planning at the University of Pennsylvania's School of Design. “They are places in which there's a

good interchange between people, where people can start businesses, and develop new products and services.” He has prepared development plans for more than 30 cities globally, and was the planning consultant to the team that won the competition to redevelop the World Trade Center in New York.

However, just as the presence of a recycling bin at an office does not mean it is a green building, the presence of a few enhancements—such as citywide Wi-Fi—doesn’t make a smart city. It is, however, a start and a worthy goal. Cities that endeavor to understand smart initiatives will not only see enhanced efficiencies leading to cost savings, but also make their residents happier.

And there is more good news: Smart technologies are not just for large cities with large economies of scale. They have “matured to the point that cities of all sizes can afford and benefit from their implementation,” the council said. For example, very small towns can now afford cloud computing services, harnessing its power to improve the quality of village life.

## **A Rising Trend**

In whole or in parts, intelligent cities are being planned and rolled out at an energetic pace around the globe. Examples of smart cities run the gamut from Barcelona, where the drive to revolutionize began more than a dozen years ago, to China’s capital city Beijing, and also India’s 3,000-year-old temple town of Bhubaneswar.

“The movement towards intelligent cities is catching fire around the world,” said Jerry M. Hultin, chairman of the global advisory board of the Smart City Expo World Congress, the preeminent forum for builders of intelligent cities that hosts its annual event in Spain. According to Munish Khetrapal, the managing director of smart cities and Internet of Things at Cisco Systems, between 3,000 and 5,000 cities are already on that journey.

The United States, which came later to the game, is now getting its act together at the federal government level, although several US cities,

including New York, Philadelphia, and San Francisco, launched such initiatives years before the term “smart city” became a buzzword.

In September 2015, the Obama administration announced a smart cities initiative that will invest more than \$160 million in at least two dozen research and technology collaborations to help communities across the country tackle challenges ranging from fighting crime and reducing traffic congestion to fostering economic growth. Leading the program is the Smart Cities Council. Its chairman, Jesse Berst, called the plan “a tipping point for smart cities in America ... and that’s a good thing, because we’re behind other parts of the world.”

China has accelerated its plan to build intelligent cities, with a strong directive from its ruling Communist Party in February 2016 to expedite the initiative. It has smart-city pilots underway in 277 cities. One challenge there is that only local authorities can collect data, which they are reluctant to share. However, the country has other problems that smart-city advocates said technology could help alleviate: severe pollution, traffic congestion, health-care challenges such as obesity and diabetes, aging of the population, and migration from rural to urban centers, among others.

India recently chose 35 cities in two rounds to serve as models for a larger Smart Cities Mission that aims to cover at least 100 cities. The government has allocated \$7.6 billion for the program in grant monies.

Indeed, the pace and scale at which intelligent cities are springing up are unprecedented. And there is no turning back, said Senthil Gunasekaran, the head of corporate development and strategic alliances at Tata Consultancy Services (TCS), who is actively involved in the company’s intelligent-city projects. “Cities don’t have a choice but to be intelligent,” he said. Given the demographic and budgetary pressures many cities face, “it is an imperative.”

Here are the basic components to becoming a smart city, according to the Smart Cities Council:



- **A holistic view of the city.** Define the parameters of the smart city. It could be an actual city, a region, or a cluster of towns or neighborhoods. But whether big or small, a smart city takes a holistic view of the entirety of human activity in an area—including city governments, schools, hospitals, infrastructure, resources, businesses, and people. Set goals for what you wish to achieve.
- **Information and communications technology.** Use technology to enhance a city's livability, workability, and sustainability by connecting various parts of government to each other as well as to residents and businesses. The goal is for the government to get an up-to-date assessment of how the city is functioning at any given time, provide the tools to refine them, and anticipate occurrences.
- **Data collection, dissemination, and analysis.** Use the connected systems to gather data and assess current conditions in the city. This requires hardware such as smart gas meters or traffic sensors to collect data, and related software to run them and sift through the information. Once the information is collected, that data is communicated through wired or wireless networks to relevant city departments, consumers and businesses. Finally, the data is analyzed to understand what's happening and to predict what's likely to happen next.

For example, according to the council, Rio de Janeiro collects data from 30 city departments relating to transportation, water, energy, weather, and other conditions. This data is analyzed to give the city an overview of what's going on and can predict conditions such as where flooding is likely to occur so the city can act preemptively.

Other examples of what's possible in a smart city: Sensors embedded along waterlines can detect leaks or burst pipes to hasten repairs. Video surveillance helps monitor conditions to prevent crime. Smart electric meters can track residents' usage patterns and help them

make choices in avoiding or deferring the expensive, peak-time use of home appliances to cut costs.

The result is that a connected government improves the functioning of its city departments, eliminating waste and improving efficiencies. It can more ably engage residents proactively by harnessing big data and analytics to resolve pain points such as pollution and traffic congestion. Over time, such cities provide more value to residents and businesses, and in turn attract more companies and talent to move in. This leads to increased economic output and happier residents and workers. The stress of urban living is then replaced with a vibrant and growing city that has become a desirable place to live and work.

## CHAPTER 2

# DRIVERS AND STRATEGIES OF SMART CITIES

**T**hree developments are driving the smart cities trend: A shift in the migration of the population toward urban centers, advances in connectivity and digital tools that have changed how people and businesses work and interact, and shrinking municipal budgets that force city officials to find smart ways of delivering more—and better—services with less money and other resources.

### **What's Driving Smart Cities**

#### *Demographic Shifts*

Globally, 54% of the population lives in urban areas today. But by 2045, the number of urban dwellers is expected to increase by 50% to 6 billion, according to the World Bank. The breathtaking speed and scale of urbanization brings challenges, to be sure, including meeting increased demand for affordable housing, basic services, well-connected transport systems and other infrastructure as well as jobs, particularly for the nearly 1 billion urban poor. The World Bank noted that “urbanization can contribute to sustainable growth if managed well by increasing productivity, allowing innovation and new ideas to emerge.”

Meanwhile, the rapid economic growth of emerging economies such as Brazil, Mexico, India, and China puts more demands on the existing infrastructure in their cities, said Anil Menon, global president of Cisco's Smart+Connected Communities initiative. Moreover, the advent of aging populations in Europe, China, and Japan means these nations will have progressively “fewer people in the productive

stage of economic development that are earning incomes,” he added. That could mean increased dependence on cities to care for their senior citizens.

### ***Digitally Defined Trends***

In the digital economy, the way people engage with each other, their employers and their governments has radically changed. The corporation is no longer the center of employment activity, said Hultin of the Smart City Expo, who is also chairman of the Global Futures Group, a consulting firm that works on intelligent-cities projects worldwide. “You may not belong to a single big corporation, but may be a freelancer consultant, programmer or attorney, and that requires networking, connectivity, and new kinds of ways to get paid. No longer is the payroll department paying you; now you are getting paid by PayPal or mobile phone banking. The whole environment has changed—and mayors in cities know that.”

As a result, providing reliable and fast broadband connectivity is an imperative for cities, at the very least. “Wi-Fi is the new sidewalk,” said Menon. “Nobody will go to a city and walk around if there is no sidewalk. Similarly, nobody will go to a city that doesn’t have Wi-Fi connectivity.”

### ***Shrinking Municipal Budgets***

A 2015 report by the National League of Cities in the United States noted that “most states are experiencing slow growth in revenues, coupled with new and expanding expenditures, including Medicaid.” As such, many states have budget shortfalls for the coming fiscal year. “This has been, and will continue to be, a challenge for cities because often the decisions that states make to balance budgets exacerbate negative fiscal and economic conditions in cities.” The bottom line: If states are hurting, they could cut general aid, shared revenues, reimbursement programs and other benefits to cities.

As pressures on city finances grow, officials look to harnessing technology to become more efficient. “Owing to budget constraints, city administrators have to optimize existing public services,” said Vincent Rouaix, chairman and CEO of French IT services firm GFI Informatique S.A., which has experience working on smart cities. Smart technologies can help.

But efficiency is not the only goal. “The central reason to call for smart cities is to remind everyone of the way information technology can help solve urban problems,” said Jonathan Barnett, an emeritus professor of practice in city and regional planning at the University of Pennsylvania and a fellow at the Penn Institute for Urban Research. The result is an enhanced quality of life.

### **Strategies for Cities Seeking to be “Smart”**

To be sure, smart-city strategies vary in degree by municipality and country. In a mature economy, it could mean creating a digitally connected city, driverless cars, smart street lighting or parking. In rapidly growing economies that are still struggling to meet their residents’ basic needs, smart-city initiatives tend to focus on raising the standard of living and using technology to maximize the impact of limited resources on housing, food, clean water, health care, and other concerns.

In India, “we have to focus on *roti, kapda, makaan* (“food, clothing, and shelter” in Hindi), and now broadband as well,” said Jayant Kohale, business leader of smart cities at Larsen & Toubro, a large engineering and construction services company in that country.

Once basic needs are met, transportation and connectivity are next in line for improvement in many cities. Erick Guerra, professor of city and regional planning at the University of Pennsylvania’s School of Design, championed the use of driverless vehicles. “All of the big car manufacturers and major taxi firms are working on driverless cars. Freight on trucks and luxury cars, and maybe even mass transit, are probably the first adopters of autonomous vehicles.”

For example, Singapore is testing driverless vehicles on six kilometers of public roads. Also, the nation's ultra-high-speed 1 Gbps national broadband network lets public hospitals test a tele-health rehabilitation system where sensors attached to patients' limbs send data through the network to the hospital as they do physical therapy at home.

Indeed, connectivity fuels all these innovations. "There is a direct relationship between access and productivity," said Penn's Hack. "The way we provide access has consequences in terms of traffic fatalities, collisions, loss of life, loss of property, air pollution, local pollution, global pollution, congestion, and even smaller things like noise pollution can become quite bad as well."

### *Leverage Technology and Talent*

Smart cities recognize the transformative power of technology. But for it to be effective, cities must work with the right talent. "In fact, in most cases technology is not the answer; instead, it's just a tool. But it is about applying the tool in the right way, and you have to bring the right people in the context," said Rahul Mangharam, a professor at the University of Pennsylvania's department of electrical and systems engineering, who is leading a novel effort to achieve energy savings across the university's 185 buildings.

Planners should also keep their options open with the types of technology being used and retain control over data, said Bob Bennett, chief innovation officer in Kansas City, Missouri. Cities have to be careful in negotiating data rights because some firms offer to build a system and sell the city the data it collects. "That is our data. That may mean our cost-sharing agreement is different and the [company] retains a greater amount of the profits, and that's okay—but I get the data."

Moreover, the city should ensure its solutions are broadly inclusive enough to be meaningful, according to Daniel Levine, practice leader of location strategies and economic development at Oxford Economics.

“The best models of economic development are those that build on those three pillars—new jobs, better community, and a workforce [that can] participate,” he said. Levine cited the case of high-tech city Austin, Texas, which has sought and attracted many out-of-state technology companies. However, not all of its residents are suitably qualified for technology jobs, and the city needs to help create manufacturing and other types of jobs as well.

### ***Use Public-Private Partnerships (PPP)***

These partnerships can be effective in solving urban problems. For one thing, most cities tend not to have the financial and technological wherewithal to do everything themselves. Second, for cities to weather business cycles, contractually guaranteed revenues from their partners can act as a stabilizing force during lean times.

But these partnerships also must evolve beyond the conventional understanding that a city’s involvement is limited to awarding contracts. “PPPs are not just about a city government giving private promoters a concession, such as a right to run a particular service,” said Cisco’s Menon. “It is where everybody gets together, saying, ‘We can do something unique.’”

### ***Learn from Others***

Cities would do well to learn from not only fellow smart cities but also unconventional sources. Take the US Golf Association. It has launched a five-year research partnership with the University of Minnesota to use data analytics to find ways to keep the sport self-sustainable into the future. Water costs have been rising 11% a year nationally, and the average golf course spends \$600,000 a year on water and other maintenance.

In one initiative, the trade group put GPS devices in the golfers’ pockets to track their play and discover which parts of courses are seldom, or even never, used. Limiting the maintenance and irrigation of the little-used portions of the golf course would save money. Also,

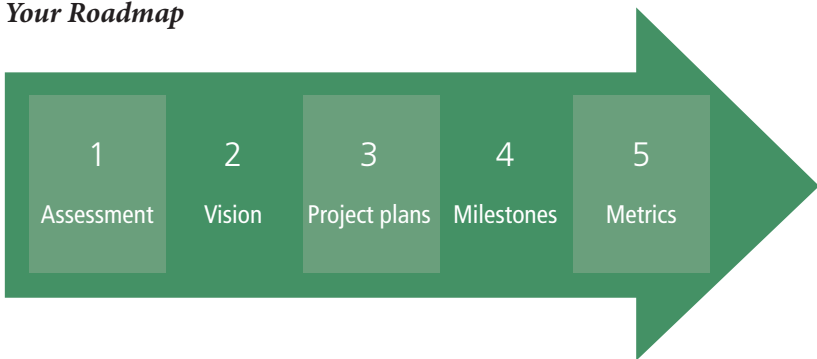
since 1983, the group has invested \$50 million in research to develop commercially viable strains of turf grass that use less water, grow at slower rates or are less susceptible to diseases and pests.

Another example is the energy efficiency solution from the University of Pennsylvania's DR-Advisor, which could be used to similarly manage utilities such as water, or distribution networks such as transportation, that face demand-supply mismatches and congestion during peak times.

## Creating a Roadmap

To put ideas into action, it's helpful to create a roadmap that provides a big-picture outline of the major steps that need to be taken on the path to becoming an intelligent city. It helps to keep the vision clear since developing a smart city is likely to take many years. However, according to the Smart Cities Council, the roadmap should not replace detailed master plans that will come with implementation.

### *Your Roadmap*



The council recommends the following five elements of a smart-city roadmap:

#### **1. Assessment: Where you are**

Set a baseline for your current level of performance.

#### **2. Vision: Where you want to go**



Cities should have a clear picture of ultimate outcome that is not solely defined in terms of technical achievements but expressed in benefits for citizens.

### **3. Project Plans: Key components of the plan**

Create master plans for implementation, such as those for land use, digital infrastructure, transportation, city services, and the like.

### **4. Milestones: Marking progress**

Set benchmarks to measure progress, share lessons learned and discuss course corrections.

### **5. Metrics: Measuring success**

Identify key performance indicators to quantify success, such as average commute time, percentage of residents with broadband, energy efficiency achievements and so forth.

## **A Note About Smaller Cities**

All these endeavors could make municipalities think that only big cities have the wherewithal to develop smart solutions. But actually, the opposite is true. Smaller cities or those in emerging markets are expected to take the lead in smart solutions. They have less to lose by way of an installed base and more flexibility to try out new ways. People in smaller cities arguably have a mindset that could be more receptive to smart-city projects. “Citizens of those second-tier cities feel like they own their cities, and that they are the ones who should run and govern the city,” said Menon. “In larger cities, there is this sense of free ridership and less of ownership.” Larger and older cities often struggle because they find it more difficult than smaller cities to change their set ways of working due to the size of their operations.

By now, you can see that technology is just one part in the transformation to a smart city. It also includes community support, funding, political will, and a vision for the way forward.

## CHAPTER 3

# FROM BARCELONA TO MEDELLÍN: SMART CITIES THAT ARE BLAZING A PATH

The worldwide trend toward building intelligent cities is bringing out the creative juices of urban planners, entrepreneurs and citizens. Some are impressive in their innovations, while others are laudable for their scale or impact. Typically, these projects began in discrete pockets of existing cities, where they can generate a “proof of concept,” improve upon their design while gaining insights and go on to replicate them in other parts of the city or in other communities. A less common example is the building of brand-new cities, such as Songdo in South Korea or one planned in China’s Guangdong province with funding from a wealthy Chinese businessman.

Here are examples from around the world of innovative work in making cities intelligent. They touch on a range of areas, including mass transportation, energy efficiency, health care, parking, connectivity, data analytics, adaptive reuse of existing and unused infrastructure, citizen participation, and importantly, enhancement of overall quality of life.

### **A Focus on Improving the Quality of Life**

#### *Barcelona*

As one of first major metropolitan areas to become a smart city, Barcelona has set the standard to beat in many ways. According to Cisco, the Barcelona Smart City Model has targeted 12 areas—environmental,

information and communications technology, mobility, water, energy, waste matter, nature, built domain, public space, open government, information flows, and services. The city has 22 major programs that cover these areas, and initiatives include smart lighting and parking, as well as water and waste management. Moreover, the city's departments are connected to deliver coordinated services. It is developing a city operating system to quickly gather and analyze data collected by its network.

Barcelona also is now readying to launch an innovative app for its senior citizens. Vincles BCN, as the app is called, is designed to help older people stay in touch with their children and other family members, get pill alerts and reach doctors or hospitals, said Mariona Soria, a press officer in the Barcelona city administration. "We have a lot of older people living alone." The Vincles app design won the Bloomberg Philanthropies' Mayors Challenge Grand Prize in September 2014.

But the overarching impact of its smart-city initiative is what makes Barcelona a model for other intelligent cities. According to Smart City Expo's Hultin, the most striking aspect of Barcelona was that it emphasized that citizens should be the real beneficiaries of smart solutions, and not just corporations selling their wares. "At every stage, they asked themselves, 'Will this make the quality of life of the individual better?'"

Hultin noted that Barcelona's focus on improving the quality of life transformed the whole idea behind smart cities as merely leveraging technology tools. In the early days, "it began to look like smart cities were about routers, sensors and Wi-Fi equipment and that was the end of the story," he said. "Instead, it is a story about how that equipment leads to a higher quality of life."

### ***Moreno Valley, California***

Video surveillance and analytics are of high interest to cities grappling with crime, especially because they can help in detecting anomalies

in people's behavior and serve as a deterrent, said Ruthbea Yesner Clarke, research director of the global Smart Cities Strategies program at research firm IDC. Such solutions are also commonly used in traffic management and finding parking spots.

Clarke cites the use of video analytics in crime prevention by the city of Moreno Valley, California, as one intelligent way to overcome budget constraints. The city has more than 200,000 residents living within 50 square miles, with 38 parks and 6,000 acres of recreational open space. About three years ago, the city wanted to improve the effectiveness of its police force. It hired Hitachi Data Systems along with other public and private entities to build out a video infrastructure.

The city's research revealed that "video critical to a situation tended to be out of the view of a single camera," according to a case study by Hitachi. It decided to deploy clusters of three cameras that would dramatically increase the likelihood of capturing all critical views of an event. At last count in August 2015, the city had installed 275 cameras, and some of them have speakers to inform park users or target abusers.

The city's police department has used the system to investigate more than 800 incidents over a two-year period, and traffic management has also seen increased efficiencies. Moreno Valley said more families are returning to its parks, as residents feel a greater sense of safety and well-being since the cameras and speakers were installed.

## **A Focus on Boosting Sustainability**

### ***Copenhagen***

The city is considering a proposal to provide data collection kits to its citizens that they can use to monitor air quality and noise in their own surroundings and pass on that data to city authorities. As an incentive to collect data, the city is weighing plans to give micropayments to participating citizens, said Marius Sylvestersen, program manager at Copenhagen Solutions Lab, who heads the units that are managing smart-city projects. City residents already have the option of using hotlines to report potholes or other problems.

With the main objective the improvement of the quality of life for its citizens, the city has embarked on initiatives such as more efficient traffic management to ease congestion; technology to help people find parking spots; a bicycle-friendly environment and a cleaner city where sensor-enabled garbage bins ensure that only those that are full get emptied.

To measure progress, the city has identified key performance indicators including the tracking of air quality through sensors. Making such an effort possible is the use of a “living lab” in the city center, a project that cost 2 million euros (\$2.2 million) and funded equally by the city, French lighting and traffic giant Citelum, Cisco and telecommunications firm TDC Erhverv.

### ***Charlotte, North Carolina***

The city has implemented successful energy efficiency programs by bringing together city officials, energy providers, business and residential users and other stakeholders to the table. The initiative uses a mix of smart meters, energy-efficient lighting and other equipment, as well as data analytics to modulate usage patterns. Since its launch in 2010, about 50 companies in 64 large downtown commercial buildings have seen an average drop in energy usage of 17%. The goal is to reduce that energy consumption by 20% by the end of 2016, said Amy Aussieker, executive director of Envision Charlotte, the nonprofit behind the program.

Collaboration was the key driver. Known as a banking center, the city hopes to attract even more firms. “If we reduce costs for our businesses, more companies will move in here,” she said. Envision Charlotte rallied the troops, bringing the mayor and other officials on board, businesses and utility giant Duke Energy. It added a new dimension to its record of public-private partnerships (PPPs) by roping in the University of North Carolina at Charlotte to house the energy data, with students doing the analytics. Added Aussieker: “I like to call it ‘PPP Plus.’”

Duke Energy joined the Envision Charlotte program, which aided its sustainability efforts by getting companies and buildings to use energy efficiency measures in a way that does not sacrifice revenues. This is how they did it: Duke Energy made the upfront investment to provide customers energy efficiency equipment, including discounted LED bulbs that consume less energy than conventional halogen lamps. It passes on the savings accrued from the reduced energy usage to consumers. The regulator, the North Carolina Utilities Commission, allowed Duke Energy to raise rates, which enabled it to recover its investment. “The consumer still saves more, Duke makes more money, and the environment wins,” said Aussieker, adding that further gains could be had by expanding the program to regulate peak-time energy usage.

### *New York City*

A subway station in Manhattan’s Lower East Side that has been lying unused for 70 years is being converted into the world’s first underground park, called Lowline, with a target opening in 2021. Spearheading the project are co-founders James Ramsey and Dan Barasch, a former Google strategist. Ramsey, who had worked at NASA, thought about using solar panels to capture sunlight above ground to light the underground park.

In another initiative, New York is planning to repurpose languishing pay phones because their electrical power opens the door to more innovative uses. LinkNYC, a partnership between New York City and CityBridge, a consortium of experts in media and connectivity, plans to replace more than 7,500 pay phones with interactive structures called Links. Each Link will provide “superfast, free public Wi-Fi, phone calls, device charging, and a tablet for Internet browsing,” the group said. Digital advertising enables the service to be free as well as add to the city’s revenues.

Another example of putting old assets to intelligent use is City24/7. A collaboration between Cisco and the City of New York, the program

provides smart screens for citizens to access helpful information, including government services, local businesses, free events, and other hyperlocal data. The smart screens replace unused and often outdated public fixtures such as pay phones located at bus stops, train stations and other well-trafficked areas.

### *India*

The city of Ahmedabad in India's Gujarat state has created a public transportation system that combines its Janmarg rapid bus lines with the city's municipality and state transport corporations. For the 5 million people who use the integrated service, this means they could use a common smart card that works across different bus services, resulting in more efficient route and fleet planning, among other benefits. "These may be common in the Western world, but in India, these are new solutions," said Larsen & Toubro's Kohale.

Surat, another large city in Gujarat, has introduced automated systems for fare collection and vehicle location services for its buses as well. Indian cities also see the need to set up command and control systems that can serve as nerve centers, into which services such as transportation, power, and surveillance would feed.

In the city of Ludhiana in Punjab state, there is a smart-city plan that includes a proposal to convert 30,000 rickshaws into "e-rickshaws" that run on electricity. Other cities want to emulate the program, so city officials are preparing a policy paper for such conversions.

As of April 2015, eight Indian cities had filed plans with the central government for projects to be launched. They include projects in affordable housing, 24/7 water supply, sewage treatment plants, transportation, smart street lighting, rooftop-mounted solar paneling, solid waste management, and waste water recycling projects. Other technology-based projects being proposed are for intelligent transport solutions, e-governance, Wi-Fi services, common payment cards, and RFID tags for trash cans of individual households.

## **A Focus on Building Brand-New Cities**

### ***Songdo, South Korea***

One of the most visible examples of an intelligent city built from the ground up is Songdo in South Korea. Costing \$35 billion, the city spans 100 million square feet and sits on 1,500 acres, including 40 million square feet of commercial space, 35 million square feet of residential space, and 10 million square feet of retail space.

According to tech blog Mashable, the city has a pneumatic waste disposal system that uses pipes to suck trash from individual homes into processing centers that automatically sort the material and recycle it. The plan is to turn that waste into renewable energy. Underneath the streets, sensors detect traffic conditions and alter signals based on congestion.

The project, which began in 2001 and will continue to build out until 2020, was designed as a smart and sustainable city by a partnership between real estate development firm Gale International in New York, South Korean engineering and construction giant Posco E&C, and the Incheon Metropolitan City organization.

“Songdo is a success story,” said Cisco’s Khetrapal, who was actively involved in the project. While the 2008 global downturn in the real estate industry impacted the city’s plans, it has since bounced back. “The average real estate price in Songdo is higher than an equal place in the neighborhood of Seoul.”

### ***Vinge, Denmark***

As a brand-new city in Denmark that fully uses renewable energy, Vinge is spread across 370 hectares and expects to support up to 20,000 residents. Several features will encourage its residents to closely interact with each other. Those include green spaces with biodiversity, a recreational waterway that will run through town, and a stipulation that all houses will have no more than two stories. It will also have a manmade delta to meet the challenge of storm water management



during periodic flooding, according to architecture website Arch Daily. Also coming up is a new commuter train station linking Frederikssund to the north and Ølstykke to the south, to help Vinge become a transit hub.

### ***Guangdong, China***

Yan Jiehe, one of China's wealthiest businessmen and founder of the China Pacific Construction Group, wants to do good for his society, and is one of several so-called impact investors in intelligent cities. He plans to invest 250 billion yuan (\$39 billion) to build a 100-square-kilometer intelligent city in South China's Guangdong province, according to the *South China Morning Post*. He wants to focus on education, occupational training, and the medical sector, and attract leading academics from around the world to the colleges in his city.

## **A Focus on Improving Transportation Systems**

### ***Seoul***

The city has used smart solutions to solve transportation problems. For example, the city wanted to add late-night bus routes for ferry workers who were getting off their near-midnight shifts because public transportation had ceased running by that time. It used data analytics to map the city into hexagonal patterns and analyzed commuter activity through sensors on taxis. Based on its comprehensive analysis, the city came up with a viable schedule for late-night bus routes. City authorities also set up bus stops at places near businesses, as well as where they tracked taxi activity. To publicize the new routes, it used analytics to place billboards and other ads at locations where they believe night shift workers would be present.

### ***European Union***

Rome-based CityMobil2 is setting up a pilot platform for automated road transport systems, which will be implemented in several urban

environments across Europe. The European Union is co-funding the project. The pilots for CityMobil2's automated road transport system will run on five locations over six months. The system has been on demonstration in La Rochelle, France, since December 2014.

"A number of city planners are at the forefront of thinking about how to deal with driverless cars," said Penn's Guerra, an expert on automated vehicles. CityMobil2 has 45 partners, including system suppliers, city authorities, and the research community. "Within the next 20 years, fully autonomous vehicles will likely be commercially available and driving themselves on city streets and highways," he wrote in a recent research paper.

### **A Focus on Meeting Basic Needs in Emerging Markets: Medellín, Colombia**

At a recent conference in New York on smart cities, Beth Simone Noveck, co-founder and director of The GovLab who served as the first deputy chief technology officer of the United States, called this city is the "most innovative city in governance." Before Medellín began to reinvent itself some 25 years ago, it was a hub for cocaine trading and rife with corruption and crime. Poverty, rural migration, population growth, and inadequate access to education, health care and employment opportunities exacerbated the situation. Drug lords and the local mafia often clashed with law enforcement, adding to the death toll of judges and suspected informers.

Medellín's turn for the better began in 1991 when new laws empowered mayors by giving them longer tenures (four years instead of two) and control over their police forces, which they didn't have before under a national police system. Around that time, Colombia also introduced urban planning reforms including stronger zoning rules. Public spaces were created with sidewalks, walking trails, parks, and libraries, following the example set in Colombia's capital city of Bogotá. "What many didn't want to understand, though, is that it's not just about improving public space, but about a completely different

way of doing politics and running cities,” Gerard Martin, an expert on Colombia who authored a book on Medellín’s resurgence, told *Citiscopes* magazine.

In subsequent years, Medellín energized its own residents as a counter to the city’s crime and corruption circles. A Metro train system that opened in 1995 with 30 stations and accompanying sidewalks and plazas served as places for its people to connect. A cable car was also launched, connecting sections that had little public transport access earlier. Neighborhood intervention programs focused on underprivileged sections, creating parks and libraries, and strengthening schools by partnering them with universities to help improve performance. A support center for small business was also set up. As a smart city, it is implementing a program called Medellín Digital to provide free Internet access in schools, libraries, and business centers.

Medellín is now a model for urban renewal. In 2013, the city was named the City of the Year by Citigroup, *The Wall Street Journal*, and the Urban Land Institute (ULI). Today, it is known more as a technology hub. It also boasts new infrastructure such as a large metro system, and museums and libraries to improve its quality of life, while its homicide rate has plunged nearly 80% between 1991 and 2010, according to a report by ULI. The city’s efforts have also spurred private investment, and promoted social equity and environmental sustainability.

---

The bottom line is that many cities are in various stages of smart initiatives because each city’s financial, environmental and social needs are different. But whatever stage of the process your city is in, remember that where you come from is not as critical as where you’re headed.

## CHAPTER 4

# BUILDING COMMUNITY SUPPORT AND AVOIDING PITFALLS

Cities aspiring to become intelligent must work hard to win support from their citizens and engage proactively with them in transparent ways about the benefits and shortcomings of those projects. That process helps build an ecosystem of stakeholders where the responsibilities and benefits are shared. Some cities, such as Barcelona, have a long history of inclusive planning, and others have had to consciously engage with the people impacted by their projects. Innovative strategies have been used in New York, Kansas City, Dallas, cities in India, and elsewhere.

Getting stakeholders on board for intelligent-city projects is no longer an optional feature, but an imperative in today's world of competing interests, social media protest campaigns, and of course, litigation. That realization is not limited to mature economies where citizen engagement is common through public hearings. For instance, India's smart cities contest for government funding strongly emphasized "citizen consultation" and assigned it a 16% weight, in addition to other criteria such as "result orientation" (20%) and "smartness of solutions" (10%).

The small port city of Kakinada in India's Andhra Pradesh state, for example, found a place in the first round of 20 smart cities because, among other pluses in its proposal, it actively involved visually impaired people in the "citizen consultation" process. Kakinada wants to transform itself from a "Pensioners' Paradise" to an "Economic

Destination,” and has proposed projects in transportation, energy efficiency, and water supply.

## **Reassuring Citizens, Averting “Divides”**

Kansas City, Missouri, is implementing a connected, smart-city project in partnership with private-sector investors. The project has been launched along a 2.2-mile stretch of the city’s downtown, and it will feature free Wi-Fi, 25 interactive digital kiosks, and LED lighting controlled by sensors. Cisco considers the project “a living lab” for its Internet of Things programs, with Sprint as the Wi-Fi provider. Over the next decade, Kansas City will invest \$3.8 million of the \$15.3 million in total project costs, with its partners bringing in the remainder.

The city administration, led by Mayor Sly James, engaged with citizens on the project, allaying concerns they may have on issues like data privacy. Citizens could see how the improvements would be valuable, such as increased business for retailers, cleaner roads, or safer streets because the savings on street lighting could be spent on the police force.

A fact sheet the city distributed clarified that taxpayers would not be required to pay for building or running the network. It also said that it would waive permit fees for the project and that the Wi-Fi provider would maintain 50% of the network for its own use. It further emphasized that it will ensure the highest standards in data privacy.

Incidentally, Google in 2012 launched the national rollout of its 1-gigabit-speed fiber-optic network in the Kansas City metropolitan area. The company took action to make sure its service did not create a “digital divide” between those who can and cannot afford the service.

And even though Google generally had a welcome reception in the city, it still deployed 60 employees to canvas the ground in underserved areas, visiting churches, community centers and schools. The team found that a quarter of the respondents surveyed did not have broadband or dial-up Internet access. Many of them said the Internet “is not relevant to their lives.” Google decided to invest in digital

literacy programs, and offered to make available grants for community organizations that may want to start such programs in Kansas City.

## **Fundamentals of Securing Support**

The case of the redevelopment of the Prudential Center in Boston is more than 25 years old, and is not a smart project, but it still holds strong lessons for today's urban planners. "Neighborhood engagement was extraordinarily successful" in the project, according to Penn's Hack, who prepared its redevelopment plan. "It doubled the rents on the retail space and in the office spaces, because it was seen as such a desirable place to be in."

Hack said patience was crucial in winning over various stakeholders, because the obstacles could be many. "You can't design something and then try to persuade people to accept it," he said. "You have to work with them on the design of what you're doing." He advised securing the initial support with a small group by transparently laying out the benefits and matching them with the community's interests, and later widening those circles.

Secondly, it's important to put together a truly representative group of all of the interests. Here, it's often useful to reach out to and include people opposed to the project in such groups. Third, the project promoters must be prepared to give residents or other interest groups something in exchange for their support. For example, the Prudential Center project funded some affordable housing in the adjacent neighborhood to satisfy some interest groups.

In some cases, intelligent solutions to problems require cities to strike alliances beyond their municipal jurisdictions. One project to reduce traffic congestion in and out of Dallas was funded by the US Department of Transportation. Here, the University of Dallas and Schneider Electric conducted studies on signal timing and analyzed tolling and traffic flows, said IDC's Clarke. "They included a large metro region and coordinated their efforts, so they all looked at similar information." Each town in that region coordinated with another and

tracked arterial traffic to see if and where they needed to redirect traffic, she explained.

Disseminating sufficient information about the projected improvements in cities is critical, but cities tend to overlook this aspect. For example, with transportation projects, planners often focus on traffic management, but forget that people could make other choices if they have travel-related information, especially for multimodal transport options, where a commuter might take a train before hopping on a bus and then walk to the office.

Securing buy-in across political parties is also important, especially when mayors or administrations change midway through a project's implementation. Some policymakers are smart to see the value of long-term gains.

India's massive project to use biometric information to assign unique identification numbers to its citizens, called Aadhaar, is an example of that long-term visioning, said Cisco's Menon. The project was initiated by the previous Congress-led government that fought bitterly with the current Bharatiya Janata Party-led regime. However, the current government has embraced Aadhaar and even expanded its reach and applications.

Finally, key to securing community support is a commitment to protecting the data of your citizens. While 24/7 video monitoring might deter crime, some residents could decry their loss of privacy as well. Smart meters reveal people's energy-consumption habits, while using a government website leaves trails of data that can be gleaned and stored.

That is why government officials should take early steps to determine what privacy rules should be set for their smart city. If rules are not determined beforehand and clearly communicated to the public, cities could find unnecessarily strong opposition to their plans.

## **Why Some Smart City Experiments Fail**

As cities attempt to revitalize, efforts must fall in line with market needs. Implementing grandiose plans that do not heed practical realities will

not work. According to Peter Linneman, Wharton professor emeritus of real estate, regional and city planning have largely been failures, as they “plan” rather than “listen and follow the market demand.”

The political structure of city governments could also hamper smart solutions to urban problems. Linneman noted that in the United States, “many people fled the inefficient and nonresponsive central city governments, which for the most part have been captured by single-party politics.” As those cities struggled with their problems, suburban areas became more livable and attracted city residents looking for a better quality of life. “For example, suburban public schools may not be great, but they are better and cost less per pupil than the central city.”

Linneman cited Philadelphia’s failed experiment to provide public connectivity as a case study of government bungling. “Philadelphia’s attempt at public Wi-Fi is a notable and expensive example.” In 2004, the city launched “Wireless Philadelphia,” a program that took two years to take off with a discounted plan and lasted just another two years. The problems it faced included resistance from existing Internet service providers that did not participate in bids to offer service. Earthlink, the provider that eventually signed up with the city, faced technical issues that caused its service to be choppy, resulting in just 6,000 subscribers. “Cities are not innovators. Looking for them to lead in technological services is a recipe for fraud, waste, and abuse,” says Linneman.

In 2009, Philadelphia’s Wi-Fi project would be revived with funding under the US economic stimulus program in a venture called KEYSLOT, which is a collaboration among the city government and various community groups. The project has 79 locations across the city called KEYSLOTS, where residents get free computer use, Internet access, and training.

The bottom line, according to Sokwoo Rhee, associate director of the Cyber-Physical Systems Program at the National Institute of Standards and Technology, is that the municipality and companies



## Building Community Support and Avoiding Pitfalls

setting up smart-city solutions must work closely with the community to ensure they are solving real problems for people if they want buy-in from all quarters.

“The important thing is to have an end user and a company communicating, and include government from the beginning of the product design and deployment process,” Rhee said in a recent Knowledge@Wharton article. “That way, whatever effort they put in is not wasted.”

## CHAPTER 5

# FINDING FINANCING FOR SMART CITIES

**I**ntelligent-city projects may improve one's quality of life, but they first need to be funded. Where can cities find the money for it? To be sure, they can expand existing sources of revenue, such as raising property taxes and other tariffs like parking fees, tolls, traffic fines, and others—all of which are typically unpopular.

Intelligent-city projects could also free up capital through cost efficiencies, according to the Smart Cities Council. Innovations such as e-procurement can help cities reduce costs, generating funds to further invest in innovation. As such, some of the projects require little or no upfront capital from the city. Instead, the city “rents” its solution as it goes. Other financing solutions include performance contracts and shared revenue models between the city and vendors.

Another idea is for cities to let private enterprises handle projects that they cannot immediately do themselves. For example, an infrastructure asset management company could lease the parking meters from the city for many years, upgrade them and collect parking fees to recoup its investment. But such projects can have pitfalls: In 2009, Chicago leased its 36,000 parking meters to a private company for 75 years in exchange for \$1.2 billion. The company, a Morgan Stanley-led consortium, hiked rates and reaped a windfall that the city could have had.

Another example: Philips and Ericsson are partnering in an LED street lighting venture that benefits both companies and the cities involved. Under the plan, Philips would offer cities LED lighting for a fee, sparing cities the pressure of making capital investments. Ericsson

would use the light poles to install mobile telecom equipment and provide broadband services. “The model also accelerates the payback time for city infrastructure, by making the up-front costs of installing and managing these systems more affordable, so reducing the strain on city budgets,” according to the *Dutch Daily News*.

Municipalities can also tap multilateral institutions such as the World Bank to fund smart-city initiatives. Often, these are in the form of seed-stage capital. Private-sector funding is also available, but cities typically have to demonstrate acceptable rates of return—for example, by monetizing new services such as public Wi-Fi or using data analytics to mine information they can sell to marketers, among other ideas.

Another option is “impact investors, who want to do good and are willing to receive a somewhat reduced return” than a comparable investment, said Smart City Expo’s Hultin. They could be interested in smart-city health care or smart-city preschools. Philanthropic investors are another source, who want to see benefits for society and don’t want a return.

### **Debt Financing**

Municipal financing tools clearly are available and the council has identified 28 of them in a [guide](#). They range from government-based finance options such as general obligation bonds, revenue bonds or social impact bonds to private sector leveraging options such as debt service reserves, loan loss reserve funds, and pooled bond financing.

What’s important to remember is a city must use the right financing tool at the right time for the right project. For example, capital-intensive projects focused on renewable energy that need a large, upfront investment should use a long-term financing package because the return on investment can take many years. Also, realize that subsidies for the initial years of the project are typically needed to cover operating costs until the system becomes financially viable, the council said. Thus, a public-private partnership might make sense.

Here are the Smart Cities Council's best practices for cities when considering financing options:

- **The source.** Understanding the context of your financial backers will help you make decisions that are sensitive to their risk concerns. It will also help you in your request for financing because you will know which risks to address.
- **The parties involved.** A major project often has multiple parties involved making decisions, such as boards. As such, they can have different goals. For example, city officials want to see benefits that include nonfinancial rewards, such as enhanced quality of life, but investors want to see profits. Make sure the project meets the goals of all the parties.
- **The ease of financing.** When choosing among funding sources, know that a project's riskiness will determine how easy it will be to get financing. Another determinant in getting financing is the level of control the financing agent (local government, limited partnership, or others) has over the revenue stream used to pay off investors. Try to mitigate some of the risks to make it easier to secure funding. For example, if an investor is concerned that projected revenues for a highway toll project might fall short, the city can offer other revenues as a backup. Note that a project that has lower risks tends to get better financing terms.
- **The duration of financing.** As a general rule, short-term tools are used for projects with a duration of two to five years; medium term for six to 15 years and thereafter is long term. For example, financing a fleet of buses would need medium-term financing due to the recommended life expectancy of 12 years or 500,000 miles. This saves money in the long run because maintenance costs are 10% to 50% higher for older buses. For bigger projects such as a bridge, project duration often exceeds 50 years.
- **The risks to investors.** Projects that use newer technologies are seen as riskier because they don't have the long track record of other

investments. The challenge is to communicate the viability of the project to the finance community as well as reassure them of the fiscal health of your city. Describing, say, the amount of expected savings from a renewable energy project may not be enough to convince lenders because the projections might not appear. One solution is to borrow from multiple sources to spread out the risk. Consider combining a revenue bond with cash from the city's general fund or investment partner.

- **Repayment risks.** Some projects that are expected to pay for themselves end up not generating the necessary revenues. For example, highways are built with the idea that fees collected from tolls would pay for them. But many toll roads in the United States have not brought in the expected revenues, and raising tolls will further drive motorists away. Have a backup plan—whether to get cash from the general fund or sell the asset.

### **Savings, Jobs, and Other Rewards**

Why go through all the fuss? Several smart-city projects have demonstrated—or are projecting—handsome gains. One such project touted as a success is Barcelona's 22@Barcelona project. It aims to convert 200 acres of industrial land into a district for knowledge-based companies with public investment of 180 million euros (\$200 million) in the infrastructure. The project got off the ground in 2000, and at last count, 4,500 new companies had moved in, with half of them start-ups. Of the projected 150,000 new jobs, nearly 50,000 have been created.

Meanwhile, the city of Glasgow, Scotland, has leveraged technology for significant cost savings. The government invested £24 million (\$31 million) in a project to rein in IT and facilities management costs at its buildings, according to a 2015 Cisco case study. The solution: It used an Energy IT app to monitor IT power usage in real time. A look at usage patterns helped the city change its policies to maximize efficiencies and devices that used energy inefficiently was flagged. As

a result, IT energy use in 29 schools fell by 9% over six months, saving the city £330,000 (\$426,000) in its first year.

In France, an electric car-sharing program developed by Paris and 46 nearby cities called Syndicat Mixte Autolib has cut transportation costs for drivers by about 90% a year, according to the council. The project's goal was to reduce traffic, noise, and air pollution as well as give people more transit options. Already, it has reduced 1.5 metric tons of carbon dioxide emissions annually and replaced 25,000 private vehicles.

In New York, an urban development project expected to see robust returns is the Cornell Tech Roosevelt Island campus, dubbed "Silicon Island." It is a new applied sciences and technology campus of Cornell University being built at a cost of \$2 billion. The campus is expected to bring in more than \$23 billion in economic activity and \$1.4 billion in tax revenues over 30 years, according to a report in the *New York Daily News*. "It should be a powerful factor in advancing technology-based industry and business, on the model of Stanford University's or M.I.T.'s influence over the growth of the entire technology sector," said Barnett.

## Limits of Financing

Urban projects that provide quick returns like smart parking systems will attract investors more readily than longer-term projects like waste management programs, because revenues from the latter would take time to come in. The key element is how long it would take investors to see returns. "Time affects risk," Oxford Economics' Levine said. "If I make firm projections that a tax increase will come next year, I could bond it [versus] if those tax increases will be phased in over the next 30 years. The shorter the time element, the easier it is to finance."

And then there is the challenge of measuring the actual return on investment (ROI) of smart-city projects. IDC's Clarke cautioned that the return for smart-city projects is still developing, as many projects are still in early stages of implementations or not at scale, and typically include social and environmental outcomes, not just financial ones.

This can be a disconnect for private companies offering smart-city solutions as they typically measure success in terms of financial results and investors do not measure returns in terms of improved road safety, job creation or attracting new businesses. “That is not how the investment community invests. They want a check at the end of the day,” Clarke said.

There is also the challenge of measuring the return on investment. According to some experts, the business case for smart-city projects is still quite theoretical and immature. Investors do not measure returns in terms of improved road safety, job creation, or attracting new businesses—they want tangible, monetary returns.

The bottom line is that finding private investors for smart-city initiatives could be tricky, and cities will most likely have to pay for these programs with a combination of debt, savings from efficiencies, private investment, and government funding through higher taxes or fees.

## CHAPTER 6

# SMART SOLUTIONS FOR ENERGY SAVINGS: THE “MINI-CITY” OF THE UNIVERSITY OF PENNSYLVANIA

The University of Pennsylvania’s Philadelphia campus is a veritable mini-city. Its facilities and real estate services division maintains 185 buildings on a campus of more than 300 acres, overseen by a staff of about 900 people. The buildings consume about 70 megawatts of energy every day, and the electric bill is about \$28 million a year. To put that in perspective, one megawatt of energy is enough to power 1,000 homes.

Many of the university’s buildings trace their origins to the 1870s, when development of the Penn campus began in the open fields of West Philadelphia. College Hall, the oldest operational building, was completed in 1873, and now houses the university president’s office and an admissions office among other departments. Designing and implementing energy efficiency projects building by building on the campus is clearly a Herculean task.

Not becoming energy efficient is simply not an option for the university, because inefficiencies are costly. In 2010, for example, its electric consumption went over the 67 megawatts contracted with the local electric company, PECO. That resulted in a demand charge, or penalty, of more than \$720,000 for 35 minutes of peak-time consumption. That works out to more than \$20,000 per minute for going into the peak power consumption regime.

Penalties for excess consumption come out to between 50 and 400 times the usual charges. In a one-year bill of \$28 million, the top



five peak power days or “red days” account for at least \$1.5 million to \$2 million. What consumes a lot of energy? The university campus has chiller plants that chill water and consume about 27 megawatts at peak time. These plants pump more than four million gallons or 16-million liters of chilled water at 42 degrees Fahrenheit throughout the campus. “It is a gigantic network with miles and miles of piping pumping this chilled water through each of the buildings,” said Penn’s Mangharam.

During peak usage times, prices could go through the roof. During the summer of 2015, the price of electricity went from \$28 per megawatt-hour on average to \$810 within 15 minutes, or an increase of nearly 30 times. It was one of the hottest years ever recorded.

### **The DR-Advisor Solution**

But an energy efficiency project driven by data analytics has led to significant cost savings at Penn, in addition to increased reliability of power availability. In 2013, Mangharam thought up a unique way to help achieve energy savings on the campus, using a model that could be applied to any of its buildings. He led the formation of DR-Advisor (or demand-response, a mechanism to optimize energy usage)—a collaboration among the university’s schools of PennDesign, Penn Engineering, and Wharton. Mangharam uses data analytics, sensors, and other embedded systems.

DR-Advisor’s plan was to develop a low-cost approach to extracting energy efficiencies that would be scalable and sustainable. It would collect data from each building, energy meters and weather, and combine the information in such a way that would lead to an analytical decision for energy savings. And unlike conventional energy-conservation programs, it does not require information about the design of each building. That makes DR-Advisor easier to deploy because each campus building is unique in its design, engineering, and energy usage patterns.

DR-Advisor did consider the historical operations data of each building. It used a “machine learning” process to predict how each

building will perform over a certain time span, such as the next couple of hours or the next day. Machine learning is critical because the Penn buildings together have more than 220,000 control points that track a variety of indicators such as temperatures, flow rates, pressures, and so on. “A human being cannot cognitively reason how to change these 220,000 control points to be able to say whether the price of energy will go up in the next three hours to 100 times of what it was in the last hour,” Mangharam said.

Using data analytics, the DR-Advisor system runs 24/7 and makes recommendations on which of those 220,000 “knobs” building facilities managers must tweak to minimize energy use. At the same time, it ensures that occupants are not uncomfortable. “We maintain the temperature at between 24 and 26 degrees Centigrade (75 to 79 degrees Fahrenheit),” said Mangharam.

Overall, DR-Advisor’s model allows it to dramatically reduce the lead time before implementing changes that bring energy efficiencies, slashing power costs. In trial runs, it has demonstrated savings of \$44,000 per building. DR-Advisor is now extending that model beyond the Penn campus. It is applying the model to a new medical facilities project—supported by a grant from the National Science Foundation—and a building in Italy that uses solar water for heating.

In March 2016, DR-Advisor was the winner of Carnegie Mellon University’s Allegheny Region Cleantech University Prize, sponsored by the US Department of Energy’s Energy Efficiency and Renewable Energy office. “This data-driven demand-response recommendation system is like the Netflix of demand management,” the Energy Department said. “By marshaling historical meter and weather data as well as set-point and schedule information, DR-Advisor supplies an affordable approach for predicting a building’s power consumption and facilitating a plan for demand-side modeling, all without having to learn the complexities of the building.”

## LESSONS FOR TOMORROW'S SMART CITIES

**S**o what have we learned? Cities aiming to become “intelligent” frustrate that goal when they misunderstand the concept as being purely dependent on technology. They tend to underestimate the importance of citizen participation. Some stick to the old ways of working and fail to overhaul regulations that haven’t kept pace with the digital world. Others slip by without demonstrating clear returns on investment that would have attracted more private investors.

Cisco’s Menon and Khetrapal point to five aspects that define an intelligent city: visionary leadership, adoption of global standards for solutions that allow for scalability, redesigned regulations for the digital world, emphasis on public-private partnerships (PPPs), and a local ecosystem catering to the needs of its citizens. Open ecosystems that enable and encourage city departments to share insights and technologies are also critical.

Here are the steps you need to take to start your smart-city journey:

- **Set clear goals.** What is your main purpose for becoming a smart city? Every municipality wants to improve its finances, attract businesses, and enhance the quality of life for its residents. So choose a focus and make your vision specific and clear.
- **Develop your implementation strategy.** To make your vision a reality, start a pilot project in a part of the city to test out a strategy. Once you demonstrate gains, that will help make the case for larger investments in similar projects elsewhere in the area. Be open to learning from unconventional teachers, such as a golf course when it comes to water conservation.

- **Get public support.** Be transparent about the project's benefits and shortcomings for your citizens. Start by making your case with a small circle of those immediately impacted by the project, and then expand to a larger group. Make sure to articulate how citizens' privacy will be protected in a connected environment.
- **Find funding, articulate ROI.** In addition to tapping the usual revenue sources available to cities, such as taxes and fees, consider municipal bonds, multilateral institutions, state and central government grant monies, impact investors, and philanthropists as potential sources of funds. Identify opportunities to monetize the delivery of urban services, including advertising and data analytics, and set a realistic return on investment.
- **Plan carefully to avoid pitfalls.** Take steps to cut through the complexities of government bureaucracies, which have felled worthy smart projects. Tap good talent in technology and make sure to retain ownership of your data.
- **Leverage technology.** As a baseline, connect the city's departments to each other as well as to residents and businesses. Embed hardware, such as sensors, and software to intelligently manage the city's systems, from traffic to water and energy usage and garbage collection.

Finally, here are five key considerations as you launch your smart-city initiatives:

- **Think beyond the community.** Many intelligent-city projects that begin as neighborhood-based pilots need to expand their horizons, according to IDC's Clarke. "They have to be undertaken at scale, otherwise the solution is less effective." For example, using cameras and video analytics for public safety in one neighborhood could merely shift criminal activity to another part of town. So plan for such shifts accordingly.
- **Ensure there will be real gains.** Many cities cite job growth or real estate development projects as examples of how their smart projects

have delivered gains. But these benefits could be illusory if jobs only move from one city to another instead of creating net new positions. Moreover, people are too quick to equate real estate development with economic growth when sometimes the projects don't pan out. So, have a realistic view of the actual gains to be had.

- **Don't ignore politics, especially in big cities.** The bigger the city, the greater is the need to find smart ways of managing the pressures on infrastructure and other assets through technology. But don't forget to develop political support for your smart initiatives as well. Keep in mind that big cities could find it harder to get political consensus than smaller towns. Midsize cities tend to have fewer political headwinds, experts said, because people there know each other and tend to have closer ties.
- **Set a realistic population goal.** Smart cities tend to attract more residents. But cities should not set the goal of capturing the glories of a bygone era. "Most cities that have fallen to a fraction of their peak size no longer need to be the size they once were when market demand (such as during World War II) pushed them to their maximum size," said Wharton's Linneman. "They need to sensibly shrink, not attempt to recover their size. Their mottos should be to become 'a better and smaller place to live' and not 'a plan to recapture bygone glory.'"
- **Remember to look ahead.** As you work on your smart projects, keep an eye on where you want to go next. Do you want to better serve your senior citizens? Barcelona, for example, provides seniors with apps to stay in touch with family members and get pill alerts. Once you are done with your initial smart projects, what other initiatives might make sense? It's wise to plan ahead.

Advancements in digital technology, new business models, and prioritization of sustainability goals have given cities the tools to become an intelligent urban landscape in ways never seen before. The road ahead might seem complicated, but the rewards—both economic and in quality of life—will be worth it. So take it one step at a time, partner with the private sector when necessary, but go for it. There is no greater imperative for cities today.

## ABOUT KNOWLEDGE@WHARTON

**Knowledge@Wharton** is the online business analysis journal of the Wharton School of the University of Pennsylvania. The site, which is free, captures relevant knowledge generated at Wharton and beyond by offering articles and videos based on research, conferences, speakers, books, and interviews with faculty and other experts on current business topics. Knowledge@Wharton has grown into a network of sites that includes a global edition in English and regional editions in Spanish, Portuguese, Simplified Chinese, and Traditional Chinese, as well as a site for high school students and educators. For more information about Knowledge@Wharton, please visit [knowledge.wharton.upenn.edu](http://knowledge.wharton.upenn.edu).

## ABOUT TATA CONSULTANCY SERVICES

**Tata Consultancy Services** is an IT services, consulting and business solutions organization that delivers real results to global business, ensuring a level of certainty no other firm can match. TCS offers a consulting-led, integrated portfolio of IT and IT-enabled infrastructure, engineering and assurance services. This is delivered through its unique Global Network Delivery Model™ recognized as the benchmark of excellence in software development.

A part of the Tata Group, India's largest industrial conglomerate, TCS has a global footprint and is listed on the National Stock Exchange and Bombay Stock Exchange in India.

For more information, visit us at [www.tcs.com](http://www.tcs.com).

Follow TCS on Twitter at @TCS.

### **About TCS Digital Software & Solutions (DS&S) Group**

TCS Digital Software & Solutions (DS&S) Group is a strategic growth unit within TCS, formed to develop enterprise customer and urban analytics software. The Group helps clients deliver relevant, differentiated experiences that make their customers' lives better through a deeper understanding of customers' needs in real time across their connected customer journeys. Developed by industry and urban planning experts, our pre-integrated, modular software for retail, banking, communications and cities is built on an open source, IoT-enabled platform with application modules configured to



## About Tata Consultancy Services

address clients' specific business pain points within their industry and government domains. With TCS as a strategic partner, organizations can respond with agility and certainty in an increasingly uncertain digital world. <http://www.tcs.com/digital-software-solutions>