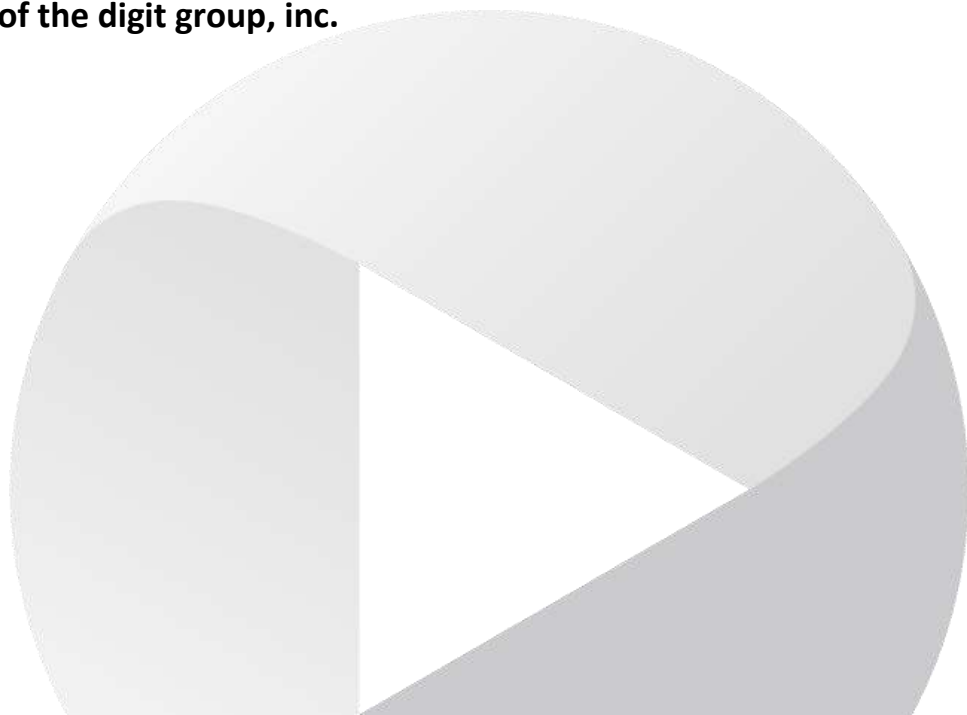


Smart Cities: A New Dynamic for the Middle East

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Executive Summary

A combination of economic growth, societal needs and human aspiration is establishing a Smart Cities culture throughout many of the urban centers of the Middle East. Dynamic Middle Eastern cities—including Dubai, Abu Dhabi, Jeddah and Doha—are creating Smart City projects and programs, setting a rapid pace of development and implementation.

Smart Cities are designed and developed to provide citizens, workers and visitors with a safe, healthy and sustainable environment in which to live and work. With strong government policies and programs that have been developed over recent years to move cities away from a dependency on hydrocarbon energy and into clean technology energies like solar and wind, the cities of the Middle East are emerging as the global benchmark for alternative energy generation, transmission and consumption. These cities are using their move toward clean technology as the foundation to a larger Smart Cities strategy.

As a key part of their energy infrastructure development, Middle Eastern cities are developing smart grids to help better manage their energy needs. Smart grids will not only improve network resilience and reliability, they will also result in better energy efficiencies and overall savings. In the context of Smart Cities, the use of smart grids enhances a city's quality of life, creating an environment for innovation. The Middle East can leverage emerging smart grid infrastructure as an opportunity to create a better educational experience, higher-level jobs, a more efficient transport system, and improved healthcare in a cleaner environment.

This white paper focuses on Smart City initiatives in the Middle Eastern market, which were highlighted during a trade mission led by U.S. Commerce Secretary Penny Pritzker to Abu Dhabi, Dubai, Riyadh and Doha in March 2014.

Although the U.A.E. has a national Smart Cities plan, Abu Dhabi and Dubai are planning and implementing two different approaches, explored here in detail, along with King Abdullah Economic City and Kingdom City, two new Smart Cities on the West Coast of Saudi Arabia, each with its own strong identity and different Smart City needs. Finally, Qatar is examined in advance of the 2022 FIFA World Cup, which has been a catalyst for Qatar's capital of Doha to emerge as a Smart City.

Four drivers are influencing governments in the Middle East to plan and implement Smart City projects and programs, not by choice, but out of necessity. First, these cities want to move their collective economies from fossil fuels to alternative energy sources. Recent protests have forced all Middle Eastern countries to reevaluate their governance, economic policies and communications with citizens, leading to fundamental changes in job creation, greater educational opportunities and the creation of more transparency in government program goals, processes and results.

Second, the populations of most Middle Eastern countries are transient, prompting a move from nation-state to city-state countries. In Qatar, where migrant workers comprise a majority of the population, the government is making accommodations for guest workers by providing housing, healthcare, transportation and education. Qatar needs these migrant workers to stay and help build massive infrastructure projects in time for the 2022 FIFA World Cup.

Third, regional security and religious conflict are always a risk in the Middle East, but through policy and action, the more secure and flourishing regions of the Middle East, such as the Gulf Cooperation Countries (GCC) of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates, are emerging as examples of stability throughout the rest of the Middle East.

Finally, the Middle East's large youth population and the education and job creation necessary to accommodate these citizens are additional concerns that have found their way into the planning discussions of Smart Cities throughout the region. The young, educated and well-connected population of the Middle East is demanding change and wants it now.

The urban population of the Middle East averages 88% of the entire population for all countries in the Middle East, and estimates show population in the region will double by 2050, with the urban population percentage rising even more. With the four drivers of influence growing at an unprecedented rate, the cities of the Middle East cannot afford to fail at their Smart City strategies, projects and programs.

United Arab Emirates

The United Arab Emirates (U.A.E.)—made up of the emirates of Abu Dhabi, 'Ajman, Al Fujayrah, Ash Shariqah, Dubai, Umm al Qaywayn and Ra's al Khaymah—has an urban population comprising 84.4% of its total population and enjoys stability in its societal, economic and political systems.

The U.A.E.'s per capita GDP is on par with those of leading Western European nations. Its high oil revenue and moderate foreign policy stance have allowed the U.A.E. to play a vital role in the affairs of the region. For more than three decades, oil and global finance drove the U.A.E.'s economy. However, in 2008-2009, the confluence of falling oil prices, collapsing real estate prices, and the international banking crisis hit the U.A.E. especially hard.

The U.A.E. has essentially avoided the unrest seen elsewhere in the Middle East. In March 2011, some leaders signed a petition calling for greater public participation in governance that was widely circulated on the Internet. In an effort to address these concerns, the government announced a multi-year, \$1.6 billion infrastructure investment plan for the poorer northern emirates.

The U.A.E. has an open economy with a high per-capita income and a sizable annual trade surplus. Successful efforts at economic diversification, a key component for Smart City development, have reduced the portion of GDP based on oil and gas output from 55% to 25%. Since the discovery of oil in the UAE more than 30 years ago, the country has undergone a profound transformation, from an impoverished region of small desert principalities to a modern state with a high standard of living. The government has increased spending on job creation and infrastructure expansion and is opening up utilities to greater private sector involvement.

The country's Free Trade Zones, offering 100% foreign ownership and zero taxes, are helping to attract foreign investors.¹ Within this framework, two of the emirates of the U.A.E., Dubai and Abu Dhabi, are not just leading in transforming into Smart Cities but are emerging as global leaders in strategy, projects and programs of Smart Cities worldwide. Incentives for foreign direct investment, regional headquarters and tax free zones are attracting foreign companies to the UAE, creating a strong foundation for a sustainable economic future while creating a market need for Dubai and Abu Dhabi to introduce smarter ways of conducting business, servicing citizens and nurturing a society that thinks of its environment in a holistic manner.

Challenges

The global financial crisis, tight international credit and deflated asset prices constricted the economy in 2009, creating a difficult environment for Smart City development. U.A.E. authorities tried to blunt the crisis by increasing spending and boosting liquidity in the banking sector, but those measures were not enough.

The crisis hit Dubai hardest, as it was heavily exposed to depressed real estate prices. Dubai lacked sufficient cash to meet its debt obligations, prompting global concern about its solvency. To avoid this crisis, the U.A.E. central bank and numerous Abu Dhabi-based banks bought the largest shares of Dubai's debt. In addition to this bailout, in December 2009, Dubai received an additional \$10 billion loan from the emirate of Abu Dhabi that has stabilized Dubai's finances and created the opportunity for Dubai to continue its growth.

Dependence on oil, a large expatriate workforce and growing inflation pressures are significant long-term challenges to Smart City development. The U.A.E.'s strategic plan for the next few years focuses on diversification and creating more opportunities for nationals through improved education and increased private sector employment.²

¹ US Central Intelligence Agency, The World Factbook <https://www.cia.gov/library/publications/the-world-factbook/geos/ae.html>

² US Central Intelligence Agency, The World Factbook <https://www.cia.gov/library/publications/the-world-factbook/geos/ae.html>

The close relationship that has emerged between Abu Dhabi and Dubai in the wake of the financial crisis has also highlighted the differences between each city. Since the bailout, Dubai has been regarded as an open city that is more tolerant of foreign customs and behaviors, allowing its tourist industry to thrive in the region. However, Abu Dhabi has been seen as having more influence over social issues, and certain tightening of rules has been put into place, slowly, since 2010. Aside from this, the differences are noticeable since each city is acting as its own city-state in how it prioritizes urban issues and delivers Smart City solutions.

For Dubai, the awarding of the 2020 World Expo, is serving as a catalyst for many projects, including the new Dubai Airport and the expansion of the Port of Dubai and other programs that will further transform this former fishing and trading outpost into a world-class Smart City. Meanwhile, as the capital of the U.A.E., Abu Dhabi is transforming itself as a leading global example of sustainable design, construction and operations with projects such as the \$27 billion Saadiyat Island multiuse sustainable development and the \$18 billion Masdar City development, positioned to be the flagship global center for renewable energy.

Dubai Silicon Oasis

As the setting for the 2020 World Expo, Dubai aims to incorporate as many Smart City solutions as possible. In late 2013, Dubai's leader Sheikh Mohammed bin Rashid Al Maktoum announced an ambitious Smart City initiative that includes more than 100 projects in transportation, communications, infrastructure, electricity, economic services and urban planning. Some of these projects include a physical address system, an expansion of their urban rail system, a new airport and the development of Smart City real estate projects like Dubai Silicon Oasis. The strength of this program will help position Dubai to advance Smart City development. The emirate has also recently made a strong push in terms of citizen engagement by providing key services and smartphone apps. It is also building its partnership ecosystem by working closely with service providers, technology vendors, and Information and Communications Technology (ICT) leaders, such as SAP, Schneider Electric and Advanced Micro Devices (AMD), within the U.A.E. and abroad.

Dubai aims to incorporate "smart" initiatives into six key pillars: the economy, the lifestyle of its population, transportation, governance, the environment and future generations (in terms of communication, integration and cooperation). The goal is to transform Dubai into the smartest city in the world between 2014-2017.

The Dubai Silicon Oasis Authority (DSOA), established in 2004, is one pilot project of the Smart City Dubai initiative. The DSOA is owned by the government of Dubai and the only technology park in the region that provides an integrated living and working community. Silicon Oasis is a free zone authority that provides a full package of incentives and benefits to companies operating within the free zone.

DSOA opened the \$299 million Silicon Park, its first integrated Smart City project, in April 2014. The project comprises over 1 million square feet of office space, 270,000 square feet of retail space and approximately 215,000 square feet of residential space along with a 115-room hotel. The Smart City development will also include lifestyle amenities such as running tracks, cycling trails, prayer rooms and underground parking for 2,500 cars.

Electric-powered vehicles and smart rechargeable bikes will be the primary means of transportation throughout Silicon Park, with charging stations widely available. Smart light poles are being equipped with digital signage that can be remotely controlled with apps, along with free Wi-Fi and charging stations for personal devices. Another example is the implementation of advanced technologies to control water consumption through recycling procedures in the home and at the office. These developments at Silicon Park are raising the bar on what it means to shape an intelligent environment that provides maximum comfort and well-being for its visitors, workers and residents. The goal of Silicon Park is to provide the best Smart City solutions and systems so it becomes the model for future Smart Cities throughout the Middle East North Africa (MENA) region and a benchmark worldwide.

Abu Dhabi

Abu Dhabi is the capital of the U.A.E. and uses this leadership role to lead by example in areas such as economic development, job creation, security, safety, sustainability and Smart City solutions. Abu Dhabi has a growth framework called “Abu Dhabi 2030” that has its roots in *estidama*, which is Arabic and means sustainability with a focus on energy and water efficiency. The Abu Dhabi municipality also understands the role it must play in improving energy efficiency and reducing carbon emissions while moving away from fossil fuels toward clean energy and a more diversified economy. Abu Dhabi 2030 is a coordinated citywide effort to address these issues in combination with focused Smart City strategies. The Abu Dhabi municipality has allocated \$4 billion to be used for Abu Dhabi 2030 with initial projects focused on technology that will make it easier to live, visit, navigate and do business in Abu Dhabi.

One major project that is being coordinated with the Department of Municipal Affairs is the modernization of its streets, in terms of addresses and signage. Abu Dhabi, along with most major Middle Eastern cities, does not have a system for street addresses in line with international best practices. To deliver mail, food, appliances or furniture, a resident must give the delivery person directions using landmarks. This often leads to errors and wasted time, money and resources. The safety and well-being of residents are increasingly at risk since emergency services also rely on landmarks to navigate around Abu Dhabi.

A Smart City initiative, currently being implemented, will digitally map addresses, rename (and geo-name) streets, and tie the system to a digital signage program. This municipal project, called *Onwani* (Arabic for “my address”), will provide tremendous value to Abu Dhabi by improving both emergency response times and utility services by accurately identifying defective water pipes and electric outages; it will also monitor neighborhood consumption. This can also boost the economy by increasing the likelihood of online shopping. The emergence of smarter solutions for delivery, distribution and navigation for residents and visitors is also expected to spur more tourism.

Saudi Arabia

Since King Abdullah of Saudi Arabia ascended to the throne in 2005, he has worked to incrementally modernize the Kingdom of Saudi Arabia (KSA). This modernization has involved a series of social and economic initiatives that expand employment and social opportunities for women, attract foreign investment and increase the role of the private sector in the economy.

In early 2011, in response to unrest, King Abdullah announced a series of benefits to Saudi citizens, including funds to build affordable housing, salary increases for government workers and unemployment entitlements—the foundation of Saudi Arabia’s Smart City programs.

The country remains a leading producer of oil and natural gas and holds about 17% of the world’s proven oil reserves. The government continues to promote foreign investment and pursue economic reform and diversification, particularly since Saudi Arabia’s joined to the World Trade Organization (WTO) in 2005.

Saudi Arabia’s urban population is approximately 83% of its total population, making its transformation into a Smart City a critical domestic challenge for future growth and social stability. Saudi Arabia has an oil-based economy with strong government controls over major economic activities. It possesses about 16% of the world’s proven petroleum reserves, ranks as the largest exporter of petroleum, and plays a leading role in Organization of the Petroleum Exporting Countries.

The petroleum sector accounts for roughly 80% of the country’s budget revenues, 45% of GDP, and 90% of export earnings. Saudi Arabia is encouraging growth of the private sector in order to diversify its economy and to employ more Saudi nationals. Diversification efforts are focusing on power generation, telecommunications, natural gas exploration, and petrochemical sectors.

Over 6 million foreign workers play an important role in the Saudi economy, particularly in the oil and service sectors, while Riyadh is struggling to reduce unemployment among its own nationals. Saudi officials are particularly focused on employing its large youth population, which generally lacks the

education and technical skills the private sector needs. Riyadh has substantially boosted spending on job training and education, most recently with the opening of the King Abdullah University of Science and Technology - Saudi Arabia's first co-educational university. As part of its effort to attract foreign investment, Saudi Arabia acceded to the WTO in 2005. The government has started establishing six economic cities in different regions of the country to promote foreign investment and plans to spend \$373 billion between 2010 and 2014 on social development and infrastructure projects to advance Saudi Arabia's economic development.³

Challenges

A burgeoning population, water aquifer depletion, and an economy largely dependent on petroleum output and petroleum prices are ongoing challenges in Saudi Arabia. Another challenge is the protests and demonstrations that began in the MENA region in 2011. The driver for many of these protests is poor economic conditions for young males living in MENA. This has prompted King Abdullah to make changes to head off any unrest. Saudi Arabia has more than 13 million citizens, half of whom are under 20 years old. King Abdullah has set goals to create more than a million new jobs and 4 million homes within the next 15 years. He has a vision to develop an economy less dependent on oil and run by a new class of professionals, including architects, doctors, engineers and businessmen who can thrive in a global marketplace.

Two new Smart Cities under construction—Kingdom City/Kingdom Tower and King Abdullah Economic City (KAEC) — are in the area surrounding the port city of Jeddah on the Red Sea, a relatively stable area of Saudi Arabia near the Holy Cities of Mecca and Medina. The success of these projects will be the framework for future cities throughout the region.

Kingdom City and Kingdom Tower

In the northern area of Jeddah, near the existing King Abdulaziz International Airport, construction of the iconic Kingdom Tower is now underway. When completed, it will surpass the Burj Khalifa in Dubai, which is currently the tallest building in the world, at 827 meters (2,716 feet). The estimated \$1.23 billion tower will be the tallest building in the world when completed in 2017. It is part of a \$20 billion development by Kingdom Holding Company, a firm owned by Prince Al-Waleed bin Talal. The tower will have 200 floors and require about 5.7 million square feet of concrete and 80,000 tons of steel. It will host mixed-use commercial, residential and resort facilities, including offices, residential units, a school, hotels and retail facilities. A bridge under construction across Obhur Creek links the site to the city center and airport. Both Kingdom City and Kingdom Tower can be viewed as two cities in one location; one is vertical, and the other is horizontal, but both are designed to be Smart Cities. The tower will be one of the first to be built as a vertical city, incorporating Smart City fundamentals into a Smart Building entity.

³ US Central Intelligence Agency, The World Factbook <https://www.cia.gov/library/publications/the-world-factbook/geos/sa.html>

Smart City fundamentals that will be employed in development of Kingdom City and Kingdom Tower include:

- Maintaining/Enhancing Quality of Life
- Information and Communications Technology (ICT) Management
- Safety/Security
- Resource Management (Natural and Man-Made)
- Energy Management
- Waste Management
- Air Quality
- Education
- Healthcare
- Economic Sustainability
- Internet of Things Management (People, Places & Things)

Within each of these Smart City categories, the Kingdom Tower is exploring the opportunity to integrate Smart City solutions as part of the construction of the building. Regarding ICT management, Kingdom Tower has critical decisions to make concerning connectivity. Traditional structured cabling is one option for a vertical asset like a skyscraper, but there are new types of ICT that move beyond traditional horizontal solutions (Wi-Fi, iBeacons and Personal Networks). Among them are Apple's operating system that iPhones and iPads employ; these choices are less expensive, more flexible and allow for multi-use.

How can ICT be used in the tower as a vertical solution? Communications, data, life safety, security, ecommerce, social media and a multitude of Kingdom Tower apps will all run on the tower's backbone, making the tower not just a city in the sky but a building that serves as a computer. Designed as a Vertical City, the Kingdom Tower will be used as holistic lifestyle environment, meaning that some people will not leave the building for days at a time, as they will work, live and play inside the Kingdom Tower. Taking this into account, the building needs to be more than a shelter or a machine; the building needs to become intelligent.

In the same way Siri has become a talking and responsive personal assistant for smartphones like the Apple iPhone, designers of the tower are exploring how the building can become a companion to its inhabitants. Tools like Siri are based on Pattern Recognition and Machine Learning (PRML), which has been in the market for many years, but now that the Internet of Things (IoT) has emerged, the value of PRML has become clear.

Universal Robotics, based in Nashville, Tenn., has developed software called Neocortex -- a form of artificial intelligence (AI) software that is independent of specific hardware and discovers patterns in chaotic environments relevant to an assigned task. It then analyzes those patterns to understand complexity and improve processes.

Neocortex can allow facility managers to measure optimization of space usage based on multi-dimensional variables; it can sense the number of people in a specific space and learn their movements during the day, optimize and anticipate their needs. It can know you need a conference room at 2 p.m. and automatically reserve the proper conference room, then inform you that this task has been completed.

Neocortex has the ability to anticipate your behavior. It can learn your actions, role, responsibilities and resources, and then provide you with a personal assistant for many tasks, such as note-taking during meetings, making and receiving calls on your behalf, taking care of email/text/video messages, ordering lunch/coffee, and searching and delivering proper documents/data for meetings. By using Apple's iBeacon technology or Google's Nest networking equipment, Neocortex helps make Kingdom Tower Smart City-efficient.

While Kingdom Tower is a vertical Smart City, the traditional horizontal Smart City of Kingdom City is incorporating the same technologies as the Kingdom Tower with the benefit of pervasive computing. The estimated cost of Kingdom City is \$18 billion, with the majority of the money devoted to sustainable infrastructure and buildings.

For instance, Kingdom City will have:

- Buildings with the intelligence to perform preventive maintenance and repairs on themselves based on real-time measures like normal wear and tear over time, incident damage and sabotage.
- Drones that seamlessly adapt to ever-changing field conditions based on immediate feedback from materials, people and environmental conditions.
- Nanotechnology that is built into building products that allow surfaces of a bathroom to "gang up" and begin to lobby to be cleaned as a social group, not according to a set schedule, but on a needs basis, saving time and money for facility managers.

The implementation of these types of solutions is meeting a market need that until now resided in research and development silos. The unleashing of these solutions into high profile projects like the Kingdom City/Kingdom Tower urban system is a fascinating experience because for the first time, both vertical and horizontal cities are working as one entity, providing the environment for innovative solutions to thrive.

King Abdullah Economic City (KAEC)

The \$86 billion King Abdullah Economic City development, commonly referred to as KAEC (pronounced “cake”), is one of six special economic zone cities in Saudi Arabia designed after similar economic zone models in the People’s Republic of China. KAEC has delivered approximately 15% of its development thus far, including a working port, residences and community support projects like schools, hospitals, markets, commercial buildings and life safety. Planned as a port city, KAEC will cost approximately \$86 billion upon completion in 2020. When fully developed, KAEC will have a projected population of 2 million people, encompassing 66 square miles. Like Kingdom City, KAEC resides on the Red Sea but is 100 kilometers north of Jeddah.

The project is being built by the international arm of Dubai-based Emaar, the developer behind the world’s current tallest building—the 2,717-foot (823-meter) Burj Khalifa—and the surrounding downtown Dubai development. The international division that is building the project is called Emaar, The Economic City and partnered with the Saudi Arabian General Investment Authority (SAGIA) as the prime investor.

Phase one development of KAEC, completed in the fall of 2013, has produced a modern shipping port meant to ease the pressure of the existing, old Jeddah shipping port and streamline logistics of transporting goods from North America and Europe to and from the Middle East.

In phase two, a high-speed rail link to Dubai from KAEC is planned for construction. The development will change the dynamics of shipping and logistics throughout the region as KAEC becomes a major port and hub for sea, land and rail. Implementing “smart” transportation systems and solutions is the initial focus for KAEC’s Smart City strategy. Pilot tests of shipping container sensors are underway as a method to gather a vast amount of data from numerous sources.

From the shipping palettes and containers to the trucks and trains that distribute the shipped goods, sensors are assisting KAEC with cost savings related to security, safety, quality assurance and efficiencies of knowing where assets are at all times. This Smart City implementation with a focus on transportation also has the potential for use throughout KAEC, employing sensors to assist in data gathering that can be used and reused to assist with traffic management, public transportation schedules, congestion pricing, and driverless car systems through the implementation of smartphone apps.

App creation for KAEC is in development, using a series of online app challenges run by KAEC. Independent software developers are developing their apps and competing for use in KAEC; this will drive innovation by leveraging use of captured sensor data as a primary requirement. One initial idea suggests using sensor data of street parking spaces to develop an app that allows a person searching for a spot to quickly see what is available in a specific area, saving an enormous amount of time, energy and effort to find a parking space in KAEC.

The King Abdullah Port (KAP) has allowed KAEC to emerge as a direct foreign investment destination, helping diversify Saudi Arabia's oil-based economy. As the next phases of KAEC become operational, the city will create up to 1 million jobs, relieving some of the pressure to employ the youthful population of Saudi Arabia.

Saudi Arabia also has the need to build 190,000 new homes a year, and KAEC's next phases will address this need with a 48-square-kilometer residential district. Unlike other cities in Saudi Arabia, the design of residential areas will include more open public spaces, such as waterfront promenades, parks, recreation areas and plazas meant to be part of a cultural diversity program that will require Smart City strategies and solutions to achieve success. In addition to the port and residential district, KAEC has planned an education district, a resort district fitted with luxury villas, an industrial park to host over 2,500 manufacturers and logistics companies, and a central business district of 13.5 square kilometers.

KAEC is also exploring the creation of its own social media system for the development that will allow interaction with government agencies and officials to take suggestions, complaints and ideas. Smart City social apps are under consideration, including an online video app for hosting town hall-style events that rely on interactive communication, coordination and collaboration. Another suggested energy-consumption app will encourage people to reduce their carbon footprint by asking users questions about their everyday life and offering suggestions for improvement.

Qatar

Qatar is embracing Smart City projects and programs in order to meet the delivery of the 2022 FIFA World Cup and leave a legacy after the event has ended, but its aspirations are challenged by autocratic bureaucracy, world crises and reliance on a workforce comprised primarily of expatriates.

As of 2007, oil and natural gas revenues enabled Qatar to attain the highest per capita income in the world with the lowest unemployment, paving the way to Smart City development. Qatar has not experienced domestic unrest or violence like that seen during the Arab Spring, due in part to its immense wealth. Since the outbreak of regional unrest, however, Doha, the capital of Qatar, has prided itself on its support for many of these popular revolutions, particularly in Libya and Syria. In mid-2013, Hamad transferred power to his 33-year-old son, Tamim bin Hamad, a peaceful abdication rare in the history of Arab Gulf states. Tamim has prioritized improving the domestic welfare of Qataris, including establishing advanced healthcare and education systems and expanding the country's infrastructure in anticipation of Doha hosting the 2022 FIFA World Cup.

Qatar's urban population is 98.8% of its total population, one of the highest in the world, making Smart City initiatives essential. Throughout the financial crisis of 2008-2013, Qatari authorities sought to protect the local banking sector with direct investments in domestic banks. GDP is driven largely by changes in oil

prices and by investment in the energy sector. Economic policy is focused on developing Qatar's non-associated natural gas reserves and increasing private and foreign investment in non-energy sectors, but oil and gas still account for more than 50% of GDP, roughly 85% of export earnings, and 50% of government revenues.

Proven oil reserves in excess of 25 billion barrels should enable continued output at current levels for about 57 years. Qatar's proven reserves of natural gas exceed 25 trillion cubic meters, about 13% of the world's total, and the reserves are the third largest in the world. Qatar's successful 2022 FIFA World Cup bid is accelerating large-scale infrastructure projects, such as Qatar's metro system, a light rail system, the construction of a new port, roads, stadiums and related sporting infrastructure. The new Hamad International Airport is expected to open in mid-2014 with an annual passenger capacity of 24 million on initial opening and 50 million when complete⁴.

Challenges

Qatar understands its immediate and long-term challenges. In its "Qatar National Vision 2030" plan, Qatar identified five main areas of concern:

1. Modernization and preservation of traditions
2. The needs of this generation and future generations
3. Managed growth and uncontrolled expansion
4. The size and the quality of the expatriate labor force and the selected path of development
5. Economic growth, social development and environmental management

Weaving through these issues are three priority challenges that the Qatar Foundation is addressing:

1. Renewable energy: raising the production of solar energy to one gigawatt by 2020
2. Fresh water: promoting scientific research in the area of water desalination
3. Cyber security: strengthening information security management

In addition, the FIFA World Cup in 2022 will require social and legal reforms in Qatar, most notably around workers' rights and the construction of the soccer stadiums for the tournament and new Smart Cities where its large expatriate population will live, work and play. The biggest challenge with hosting the FIFA World Cup is how to achieve a balance in developing enough infrastructure to host the event but not so much that it becomes unsustainable after the event.

⁴ US Central Intelligence Agency, The World Factbook <https://www.cia.gov/library/publications/the-world-factbook/geos/qa.html>

With nine stadiums, tens of thousands of new hotel rooms and thousands of new restaurants are planned for Qatar, a country of 1.8 million people (280,000 citizens and the rest foreign nationals); the concept of sustainable infrastructure is a critical discipline to adopt and follow. Qatar is expecting approximately 500,000 visitors to attend the FIFA World Cup. A major challenge is determining what to do with the surplus of infrastructure once they leave. The Supreme Committee for Delivery and Legacy, the Qatar government authority in charge of the FIFA World Cup, is working on the following key areas based on sustainable infrastructure best practices:

- Tourism: Create a long-term appeal for tourists by creating the Qatar experience using online and in-person continuous marketing after the world sees a successful FIFA World Cup.
- Dual-use construction: Identify community needs and develop creative adaptive reuse of surplus facilities.
- Temporary and moveable facilities: Design and build removable facilities. The Supreme Committee has already booked ocean liners for the period of the FIFA World Cup for use as hotels to accommodate the visitors, limiting the amount of hotel construction needed. Another plan is to float some of the stadiums to poor countries in areas like Africa after the event has concluded.

Doha – Host City of the FIFA World Cup 2022

With the rare opportunity to reinvent itself by hosting the FIFA World Cup, Doha, the capital of Qatar, is embracing Smart City strategies and projects to meet the objectives of hosting the event and having a sustainable future after the event. Since the majority of the population lives in Doha (population: 1 million), it is a priority to improve the lives of its inhabitants and drive the economy beyond its wealth-producing Liquid Natural Gas (LNG) industry. Known for its high-quality institutional framework, stable macroeconomic conditions and efficient goods market, Qatar wishes to also achieve sustainable development that safeguards natural resources, including delivering a carbon-neutral FIFA World Cup. There are over \$120 billion worth of projects that lead up to the World Cup, with exponential growth in ICT, product innovation, smart grids for water and electricity, all having Smart City connections for Doha.

Education City, a new district on the outskirts of Doha, is projected to have a population of 66,000. It will have research labs, educational facilities, student housing, offices, athletic facilities and physical plant utilities, such as district cooling plants (DCP). In order to follow Smart City strategies, an optimization plan was adopted to utilize eight planned DCPs to connect into a ring network and provide cooling to connected customers. Under a traditional plan, DCPs would connect only to different primary substations. This subtle design shift of employing a ring network ensures that each customer is capable of receiving energy from one of two district cooling plants.

The DCP network is then managed by an Intelligent Operations Center (IOC) that monitors the DCP sensors indicating which customers are being served by which DCP. The IOC can also communicate what final energy sources are carrying the significant load based on real-time DCP loadings. The IOC also allows the physical plant manager to make informed decisions on which connected buildings can be served from which DCP to relieve energy usage on the primary substations during times of coincidental peak load. The IOC can also analyze the captured data and communicate results to a Smart City Green Energy Dashboard app, so a customer can see how they use energy throughout the day and potentially change their behavior.

This Smart City initiative will also avoid the need to build additional expensive energy substations as Education City grows. Under the plan, the physical plant manager will be able to move DCP loadings from one energy substation to another during peak times where energy usage in a particular area is impacting the operation of that energy substation, saving vast amounts of resources.

Lusail City

Lusail is a \$5.5 billion ambitious waterfront city development currently under construction. Located about 15 kilometers north of Doha, on the Qatari coast, it is 35 square kilometers (377 million square feet) in size and will have an approximate population of 260,000 when completed in 2019. Innovation is the key at Lusail for construction of marinas, island resorts, residential and commercial districts, luxury shopping, leisure facilities and an entertainment district. Lusail is also home to the new 90,000-seat Lusail Iconic Stadium, which will host the 2022 FIFA World Cup opening ceremonies and the finals. As the largest development in Qatar, Lusail is under development by the state-owned enterprise Qatari Diar Real Estate Investment Company. The investment firm is developing Lusail with the Smart City principle of a three-layer system:

1. Network Layer: OCT infrastructure that connects people, places and things. Also referred to as the Internet of Things (IoT).
2. Control Layer: Using an Intelligent Operations Center, a city can manage and maintain service delivery.
3. Service Layer: Human and machine interactions are conducted using Smart City apps to deliver services to residents and visitors.

Lusail has built-in environmentally responsive protection policies and a controlled development strategy that is meant to transform an existing raw tidal basin into a Smart City with sustainable features (such as building design) that use the building's mass and shade to reduce heat and the need for cooling mechanisms.

Conclusion

The world's population continues to grow, especially in the Middle East, and more and more people are relocating to urban areas, straining the infrastructure of the world's major cities. It is therefore vital that technology is utilized to create effective, innovative ways of making urban cities "smarter" to improve standards of living.

These Smart City innovations can only transpire with adequate investment. As more people migrate to cities, increased financial investment in Smart City technologies and initiatives is needed to ensure completion of these projects. This capital can come from a multitude of sources, whether the private or public sector, research grants, or sponsorships.

Urban populations in these Middle Eastern cities will only continue to grow, due to the encouraging factors of employment, a better lifestyle and social support. Citizens, visitors and migrant-worker guests need an urban experience that is safe, secure and improves the quality of life. The municipal governments of the Middle East are using the stimulus of hosting world events like the World Expo and the FIFA World Cup as delivery milestones that create legacy opportunities when implemented in a Smart Cities framework.

To create Smart Cities, it is necessary that city planners and governments have the vision to drive change, and a strong overarching vision is ultimately required. Technology can help create ways of making cities work better, and collaboration across the public and private sector can bring endless possibilities.

In order to assure this transformation, the cities of the Middle East will need to provide:

- More local digital knowledge content.
- Lower prices for connectivity.
- Business-to-business market structure, competition and governance.
- Higher mobile and fixed broadband penetration.

The Middle East is leading by example by aggressively implementing Smart City solutions in both its new and existing cities. A Smart City strategy of developing a Smart Grid using CleanTech energy sources is a fundamental first step in the Middle East. This sustainable foundation is creating the opportunity for urban environments throughout the Middle East to improve the lifestyle for its citizens, workers and visitors. The world has definitive benchmarks for Smart Grid planning and management in addition to learning from the best practices of the design, construction and sustainable maintenance of the world's tallest vertical cities.

There is much to learn from the Middle East as its biggest cities create leading sustainable environments. Given a growing demand for efficiency and resources, these cities must increase reliance on innovative measures and new technologies to meet the needs of a large and growing urban population. The Smart City initiatives discussed in this paper will help these countries manage their resources more efficiently, improve the quality of the services provided to citizens, facilitate new approaches to driving efficiencies, promote innovation and improve transparency by providing information in real time. Perhaps most importantly, the initiatives will cut energy use and generate income – making the cities leading global competitors and role models for other smart city developments around the world.

About the Author

Paul Doherty, AIA, is the president and CEO of the digit group, inc., (www.thedigitgroupinc.com) a market leading Cloud software incubator for Smart City products and co-founder of the critically acclaimed AEC Hackathon (www.aehackathon.com). He is an author, educator, analyst and advisor to Fortune 500 organizations, global government agencies, prominent institutions and architectural, engineering and contracting firms. As a frequent guest writer for numerous publications, Doherty has authored or edited nine books. Widely quoted in the media, Paul is a licensed architect who brings a global perspective to industry issues and is a highly rated speaker at numerous industry events around the world each year.