REGIONAL INITIATIVES – ARAB REGION

# ICT Roadmap for the TRANSITION TO SMART SUSTAINABLE CITIES IN THE ARAB REGION

Report


Telecommunication Development Sector

ITU

# ICT roadmap for the transition to smart sustainable cities in the Arab region

This report on the ICT roadmap for the transition to smart sustainable cities in the Arab region was prepared by Dr Dave Faulkner under the supervision of the International Telecommunication Union (ITU) Telecommunication Development Bureau (BDT). The ITU Regional Office for the Arab region, with support from the Telecommunication Standardization Bureau (TSB), worked closely with the expert to produce this report. Special focus has been given to the requirements of smart sustainable cities (SSC) in the Arab region. The report was drafted prior to the ITU Forum on Smart and Sustainable Cities and the last Meeting of Focus Group on Smart and Sustainable Cities, Abu Dhabi, United Arab Emirates, from 3 to 7 May 2015 and has been revised to include discussions and recommendations made at this event.

ISBN:
978-92-61-21841-6 (paper version)
978-92-61-21851-5 (electronic version)

**Please consider the environment before printing this report.**

## Executive summary

This report identifies Information Communication Technologies (ICTs) and a deployment timeline to make a city smart and sustainable with a focus on the needs of the Arab region. A smart city needs the best telecommunication services available on both wireless and fixed networks. This includes 4G wireless, WiFi hotspots and fibre optic networks to every new building and other possible location.

In the Arab region, the legacy fixed network subscriptions are in decline whereas wireless services are growing. Furthermore the wireline services peaked in 2008 with 10.3 subscriptions per 100 inhabitants. This compares with Europe which peaked in 2005 with 45.5 per 100 inhabitants. If a typical household has two to three occupants, this implies that only about 25 per cent of Arab households have a fixed line.

It has been predicted that for the Internet of Things (IoT) there will be 25 billion connected devices by the year 2020. Smartphones plus their peripheral devices, and machine to machine (M2M) communications are the main drivers for IoT development.

The connection and powering of these devices also need to be considered. Initially, most devices such as smartphones will be connected via wireless and powered via rechargeable batteries. However, in the case of sensors and actuators in the smart sustainable cities (SSC) infrastructure, the task of locating and replacing worn out batteries is a costly exercise. Powering options are therefore examined in this report and it is suggested that fixed lines to sensors using twisted pair technology is an important option.

In the next 10 years in the Arab region, 10-20 million new homes will be needed to serve a population predicted to rise by 55 million [1]. It is recommended that these homes should be served by traditional twisted pair technology in addition to high capacity fibre in order to power emerging sensors and the IoT, and to provide high speed access for applications such as e-commerce.

It is further recommended that twisted pair cabling should be used to connect and power the expected thousands of sensors around the city so that parameters such as temperature, pollution and traffic volumes can be measured. City planners should take note of the expected growth of IoT when considering whether twisted pair is the technology of choice for the sensor layer network.

Whilst the Arab region has some specific requirements for SSC, many of the objectives are common to SSC around the world. It is therefore recommended that city planners with an interest in ICT read the reports produced by the ITU-T Focus Group on Smart Sustainable Cities (FG SSC) and follow and/or contribute to the subsequent activities in ITU as detailed in this report.

With an arid climate and a population set to increase by 55 million by 2025, provision of an adequate water supply with smart water management is also a high priority for the Arab region. This report also shows that by meeting this requirement, the Arab region could take a leading role in future entrepreneurship and global standardization activities in this domain.

[1] Katja Schäfer "Urbanization and Urban Risks in the Arab Region" 1st Arab Region Conference for Disaster Risk Reduction, 19-21 March 2013 at Aqaba – Jordan: www.preventionweb.net/files/31093_habitataqabaurbanresillience.pdf

# Table of contents

# 1 Introduction

This report was requested by the ITU Regional Office for the Arab region as an additional document to those produced by The ITU Focus Group on Smart Sustainable Cities (FG-SSC)[2], presented at the ITU Forum on Smart Sustainable Cities Abu Dhabi, United Arab Emirates, May 2015[3]. The FG-SSC acted as an open forum for smart-city stakeholders such as: municipalities, academic and research institutes, non-governmental organizations (NGOs), ICT organizations, industry forums and consortia; to exchange knowledge in the interests of identifying the standardized frameworks needed to support the integration of ICT services in smart cities. To keep this document brief, the approach taken assumes that the reader is familiar with the deliverables of the FG-SSC that are relevant to all parts of the world. Here focus is given to additional requirements of the Arab region. There are a total of 22 ITU Arab Member States: Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, and Yemen.

**Figure 1: Map of the Arab region**

*Source: Arab League of States: www.lasportal.org/ar/Pages/default.aspx* [4]

ITU supports a number of objectives in the ITU Arab region including:

- To foster international cooperation.
- To foster an enabling environment conducive to ICT development.
- To deploy telecommunication/ICT networks as well as relevant applications.
- To bridge standardization gaps.
- To build human and institutional capacity, providing data and statistics.
- To promote digital inclusion and provide concentrated assistance to countries in special need.

[2] Focus Group On Smart Sustainable Cities: www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx

[3] www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Pages/Events/2015/SSC/SSC.aspx

[4] The designations employed and presentation of material in this publication, including maps, do not imply the expression of any opinion whatsoever on the part of ITU concerning the legal status of any country, territory, city or area, or concerning the delimitations of its frontiers or boundaries.

- To enhance environmental protection, climate-change adaptation and mitigation, and disaster-management efforts through telecommunications/ICTs.
- To assist in the development process using applications in areas such as health and education.
- To develop the information society in the Arab countries, supporting open source software.

These objectives fall within the scope of reports written by the ITU-T Focus Group on Smart Sustainable Cities[5]. In the context of SSC, this report focuses on the above objectives, in particular on the additional infrastructure that may be needed in the Arab region to enable 'sensor layer networks' and the 'Internet of things' to be fully adopted in new cities and urban developments in the Arab region.

**Box 1: ITU Focus Group on Smart and Sustainable Cities (FG-SSC) – Results**

- Defining the role of ICTs in cities that aim to be environmentally sustainable. This will include identifying ICT systems necessary to develop an environmental and sustainable city.
- Formulating an international definition for smart sustainable cities.
- Developing key performance indicators (KPIs) to help urban stakeholders measure the level of transitions to SSC.
- Presenting a master plan and guide on smart sustainable cities.
- Establishing relationships with other organizations that could contribute to the standardization activities of ICTs, environment and climate change in cities.
- Establishing a roadmap of the ICT sector contribution to smart and sustainable cities.
- Suggesting future ITU-T study items and related actions within the scope of the ITU-T SG5 for example on:
  - concepts, coverage, vision and use cases of smart and sustainable cities;
  - characteristics and requirements of smart and sustainable cities;
  - efficient services and network infrastructure of smart and sustainable cities, as well as its architectural framework from the environmental impact point of view.
- Identifying and developing a set of KPIs to assess how the use of ICTs has an impact on the environmental sustainability of cities.
- Fostering the development of strategies and best practices related to policies and standards to help cities deliver ICT environmental services including the optimization of the use of scarce resources and build resilience to climate change in cities.
- Identifying potential barriers in the use of ICTs to achieve environmental sustainability in cities.
- Helping ITU-T Study Group 5 to become a global reference on ICTs and smart and sustainable cities.
- Setting up a global gateway on ICTs contribution to smart and sustainable cities.
- Completing the development of 21 technical reports and specifications on smart sustainable cities

The FG-SSC concluded its work in May 2015. Following on from this, it was deemed essential to conduct work on smart cities on a global scale. Subsequently, a new ITU-T Study Group 20 (SG20) on "IoT and its applications, including smart cities and communities" has been created to address the standardization requirements of Internet of Things (IoT), with an initial focus on IoT applications in smart cities.

[5] Focus Group On Smart Sustainable Cities: www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx

**Box 2: ITU Study Group 20 on IoT and its applications, including smart cities and communities**

The new Study Group entitled "ITU-T Study Group 20: IoT and its applications, including smart cities and communities" is responsible for the development of international standards to enable the coordinated development of IoT, including machine-to-machine communications and ubiquitous sensor networks. This Study Group develops standards that leverage IoT to address urban-development challenges.

An important aspect of research covered by this Study Group is the standardization of end-to-end architectures for IoT and mechanisms for the interoperability of IoT applications and datasets employed by various vertically oriented industry sectors.

SG20 commenced its first meeting from 19-23 October 2015 at the ITU Headquarters in Geneva, Switzerland. The first SG20 meeting had 179 participants and 94 Contributions overall.

During the SG20 meeting, the terms of reference of the Joint Coordination Activity on Internet of Things and Smart Cities and Communities (JCA-IoT and SCC) was agreed on. It was decided that the next JCA-IoT and SCC meeting would be held in conjunction with the next SG20 meeting.

The following Questions are currently under study within SG20:

- Q1/20 which deals with Research and emerging technologies including terminology and definitions.
- Q2/20 which deals with Requirements and use cases for IoT.
- Q3/20 which deals with IoT functional architecture including signalling requirements and protocols.
- Q4/20 which deals with IoT applications and services including end user networks and interworking.
- Q5/20 which deals with Smart Cities and Communities requirements, applications and services.
- Q6/20 which deals with Smart Cities and Communities infrastructure and framework.

The next SG20 meeting will take place in Singapore from 18-26 January 2016.

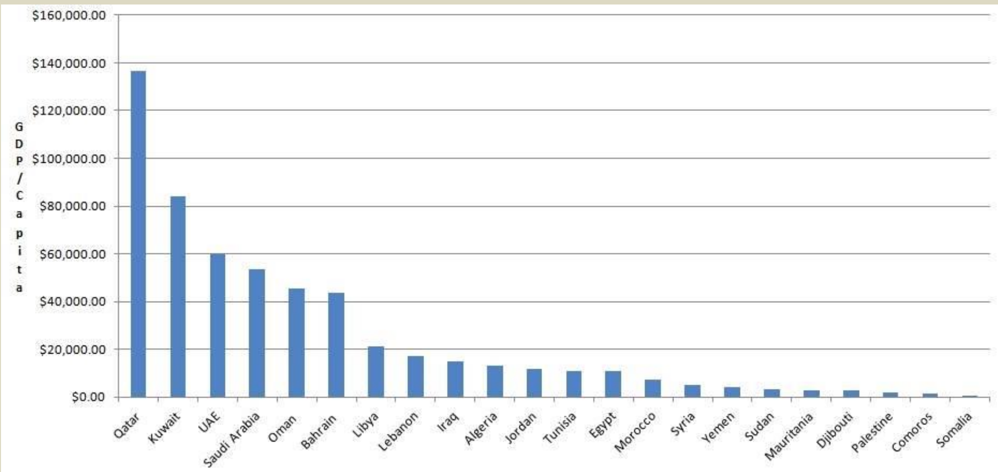
*Please see: www.itu.int/en/ITU-T/studygroups/2013-2016/20/Pages/default.aspx*

# 2 Background

## 2.1 Economic situation in the Arab region

The gross domestic product (GDP) per capita for the Arab region is given in Figure 2.

**Figure 2: Comparison of GDP of the Arab States (World Bank - 2013)**




*Source: http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?order=wbapi_data_value_2013+wbapi_data_value+wbapi_data_value-last&sort=des*

The overall GDP from the Arab region may be calculated from the data shown in Table 1.

**Table 1: Economic indicators for the Arab region compared with Europe**

| | GDP/Capita | Population | GDP |
|---|---|---|---|
| Arab States | USD 16 945.58 | 359 095 389 | USD 6 085 079 793 087 |
| Europe | USD 34 300.00 | 742 452 000 | USD 25 466 103 600 000 |

The distribution of GDP among the Arab States has a very wide range with the oil-rich states being the wealthiest. The ratio between richest and poorest is 230 000. This compares with the 28 countries in the European Union where the ratio is 8.9[6].

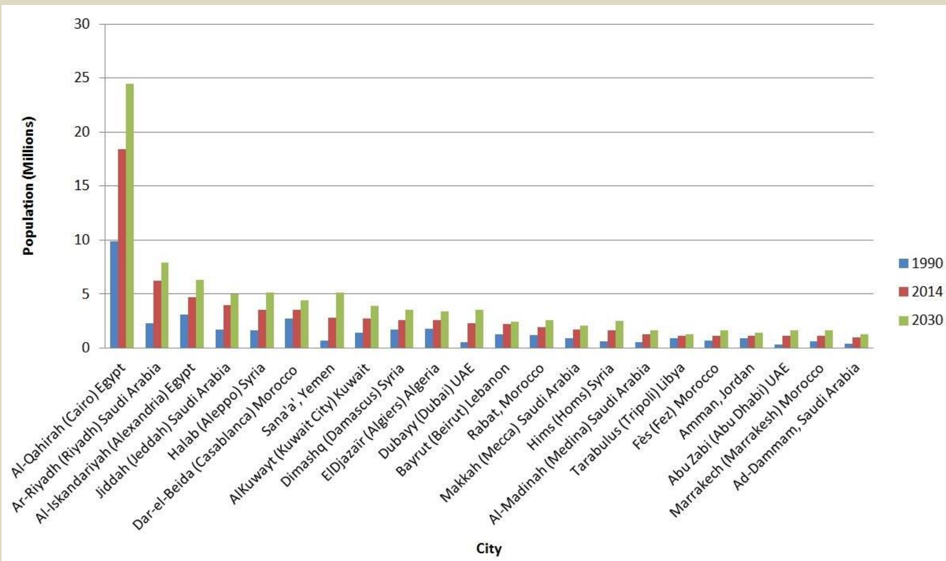
## 2.2 Trends in urban population

In 2010, the population in the Arab region was about 357 million people, reaching an estimated 646 million by 2050; this represents an urban growth rate of approximately 2.2 per cent per annum. There is also an interesting predicted change in urban population[7]:

- 2010: 357 million residents – 56 per cent live in cities;
- 2050: 646 million residents – 68 per cent will live in cities.

Rapid population growth is a major challenge. The next decade could see a population growth of 55 million or 15 per cent if present trends continue. If achieved through urbanisation, this would equate to 55 cities of 1 million inhabitants. This may create cities or cause the expansion of the 32 cities that currently have a population greater than 1 million. The chart in Figure 3 shows 21 cities with growth rate predictions to 2030.

**Figure 3: Predicted growth of cities with forecasts to 2030**




*Source: UN http://esa.un.org/unpd/wup/wallcharts/WUP_2014%20Urban%20Agglomerations%20Wallchart.pdf*

6 European Union: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=tec00114

7 Katja Schäfer "Urbanization and Urban Risks in the Arab Region" 1st Arab Region Conference for Disaster Risk Reduction, 19-21 March 2013 at Aqaba – Jordan: www.preventionweb.net/files/31093_habitataqabaurbanresillience.pdf

## 2.3 Urbanisation trends and challenges

A number of trends and risks have been previously identified[8]:

- Urbanization is driven by economic development, migration to oil-rich countries, drought and conflict (importance varying by sub-region). In 2010 there were 7.4 million refugees, 9.8 million internally displaced people, and 15 million international (economic) migrants.
- Several primary cities have become extended metropolitan regions; some are actual or emerging mega-urban regions with complex issues of region-wide urban governance, authority conflicts and governance voids.
- Highly-centralized government modalities weaken relationships between citizens and local government.
- Disparities of wealth and urban poverty exist across regions.
- Affordable housing shortage exists, with speculatively escalating land prices, cumbersome and expensive property registration and limited access to housing finance.
- Urban informal settlements have developed in some part of the Arab region.
- Security of urban water and food are key defining social problems.
- Youth bulge (60 per cent of population below 25 years) and unemployment rates are a growing concern.
- Marginalisation and poverty induced by lack of mobility have fuelled recent political polarisation.
- Internal trade is underutilized, with an evident need for greater intra-Arab cooperation.

Smart sustainable cites are therefore a top priority for the Arab region, and offering housing and employment for young people is a particularly important focus.

The Arab region has considerable internal disparities that are reflected in the living conditions in its cities and have resulted in widely varying domestic needs and priorities[9]:

- rehabilitation and reconstruction (Iraq, Lebanon, Palestine, Somalia);
- poverty alleviation (Egypt, Jordan, Morocco, Syria, Yemen);
- urban management and housing needs (Algeria, Egypt, Jordan);
- capacity building (Gulf countries).

### Example: Cairo

In 2014, Cairo had an estimated metropolitan population of 18 million, which makes it the largest city in Africa and the Middle East, and the world's tenth largest metropolitan area[10]. The annual growth rate is 23 per 1 000 people per annum excluding migration, and the city is set to expand by at least 2.3 per cent per annum. Over a 10 year period this could mean 5.6 million more people need to be accommodated in the metropolitan area, which could be achieved by a mixture of infill, construction of new cities or suburban development[11]. Perhaps the most likely housing scenario for the Arab region will be similar to that in other

---

8 Idem.

9 UN Habitat: www.un.org/ga/Istanbul+5/13.pdf

10 World population review: http://worldpopulationreview.com/world-cities/cairo-population/

11 According to The Guardian, a new city of 5 million people is being planned with 21 residential districts, 663 hospitals and clinics, 1 250 mosques and churches, and 1.1 million homes housing at least five million residents: www.theguardian.com/cities/2015/mar/16/new-cairo-egypt-plans-capital-city-desert

regions where new developments are planned at the edge of the existing cities so that business and transport can naturally expand into them as prosperity grows and new accommodation becomes available. Toulouse in France could be a good example, where growth has been driven by the aviation industry. The metropolitan area registered a population growth rate of +1.34 per cent per year between 2006 and 2011, the highest growth rate of any French metropolitan area larger than 500 000 inhabitants[12].

**Example: Dubai, United Arab Emirates**

The ITU Forum on Smart Sustainable Cities, Abu Dhabi, United Arab Emirates, May 2015, featured a presentation by H.E. Dr. Aisha Bin Bishr, a member of Smart Dubai Initiative[13]. She presented the Dubai city vision "To make Dubai the happiest city on Earth".

In the opening session of the Forum, Chaesub Lee, Director of the ITU Telecommunication Standardization Bureau, said that a pilot trial is being planned with Dubai in cooperation with ITU-T to test key performance indicators (KPIs). This project will help evaluate the feasibility of the indicators with the aim of contributing to their international standardization. The agreement between ITU and the Executive Office of Dubai was signed at the ITU Forum on Smart Sustainable Cities in Abu Dhabi, 3-4 May 2015. These are being developed in ITU-T Study Group 5, Question 18. Dubai, by sharing the results with ITU-T, will also share them with the rest of the world so that all may benefit.

**Example: Madīnat (Masdar) City**

The core of Masdar City is a planned city, in terms of both architecture and environmental impact. It is near Abu Dhabi International Airport and is being built by Masdar[14], a subsidiary of Mubadala Development Company, with the majority of seed capital provided by the Government of Abu Dhabi. Key features from an SSC perspective are[15]:

- The city is envisioned to cover 6 square kilometres (2.3 square miles) and will be home to 45 000 to 50 000 people and 1 500 businesses.
- It is a research and technology-intensive municipality that incorporates living accommodation.
- The city is designed to be a hub for clean technology companies.
- The temperature in the streets is generally 15 to 20°C (59 to 68°F) cooler than the surrounding desert. The temperature difference is due to the unique Masdar construction. A 45-meter (148 ft) high wind tower has been modelled on a traditional Arab design to suck air from above and push a cooling breeze through Masdar streets. The site is raised above the surrounding land to create a slight cooling effect. Buildings are clustered close together to create streets and walkways shielded from the sun.
- Masdar will use a mix of electric vehicles and other clean-energy vehicles for mass transit inside the city.
- The Masdar Institute of Science and Technology is a graduate-level research university focused on alternative energy, environmental sustainability, and clean technology.
- The Institute's building, developed in cooperation with the Massachusetts Institute of Technology, uses 51 per cent less electricity and 54 per cent less potable water than traditional

12 Wikipedia: http://en.wikipedia.org/wiki/Toulouse

13 H.E. Dr. Aisha Bin Bishr: www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2015/SSC/S1-DrAishaBinBishr.pdf

14 Masdar (Company) 2013: www.masdar.ae/en/media/detail/masdar-fact-sheet-ver-1-jan-2013

15 Masdar City, Wikipedia http://en.wikipedia.org/wiki/Masdar_City

buildings in the UAE[16] and is fitted with a metering system that constantly observes power consumption.

- Masdar is powered by a 22-hectare (54-acre) field of 87 777 solar panels with additional panels on roofs. (Note special coatings are being tested on the panels to reduce build-up of sand).
- Approximately 80 per cent of the water used will be recycled and waste water will be reused "as many times as possible", with this grey water being used for crop irrigation and other purposes.

# 3 What are the trends in telecommunication services in the Arab States?

## 3.1 Indicators from ITU

Some key statistics have been chosen as Arab region indicators[17]:

- Fixed line peaked in 2011 with 9.8 subscriptions per 100 inhabitants (Europe peaked in 2005 when there were 45.5 subscriptions per 100 inhabitants, with a steady decline since).
- Mobile cellular subscriptions are estimated to reach 108.2/100 inhabitants in year 2015 (Europe: 120.6/100).
- Active mobile broadband subscriptions are estimated to reach 40.6 per 100 inhabitants by 2015 (Europe: 78.2/100).
- Fixed line broadband subscriptions are estimated to reach 3.7 per 100 inhabitants by 2015 (Europe: 29.6/100).
- Internet is estimated to reach 37 per 100 inhabitants by 2015 (Europe: 77.6/100).

## 3.2 Analysis of indicators

People in Arab States use telephony services mainly via mobiles. Subscriptions are approaching saturation with some inhabitants having more than one subscription, such as a personal and a business account. People in the Arab States access the Internet mainly through mobile subscriptions. Only 40.6 per cent has Internet access compared with Europe at 78.2 per cent. Fixed line connections appear to be quite low and declining. This means that broadband is available mainly through wireless services. Wireless broadband services generally suffer from low data throughput even though the maximum speed is high. For example, if the base station has a maximum data rate of 50 Mbit/s and there are 50 users connected the average throughput is only 1 Mbit/s. With a fixed line the speed can be up to the maximum rate of the line which may be 50 Mbit/s or more.

## 3.3 What telecommunications capability is recommended for SSCs in the Arab region?

*It is recommended that the coverage, speed and take up of broadband services should be targeted at 100 per cent of the population with a target of at least 30 Mbit/s by 2020*

*It is recommended that for new buildings, fixed lines should be provided, including at least one optical fibre plus at least one twisted pair. The provision of two of each should also be considered as a low-cost way of enabling future growth or upgrade without disrupting existing services.*

[16] Energizer “Typical Temperature Effects”: http://data.energizer.com/PDFs/temperat.pdf

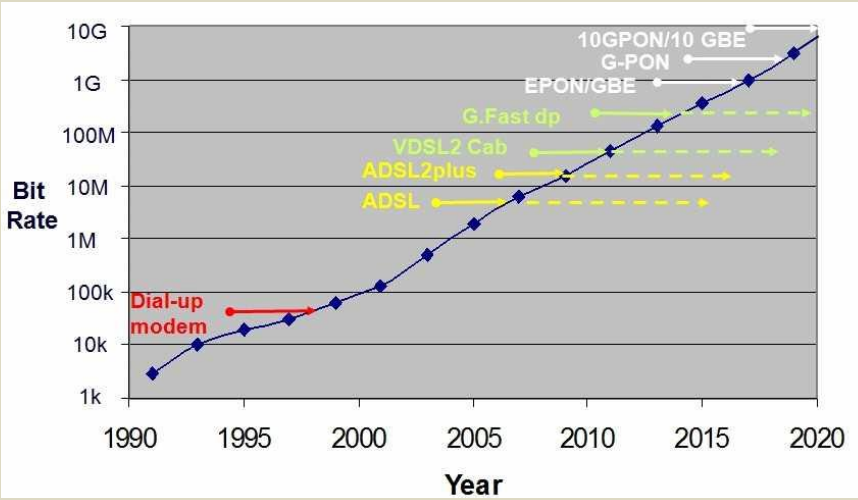
[17] ITU statistics and indicators 2015: www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

### Rationale

This would make telecommunications in Arab States comparable with the best reported access speed targets for countries making National Commitments in the ITU Connect 2020 Agenda for Global Telecommunications targets for ICT development[18].

The trend in take-up of fixed line services is declining. However, it is very expensive to provide a fixed line after a new building is completed but is not costly at the outset when trenches are open. The availability of fibre at the edge of the network is an important requirement which will be increasingly needed so that broadband access speeds can be improved. The edge of the network will most likely be terminated on a 5G femto-cell or WiFi router so that an access data rate of 100 Mbit/s or more will be possible with a low sharing-factor. The sharing factor in a household might be typically 1-5 persons. Even if they are no longer used for telephony or access to emergency services fixed lines are an ideal way of supporting a sensor-layer network because power and a transmission path can be provided together. Power on a telephone line is more secure than grid electricity because back-up power is normally provided at the central office/exchange.

**Figure 4: Fixed access timeline**




*Source: Adapted from ITU,[19] and Ericsson[20]*

At the ITU Forum on Smart Sustainable Cities (May 2015), the question of what downstream and upstream access rates should be provided was discussed. This illustrates the peak downstream rates and the time at which they first become commercially available and begin deployment. For wire-line systems the maximum rate depends strongly on the length of line. The average upstream rate is approximately 25 per cent of the downstream rate and varies from product to product. Business users may choose symmetrical services whereas residential users may opt for asymmetrical services with entertainment as an important requirement.

The sustainable downstream rate is dependent on the contention ratio (or oversubscription ratios) of the access node which is set by the operator. This also varies according to the number of users online and

[18] ITU Connect 2020 Agenda for Global Telecommunication/ICT Development http://www.itu.int/en/connect2020/Pages/default.aspx

[19] www.itu.int/en/ITU-T/studygroups/com15/Documents/tutorials/tutorial_2005_10_26_faulkner.ppt

[20] Ericsson "Next generation Broadband in Europe: The Need for Speed" Heavy Reading Report, Vol. 3 No 5 March 2005.

therefore the time of day. As an example, the following contention ratios may be typical of different commercial offerings that are targeted at specific user groups[21]:

- 5000:1 emerging markets
- 500:1 base residential
- 200:1 residential
- 100:1 basic
- 10:1 bursting
- 8:1 pooled dedicated
- 4:1 shared services
- 1:1 account dedicated

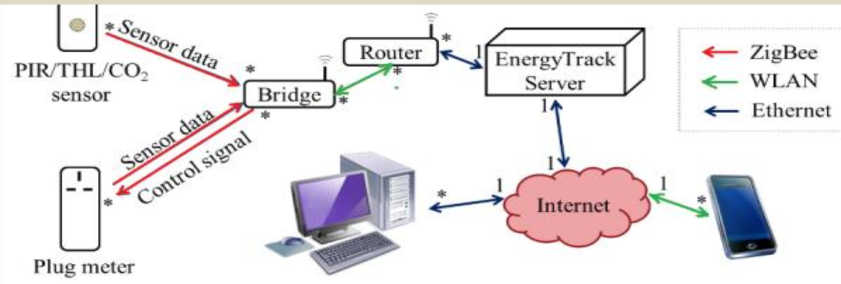
The sustainable bit rate is also dependent on how the access lines are apportioned to the backhaul connection[22]: “One of the issues with a stated contention ratio is that it is not on its own, adequate for comparing services. There is a huge difference between 1000 users each on a 2 Mbit/s service sharing a 40 Mbit/s pipe, and 50 users each on a 2 Mbit/s service sharing a 2 Mbit/s pipe. In the latter case two users trying to download at the same time means each get 50 per cent of the speed. When there are 1000 users it would take 20 users maxing out their 2 Mbit/s link at the same time to show any congestion. However both of these would be quoted as 50:1 contention”.

When considering the appropriate technology for a particular city or country, much depends on what is already installed and what investment in infrastructure can be sustained. Without state aid, the technology and bit-rate is determined by the market and GDP. Wireless systems give a broadband capability to citizens at a lower entry-cost than wired because less infrastructure is needed. In the long-run fibre technology with a wireless edge, such as 4/5G and WLAN, is the likely access technology of choice.

## 4 The sensor layer network and Internet of Things

The sensor layer network and Internet of Things (IoT) is described in ITU-T FG-SSC deliverable *Technical Report on Smart Sustainable Cities Infrastructure, 2014* and ITU-T FG-SSC deliverable *EMF Considerations in Smart Sustainable Cities, 2014*. This is illustrated in Figure 5.

**Figure 5: Sensor layer network**




*Source: ITU*

[21] Quora Blog “How much oversubscription is acceptable (given today's standards) for an ISP for (1) dedicated IP access and (2) broadband access? www.quora.com/How-much-oversubscription-is-acceptable-given-todays-standards-for-an-ISP-for-1-dedicated-IP-access-and-2-broadband-access

[22] Contention Ratio: http://en.wikipedia.org/wiki/Contention_ratio

The IoT, together with the other emerging Internet developments such as: the Internet of Energy, Media, People, Services and Business/Enterprises, are the backbone of the digital economy, the digital society, and IoT trends show that we will have 25 billion connected devices by the year 2020[23].

Devices like smart phones and machine to machine (M2M) or thing to thing (ToT) communications will be the main drivers for further IoT development. Sensors may be used for security, lighting, presence, weather, transportation, movement or position installed on the physical infrastructure of the SSC. These devices make it possible to monitor climate, road congestion, air pollution and criminal behaviour.

Many of these devices will be connected by short range wireless, using communications protocols such as ZigBee and Bluetooth to connect to a routing device. Lower power radio solutions are emerging which will help to prolong battery life. Whilst short range wireless may be suitable for the home or personal environment it may not be suitable for longer range applications within cities where buildings will shield the signals and so mesh networks will become more important for these applications.

The power consumption of wireless devices has been compared by Dementyev: "We provide experimental data comparing power consumption of Bluetooth Low Energy (BLE), ZigBee and ANT protocols for a cyclic sleep scenario, in which a short-range and low-power wireless sensor node periodically sends a data packet to a remote hub with intervening sleep intervals. Devices such as wearable health monitors often use this scenario when interfacing with a mobile phone-based hub. For all measured sleep intervals BLE achieved lower power consumption (10.1 µA, 3.3 V supply at 120 s interval), compared with ZigBee (15.7 µA), and ANT (28.2 µA). Most of the power consumption differences can be attributed to the time taken for a node to connect to the hub after waking up and the use of sleep between individual RF packets" [24].

The power consumption of Zigbee wireless devices is therefore the lowest, of the order of 50µW when sending short data updates every two minutes.

Powering the sensor layer network is an important lifecycle consideration. Whilst batteries may be suitable for the home or personal environment, a visit to a remote location in a city to replace batteries in wireless sensors is a costly service maintenance consideration. A battery life of less than 10 years is likely to mean that a business case cannot be made for the deployment of a smart city application such as smart parking or smart lighting. Wireline options should therefore be considered as a more sustainable alternative to wireless devices for the urban environment. More advanced solutions such as recharging batteries using ambient energy harvesting should also be explored[25].

More research on this topic area for IoT, will be conducted within the new ITU-T SG20.

## 4.1 Powering options: Wireless sensors

- Mains power (as in the plug meter example shown in Figure 5 above).
- Rechargeable batteries topped up by solar cells or a wind turbine (as in a remote weather station).
- Energy storage devices topped up using ambient energy harvesting or wireless energy recharge.

As can be seen above, a current of 15.7 µA is required to power a Zigbee device operating at a low duty-cycle. A small a pair of alkaline primary cells of size AA may typically have current capacity of 3000 mAh. This current drain would give fully charged cells a life of 21.7 years. However, this is more than the expected

[23] Gartner "4.9 Billion Connected 'Things' Will Be in Use in 2015" www.gartner.com/newsroom/id/2905717

[24] Dementyev, A. et al. "Power consumption analysis of Bluetooth Low Energy, ZigBee and ANT sensor nodes in a cyclic sleep scenario", Wireless Symposium (IWS), 2013 IEEE International Conference 14 18 April 2013, http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6616827&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6616827

[25] CYMBET Corporation Energy Harvesting & Storage: www.cymbet.com/design-center/energy-harvesting.php

life of the battery which is typically 10 years, but is even less with high temperature and/or humidity. High temperatures can be expected in the Arab region which will reduce the life of the battery. For example, if the battery is stored at 0 degree it will have a 95 per cent capacity of 10 years whereas at 40 degrees it will have only 70 per cent capacity after four years[26]. Battery life is also reduced when the positive terminal is exposed to the air. For a long lifecycle this must be coated in a suitable sealant. It is recommended that further studies should be made on the expected lifecycle if batteries are to be used to power remote devices in the sensor layer network especially at elevated temperatures.

## 4.2 Powering options: Wired sensors

Power and signal transmission may be enabled over wired networks as the four following examples show:

1. Power over Ethernet[27] can power sensors or actuators in a sensor layer network without recourse to batteries or a separate electricity supply from the network connection.
2. Telephony cable (twisted pair) may be used to provide both backhauling (e.g. A/VDSL) and powering. This is a typical case of use of the telecommunication company access network with power (e.g. power for a telephone or ADSL loop extender is provided along the line together with DSL signals for Internet access). Powering via the telephone line is also used for ISDN and alarm services.
3. The Home Plug Alliance (HPA) has developed standards enabling devices to communicate with each other, and the Internet, over existing home electrical wiring[28]. Power and communications may therefore be combined over a common mains facility to sensors or actuators on the periphery.
4. USB Wall socket[29]. In the domestic environment USB wall sockets are available combining both a mains outlet and a USB charger outlet. Due to the reach limitation of 3 m the sockets would need additional communications paths to enable communications to a central server.

## 4.3 Sensor powering at city scale

Whilst the demand for fixed telephone lines is falling they may be given a new lease-of-life as they may be needed to power sensor networks and transmit the signals. A further advantage of telephone lines is that the power is normally backed up by a battery and generator at the telephone exchange, which would not be the case for sensors relying on grid electricity. A question for city planners to consider is whether provision should be made for metallic telephone lines at remote points in the city where sensors are required.

Line-powered devices such as a symmetric digital subscriber line (SDSL) network termination are available that allow an Internet connected device to be added directly with power derived solely from the line. Further development may be necessary to optimise the way IoT devices may be terminated in the field so that line power is provided and two-way digital communications is possible. An example of a means of achieving this is given in the United States Patent Application 20150071098 “Delivery of electrical power”, 27 February 2013 (see Figure 6).

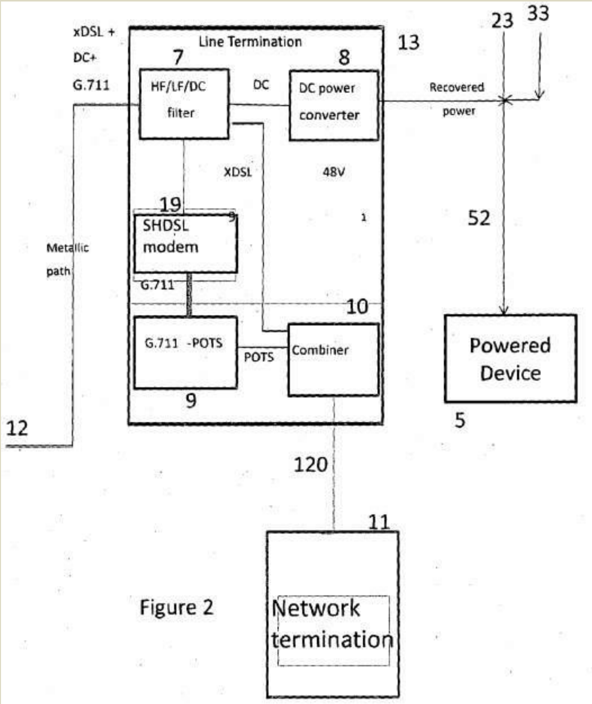
[26] Energizer “Typical Temperature Effects”: http://data.energizer.com/PDFs/temperat.pdf

[27] IEEE Standard IEEE 802.3 series; see IEEE 802.3af-2003 and the higher power IEEE 802.3at-2009. These are both included in 802.3-2012

[28] Home Plug Alliance, Technical Overview: www.homeplug.org/tech-resources/techoverview/

[29] BRE Trust: www.designingbuildings.co.uk/wiki/Power_over_USB

**Figure 6: Devices powered via a telephone line**




*Source: USA Patent Application 20150071098: www.freepatentsonline.com/20150071098.pdf*

According to this invention by British Telecom, more than one piece of equipment may be connected, whilst basic telephony and broadband access are also assured if needed. "Examples of remotely powered equipment currently contemplated include a specially adapted wireless access point or other type of end terminal, such as a Power-over-Ethernet adaptor. This allows provision of services such as wireless communications; and the provision of electrical power for distribution over Ethernet communications cable networks even at locations where no other form of power is available". This type of equipment could pave the way for WiFi networks at any location in a SSC and allow sufficient power for a number of sensors and actuators to be connected to a single DSL network termination.

*It is recommended that the technical feasibility and business case for providing twisted pair for sensor-layer networks is studied further both for existing cities and for new build.*

A number of questions emerge which will need studies of lifecycle and business case to obtain the best way forward:

- Will the twisted pair make a comeback and be the technology of choice for sensors in SSCs? In the next 10 years in Arab region there will be a need for between 10-20 million new homes to serve a population which is predicted to rise by 55 million.
- Should all these homes be served by traditional twisted pair in addition to high capacity fibre in order to power emerging 'sensors'?
- Will twisted pair also need to connect and power thousands of sensors around the city so that parameters such as temperature, pollution and traffic volumes may be measured?
- What should be done about existing households and businesses which have no fixed line access whether fibre or twisted pair?
- Can the cost of a sensor layer network, which may not be justifiable for a single service alone, be justified by taking account of the range of possible sensors which may share the same access platform?

City planners should take note of the expected growth of both broadband services and IoT and consider whether fibre is the technology of choice for broadband services and twisted pair is the technology of choice for the sensor layer network.

# 5 The way forward for SSC in the Arab region

The World Urbanisation Prospects[30] report includes two noteworthy paragraphs in the context of an ICT roadmap:

"*Successful sustainable urbanization requires competent, responsive and accountable governments charged with the management of cities and urban expansion, as well as appropriate use of information and communication technologies (ICTs) for more efficient service delivery. There is a need for building institutional capacities and applying integrated approaches so as to attain urban sustainability*".

"*Accurate, consistent and timely data on global trends in urbanization and city growth are critical for assessing current and future needs with respect to urban growth and for setting policy priorities to promote inclusive and equitable urban and rural development. In order to systematically track levels and trends in urbanization around the world and to monitor progress in sustainable development goals in urban and rural areas, governments, with the support of international cooperation, should continue their efforts to produce more extensive and better quality data on the size, distribution and characteristics of the population." Table 2 gives a basic comparison of differences in approach to smart cities*[31].

**Table 2: Alternative approaches to smart city design**

| | European Smart Cities | Chinese Smart Cities |
|---|---|---|
| Goals | More emphasis on green, low-carbon, energy, and transport | Economic restructuring, and urban upgrading |
| Formats | Independent smart projects targeting key areas | Comprehensive, systematic engineering projects |
| General design | Fewer municipal-level systematic planning, openness and PPP | Emphasis on smart city planning and action guideline, and top-level design |
| Appraisal | Attention on the cost-benefit of individual projects | Huge system, with great difficulty |

In Europe the population of cities is not increasing rapidly. Migration into cities has already taken place over the last two centuries through industrialisation. The situation in China is different, with rapid migration to cities as rapid industrialisation is still taking place. Arab States could be in yet a different situation. Table 3 could be one example.

**Table 3: Alternative approaches to smart city design**

| | Arab Region Smart Cities (suggestion) |
|---|---|
| Goals | Efficient use of water and cooling, homes and jobs for young people |
| Formats/scale | Suburban expansion plus new cities at the scale of 1 million citizens |
| General Design | Top-level vision and design is needed |
| Appraisal/difficulty | Huge system with great complexity |

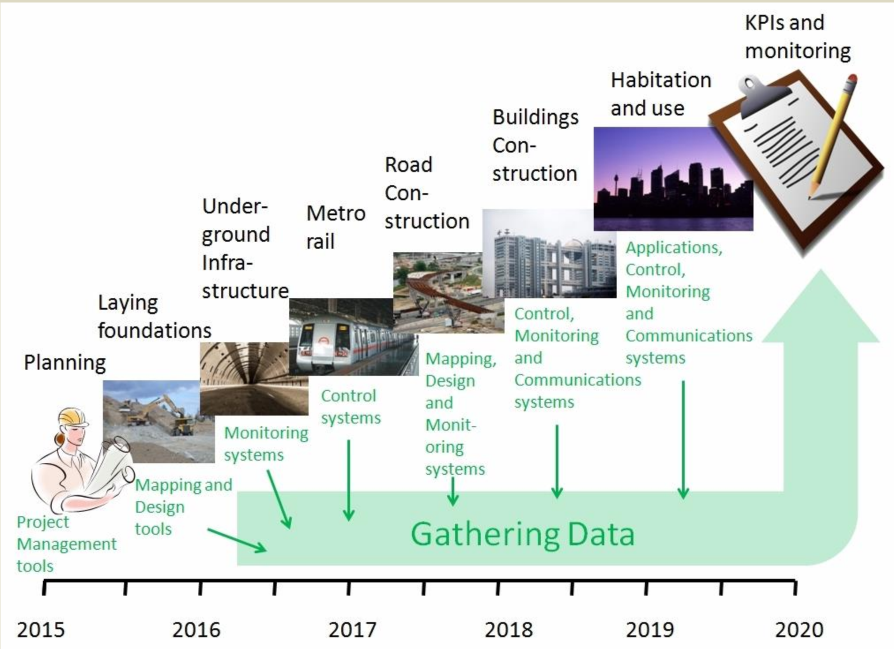
[30] World Urbanization Prospects 2014 Revision", page 18: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

[31] Yu Xiaohui, China Academy of Telecommunication Research, MIIT, "The Development of Smart Cities in China", 4th ITU Green Standards Week: www.itu.int/en/ITU-T/Workshops-and-Seminars/gsw/201406/Pages/Programme-24-sep.aspx

Figure 7 illustrates how a new city may be constructed from the ground up. The timescale is indicative of the stages of the project as they might appear on an architect's Gantt chart. In addition to the installation of traditional telecommunications services, the FG-SSC had placed great emphasis on the need to adopt a sensor layer network. The sensor layer network should have the capability of gathering real-time data, which could be used to provide an online real-time 'dashboard'. The data may be interpreted as performance indices to enable the performance of the city to be assessed by summing a range of weighted indices to produce an annualised key performance indicator (KPI)[32]. Additional data will need to be gathered from sectors other than ICT, and from citizens via questionnaires (online or gathered by interview) to obtain an overall assessment for the city.

To make it possible for a KPI to be derived, it is necessary to plan for its development from the outset involving key stakeholders such that the necessary sensors can be provided at each stage of the construction as the project develops. This will save significant cost compared with retrofitting especially if twisted pair cabling is to be provided to key locations for the sensor layer network.

**Figure 7: A sensor layer roadmap for smart sustainable cities**




*Source: ITU*

## 6 The way forward in standards

Whilst the Arab region has some specific requirements for SSC, many of the objectives are common to SSC around the world. It is therefore recommended that city planners with an interest in ICT read the reports produced by the FG-SSC and use the referenced standards.

The work of the FG-SSC was completed on 6 May 2015. Work on SSC is continuing in the newly established ITU-T SG-20 "IoT and its applications, including smart cities and communities which held its first meeting from 19 -23 October 2015 in Geneva, Switzerland. This Study Group is responsible for the formulation of international standards to enable the coordinated development of IoT. (See Box 2) It is therefore recommended that the ITU members from the Arab region follow the activities of this new Study Group which now helms the research on SSC.

---

32 ITU-T FG-SSC "Technical Report on Key Performance Indicators (KPIs) related to the level and usage of Information and Communication Technology (ICT) in Smart Sustainable Cities" 2015.

## 6.1 Assessing the $CO_2$ emissions of ICT in cities

### Why consider this?

- ICT contributes to the energy used in a city. By reducing the energy requirement, both $CO_2$ emissions and the energy costs over the lifecycle can be reduced. This is a first order effect.
- ICT can also help reduce the $CO_2$ emissions of the city. For example, ICT can be used to transform processes so that tasks can be carried out using teleworking and eliminate the need for travel to central offices. This is a second order effect (see below).

The desired outcome is to reduce overall emissions by using ICT to improve energy efficiency. A two-step approach is recommended here. The first step is to establish a set of indices which are relevant to the ICT energy efficiency and $CO_2$ emissions of a SSC. These indices may be collected and used to assess the overall change in energy efficiency or emissions from year to year. The second step in the assessment of the ICT related emissions of a SSC is described in the next section.

### How to assess it?

Recommendation ITU-T L.1440 "Methodology for environmental impact assessment of information and communication technologies at city level" [33] gives general guidance for city level environmental assessments related to ICT, and provides a description of methodologies to be used for the assessment of the environmental impact of ICT in cities. The current assessment is limited to energy consumption and GHG emissions.

Part I relates to the first order effects from the use of ICT goods and networks in a city´s organizations and households. It provides specific guidance in setting the city boundaries, preparing and performing the assessment of ICT related GHG emissions and energy consumption at city level.

Part II relates to the first and second order effects from ICT projects and services applied in the city environment. This Recommendation is currently under review by the ITU-T membership and (at the time of writing, May 2015) is due to be released during the next few weeks.

The ITU has also addressed this issue through its environmental targets of its Connect 2020 Agenda through its Target 3.3 "Greenhouse gas emissions generated by the telecommunication/ICT sector to be decreased per device by 30% by 2020". In line with this Target, the Connect 2020 Agenda presents a Roadmap for GHG emissions management which sets the basis for a framework to assess how ICTs reduce emissions in other sectors of the economy, providing value for the enabling effect of the ICT sector.

## 6.2 Smart water management

Smart water management is a key requirement for the Arab region. At the ITU Forum on Smart Sustainable Cities, there were two presentations on this topic[34] [35]. The ITU-T Focus Group on Smart Water Management (FG-SWM) which has finished its mandate on 2 March 2015 had some key technologies under study including:

- smart pipes and sensor networks;
- smart metering;
- communication modems;

---

[33] Recommendation ITU-T L.1440 "Methodology for environmental impact assessment of information and communication technologies at city level" www.itu.int/itu-t/aap/AAPRecDetails.aspx?AAPSeqNo=3209

[34] Dr Sekhar Kondepudi, Sustainable Cities and the Role of Information and Communication Technologies (ICTs): www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2015/SSC/S3-DrSekharKondepudi.pdf

[35] Dr Ramy Ahmed Fathy, Smart Water Management Regional Challenges and Future Prospects": www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2015/SSC/S4-DrRamyAhmedFathy.pdf

- geographic information systems (GIS);
- cloud computing;
- supervisory control and data acquisition system(SCADA);
- models, optimization, and decision-support tools;
- web-based communication and information system tools.

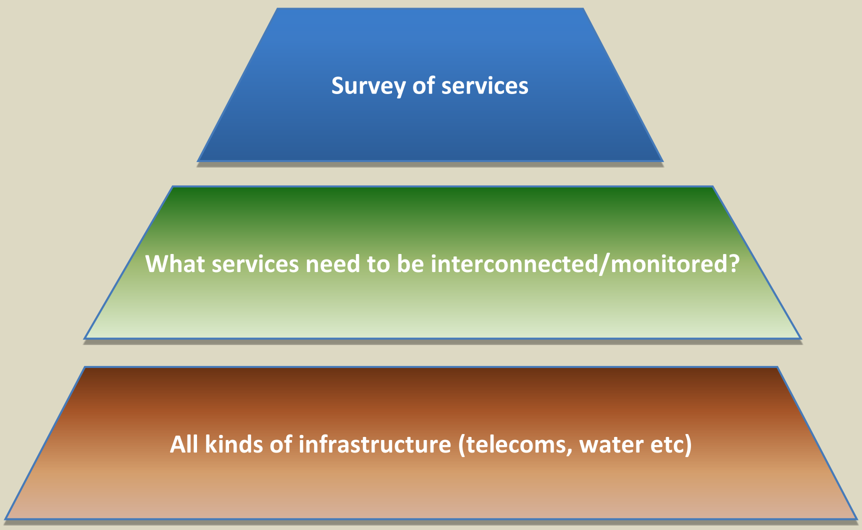
The FG-SWM also developed five deliverables.

Before completing its tenure, the FG-SSC also developed a Technical Report on Smart Water Management which can be referred to by the ITU Member States in the Arab region for their respective countries.

### 6.3 Mapping services to infrastructure: a general requirement for standards

At the ITU Forum on Smart Sustainable Cities, Dr. Ziqin Zang commented that there were some general requirements for matching city services to the infrastructure and identifying the points of interconnection between utilities. A proposed model is illustrated in Figure 8. This shows that a survey of service requirements is needed first. Next the infrastructure types needed to deliver the services are identified. Finally the need for possible interconnection, monitoring and control are identified and implemented.

**Figure 8: Mapping services to infrastructure**




*Source: ITU*

## 7 Business opportunities

It is estimated by IDC[36] that there will be 30 billion connected devices by 2020, revenue over the period 2012-2020 will be over USD 8 trillion, and that a lack of standards is a barrier to the take-up of IoT.

A portion of this massive revenue opportunity is open to entrepreneurs. Any business large or small with a creative flair could enter the market that is being opened up in the sensor layer network for SSCs. Two prerequisites are to be smart and well connected to the Internet.

[36] IEEE Comsoc, Internet of Things (IoT) Key Messages at 'IDC Directions 2014': http://community.comsoc.org/blogs/alanweissberger/internet-things-iot-key-messages-part-2-idc-directions-2014-market-survey-abst

Arab regional expertise could play a role in solving the problems of SSCs. The steps needed are to:

- identify, quantify and rank the problems;
- be pioneering;
- be entrepreneurial; and
- share results via standards.

## 8 Conclusion

It is recommended that the coverage, speed and take-up of broadband services should be targeted at 100 per cent of the population, with at least 30 Mbit/s download speed to all occupied buildings and to the majority of urban locations. This will allow people to participate effectively in online activities such as e-education and e-commerce.

It is suggested that fixed-lines should be provided to all new buildings, including at least one optical fibre and one twisted pair.

Additionally, it is recommended that the technical feasibility and business case for providing twisted pair cable for sensor-layer networks is studied further; both for existing cities and for new-build. The advantage of this is that a central power supply may be used that avoids the maintenance cost of replacing possibly thousands of batteries at the edge of the network.

Whilst the Arab region has some specific requirements for SSC, many of the objectives are common to SSC around the world. It is therefore recommended that city planners with an interest in ICT read the reports produced by the FG-SSC and follow and/or contribute to the new ITU-T SG20 activities. With an arid climate and a population set to increase by 55 million by 2025 [37], provision of an adequate water supply with smart water management is a high priority for the Arab region. The way in which this requirement is met is an example of how the Arab region could take a leading role in future entrepreneurship and global standardisation activities especially with reference to SSC.

[37] Katja Schäfer "Urbanization and Urban Risks in the Arab Region" 1st Arab Region Conference for Disaster Risk Reduction, 19-21 March 2013 at Aqaba – Jordan: www.preventionweb.net/files/31093_habitataqabaurbanresillience.pdf

## Abbreviations

| | |
|---|---|
| FG-SSC | ITU-T Focus Group on Smart Sustainable Cities |
| GDP | Gross Domestic Product |
| ICT | Information Communication Technologies |
| IoT | Internet of Things |
| ISDN | Integrated Services for Digital Network |
| ISO | International Organization for Standardization |
| KPI | Key Performance Indicator |
| M2M | Machine to Machine |
| SDSL | Symmetric Digital Subscriber Line |
| SSC | Smart Sustainable City |
| SSCC | Smart Sustainable Cities and Communities |
| xDSL | Any of the family of Digital Subscriber Line technologies |

## Bibliography

Arab region ITU Member States:
www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Pages/Membership/Membership.aspx

UN Conference on a World of Cities, New York, 2006, page 13
www.un.org/ga/Istanbul+5/13.pdf

Focus Group On Smart Sustainable Cities, Terms of Reference
www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx

World Bank 2013
http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?order=wbapi_data_value_2013+wbapi_data_value+wbapi_data_value-last&sort=desc

European Union, Eurostat 2013
http://ec.europa.eu/eurostat/tgm/table.do?tab=table&plugin=1&language=en&pcode=tec00114

Katja Schäfer "Urbanization and Urban Risks in the Arab Region" 1st Arab Region Conference for Disaster Risk Reduction, 19-21 March 2013 at Aqaba – Jordan
www.preventionweb.net/files/31093_habitataqabaurbanresillience.pdf

UN Habitat
www.un.org/ga/Istanbul+5/13.pdf

World population review
http://worldpopulationreview.com/world-cities/cairo-population/

United Kingdom, The Guardian:
www.theguardian.com/cities/2015/mar/16/new-cairo-egypt-plans-capital-city-desert

Wikipedia:
http://en.wikipedia.org/wiki/Toulouse

Masdar (Company) 2013:
www.masdar.ae/en/media/detail/masdar-fact-sheet-ver-1-jan-2013

ITU statistics and indicators 2014:
www.itu.int/pub/D-IND

ITU-T FG-SSC deliverable "Technical Report on Smart Sustainable Cities Infrastructure", 2014.
ITU-T FG-SSC deliverable "EMF Considerations in Smart Sustainable Cities", 2014.
ITU-T FG-SSC deliverable "Multi-service infrastructure for smart sustainable cities in new-development areas", 2015.
IEEE Standard IEEE 802.3 series; see IEEE 802.3af-2003 and the higher power IEEE 802.3at-2009. These are both included in 802.3-2012.
Home Plug Alliance, Technical Overview:
www.homeplug.org/tech-resources/techoverview/

BRE Trust:
www.designingbuildings.co.uk/wiki/Power_over_USB

"World Urbanization Prospects 2014 Revision", page 18:
http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

Yu Xiaohui, China Academy of Telecommunication Research, MIIT, "The Development of Smart Cities in China", 4th ITU Green Standards Week, Sep 24, 2014, page 23:
www.itu.int/en/ITU-T/Workshops-and-Seminars/gsw/201406/Pages/Programme-24-sep.aspx

United Nations, Department of Economic and Social Affairs, Population Division, Urban Agglomerations Wallchart 2014:
http://esa.un.org/unpd/wup/wallcharts/WUP_2014%20Urban%20Agglomerations%20Wallchart.pdf

Gartner "4.9 Billion Connected 'Things' Will Be in Use in 2015":
www.gartner.com/newsroom/id/2905717

ITU Blog "Beyond Convergence: 5G and IoT need Wireless-wireline integration":
https://itu4u.wordpress.com/2015/04/20/beyond-convergence-5g-and-iot-need-wireless-wireline-integration/

Masdar City, Wikipedia:
http://en.wikipedia.org/wiki/Masdar_City

Elcon Systemtechnik "SHDSL Remote Power Supply Module":
www.elcon-system.com/uploads/media/Data_sheet_RPS12_SNMP_en.pdf;

United States Patent Application 20150071098 "Delivery of electrical power", 27 Feb. 2013:
www.freepatentsonline.com/20150071098.pdf

ITU-T FG-SSC "Technical Report on Key Performance Indicators (KPIs) related to the level and usage of Information and Communication Technology (ICT) in Smart Sustainable Cities" 2015.
Dementyev, A. et al. "Power consumption analysis of Bluetooth Low Energy, ZigBee and ANT sensor nodes in a cyclic sleep scenario", Wireless Symposium (IWS), 2013 IEEE International Conference 14-18 April 2013:
http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6616827&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6616827

Energizer "Typical Temperature Effects": http://data.energizer.com/PDFs/temperat.pdf

Recommendation ITU-T L.1440 "Methodology for environmental impact assessment of information and communication technologies at city level":
www.itu.int/itu-t/aap/AAPRecDetails.aspx?AAPSeqNo=3209

Digital Agenda for Europe "Broadband Strategy & Policy":
http://ec.europa.eu/digital-agenda/en/broadband-strategy-policy

ITU-T FG-SSC deliverable, "Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities".

CYMBET Corporation Energy Harvesting & Storage:
www.cymbet.com/design-center/energy-harvesting.php

Faulkner ITU-T Tutorial:
www.itu.int/en/ITU-T/studygroups/com15/Documents/tutorials/tutorial_2005_10_26_faulkner.ppt

Ericsson "Next generation Broadband in Europe: The Need for Speed" Heavy Reading Report, Vol. 3 No 5 March 2005.
Ana Petovic and Randy Sharpe, Alcatel "Is Symmetrical Bandwidth a Myth or a Must?" 16 Oct 2012 www2.alcatel-lucent.com/techzine/is-symmetrical-bandwidth-a-myth-or-a-must/
Quora Blog "How much oversubscription is acceptable (given today's standards) for an ISP for (1) dedicated IP access and (2) broadband access?
www.quora.com/How-much-oversubscription-is-acceptable-given-todays-standards-for-an-ISP-for-1-dedicated-IP-access-and-2-broadband-access

ITU Forum on Smart Sustainable Cities, Abu Dhabi-UAE, May 2015
www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Pages/Events/2015/SSC/SSC.aspx

Contention Ratio
http://en.wikipedia.org/wiki/Contention_ratio

Thomson Reuters: Zawya
www.zawya.com/story/Dubai_Earns_ISO_37120_Platinum_Designation-ZAWYA20150111075151/

ISO 37120:2014 "Sustainable development of communities – Indicators for city services and quality of life"
http://www.iso.org/iso/catalogue_detail?csnumber=62436

H.E. Dr. Aisha Bin Bishr, "Smart Dubai: Introduction, Strategy and Progress Report", ITU Forum on Smart Sustainable Cities, Abu Dhabi, UAE, May 2015
www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2015/SSC/S1-DrAishaBinBishr.pdf

Dr Sekhar Kondepudi, "An Overview of Smart Sustainable Cities and the Role of Information and Communication Technologies (ICTs)", ITU Forum on Smart Sustainable Cities, Abu Dhabi, UAE, May 2015
www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2015/SSC/S3-DrSekharKondepudi.pdf

Dr Ramy Ahmed Fathy "Smart Water Management Regional Challenges and Future Prospects", ITU Forum on Smart Sustainable Cities, Abu Dhabi, UAE, May 2015,
www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2015/SSC/S4-DrRamyAhmedFathy.pdf

ITU Focus Group on Smart Water Management
www.itu.int/en/ITU-T/focusgroups/swm/Pages/default.aspx

IEEE Comsoc, Internet of Things (IoT) Key Messages at 'IDC Directions 2014'
http://community.comsoc.org/blogs/alanweissberger/internet-things-iot-key-messages-part-2-idc-directions-2014-market-survey-abst

International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Office of the Director
Place des Nations
CH-1211 Geneva 20 – Switzerland
Email: bdtdirector@itu.int
Tel.: +41 22 730 5035/5435
Fax: +41 22 730 5484

Deputy to the Director and Director，Administration and Operations Coordination Department (DDR)
Email: bdtdeputydir@itu.int
Tel.: +41 22 730 5784
Fax: +41 22 730 5484

Infrastructure Enabling Environmnent and e-Applications Department (IEE)
Email: bdtiee@itu.int
Tel.: +41 22 730 5421
Fax: +41 22 730 5484

Innovation and Partnership Department (IP)
Email: bdtip@itu.int
Tel.: +41 22 730 5900
Fax: +41 22 730 5484

Project Support and Knowledge Management Department (PKM)
Email: bdtpkm@itu.int
Tel.: +41 22 730 5447
Fax: +41 22 730 5484

## Africa

### Ethiopia
International Telecommunication Union (ITU)
Regional Office
P.O. Box 60 005
Gambia Rd., Leghar ETC Building
3rd floor
Addis Ababa – Ethiopia
Email: itu-addis@itu.int
Tel.: +251 11 551 4977
Tel.: +251 11 551 4855
Tel.: +251 11 551 8328
Fax: +251 11 551 7299

### Cameroon
Union internationale des télécommunications (UIT)
Bureau de zone
Immeuble CAMPOST, 3e étage
Boulevard du 20 mai
Boîte postale 11017
Yaoundé – Cameroon
Email: itu-yaounde@itu.int
Tel.: + 237 22 22 9292
Tel.: + 237 22 22 9291
Fax: + 237 22 22 9297

### Senegal
Union internationale des télécommunications (UIT)
Bureau de zone
19, Rue Parchappe x Amadou Assane Ndoye
Immeuble Fayçal, 4e étage
B.P. 50202 Dakar RP
Dakar – Senegal
Email: itu-dakar@itu.int
Tel.: +221 33 849 7720
Fax: +221 33 822 8013

### Zimbabwe
International Telecommunication Union (ITU)
Area Office
TelOne Centre for Learning
Corner Samora Machel and Hampton Road
P.O. Box BE 792 Belvedere
Harare – Zimbabwe
Email: itu-harare@itu.int
Tel.: +263 4 77 5939
Tel.: +263 4 77 5941
Fax: +263 4 77 1257

## Americas

### Brazil
União Internacional de Telecomunicações (UIT)
Regional Office
SAUS Quadra 06, Bloco "E"
11º andar, Ala Sul
Ed. Luis Eduardo Magalhães (Anatel)
70070-940 Brasilia, DF – Brazil
Email: itubrasilia@itu.int
Tel.: +55 61 2312 2730-1
Tel.: +55 61 2312 2733-5
Fax: +55 61 2312 2738

### Barbados
International Telecommunication Union (ITU)
Area Office
United Nations House
Marine Gardens
Hastings, Christ Church
P.O. Box 1047
Bridgetown – Barbados
Email: itubridgetown@itu.int
Tel.: +1 246 431 0343/4
Fax: +1 246 437 7403

### Chile
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Merced 753, Piso 4
Casilla 50484, Plaza de Armas
Santiago de Chile – Chile
Email: itusantiago@itu.int
Tel.: +56 2 632 6134/6147
Fax: +56 2 632 6154

### Honduras
Unión Internacional de Telecomunicaciones (UIT)
Oficina de Representación de Área
Colonia Palmira, Avenida Brasil
Ed. COMTELCA/UIT, 4.º piso
P.O. Box 976
Tegucigalpa – Honduras
Email: itutegucigalpa@itu.int
Tel.: +504 22 201 074
Fax: +504 22 201 075

## Arab States

### Egypt
International Telecommunication Union (ITU)
Regional Office
Smart Village, Building B 147, 3rd floor
Km 28 Cairo – Alexandria Desert Road
Giza Governorate
Cairo – Egypt
Email: itucairo@itu.int
Tel.: +202 3537 1777
Fax: +202 3537 1888

## Asia and the Pacific

### Thailand
International Telecommunication Union (ITU)
Regional Office
Thailand Post Training Center, 5th floor,
111 Chaengwattana Road, Laksi
Bangkok 10210 – Thailand

Mailing address
P.O. Box 178, Laksi Post Office
Laksi, Bangkok 10210 – Thailand
Email: itubangkok@itu.int
Tel.: +66 2 575 0055
Fax: +66 2 575 3507

### Indonesia
International Telecommunication Union (ITU)
Area Office
Sapta Pesona Building, 13th floor
Jl. Merdan Merdeka Barat No. 17
Jakarta 10001 – Indonesia

Mailing address:
c/o UNDP – P.O. Box 2338
Jakarta 10001 – Indonesia
Email: itujakarta@itu.int
Tel.: +62 21 381 3572
Tel.: +62 21 380 2322
Tel.: +62 21 380 2324
Fax: +62 21 389 05521

## CIS countries

### Russian Federation
International Telecommunication Union (ITU)
Area Office
4, Building 1
Sergiy Radonezhsky Str.
Moscow 105120
Russian Federation

Mailing address:
P.O. Box 25 – Moscow 105120
Russian Federation
Email: itumoskow@itu.int
Tel.: +7 495 926 6070
Fax: +7 495 926 6073

## Europe

### Switzerland
International Telecommunication Union (ITU)
Telecommunication Development Bureau (BDT)
Europe Unit (EUR)
Place des Nations
CH-1211 Geneva 20 – Switzerland
Switzerland
Email: eurregion@itu.int
Tel.: +41 22 730 5111

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland
www.itu.int

ISBN 978-92-61-21851-5
9 789261 218515

Printed in Switzerland
Geneva, 2016