OaV GERMAN ASIA-PACIFIC
BUSINESS ASSOCIATION

China's Urban Future

Opportunities through smart cities

This report has been prepared by Siemens, Volkswagen Group China and OAV - German Asia-Pacific Business Association

Spring 2019

SIEMENS
Ingenuity for life

VOLKSWAGEN
GROUP CHINA

OAV GERMAN ASIA-PACIFIC
BUSINESS ASSOCIATION

About this report

This report has been prepared by Siemens, Volkswagen Group China and OAV. It sets out the context for smart cities in China, making the case that they are vital to achieving sustainable development. It explores some of the challenges cities are facing and shows how smart technology could help. Many OAV companies see this report as the start of a journey to engage and contribute to creating China's smart society and it showcases some of the capabilities of OAV members in driving forward China's smart city agenda.

Siemens

Siemens is a global technology powerhouse that has stood for engineering excellence, innovation, quality, reliability and internationality for more than 170 years. The company is active around the globe, focusing on the areas of electrification, automation and digitalization. One of the largest producers of energy-efficient, resource-saving technologies, Siemens is a leading supplier of efficient power generation and power transmission solutions and a pioneer in infrastructure solutions as well as automation, drive and software solutions for industry. With its publicly listed subsidiary Siemens Healthineers AG, the company is also a leading provider of medical imaging equipment – such as computed tomography and magnetic resonance imaging systems – and a leader in laboratory diagnostics as well as clinical IT. In fiscal 2018, which ended on September 30, 2018, Siemens generated revenue of €83.0 billion and net income of €6.1 billion. At the end of September 2018, the company had around 379,000 employees worldwide.

**Further information is available
at www.siemens.com**

Volkswagen Group

The Volkswagen Group is a key player in the Chinese automobile industry. At present, Volkswagen Group China employs more than 100,000 people and the workforce is to increase to 120,000 people by 2019. Annual production capacity is set to grow from about 4 million to around 5 million units per annum in 2020. Two joint ventures, SAIC VOLKSWAGEN AUTOMOTIVE COMPANY LIMITED (SAIC VOLKSWAGEN) and First Automotive Works-Volkswagen Automobile Co., Ltd. (FAW-Volkswagen), produce Volkswagen Group brand models, for the Chinese market. Engines, transmissions, chassis components and seat systems are also produced in China. A new joint venture, established by Volkswagen Group and Chinese automaker Anhui Jianghuai Automobile Group Corp., Ltd. (JAC), will develop electric vehicles for the growing NEV market. Volkswagen Group China has established plants in Shanghai, Changchun, Dalian, Chengdu, Ningbo, Changsha, Urumqi and Tianjin etc. and currently manufactures vehicles and components at 24 locations in China.

Together with our joint venture partners, Volkswagen Group China is investing into new production facilities and local product development. Until 2025, around 10 billion EUR is planned for investment in industrialization of E-Mobility including digitalization, autonomous driving and mobility services.

**Further information is available at
www.volkswagenag.com**

OAV – German Asia-Pacific Business Association

Since its foundation in 1900, OAV has been working as a strong network of German companies with activities in the Asia-Pacific region. OAV is a privately held non-profit organization financed by its corporate members. They include the most renowned companies from major industries and the banking sector, trading companies and a great number of small and medium-sized enterprises from all industries located all over Germany. High-ranking representatives of German businesses are active in the OAV board. OAV Chairman is Mr. Hans-Georg Frey, Chairman of the Board of Management, Jungheinrich AG. The Smart City China Initiative was launched by the OAV Infrastructure Alliance in cooperation with the Volkswagen Group and Siemens AG, to create a platform for German SMEs to participate in urbanization projects in China. The OAV Infrastructure Alliance is a working group inside OAV, utilizing its resources, know-how and international network with the goal to improve the infrastructure in Asian countries and to support the activities of German companies in the field of infrastructure.

Further information is available at www.oav.de

The ALBA Group
The ALBA Group, one of the leading recycling and environmental services companies as well as raw material providers worldwide, operates with its two brands – ALBA and Interseroh – within Germany, Europa and Asia. In 2017 its divisions generated an annual turnover of approx. 1.8 billion Euros and employed a staff of about 7,500 employees. In 2017 alone ALBA Group saved almost 4.1 million tonnes of greenhouse gases compared to primary production and at the same time about 30.2 million tonnes of primary raw materials through its recycling activities. As a full-service provider, we cover the entire spectrum of environmental services, from consultation on waste management, to packaging licensing in markets using the German "dual system", to the provision of dependable recycling solutions, state-of-the-art sorting technologies and innovative logistics and product development, and the delivery of raw materials worldwide.

Further information is available at www.alba.com

dena
dena is Germany's center of expertise for energy efficiency, renewable energy sources and intelligent energy systems. As an 'Agency for the Applied Energy Transition' we contribute to the attainment of energy and climate policy objectives. We develop solutions and put them into practice, both nationally and internationally. In order to achieve this, we bring together partners from politics and industry across all sectors – with an enthusiasm for one of the most exciting challenges of our time. We focus our efforts on the building, power and transport consumption sectors, as well as on issues relating to energy generation, storage, networking and digitalization. We realize pilot projects, advise politicians, manufacturers and service providers, qualify multipliers, inform consumers, build networks, encourage international exchanges and develop future scenarios. To do so, dena primarily focuses on market instruments and innovative business models. And we view the energy system as a whole, because it is becoming increasingly vital to link many different parts of the world of energy to each other. dena's shareholders are the Federal Republic of Germany and KfW Group.

Further information is available at: www.dena.de/en

Deutsche Bahn Group
Deutsche Bahn Group offers global mobility and logistical services and operates in over 130 countries world-wide. More than 310,000 employees work for DB Group, of which about 40 percent are located outside Germany. We design and operate the transport networks of the future. Through the integrated operation of traffic and infrastructure as well as the economically and ecologically intelligent connection of all modes of transport, we move people and goods. During the 2017 financial year DB Group posted revenues of about € 42.7 billion and EBIT of € 2.15 billion after adjustments for special items. DB Group's strategy is the commitment and the expansion of our market position, sustainability and digitization.

Further information is available at: www.deutschebahn.com

EGS-plan international
EGS-plan is one of the most advanced engineering offices in Germany in the field of energy-efficient building and integration of renewable energy applications in buildings and urban neighbourhoods. It has branches in Stuttgart, Bangkok and Shanghai. energydesign is our Shanghai-based engineering and consulting firm for low-energy, high functionality and optimal cost solutions in the built environment. We work as designers, engineers and specialized design consultants in collaboration with professional design teams for our clients. We provide services towards low carbon solutions with high functional performance and with optimized cost on a high level of sustainability. Coming from Germany with a background of over 25 years professional experience, energydesign has provided engineering and consulting services in China and other Asian countries for more than 10 years. energydesign has pioneered advanced technologies and approaches towards sustainable design, building and development in China and throughout Asia such as DGNB certification, passive house design and integrated energy concepts.

Further information is available at: www.egs-int.com

HPP Architects
HPP Architects is one of Germany's leading architectural partnerships and for 85 years they have been producing buildings of every type and size in Germany and abroad. HPP provide a full range of architectural and master planning services. They specialize in the design of corporate headquarters, hotels, laboratories, hospitals, sport and leisure facilities, shopping centres, transport buildings, town planning, residential units and in refurbishment and listed building projects. The Düsseldorf-based partnership is now in its 4th generation since it was founded in 1933 by Professor Hentrich and today comprises 11 offices with approx. 450 employees in Germany and abroad. Among their most well-known projects are the "Dreischeibenhaus" in Düsseldorf, the German Football Museum Dortmund or the Expo Village in Shanghai. The most recently completed projects are the L'Oréal Germany Headquarter and the 25hours Hotel in Düsseldorf. HPP just won the competition of Nanshan Science & Technology Innovation Center in Shenzhen. HPP Architects' headquarter is in the Düsseldorf Media Harbor, other offices are located in Berlin, Beijing, Cologne, Frankfurt, Hamburg, Istanbul, Leipzig, Munich, Stuttgart and Shanghai.

Further information is available at: www.hpp.com

Kirow
Kirow is the world market leader for railway cranes and slag pot carriers. Our products are based on extensive experience and a high degree of innovation. As, more than 130 years of engineering design history, and the Free State of Saxony 'Innovation Award' bear witness. Our engineers uncompromisingly apply the established rules of German engineering to the further development and design of all products. The goal always remains the same: increasing efficiency and safety whilst lowering environmental impact.

Further information is available at: www.kirow.de/en

NXP Semiconductors N.V.
NXP Semiconductors N.V. (NASDAQ: NXPI) enables secure connections and infrastructure for a smarter world, advancing solutions that make lives easier, better, and safer. As the world leader in secure connectivity solutions for embedded applications, NXP is driving innovation in the secure connected vehicle, end-to-end security & privacy, and smart connected solutions markets. Built on more than 60 years of combined experience and expertise, the company has approximately 30,000 employees in more than 30 countries and posted revenue of $9.41 billion in 2018.

Further information is available at www.nxp.com

The OBERMEYER Corporate Group
The OBERMEYER Corporate Group operates throughout the world and offers qualified specialist planning and integrated overall planning with interdisciplinary know-how. Through the business fields Buildings, Transport as well as Energy and Environment it renders planning and advisory services in almost every sphere of construction engineering applying digital methods (BIM). Project management and construction supervision complement this scope of services. The company was founded in 1958. Nowadays it ranks as one of the leading independent planning consultancies in Germany with its Headquarters in Munich. The company is located in 20 cities in Germany and more than 25 countries around the world. Worldwide the corporate group has more than 1400 employees. The fast pace of development creates new challenges and responsibilities often together with a shift in priorities, especially with regards to significant ecological requirements. OBERMEYER is committed to a number of goals to address these effectively: to preserve nature, provide areas for recreation, save energy with smart and green technologies, improve air quality, set up livable and social zones within the cities and design buildings which respect the needs of the inhabitants. As Green Building standards and traffic reduction measures become more and more important globally but especially in China, OBERMEYER takes on the responsibility to apply those measures at earliest project stages.

More information: www.obermeyer-cn.com and www.opb.de

TÜV SÜD

TÜV SÜD is a trusted partner of choice for safety, security and sustainability solutions. It specializes in testing, certification, auditing and advisory services. Since 1866, the company has remained committed to its purpose of enabling progress by protecting people, the environment and assets from technology-related risks. Today, TÜV SÜD is present in over 1,000 locations worldwide with its headquarters in Munich, Germany. Through expert teams represented by more than 24,000 employees, it adds value to customers and partners by enabling market access and managing risks. TÜV SÜD's headquarter in the Greater China Region is located in Shanghai, with main offices in Beijing, Guangzhou, Xiamen, Shenzhen, Hong Kong and Taipei and further branches across the region. TÜV SÜD has more than 3,000 experts and well-trained staff in China who are dedicated to enabling our customers to obtain global market access of their new products, services and systems.

Further information is available at: www.tuvsud.com

WEINMANN Emergency

WEINMANN Emergency has been dedicated to developing life-saving medical devices specifically for the EMS profession for more than 45 years. WEINMANN Emergency sets the standard for effective and intuitive ventilation, defibrillation and suction products and has an international reputation for innovation and reliability. With many employees who also serve as paramedics, our team understands the unique needs of our customers and their patients. Our engineers place high value on designing innovative equipment that is compact and easy to use, especially in the stressful out-of-hospital environment. Originally founded in 1874, WEINMANN Emergency is a family-owned business headquartered in Hamburg, Germany, and its products are used in more than 100 countries worldwide. We have branches in St. Petersburg, Paris-Igny, Shanghai, Singapore, Madrid, Dubai and Atlanta.

Further information is available at www.weinmann-emergency.com

WILO SE

WILO SE Founded in 1872 as Kupfer- und Messingwarenfabrik in Dortmund, the Wilo of today is an international company. In accordance with its global production strategy, the Wilo Group manufactures high-quality pumps and pump systems around the world at locations in Europe, Asia and the Americas. We also have a dynamic, customer-oriented network of more than 60 production and sales companies in over 50 countries. Experience, pioneering spirit and leading technology have made us who we are today: one of the world's leading premium providers of high-efficiency pumps and pump systems for the building technology, water and industrial sectors. We are driven by a desire to answer the challenges of tomorrow today and make people's lives easier. In 2017 net sales rose to €1,424.8 million and EBIT remained largely stable at €106.3 million. An annual average of more than 7,700 people were employed in the Wilo Group around the world.

Further information is available at www.wilo.com

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'We must pursue with firmness of purpose the vision of innovative, coordinated, green and open development that is for everyone.'

Xi Jinping, President of the People's Republic of China, 19th National Congress, October 2017

Introduction

Cities are beginning to recognize the huge potential value from investing in smart technologies. Economies of scale, pressures on infrastructure and services as well as a willingness to innovate mean cities are the perfect places to take advantage of smart technologies.

The smart city opportunity

Cities are beginning to recognize the huge potential value from investing in smart technologies. Economies of scale, pressures on infrastructure and services as well as a willingness to innovate mean cities are the perfect places to take advantage of smart technologies.

Whilst many smart city definitions exist they all share common characteristics. At their core, smart cities integrate physical, digital and human systems for the purpose of delivering sustainable, prosperous and inclusive outcomes for their citizens. This is also central to China's thinking around development, which seeks to improve quality of life through more evenly distributed economic growth, innovation and urban development.

Globally the smart cities market will be more than two trillion USD by 2025 and half of Asia's smart cities will be in China, generating USD $320 billion for the China economy, Artificial Intelligence, personalized healthcare, robotics, advanced driver systems and distributed energy generation are anticipated to be the cornerstone[1].

Scaling up and connecting smart infrastructures is essential to success. Failing to deliver at scale will lead to disparity in economic growth and opportunity. It will also ultimately fail to relieve pressure on resources. Smart technology will not only benefit citizens and businesses within China's cities, but create opportunities for knowledge and technology transfer globally, as many other nations transition to sustainable practices.

City governments that create the conditions for connecting their data will gain a competitive advantage over other urban areas. The next wave of innovation in cities will see a shift from digital silos (focused on specific sectors such as energy or transport) to digital integration (where these different sectors are connected).

Purpose of this report

This report has been prepared by Siemens, Volkswagen Group China and the OAV.

China's Urban Future sets out the context for smart cities in China, making the case that they are vital to achieving sustainable development. It explores some of the challenges facing cities and shows how smart technology could help. Many OAV companies see this report as the start of a journey to engage and contribute to creating China's smart society through its cities. The report showcases some of the capabilities of OAV members in driving forward China's smart city agenda.

The report gives city decision makers a perspective on applicability of German technology and expert knowledge. In many cases it shows what these companies are already doing to help create smart cities. The report is also intended to give German enterprises some insights into the challenges for China's cities. By supplying both sides with a joint platform, it hopes to promote further collaboration and ultimately deliver real benefits to China's cities.

In summary this report focuses on three things

1. Sets out the challenges faced by China and its cities

2. Explores the national smart city policy context and five of the key smart city regional clusters

3. Explores some of the technologies, solutions and innovations that will ensure that China leads the smart city agenda and showcases the capability of OAV companies in supporting that goal.

China's Urban Future sets out the context for smart cities in China, making the case that they must be at the heart of the government's approach to development.
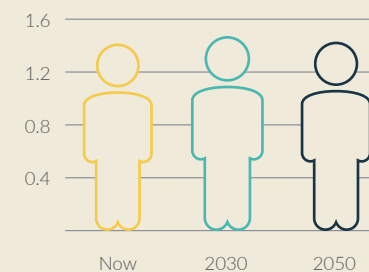
China in Numbers

As China rapidly urbanizes and the economy continues to grow, cities will be central to delivering sustainable development.
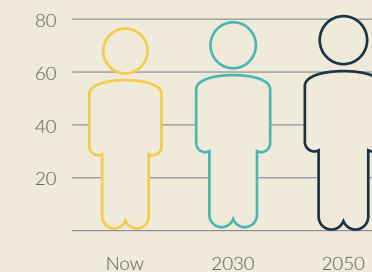
Population growth and urbanization

Population growth
(billions)

1.6		
1.2		
0.8		
0.4		
Now	2030	2050

China's population continues to grow until 2030 rising to 1.474 billion

↑1.474B

Life expectancy at birth
(years)

80		
60		
40		
20		
Now	2030	2050

People are living longer in China, by 2050 life expectancy will exceed 80 years

+80 years

Population 65+
(millions)

400		
300		
200		
100		
Now	2030	2050
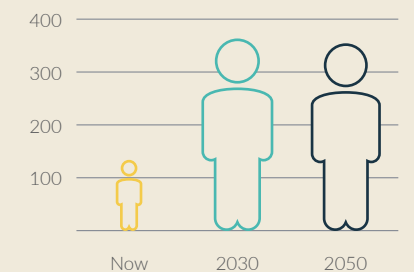
Over 65's will make up 25 percent of the population from 2030

↑25%

Urban population
(billions)

1.2		
0.9		
0.6		
0.3		
Now	2030	2050
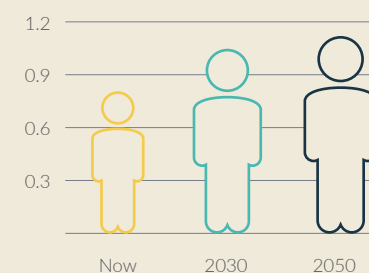
China's urban population will be one billion by 2030

↑1.046B

Cities by population
(million)

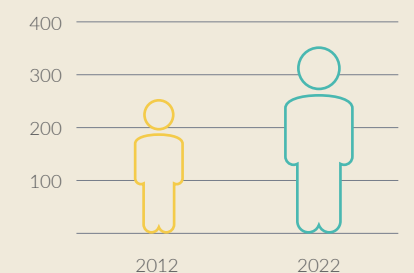|		
240	2030	
180	Now	
120		
60		
+1m	+5m	+10m
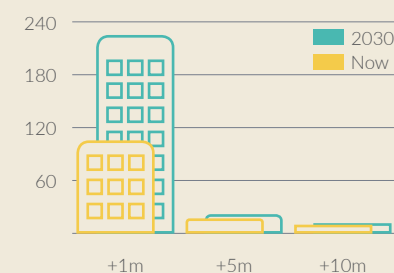
Cities of all sizes are growing. Cities with one million population will more than double by 2030

↑116%

Urban middle class
(millions)

400	
300	
200	
100	
2012	2022

The wealth and spending power of China's urban middle class is increasing

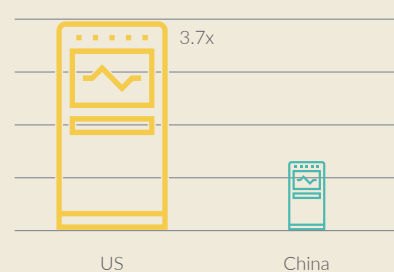**↑25.2%**

Economy and Digitalization

Economy
(GDP $ trillion)

China's economy grew by 6.8 percent last year and is the second largest globally worth 12.238 trillion

12.238T

Digitalized Industry
(level of digitalization)

3.7x

US   China

Digitalization could make the economy more productive

But labor productivity is 15-30 percent of OECD average and US industry is 3.7 times more digitalized than China's
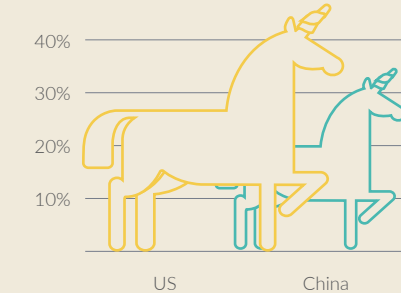
Cleaner technologies
(% share of global investment)

EVs   Wind   Solar   Nuclear   Efficiency
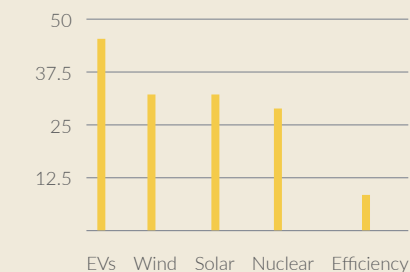
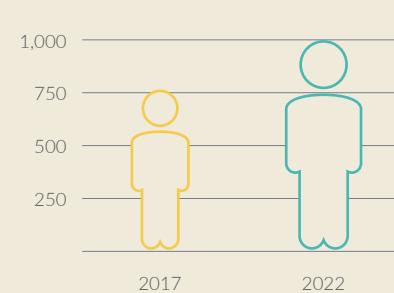China invested $44bn in green energy in 2017

$44B

Unicorns
(Global start ups valued at $1billion)

US   China

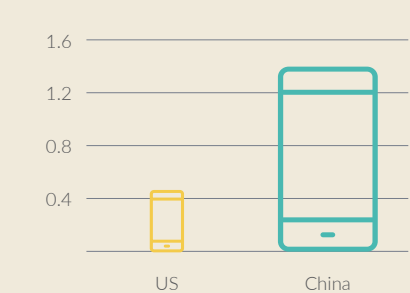China has 34 percent of the most successful global digital start ups, 100+ unicorns valued at +$1b

100+

Sharing economy
($ billion)

2017   2022

Worth $764 billion and employing 700 million. It will grow by 30 percent in 2022

↑ 30%

Smart phone use
(billion subscriptions)

US   China

There are three times the number of smart phones in China compared to the United States

1.4B

Challenges of growth

Total energy consumption
(billion tons of SCE)

2000   2017
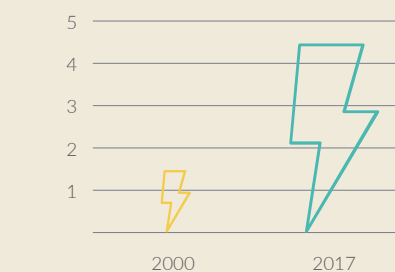
Total Energy consumption has grown from 1.485 billion to 4.49 billion tons of SCE in 2017

202%

Total water consumption
(billion m³)

2000   2017

Two thirds of China's cities suffer from water shortages

66%

Car ownership
(per 1,000 population)

Germany   China
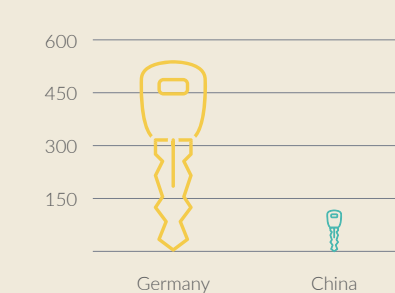
Car ownership in China is low but growing. Rising from 59 million (2010) to 181 million (2017)

↑ 181M

Electrification of mobility
(kWh - billions)

2020   2025   2030
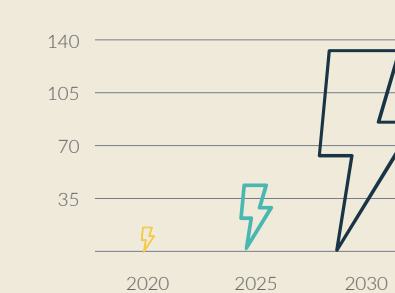
China's electrification of mobility means a huge increase in power consumption by transport

↑1,637%

Carbon footprint
(% of global greenhouse gas)

US   China

China was responsible for 27.6 percent of global greenhouse gas emissions in 2017

27.6%

China and its cities in context

Cities and smart technology will be essential to shifting the economic focus from a nation that 'makes' to one that 'creates'. This section explores some of the challenges and opportunities China and its urban areas are facing.

China's economy by sector 2000-2016
Source: National Bureau of Statistics

Legend: Tertiary Industry · Secondary Industry · Primary Industry

A new era of development

At the 19th National Congress of the Communist Party of China in 2017, President Xi Jinping outlined a new era of development which placed innovation and improving quality of life at the center. The 2018 National Plan for National Economic and Social Development shifts the economic focus from a nation that 'makes' to one that 'creates', from one with high economic growth to one with a better-quality (more efficient, fairer, and sustainable) growth.
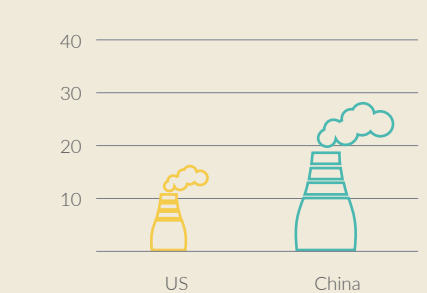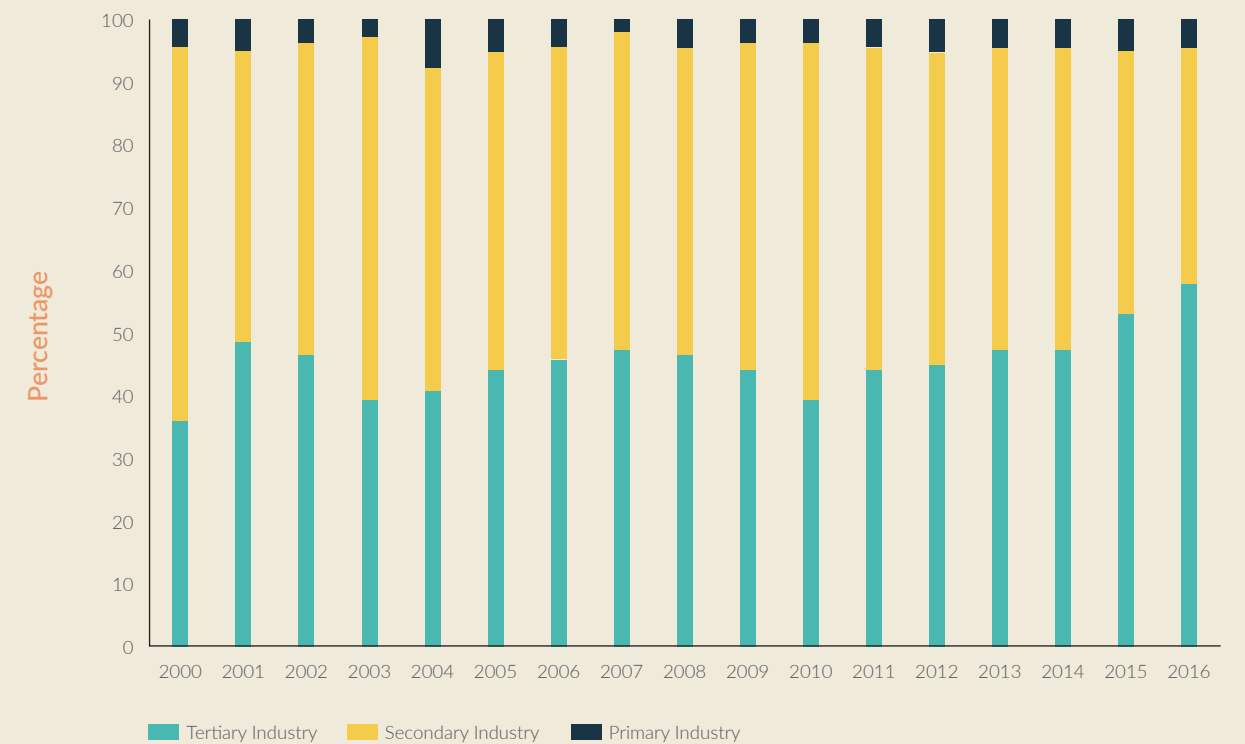
Cities and smart technology will be essential to realizing this approach. This section explores some of the challenges and opportunities China and its urban areas are facing.

China's GDP and shifting economic growth

China's economy has grown at an extraordinary pace. The world's second largest economy has grown from 1,451 billion (2000) to 12,238 billion USD (2017). GDP growth since 1998 has averaged 9.6 percent a year. However, growth has slowed to below seven percent since 2016, a trend forecast to continue. To date much of the growth has been supported by government investment, but that is changing too. By 2017 nearly 60 percent of economic growth was consumer led.

The contribution of industry sectors to China's GDP underlines this shift. Primary and secondary industries accounted for 53.3 percent of GDP in 2013 and 48.4 percent now. Tertiary industry contribution has grown from 48.4 percent to 51.6 percent.

China a rapidly urbanizing nation

Legend:
- Total Population
- Urbanization Rate (%)
- Urban Population

Y-axis left: Population (Billions) — 0.2 to 1.6
Y-axis right: Urbanization Rate (%) — 20 to 100
X-axis: Year — 1950 to 2050
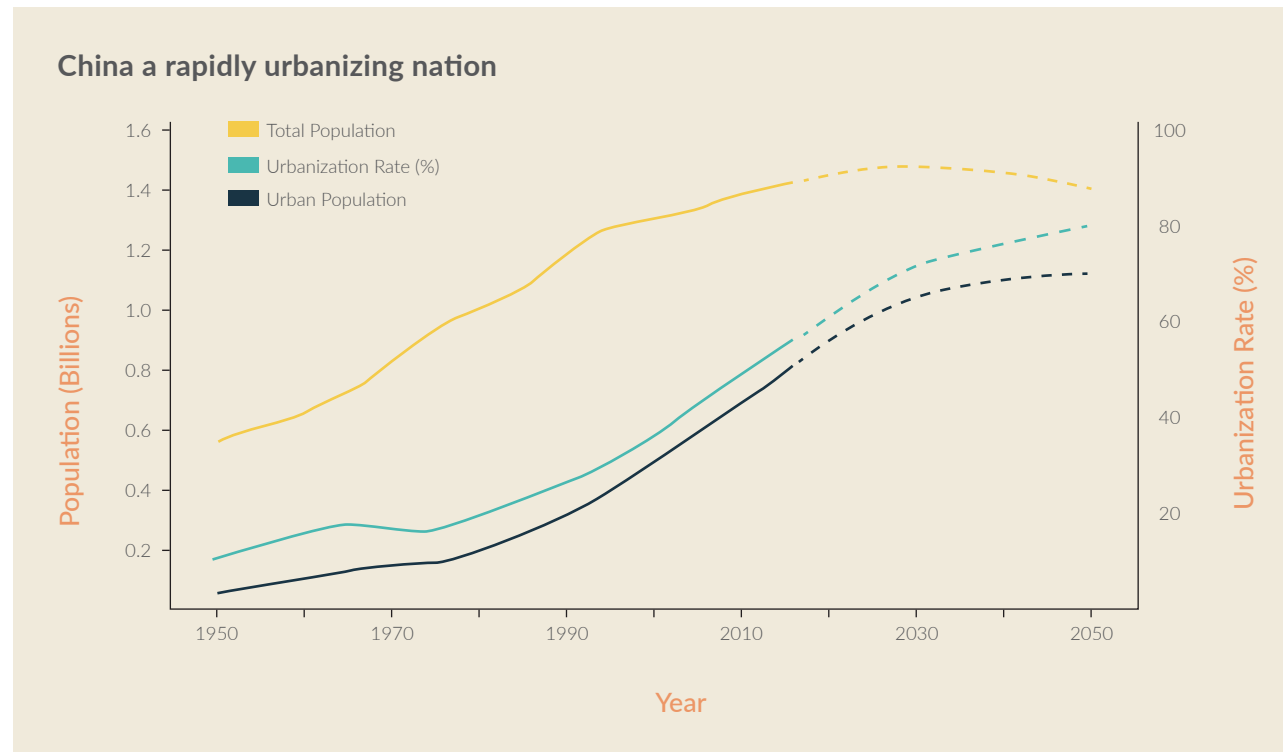
Population growth and urbanization

China had a population of 1.415 billion people in 2018 and its population has grown by 0.6 percent a year since 2000. The urban population has grown from 37 percent to 59 percent during that time. By 2030 it will be 71 percent and by 2050, 80 percent. In real terms urban population will grow from 839 million to more than one billion by 2030 – the equivalent of another 11 Shanghai sized cities.

China's urbanization is happening in an era where digitalization, electrification and automation are allowing infrastructure to do more than ever before and where our ability to mitigate the negative effects of urbanization are vastly improving. Harnessing innovation and scaling up activity across all urban areas will be important in meeting the demands of urbanization.

China's city tiers

China has over 600 cities which analysts place into tiers to contextualize them based on their governance, GDP and population size.

China is home to three of the world's twelve cities with populations greater than 20 million. It also has 56 cities with more than two million people. Urbanization is happening across all city tiers. Currently 102 Chinese cities have populations of more than one million, but that number will more than double by 2030. Cities with populations over five million are set to increase from 14 to 20.

An increasing focus is being placed on lower tier cities in order to take pressure off the largest conurbations whilst spreading the benefits of economic growth more evenly. At the same time these cities are competing to capture talent and investment against a growing internal and external city market.

City classification	GDP (USD bn)	Governance	Population (millions)
Tier 1	>30	Directly controlled by the Government	>15
Tier 2	68 - 299	Provincial and sub-provincial capital cities	>3-15
Tier 3	18 - 67	Prefecture capital cities	>0.15 - 3
Tier 4	<18	County level cities	<0.15

China's urban population is growing at increasing rates and by 2050 it will account for 80 percent of the population.

China Urban Population (% of population)

2000   2050

Cities with populations over two million
Source: UN population statistics

China
Rest of the World

2015 Population (000,000s)

Population Density per km² (Thousands)
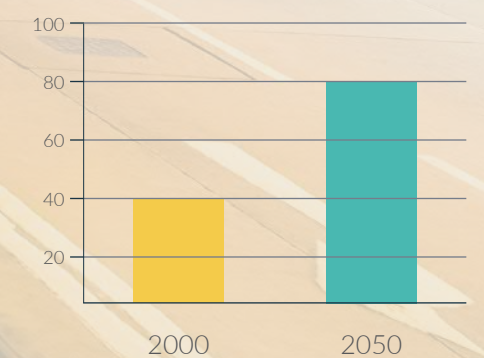
Shifting demographics

The demographics of China are changing. Life expectancy at birth was 74.7 years for females and 71.7 for males in 2005. By 2017 it increased to 77.2 and 74.2 years, whilst the fertility rate has remained at 1.6 live births per woman. As a consequence, China's population is growing older.

23.4 percent of people were under 19 years of age in 2015. By 2050, 18.7 percent will be 19 or under. At the same time over 65's have grown from 9.8 percent to 26 percent[2], an increase from 139 million to 369 million people. New services and products th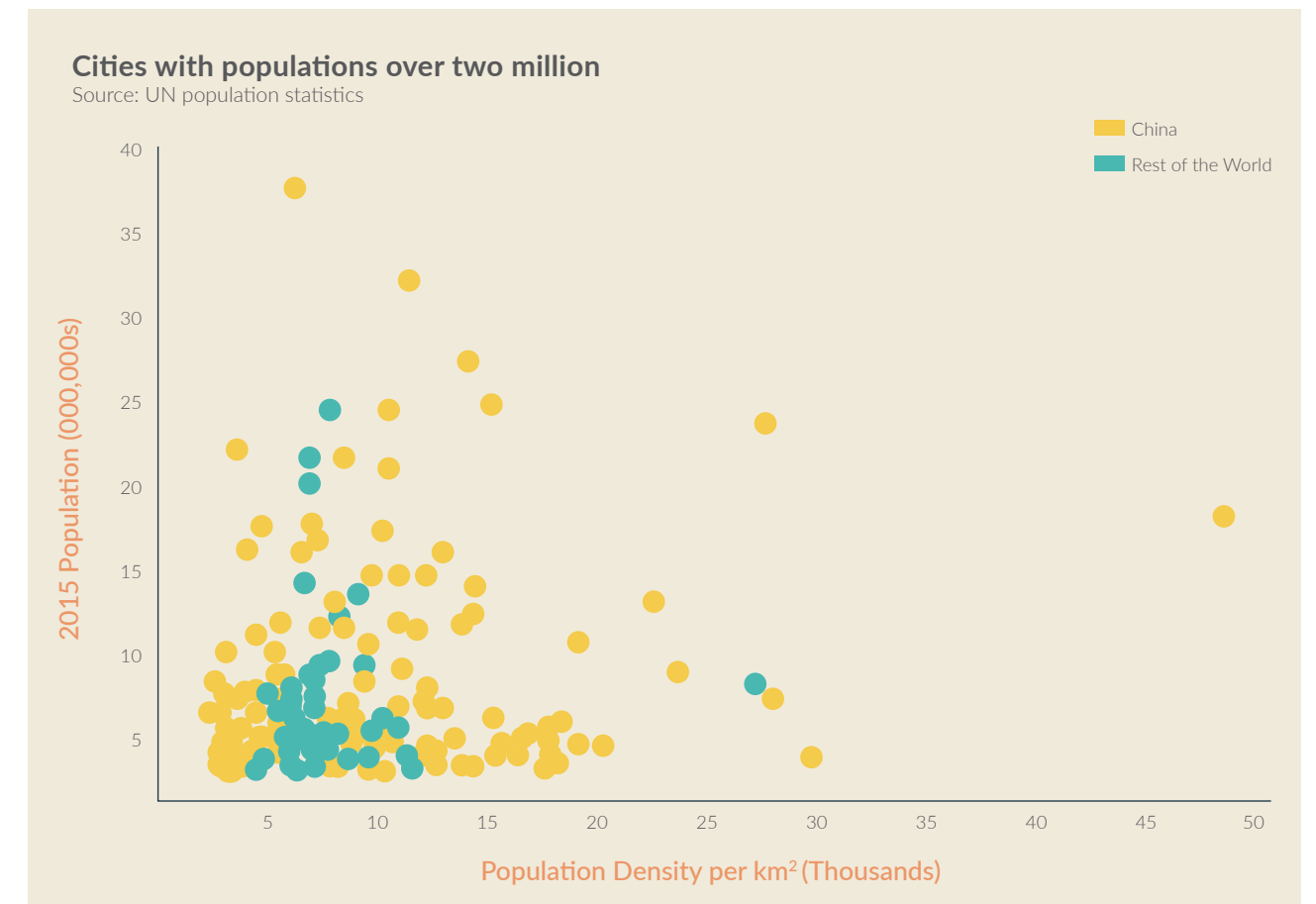at are tailored to the elderly will become an important aspect of the future economy, while automation and digitalization could support a shrinking workforce.

The spending power of the growing urban middle class

China's urban middle class is expanding from 256 million in 2012 to 357 million by 2022. Household income in cities will more than double from 10,048 billion yuan to 26,804 billion yuan[3].

The geography of the middle class will also shift towards inland China. Tier 1 cities accounted for 40 percent of the middle class in 2002. By 2022, just 16 percent will reside in tier 1 cities, whilst the share in tier 3 and 4 cities will grow from 18 to 39 percent[4]. At the same time the proportion of the middle class in inland China will grow from 13 percent to 39 percent.

As the middle class expands expectations are likely to shift. By 2022, those born after the 1980s will outstrip baby boomers three to one. Having grown up in periods of relative abundance, the spending habits of these younger generations are already markedly different. They are typically less likely to save than older generations and much more likely to buy access to services rather than own assets.

China's ageing population
Source: UN population statistics

Male
Female

2015 Population (million)

2050 (median variant) Population (million)

Since 2000 migration has flowed from inland rural areas towards coastal provinces.

China's greenhouse gas emissions
Source: Climate Action Tracker, Country Assessments 2018 - http://climateactiontracker.org

Sharing the economic benefits of growth

There is a disparity in terms of GDP across different provinces. Typically, the coastal provinces and higher-tier cities achieve a higher level of GDP per capita. Whilst that gap has reduced it is still large. According to government statistics GDP per capita in Beijing was 118,000 yuan (2016). Similar levels were achieved in Tianjin and Shanghai. At the other end of the spectrum, provinces such as Shanxi, Guizhou and Yunnan have GDP per capita below 36,000 yuan per capita. Closing this gap is a key policy driver of the National Economic and Social Development Plan.

Since 2000 migration has flowed from inland rural areas towards coastal provinces. This follows the highest economic growth and job opportunities in provinces such as Guangdong, Shanghai and Zhejiang.

However, government policy is anticipated to alter this trend. Net migration towards the coastal areas is expected to be around one third of 2000-2016 levels between now and 2030. Many first-tier cities are actively looking to cap their populations and some industries are relocating in search of cheaper land, labour cost and energy[5].

Some poorer provinces may even record some positive net migration, reflecting the relative strengthening of their economies and opportunities for migrant workers, as they develop their economies. Support from government initiatives, including the 'Rise of Central China' and 'Go West' strategies which look to develop infrastructure and alleviate poverty will also contribute.

Other initiatives such as the Belt and Road initiative offer benefits to the China interior and border provinces.

China's lower tier cities are emerging as destinations for economic migrants from rural areas. In the Guangdong province, Dongguan is seeing an increasing relocation of manufacturing from tier 1 city Shenzhen, due to costs. As large manufacturers shift, many suppliers are following suit. The new intercity railway connecting the two cities is making this easier, by reducing the travel time to less than one hour. This underscores the valuable role of investing in infrastructure to support these goals.

As the economy shifts, there will be an increasing competition between second, third and fourth tier cities to attract talent to sustain economic growth. Many local policies are aimed at making their cities more attractive to workers, from fast-tracked household registration (hukou) which gives migrants greater job opportunities and access to services, subsidies and start-up funds.

It is within this space that smart infrastructure could 'play' to make these cities even more attractive for investment and talent acquisition. By focusing on smart infrastructure, cities could spur innovation and productivity, whilst transforming public services and improving quality of life. The skills, competencies and experience of cities and their businesses leading this charge will not only give them a competitive edge with China but also globally.
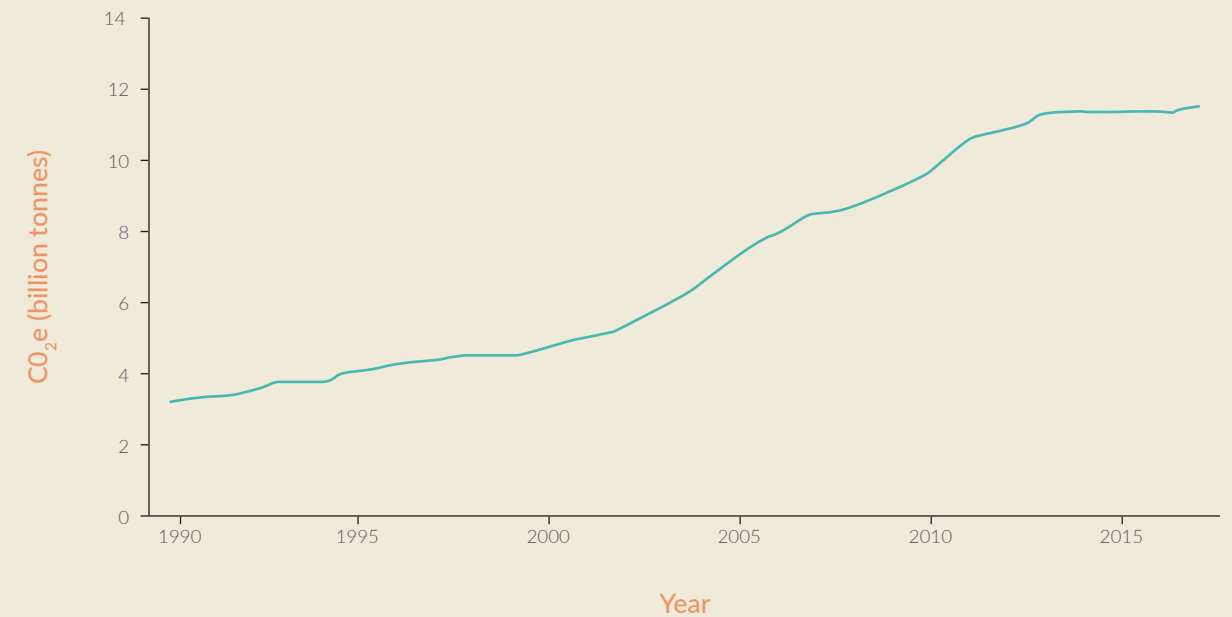
Unlocking economic growth from greenhouse gas emissions

More people living in cities and greater spending power will place even more pressure on housing, transportation, the environment and other resources. As the middle class in China continues to grow and spend more, cities must ensure that economic growth is resource efficient and minimizes the impact on both the local and global environment.

China generates just under 28 percent of global greenhouse gas (GHG) emissions. Until recently there has been some hope that emissions had peaked at around 12 Giga tonnes CO_2e. However as economic growth picked up in 2017, so did GHG emissions. In the first quarter of 2018 they grew by four percent compared with 2017. Undoubtedly China's success in driving down GHG emissions will have a huge bearing on keeping global warming within the two degrees Celsius commitment of the Paris Agreement or in going further and meeting the 1.5-degree pledge.

China's greenhouse gas emissions

China's Paris Agreement targets include emissions peaking by 2030 or earlier. It aims to reduce carbon intensity to between -60 and -65 percent of 2005 levels by 2030.

Decoupling GHG emissions from the economy must be a priority if China is to meet its competing demands of development and environment protection. Digitalization can contribute to driving greater efficiency and sustainable resources. Digital leaders Norway, Finland, Denmark and Sweden have all successfully grown their economies whilst reducing their GHG emissions.

Annual mean concentrations of PM$_{2.5}$ and PM$_{10}$ in Chinese cities against national and international standards
Source: WHO, Air Quality database, 2018

Annual mean PM$_{10}$ ug m^3

- Meets China's AQ limits
- Meets EU AQ limits
- WHO guidelines

Annual mean PM$_{2.5}$ ug m^3
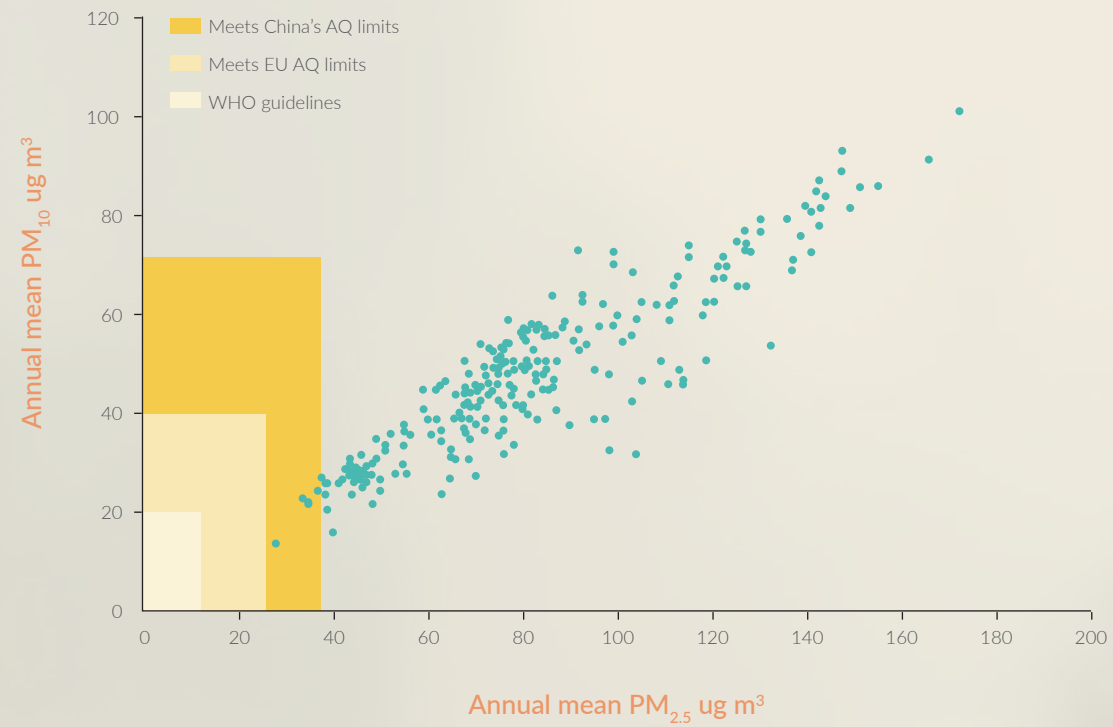
Air pollution

Poor air quality contributes to 1.6 million deaths in China every year with the greatest pollution on the eastern coast.

One key challenge for China's cities is air pollution. Increasing numbers of people, industry, fossil fuels and more vehicles merely add to the problem.

Many cities are not meeting national targets and remain far from the World Health Organisation's recommended levels for cities. Poor air quality contributes to 1.6 million deaths in China every year with the greatest pollution on the eastern coast but significant levels also in central and northern regions[6].

While concerted action is being taken and air pollution data is being made available, clear plans both nationally and locally will need to be formulated, implemented and monitored to tackle the problem. The shift of emphasis towards the development of smaller cities and inland China creates an opportunity to think about cities differently and develop urban centers where air quality is not compromised.
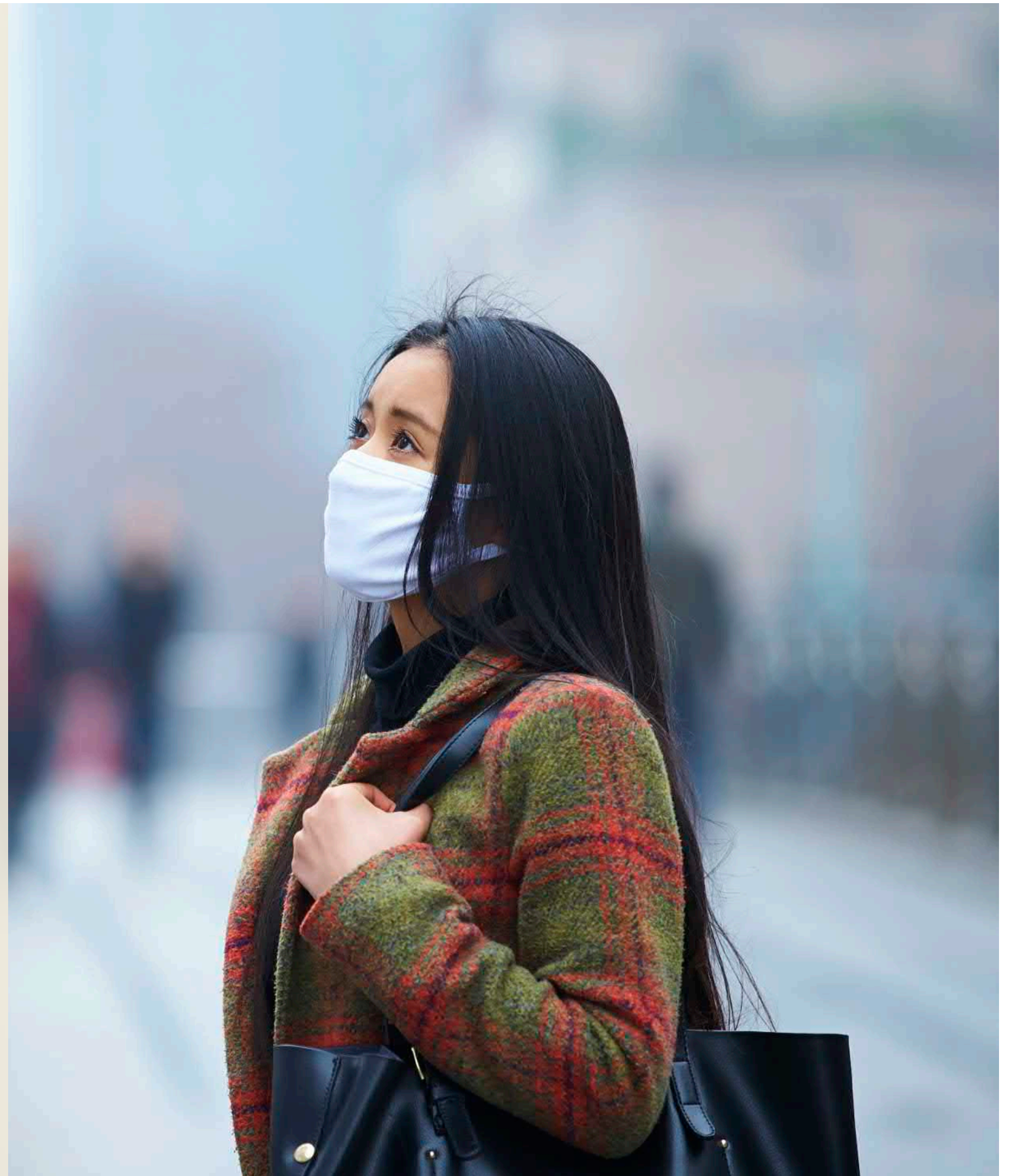
China is a top three investor in new technologies and is home to one third of digital start-ups valued at more than USD one billion.[7]

The Digital opportunity

Digitalization can contribute towards meeting the economic, social and environmental demands facing China's cities.

The 21st century's most successful cities will connect the physical world to the digital one. Digitalization will help our transport systems to be more responsive and to cope with more passengers. It will change how we generate, store and consume energy, making it cleaner, more reliable and efficient. It will play a pivotal role in dealing with chronic city problems like air pollution and congestion. In short it will help our cities work more efficiently and become better places to live and more attractive to businesses.

China's growing cities, market size and economy of scale, coupled with governance structures that can give clear long-term direction suggest that it is well positioned to take advantage of digitalization.

China already received USD 15.5 billion of venture capital investment in 2015, just behind the United States and the European Union[7].

It is a top three investor in new technologies such as big data, artificial intelligence, wearables, virtual reality, connected and autonomous vehicles, additive manufacturing, robotics and drones and is home to one third of digital start-ups valued at more than USD one billion[8].

As previously highlighted, the growing middle class of China with greater levels of income will drive the economy. Over the next decade, household income is expected to grow by five percent a year, driven by a shift towards the service sector and urbanization[9]. Younger generations are already driving the sharing economy, with consumers paying to access services rather than owning products.

China's sharing economy is growing at an astonishing pace. In 2017 it was worth USD 764 billion with over 700 million people involved. It is set to grow at 30 percent a year over the next five years. The benefit for cities is not just new services but jobs too. Sharing platforms accounted for 7.16 million (ten percent) of all new urban jobs in 2017[10].

China already has good technological infrastructure. It has three times (1.4 billion) the number of smart phone subscribers as the United States. However, greatest penetration is in tier 1 cities (80 percent of the market). 4G and 5G network coverage is expected to reach the whole population by 2025[11]. China will be the largest 5G market by 2025 and will have 576 million connections by 2027[12].

Whilst China is rapidly advancing it is still some way behind digital leaders in terms of coverage and uptake in some sectors. US industries were 3.7 times more digitized than Chinese counterparts in 2016[13]. Grasping the digital opportunity is central to delivering sustainable economic growth in its cities.

5G network coverage (million connections)

600	
500	
400	
300	
200	
100	
2021	2050
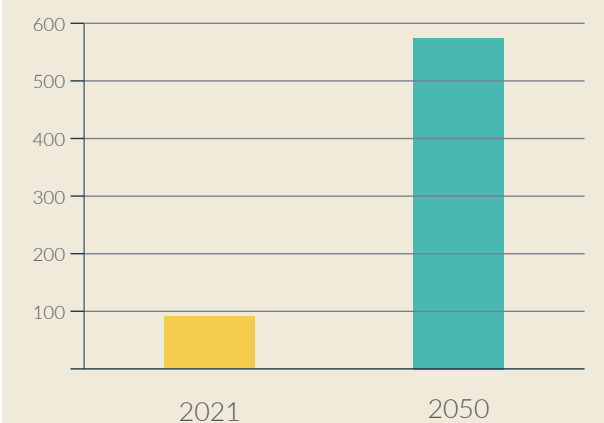
100% of the population will have 4G or 5G network coverage by 2025

China's smart city policy development

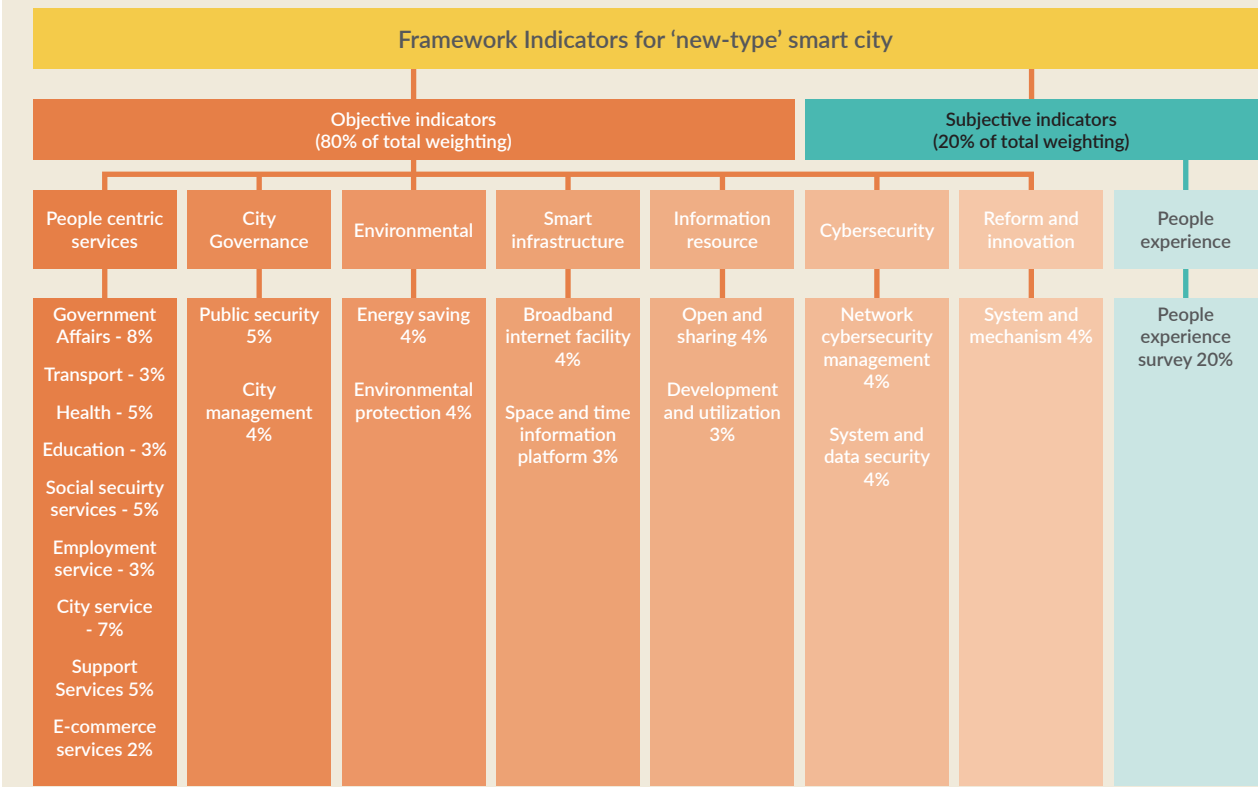China has been a leader in promoting smart cities as a concept, with greatest uptake in the largest, wealthiest tier-1 cities. But many cities remain in the early pilot stages of development.

GB/T 33356-2016 Evaluation Indicators for New Type Smart City and weightings

Framework Indicators for 'new-type' smart city							
Objective indicators (80% of total weighting)					Subjective indicators (20% of total weighting)		
People centric services	City Governance	Environmental	Smart infrastructure	Information resource	Cybersecurity	Reform and innovation	People experience
Government Affairs - 8% / Transport - 3% / Health - 5% / Education - 3% / Social secuirty services - 5% / Employment service - 3% / City service - 7% / Support Services 5% / E-commerce services 2%	Public security 5% / City management 4%	Energy saving 4% / Environmental protection 4%	Broadband internet facility 4% / Space and time information platform 3%	Open and sharing 4% / Development and utilization 3%	Network cybersecurity management 4% / System and data security 4%	System and mechanism 4%	People experience survey 20%

China's smart city policy development

The government has placed a great emphasis on smart technology to help meet the challenges it faces from urbanization and congestion through to creating equitable economic growth. This is clearly demonstrated by the government's investments into artificial intelligence and smart cities. The 12th five-year plan in 2010 strengthened policy on information technology and smart cities. That year Ningbo city became the first to produce a smart city plan. By 2012 the Ministry of Science and Technology, the Ministry of Industry and Information Technology (MIIT) and the NRDC began funding research, developing technologies and standards. A Ministry of Housing and Urban-Rural Development (MOHURD) circular set up smart city pilots in 2012 funded by USD 15 billion from the China Development Bank.

To coordinate activity, the NRDC published 'Guidance on promoting healthy smart city development' in 2014 and the Central Committee and State Council released New-Type Urbanization Planning 2014-20, which promoted smart city pilots.

By 2015 the State Council, identified smart technologies and smart cities as two priorities, emphasizing how China would promote extensive applications of IT in industrialization and develop The Internet Plus Action Plan to integrate mobile Internet, cloud computing, big data, and the IoT with manufacturing.

By 2016 the standard GB/T 33356-2016 Evaluation Indicators for New-Type Smart City was published by General Administration of Quality Supervision, Inspection and Quarantine, and the Standardization Administration of the PRC, setting out a framework for assessing smart city performance. This framework places emphasis on the experience of citizens and services directly aimed at them such as healthcare, education and transportation. They make up 57 of the 100 available marks. The remaining elements include smart infrastructure, environmental protection, cybersecurity and good governance.

In December 2017 a joint working group of 25 national ministries and agencies assessed smart city readiness of 220 cities based on the indicators. Cities were classified in four phases 'preparation', 'starting', 'growth' or 'maturing'. 93 cities were classified as in preparation, 86 in the starting phase and 41 in the growth phase.

China has been a leader in promoting smart cities as a concept, with greatest uptake in the largest, wealthiest tier-1 cities. But many cities remain in the early pilot stages of development. Scaling up smart city activity in lower tier cities will be an important part of achieving China's wider economic goals.

Key regional city clusters

The 13th five-year plan for Economic and Social Development (2016-2020), identifies 19 super city clusters that will drive economic activity. These super city clusters will account for 80 per cent of the economy by 2030.

The 19 super city clusters

1	Lanzhou-Xining City Cluster	8	North Slope of Mount Tianshan City Cluster	14	Shandong Peninsula City Cluster
2	Middle Shanxi City Cluster	9	Ningxia along the Yellow River City Cluster	15	Central Plain City Cluster
3	Guanzhong Plain City Cluster			16	**Yangze River Middle-reach City Cluster**
4	**Chengdu-Chongqing City Cluster**	10	Huhehot-Baotou-E'erduosi-Yulin City Cluster		
5	Middle Guizhou City Cluster	11	**Jing-Jin-Ji City Cluster**	17	**Yangze River Delta City Cluster**
6	Middle Yunnan City Cluster	12	Ha'erbin-Changchun City Cluster	18	West Coast of Taiwan Strait City Cluster
7	North Bay City Cluster	13	Middle/South Liaoning City Cluster	19	**Great Bay Area City Cluster**

The 13th five-year plan for Economic and Social Development (2016-2020), identifies 19 super city clusters that will drive economic activity. These super city clusters will account for 80 per cent of the economy by 2030[14]. The plans aims to strengthen links between cities and their surrounding areas to better share economic growth and to better manage the negative consequences of growth.

The five key super city clusters

This report highlights five of the city clusters and explores the opportunities and challenges faced by them. In total these five clusters include 92 cities and have a combined population of 539 million. They cover 986,000 km^2 of land and have a GDP of 38,277 billion yuan.

Jing-Jin-Ji: the Beijing-Tianjin-Hebei Cluster

Located on the north east coast this cluster is known informally as the Jing-Jin-Ji. It includes two tier-1 cities Beijing and Tianjin and one tier-2 city, Shijiazhuang in the Hebei province. The cluster accounts for just over ten percent of China's GDP and 8.1 percent of its population. Beijing and Tianjin have populations of 21.7 and 15.6 million and similar population densities of 1,311 and 1,290 people per km^2. In contrast the majority of the cluster lives in the Hebei province (74.7 million) surrounding Beijing and Tianjin which has a far lower population density of 394.3 per km^2.

Beijing is the world's largest capital city and is directly administered by the national government. It is the political, educational and cultural center of the country. Most of China's largest state-owned companies and many large global companies are located there[15] and it is home to the world's four biggest financial institutions by assets[16].

Tianjin is a major seaport and gateway to Beijing. It is China's fourth biggest city and administered by the national government. Its main urban area is located on the Hai River, which is connected to the Yellow and Yangtze Rivers via the Grand Canal. Tianjin has the highest GDP per capita of any city in China. Its major industries include petrochemical industries, textiles, car manufacturing, mechanical industries, and metalworking.

The Hebei province surrounding Beijing and Tianjin has a large agricultural workforce, mainly providing food to the two cities. The province has many heavy industries including oil drilling, coal and iron mining, steel production and manufacturing.

The formation of the Jing-Jin-Ji Cluster looks to deliver an integrated development around the capital using the natural advantages of the three parts. Central to this will be improving strategic planning to distribute greater resources to the less developed Hebei Province and take pressure off saturated Beijing. Key to this will be better transportation across the region and environmental protection, with a focus on mobility among provinces and municipalities to create more balanced economic growth.

Key challenges

Air pollution

Jing-Jin-Ji is one of the most heavily polluted areas and consumes ten percent of China's energy. The proportion of days with good and excellent air quality in the first six months of 2017 was 51 percent compared to the national average of 77 percent. Average concentration of PM$_{2.5}$ (50 μg/m^3) are far higher than the national average (27 μg/m^3). The cold climate and coal fueled heating means pollution is more severe in winter. Industry and transportation are also major sources of air pollution[17]. Coal consumption in Hebei Province makes up seven percent of the country's entire coal consumption (and 81 percent of the entire clusters). Urban development of the Hebei province must go hand in hand with efforts to shift to cleaner energy sources.

Congestion

Beijing is the tenth most congested city in the world. Shijiazhuang is 18th and Tianjin 23rd. In Beijing congestion slows traffic speeds in the morning peak by 72 percent and 84 percent in the evening rush hour. Drivers in Shijiazhuang fair no better, with the morning peak slowing journeys by 70 percent and 84 percent in evening peaks[18].

Urban density and population reallocation

Beijing and Tianjin continue to have high population growth whilst it has stagnated in Hebei Province. This exacerbates pollution, traffic congestion and puts pressure on public services. By 2020, Beijing plans to limit the population to 23 million and transfer non-capital-function industries to surrounding cities to drive its economic growth, better allocate human resources and achieve better urban planning[19].

Development of Hebei Province

To reduce economic disparity in Jing-Jin-Ji, Hebei has to undergo industrial transformation. Hebei suffers from a shortage of good education, medical care resources and the capabilities to construct satellite cities The development plan of Jing-Jin-Ji, aims for a one-hour commute circle consisting of 9,500 km of railways and 9,000 km of expressways to integrate the region. The Xiongan New Area will also generate opportunities, such as sustainable and smart development as Hebei[20] looks to shift from traditional heavy industry to innovation driven industries.

Jing-Jin-Ji City Cluster
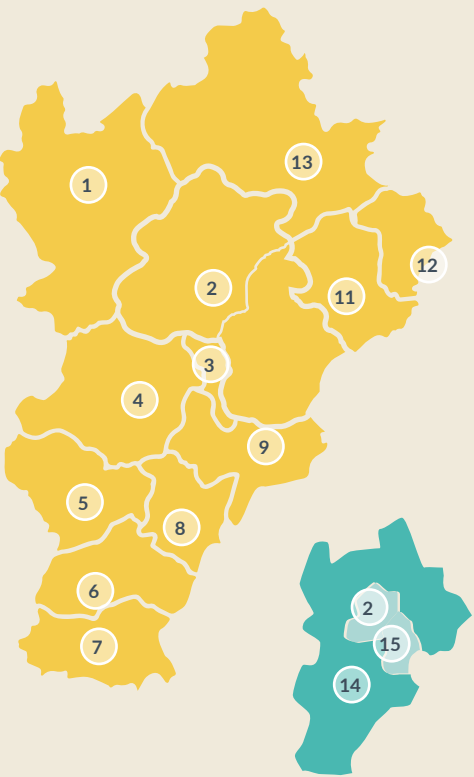
1	Zhangjiakou
2	Beijing
3	Langfang
4	Baoding
5	Shijiazhuang
6	Xingtai
7	Handan
8	Hengshui
9	Cangzhou
10	Tianjin
11	Tangshan
12	Qinhuangdao
13	Chengde
14	Hebei
15	Tianjing

Name	Jing-Jin-Ji City Cluster*
Number of Cities	13 cities
First-tier City**	Beijing
New First-tier City**	Tianjing
Second-tier City**	Shijiazhuang (Hebei Province)
Third-tier City**	Baoding, Tangshan, Langfang, Handan, Qinhuangdao, Cangzhou (Hubei Province)
Fourth-tier City**	Xingtai, Zhangjiakou, Chengde
Fifth-tier City**	Hengshui
Area (km²)	216,000
Population (Millions)	111
GDP (Billions RMB)	6,647
Key Opportunities	Reduce population density in Beijing and promote human resource mobility in the city cluster.
	Build integrated and sustainable transportation network, with emphasis on high-efficient and intensive rail way network, unobstructed highway network, Jing-Jin-Ji harbor cluster and world class airport hub.
	Promote ecosystem protection and green development, with focus on environment pollution control, water cleanness and recycling economy.
	Carry out institutional innovation to provide system assurance for Jing-Jin-Ji connected infrastructure.

*   According to the Outline of Collaborative Development of Beijing, Tianjin and Hebei Province approved by the Political Bureau of the Central Committee of the CPC in Apr 2015

** The classification is based on the business attraction ranking of China City 2017 by CNB(China Business Network).

Yangtze River Delta City Cluster: A world class city cluster with global influence

Yangtze River Delta (YRD) city cluster is at a key stage of development, after the joining of Anhui Province. The region generates 25 percent of China's GDP and consumes 17 percent of energy, illustrating the efficiencies of city living. Its location and resource advantages mean YRD simultaneously promotes the development of industrialization, information technology, urbanization and agriculture modernization. Nevertheless, YRD city cluster still faces challenges. A key focus is driving up the development quality and international competency of the cluster, as well as finding a balance among different cities to achieve integrated development.

Key challenges

Energy infrastructure[21]

Cities in YRD are expected to decelerate their energy consumption and restructure energy generation to meet national standards (reducing coal consumption to below 58 percent by 2020). In 2015, coal consumption for Anhui Province was 78 percent and contributed heavily to the China's greenhouse gas emissions and poor air quality.

An Ageing population[22]

The population over 80 years old is expected to reach ten million by 2035 and exceed 20 million by 2050. One third of Shanghai's population is over 60. An ageing population could result in several challenges, such as a shrinking workforce to drive economic growth and insufficient elderly care services and infrastructure to accommodate the population. According to the YRD development plan, livelihood projects like trans-regional settlement of medical insurance should be conducted to enhance cross-province elderly care services.

Connectivity

To achieve integrated development, YRD is aiming to construct a comprehensive transportation network combining railways, highways and waterways. The function of Shanghai as an international transportation hub and Nanjing, Hangzhou, Hefei as national transportation hubs need to be enhanced. YRD should also deliver new global competitive advantages and driving the construction of the Belt and Road Initiative and Yangtze River economic belt as part of the clusters development. Achieving this means optimizing communication and internet infrastructure, including the construction of big data, cloud computing and IoT platforms. Tier 1 cities like Shanghai, Hangzhou and Ningbo are expected to drive the economic and industrial development of surrounding cities.

Yangze River Delta City Cluster
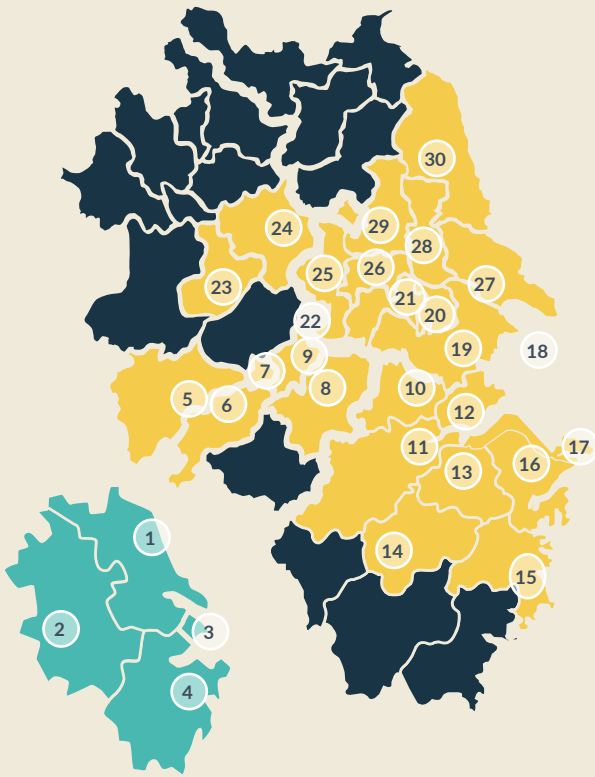
1	Anhui	16	Ningbo
2	Jiangsu	17	Zhoushan
3	Shanghai	18	Shanghai
4	Zhejiang	19	Suzhou
5	Anqing	20	Wuxi
6	Chizhou	21	Changzhou
7	Tongling	22	Ma'anshan
8	Xuancheng	23	Hefei
9	Wuhu	24	Chuzhou
10	Huzhou	25	Nanjing
11	Hangzhou	26	Zhenjiang
12	Jiaxing	27	Nantong
13	Shaoxing	28	Taizhou
14	Jinhua	29	Yangzhou
15	Taizhou	30	Yancheng

Name	Yangze River Delta City Cluster of Yangze River Economic Belt*
Number of Cities	26 cities
First-tier City**	Shanghai
New First-tier City**	Hangzhou, Ningbo (Zhejiang Province); Nanjing, Suzhou (Jiangsu Province)
Second-tier City**	Changzhou, Jiaxing, Jinhua, Shaoxing, Taizhou (Zhejiang Province); Wuxi, Nantong (Jiangsu Province); Hefei (Anhui Province)
Third-tier City**	Huzhou, Zhoushan (Zhejiang Province); Zhenjiang, Yangzhou, Yancheng, Taizhou (Jiangsu Province); Wuhu, Ma'anshan (Anhui Province)
Fourth-tier City**	Anqing,Chuzhou, Xuancheng (Anhui Province)
Fifth-tier City**	Tongling, Chizhou (Anhui Province)
Area (km²)	211,700
Population (Millions)	150
GDP (Billions RMB)	12,670
Key Opportunities	Reduce population density in Shanghai and grow its international competiveness.
	Develop high-tech and service industries with high value-added and build high-quality entrepreneurial and residential environment.
	Improve citizen basic public service to settle down more external population.
	Enhance city construction planning and increase the space usage efficiency.
	Promote ecosystem protection and environmental quality.

* According to the Outline of Yangze River Economic Belt Development published by Central Committee of the CPC in March 2016 and the Regional Planning of Yangze River Delta City Cluster approved by the State Council in May 2016.

** The classification is based on the business attraction ranking of China City 2017 by CNB (China Business Network).

Greater Bay Area City Cluster:
a high-tech hub

The Greater Bay Area (GBA) has experienced USD 1.6 trillion of GDP growth between 2014 and 2017[23]. The cluster has a large working population (76 percent) which has enabled it to become one of the most productive regions, generating 13 percent of GDP with just five percent of national population[24]. GBA has the greatest number of high-tech enterprises and contributes 56 percent of China's international patents. Operating under the norm of "one country, two systems, three customs and four core cities", the complexity of the political and economic environment poses challenges to achieving total integration of markets, economy and resources. Further improvement of the flows of talents, capitals, information and logistics are expected as the cluster continues to develop and require a strong unified development plan.

Key challenges

Mobility
GBA has relatively comprehensive infrastructure system, but cross-border networks still need to be improved. To reach new levels of connectivity, GBA seeks to construct a one-hour commute circle among Hong Kong, Macao and the nine mainland cities in Guangdong. The construction of Guangzhou-Shenzhen-Hong Kong Express Rail Link and Hong Kong-Zhuhai-Macao Bridge provides opportunities to improve labor mobility and relieve land shortage in Hong Kong and Macao. Apart from transportation, mobility in information and data also needs to be improved by establishing big data and cloud computation centers. More infrastructure projects are expected to be conducted to enhance GBA's connectivity and transform the area into an international business and economy hub[25]. Other challenges that could hinder mobility include protectionism within the region and silos between and within governments[26].

One joint plan and the better flow of information will aid regional decision making. Data will help unleash the potential of smaller cities and development of robust economies and talent acquisition.
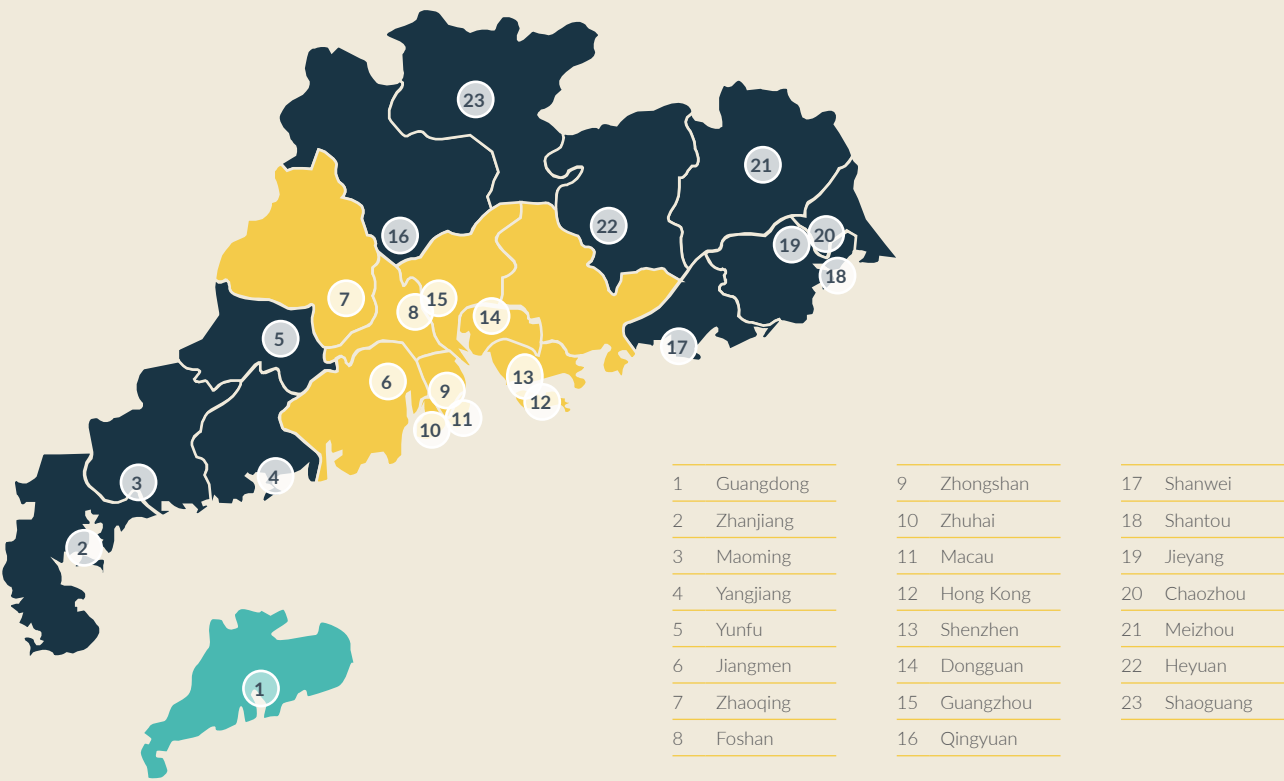
Pollution and environmental protection
The main cause of air pollution in the GBA is from shipping. Cargo throughput at major ports in GBA far surpassed that handled by New York Bay (4.65 million TEU), Tokyo Bay (7.66 million TEU) and San Francisco Bay (2.27 million TEU), reaching 62.47 million TEU. Reducing emissions from ports and associated mainland freight movements will improve local air quality and lower GHG emissions.

The Pearl River Delta of GBA aims to control its coal consumption to 70 million tons[27,28,29] and reduce GHG emissions to 0.456-ton CO_2 per 10,000 yuan by 2020[30]. Guangdong Province also plans to adopt the circular economy model in over 100 industrial parks during the period of 13th five-year plan.

Smart manufacturing
Guangdong Province known for its manufacturing aims to enhance its leading position but faces challenges to promote its smart manufacturing plan and to align itself with the Made in China 2025 Action Plan. It is expected that information and internet infrastructure will be enhanced to enable cross-border e-commerce services as well as to encourage automation along the supply chain. An industrial big data platform will be developed to enhance production optimization, track market transaction and achieve data transparency[31].

Greater Bay Area City Cluster

1	Guangdong	9	Zhongshan	17	Shanwei
2	Zhanjiang	10	Zhuhai	18	Shantou
3	Maoming	11	Macau	19	Jieyang
4	Yangjiang	12	Hong Kong	20	Chaozhou
5	Yunfu	13	Shenzhen	21	Meizhou
6	Jiangmen	14	Dongguan	22	Heyuan
7	Zhaoqing	15	Guangzhou	23	Shaoguang
8	Foshan	16	Qingyuan		

Name	Greater Bay Area City Cluster*
Number of Cities	9+2=11
First-tier City**	Guangzhou, Shenzhen, Hong Kong, Macau
New First-tier City**	Dongguan
Second-tier City**	Foshan, Zhuhai, Huizhou, Zhongshan
Third-tier City**	Jiangmen, Zhaoqing
Area (km²)	5,600
Population (Millions)	66
GDP (Billions RMB)	9,200
Key Opportunities	Build up one-hour inter-city life cycle.
	Strengthen R&D capability and boost innovation.
	Develop outline and legal norm for trading/economic development.
	Set up regional administrative collaboration mechanism.

*   The Outline of Greater Bay Area Development will be released by Central Committee of the Communist Party of China soon in 2018.

** The classification is based on the business attraction ranking of China City 2017 by CNB (China Business Network).

Chengdu-Chongqing City Cluster: Driving the new type urban development

Chengdu-Chongqing City Cluster has the responsibility of boosting the economic development of western China and driving Belt and Road Initiatives. It seeks to drive urbanization and agricultural modernization while promoting the coordinated development between urban and rural areas. It is the first cluster that brings two provinces together in the west of the country. The collaboration between Chongqing and Chengdu still lacks a joined-up approach while lower-tier cities do not show strong growth potential. The cluster needs to develop more integrated infrastructure and create an open platform for further collaboration between the areas.

Key challenges

Traffic congestion
Chongqing and Sichuan Province face serious congestion. The economic impact of congestion in Chongqing is 2,857 yuan[32] per person per year and 5,050 yuan[33] in Chengdu. A shortage of good public transportation, poorly managed road traffic and rising car ownership (Chengdu has four million cars for its population of 14.6 million, Beijing has five million cars for 21.7 million, Chengdu has three ring roads, Beijing six[34]) are the main factors. In Chengdu, the ring-shaped radial road network causes severe congestion towards the city center. Improvements to public transportation and more efficient transportation planning will help alleviate the situation. A one-hour commute life circle is expected to be developed, following the construction of a series of high-speed railway and inter-city expressways.

Urbanization
Urbanization is prioritized in the Chengdu-Chongqing integration plan. The current urbanization rate in Chongqing is 64 percent and will reach 70 percent by 2020 (an urban population of 24.2 million[35]). Sichuan Province has a lower urbanization rate of 45 percent, which is expected to reach 54 percent by 2020[36]. The main obstacles to urbanization are low education levels amongst the rural populations, dead-end roads among central districts and suburban areas which prevent efficient mobility and connectivity between cities and an incomplete service sector.

The development of integrated social services including optimizing regional medical care services, education and social security is a priority.

Natural disasters
Due to its location, Chengdu-Chongqing is at risk of natural disasters, such as earthquakes and flooding, which result in direct economic cost of 7.75 billion yuan and 4.79 billion yuan for Sichuan Province and Chongqing Municipal respectively[37]. The region faces the challenge of constructing resilient infrastructure and an emergency monitoring platform to reduce the impacts of natural disasters and allow a faster recovery from them.

Ecosystem maintenance and environmental protection
The cluster has relatively big nature reserves (9.13 million hectares) and water bodies. Maintaining a good quality ecosystem and recovering areas polluted by industry and poor waste management practices must be a focus. Chongqing aims for 45 percent greenspace within its urban area and 55 percent[38] of forest coverage across the whole area while Sichuan Province aims to reach a green coverage of 70 percent in urban areas and forest coverage of 40 percent in the near future[39].

Chengdu-Chongqing City Cluster
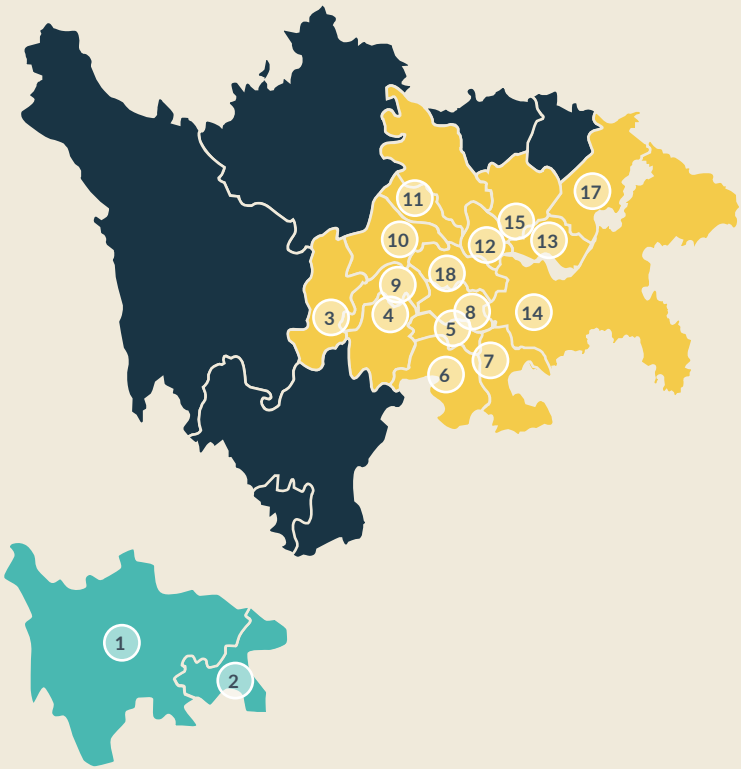
1	Sichuan
2	Chongqing
3	Ya'an
4	Leshan
5	Zigong
6	Yibin
7	Luzhou
8	Neijiang
9	Meishan
10	Chengdu
11	Deyang
12	Suining
13	Gaung'an
14	Chongqing
15	Nanchong
16	Manyang
17	Dazhou
18	Ziyang

Name	Chengdu-Chongqing City Cluster of Yangzi River Economic Belt*
Number of Cities	16 cities
New First-tier City**	Chongqing, Chengdu (Xichuan Province)
Third-tier City**	Mianyang, Nanchong (Xichuan Provicne)
Fourth-tier City**	Leshan, Deyang, Yibian, Luzhou, Meishan, Neijiang, Suining, Ya'an (Xichuan Province)
Fifth-tier City**	Ziyang, Dazhou, Guang'an, Zigong (Xichuan Provicne)
Area (km²)	185,000
Population (Millions)	91
GDP (Billions RMB)	3,760
Key Opportunities	Enhance the collaboration between Chongqing and Chengdu in city space planning, high-end development platform construction, industry division and cooperation.
	Grow secondary cities with good geographic position and rich resource.
	Develop high-speed rail and commuter, make overall plan of harbor construction along the river and raise navigation capability of the Three Gorge Dam.
	Promote ecosystem protection in land, water, energy and mineral resource.
	Break regional protectionism and administrative obstacles.

* According to the Outline of Yangze River Economic Belt Development published by Central Committee of the CPC in March 2016 and the Regional Planning of Chengdu-Chongqing City Cluster approved by the State Council in Apr 2016.

** The classification is based on the business attraction ranking of China City 2017 by CNB (China Business Network).

Middle Reaches of Yangtze River City Cluster

1	Hunan	22	Xianning
2	Hubei	23	Jingzhou
3	Jiangxi	24	Huangshi
4	Loudi	25	Ezhou
5	Hengyang	26	Xiantao
6	Xiangtan	27	Qianjiang
7	Zhuzhou	28	Huanggang
8	Pingxiang	29	Wuhan
9	Ji'an	30	Tianmen
10	Xinyu	31	Yichang
11	Yichun	32	Xiaojiao
12	Changsha	33	Jingmen
13	Yiyang	34	Xiangyang
14	Changde		
15	Yueyang		
16	Nanchang		
17	Fuzhou		
18	Yangtan		
19	Shangrao		
20	Jingdezhen		
21	Jiujiang		

Middle Reaches of Yangtze River City Cluster: Rise of central China

The Middle Reaches City Cluster plays a significant role along the Yangtze River economic belt, linking both the Chengdu-Chongqing and Yangtze River Delta City clusters. It also plays a strategic role in the economic growth of central China. Compared to the other clusters it is in an early stage of development. It faces challenges of enhancing the economic capability of cities, optimizing industrial structure, strategic planning and balancing development of urban and rural areas. Pollution remains a top issue. It can seek opportunities to exploit its geographic and resource advantage to achieve agriculture modernization, urbanization and to strengthen its international collaboration.

Key challenges

Outward migration
The cluster has experienced a serious outflow of population, especially in Jiangxi Province driven by the uneven distribution of education resources, lack of employment opportunities and quality of public services. The working population (74.6 percent) is much smaller than other clusters such Jing-Jin-Ji (77.2 percent), Greater Bay Area (82.7 percent) and Yangtze River Delta (79 percent)[40]. The loss of people and low average education level could have long term impacts on economic growth. Education, healthcare and other public services must be a focus.

Pollution
Annually, around 12 million tons of grain products are polluted by heavy metal in soil in China, causing a direct economic impact of 20 billion yuan. The middle and lower reaches of Yangtze River are home to more than 400,000 chemical enterprises which have created a 600 km long pollution belt containing over 300 hazardous pollutants[41]. Hunan Province, known for its agriculture industry and accounting for five percent of grain products, unavoidably suffers great loss from heavy soil and water pollution. The Cluster will focus on efficient resource use, strictly control the activities of high energy consumption and high emission industries. The concept of circular economy will be promoted to create a more sustainable supply chain.

In addition, air quality continues to be problem. Hunan Province shows a slower rate of air quality improvement compared to other provinces. Hubei Province faces growing issues with O_3 and VOCs. Jiangxi Province aims to reduce its proportion of coal in its energy consumption to below 65 percent by 2020 and increase the use of natural gas and renewable energy. SO_2 and NOx emission reduction continue to be its main priorities.

Transportation
Three metropolitan circles are identified in Middle Reaches city cluster: Poyang Lake Circle in Jiangxi province, Chang-Zhu-Tan Circle in Hunan province and Wuhan Metropolitan Circle in Hubei province. The government aims to improve connectivity among them to enable integrated development. A key challenge is to develop a 90-minutes economic circle within the cluster and construct a highspeed railway network among four provincial capitals (Changsha, Wuhan, Nanchang and Hefei in Anhui Province). Airport capabilities in the capitals will also be enhanced. Investing in the transport network opens opportunities for advanced technology adoption, such as big data, AI and cloud computing. All improvements need to be aligned with the focus on resource efficiency and reducing environmental impacts of the region.

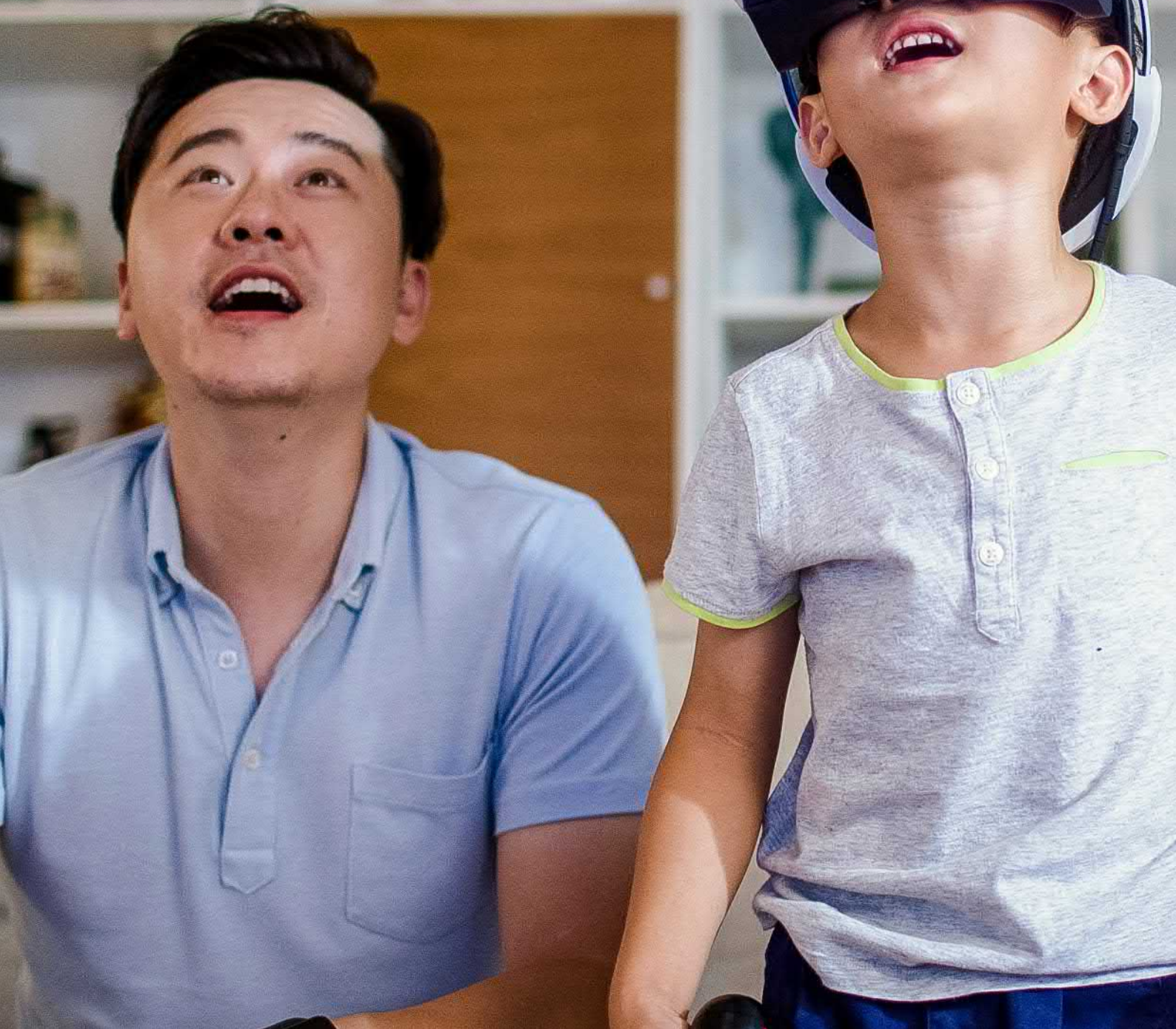| Name	Jing-Jin-Ji City Cluster*
Number of Cities	31 cities
New First-tier City**	Wuhan (Hubei Province); Changsha (Hunan Province)
Second-tier City**	Nanchang (Jiangxi Province)
Third-tier City**	Yichang, Xiangyang, Jingzhou, Xiaogan (Hubei Province); Zhuzhou, Hengyang, Yueyang (Hunan Province); Jiujiang, Shangrao (Jiangxi Province)
Fourth-tier City**	Huanggang, Huangshi, Xianning (Hubei Province); Xiangtan, Changde, Loudi (Hunan Province); Yichun, Fuzhou, Ji'an, Jingdezhen (Jiangxi Province)
Fifth-tier City**	Jingmen, Ezhou, Tianmen, Qianjiang, Xiantao (Hubei Province), Yiyang (Hunan Province); Yingtan, Xinyu, Pingxiang (Jiangxi Province)
Area (km²)	317,000
Population (Millions)	121
GDP (Billions RMB)	6,000
Key Opportunities	Balance the urban and suburban development according to 3 city centers, 2-horizontal and 2-vertical axis.
	Build intensive water carriage network, connected land carriage network and convenient air transportation.
	Strengthen advanced manufacturing, grow modern agriculture and innovation.
	Enhance foreign cooperation and establish sample for inland openness.
	Promote ecosystem protection, especially for Yangzi river water resource.

*   According to the Outline of Yangzi River Economic Belt Development published by Central Committee of the CPC in March 2016 and the Regional Planning of Yangzi River Middle-reach City Cluster approved by the State Council in Apr 2015.

** The classification is based on the business attraction ranking of China City 2017 by CNB (China Business Network).

Delivering smart cities

This section explores six priority areas for smart cities taking account of the government's smart city framework. It explores some of the challenges faced and the opportunities within these sectors and contains case studies to highlight OAV member capabilities in delivering smart cities.

Six smart cities focus themes

Health and Education

City Management and Digital Enterprise

Resource Management

Smart City

Safety and Security

Mobility

Buildings and Energy

What makes a successful city?

A vision and plan for the future

Urbanization has a wide range of effects on the economy, the environment, infrastructure and logistics. Cities need to be developed in a new way in the future: integrated, sustainable and more efficient.

All around the world, big cities and the surrounding areas are coming together to form smart urban areas – urban areas that use state-of-the-art digital information and communication technologies to tackle the challenges of growing agglomerations and thus make the lives of their residents safer, more convenient and more pleasant. Technology will play an important role in enabling cities to cope with the future. Dealing with more people, keeping economies growing, people moving, making roads safer, keeping the lights on and protecting the environment. Future smart cities will connect together urban infrastructure allowing it to do more than ever before.

The focus for any successful city must be people. Smart cities create environments where people enjoy living and working, where they have access to social and economic opportunities and enjoy a good quality of life.

They are places where businesses want to locate and invest, where economic growth does not sacrifice the environment or social well-being. Smart city technologies must be seen through this lens and effective plans must be put in place that integrate different sector strategies within cities. City government must play the role of regulator, facilitator and promoter of local investments in infrastructure within the context of provincial and national government frameworks. While private industries can provide capital, technology transfer and development of solutions. Driving innovation through a city vision and strategic goals and crystallizing them through transformation policy will create thriving places and lead to increased global opportunity and competitiveness. Success requires territorial cooperation and multi-level governance, cohesion and integration between the use of resources and new technologies.

Regenerating Beixinjing (Suzhou Creek Waterfront Innovation Park), Shanghai

Beixinjing, located at the west part of the Suzhou Creek, is a major shipping watercourse that connects Shanghai with Suzhou. It used to be an important industrial zone of Shanghai. As the city grows, re-planning has become essential. HPP Architects propose an urban planning solution that will rebuild the area as a "Park City": The plan includes a vertical, multi-layered park, with an elevated platform creating a connection with surrounding quarters and water landscapes. Blocks were reduced in size and inlayed with green fields, making the site more convenient and pleasant for residents. A compound industrial community was also planned, to better support innovative ways of working. The plan will enhance the Suzhou Creek Waterfront areas ecology, economy and urban living. The Project embodies five smart city aspects:

Smart resources
- Urban water system control and recycling.
- Network of shared diversiform service hubs.
- The 15-minute living circle fully covers social facilities and resources.
- Management of production and consumption integrated into daily life and building.

Smart blocks
- The size of the block unit is limited within 1-3 hectares, making it easily accessible and flexible to accommodate various functions.
- Modular typological spaces are created to provide different spatial combinations to meet the requirements of future block space quality and diversity.

Smart traffic
- Created multi-layered traffic control at the main intersections, districts and the whole area to optimize the traffic operations.
- Distribution system: Real-time traffic monitoring and signal coordinating system are planned region-wide to change the traffic distribution and release the traffic jam.

- Information publication system: Setting traffic information collection system and posting the traffic information to improving traffic efficiency.
- Smart parking system: Traffic guidance system and a parking dynamics induction system are provided to promote the macro-control ability in the whole area.

Smart life
- Operate smart sharing communities, including high-quality shared spaces such as co-living space, co-working space, co-innovated lab and co-managing store for a future-oriented life style.
- Provide people of a wide age span with diversiform learning and entertainment resources, as well as intelligent control of time and space of the life cycle.
- Create a communicative society equipped with devices that provide people with easy access to information.

Smart green
- Biological circle complex: The City Park is a compound green space which covers a range of architecture, culture, sports and events.
- Cradle to cradle: A multi-layered green space was created around the central park, equipped with a shared service hub and an efficient connection, which forms an innovative city park in terms of industry, living and ecology.
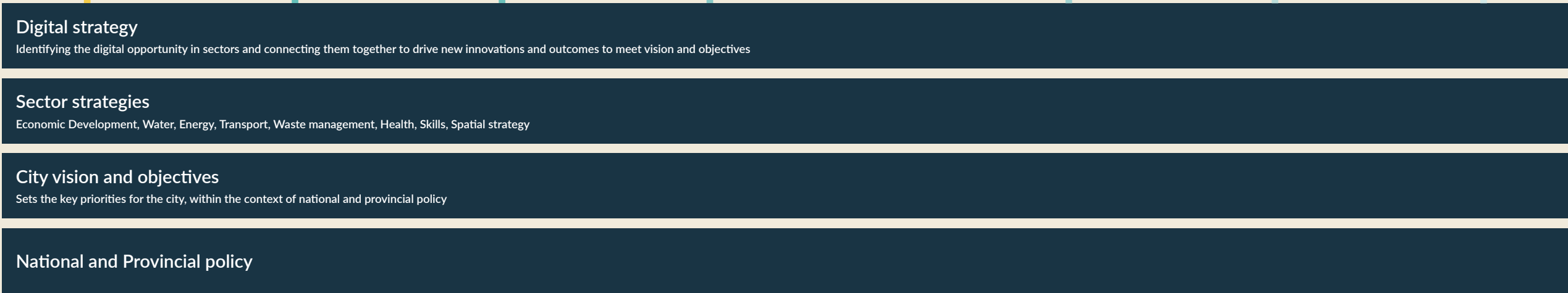
The project aims to create a livable, flexible and borderless shared space and provides an example of the future development of our cities with lower resource needs, in a smart urban living environment which provides quality living and producing conditions on the basis of ecological balance and sustainability.

The project aims to create a livable, flexible and borderless shared space and provides an example of the future development of our cities with lower resource needs.

HPP Architects

Smart city solutions driven by digitalization will drive many benefits across cities

Example Outcomes[42]	Connection of IoT applications will drive 40 percent more potential value	30 – 300 lives saved each year in a city of five million	Up to 40 percent reduction in energy use in buildings	15 – 30 minutes less in daily commute	25 – 80 liters of water saved per person per day	8 – 15 percent lower disease burden
City Benefits	More efficient; Better intelligence and decision making; Better services; New business models; Increased resilience	Optimized performance of systems; Coordinated systems; Safer working environment; Safer cities; Greater reliability; Public trust	Reduced energy losses; Reduced GHGs; Improved power quality & availability; Increased revenue generation; Reduced maintenance costs; Increased resilience; Improved air quality	Reduced congestion; Improved air quality; Greater productivity; Greater accessibility; Reduced GHGs emissions and noise pollution; Improved resilience; Increased safety; Health benefits	Reduced water loss from networks; Improved revenue generation and collection; Reduced energy consumption and GHGs and environmental impacts; Increased city resilience; Reduced maintenance costs	Greater access to services; More targeted use of resources; Reduced pressure on services; More effective prevention strategies; Digitally skilled workforce
Smart Solutions	Internet of things; Cloud platforms; Edge computing; Artificial intelligence; Data analytics; Sensors; Citizen services & engagement platforms; City Digital twin, performance monitoring & prediction	Security operation center; Video & area surveillance; Crime analytics/predictive policing; Public address systems & Fire detection; Access control; Coordinated emergency response; Emergency and transport ventilation; Cybersecurity and multidimensional testing	Decentralized energy systems; Smart grid & storage; Demand response & dynamic pricing; Virtual power plants; Building automation and management; Building Information Modeling & sustainable design; Building data analytics & performance monitoring; Smart environmental controls and customizable workplaces; Grid interactive buildings	Mass transit; E-mobility; Integrated traffic management & Smart parking; Connected and Autonomous vehicles; Shared Mobility/Mobility as a Service (MaaS); E-highways and smart logistics; Road user charging and congestion charging; Real-time transport information and integrated payment systems	Leakage detection; Water automation systems; Quality monitoring and supervisory control; Smart irrigation; Grey and blackwater recycling; Digital tracking and payment for waste management; Waste collection route optimizations; Incentives programs	Telemedicine & remote patient monitoring; Real time air quality information; Digital twins for prescribing & planning procedures; Person centric healthcare; Data based health interventions; Patient management systems; Online retraining programs; Personalized education; E-career centers
City Sectors	City Management & Digital Enterprise	Safety & Security	Buildings & Energy	Mobility	Resource Management	Health & Skills

Digital strategy
Identifying the digital opportunity in sectors and connecting them together to drive new innovations and outcomes to meet vision and objectives

Sector strategies
Economic Development, Water, Energy, Transport, Waste management, Health, Skills, Spatial strategy

City vision and objectives
Sets the key priorities for the city, within the context of national and provincial policy

National and Provincial policy

City Management & Digital Enterprise

Greater than the sum of its parts – connecting cities

Smart cities in the future will rely on fully automated infrastructure. They will benefit from adding greater intelligence and capitalizing from real-time data connected across different systems. This will allow infrastructure to operate them more efficiently, drive new insights and predict maintenance. Greater data intelligence will help manage challenges such as congestion or air pollution using real-time data and drive new systems and services. In short, smart cities will function more efficiently, making them more productive places for businesses, which in turn will drive growth, jobs and investment. To realize the benefits, cities should must begin enhancing their understanding of the digital opportunity now, with a view to developing plans for implementing scalable citywide programs. In the regional city clusters, data could form the building blocks for the implementation of joint, collaborative plans between places.

E-Governance for municipalities
Whilst cities don't always have powers over infrastructure they can play a role in convening key actors within sectors. One opportunity proving considerable benefits is e-Governance and integrated service platforms which enable informed decision making and faster responses for city administrators, and more civic engagement for citizens.

Digital infrastructure will help cities to capture information across their network and facilitate citizen interaction with city managers. Making citizens responsible for reporting issues, good and bad, will help plan services more effectively and manage communities with greater accuracy.

Digital infrastructure can provide city managers with the ability to better understand the people who live, work and visit the city. It will provide them with the data they need to plan for future investment, and investors with a solid baseline upon which they can assess investment potential and realize their expected returns. By ensuring the governance structures within cities recognize the benefits of shared planning, investment and management, the fully integrated, digitally connected smart city can become a reality.

Making public transport easy

Making mass transit smarter, with support for mobile payments and digital analytics, is an important part of smart-city development. The increasing availability of near field communication (NFC) enabled smartphones and wristbands in China is accelerating adoption of NFC-driven mass transit applications and, as a result, is making China's mass transit more convenient to use, more efficient to operate, and more sustainable to maintain.

As the availability of mobile transit continues to spread, Chinese consumers are activating services in record numbers. The latest phone models, which include NFC functionality and offer support for mobile wallets, are in high demand and have attracted new users to mobile transit. Several of China's leading systems for mobile payments, including One+Pay, Huawei Pay, and Xiaomi Pay, now support NXP's NFC-based wallets for mobile transit. With their recent announcement of the Mi 8 smartphone, Xiaomi saw historic activation rates for mobile transit wallets, reaching as high as 60 percent in Beijing and Shanghai in the first month of availability.

Activation of mobile transit wallets is also on the rise with the latest generation of wristbands. The new Xiaomi Mi Band 3, for example, is a premium fitness band with an enhanced OLED screen and NFC. It currently supports mobile transit in several major cities, including Beijing, Guangxi, Jiansu, Jilin, Shenzhen, and Wuhan.

In mobile transit, QR codes are most widely used in single-journey tickets, as an alternative to paper tickets. For multi-journey tickets, however, NFC is becoming the preferred solution. The market for multi-journey tickets is roughly five times the size of the single-journey market.

In Beijing, for instance, the Beijing Municipal Administration & Communication Card, more commonly known as the Yikatong, reported that, as of August 2018, their mobile transit service had a total of three million users and two million transactions per day, of which the clear majority were NFC-based transactions. A similar trend has been reported in Shanghai, with more than a third of users migrating from QR code to NFC in the last few months.

The combination of fast internet speeds, data analytics, artificial intelligence and the IoT is already transforming China's industrial sector. The China Economic Information Service believes the Chinese IoT market could reach 230 billion US dollars by 2020[38]."

Digital planning of cities

Cities could be better designed, more flexible and cheaper using digital twins. The car industry shows the benefits. Traditionally car makers would develop prototypes, crash them and then analyse what happened. They would then refine the prototype and do the same again. Creating the physical city in digital form will allow city planners, like car makers, to test different approaches in the digital world and understand the consequences, before spending public money on physical infrastructure.

Internet of things (IoT) and open cloud platforms

Globally there are already more than 26 billion connected devices, and this will grow to 75 billion by 2025. The IoT will drive better insights, decision making, create new approaches, services and drive efficiencies in cities.

The combination of fast internet speeds, data analytics, artificial intelligence and the IoT is already transforming China's industrial sector. The China Economic Information Service believes the Chinese IoT market could reach 230 billion US dollars by 2020[43]."

Sensors are becoming cheaper and more ubiquitous and are being deployed more and more in cities. From smartphones which can act as mobile sensors as they move around urban areas, to those measuring or monitoring air pollution, weather, traffic, parking, water quality, energy and water, waste and undertaking surveillance could all be connected via cloud-based platforms to drive new insights. Open standards and communication protocols will be important in maximizing the potential for cities.

Cloud-based, open IoT operating systems will allow cities to connect products, systems and machines, enabling them to harness the wealth of data generated by the IoT through advanced data analytics.
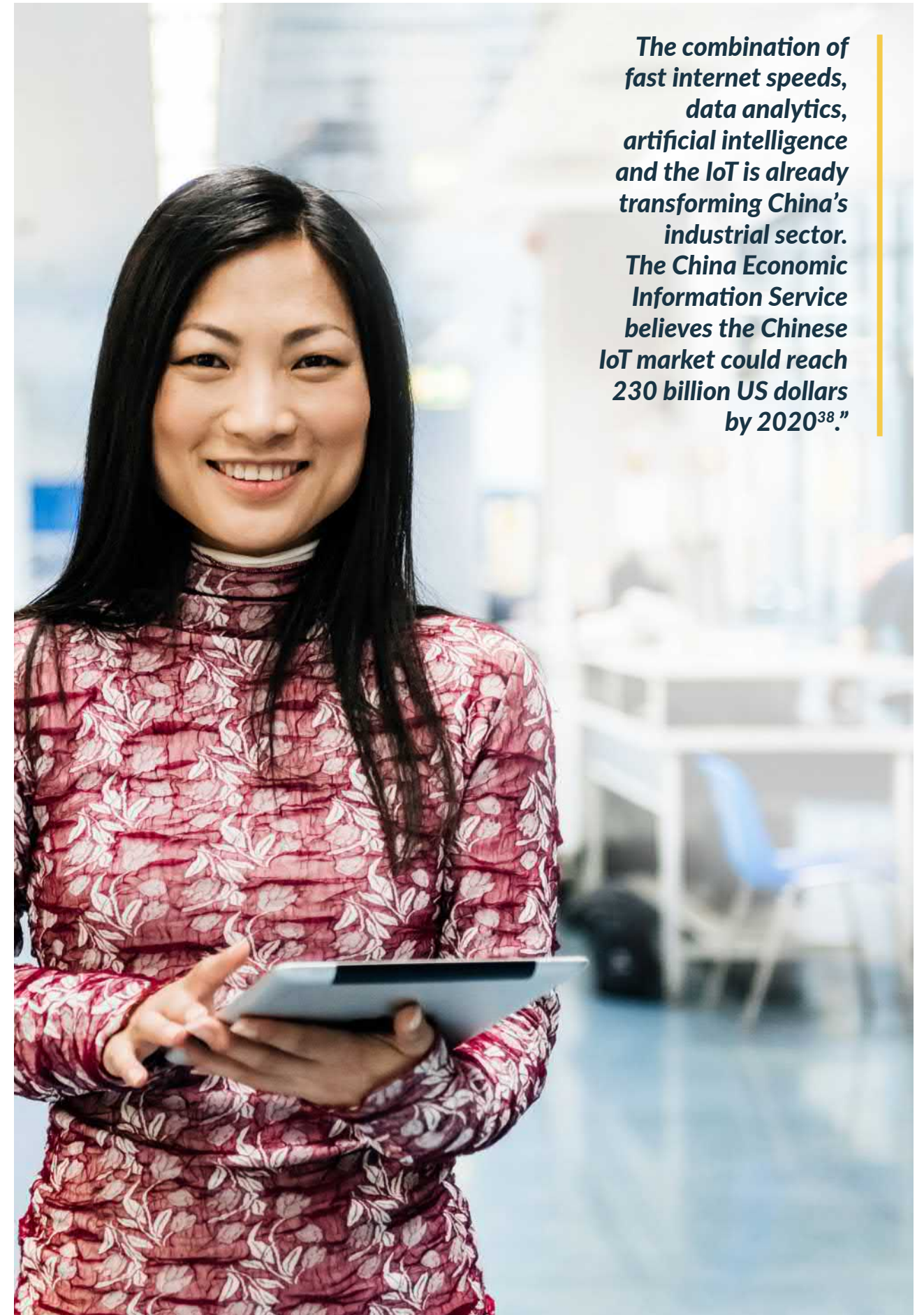
Big data analytics

Many cities globally are now converting data sets into standardized, sharable formats and making them available through open data platforms. This maximizes the opportunities from data by allowing deep analytics and supporting artificial intelligence systems in performing ever more complex tasks.

Artificial intelligence

The IoT has created a global web of assets that has already enhanced our lives. IoT gives the opportunity to reach out from the edge of networks into the real world where raw information gathered via the cloud is processed into knowledge. High-performance processing is now allowing more analysis at the edge, rather than the cloud. For example, smart traffic infrastructure reacting to immediate challenges at a road junction.

The IoT in its present shape is only the start of a journey towards something even bigger and more impactful – the artificial intelligence of things[44]. That means shifting from smart technologies that can communicate with each other to systems where artificial intelligence makes decisions on our behalf. Expanding the IoT with cognitive functions such as learning, problem-solving and decision making will multiply the possibilities to interact with the physical world. From autonomous vehicles to smart digital assistants, we are seeing rapid progress. Artificial intelligence derived predictions about when energy usage is highest can point to ways to reduce consumption, and data about when and where shared bikes are used can ensure that enough bikes are in the right places at the right time.

With data collected by embedded intelligent sensors and devices, Connected City Solutions supports smart city management and enables public convenience.

Connected City Solutions in Hong Kong

To unleash the potential of digitalization, the MindSphere Application Center for cities (also known as Smart City Digital Hub) was set up by Siemens at Hong Kong Science Park to create an innovative ecosystem and tackle city challenges with Siemens smart technologies. MindSphere is an open, cloud-based IoT operating system from Siemens that allows machines and physical infrastructure to connect to the digital world.

Sensors will play a crucial role, providing the 'senses' to intelligent platforms. The Embedded City Box (ECB), deployed in the Suzhou Industrial Park, Suzhou, Jiangsu, contains a number of sensors collecting real-time information such as video, temperature, humidity, light intensity, WIFI, infra-red, RFID, location and pollution. With data collected by embedded intelligent sensors and devices, Connected City Solutions integrates the Internet of Things, cloud computing and connectivity technologies to support smart city management and enable public convenience.
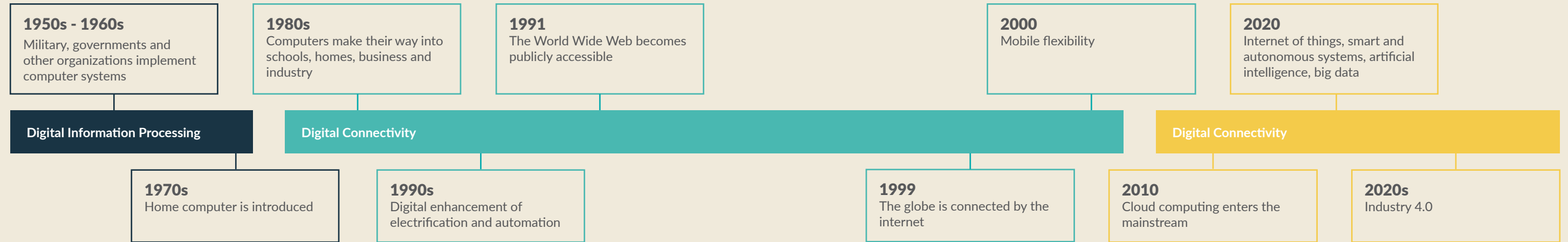

Green City Digital Platform in Guangzhou, Guangdong province

Located at the heart of the Pearl River Delta district, Sino-Singapore Guangzhou Knowledge City (SSGKC) is to be developed as a vibrant hub that appeals to global talent in the knowledge economy and will have a population of 500,000 people within the next 15 to 20 years. The 123 km² Guangzhou Knowledge City (GKC) began its development in 2010 and was updated as a national level bilateral cooperation project in November 2018. The knowledge-based city will comprise hi-tech business parks, residential, commercial and public amenities with two metro lines. In July 2018, Siemens signed MoU with SSGKC to jointly develop the City Air Management (CyAM) and Green City Digital Platform in GKC. Both Siemens and SSGKC will also be exploring the establishment of a Green City Digital Exhibition Center, which will be considered as the showcase to demonstrate how digital city solutions will support and facilitate GKC to become a sustainable, eco-friendly, knowledge sharing and smart city.
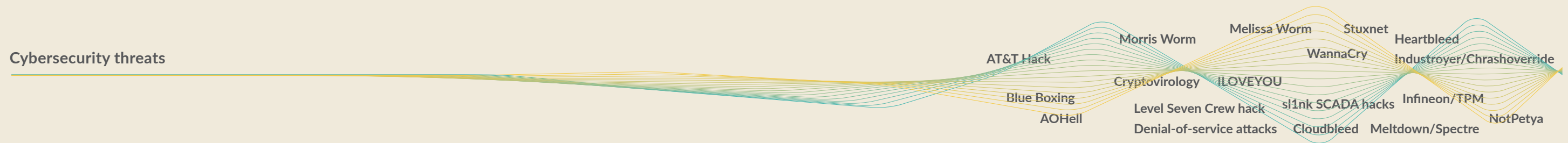
Guangzhou is the first city to commit to use CyAM, a cloud-based software suite with a dashboard that displays real-time information on the air quality detected by sensors across a city and predicts values for the upcoming three to five days. CyAM allows cities to monitor, predict and simulate air quality. Using artificial intelligence, it allows cities to see forthcoming air pollution levels and plan actions from a set of measures that can be implemented at short notice to improve air quality. Examples of such measures include establishing low-emission zones, reducing speed limits and offering local public transportation services at no charge for a limited period. CyAM will be the first solution on the jointly developed Green City Digital Platform. The platform, powered by MindSphere aims to tackle the city's challenges in an open, interactive and holistic manner. Following CyAM further modules will be deployed around smart traffic, smart energy, intelligent buildings and smart manufacturing.

Advances in digitalization have led to continuous development of cybersecurity threats

Advances in digitalization

1950s - 1960s	1980s	1991	2000	2020
Military, governments and other organizations implement computer systems	Computers make their way into schools, homes, business and industry	The World Wide Web becomes publicly accessible	Mobile flexibility	Internet of things, smart and autonomous systems, artificial intelligence, big data

Digital Information Processing   **Digital Connectivity**   **Digital Connectivity**

1970s	1990s	1999	2010	2020s
Home computer is introduced	Digital enhancement of electrification and automation	The globe is connected by the internet	Cloud computing enters the mainstream	Industry 4.0

Cybersecurity threats

AT&T Hack
Morris Worm
Melissa Worm
Stuxnet
Heartbleed
WannaCry
Industroyer/Chrashoverride
Cryptovirology   ILOVEYOU
Blue Boxing
sl1nk SCADA hacks   Infineon/TPM
Level Seven Crew hack
AOHell
NotPetya
Denial-of-service attacks   Cloudbleed   Meltdown/Spectre

Safety & Security

Cybersecurity and privacy

Digitalization is transforming many sectors for the better, but the risk of exposure to malicious cyber-attacks also grows and becomes more sophisticated. If citizens are to 'buy-in' to smart cities, they must have confidence in them. Confidence that their data is safe and kept private, and that automated machines making decisions on their behalf are not placing them or their assets in danger.

The costs of global data breaches are already estimated to be two trillion dollars. Every second, five new malware variants are discovered and organizations across the globe are hit by one hundred previously unknown malware attacks every hour. Each day, one million new malicious files appear in the connected world. With ever more devices and systems connected to the internet, cybercrime has become an increasing threat to our technological assets[45].

China's cities have a digital advantage. We have already seen the willingness of the population to embrace digitalization, from shared bikes to cashless payments the take up of digital services is high. Maintaining high levels of trust and protecting data will be essential ingredients for maintaining this enthusiasm for digital services.

Keeping pace with the continuous progress of digitalization and the subsequent threats of criminal activities will require the coordinated efforts from governments, industry and society. A Charter of Trust has been established which defines and implements principles that will make digitalization safer.

Charter of Trust
The Charter of Trust focuses on three goals:

1. Protecting the data of individuals and companies

2. Preventing harm to people, companies and infrastructures

3. Establishing a reliable foundation on which confidence in a networked, digital world can take root and grow

The Charter is based on ten key principles to deliver the goals. Many pioneers of digitalization are working together through the Charter of Trust to intensify the cooperation between companies and policymakers and create a common understanding of cyber threats. The Charter of Trust members are currently AES, Airbus, Allianz, Atos, Cisco, Daimler, Dell Technologies, Enel, IBM, MSC, NXP, Siemens, SGS, Deutsche Telekom, Total, Mitsubishi Heavy Industries and TÜV SÜD.

## Charter of Trust for a secure digital world

1 Ownership of cyber and IT security
Anchor the responsibility for cybersecurity at the highest governmental and business levels by designating specific ministries and CISOs. Establish clear measures and targets as well as the right mindset throughout organizations – "It is everyone's task."

2 Responsibility throughout the digital supply chain

Companies – and if necessary – governments must establish risk-based rules that ensure adequate protection across all IoT layers with clearly defined and mandatory requirements. Ensure confidentiality, authenticity, integrity, and availability by setting baseline standards, such as

- **Identity and access management**: Connected devices must have secure identities and safeguarding measures that only allow authorized users and devices to use them.

- **Encryption**: Connected devices must ensure confidentiality for data storage and transmission purposes wherever appropriate.

- **Continuous protection**: Companies must offer updates, upgrades, and patches throughout a reasonable lifecycle for their products, systems, and services via a secure update mechanism.
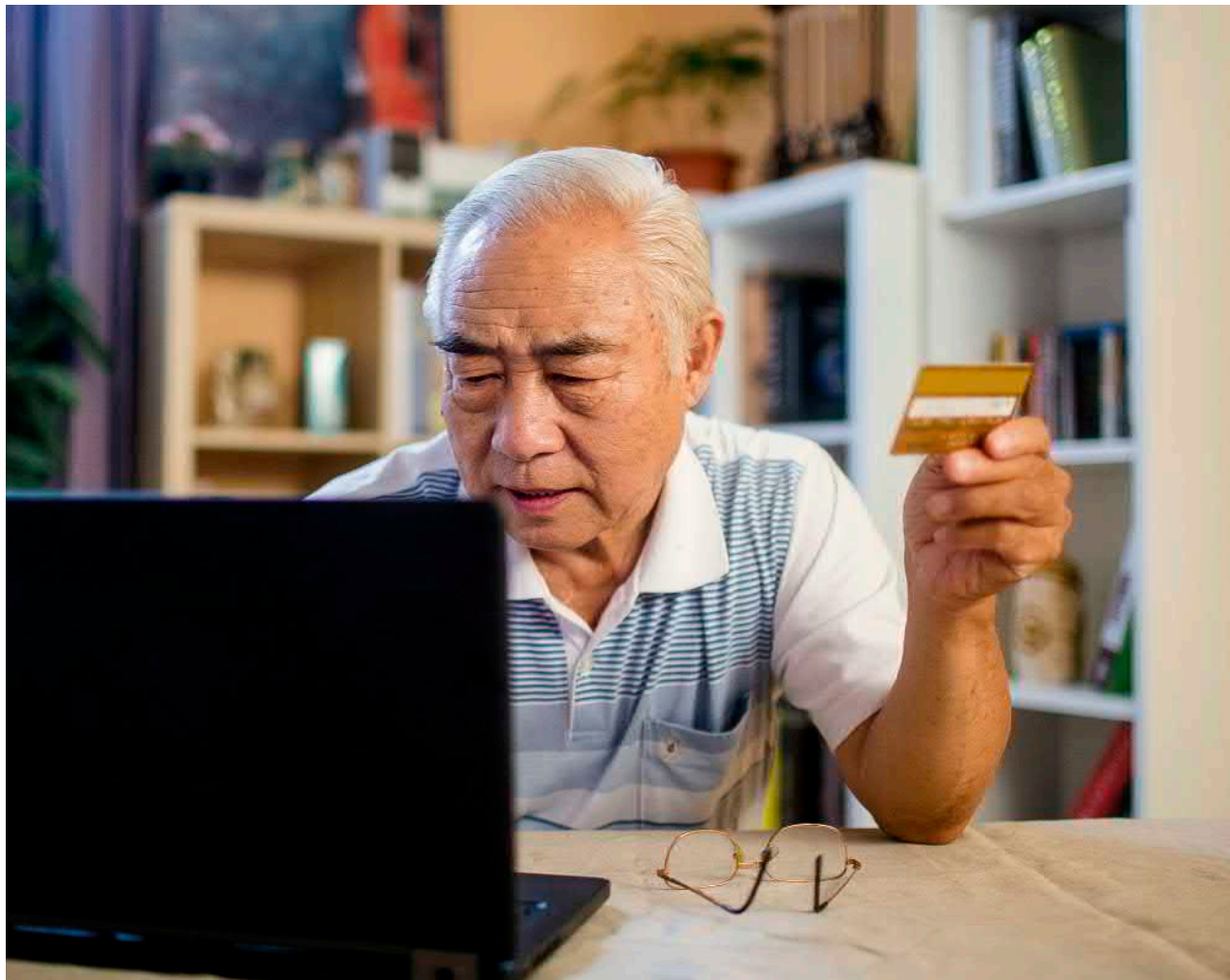
3 Security by default
Adopt the highest appropriate level of security and data protection and ensure that it is preconfigured into the design of products, functionalities, processes, technologies, operations, architectures, and business models.

4 User-centricity
Serve as a trusted partner throughout a reasonable lifecycle, providing products, systems, and services as well as guidance based on the customer's cybersecurity needs, impacts, and risks.

5 Innovation and co-creation
Combine domain knowhow and deepen a joint understanding between firms and policymakers of cybersecurity requirements and rules in order to continuously innovate and adapt cybersecurity measures to new threats; drive and encourage i.e. contractual Public Private Partnerships.

6 Education
Include dedicated cybersecurity courses in school curricula – as degree courses in universities, professional education, and trainings – in order to lead the transformation of skills and job profiles needed for the future.

7 Certification for critical infrastructure and solutions
Companies – and if necessary – governments establish mandatory independent third-party certifications (based on future-proof definitions, where life and limb is at risk in particular) for critical infrastructure as well as critical IoT solutions.

8 Transparency and response
Participate in an industrial cybersecurity network in order to share new insights, information on incidents, report incidents beyond today's practice which is focusing on critical infrastructure.

9 Regulatory framework
Promote multilateral collaborations in regulation and standardization to set a level playing field matching the global reach of the WTO; inclusion of rules for cybersecurity into Free Trade Agreements (FTAs).

10 Joint initiatives
Drive joint initiatives, including all relevant stakeholders, in order to implement the above principles in the various parts of the digital world without undue delay.
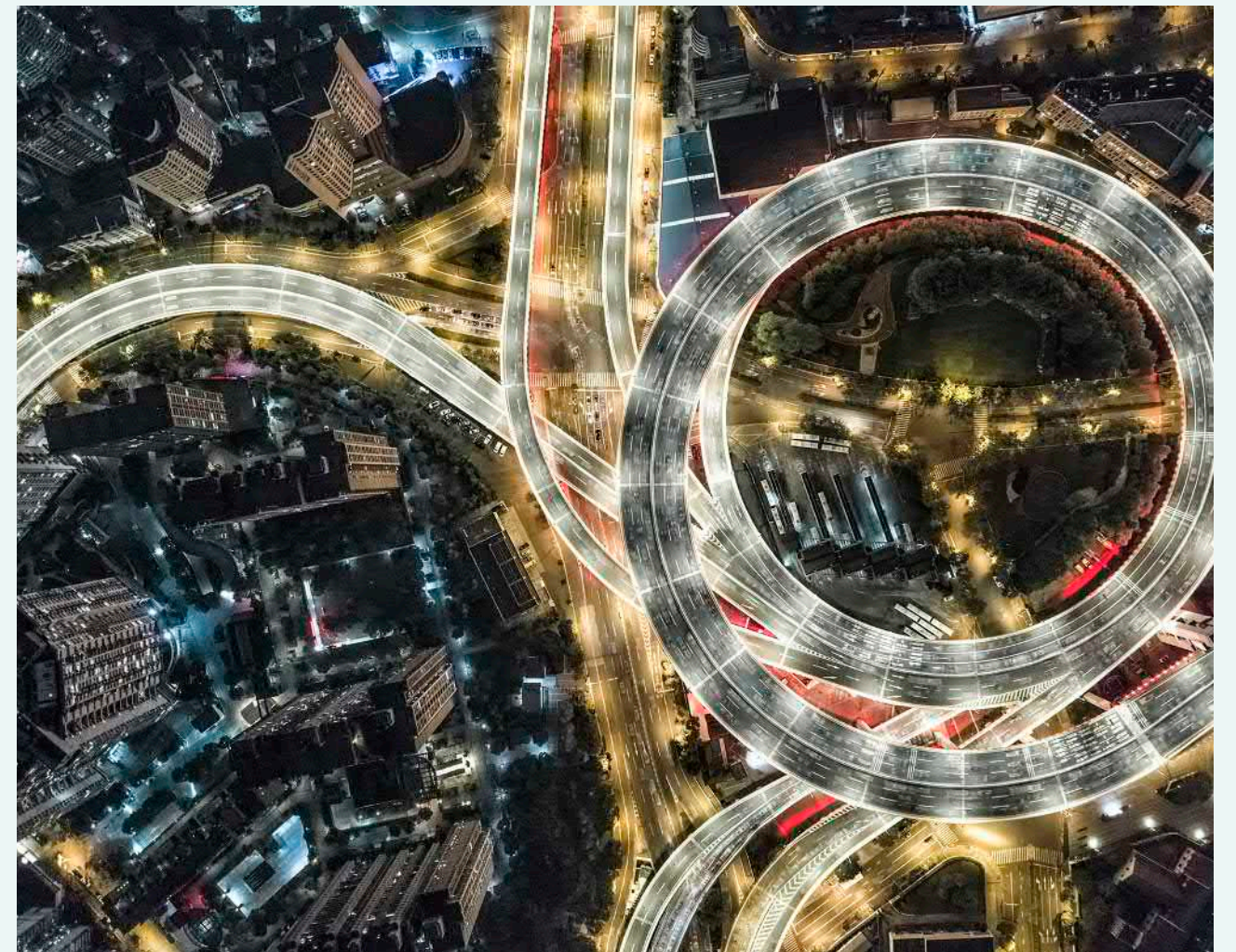
Safety in the digital world

Digitalization offers the prospect of increased efficiencies, unmatched flexibility and innovative business models in the development of a smart city. But this new connectivity also translates to a shift in the risk landscape, as cyberattacks on industrial systems are constantly increasing. Against this backdrop, end users, suppliers and system integrators must optimize the cyber resilience of their components and systems by improving development, integration and support processes.

A security breach involving a connected industrial application can put an entire facility at risk and the consequences for operations, people and equipment could be devastating. Consequently, end users, suppliers and system integrators are required to mitigate risk, even when the prospective configuration and the potential threats are still largely unknown.

In 2018, for instance, a Chinese supplier providing a power dispatch system to a power company faced for the first time the challenge of presenting evidence of industrial cybersecurity compliance with international requirements. Thereafter they partnered TÜV SÜD to create trainings tailored to their needs.

Research & Development engineers and all relevant parties within the company involved in the cybersecurity analysis were trained on the topic before a model for cybersecurity threats and vulnerabilities was developed. Together with TÜV SÜD experts, the system was thoroughly tested, including penetration testing, fuzzy testing, functional testing, abuse testing, and others. These tests ensure that all weak points in the system are identified and protective measures are implemented. Once all documentation required as evidence for compliance with IEC 62443 is finalized, TÜV SÜD can issue the final certification for the system.

TÜV SÜD's approach is to provide a holistic cybersecurity solution to achieve a "secure-by-design" product/system throughout the product's life cycle. TÜV SÜD's cybersecurity services aim to enable organizations to understand the security context, actively shape it and ultimately initiate processes in order to integrate security technologies sensibly into their core processes.

Keeping cities, people and assets safe

As well as digital threats, cities need to manage physical ones. Key to security systems is a proven holistic approach. Taking this approach offers value to city authorities, emergency services like police and rescue, as well as the private sector and the citizens. Integration of different systems and the communication between key factors are central aspects to maximizing the effectiveness of both prevention and response relating to security and safety issues.

Having too many separate systems makes it difficult to monitor and manage incidents as well as coordinate an effective response. Technology can help to integrate systems, improve the detection of incidents and automate an appropriate response as well coordinate a response between different agencies (such as police, fire, ambulance, security).

Some of the ways in which digitalization is improving and enhancing the safety and security of cities are explored further below.

Crime and security

Security operations center
Digital tools are transforming urban policing and helping authorities do more with their resources. Many cities around the world now have high-tech command centers that collect real-time information and share across agencies.

Emergency management
Quickly reacting to events needs effective planning and coordination of all remedial or preventive procedures. To take the right decisions in dangerous situations, a complete overview of the current situation and the available emergency personnel is needed. Structured operational sequences also ensure the fastest possible implementation of the deployment of security or emergency personnel.

Tying together all sub-systems currently used can help protect and manage sites and key assets, but also allow for the customization and integration of security policies and procedures across wide areas.

Crime analytics / predictive policing
Real-time crime mapping and predictive policing are two of the applications that could have an impact on cities. Crime mapping uses statistical analysis to identify higher crime areas from existing crime and associated data. This can enable the more effective deployment of police resources.

Predictive policing strategies analyze data to try and anticipate crimes before they happen, allowing cities to allocate police resources across geographies and times of the day more effectively and proactively reduce crime.

Intelligent video surveillance
Surveillance cameras in highly frequented public areas or around key infrastructure are a common used security option. Whilst they discourage some criminal activity in the first instance, what really matters is not so much the camera hardware but rather the intelligence and integration capabilities beyond the camera. Intelligent video analytics improve the identification of incidents by automatically identifying irregular events and alerting operators, so that a response can be taken swiftly and effectively. Studies show that after 12 minutes of viewing two or more monitors, up to 45 percent of activities are missed through human operator error. Technology reduces human errors in prevention of incidents.

Access control and Intrusion detection
Access control and time tracking systems allow authorized individuals to move about buildings or campuses freely while keeping unauthorized persons out. Advanced systems allow for real-time changes to data with immediate effect through entire systems.

Solutions for every emergency response

Mobile system solutions for emergencies, patient transport and disaster medicine need to withstand the toughest conditions and satisfy the most stringent requirements. Making sure emergency medical professionals and hospital personnel have the right medical equipment is crucial in ensuring successful emergency and transport ventilation. Using machine ventilation means the personnel deployed can keep their hands free and get on with other important tasks. Furthermore, constant ventilation frequency and constant volume mean that excessively aggressive ventilation can be avoided and consistent ventilation quality guaranteed.

Weinmann Emergency ventilation consists, among other devices, of emergency and transport ventilators, the MODUL system for therapy and oxygen inhalation as well as resuscitators. Components can be compiled for application areas for use by emergency medical services, military medical corps or in the hospital. Since 2014 Weinmann have been working with the Shanghai emergency management systems. Over 150 units have been placed in centers across the city, providing important first steps in upgrading the city's emergency service.

Making sure emergency medical professionals and hospital personnel have the right medical equipment is crucial in ensuring successful emergency and transport ventilation.

In 2040, China's households will consume twice as much electricity as they do now. Buildings (both new and existing) must become increasingly efficient in their energy use, if China is to cope with the demands.

Buildings and Energy

The transformation of energy generation away from fossil fuels and increasing electrification of buildings and mobility powered by renewable energy will bring the energy and building sectors ever closer together. Smart buildings in the future will have a two-way relationship with energy grids, not only consuming energy, but also generating and storing it and making it available to electric vehicles or for use in periods of high demand. Buildings (both new and existing) must become increasingly efficient in their energy use, if China is to cope with the demands of a growing urban population. Greater electrification will drive greater levels of automation, opening more opportunities for digitalization.

Energy

Meeting rising demand through new sources of power generation

Energy consumption has tripled since 2000 and fossil fuels are the main source of energy with coal providing 60 percent of energy and oil 19 percent. Coal is also the most significant energy source for electrical power generation (66 percent in 2016). Hydro power accounted for just under 20 percent. While renewable energy sources such as wind and solar are growing quickly, they accounted for four and one percent respectively.

The installed generation capacity has grown from 793 GW to 1,777 GW over the last decade. Over that time wind and solar energy have grown from zero to 164 GW and 135 GW capacity. Thermal power plants have also grown from 651 to 1,106 GW. However, the majority of China's installed generation capacity remains thermal and around 85 percent of all thermal power plants are coal fired.

Despite more modest forecasts for economic growth in the future, demand for energy will continue to grow. Electrification will become the leading source of final energy consumption by 2040, overtaking coal in the late 2020s, and oil shortly thereafter. In 2040, China's households will consume twice as much electricity as they do now[46]. Renewables will also be directly used in some sectors for example in solar thermal heating or biofuels in transport.
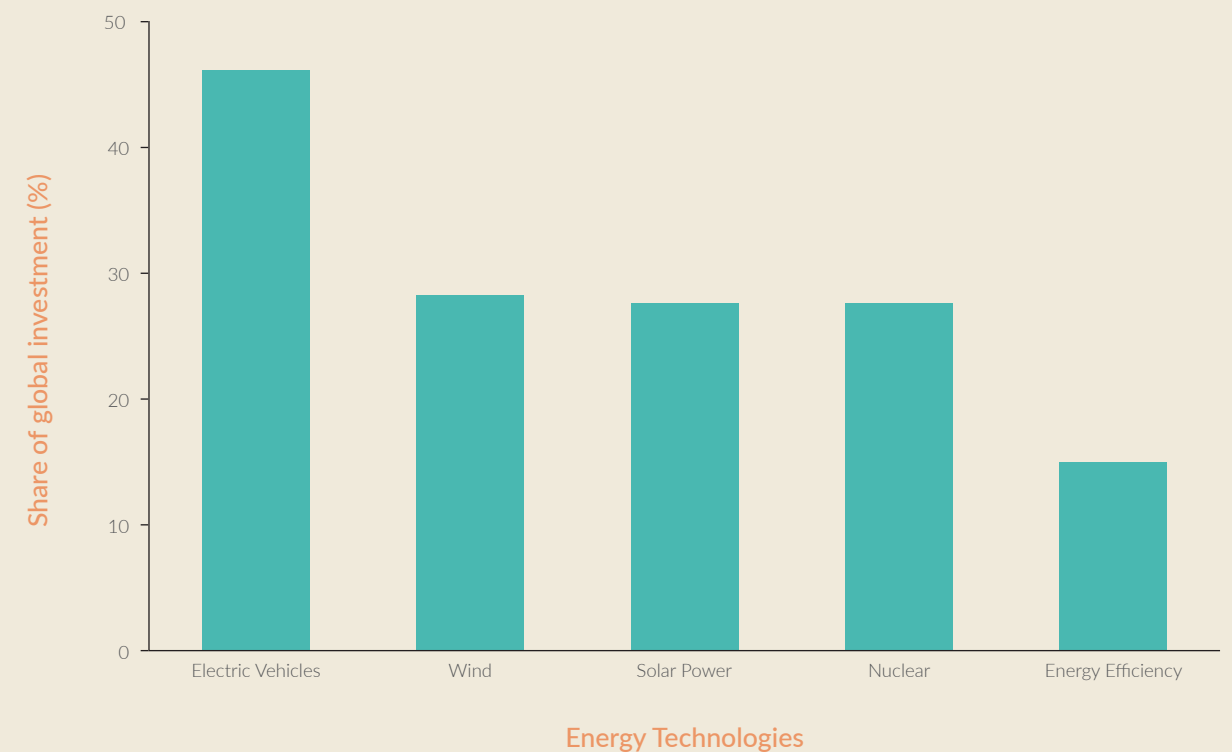
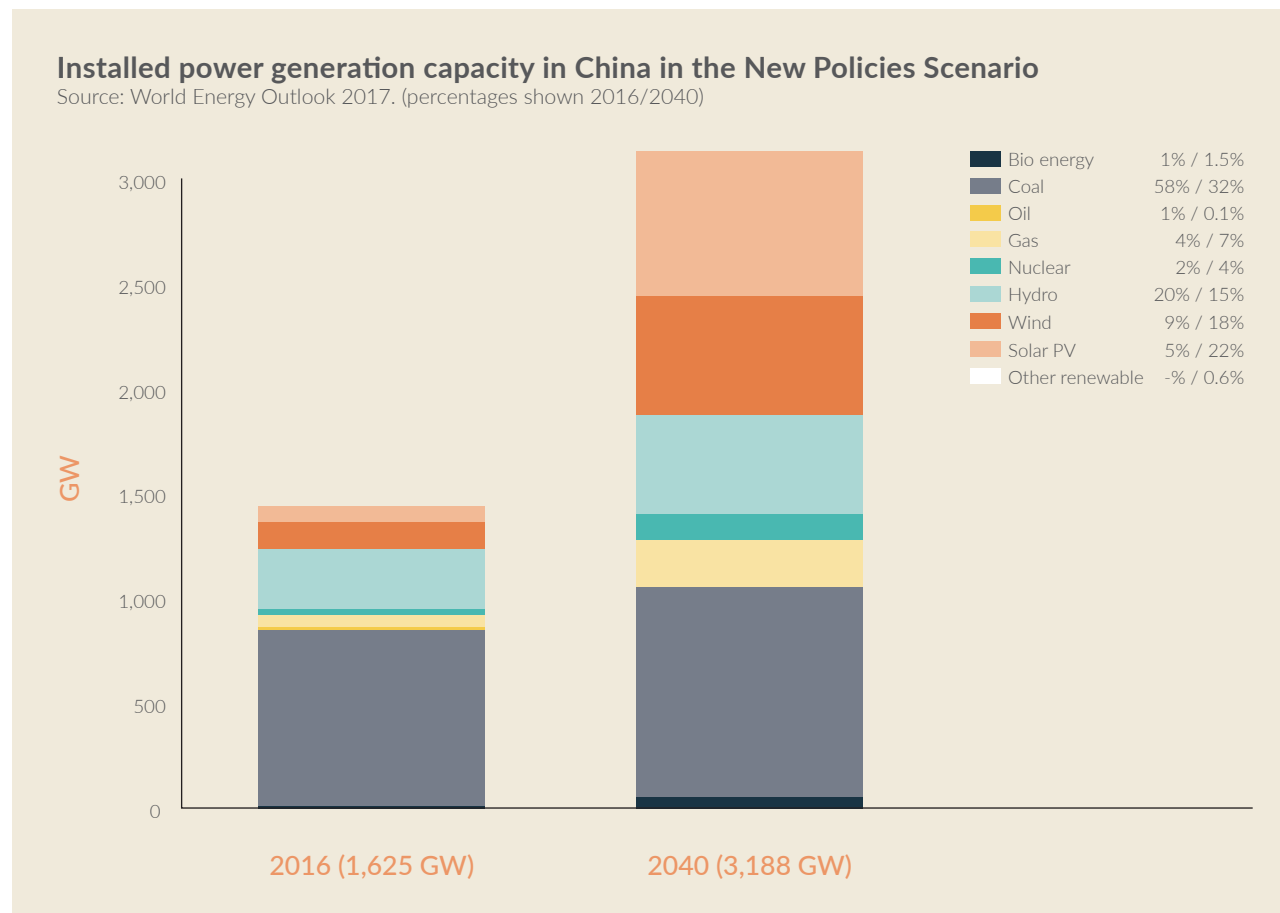**Energy consumption since 2000 by energy source**
Source: China Statistical Yearbook, 2018
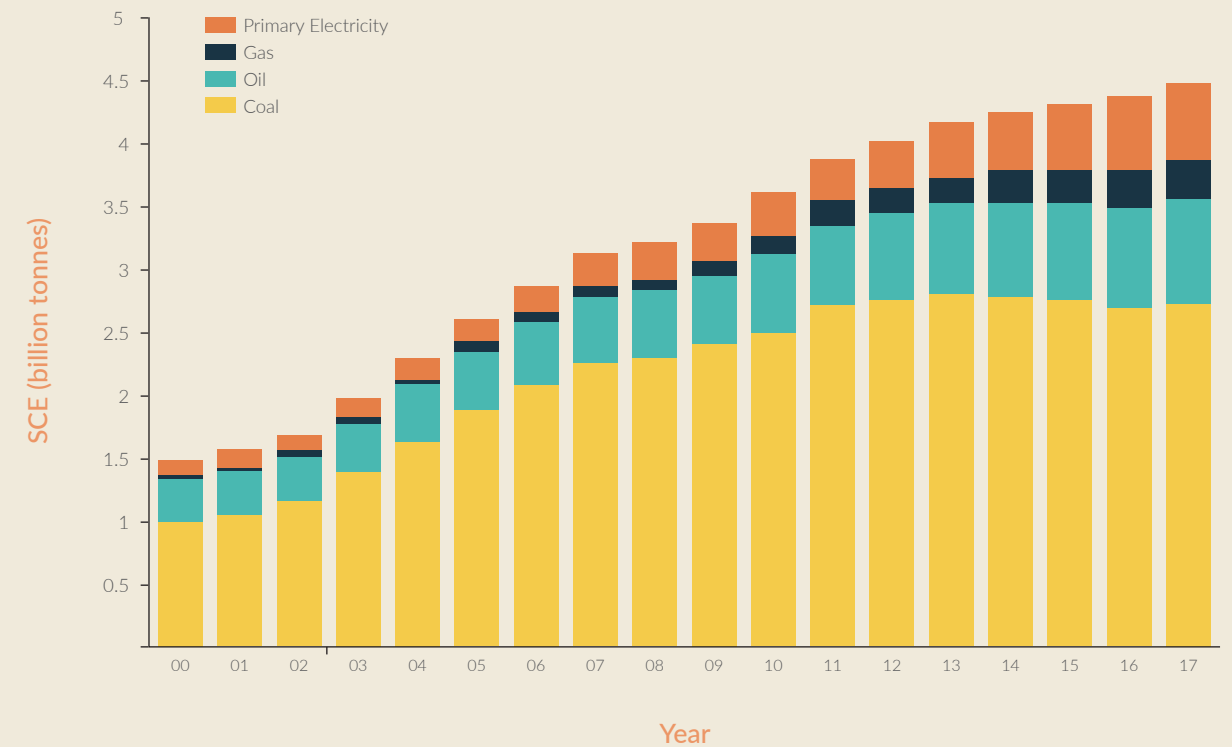
China's share of global investment in clean energy technologies
Source: IEA, World Energy Outlook 2017

Installed power generation capacity in China in the New Policies Scenario
Source: World Energy Outlook 2017. (percentages shown 2016/2040)

	2016/2040
Bio energy	1% / 1.5%
Coal	58% / 32%
Oil	1% / 0.1%
Gas	4% / 7%
Nuclear	2% / 4%
Hydro	20% / 15%
Wind	9% / 18%
Solar PV	5% / 22%
Other renewable	-% / 0.6%

2016 (1,625 GW)   2040 (3,188 GW)

Driving a low carbon future

China is playing an important role in transitioning the world from fossil fuels to cleaner forms of energy. With installed capacity set to double by 2040, China's power mix could look very different from today. The vast majority of the growth will be met through increasing renewable energy. Wind power will grow its share from nine percent (146 GW) to 18 percent (573 GW) and solar from five (81 GW) to 22 percent (637 GW). Gas and nuclear will also play greater roles than at present (98 GW to 351 GW). This shift is globally important as much of the investment in new technology is being driven in China.

A new electrical future needs a smart grid
Growth in demand and the need to replace aged infrastructure reaching the end of its serviceable life present the opportunity to rethink our energy systems, without creating "stranded assets." The need for stable energy prices and resilience of city infrastructure to shocks, are also shifting the energy conversation towards the small and local. The economies of scale that created large electricity producers are diminishing, although we may still rely on them in the near term, while the advance of digitalization presents the opportunity for more local networks to interact with city-scale ones.

The 12th five-year plan identified smart grid development as a national priority. The country's electric grid is overseen by two companies, State Grid Corporation of China (SGCC) and China Southern Power which are putting in place plans for strong and smart power grids by 2020.

A smart grid offers many benefits:
• More efficient distribution of electricity
• Greater resilience of electrical grids
• Reduced operations and management costs for utilities, and ultimately lower power costs for consumers
• Reduced peak demand, which will also help lower electricity requirements
• Increased integration of large-scale renewable energy systems and reduced air pollution and greenhouse gas emissions
• Better integration of customer-owned power generation systems, including renewable energy systems
• Improved reliability
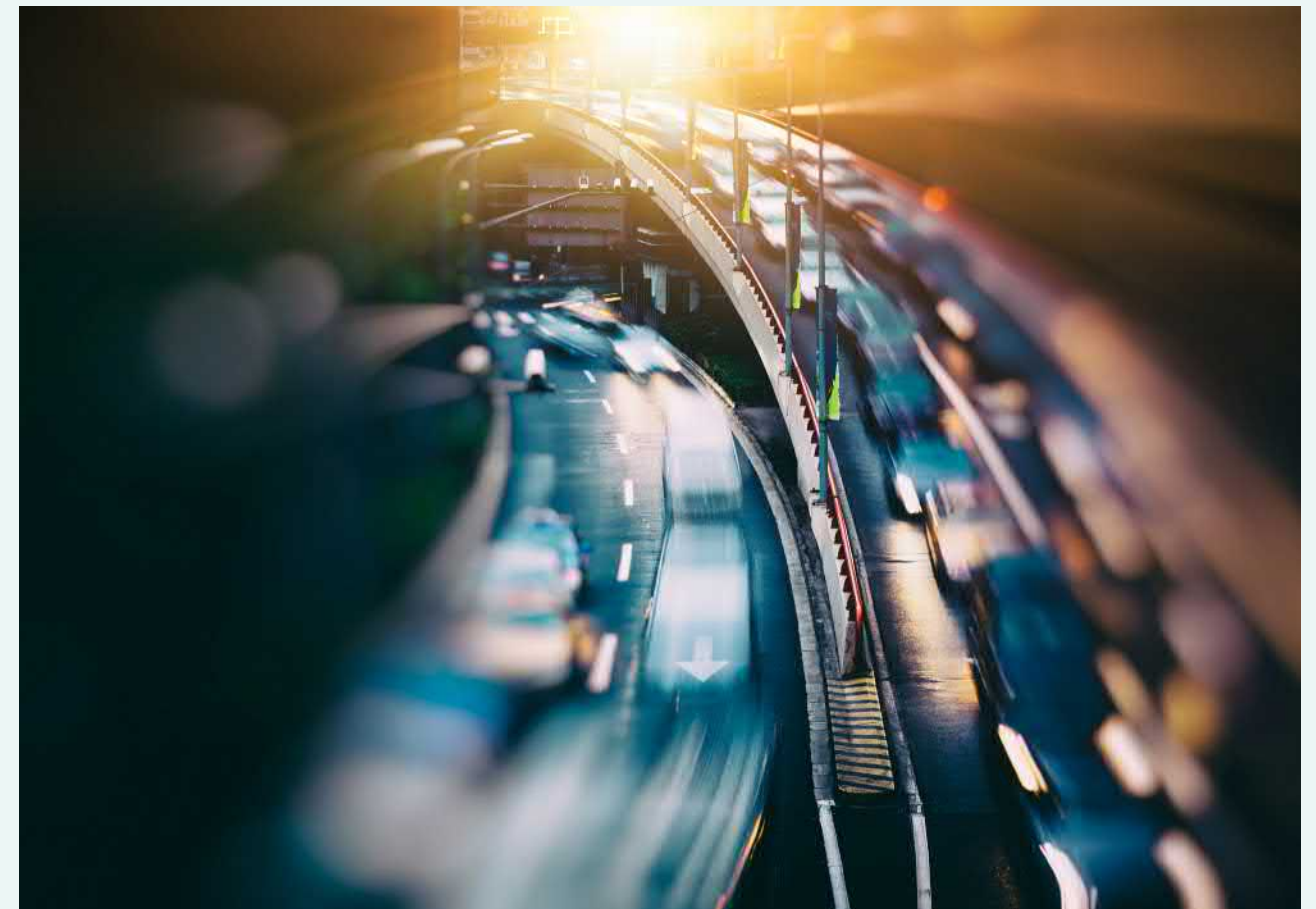
Smart solutions for integrated energy transition and climate protection in City of Suzhou, Jiangsu Province

The German Energy Agency (dena) is Germany's center of expertise for energy, efficiency, renewable energy and intelligent energy systems. It develops solutions and puts them into practice by bringing together partners from government and industry. In the city of Suzhou, dena is supporting the State Grid Corporation of China (SGCC) to deliver one of the most innovative urban energy systems worldwide. 'Tongli New Energy Town', located about two hours west of Shanghai, showcases smart state of the art and climate friendly technologies.

dena, in partnership with the E.ON Energy Research Center at RWTH Aachen University, has developed an innovative and unique simulation tool for calculating an optimized and integrated energy system. The simulation tool calculates the interdependencies of heat, cooling and electricity.

The simulation provides an optimized mix of standard as well as cutting-edge technologies that reconcile energy demands with existing resources, mainly from renewable energy.

In addition to this, dena has created a holistic assessment method to monitor achievements throughout the planning, implementation and operation phases of the project. Objectives are translated into measurable assessment categories and indicators. The foundation for this is a set of guidelines for the development of specific plans and processes, including an integrated energy, building, mobility, land-use as well as a participation plan.

The opportunity for decentralized energy networks in cities

The development of affordable alternative energy sources creates the opportunity to develop a more flexible, cleaner and efficient local system, allowing building owners or local producers to generate and sell electricity. Establishing and promoting local energy networks are complementary to improvements to the centralized smart grid, taking pressure off the system, reducing centralized capacity requirements and increasing resilience of networks.

Digitalization enables providers to better manage peaks and troughs of energy use and produce at least a portion of the power locally from renewable or low carbon sources. Decentralized energy systems do not necessarily mean creating totally isolated energy systems, because resilience means maintaining options, but it could mean that new developments or districts in cities use cleaner more efficient locally generated electricity, may heat some buildings with heat pumps, and store excess power in batteries to help with peak demand. Decentralized energy takes pressure of city distribution networks and regional power grids.

Demand Response

With more fluctuating energy sources such as solar or wind power plants there is a need for greater flexibility on both the generation and the demand side. This will compensate for the fluctuating in-feed and allow operators to optimize and stabilize local distribution networks.

Demand Response provides the flexibility needed to enable consumers to respond to price signals or network utilization. If there is under-frequency in the grid, large consumers such as large-scale, industrial heat pumps or fans can be switched off, or loads can be switched on in the case of excess supply, such as from PV panels on a sunny day. Demand response allows the bundling of energy loads and energy generation, as well as the possibility to offer this flexibility in reserve energy markets.

Virtual Power Plants

A virtual power plant is an association of decentralized units in the power grid, which are coordinated via a common control system. The units can be electricity producers, including biogas turbines, wind power, photovoltaic, combined heat and power plants, hydroelectric power plants, electricity consumers, electricity storage and Power-to-X (Power-to-Gas, Power-to-Heat) plants.

The Virtual Power Plant enables the flexible aggregation of power from the connected assets. The individual units are managed by a central control system, which not only coordinates the individual systems by means of a special algorithm but also reacts to network conditions and reserve energy call commands by transmission system operators. Virtual Power Plants can react quickly and efficiently to price signals from the electricity markets and adapt their operational style accordingly.

On-Site Energy Storage – Thermal and Battery

On-site electrical or thermal energy storage allows excess electricity or heat within a system to be stored. Storage will help both centralized smart grids and microgrids to balance renewable wind and solar sources and manage peak loads. Storage could close the gap in daytime and night-time electricity prices, as they can be programmed to sell or provide stored energy at a certain price point. Real-time selling of electricity at a specific price point is not yet possible for relatively small users like households, but it is expected to become a new normal in the near future.

Batteries and thermal storage allow for the storage of energy in the form of heating, cooling or electricity. Thermal energy storage is possible through a variety of systems, including heat storage in steam tanks, hot stones, concrete, or molten salt. Excess electrical power can also be converted to a gas fuel (power-to-gas).

A role for blockchain

Blockchain is one digital technology predicted to disrupt the energy sector. It is already used to allow local generators to connect to consumers locally[47]. According to the World Energy Council, blockchain "has the potential to change the way we arrange, record and verify transactions, with the underlying model shifting away from a centralized structure (exchanges, trading platforms, energy companies) towards decentralized systems (end customers, energy consumers interacting directly)"[48]. This means creating more direct relationships between energy producers and consumers and making it easier for small providers to participate in the energy market, on a scale that can disrupt the whole sector. These changes are not so far off – 87 percent of industry experts expect major changes in less than five years[49].
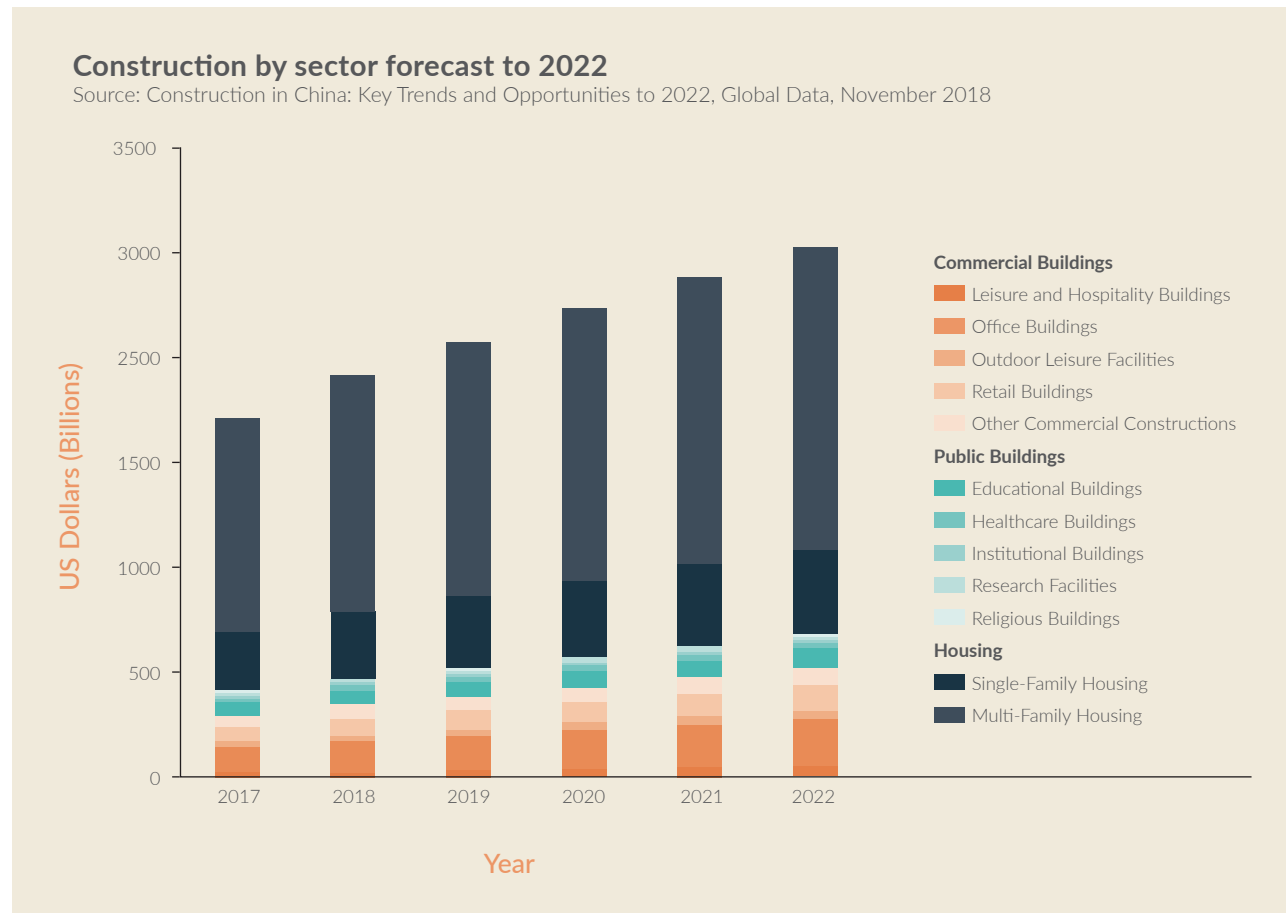

Energy storage solutions for smart grids

The energy transformation is changing power infrastructure all over the world. Increasing renewable energy integration into traditional power grids requires reliable technologies to minimize the loss of efficiency or blackouts. With China's significant growth in renewable energy, lithium battery energy storage systems are becoming a critical component in smart grids.

The country's push to replace internal combustion engine vehicles with electric vehicles (EVs) until 2040 will call for more demand on power generation and puts further strain on the existing power grid. Energy storage systems will become the cornerstone of new smart grids and support the additional demand from EVs. Their reliability, safety and peak-performance are key to enable the nation's smooth transition to an electrified mobility.

Testing and certification of power devices against conformity requirements and standards are fundamental measures to build up a reliable smart grid. With experience and know-how in renewable energy and battery technology, TÜV SÜD has developed a battery energy storage system guideline with the China Energy Storage Alliance (CNESA), headquartered in Beijing.

The alliance addresses the complexity of concerns relating to safety, environmental impact, power quality, energy efficiency, and more. As an independent testing, inspection and certification body, TÜV SÜD supports the safe handling of energy storage technology in China.

Construction by sector forecast to 2022
Source: Construction in China: Key Trends and Opportunities to 2022, Global Data, November 2018

US Dollars (Billions)

Year

Commercial Buildings
- Leisure and Hospitality Buildings
- Office Buildings
- Outdoor Leisure Facilities
- Retail Buildings
- Other Commercial Constructions

Public Buildings
- Educational Buildings
- Healthcare Buildings
- Institutional Buildings
- Research Facilities
- Religious Buildings

Housing
- Single-Family Housing
- Multi-Family Housing

Obermeyer

Buildings

China's built environment
Buildings account for 20 percent of China's greenhouse gas emissions, second only to industry. Between 2001-2014 primary energy and power consumption in buildings in China doubled. In 2014 it was estimated that China's urban centers had 30.7 billion m² of floor space of which 21.3 billion m² (69 percent) were residential and 9.4 billion m² were public and commercial buildings[50].

New buildings
New construction provides an opportunity to build more efficient and future proof buildings. Housing accounts for around 72 percent of the new build expected by 2022, with nearly four fifths multi-family housing. Commercial properties by 2022 amount to around 21 percent and just over six percent are public buildings. The total construction value in 2022 is forecast as 3,981 billion US dollars. Cities should think carefully how they use their own new buildings to drive better outcomes and how they can support exemplar buildings through the use of their planning powers.

Constructing sustainable buildings
China rolled out its national standards for green buildings in 2006. There are three levels of green building certifications now in China. In 2016, 700 construction projects had achieved the top two levels of green building certifications[51]. By 2020 China's market size of the green building consultancy services is expected to be 5.8 billion yuan[52].

China has set a goal of 30 percent green buildings for new construction in 2020. By setting more aggressive targets cities will reduce pressure on energy, water and power systems whilst helping deal with pollution. Failing to do so will ultimately require more expensive future retrofit of buildings. Cities can focus on improving their own existing buildings which will not only reduce their resource consumption but make their operation cheaper.

Building Information Modeling
Building Information Modeling (BIM) supports planning, construction and operation of buildings. BIM allows for simulation of energy consumption and usage scenarios and helps future-proof buildings.

The core of BIM is a 3-D digital model that, in addition to dimensions and room positions contains information on materials, time sequences, costs and usage. Data can be exchanged between all parties involved in the planning, construction and operation of the building, allowing a comprehensive and efficient consideration of a building throughout its lifecycle.

Driving new standards for buildings in Qingdao, Shandong province

Sino-German Eco Park in Qingdao is one of the leading examples for future and smart city objectives. The 12 km² large zone west in Huangdao includes offices and retail, residential areas, a university, a football campus and industrial land. The mixed-use approach decreases traffic, encourages urban density and provides large areas of public realm.

The construction of the German Enterprise Center in Qingdao planned according to the German DGNB building certification system and using state of the art technology delivers a building complex with energy consumption 45 percent below a Chinese reference building. The project has been awarded the Chinese 3-star Label for Sustainable Buildings and the DGNB Platinum Label. Energydesign (Shanghai) (part of EGS-plan International GmbH) delivered the energy concept and design, as well as DGNB certification services.

The German Center establishes a business platform for cooperation opportunities between small to medium sized German companies and the China market. It consists of three buildings, embedded in a landscaped park on the shores of the Heluofu water reservoir. It includes the German Center, an administrative building, a hotel, an energy center as well as a canteen, cafeteria and gym.

The outside walls are made of red clinker façade, reminiscent of North German architecture. On a plot of 28,314m², the buildings have a gross floor area of 75,384m² and between two to ten upper floors and up to two basement floors.
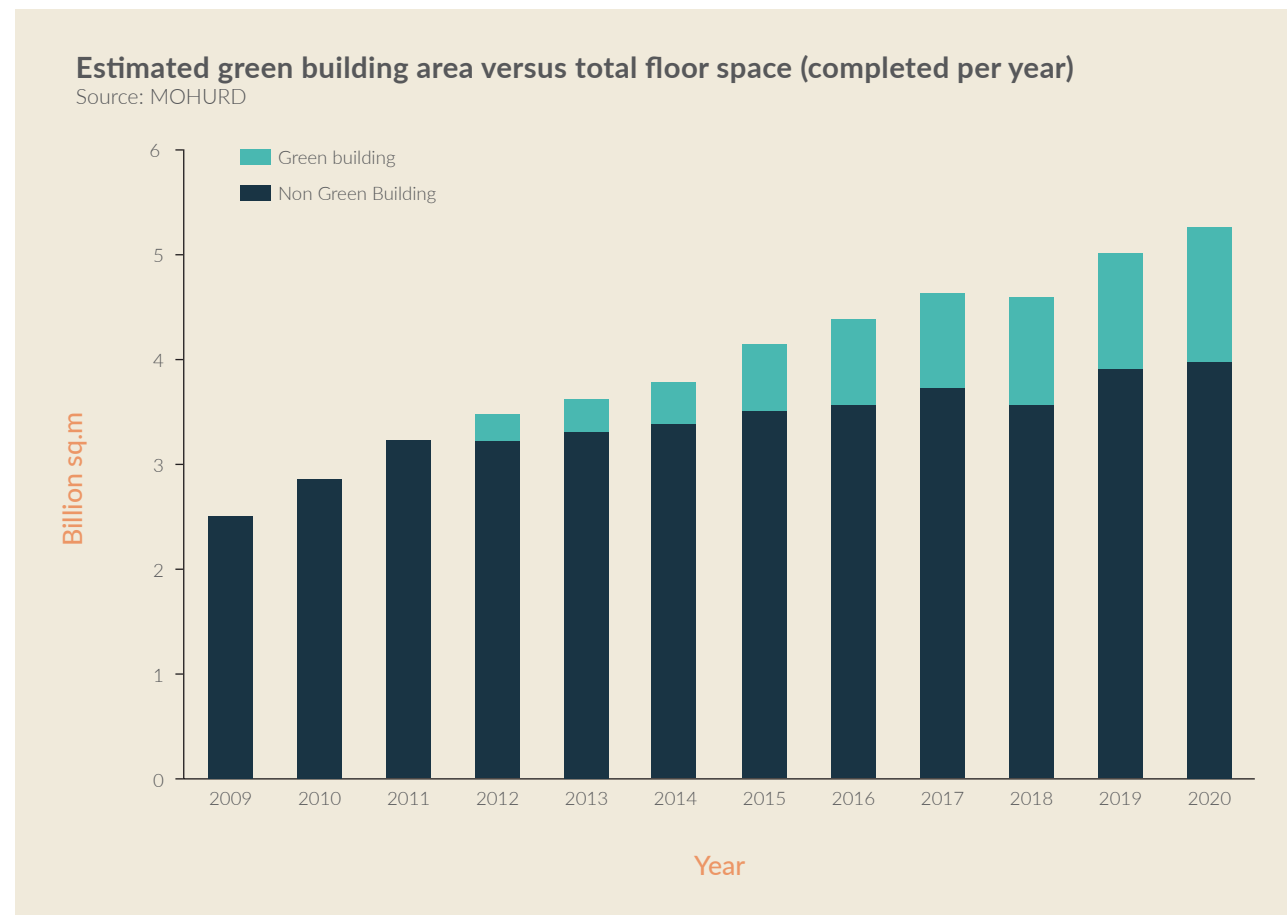
Located in the cold climate zone (A) with a heating period of 99 days a year and an average outside temperature of 2.1°C during the heating season, the building envelope is designed with a high insulation standard and high air tightness requirements.

Heating and cooling are provided by a coupled heating and power plant (CHP) with integrated absorption chiller, which provides hot water at 45/35°C and cold water at 7/12°C in summer. Photovoltaic and solar thermal systems on the three high building parts harvest renewable energy for the building services. In addition, the roofs of the 2-storey buildings of the German Energy Centre are equipped with a green roof and thus offer pleasant opportunities for retreat and direct supply of fresh air.

The Eco park originally designed by OBERMEYER and GMP was recently certified with the DGNB-Gold-Label for City Districts supported by the DGNB-auditors of Energydesign. This certification is the first of its kind in China.

For the entire Eco Park OBERMEYER developed a new green building standard based on Chinese and German standards. As a smart governance tool, the standard requires investors in the Eco Park to follow the Green Building requirements and receive certification by the Eco Park owners and operators.

The C2 cluster has been designed by OBERMEYER as a pedestrian realm, locating car traffic underground. The sloped center plaza connects the cluster with the German Center a large park in the south and includes an urban farming area in the north of the cluster.

Estimated green building area versus total floor space (completed per year)
Source: MOHURD

Legend:
- Green building
- Non Green Building

Y-axis: Billion sq.m (0, 1, 2, 3, 4, 5, 6)
X-axis: Year (2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020)

Constantin Meyer, Köln

Creating tomorrow's building stock, today

The concept of what a building can be is rapidly evolving. Rather than static boxes that house technologies, buildings themselves can become smart, automated, digitally-integrated technology systems. One of the key opportunities comes from focusing on opportunities for the integration of different building management functions, driving optimized building performance, whilst making energy use as efficient as possible. This approach allows for improved comfort, convenience and safety of their occupants. Buildings can automatically adjust the indoor environment to suit real-time weather conditions or individual preferences, while optimizing for energy efficiency.

Technologies for buildings and energy are starting to merge, becoming more synergistic. They will communicate digitally with the surrounding smart grid to sense when it would be advantageous to take electricity from the city's network, or possibly sell it to the grid for a profit.

High Performance Building Automation System

Building automation and controls are responsible for the control of indoor environmental quality. These systems are still not being used to their full potential to lower energy consumption. A building with high performing systems will maintain indoor environmental quality parameters appropriately, resulting in excellent energy performance and productive work environments.

Heating, Ventilation, Air Conditioning (HVAC)

Heating, Ventilation and Air Conditioning is used in buildings to maintain internal air quality and regulate temperatures and humidity. Internal air quality can be maintained by introducing fresh outside air and by extracting used air, by either mechanical systems including fans or by natural ventilation systems.

In commercial developments, HVAC is provided by air handling units connected to ducts, which supply air to and extracts air from internal spaces or by heating systems using gas- or oil-fired boilers to heat up water to be circulated through a system of pipes connected to radiators which deliver heat through convection. Air handling units typically comprise filters, fans, heating, cooling elements, dehumidification equipment, and dampers, heating systems comprise boilers, pipes, pumps and radiators or underfloor heating systems. HVAC can consume large amounts of energy, and where possible, supply should be reduced to the real demand by dedicated demand control strategies and passive systems adopted.

Ventilation can increase the need for heating and cooling, but this can be reduced by re-circulating a proportion of internal air, or by heat recovery systems that recover heat from air that is being extracted and uses it to pre-heat incoming fresh air.

Shifting the standard to plus-energy in Frankfurt, Germany

With Passive and Zero-Energy-Houses becoming more and more common, the focus of innovation has shifted towards the Plus-Energy-Standard. Instead of consuming as little energy as possible, the goal of Plus-Energy-Buildings is to produce more energy than the building consumes.

Architects HHS Planer + Architekten and building energy planners EGS-Plan developed the 'Active City House' in Frankfurt in 2015, which has a positive net energy balance. It produces more primary and final energy over the year than is used and has a CO_2 balance of zero.

The eight-story high building, near the city's main train station provides 74 two-, three-, and four-room-apartments on a total area of 11,700 m². Reducing energy consumption is a key part of the building. The facade (which is made from prefabricated wooden elements) is super-insulated with windows that are triple-glazed. The building envelope is extensively used for energy production. The most dominant feature is the overhanging single pitch roof, which is equipped with 1,000 high-performance PV-modules and is the building's main source for electrical energy. A further 300 PV-modules are installed on the south facade. Warm water and heating is produced by a heat pump which uses a nearby sewer as the heat source.

To further improve the energy balance, the apartments are equipped with energy saving domestic appliances and a fleet of e-cars is based on the ground floor. Every apartment provides a touch panel, where the tenants can monitor and question their individual energy consumption.

With this project the Plus-Energy-Standard has been implemented on a multi-story residential building in the downtown of a city in Germany for the first time. It shows the vast potential for Plus-Energy-Buildings in urban environments. Key factor in the realization was an integrated energetic concept: the reduction of energy consumption combined with the use of renewable energy sources on the building envelope. Not least a positive behavior of the tenants is enhanced by monitoring their energy consumption and providing a fleet of e-cars.

China has set a goal of 30 percent green buildings for new construction in 2020. By setting more aggressive targets cities will reduce pressure on energy, water and power systems whilst helping deal with pollution.
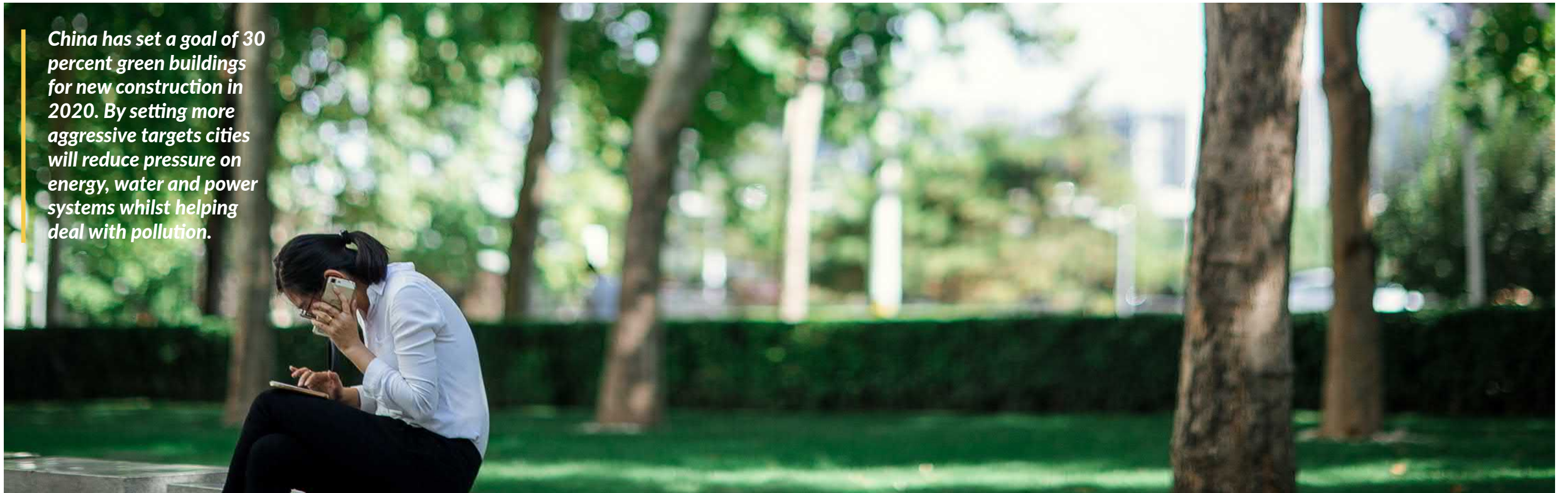
Grid-Interactive Buildings

Grid-interactive buildings will play a key role in future energy systems. They consume, generate, and store energy, reduce their own energy consumption, and communicate with the power grid. They will react to price signals from the utility and include electric vehicles into their energy strategy.

Grid-interactive buildings make use of energy storage systems. In the future, they will not only charge their storage systems with surplus energy from their own generation, they will also react to price signals from the utility and charge their storage systems at cheap tariff times from the grid. At peak demand or high tariff times, their batteries can be used to cover the electrical demand of the building, and then they will be recharged before a pick-up time agreed with the owner. By using the cheapest energy tariffs, buildings will minimize their operational costs.

Performance monitoring

In the future, performance monitoring will analyze offline and online building consumption data as it does today. But it will also analyze performance in real-time and have a direct connection to the building management system enabling it to autonomously adapt process settings to optimize comfort and energy efficiency. In the future, BMS functionality will move into the cloud and onto IoT platforms. BMS logic will at least partly stay in the building, so that it can still control itself in case of network issues or natural disasters.

Centralized and integrated building functions

A centralized, customizable platform that integrates the management of multiple disciplines, from heating, ventilation and air conditioning to lighting and shading, power, fire safety and security will drive further improvements in how buildings operate and their efficiency. Centralized building management systems allow the intelligent interaction between multiple disciplines to realize new application scenarios tailored to the requirements of the user.

Smart, digital management of space and assets means that rooms and equipment can be allocated and served efficiently. Above all, smart building security systems can more sensitively detect dangers like a fire or an intruder. As self-learning AI systems progress, buildings can continuously improve these features while requiring less human intervention, which will save valuable time and resources.

Building management platforms will integrate all aspects of a building – from building automation to fire safety, security and energy. This holistic approach will enable building managers to monitor and control different features in real time, to create synergies and to reduce operational costs.
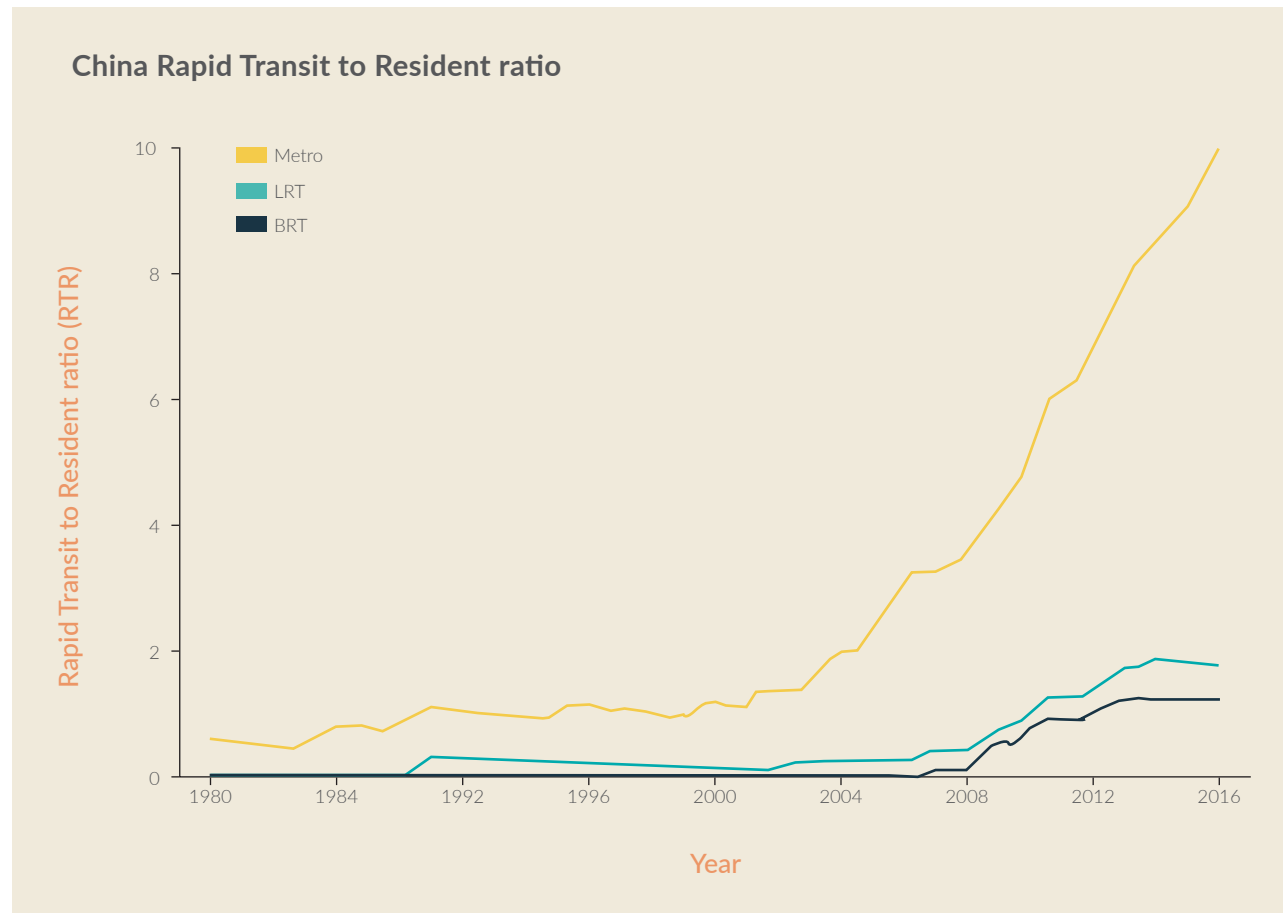
Building Data Analytics

Building data analytics software enables building managers to improve their equipment efficiency to reduce energy costs while maintaining user comfort. The key to optimizing energy performance is using sensor and meter information to take actions to eliminate any possible inefficiencies.

Digital workplace user experience

As important as optimizing energy efficiency of buildings is the interaction of the buildings systems with the users who work in the building or have the task to run it. Smart Apps offer the ability to connect, control, and communicate with the workplace. Their features help users adjust lighting, find and book available rooms and desks, and share immediate feedback with workplace teams.

Location-based services will allow building users to define their own individual comfort profiles that travel with them to any location in the building as their personal comfort bubble. Services and environmental controls will also adjust to the current or shortly-anticipated number of occupants, and local weather conditions.

New developments in building management, lighting, air conditioning, monitoring, security, system apps, information screens, Wi-Fi, and automated elevators will mean that services are adjusted before arrival.

China Rapid Transit to Resident ratio

Legend:
- Metro
- LRT
- BRT

Y-axis: Rapid Transit to Resident ratio (RTR)
X-axis: Year

Kirow

Mobility

An effective transport network makes a city more productive, more attractive for inward investment, supports greater equity amongst citizens and also between regions. It creates urban jobs, drives greater efficiency and has the potential to reduce environmental impacts. Cities failing to put in place effective transport networks risk chronic congestion, very poor air quality, poor productivity, inequality and unhealthy populations.

China's growing metro network

China's transportation system has seen major investments over a short period of time. An estimated 1,347 billion yuan has been invested into road construction with total road length reaching 4.77 million kilometers[53]. In 2017, China invested 226.4 billion yuan into urban transport. There has been a very significant increase in Metro, light rail transit (LRT) and bus rapid transit (BRT) in China's cities over the last decade. In 2016, 37 cities globally added 754.5 km of metro, nine cities added 163.2 km of BRT and seven cities added 72.1 km of LRT. Of the 754.5 km of metro 71 percent was in China. This large investment shows the government's intention to improve transport.

However, these trends in many ways reflect the economic growth of the country. Whilst there are many examples of innovation and rapidly improving public transport networks, the most significant improvements are seen in China's tier 1 and tier 2 cities. Ensuring more equitable growth will require investment in improving the connection between cities in its regions but also upgrading existing transport infrastructure in its smaller (but rapidly growing) cities.

Decoupling economic growth and car ownership
Urbanization and increasing affluence is increasing car ownership. China currently has 185 million motor vehicles of which 170 million are private passenger vehicles. The total passenger vehicle fleet has grown 46.5 times since year 2000. Despite the large growth, car ownership levels are still low in comparison to Europe and North America. China has 122 passenger vehicles per 1,000 population, compared to 552 per 1,000 in Germany (a total of 45.7 million cars). If equivalent levels of car ownership were reached in China this would add another 760 million cars to the streets.
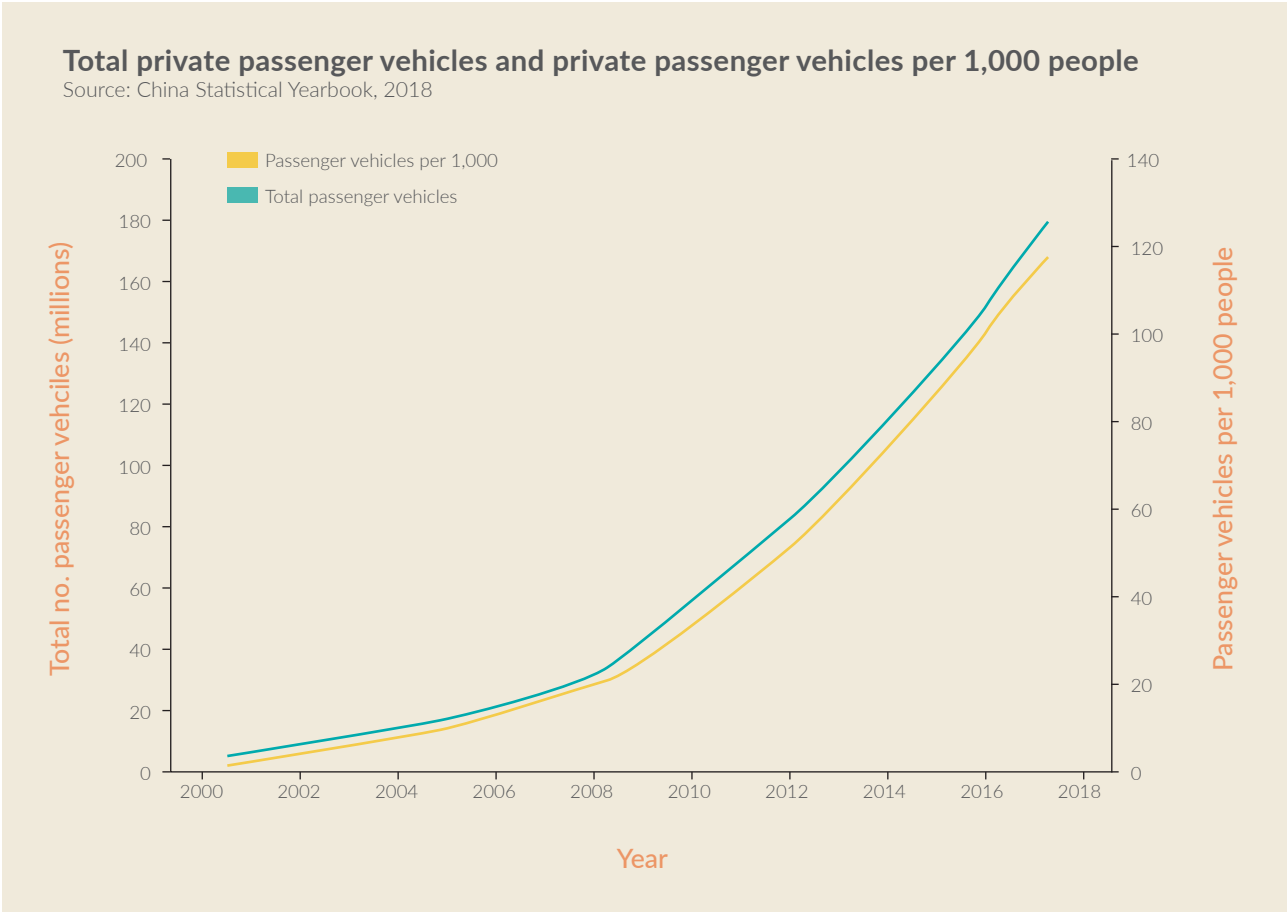
Keeping people moving, while upgrading urban rail network

On urban railway networks with high traffic density, lines must be replaced sooner due to higher wear. In maintaining networks there is a pressure to minimize the impacts of maintenance activities on passengers while ensuring high quality of the installed rail both on straight track as well as in switch sections. London is no exception, with around one million people in London traveling by rail every day, with over 500,000 passengers arriving during the morning rush hour. Upgrading of key commuter lines to increase demand and replace ageing infrastructure while keeping key stations such as London Bridge operating has been very challenging.

Railways lines are gathering more and more data and feature delicate electronic systems. In order to improve productivity and to realize the highest possible installation quality and gentle handling of switch sections, the renewal process needs to be mechanized. As with London Bridge, land and traffic constraints limit the possibilities to transport construction material to the site by road as well as limiting the accessibility for road cranes.

Kirow's modular switch renewal approach uses tilting wagons which allow the transport of wide panels even through the narrow rail infrastructure and rail bound cranes are especially designed to work within the confined space of the railway environment. This approach starts with the transport of newly manufactured railway switches directly from the factory to the construction site. Once the switch tilting wagons reach the construction site they are unloaded by railway cranes that are equipped with a sophisticated load handling system to guarantee gentle and precise lifting, to increase the working speed and at the same time to reduce the necessity for manual labor to a minimum.

A fleet of 24 tilting wagons and two railway cranes were used to complete the London Bridge station upgrades. The benefits are clear. In London, the railway operator Network Rail was able cut the necessary track closure times for the renewal of one switch and crossing (S&C) section from 48 hours to a single night shift only. Mechanized handling from factory to site provides better quality, whilst the shorter track closure time and more efficient construction reduced costs by up to 30 percent.

Total private passenger vehicles and private passenger vehicles per 1,000 people
Source: China Statistical Yearbook, 2018

China's most congested cities

Morning Peak

Evening Peak

But low overall ownership levels masks regional variations. Typically, coastal regions and those which are more urbanized have greater levels of ownership. For example, ownership levels are over 200 per 1,000 people in Beijing and Zhejiang but below 80 in Gansu and Tibet. Eight of the 11 most urbanized regions have the greatest levels of car ownership.

The approach to reducing private car use and congestion in China's larger cities has focused on slowing down ownership or deterring use of the car. As early as 1994 Shanghai began limiting car ownership by using an auction mechanism. Beijing adopted a license plate lottery, restricting the number of new car purchases every year.

The congestion conundrum
China's cities are among the most congested globally. While motorization rates are low, population density is far higher than in Europe or North America. While high density can create the ideal conditions for land-use planning and access to public transportation, the focus of transport planning has been on access to road infrastructure. This has had the knock-on effect of developing urban canyons and sprawl around roads. Such an approach not only encourages the use of the private car but drives the avoidable negative impacts on the ease and accessibility of public transportation networks.[54]

Freight
While smaller in overall numbers the number of trucks has grown from 250,000 vehicles to nearly 15 million since 2000. The freight industry is very fragmented, with nearly 7.5 million hauliers. Of the 48 billion tons of freight, the vast majority (77 percent) is transported by road. The NRDC estimates that 37 percent of all freight trips in 2014 were made with no cargo. Given the pressure on urban road networks, optimization of the logistics chain, greener forms of transportation and cleaner vehicles would play an important role in helping reduce the negative impacts of freight transportation.

Of the 48 billion tons of freight, the vast majority (77 percent) is transported by road. The NRDC estimates that 37 percent of all freight trips in 2014 were made with no cargo.
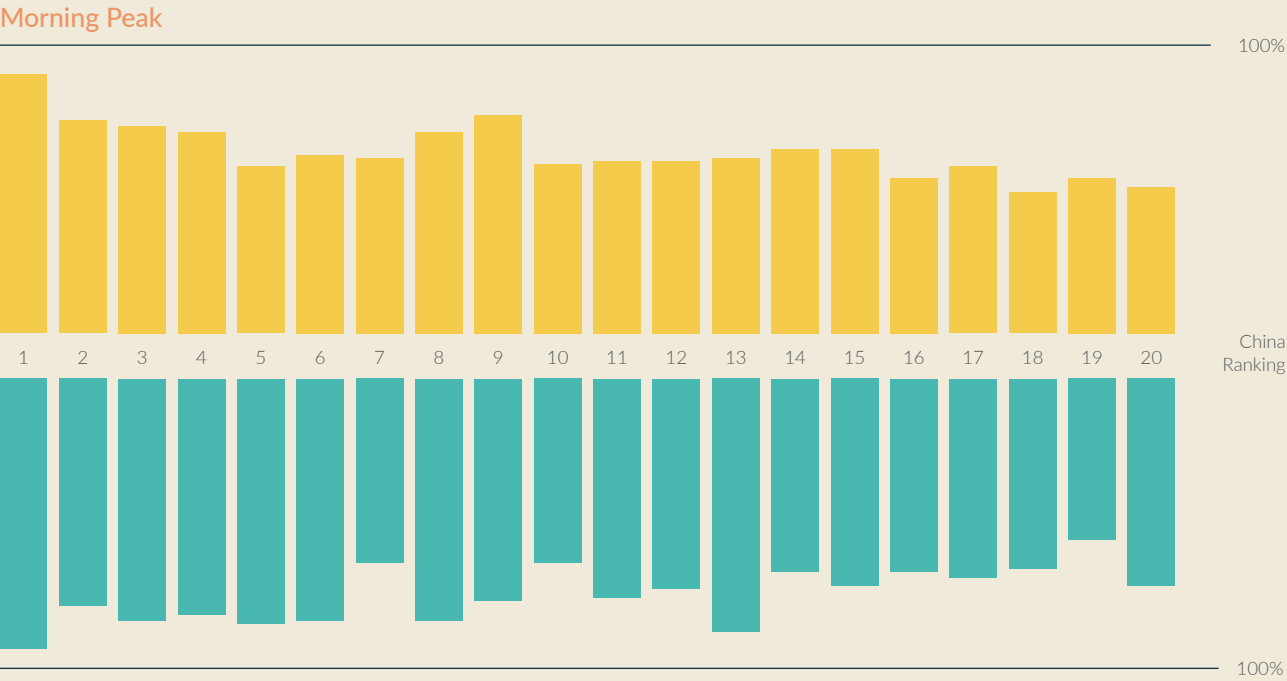
China Ranking	World Rank	City	Congestion Level (Increase From Previous Year)	Morning Peak	Evening Peak
1	4	Chongqing	52% (up 14%)	90%	94%
2	7	Chengdu	47% (up 6%)	74%	79%
3	10	Beijing	46% (up 8%)	72%	84%
4	11	Changsha	45% (up 8%)	70%	82%
5	14	Guangzhou	44% (up 7%)	58%	85%
6	15	Shenzhen	44% (up 7%)	62%	84%
7	16	Hangzhou	43% (up 5%)	61%	64%
8	18	Shijiazhuang	42% (up 6%)	70%	84%
9	22	Shanghai	41% (up 5%)	76%	77%
10	23	Tianjin	41% (up 2%)	59%	64%
11	31	Fuzhou	39% (up 2%)	60%	76%
12	32	Shenyang	39% (up 2%)	60%	73%
13	33	Zhuhai	39% (up 5%)	61%	88%
14	38	Nanjing	38% (up 5%)	64%	67%
15	45	Changchun	36% (up 3%)	64%	72%
16	50	Wuhan	35% (up 1%)	54%	67%
17	51	Ningbo	34% (up 4%)	58%	69%
18	57	Dongguan	33% (up 6%)	49%	66%
19	62	Suzhou	32% (up 6%)	54%	56%
20	66	Xiamen	31% (up 4%)	51%	72%

Source TomTom Traffic Index Accessed 7/1/2019 https://www.tomtom.com/en_gb/trafficindex/list?citySize=LARGE&continent=AS&country=CN

Deutsche Bahn & weColli

Integrated transport planning, incentivizing and investing in public transport

With cities facing such substantial growth, active transportation (walking and cycling), rail systems and public transportation need to be considered as a key aspect of land-use planning. Integration of land use and transport planning is essential to ensure that public transport offers effective services that meet demand and shift passengers from private cars. The integration of public transportation with land use highlights the importance of coordination across a range of public institutions. Equally cities must ensure they have data collection systems in place to ensure they are collecting and utilizing data about how goods and people move around the city.

Funding transport improvements
Typically fuel and vehicle taxes are earmarked for highway construction and funding for public transport is provided as capital. Cities have relied on land concessions to generate revenue to fund transport services but this approach risks encouraging urban sprawl, makes incomes streams unpredictable and also works against creating the densities of population which are needed to sustain effective public transportation.

Alternative strategies have been adopted in other cities globally, which if effectively implemented can reduce congestion and contribute to funding public transport improvements. London, while being one of the wealthiest cities in the world, has managed to reduce car ownership levels. A combination of good public transportation options and a central London congestion charge zone, payable by any car entering the zone has made driving in the capital less appealing. Many of the improvements to the transport network since the introduction of the zone have been funded through the charge. During the first ten years of the scheme more than £1.2 billion of revenue from the charge has been re-invested in transport, including £960 million of improvements to the bus network.

Driving new forms of mobility

Mobility is a basic need of people. A functioning, modern and efficient transport system as well as good and reliable mobility are just as decisive for the quality of life of people in cities as they are for the economic power and competitiveness.

In 2017 the City of Hamburg and Deutsche Bahn (DB) signed a memorandum of understanding to bring forward innovative forms of mobility. The project enhances the quality of stay at the stations and their immediate vicinity. Tasks range from basic improvements and repairs to the use of digital technologies at the stations Dammtor, Elbgaustraße and Harburg, all geared to turning these locations into 'Third Places', providing an enjoyable experience for people.

Intelligent guidance systems help travelers to access on-demand-shuttle services by ioki. Since July 2018, ioki serves two large districts of Hamburg where limited public transport exists. 20 dedicated vehicles solve the last mile problem by taking passengers to the next public transport stop. The shuttle service is being extended after the successful pilot phase.

In context of a pilot project, Smart City | DB joined forces with WeColli to offer electric-powered cargo bikes for last-mile-distributions to shops.

The use of electrical cargo bikes has been realized in cooperation with regional partners for low-volume shipments in Hamburg's inner-city area.

Smart lockers complete the logistical services with an area-wide, cross-vendor network of automated and intelligent lockers set up at several stations. This way, Smart City | DB facilitates a parcel and goods acceptance 24/7 at centrally located places.

All plans and actions are supported by the intelligent integration and linking of traffic data and other central city data. Urban Analytics, as part of the Smart City | DB portfolio, analyzes a range of different locations and service areas to identify optimum features and provides in-depth consultancy services for municipalities. In 2019 the project is focusing on creating co-working spaces integrated into the infrastructure of train stations.

Volkswagen Group

Four transformative trends shaping city transport systems

Four transformations have the potential to shape transportation systems in the future. Cities that advance them together will maximize the benefits. The transformations are:

- Autonomous mobility
- Connectivity
- Electrification
- Shared mobility

An autonomous future
In the future all transportation options in cities could be autonomous, providing an integrated transport network from the autonomous vehicle or shuttle bus, to mass transit options such as bus rapid transit, light rail and Metros. This bring the potential for more efficient, responsive and safer networks.

Autonomous road vehicles implemented with careful consideration could also reduce air pollution and greenhouse gas emissions, as well as improve how we use the urban realm in our cities, changing the focus from the vehicle to the citizen. Cities need to proactively plan for the arrival of autonomous vehicles to ensure that they maximize the benefits and ensure that they operate in the strategic interests of the city.

In March 2018[55], Beijing pipped Shanghai to be the first city in China to publish road testing rules for autonomous vehicles. However, Shanghai was the first city to issue test permits. Beijing swiftly followed suit and granted test permits in April 2018. Cities that followed issuing test permits include Chongqing, Shenzhen, Changchun and Pingtan Free Trade Zone in Fujian. The Ministry of Industry and Information Technology (MIIT), the Ministry of Public Security (MPS) and the Ministry of Transport (MOT) published China's first national road-testing rules of connected autonomous vehicles[56].

Cities must think more holistically about the autonomous vehicle. As well as replacing conventional cars, they could offer new public transportation services and support mass transit. Cities could take advantage of new services around ride sharing and on-demand bus fleets, supporting areas where the provision of buses is not economic. On-demand mobility services would let cities change the routes and capacity of certain transit modes according to fluctuations in passenger demand. Such an approach would bring efficiencies whilst providing a more responsive and personalized service to citizens. They could also play an important role in first and last mile trips, acting as a route to a city transport hub and encouraging public transportation.

Autonomous shuttle buses are already being tested in some city streets in France, Switzerland, Australia, UK, USA and Qatar.

Ramping up the development of Intelligent Connected Vehicles in China

Intelligent Connected Vehicles allow relevant information to be exchanged with the surrounding environment. To achieve this, cars need a high-quality, stable data connection. The expansion of this communication requires intensive research and development.

Audi China has also obtained a test license for Level 4 autonomous driving in the capital city of Beijing which aims to provide Chinese customers with smart driving technology that is adapted to China's road conditions.

Audi China obtained its first test license for autonomous driving in China's eastern city of Wuxi during the World Internet of Things Exposition 2018 in September last year. Audi is the first international automobile manufacturer to send autonomous Level 4 test vehicles to the road in Wuxi, the model city for connected traffic in eastern China. Together with its partners Huawei, China Mobile and Wuxi traffic police, Audi tested and demonstrated 15 different "vehicle to everything" (V2X) functions which with the results provide an important basis for autonomous driving worldwide. Intensifying development of autonomous driving and intelligent connected cars, Audi China has also obtained a test license for Level 4 autonomous driving in the capital city of Beijing which aims to provide Chinese customers with smart driving technology that is adapted to China's road conditions.

Audi China continues the momentum this year and plans to launch another development and testing hub in Wuxi to support testing of autonomous and connected driving technologies. In the long-term, approximately 150 employees will support the tests for autonomous and connected driving on site.
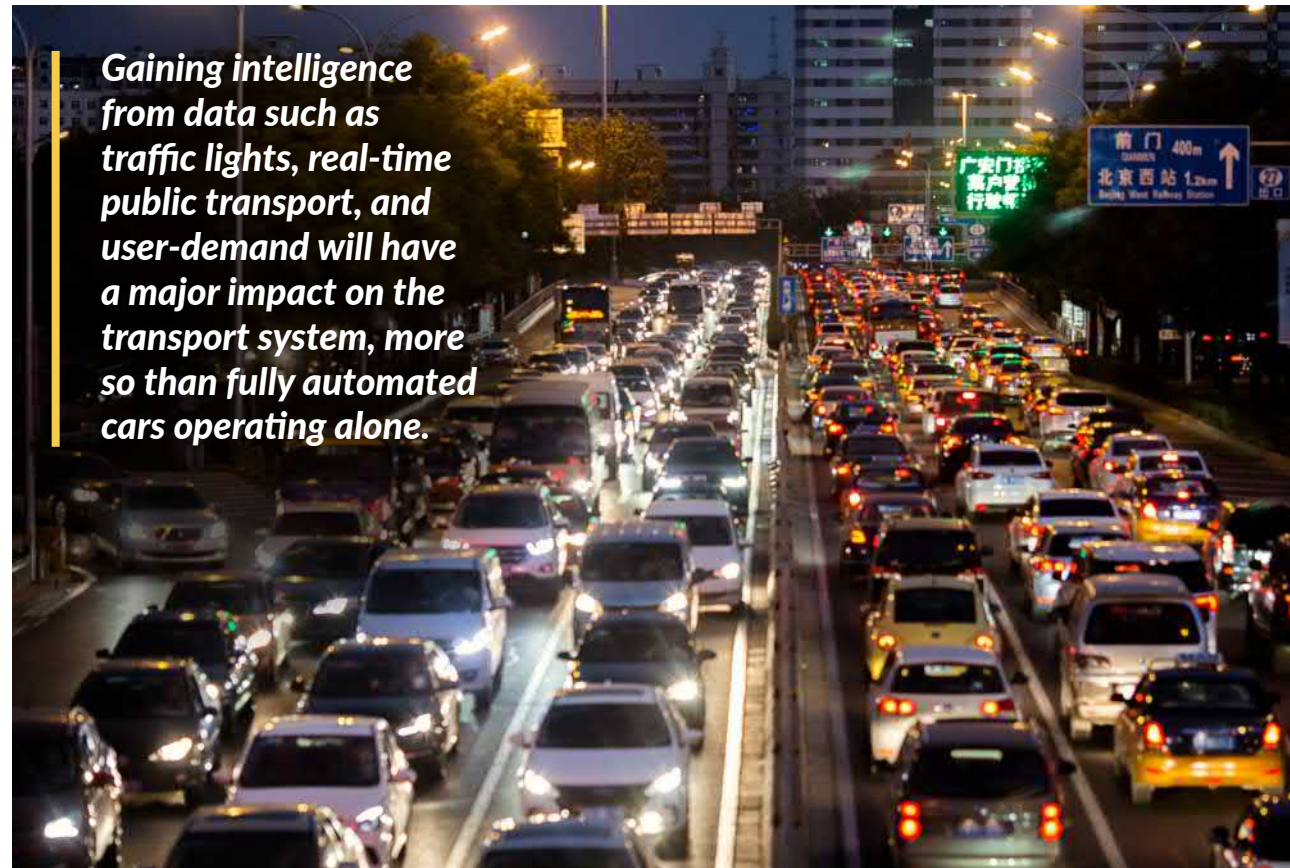
> *Gaining intelligence from data such as traffic lights, real-time public transport, and user-demand will have a major impact on the transport system, more so than fully automated cars operating alone.*

Volkswagen Group

A connected future

Information and communication technologies (ICT) allow communication between vehicles (V2V), vehicles and infrastructure (V2I), and other vehicles (V2X). Onboard units (OBU) in vehicles and road side units (RSU) are the main hardware facilitating this, using dedicated short-range communication (DSRC) signal. Increasing connectivity between vehicles and infrastructure will secure many of the promised improvements of autonomous driving.

Gaining intelligence from data such as traffic lights, real-time public transport, and user-demand will have a major impact on the transport system, more so than fully autonomous cars operating alone. They give information about road conditions, outside temperatures, read speed limits - together with connected road infrastructure this information will change how cities and highway authorities manage transport systems. Digitalization will allow for predictive maintenance of infrastructure which increases reliability of services, increases safety, and improves energy consumption. Further, collecting information from local objects in a single place can reveal opportunities for large-scale systematic improvements of a complex network, such as a road network. To gain these benefits, automated vehicles must be fully integrated into city networks.

An electric future

As with automation, mobility in smart cities will be electrified. From trains and buses to freight and passenger cars. This creates many opportunities to deploy more efficient, cleaner systems with the complimentary benefits of capturing and utilizing data from vehicles to optimize the mobility network.

China is the largest market for electric vehicles accounting for 48 percent of the 1.2 million global sales in 2017[57]. Many policies support the take-up of electric vehicles. The Ministry of Transport identifies city buses, taxi and urban logistics as key sectors for electrification and aims to have 200,000 new energy taxis and 100,000 new energy logistics vehicles on the roads[58]. The NDRC aim to construct 12,000 centralized charging stations and 4.8 million distributed charging points by the end of 2020[59], whilst the General Office of the State Council states that by the end of 2020, charging infrastructure must meet the demand of five million vehicles.

By 2020 there could be four million electric and plug-in hybrid electric vehicles in China, rising to 74 million by 2030. This requires a substantial increase in electrical demand for mobility. By 2020 electric vehicles will use eight billion kWh of electricity and 139 billion kWh (over half of global demand)[60] by 2030. Supporting this uptake of electric vehicles will require five million chargers by 2025 and 14 million chargers by 2030 and investment of 19 billion USD[61].

While electric vehicles will bring positive benefits for local air quality, decarbonizing electricity supply will maximize their impact. Siemens estimates for a city of around eight million, a switch of 40 percent of the car fleet to electric, would result in GHG reductions of between nine to 38 percent, depending on the carbon intensity of electrical power. Cities will be the biggest markets for electric vehicles and decarbonizing city networks must be a priority[62].
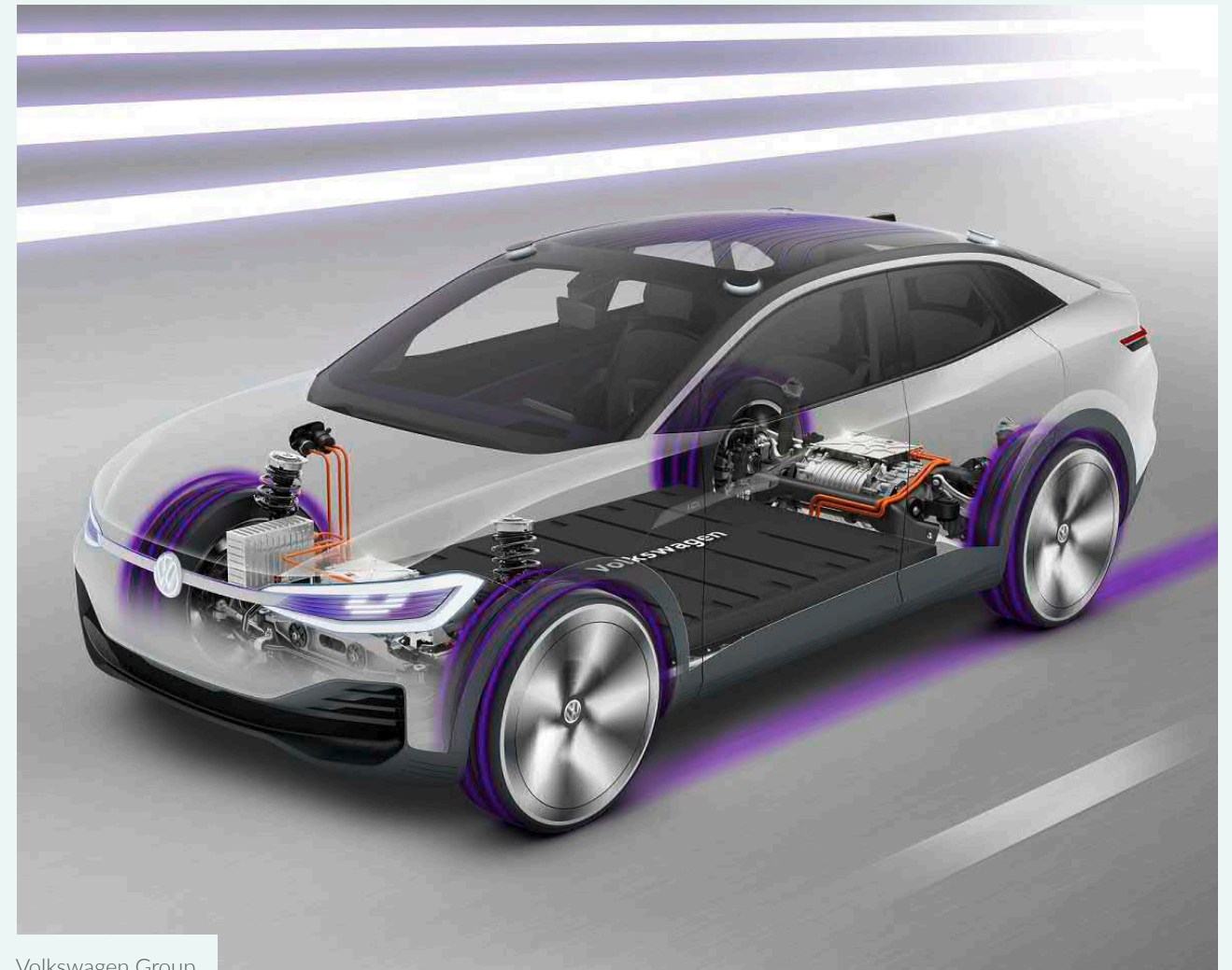
E-Mobility and charging gaining traction in Volkswagen Group

After the announcement of Roadmap E in 2017, Volkswagen Group continues with its commitment to delivering quality e-mobility and charging mobility solutions for all.

In November 2018, Volkswagen Group China, JAC and Volkswagen Group brand SEAT signed a new deal to intensify the cooperation to drive forward e-mobility in China. All parties commit to leverage their technologies into developing a battery electric vehicle platform. The joint efforts will establish a new R&D Centre, which will also focus on key areas such as connectivity and autonomous driving which are specifically tailored to the Chinese market.
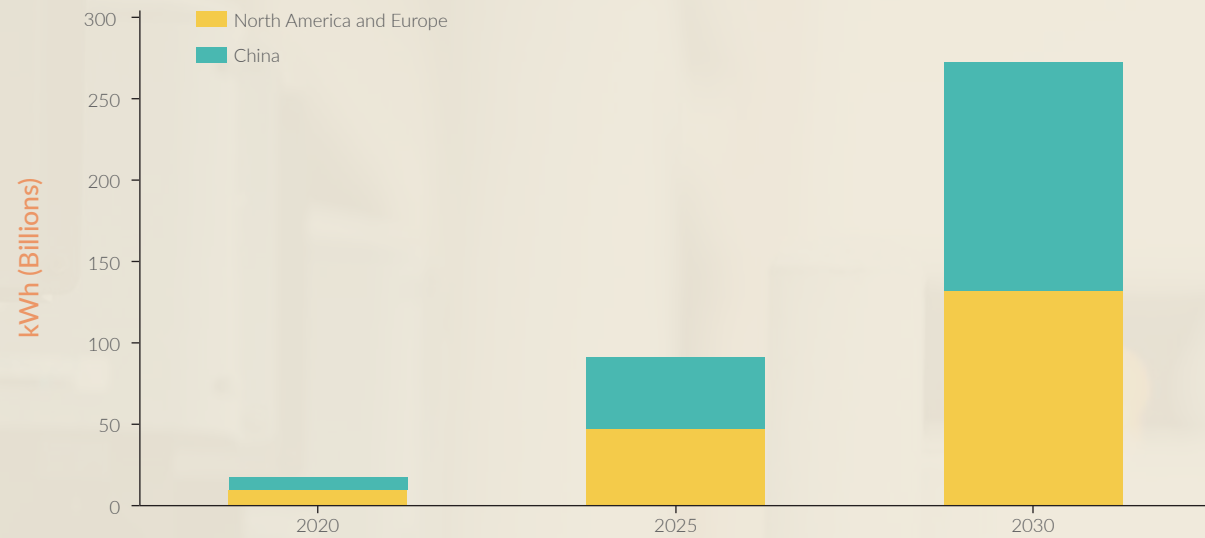
These developments are a part of Volkswagen Group China's vision to support sustainable mobility, with a target to deliver around 400,000 NEVs in China in 2020 and 1.5 million in 2025. The first specialized MEB factory of Volkswagen Group in the world is being constructed in Shanghai Anting. The factory adopts production network structure based on Industrial 4.0, greatly increasing the automation rate and labor productivity. Various new pure electric vehicle of SAIC VOLKSWAGEN will go into production in the new factory, including medium and large sized pure electric SUVs.

More recently, Volkswagen Group China and FAW Group Co. Ltd signed an MOU to establish a new joint venture focusing on charging infrastructure and charging-related services in China.

At the same time, in Hanover in Germany, the transformation of the Volkswagen Group Components towards e-mobility also gathers momentum. It announced in January this year its decision to start series production of the fast flexible charging station from 2020 onwards, which can enable 4 vehicles to be charged at once and can be used for interim storage of eco-power.

Electrical power consumption by electric cars in 2020, 2025 and 2030
Source: McKinsey. Annual mileage in China assumed to be 11,000km per year

Around ten percent of the country's vehicle fleet is shared and its rapid increase shows there are changes in the customer`s perception of the car as a status symbol.

Planning for an electric future
The roll-out of charging infrastructure is financially supported by the Ministry of Finance, with the government transferring subsidies to city governments proportional to the number of registered electric vehicles in their areas. Some cities are incentivizing take up. In 2018, Beijing allotted 60 percent of the 100,000 new car registration quota to electric cars, while in other cities electric vehicles are exempted from charges such as parking or road tolls. Similar approaches could also incentivize electric car sharing.

In addition to incentivizing electric car sharing, as part of the development of integrated transport plans cities should develop strategies for the roll out of electric vehicle charging infrastructure that meets the needs of different vehicle fleets, while ensuring that low and zero carbon energy sources are maximized. Planning such infrastructure requires the coordination across many sectors and bodies, including local power network operators, to ensure that systems are resilient, optimized and green.

A shared mobility future
Shared mobility already has a strong foothold in China and supports both motorized and non-motorized transport options. On average four million passenger trips a day are made in Beijing using Mobike shared bicycles. The city now has 2.2 million shared bikes, one bike per 10 residents. The city has over 1,014 kilometers of paths specifically for bicycles and pedestrians and is planning to reach 3,200 kilometers[63] by 2020.
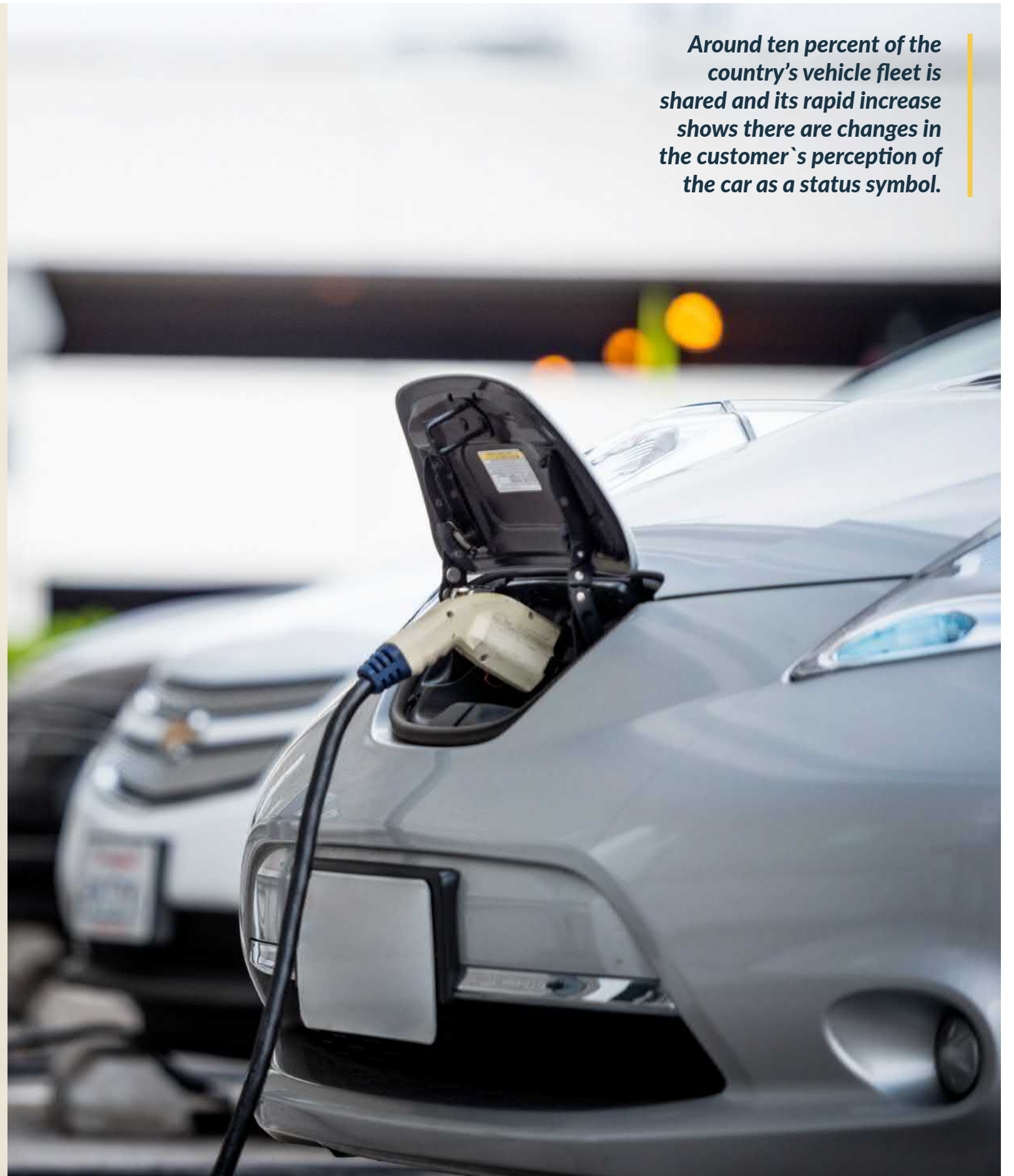
By 2018, there were 40 car-sharing operators with more than 40,000 vehicles mainly in Tier 1 and 2 cities.

Didi Chuxing, China`s largest car sharing firm, has about 450 million registered users according to the company in 2017. It provides about 30 million trips daily. Around ten percent of the country's vehicle fleet is shared (taxis, ride-hailing and ride-sharing)[64]. This rapid increase in shared mobility use shows there are changes in the customer`s perception of the car as a status symbol and an increasing willingness to consider alternative mobility solutions.[65]

All travelers, whether they are commuters, long distance rail or road customers, or tourists, demand seamless, multi-modal travel with accompanying services. Mobility as a Service (MaaS) integrates various forms of transport services into a single mobility service accessible on demand be they public transport, ride-, car- or bike-sharing, taxi or car rental/lease, or a combination of them. MaaS can offer added value through use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations. A successful MaaS brings new business models and ways to organize and operate the various transport options, with advantages for transport operators including access to improved user and demand information and new opportunities to serve unmet demand. The aim of MaaS is to provide an alternative to the use of the private car that may be as convenient, more sustainable and help to reduce congestion and constraints in transport capacity.

City governments need to think about how they could support or enhance their own transport infrastructure through shared mobility as well as that of private operators. Integrating shared mobility (both private and public) into one approach can optimize the transport network and make it work better for citizens.

In 2013 MOHURD estimated that one third of cities were overwhelmed by waste, with urban waste disposal taking up 500 square kilometers of land.

The ALBA Group

Resource Management

Decoupling waste and economic growth

Waste has traditionally been seen as a necessary by-product of thriving economies. However, like in other sectors greater emphasis is being placed on the more efficient use of resources. As with energy and water it is possible to decouple waste from economic growth.

Poor waste management practice leads to negative impacts on health, amenity and the contamination of air, water and land. Methane gases from landfill sites and especially poorly managed ones are also a significant source of greenhouse gas emissions. Poorly managed waste is a source for odor, illnesses and pests. Without effective waste management plans in place cities face the risk of becoming islands surrounded by their own waste.

Waste management remains a challenge for China's environmental quality and the sustainable development of its cities[66]. In 2013 MOHURD estimated that one third of cities were overwhelmed by waste, with urban waste disposal taking up 500 square kilometers of land.

China has surpassed the USA as the world's largest waste generator and it will generate twice as much municipal waste as the United States by 2030. Municipal waste is expected to amount to 1.398 billion tons per day by 2025 or 1.7kg per head per day across China[67]. While plans are being put in place for more incineration and increasing household recycling the majority of managed waste ends up in landfill.

Going underground to provide sustainable solutions in cities tight for space

Berlin like most cities faces a competition for space for utilities. The Berlin-Potsdamer Platz is one of the city's highest value real estate areas and the Daimler area includes 34 restaurants/café's, two cinemas, two theatres and 91 retail businesses. High land values and a focus on preserving the historic streetways means very limited space is made available for waste management and disposal at the street level. But that does not compromise standards with the expectation to maximize resource recovery from the development for up to 20 waste materials including food waste, glass, paper, cardboard and plastics.

To meet these competing demands an underground building-integrated supply and disposal center was developed including five kilometers of transport ways 15 meters below the surface. Operated by ALBA 365 days a year, the system manages around 3,000 tonnes a year. All waste produced is linked to the producer, with the net weight and kind of container identified via code scanning.

The weight and container information are automatically transferred providing exact daily accounting for businesses. Collection is undertaken entirely underground and transferred to ALBA's recycling plant allowing for reuse of secondary commodities in production cycles and saving primary commodities. Food waste is dehydrated in a processor, reducing five tonnes of food waste to one. The residual is shredded and transferred to a bio-gas plant for energy recovery whilst water is treated to return it to drinking water standards.

Innovations such as this demonstrate how cities, even with a shortage of space can meet their waste management demands in a sustainable, clean way without additional real estate demand, while establishing "Pay As You Throw" Mechanisms, which directly links waste generation to the producers.

The simple introduction of a 'no chopsticks' option on Ele.me food delivery app has already saved 43 million pairs of chopsticks.

Opportunities through the circular economy

A circular economy is a systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the 'take-make-dispose' linear economy, a circular economy aims to decouple growth from the consumption of finite resources. It is based on three principles: Designing goods, services and systems, which produce minimal waste and pollution, keeping products and materials in use and regenerating natural systems via material recycling and energy recovery. China has been a front runner in developing the theory of the circular economy, with policy makers looking to link economic growth and environment protection for many years. A recent report highlights the opportunities from a circular economy across five-sectors; built environment, mobility, nutrition, textiles and electronics. Its application in China's cities could save 5.1 trillion USD by 2030. Additional benefits include a ten percent reduction in particulate matter, 11 percent reduction in greenhouse gases, 36 percent reduction in congestion and 30 percent reduction in water pollution from the textiles industry[68].

The importance of effective waste management strategies

Cities need to develop plans for minimizing waste, improving recycling services, educating urban populations on how to segregate waste and the implications of not doing so, as well as constructing infrastructure to recover value from it.

Modern waste sorting and reprocessing technology maximizes the raw material recovery while providing easy and convenient waste separation. This, alongside plans from the government to introduce a new system of charging for waste management, which will focus on incentivizing the sorting of waste streams and reducing waste through weight and material-based charging, could form the basis for a more sustainable approach to waste.

With pressures on water and energy systems and pollution of waterways and land, effective waste management practices will help improve these systems. Synergies between solid waste management and wastewater management allow a new level of efficiency. Wastewater sewage canals can be equipped with pneumatic waste conveyor systems for underground transport and organic waste and wastewater sludge can be co-fermented to produce renewable Biogas. Such systems can contribute to water and energy systems while reducing traffic on the roads.

The digital opportunity

The World Economic Forum recently illustrated the potential impact of digitalization on waste in China. A social media article highlighting the environmental impact of packaging from food delivery apps led to pressure to cut packaging waste. One of the largest food delivery apps Ele. me, responded by establishing a sustainability lab to drive innovation and reduce the impact of packaging.

This led to the simple introduction of a 'no chopsticks' option on their food delivery app. This has already saved 43 million pairs of chopsticks. Following the addition of 'no chopsticks' to apps tracking sustainable consumer behavior, the company saw a five to seven times increase in customers opting out of chopsticks[69].

Digitalization will play an important role in many other aspects of waste management.

Sensor technology

Waste bins are equipped with small sensor that measures the fill-level and sends real-time data to collector. Thanks to its small footprint and technology, this smart application enables the waste management entities to increase their waste collection efficiency; to reduce unnecessary collection trips, their energy consumption, noise and other emissions; and to release the traffic pressure in the city from heavy truck transport. Moreover, modern sensors can further be implemented to support waste separation and fair attribution of waste disposal cost under the principle of producer pay-as-you-throw.

Autonomous driving

Autonomous driving for waste vehicles could have a long-term impact on waste management, providing a better utilization of the staff; improves working conditions in areas like landfill and recycling plants; and making more environmentally-friendly throughout.

Data mining

Measurement stations installed on the roof of collection vehicles could measure the environment performance at each street for every week and gather the important citizen behaviors. These data can be transferred to the authorities for analyzing, prediction, campaigning and better city management, for example for air pollution monitoring.

Digital management

Blockchain could record all transactions and share data among authorized users, enabling decentralized refund-systems or producer-responsibility-schemes. It could precisely track down the route of waste and identify the waste producer for quicker and decentralized resolution.

Platform-concepts encourage the participation of stakeholder companies in the field of waste collection and recycled material trading to collaborate together on building a joint smart waste management system.

Water consumption has risen by 0.55 billion m³ a year despite consumption per head remaining the same

Water consumption (billion m³)

	2004	2017

Wilo
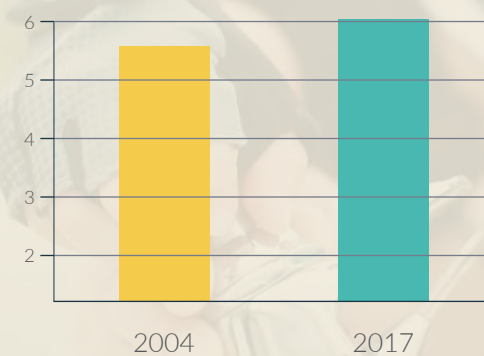
Managing water needs in cities

Water resources now present a challenge to realizing China's strategic objective of building a wealthy society through a process of sustainable development[70]. Two thirds of China's cities suffer from water shortages despite China having the sixth largest water resources in the world. Available water is just 2,100 m³ per capita (one quarter of the world average) and just above the accepted definition of water stress (1,700m³ per capita). On average, annual water shortages across the country exceed 50 billion m³. 80 percent of water resources are in the south of the country, while in the north, eight provinces suffer from acute water scarcity and four from water scarcity.

In the north, groundwater levels are falling. The Jing-Jin-Ji region has seen groundwater levels fall by between one and three meters a year and many rivers have disappeared. Parts of Beijing see subsidence of up to 11 centimeters a year[71].

Against that backdrop water consumption has risen from 5.49 billion m³ a year to 6.04 billion m³ a year, despite consumption per head remaining at the same levels as 2000. Whilst most of the water is used by agriculture and industry, consumption outside of these two sectors has grown fastest (increasing by 50 percent since 2000).

Low water efficiency is a common problem, Industry for example uses 108m³ for every 1,600 USD of added value. Irrigation efficiency is just 48 percent, whilst leakage from pipe networks in many cities is above 20 percent. Water pollution further aggravates the water supply challenge and poor effluent treatment capacity has led to severe pollution in waterways.

The world's first semi-central supply and disposal system, Qingdao

Water shortages are challenges faced by many urban areas in China. Meeting this challenge will require more efficient systems, capturing and reusing wastewater in order to take pressure of systems.

The supply and disposal center was opened in early 2014 as part of the World Garden Show. It is the first reference installation in the world for a semi-central, integrated infrastructure approach, and will supply water for 12,000 people.

SEMIZENTRAL is a project by the Technical University of Darmstadt in cooperation with Tongji University in Shanghai. As a specialist in pumps and pump systems, Wilo was involved in the project's planning and implementation, and supplied a wide range of pump systems in the areas of building services and water management. In 2015, the project was recognized in the 'Urbanization' category of the Greentech Awards, one of the most prestigious environmental and business awards in Europe.

Semizentral is a flexible infrastructure approach for the cities of the future; a middle ground between decentralized and centralized sewage treatment. Each new district has the requisite infrastructure at its disposal. Instead of processing and distributing water using expansive systems with long lead times, Semizentral grows with the city. It integrates sewage and organic waste flows in a modular solution concept. The ground-breaking infrastructure approach reduces not only drinking water requirements but also the amount of sewage generated in the catchment area by about 30 – 40 percent.

Process water is not transferred directly to the preparation system but is reused. For example, sewage from showers is reused to flush toilets. The energy required to do so is produced by directing the resultant sewage sludge and domestic organic waste to the integrate biogas plant.

Conservation of resources is a key goal in the smart city concept of the planned city Qingdao. In order to achieve this efficient components and systems are essential – for example, in the treatment of sewage and industrial water. The submersible mixer Wilo-EMU TRE 312 satisfies these requirements with a highly efficient motor and low-wearing materials adapted to the harsh operational environment.

Wilo high-efficiency pumps make a significant contribution at the project's plant. They help to produce industrial water and energy from sewage and organic waste. The heat generated in this process can be used for heating. This means the supply and disposal center operates autonomously in terms of energy supply. In total, around 56 high-efficiency submersible motor-mixers, pumps, pressure-boosting systems and fire extinguishing systems have been deployed. The adaptable water infrastructure uses resources efficiently, is flexible and can grow with its urban surroundings. This means the center is always "as large as necessary and as small as possible".

Obermeyer

Efficient water use and integration at the city level
National schemes are underway to relieve water stress such as the south-north water diversion, the largest scheme of its kind. Planned for completion in 2050 it plans to eventually divert 44.8 billion m³ of water from the south to drier cities in the north every year. In the meantime, cities must focus on water efficiency and protecting existing sources of water from pollution.

As with energy, efficiency must be at the very heart of tackling the challenge, simply supplying more capacity is ultimately not sustainable. Solutions at the city, regional and national level also need to consider wider implications. Water provision is inherently linked to energy use as well. The two sectors should be considered together to make sure that energy and water are efficiently used.

Ultimately as a resource, improving the efficiency of its use (and its quality) will have knock-on effects for productivity, equally improving quality of waterways will improve quality of life and the amenity value of water. Effective building management and design will also reduce water waste. As already discussed the automation and management at the building level of all systems, including water can help identify opportunities to run operations more efficiently. Given the impact of gamification on consumer choices already demonstrated in reducing waste, cities could consider how a similar approach might incentivize better user behaviors.

Cities should also consider how they can make more effective use of rainwater and capture and reuse water through greywater recycling. Such an approach will also slow down the entry of water into rivers and to reduce flooding. This approach is now being taken in many cities globally and in China, where they are known as 'sponge cities'. By utilizing water via rainwater harvesting for use in buildings, using porous concrete, protecting existing wetlands and green spaces and adding more greater use of rainwater is possible while delaying entry into rivers. The government has announced 16 cities and districts to test the program, with a goal of capturing 70 percent of rainfall[72].

The automation and digitalization of water treatment processes can substantially improve energy efficiency at the plant level, particularly as treatment accounts for between 40-60 percent of energy use.

Protecting water supplies
But tackling pollution of waterways and groundwater also needs to be addressed to open up access to drinkable water. Putting in place an effective and well administered water regulation framework is critical. While a legal framework including systems for water licensing, paying water resources fees, evaluating water resources, water function zoning, and monitoring polluted water discharges into rivers exists it needs to be better supported. Currently less than 30 percent of water resources fees are collected, and many unlicensed abstractors are not penalized[73].

Reducing water loss and maintaining networks
Around 20 percent of drinking water is currently lost in cities. Tackling this must be a priority. Smart valves and pipes, hydraulic modelling, water metering and demand control all reduce water loss and maximise revenues. SCADA systems enable both leak detection for controlling complex water distribution networks and also leakage detection in water transport pipelines. Metering and monitoring flows combined with SCADA systems allow the rapid detection and location of water leakages and reduction of losses. In addition to monitoring and managing leaks, smart metering can increase revenues by ensuring accurate readings of water consumption.

Planning new networks
Planning effective networks will ensure that systems are efficient and do not waste valuable resources. Getting this right will save money, water and energy resources. Digitalization allows water planners to plan and design networks and optimize the training of operators by simulating the planned water network, allowing for validation and scenario planning.

Making the most of water resources, Guangu Central Park

The city of Wuhan is developing a large new urban area in Guangu Optic Valley. The core area with super-high-rise office towers will include a central park which is currently being constructed, with the first elements completed in 2019. OBERMEYER has designed the park as a smart system with a multitude of functions.

The park has a water system, which has to deal with different situations. In the raining seasons, large amounts of water have to be collected in bio-swales. These are located in lowered areas, which are dry in normal situations. In the event of storms and after the lakes in the park have been reaching their capacities, the swales will be filled to collect the storm water. Afterwards the water will drain away slowly, this relieves the storm water drainage systems significantly. The bio-swales are covered with a special type of grass and can be used by the park visitors when dry.

The park also has areas to clean the rain water system from the surrounding CBD area. In dense city areas, there are not enough spaces for water cleaning, therefore the idea is to use a biological cleaning system which is also part of the public park area. Facilities and special plant zones improve the rain water quality before it gets discharged into the lake system.

To maintain the cleaning process, the water needs to keep flowing. Therefore, during the dry seasons the water will be circulated by pumps.

All these features are included in the public park landscape. In different zones, the visitors can also enjoy theme gardens, restaurants and cafes, art galleries, leisure and sport areas.

The natural atmosphere is a relaxing contrast to the busy downtown and the natural water cleaning zones will demonstrate the value of ecologic surroundings and the city of Wuhan's responsibility for this.

Healthcare spending has increased and increased as a percentage of GDP. China still spends far less of its GDP on health compared to most developed nations.

Health and Skills

Health

An ageing population

China's population is living longer. Those aged over 65 will almost treble between now and 2050 with implications for the workforce and healthcare. Chronic conditions such as diabetes are already increasing. In 2010 there were 92 million diabetics and 159 million prediabetics in the population (the United States has 27 million). Healthcare spending has increased as a percentage of GDP. China still spends far less of its GDP on health compared to most developed nations.

Digitalization is already helping make more efficient use of resources. The IoT and Artificial intelligence enabled solutions could help address chronic diseases, whilst big data analytics could minimize over-treatment resulting in an impact equivalent to 12-45 percent of healthcare expenditure[74].

Artificial intelligence is driving forward a number of opportunities in the healthcare sector including[75]:

- further improving the diagnosis and treatment of diseases

- creating new possibilities for prescribing and planning

procedures through digital twins.

- elimination of unnecessary interventions, prioritizing acute cases, improving the quality and productivity of healthcare, advancing precision medicine and generating more clinical knowledge.

- shifting from patient-centric disease management to person-centric healthcare.

Cloud hospitals

Ningbo Cloud Hospital aggregates the resources of all offline public hospitals and community clinics in Ningbo into a regional medical network serving local residents[76]. Through a cloud platform at the hospital, patients can access a world-renowned physician while sitting in a community hospital with community doctors. Cities such as Hangzhou, Guangzhou and Wuhan have introduced their own online services too. The Guangzhou Second Provincial Central Hospital, in the southern metropolis of Guangzhou is addressing its challenges through AI. The hospital has incorporated AI in most operational areas, including patient pre-diagnosis, CT scans, organizing patient records, and transporting operating-room supplies[14].

Air Pollution

Whilst much progress has been made at the end of 2017, only 107[77] of China's 338 cities of prefectural level or higher had reached the WHO's interim standard of 35µg/m^3[12].

Helping cities monitor, forecast and simulate air pollution

The deployment of sensors and digital analytics provide unique opportunities to harness data to make better informed decisions and take-action on air pollution. Utilizing artificial intelligence, neural network models take data from different sources such as air pollution sensors, weather and climate data, time or traffic data to learn the likely pollution levels across the city. Such an approach enables cities to:

- Monitor city-wide, hotspot emissions of all environmental sensors which have been integrated in the tool, focusing primarily on $PM_{2.5}$, PM_{10} and NOx.

- Forecast air quality and inform city leaders through a dashboard about where, and by how much air quality is expected to exceed health or regulatory thresholds over coming days.

- Allow city leaders to simulate specific pre-defined emission-reducing actions against the expected emission levels in order to reduce the risk of exceeding emissions thresholds or key indicators.

By utilizing the power of predictive and simulation models, cities will be able to take preventative action earlier. This will enable them to be more proactive, rather than reacting to events and deploy resources where they are most needed

As more and more sensor data is added, the ability of systems such as this will only increase more. This will become an important part of the armory in taking on air pollution in cities.
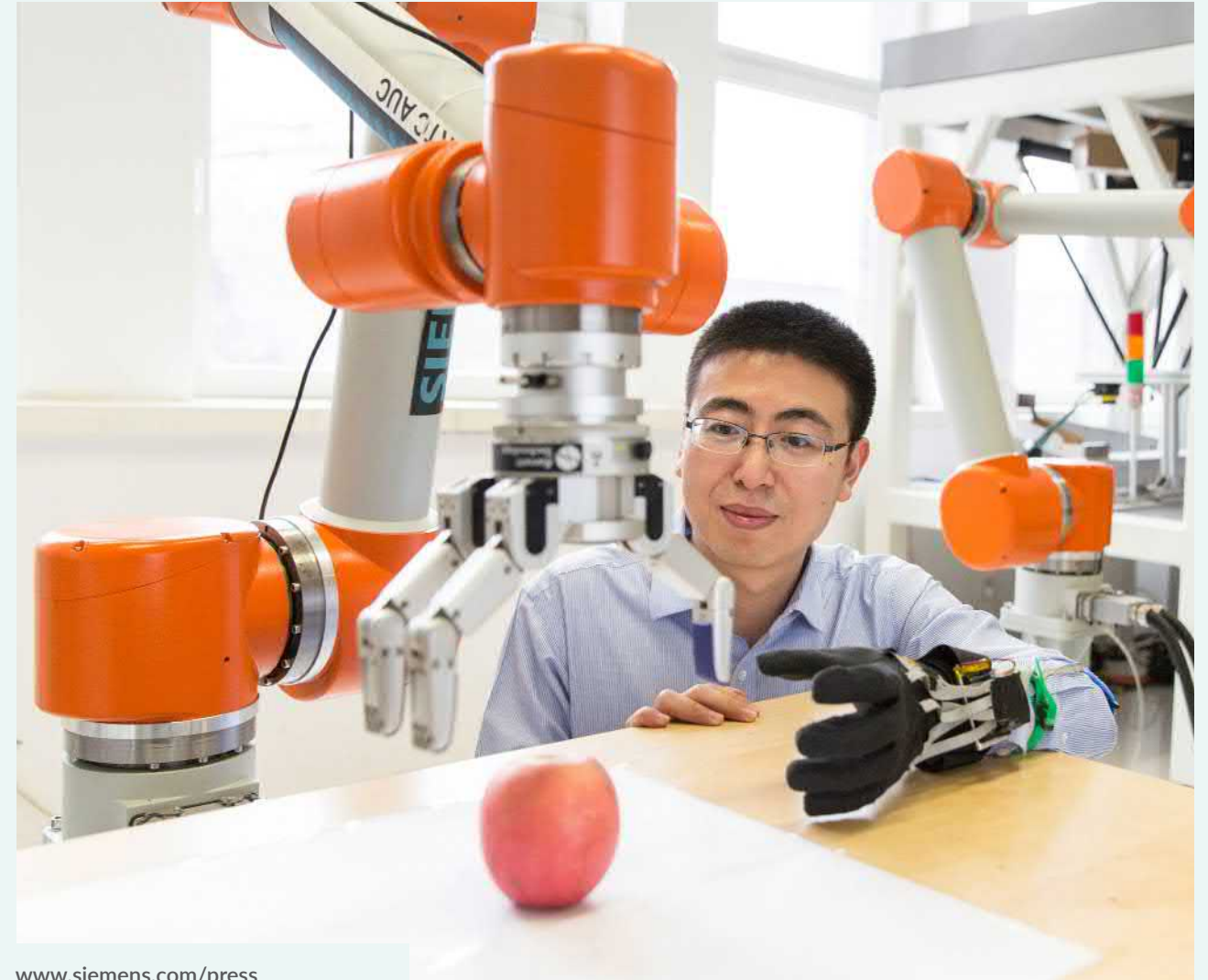
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Education and skills

China invests four percent of its total GDP in education. Preparing for smart cities needs support from national, regional and local government. Equally, companies need to ensure they play a role in supporting and developing the skills of the workforce. It can't simply be the responsibility of the government. Government, companies, and individuals all need to contribute to making the transition as smooth as possible through education reform, skills training, job-redeployment programs, and increasing labor mobility[78].

The rise of the digital industry in China opens the door for new opportunities. In the health sector, for example, we could see care workers assisting with home-based diagnostic and monitoring devices, as well as teams of clinicians, engineers and programming specialists working on the next wave of personalized patient treatments. In the construction sector, increasingly sophisticated building technologies, such as building automation, will demand new installation, maintenance and repair skills, while architects and building managers will use life-cycle digital modelling in their projects, to both design and build physical structures. To manage the transition the government can equip them with the skills they need through reform in education and training; use digital technology to help people find jobs and help employers fill them; support people working independently; and do everything in its power to enhance labor mobility to ease job searches than may end in a different city.

As almost every job becomes increasingly technology-related, some may find themselves unable to adapt to changes. The World Economic Forum estimates that by 2020, on average more than one-third of core skills in most occupations will be different from those considered necessary today. Technological growth, and the accompanying changes in business models, make the continuous adaptation of skill sets fundamental to successful participation in the labor market. Digitalization and automation could create 176 to 253 million jobs and potentially impact on 161 to 281 million jobs. Given that China's labor supply might decline from 773 million today to 757 million by 2030, the digital shock to the labor market appears manageable —as long as government, companies, and individuals all contribute to making the transition as smooth as possible through education reform, skills training, job-redeployment programs, and measures to increase labor mobility"[79].

The Chinese government has begun to take action to update the population's skills for the digital age. One thrust of policy is training for workers who lose their jobs in one occupation and need to redeploy elsewhere in the economy. In the 13th Five-Year Plan, the Ministry of Human Resources and Social Security declared its intention to provide vocational training for the digital economy to 40 million workers.

Contributing to China's digital future

Siemens China is one of the largest foreign invested companies with revenues of 8.1 billion euros in 2018 and 32,000 people in the country. Siemens is supporting the transformation to a digital economy in China in a number of ways: Including

- 21 research and development hubs around the country

- Around 12,000 active patents or patent applications

- More than 4,500 research and development staff

- Research and development cooperation with 90 universities and education organizations

- Siemens China Innovation Center opened in 2016 is leading the company's global research in autonomous robotics

- Established the smart city digital hub in cooperation with Hong Kong Science and Technology Parks. Powered by MindSphere, Siemens cloud-based open IoT operating system, the hub is exploring how digitalization can tackle city challenges in the region

- In 2017 we opened Siemens first Digitalization Experience Center in Beijing

- Siemens Industrial Automation Products Ltd, Chengdu is the company's first digital factory outside of Germany. It is highly digitalized from product design to manufacturing. Its first-pass yield of products could reach 99.5 percent.

- In cooperation with the Ministry of Education Siemens has helped universities establish labs and develop text books. It has also sponsored the intelligent manufacturing contest for 11 years to cultivate innovative engineering talents.

- Working with over 100 Chinese companies to explore opportunities in 100 countries, over six continents

- 22,500 children in nine cities benefited from Siemens I-Green education program in 2017.

Closing remarks

China is planning for the future, but it faces many challenges. The creation of smart cities could be the key to its future successes. With a fast pace of urbanization and a growing middle class with the ability to spend more it faces challenges to manage growing consumer demands for everything from cars, to consumer goods.

The pace of growth means increasing pressure on resources such as water, energy and ever more waste and other urban challenges such as poor air quality and congestion. Equally there is a shifting emphasis to supporting more balanced and sustained economic growth, which is shared more evenly across the country.

Whilst cities cannot escape the need to invest in infrastructure if they are to meet their ambitions, this document shows how digitalization is enabling infrastructure to work harder for citizens and do more than ever.

Digitalization will not only help cities cope with urban growth but is already creating new economic opportunities. The sharing economy is forecast to grow by 30 percent and provided ten percent of all new jobs in cities last year.

The decisions taken now will impact on China's development over the next 50 years and the ability of the planet to take on and meet challenges like climate change head on.

By focusing on the digital, aligned with sustainable infrastructure and effective and integrated planning, China may well set the gold standard for others to follow.

The decisions taken now will impact on China's development over the next 50 years and the ability of the planet to take on and meet challenges like climate change head on.
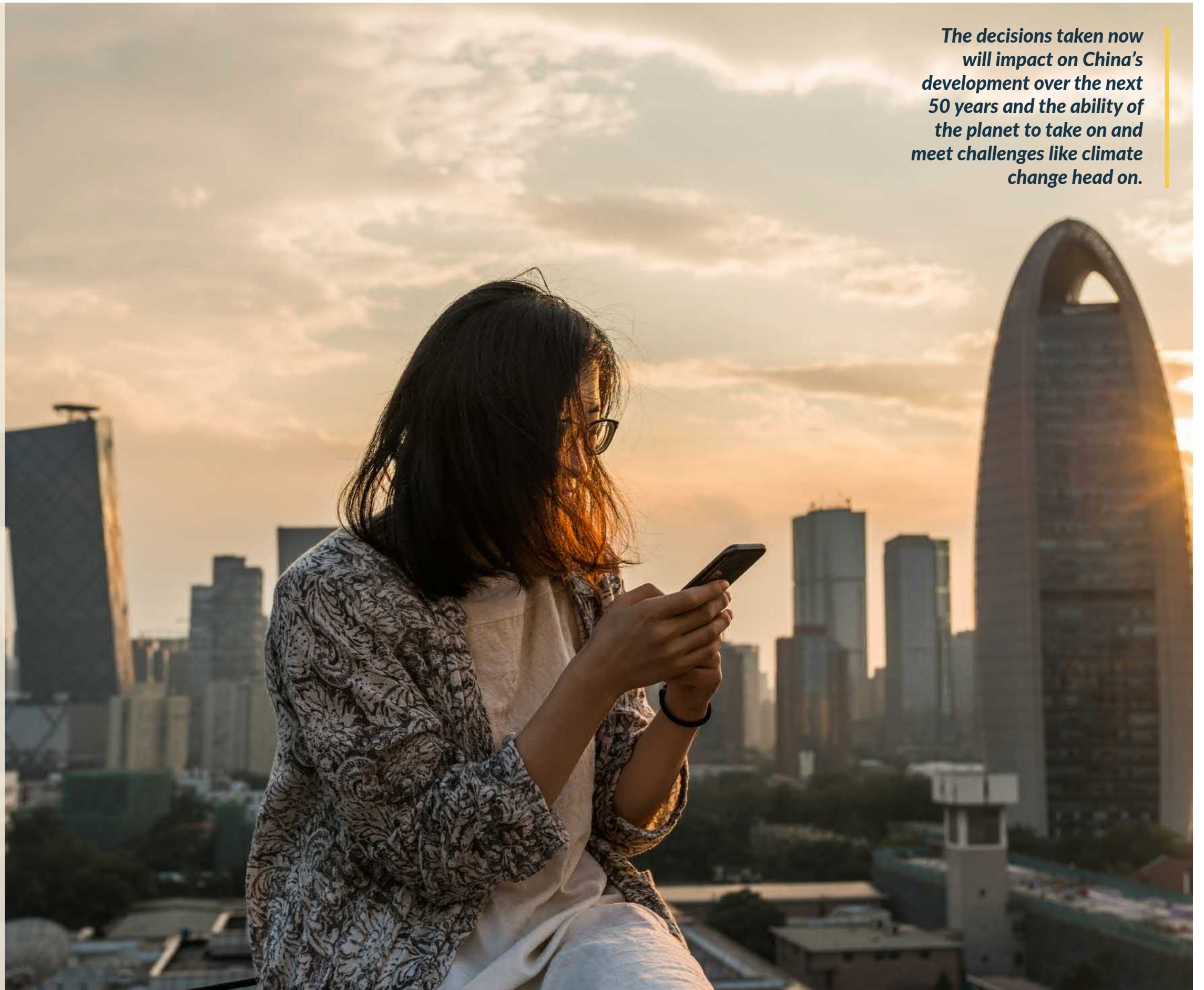
References

1   Frost & Sullivan, April 2017
2   United Nations, Population Division, Department of Economic and Social Affairs, World Population Prospectus: The 2017 Revision, Medium growth variant
3   https://www.mckinsey.com/industries/retail/our-insights/mapping-chinas-middle-class
4   https://www.mckinsey.com/industries/retail/our-insights/mapping-chinas-middle-class
5   The Economist, Regional China: Internal migration http://country.eiu.com/article.aspx?articleid=1326926316&Country=China&topic=Economy
6   http://berkeleyearth.org/wp-content/uploads/2015/08/China-Air-Quality-Paper-July-2015.pdf
7   World Economic Forum, Alternative Investments 2020: An Introduction to Alternative Investments
8   McKinsey Global Institute, Digital China: Powering the Economy to Global Competitiveness, December 2017
9   World Economic Forum, Future of Consumption in Fast-Growth Consumer Markets: China, January 2018
10 China Daily, China's sharing economy to grow 30% per year, http://www.chinadaily.com.cn/a/201806/04/WS5b-14d719a31001b82571e031.html accessed on 21 September 2018
11 Ernst & Young, China is poised to win 5G race, 2018
12 GSMA Intelligence and the China Academy of Information and Communications Technology (CAICT), 5G in China: Outlook and Regional Comparisons, 2017
13 Digital China: Powering the Economy to Global Competitiveness, December 2017
14 The rise of China's super cities, HSBC, 2018, https://www.hsbc.com/news-and-insight/insight-archive/2018/the-rise-of-chinas-super-cities, accessed on 22/09/2018 http://www.ebeijing.gov.cn/BeijingInformation/BeijingNewsUpdate/t1399744.htm
15 http://www.ebeijing.gov.cn/BeijingInformation/BeijingNewsUpdate/t1399744.htm
16 https://www.relbanks.com/worlds-top-banks/assets
17 https://www.thepaper.cn/newsDetail_forward_2136516
18 https://www.tomtom.com/en_gb/trafficindex/list?citySize=LARGE&continent=ALL&country=ALL
19 http://www.xinhuanet.com/english/2017-04/15/c_136209823.htm

20 http://www.xinhuanet.com/politics/2017-04/01/c_1120741571.htm
21 http://www.sohu.com/a/146106524_120809
22 http://sh.eastday.com/m/20180512/u1a13898139.html
23 China Bureau of Statistics: http://data.stats.gov.cn/search.htm?s=%E4%B8%8A%E6%B5%B7%20%E8%83%BD%E6%BA%90
24 Guangdong Academy of Social Statistics: http://www.gdass.gov.cn/MessageInfo_6600.shtml
25 https://www.bayarea.gov.hk/en/opportunities/it.html
26 https://assets.kpmg.com/content/dam/kpmg/cn/pdf/en/2017/09/the-greater-bay-area-initiative.pdf
27 Hong Kong Census and Statistics department: https://www.censtatd.gov.hk/hkstat/sub/sp90.jsp?productCode=B1100002
28 Hong Kong Energy statistics report: https://www.statistics.gov.hk/pub/B11000022017AN17B0100.pdf
29 Macao Census and Statistics department: https://www.dsec.gov.mo/Statistic.aspx?lang=en-US&NodeGuid=d45b-f8ce-2b35-45d9-ab3a-ed645e8af4bb
30 http://finance.ifeng.com/a/20170908/15662337_0.shtml
31 http://zwgk.gd.gov.cn/006939748/201507/t20150729_595930.html
32 http://www.itbear.com.cn/html/2018-01/251340.html
33 http://mini.eastday.com/mobile/160121133505003.html
34 https://www.chinadialogue.net/article/show/single/en/9099-Chengdu-s-pollution-is-complicated-by-taxi-apps
35 http://www.mnw.cn/news/shehui/1577686.html
36 http://scnews.newssc.org/system/20161225/000735052.html
37 National Bureau of Statistics
38 https://cq.ifeng.com/a/20180222/6385035_0.shtml
39 https://sichuan.scol.com.cn/fffy/201608/55613479.html
40 http://www.360doc.com/content/17/1119/14/22587800_705267163.shtml
41 http://www.xinhuanet.com/english/2016-10/10/c_135743494.htm
42 Based on MGI: Smart Cities: Digital Solutions 2018, MGI: The Internet of Things: Mapping the value beyond the hype, Siemens, Better Cities Better Life, 2015

43 forbes.com/sites/forbestechcouncil/2018/03/05/what-we-can-learn-from-china-about-iot
44 Artificial Intelligence: Implications for IoT Security by Lars Reger (SVP & CTO NXP Automotive) & Fariborz Assaderaghi (SVP & CTO NXP IoT and Security), https://assets.new.siemens.com/siemens/assets/public.15450 43675.402c3347-2bb6-4021-aa19-3c8eb-8325be9.181217-shi-cot-artificial-intelligence.pdf accessed on 19 January 2019
45 Artificial Intelligence: Implications for IoT Security by Lars Reger (SVP, CTO of NXP Semiconductors) & Fariborz Assaderaghi (SVP & CTO NXP IoT and Security)
46 IEA, World Energy Outlook 2017, https://www.iea.org/weo/china/
47 http://fortune.com/2017/12/24/siemens-blockchain-lo3/
48 https://www.worldenergy.org/wp-content/uploads/2017/11/Blockchain_full-paper_FINAL.pdf
49 https://www.worldenergy.org/wp-content/uploads/2017/11/Blockchain_full-paper_FINAL.pdf
50 China Building Energy Use 2016, Building & Energy Research Center, Tsinghua University
51 http://www.xinhuanet.com/english/2017-06/13/c_136362465.htm
52 https://www.statista.com/statistics/688114/china-market-size-of-the-green-building-certification-consultancy-industry
53 https://www.statista.com/topics/1516/transport-infrastructure-in-china/
54 Energising transport and mobility in China, GIZ
55 http://www.xinhuanet.com/english/2018-03/22/c_137057593.htm
56 https://www.herbertsmithfreehills.com/latest-thinking/connected-and-autonomous-vehicles-is-china-ready#one
57 Frost & Sullivan, https://store.frost.com/global-electric-vehicle-market-outlook-2018.html, accessed on 9 January 2019
58 MOT, Application Opinions about Accelerating the Promotion and Application of New Energy Automobiles in the Transport Sector, 2015
59 NRDC, Electric Vehicle Charging Infrastructure Development Guidelines (2015-2020)
60 McKinsey, Charging ahead: Electric vehicle infrastructure demand, October 2018, Charging-ahead-electric-vehicle-infrastructure-demand-final
61 McKinsey, Reserve a seat – the future of mobility is arriving early, December 2018

62 Cities in the Driving Seat, Connected and Autonomous vehicles in Urban Development, 2018 https://w3.siemens.com/topics/global/en/intelligent-infrastructure/pages/cities-driving-seat.aspx
63 http://www.chinadaily.com.cn/a/201802/12/WS5a8143b4a3106e7dcc13c4e2.html
64 https://www.rolandberger.com/en/Point-of-View/New-mobility-trends-China-leads-the-way.html
65 http://www.sustainabletransport.org/archives/5934
66 Evaluating the efficiency of municipal solid waste management in China, Qing Yang, Lingmei Fu, Xingxing Liu & Mengying Cheng, International Journal of Environmental Research and Public Health, November 2018
67 What a Waste: A global review of solid waste management, March 2012, World Bank
68 The Circular economy opportunity for Urban and Industrial Innovation in China, Arup & Ellen Macarthur Foundation, 2018, https://www.ellenmacarthurfoundation.org/assets/downloads/The-circular-economy-opportunity-for-urban-industrial-innovation-in-China_19-9-18_1.pdf
69 https://www.weforum.org/agenda/2018/12/no-chopsticks-with-my-takeaway-how-china-is-tackling-food-waste-with-digital-innovation/
70 gwp.org/globalassets/global/toolbox/publications/technical-focus-papers/tfpchina_2015.pdf
71 https://www.ft.com/content/3ee05452-1801-11e8-9376-4a6390addb44
72 https://edition.cnn.com/2017/03/21/asia/china-water-crisis/index.html
73 gwp.org/globalassets/global/toolbox/publications/technical-focus-papers/tfpchina_2015.pdf
74 McKinsey Global Institute, Digital China: Powering the economy to global competitiveness, December 2017
75 https://www.healthcare.siemens.com/insights/news/dorin-comaniciu.html, accessed January 17 2019
76 https://www.telegraph.co.uk/news/world/china-watch/technology/smart-healthcare-china/
77 https://www.chinadialogue.net/article/show/single/en/10711-China-releases-2-2-action-plan-for-air-pollution
78 https://www.mckinsey.com/featured-insights/china/digital-china-powering-the-economy-to-global-competitiveness
79 https://www.mckinsey.com/featured-insights/china/digital-china-powering-the-economy-to-global-competitiveness

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