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Digital Roadmap for Smart Township

Introduction

In the late nineties, Aveiro in Portugal pioneered a "digital town programme". At the time, it had a population of over 75,000 people and today is an urban agglomeration with over 120,000. Similarly, Fujisawa, a prominent Japanese smart town project, is an urban area with a population of over 420,000 people. The Digitale Doerfer project in Germany includes Billerbeck, with a population of 450 people and Bodenheim, with a population of over 20,000.

In arriving at a usable definition of a Digital Town, one must recognise and account for the increasing expansion of cities and accommodate the new higher resolution OECD definitions. One should also identify existing perspectives on digital towns during general and local contextual rationales for digital adoption and use at a town level.

The definition of town as per the revised definition in OECD and European Union, "A new perspective on urbanisation," 2020:

1) Cities consist of contiguous grid cells with a density of at least 1,500 inhabitants per km2 and at least 50% built up with a population of at least 50,000.

2) Towns and semi-dense areas consist of contiguous grid cells with a density of at least 300 inhabitants per km2, are at least 3% built up, and have a total population of at least 5,000.

3) Rural areas are cells that do not belong to a city or a town and are semi-dense areas and, for the most part, have a density below 300 inhabitants per km2.

A smart township combines several elements of the latest technologies, focusing on IoT-connected devices, to deliver a smooth experience and improve the quality of life for residents.

Smart Planning

Proper zoning and planning ensure more space and more convenience per resident:

- Over 80 acres of open space.
- Scientific density-based zoning with separate public and private zones.
- An integrated living concept with everything required for a wholesome lifestyle built into the enclave. The enclave will include offices, a school, a proposed hospital, a shopping arcade, a Signature club resort, and a sports arena.
- From airy villas and luxury apartments to senior living, one can choose a home that fits one's budget and needs.

First and foremost, a smart township is always located near areas where there are clusters of companies so that residents have the opportunity to work and earn. Secondly, all other essential amenities are located within the smart society. A typical smart community will have a school, hospital, wellness centres, entertainment and retail centres, shopping centres and clubhouses within the perimeter of the society itself. The existence of those outlets makes life highly convenient for the residents.

Smart Living

Smart living is a trend encompassing advancements that give people the opportunity to benefit from new ways of living. It involves original and innovative solutions to make life more efficient, controllable, economical, productive, integrated, and sustainable.

Smart Home

The homes within a smart society are smart homes. On a more magnified scale, these homes have similar frameworks to the smart community. A smart home is simply a connected home — it is a home which is laden with high-tech IoT devices which can be controlled remotely via mobile apps. Everything about the smart home, from lighting to appliances and even the thermostat, can be managed remotely. This automation makes life in a smart home a lot more convenient.

Home Safety: Smart Gas Detection

With the sheer volume of connected devices, electric equipment, and automation, the risks of fires because of various gas leaks are much higher in smart townships. Smart townships obviously need each home to be equipped with an excellent IoT-enabled LPG/ PNG gas detector which can be monitored and controlled using a mobile app by the house owners. A smoke alarm can alert you if there's a fire while you're at home, but when your loved ones and pets are there alone, you'll want to know right away if anything is wrong. These smart detectors will inform you of the presence of many harmful gases, like propane, carbon monoxide, and radon, while some use Wi-Fi to send notifications to a smartphone, so you can take care of the problem immediately.

Depending on the type of gases you want to monitor, there are various smart detectors which will give audible, visual, and smart device notifications, giving you time to take preventative action to eliminate the problem. Due to the nature of gas compounds, there are many types of devices which are able to detect different harmful gasses—for example, for flammable or explosive gasses, with the digital device alerting users via push notifications in conjunction with a downloadable app. There are also devices to monitor carbon monoxide, which is usually detect if there is a fire, hence detects explosive gas levels and updates every 15 seconds. There are also devices which detect naturally occurring radon levels, and also devices which measure air quality and chemical impurities. There are also devices which use intuitive app that displays several metrics on the quality of air in your home, including carbon dioxide and nitrogen dioxide.

The vast parking areas also need to be equipped with connected Carbon Monoxide gas leak detectors, and the substantial battery rooms need to be fitted with Hydrogen gas detectors. These detectors should be IoT-enabled and be able to send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker actions.

Digital Application for Home safety in most towns in Malaysia

Digital Application		Home (Landed property)	Home (High rise building)
Kitchen	IoT-enabled LPG/ PNG gas detector.	No	No
	It can be monitored and controlled using a mobile app by house owners from anywhere with a connection.	No	No
Parking lots	Equipped with connected Carbon	Garage	Shared Parking Lots.

	Monoxide gas leak detectors	No	No
	IoT-enabled can send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker actions.	No	No
Huge battery rooms	Hydrogen gas detectors/sensors	Only applicable for home users (who own an electric vehicle)	Nearby Parking Bays of Electric Vehicle
		No	No
	IoT-enabled and be able to send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker actions.	No	No

Table 1: Digital Application for Home safety in most towns in Malaysia

Smart Security

Besides surveillance equipment and CCTV cameras, smart townships require smart security solutions. Here, security cameras cover more expansive areas, including blind spots. House access is more controlled through RFID, smart cards, or biometric entry. Each home is equipped with connected video door phones, and doors are fitted with motion sensors. Through automatic activity monitoring, intrusion detection, and automatic workflows, appropriate alerts are raised for immediate action by the concerned authorities.

1. Home Security

Wireless CCTV Outdoor/Indoor for Monitoring

CCTV uses the wireless network of the home. The real-time video can be viewed worldwide, providing a data connection to the mobile phone and the CCTV. The video can be accessed via the manufacturer or third-party apps.

Figure 9: Wireless indoor/outdoor CCTV.

Wireless Door Lock

This digital device can be viewed on a smartphone worldwide, providing a data connection to the mobile phone. The lock can be set to engage or disengage. It can also be set according to the time preferred, for example, locked from midnight to 6 a.m. And locked again when nobody is at home. The lock can also be set to 'be able to open from inside only' or locked from both sides.

Figure 10: Wireless smart door lock

2. Home Intrusion

Motion Sensor

A motion detector is an electrical device that utilises a sensor to detect nearby motion. Such a device is often integrated as a system component that automatically performs a task or alerts a user of motion in an area. They form a vital component of security, automated lighting control, home control, energy efficiency, and other useful systems. Normally the motion sensor is installed outside the house. This smart device can be connected to a mobile phone to notify the owner if a motion has been detected.

Figure 11: Wireless motion detector/sensor

Motion Sensor activated light/ spotlight

A motion sensor light triggers a response when motion is detected. They can be installed indoors, on walls, ceilings, and doorways, or on the exterior of buildings and homes. Some motion sensor lights, called occupancy sensors, operate by turning off lights in unoccupied rooms and spaces. When motion is detected, the sensor triggers the light; when the motion stops and ends, the sensor shuts off the light. Occupancy sensors are one low-maintenance method for cutting down on electricity bill charges from lights left on when no one is home or in a room.

Figure 12: Motion Sensor activated spotlight

Motion Sensor Activated Audio Warning/Motion Security Alarm

A security alarm is a system designed to detect intrusion into a building or other areas, such as unauthorised entry. Security alarms used in residential, commercial, industrial, and military properties protect against burglary (theft) or property damage and personal protection against intruders. Security alerts in neighbourhoods show a connection with a diminished robbery.

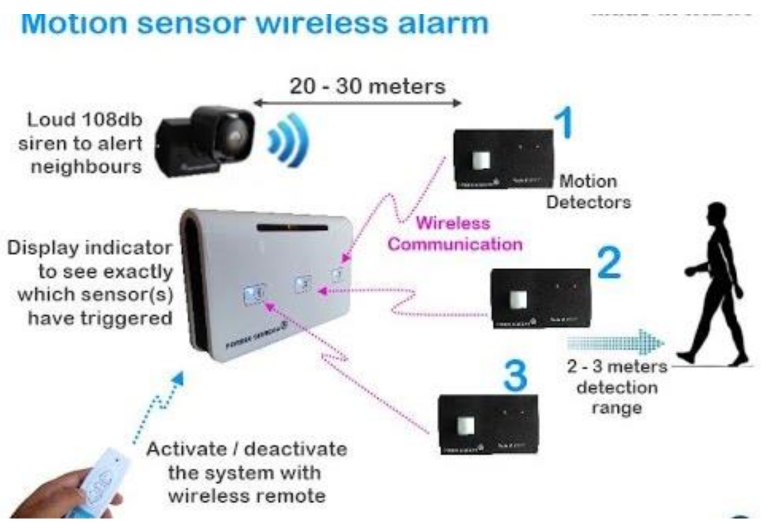


Figure 13: Wireless Alarm Motion Sensor

Some alarm systems serve a single purpose of burglary protection; combination systems provide fire and intrusion protection. Intrusion-alarm systems are combined with closed-circuit television surveillance (CCTV) systems to record intruders' activities and access control systems for electrically locked doors. When a motion is detected, the sensor will automatically produce many kinds of audio, sounds, noises, and microwave sounds, depending on the purpose of the motion detector.

Digital Application for Home Security in most towns in Malaysia

Digital Application		Home (Landed Property)	Home (High Rise Building)
Security cameras at: 1. Main street 2. Gate (Landed)	IoT-enabled and be able to send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker	No	No

3. Entrance (High Rise)	actions.		
Video communication device.	IoT-enabled and be able to send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker actions.	Installed at the gate.	Only installed on the main entrance door or lifts.
		No	No
Intrusion	Main doors are equipped with motion sensors. IoT-enabled and be able to send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker actions.	No	No
Smart door lock	This digital device can be viewed on a smartphone worldwide, providing a data connection to the mobile phone. The lock can be set to engage or disengage. It can also be set according to the time preferred, for example, locked from midnight to 6 a.m. And locked again when nobody is at home. The lock can also be set to 'be able to open from inside only' or locked from both sides.	No	No

Table 2: Digital Application for Home safety in most towns in Malaysia

Digital Roadmap for Smart Living

Basic	Intermediate	Advance
Motion sensors	• Security cameras at: 1. Main street 2. Gate (Landed) 3. Entrance (High Rise) • Video Communication Device.	IoT-enabled and be able to send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker actions.
Motion Sensor light/ spotlight	Outside the house perimeter.	IoT-enabled and be able to send appropriate alarms, texts, and mobile app notifications to the right stakeholders for quicker actions.

Table 3: Digital Roadmap for Smart Living

Greener environment

Smart townships are not just about making our lives more straightforward but also about easing the load on the environment. Smart townships have electric charging points everywhere to promote electric cars' use. Cycles are stationed everywhere for travel within the township; these are also digitally enabled to calculate charges so one may follow the self-service module.

Smart roads could benefit cities in numerous ways:

- Reducing congestion – Monitoring vehicle movement and adjusting traffic lights can help reduce traffic jams. The Smart Road System uses computer vision to monitor intersections and collect near real-time traffic data. The system reduced delays by 20 per cent on weekdays and 43 per cent on weekends.

- Improving safety – Computer vision can help detect and avoid other vehicles, pedestrians, and bicyclists. Smart devices also can alert first responders in the event of a crash or criminal activity.

- Detecting and avoiding problem areas – Smart roads can provide analytics about intersections and roadways with high collisions. It can help traffic planners determine mitigating measures, such as signals, signage, or speed limit changes.

- Monitoring road conditions – With smart roads, cities can monitor and repair pavement conditions more timely.

- Reducing pollution – Idling engines produce a lot of pollution. Smart road technology can help optimise traffic flow to prevent traffic jams.

Technologies that are advancing smart road implementation:

1. Electric charging lanes – Many communities are working to integrate more significant numbers of non-polluting electric vehicles (EVs). Malaysia has taken the initiative to develop an infrastructure roadmap for the use of electric cars in Malaysia. Concerning this, the National Electric Mobility Blueprint was launched on 3 April 2015. The blueprint aims to position Malaysia as the electric mobility marketplace. The first aim is to fast-track Malaysia's transformation into a global electric marketplace, and the second is to propel Malaysia forward in sustainable practices and economic development.

2. Smart pavement – has high-resolution fibre optic sensors and other technologies inside the pavement that can detect vehicles, gauge road conditions, identify accidents, and notify emergency responders automatically. (Example: Integrated Roadways, a Kansas City)

3. Solar road paint –solar paint installation collects energy during the day and glows at night to increase visibility and safety. (Example: Netherlands' Smart Highway project, the Glowing Lines)

4. Roads that Honk – IoT-enabled poles are installed at sharp curves and hairpin bends. The poles are advanced networked devices that detect vehicle speeds and sound horns to alert oncoming vehicles. (Example: India's NH1 highway HP Lubricants and Leo Burnett India install SmartLife poles)

Digital Roadmap to Green Environment

	Basic	Intermediate	Advance
Reducing	CCTV	Uses computer vision to monitor intersections	The system reduced delays by 20 per cent on

congestion		and collect near real-time traffic data	weekdays and 43 per cent on weekends.
Improving safety	Motorist alertness	Computer vision can help detect and avoid other vehicles, pedestrians, and bicyclists.	Smart devices also can alert first responders in the event of a crash or criminal activity.
	Motorist alertness	Roads that Honk – IoT-enabled poles are installed at sharp curves and hairpin bends. The poles are advanced networked devices that detect vehicle speeds and sound honk to alert oncoming vehicles.	Solar road paint –solar paint installation collects energy during the day and glows at night to increase visibility and safety.
Detecting and avoiding problem areas & Monitoring road conditions	Manual Inspection.	CCTV Monitoring System.	Smart pavement –high-resolution fibre optic sensors and other technologies inside the pavement that can detect vehicles, gauge road conditions, identify accidents, and notify emergency responders automatically.
Reducing pollution	National Electric Mobility Blueprint 2015.	By 2020: 100,000 electric cars, 100,000 electric motorcycles, 2,000 electric buses and 125,000 charging stations.	Electric charging lanes on highways. Dynamic Wireless Power Transfer (DWPT) to power the electric buses with renewable energy while moving.

Table 4: Digital Roadmap to Green Environment

Smart Transport

‘Smart transport’ refers to the integrated application of modern technology and management strategies into transportation systems. Smart transportation can simply mean the basic management systems such as:

1. **Car navigation**- This uses satellite navigation to get position data which is then correlated to a vehicle's position on a road. When directions are needed routes can be then calculated.

2. **Traffic signal control systems**- Newer traffic control systems have been adapted to work in a smart way. They’ve been developed to respond to their surroundings and adjust to traffic conditions. If you're driving at rush hour and you're seeing green all the way from work to home, you're in luck: dynamic signals have turned all traffic lights to green to maintain traffic flow.

3. **Automatic number plate recognition**- This uses character recognition on images to detect and read vehicle registration plates. This creates vehicle location data, used for law enforcement, electronic toll collection and pay-per-road systems.

4. **Speed cameras-** using detectors embedded in the road or radar technology to detect vehicles going above the legal speed limit. A digital picture is then taken and sent to the driver. This is a prevention method, used to encourage safer driving.

But with further technology being created every day, smart transportation is becoming more advanced. We are seeing more applications that integrate live data and feedback to multiple sources—this is what the future of smart transportation will look like. With the potential to constantly evolve, most smart transport in towns already seen improvements such as:

1. The use of navigation to find the best route possible in real-time.

2. The ability to alert drivers of potentially hazardous situations quickly.

3. Public transport is more convenient and reliable.

4. The ability to adjust speed limits and signals in real-time based on conditions.

Most towns in developed countries have the following features:

- Bicycle docking stations at designated areas and dedicated bicycle lanes for the internal commute.

- Eco-friendly shuttle service connecting the township with neighbouring landmarks.

- Electric vehicles for transport within the enclave.
- Charging points for electric vehicles.

The benefits of smart technology and the advantages they bring to transportation within a smart city are numerous as follows:

- **Smart Transportation is safer:** By combining machine learning with IoT and 5G, autonomous transportation systems (both in vehicles and in stationary infrastructure such as intersections) have proven to reduce the "human factor" in accidents. Computers don't get distracted or fatigued or emotional.
- **Smart Transportation is better managed:** Data collection is an important key to responsible public management of infrastructure. Smart transportation not only provides detailed data points for every aspect of the transportation system, but allows administrators to better monitor operations, track maintenance needs, and identify key sources of problems that need to be fixed.
- **Smart Transportation is more efficient:** With better management comes more efficient use. Quality data can help to pinpoint areas where efficiency can be improved. Maybe a slight adjustment in train schedules would provide for better fill rates, Or, perhaps bus routes would better serve the community if stops were allocated differently.
- **Smart Transportation is cost effective:** Because smart transportation makes better use of the resources available, it can cut down costs thanks to preventative maintenance, lower energy consumption, and fewer resources used towards accidents. Cost savings can also be gained by riders when inexpensive public transit is efficient enough to compete with private vehicle ownership.
- **Smart Transportation provides rapid insights**: City traffic management centers (TMCs) can get rapid visibility and notifications for trouble spots or city-wide issues affecting congestion on city streets, public safety and emergency response systems, in order to take action or communicate more effectively with other agencies and emergency responders.

Beyond the better management, safety, and efficiency already discussed, there are several additional benefits that the general public, local governments, and the world at large can enjoy. These are:

1. Security
2. Environmental Considerations
3. Supply Chain Resiliency

Digital Roadmap for Smart Transport

Basic	Intermediate	Advance
Bicycle docking stations at designated areas and dedicated bicycle lanes are provided for internal commuting.	Eco-friendly shuttle service connecting the township with neighbouring landmarks.	• Electric vehicles for transport within the enclave. • Charging points for electric vehicles.

Table 5: Digital Roadmap for Smart Transport

Smart Parking

Smart parking completely removes the guesswork of the parking experience. For more than 135 years or so, since the invention of the car, drivers have relied on instinct or luck to locate an available parking space.

Three main elements in smart parking:

1. Real-time data and guidance guide drivers to quickly locate the best available parking space.

2. Parking asset control for cities, operators and facility management so they can understand occupancy, payment compliance and much more.

3. A direct way to affect climate change is with cars searching for parking less, so we have a sustainable future on this planet.

How does smart parking work?

Smart parking, at its core, is data collected from IoT technology and AI to deliver a better overall parking experience.

Essential elements that are needed to make smart parking work:

- A sensor
- Communication to the driver
- A dashboard

The sensor collects and processes data at the location of the parking area or parking spaces. There are many types of smart parking sensors.

Smart parking systems can be divided into 3 main types:

1. Ground sensor technology
2. Counter technology
3. Overhead sensor or camera-based technology

Smart Parking Ground Sensors

Ground sensors have been around for decades now and haven't changed much over the years. With the use of radar technology, ground sensors are installed into the concrete at each parking space or bay. When a car enters the space, the sensor below will identify an object above it and register that single parking space as occupied.

Parking Counter Systems

Typically done in more structured parking lots or enclosed parking garages, a smart parking counting system can be deployed. This usually involves a raiseable gate that allows cars to enter and exit while it counts the number of vehicles and dispenses a ticket for payment.

Overhead Parking Sensors Or Camera-Based Systems

With the use of overhead parking sensors or cameras, large parking areas or on-street parking can be viewed more efficiently from above. Utilizing a lamppost or building, 1 smart parking sensor can detect many cars at once rather than one space at a time.

Communicating to the driver happens in various ways depending on the environment or goal trying to be reached. Once data about vehicle occupancy, time of stay, payment information and more is collected from advanced parking sensors, some of this information will be delivered to the driver in real-time. This is typically done through an app or with local on-street digital signage.

Benefits of smart parking

This is a list of the top benefits of deploying a smart parking solution:

- Reduces unnecessary vehicle emissions caused by parking search traffic.

- It saves time and hassle for drivers to find (and pay) their ideal parking space quickly and easily.
- Generating data that can be leveraged to connect other transportation modes hints at the concept of a mobility hub, such as ride-sharing, bike hire, scooters or public transportation.

Digital Roadmap for Smart Parking

	Basic	Intermediate	Advance
Smart parking (to assist consumers)	Apps for payment	1) Apps to locate an available parking space. 2) Mobile network gateways Function: Multifunctional communications gateways relay live parking event data from on-site sensors to smart parking's IoT platform in the Cloud. Robust and scalable smart city building blocks that provide a common IoT gateway in a single unit, making obsolete the growing issues emerging in cities where operators are faced with many costly and isolated communication devices installed within the city street	Advanced parking sensors: Able to detect vehicle details, time of stay, and an automatic deduction of payment from digital payment apps. Data is collected from IoT technology and AI and stored at the Cloud to deliver a better overall parking experience.

		environments. Connectivity between hotspot and sensor through Ethernet/Fibre Optic, Wi-Fi, and wireless sensors.	
Smart parking management (back office management system) # To assist councils, municipalities and other businesses in managing parking compliance and enforcement more efficiently.	Paper-based parking ticket/ coupon.	Mobile Apps for parking time. Information on parking slots/bay is not mentioned.	Vehicle detection hardware, through the smart city building blocks, variable message signage, customisable parking guidance & payment app, and API. Vehicle Detection Sensors These robust and scalable devices monitor bays and relay live status information to Cloud Storage Management.

Table 6: Digital Roadmap for Smart Parking

Creating zones open Wi-Fi connectivity

Smart spots provide an IoT gateway in a single unit, allowing hundreds of different devices to connect and providing areas of open connectivity called smart zones.

Once the hotspot system is installed, city operators have a compatible unit with the ability for other services such as lighting, public Wi-Fi, surveillance and more to be connected later. It also means less hardware cluttering city streets and a more streamlined way of managing a raft of smart city services.

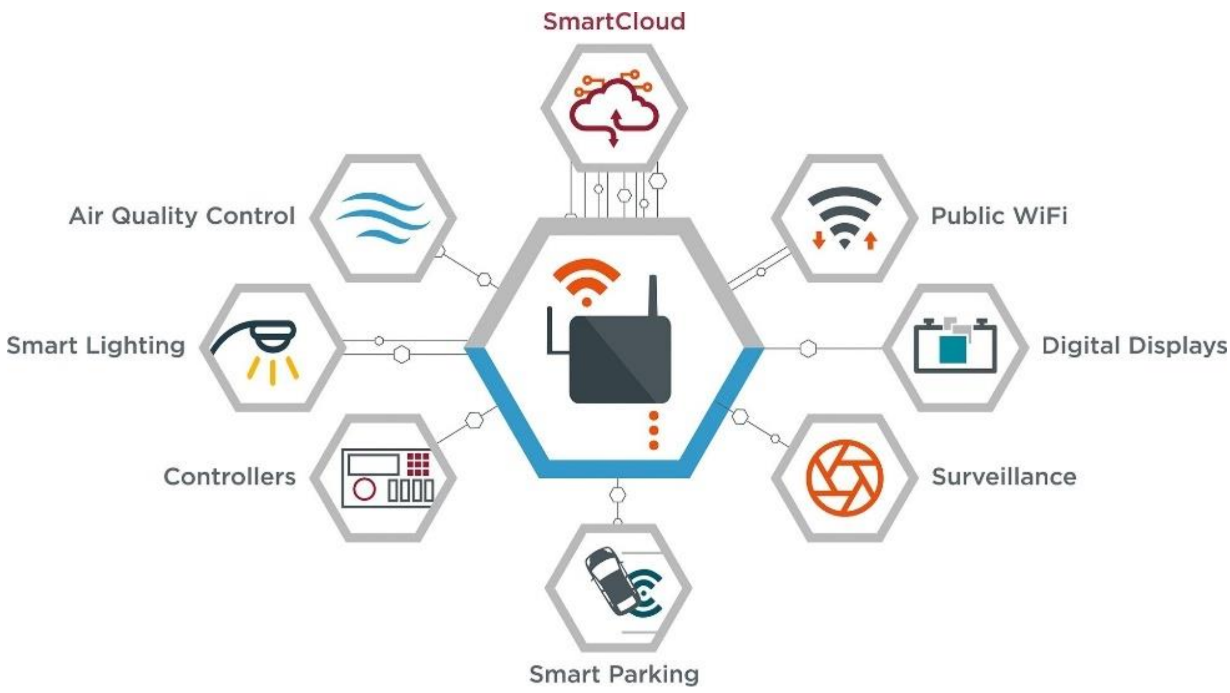


Figure 1: Integrated digital services in the smart township streets and public places.

Smart Healthcare

Figure 2: Smart digital integrated healthcare system provided for every resident in the smart township

Malaysia's smart hospitals will be built on new clinical processes, highly digitised infrastructure and enhanced management systems. They will be powered by interconnected devices and provide outcomes and intelligence to achieve patient-centricity. These hospitals will be more effective, highly efficient, and cost-optimised.

Smart hospitals combine the infrastructure, people, clinical processes, and administrative workflows using cutting-edge technologies such as IoT, AI, Machine Learning, RFID, etc. The data generated by these systems is gathered and analysed to improve patient care and safety, enhance the quality of the patient experience, and bring efficiencies and effectiveness to hospital administration and operations.

Smart Hospitals offer:

- Automated and optimised hospital processes for improved patient care.
- A high degree of efficiency for the historical data of patients is easily retrievable.
- Seamless exchange of data and information amongst doctors, patients, caregivers, hospital staff, technicians, etc.
- Easy availability of patient data - when and where it is needed.
- Secure and ethical data management.
- Improvement in quality of care and patient experience.
- Efficiency and effectiveness in hospital operations.
- Patient engagement for long-term relationships from historical data.
- Growth and professional development of hospital staff for data handling.
- An extensible framework ready for current and future use cases.

Figure 3: The integrated digital healthcare system can be accessed through the smartphone

Smart Hospitals are more than digital hospitals; they are much more than just paperless hospitals. They are more than technology.

The implementation of smart hospitals requires a comprehensive strategy, holistic vision, alignment with business goals, and an understanding of cutting-edge technology. It needs a robust framework that can bring all these together – it has to be flexible, scalable, and future-ready.

Other connected services of the smart healthcare in a smart town are as in the illustration below:

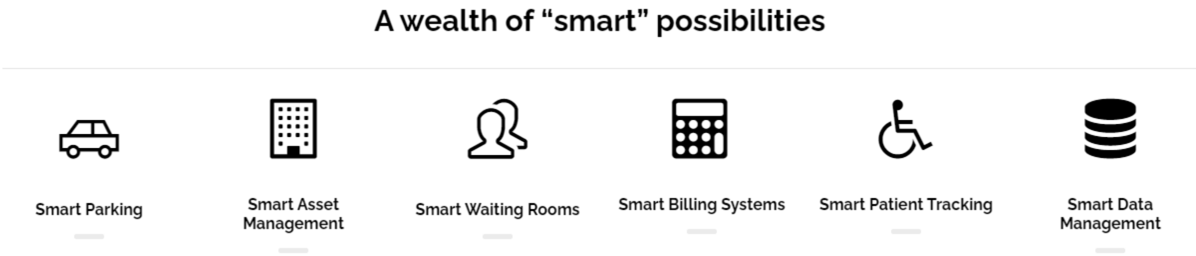


Figure 4: Other digital services integrated with the smart healthcare system

Smart health systems share five foundational design principles:

- Hyper-connected: Physical and virtual environments and a health information architecture built upon data liquidity within and between systems; this includes connecting with other care settings and organizations, such as primary care, specialists, and community care workers.
- Intelligent: Through connected platforms and data, with access to insights that support fast and accurate real-time decisions, both clinical and operational.
- Human-centred: Patient, family, and employee-centric where human-centered service design puts people at the centre of problem-solving by developing a deep appreciation for their needs, motivations and challenges.
- High reliability: Combines high reliability process design with intelligent automation, sensors and predictive analytics, to prevent, predict and minimize the risk of harm, medical errors and sub-standard care.
- Sustainable: Models of care which are clinically, financially, economically, and environmentally sustainable for hospitals, their workforce, patients, and communities.

Key assets of smart hospitals

A smarter future where advanced clinical technologies integrate with built infrastructure and sustainable technologies awaits. The transition to a smart hyper-connected and intelligent hospital will incorporate the following:

1. Patient-centric for a better patient experience

Patients are at the heart of a smart hospital service design. In a broad-based, hyper-connected health ecosystem, physicians, providers, data technicians, pharma companies, biometric systems, med-tech professionals and others all work together, leveraging AI and other advanced technologies to provide bespoke care for each and every individual.

2. Technologies that enable fast, flexible and reliable care

Smart hospitals leverage technologies not only to improve care delivery within the hospital itself, but also to connect the hospital to a wider health care delivery ecosystem and drive patient centricity across all care environments. Algorithms embedded in care pathways and operations automate processes, optimize resources, predict conditions, and support clinical decisions to provide the best individualized care for every person. In Canada, for example, Humber River Hospital is extending its digital transformation into a whole of system care coordination focus, coordinating between the hospital and community care providers with hub and spoke command centres.

- AI and intelligent automation: Smarter front- (for example, patient-facing apps), middle- (real-time diagnostics) and back-office (logistics and supply chain) processes will drive better patient experiences, productivity gains and improved outcomes.

- Virtual care: Interactive consultation will be possible between patient and clinician or between clinicians via a range of capabilities (voice, video, or both) and modalities (synchronous or asynchronous) across the continuum of care.

- IoT and smart sensors: These will enable connectivity between different departments within a hospital, as well as to the extended health ecosystem. Wearables and sensors collect and broadcast real-time data about patients to a central organizing platform.

- Robots, drones and 3-D printing: These support new and highly accurate medical procedures, optimize the utilization and deployment of the human workforce, and improve the speed and availability of care and across the supply chain.

- Digital reality (augmented reality/virtual reality): Immersive experiential learning and workforce training, creation of a virtual world for complex procedures, and effective patient healing will be possible.

3. Interconnected platforms for real-time decision making

Utilizing real-time data, patients can be treated in the right place at the right time. This also allows for rapid, evidence-based decision making. With shared technical and semantic specifications and standards for data and information exchange, platforms aggregate data from multiple sources (including ecosystem partners) and integrate it with EHRs and other IT systems, making the data valuable. Only 20% of the information relevant to health is available in the health system today. Integrating health system information with new data sources (social, behavioral, financial, and environmental) is becoming increasingly important in the pursuit of proactive and participatory care.

4. Partnerships with ecosystem players

Smart health systems proactively seek out new ways of partnering (especially with technology companies) that blend their health care expertise with high-tech skills, connected technologies, and deep consumer insights. In so doing, they leverage technologies to take the lead in developing innovations and delivering transformation essential to thrive in the new environment of partnerships, alliances, new locations and consumer orientation.

5. Smart infrastructure

- Healing environment: A built environment is designed to aid patients to recover faster, physically and mentally. Specifically, this refers to architecting physical and digital spaces as supportive environments for health improvement, supporting workforce productivity and efficiency and reducing workforce stress, and minimizing waste.

- Digital twin: A digital twin refers to the digital replica of the physical assets, people, and systems of a hospital. A convergence technology that bridges the gap between the real and virtual, a digital twin is used to monitor, adjust, and optimize the functions of physical settings, such as pre-emptive maintenance or demand management prediction. Clinical applications include health status monitoring and continuous feedback to improve well-being and behavioural nudges and support for adherence to treatment programs.

- Command centres: AI-powered command centres, often compared to an air-traffic control centre, analyze the clinical and location data to monitor supply and demand across the network in real time. Real-time monitoring of patients enables the hospital to identify patients with deteriorating health status, synchronize care delivery, reduce errors, and predict pressure points and bottlenecks in patient-flow.

- Data environment: For the platforms to function effectively, smart health systems create an open platform environment to connect and share data, at scale, within and between enterprises and systems. The optimal platform will separate content and technology and be vendor-neutral, distributed and modular incorporating third-party as well as legacy systems.

- Hospital-at-home: Portable, user friendly infrastructure and equipment extends the hospital environment into the patient’s home, to avoid hospitalization or reduce the length of stay.

Transformation towards Smart hospital

While advanced technology is the key enabler, developing a smart hospital is not just a technology project. Embarking on a smart health journey requires thoughtful consideration of known challenges, strong change management and executive leadership. It involves participation of all stakeholders – management, physicians, nurses, staff, and ecosystem partners.

The transformation journey to the smart hospital of the future must occur at the right pace for the organization and deliver the right combination of elements that are wanted and needed. For some, this will mean looking to optimize existing assets (either by modification or extension), introduce resources that complement the existing core, or to create a new ecosystem from the ground up.

Digital Roadmap for Smart Healthcare

Basic	Intermediate	Advanced
Paper storage of historical health data.	Data is only available for healthcare in a paperless environment.	Using cutting-edge technologies such as IoT, AI, Machine Learning, RFID and Cloud System. The implementation of smart hospitals requires a comprehensive strategy, holistic vision, alignment with business goals, and an understanding of cutting-edge technology. It needs a robust framework that can bring all these together – the framework has to be flexible, scalable, and future-ready.

Table 7: Digital Roadmap for Smart Healthcare

Smart Water Management

Smart water management requires the integration of systems and a complex of measures to monitor, control and regulate the usage and quality of water resources as well as maintain the associated equipment (pipes, pumps, etc.).

There is a wide range of hardware and software instruments, including sensors, meters, data processing and visualization tools, actuators and web and mobile controls connecting people with water systems.

Modern smart water technologies

Today, smart water technology brings transparency and improved control to the whole water supply chain starting from a freshwater reservoir to wastewater collecting and recycling.

This category includes IoT devices for water management, systems and software tools that help optimize production, distribution and consumption of water and enable smart water treatment practices.

Sensors

Sensors have broad applications in smart water management due to their great diversity and purposes. In a very basic water supply chain, sensors measure:

- the quality of raw catchment water, the chemical composition in the water after treatment and wastewater, etc.
- changing quantity in the storage reservoir,
- pressure on the pipes in the distribution pipeline,
- wear of the equipment and machinery that process and distribute water to end-users, and more.

Using the data collected by IoT water sensors, managers at different points of the water supply chain receive key insights into the changing conditions of water resources and equipment and can take data-driven corrective measures on demand.

Smart meters and monitoring systems

Smart meters and monitoring hubs allow real-time water consumption measuring, help identify overly excessive usage and waste points as well as correct usage patterns and make predictions for future consumption.

This water management technology is useful for production and distribution managers and bulk households. Using smart meters and water monitoring systems, we can correct water consumption routines and reach sustainability and budgeting goals.

Automated distribution systems and precision algorithms

More and more companies switch to fully automatic water management practices. Using environmental sensors and predefined or machine learning algorithms, distribution systems can dynamically regulate and control the supply of water. In the case of smart irrigation, for example, sprinklers provide just enough water depending on the reads from soil moisture, air humidity and crop condition sensors.

Objectives of smart water management

The primary objective of smart water management is reasonable and sustainable usage and recycling of water resources. Growing population, increasing environmental issues and pressure on the food and agriculture sector make water even a more precious asset.

In this respect, water management technologies and activities pursue the following objectives:

1. **Reduce wasting water** used in high volumes for agriculture, manufacturing, power production. It implies the introduction of high-tech practices like precision farming, smart irrigation, crop water management, real-time water metering and other applications of Internet of Things in agriculture.

2. **Improve water quality** and prevent contamination by chemical waste and natural pollution such as acidification. In order to improve and maintain the quality of water, companies use sensors and IoT technology for real-time monitoring and control.

3. **Enhance the efficiency of water systems** such as water collectors, treatment plants, distribution mains and wastewater recycling centres. Using IoT and data solutions for asset management, companies can keep important measurements such as water pressure, temperature, flow, etc. at hand, integrate predictive maintenance and avoid breakage and downtime of equipment.

4. **Implement leakage control** by using smart water management devices equipped with leak and moisture sensors, where the water leak detection system would generally activate an alarm to alert the engineering team of an issue and to allow them to respond quickly and efficiently.

Water Leak Detection Systems are commonly found in critical areas of Data Centres, Data Halls, Server Rooms, Plant Rooms, Offices, Pantries, Hospitals, and Commercial Applications.

5. **Practice consumption monitoring** via IoT-based water management systems. It helps to optimize and keep under control the usage of water resources at different levels — households, communities and towns. Water

Monitoring System gives you the power to monitor your water usage, by combining software, hardware, wireless communications and sensors. It helps households, industries and towns to increase productivity, and compliance while enhancing safety, sustainability and service

Among smart water management initiatives are as follows:

- Rainwater harvesting systems and check dams.
- Mature trees within the existing orchard have been retained to conserve groundwater. Lush tropical landscaping has been planned, ensuring minimal water consumption.
- Recycle treated water for landscaping and toilet flushing requirements.

Digital Roadmap to Smart Water Management

Basic	Intermediate	Advance
Rainwater harvesting systems and check dams.	Mature trees within the existing orchard have been retained to conserve groundwater. Lush tropical landscaping has been planned, ensuring minimal water consumption.	Recycle treated water for landscaping and toilet flushing requirements.

Table 8: Digital Roadmap to Smart Water Management

Smart Waste Management

Waste collection is an essential city service, yet existing waste management systems are resource-intensive, inefficient, and outdated. The Internet of Things (IoT) has the potential to greatly optimize collection services and reduce operational costs for cities.

Smart waste management solutions use sensors placed in waste receptacles to measure fill levels and to notify city collection services when bins are ready to be emptied. Over time, historical data collected by sensors can be used to identify fill patterns, optimize driver routes and schedules, and reduce operational costs. The cost of these sensors is steadily decreasing, making IoT waste bins more feasible to implement and more attractive to city leaders.

A smart lifestyle in a smart town also means responsible resource management, which attempts to reduce, reuse and recycle the following:

- Sewage treatment plants
- Waste segregation
- Organic waste converters convert garbage into manure.

New York has one of the more complicated waste management ecosystems in North America. It takes around 72 hundred waste collectors and a lot of infrastructure to keep the city of roughly 8.6 million people sanitary and clean. In Times Square alone, an estimated 500,000 pedestrians pass through on a daily basis, creating roughly 15,300 pounds of garbage. In March 2013, 30 Bigbelly smart waste and recycling stations were deployed in Times Square as part of the largest public space recycling initiative in New York City. The Bigbelly units are equipped with waste compaction capabilities, real-time fill level monitoring, and collection notifications. With the Bigbelly smart stations, the total trash capacity was increased by nearly 200 percent and the frequency of collection per bin decreased by 50 percent. The program was such a success that the city expanded the deployment to 197 smart stations.

In the Netherlands, starting in 2009, the city of Hague began installing underground trash bins that can hold a larger quantity of waste. As of 2017, the city has 6,100 units installed below the sidewalk with the top of the bin emerging out of the ground at waist height. Around 3,500 of these submerged receptacles are sensor-enabled, which has allowed waste-management officials to remotely monitor the fill levels of containers and set up “smart schedules” for emptying them. The success of these underground containers landed them in a 2017 New York City Zero Waste Design Guidelines Report, where they act as an example of innovative waste solutions.

Digital Roadmap to Smart Waste Management

Basic	Intermediate	Advance
Sewage treatment plants.	Waste segregation.	Organic waste converters convert garbage into manure.

Table 9: Digital Roadmap to Smart Waste Management

Smart Energy Management

Smart energy management is a way to understand smart energy and how the systems work most efficiently. Some smart energy systems are basic like energy saving air conditioners or using smart appliances. Some smart energy systems are more complex, like multi-building automation utility systems and installation of solar panels. Depending on the type of smart energy used there are ways to manage the systems and enhance their abilities to save energy.

Sometimes the first step in energy management is to diagnose potential energy losses and existing problems in traditional commercial, residential and industrial energy systems. By simply installing an energy management system which uses technology to identify wasted electricity, times of high usage and monitoring, you know how much energy is being used and when.

Different Types of Smart Energy in Town

Residential Houses

As technologies continue to advance, homeowners have found ways to help lower their utility bills and conserve electricity. There is the installation of home appliances that are energy-saving like dishwashers, washing machines, dryers and air conditioners. They also install better insulation in their walls, double paned windows and energy saving window coverings (blinds, black out curtains) that enhance their control over the temperature in their home. Homes also have automatic or motion sensitive lighting or electric outlets that turn off when they are not being used.

Commercial Buildings

Businesses and commercial buildings are similar to homes but must consider how to save energy on a larger scale. Like homes, businesses have installed energy-efficient HVAC systems and have remodeled buildings to have thicker, tinted windows and better insulation. They have also implemented lighting systems that turn off at certain times of the day (after everyone has gone home) or only turn on when they detect motion. They have also changed the type of fluorescent bulbs used in lighting fixtures and use power saving outlets/power strips to run their computers and electronic office devices (printers, copiers, etc.)

Forms of Smart Energy Management

Smart energy management takes the methods that homes and businesses already use to the next level, promoting the highest level of energy conservation.

For the home there are many devices that can be plugged in or installed to existing systems that will allow the home owner to track energy uses. One of these devices is an electricity monitor that goes onto the home's breaker panel and receives data from the powerlines that connect to the home. The receiving unit can be plugged into any outlet in the home and the software installed will relay the information from the breaker to your smart phone or computer.

The monitor also keeps track of data over a 10-year period so the homeowner can discover how their improvements to the home have impacted their energy use. Another device for the home is a smart meter that turns any outlet into a smart energy management system. By simply plugging the meter into an outlet it will relay information about whatever is plugged into it and control the power to the plugged-in devices. The meter communicates with its gateway or network which then transfers data to the user who can monitor energy level, usage statuses, range or strange behaviour.

There are also Bluetooth monitoring systems that plug straight into sensors located throughout the home that monitor the home's temperature, humidity, air quality and air pressure. These sensors transfer data to an app which shows energy usage levels and even lets the home owner turn on/off air conditioning units and other appliances. Another Bluetooth system attaches straight to the outside utility meter to track usage and reports it to the devices in the home. This system offers reports in real-time so the user can know exactly when the meter outside is registering energy use.

For commercial buildings and large businesses there are many smart energy management systems and agencies that aid in conservation. This is to improve monitoring techniques and energy saving practices that improve the building's energy efficiency.

There are several EMIS (energy management and information systems) that are technologies aimed at making energy systems automated, tracking utility bills, detection of weaknesses and other tools for diagnosing problems and solutions. They also offer the analysis of energy use whether it be with lighting or office appliances.

Smart Grid

In both the home and office, there is a technology called Smart Grid which monitors what is used inside and communicates that with the consumer and the utility company. Since the system communicates with the energy company – it can know peak-hours, energy draining appliances and keep track of what source uses the most energy. By having access to the utility company's information – the system can schedule certain plugs (for electric cars) or appliances (like pool pumps) to turn on during off-peak hours. By utilizing this information business and home owners can save money and energy all year round.

In short, the digital technology is grid smart as it allows for two-way communication between the utility and its customers, and the sensing along the transmission lines. Like the Internet, the Smart Grid will consist of controls, computers, automation, and new technologies and equipment working together, but in this case, these technologies will work with the electrical grid to respond digitally to our quickly changing electric demand.

The Smart Grid represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to our economic and environmental health. During the transition period, it will be critical to carry out testing, technology improvements, consumer education, development of standards and regulations, and information sharing between projects to ensure that the benefits we envision from the Smart Grid become a reality. The benefits associated with the Smart Grid include:

- More efficient transmission of electricity
- Quicker restoration of electricity after power disturbances
- Reduced operations and management costs for utilities, and ultimately lower power costs for consumers
- Reduced peak demand, which will also help lower electricity rates
- Increased integration of large-scale renewable energy systems
- Better integration of customer-owner power generation systems, including renewable energy systems
- Improved security

Today, an electricity disruption such as a blackout can have a domino effect—a series of failures that can affect banking, communications, traffic, and security. A smarter grid will add resiliency to our electric power System and make it better prepared to address emergencies such as severe storms, earthquakes, large solar flares, and terrorist attacks. Smart Grid will allow for automatic rerouting when equipment fails or outages occur with its two-way interactive capacity. This will minimize outages and minimize the effects when they do happen. When a power outage occurs, Smart Grid technologies will detect and isolate the outages, containing them before they become large-scale blackouts. The new technologies will also help ensure that electricity recovery resumes quickly and strategically after an emergency—routing electricity to emergency services first, for example. In addition, the Smart Grid will take greater advantage of customer-owned power generators to produce power when it is not available from utilities. By combining these "distributed generation" resources, a community could keep its health centre, police department, traffic lights, phone System, and grocery store operating during emergencies. In addition, the Smart Grid is a way to address an aging energy infrastructure that needs to be upgraded or replaced. It also addresses energy efficiency, bring increased awareness to consumers about the connection between electricity use and the environment. It also brings increased national security to our energy System—drawing on greater amounts of home-grown electricity that is more resistant to natural disasters and attack.

Giving Consumers Control

The Smart Grid is not just about utilities and technologies; it is about giving you the information and tools you need to make choices about your energy use. If you already manage activities such as personal banking from your home computer, imagine managing your electricity in a similar way. A smarter grid will enable an unprecedented level of consumer participation. "Smart meters," and other mechanisms, will allow you to see how much electricity you use, when you use it, and its cost. Combined with real-time pricing, this will allow you to save money by using less power when electricity is most expensive. While the potential benefits of the Smart Grid are usually discussed in terms of economics, national security, and renewable energy goals, the Smart Grid has the potential to help you save money by helping you to manage your electricity use and choose the best times to purchase electricity. Hence, you can save even more by generating your own power.

Building and Testing the Smart Grid

The Smart Grid will consist of millions of pieces and parts—controls, computers, power lines, and new technologies and equipment. It will take some time for all the technologies to be perfected, equipment installed, and systems tested before it comes fully on line.

Now more than ever, it is important for consumers to monitor their carbon-footprint. Updating home and office energy systems so that they are more efficient is one step forward to change how we consume electricity. By managing these systems with new technologies and software we can reduce our cost and our carbon footprint. Government and city agencies have given incentives for homes that do install energy saving practices. Smart Energy Management systems can truly change how we view our energy usage and reduce waste. These systems make it easier for consumers to monitor their usage and make effective changes.

Solar-powered LED street lights

Carrying forward the point about greener solutions, a smart township typically has solar-powered LED street lights and intelligent systems to monitor the use of resources. Solar panels may also be installed for all homes and commercial areas. All this cuts long-term costs and makes a massive difference to the carbon footprint.

The township also has segregation of waste, centralised garbage management, and treatment facilities.

Solar Carports

Solar carports take full advantage of ample parking areas to produce electricity while providing shaded or covered parking for tenants, employees and customers.

A solar carport is an overhead shade designed as parking area shelters with solar panels mounted on them. These structures have multiple similarities with the ground-mounted panels, which are mostly installed on the ground, instead of rooftops.

The major difference between ground-mounted panels and solar carports is that carports are much taller, to help accommodate parked cars. Also, solar carports are more space-efficient than ground-mounted solar panels.

Solar carports are meant to offer shelter to vehicles parked below them, as well as efficiently generate electricity. They are ideal for large parking areas and home driveways. One unique feature with solar carports is that they don’t demand a surface or a roof for the installation of solar panels.

Energy efficiency and demand-side management strategies represent a core part of re-balancing the smart city’s energy mix. Underpinning support from city authorities is vital, of course, as the city of Charlotte, North Carolina demonstrated back in 2011 when it launched Envision Charlotte, a public-private smart city project turning the city’s downtown area into a ‘living laboratory’ for energy efficiency schemes, with a goal of reducing the 61 participating buildings’ energy usage by 20% by 2016, on 2010 levels. Shadow meters and usage information kiosks were installed in buildings, and the project achieved a 19% reduction by last year – just short of its goal, but still representing $26m in energy savings and a CO_2 reduction equivalent of 11,000 cars taken off the road.

Connected technologies are making meaningful contributions to city efficiency and demand-side response efforts already. Many urban centres have carried out street light replacement programmes, switching to more efficient LED bulbs and incorporating sensors that automatically decrease lighting output when there is no one on the street. Earlier this year, Chicago Mayor Rahm Emanuel announced the city would replace 270,000 light fixtures with an intelligent lighting management system.

The energy transition also presents issues for those working to reduce urban energy demand. The rise of electric vehicles is an important part of decarbonisation and air quality efforts, especially in cities, but handling the extra demand generated by tens of thousands of energy-hungry EVs and plug-in hybrids will be one of the key challenges for energy management in a smart city.

Every scrap of savings from efficiency schemes and demand-response incentives will be important in this context, while new vehicle-to-grid innovations, while still nascent, could see EVs feed electricity back into the grid are periods of peak demand if technical and regulatory hurdles can be overcome.

Digital Roadmap to Smart Energy Management

Basic	Intermediate	Advance
Streetlights Powered by Utilities Company.	Solar-powered LED streetlights.	Solar Carports- All open parking spots are equipped with a solar roof cover.

Table 10: Digital Roadmap to Smart Energy Management

SolarNova Programme: Case Study: Singapore

Under this programme, HDB progressively rolled out 220 MWp of solar panels across 5,500 HDB blocks in 2019, generating 350 MWp of solar power from solar photovoltaic (PV) systems alone.

This is equivalent to powering 82,500 4-room flats with solar energy, potentially reducing carbon emissions by 198,000 tonnes per year.

A new solar target of 540 MWp by 2030 has since been announced, and this could potentially help generate 648 GWh of green energy annually. It also aligns with the HDB Green Towns Programme, which aims to bring green energy to all HDB towns.

Digital Roadmap for Urban Building Planning in Malaysia

Short term developments	Mid-term developments	Long term developments
In the short term, integrated mapping of the existing building stock, including its energy performance and the potential for improvement and use, supports integrated urban planning processes.	Once the experience has been gained and processes and strategies have been developed, the annual building refurbishment rate will be scaled up to 3 to 5% of the existing building stock, from today's typical rate of	In the long- term, buildings increasingly adopt nature-based strategies and are integrated into and adapting to the surrounding natural systems. In this way, they offer harmonious

• Specific energy strategies for cultural heritage buildings are developed to refurbish historical buildings, incorporating available and upcoming technologies. • Re-wealth and rejuvenation strategies focus on the quality of internal and external spaces of the existing building stock. This includes the implementation of new and flexible forms of use, as well as sharing of areas and infrastructure. • General city design strategies focus on reuse, re-densification and re-building of the existing buildings and public spaces, defining priority areas for intervention. • A building lifecycle approach is considered, based on the design for disassembly and reuse of materials, using closed cycle systems as far as possible.	1%. The minimum energy standard for refurbished buildings is the 'passive house' standard. However, the standards will develop further, with increasing requirements for higher levels such as zero-emission, energy-positive or CO2- neutral performance over a lifetime.	living environments for their occupants.

Table 11: Digital Roadmap for Urban Building Planning in Malaysia

Digital Roadmap for Energy-saving building solution

Short term developments	Mid-term developments	Long term
Refurbishment plays a significant role, and solutions for upgrading building envelopes and installations are gaining importance, including on-site renewable energy generation. The aim is to achieve nearly zero-energy standards in new buildings and, where possible, also in existing buildings. • Modular, prefabricated building blocks allow material and energy savings through centralised production processes, with increasing flexibility and adaptability of buildings over their lifecycles. • Customised refurbishment solutions for cultural heritage buildings allow energy performance improvement while meeting cultural protection standards. Increased energy performance is achieved through higher standards for both new buildings and those surrounding them	Buildings are becoming increasingly energy-efficient and energy-producing, with development towards energy-positive buildings as standard. Energy-producing facades and roofs cover all users' energy needs, including extra demand for electric mobility. • Wood is increasingly used as a sophisticated building material, even for structural purposes in multi-storey buildings. • Buildings are based on customised local building components produced by new technologies such as 3D printing or Factory 4.0 solutions, enabling greater flexibility and diversity.	Entire buildings are produced decentrally and on-site using new production technologies such as 3D printing and local organic materials. • Self-adapting buildings based on 'living' organic materials can adapt to changing user needs, climate conditions and usage

Table 12: Digital Roadmap for Energy-saving building solution

Digital Roadmap for Materials & circular systems

Short term developments	Mid-term developments	Long term developments
Water is considered an increasingly valuable resource in the short term, and water cycles in buildings will be closed as	In the mid-term, smart lifecycle assessment allows calculation, tracking and optimising of material life cycles, energy use and	In the long term, buildings are automated, with materials and systems that proactively adapt to different climatic

far as possible. • Closed water cycles at the district level connect buildings, terraces and gardens to water retention, storage and reuse systems. • Building work increasingly uses organic materials such as clay and wood. These are locally produced and reusable, reducing the overall carbon footprint of constructions. • Biomass energy solutions use urban green waste for energy production, closing green waste cycles	even societal value of buildings over their lifetime. • High-performance materials and eco-materials with a shallow lifecycle impact are standard in buildings. • Materials and components are locally produced through tailored production processes based on the (re-)use of locally available resources. • Adaptive building systems and materials with changing properties are available, optimising the thermal performance of building envelopes.	conditions or usage. • Buildings contribute to an urban metabolism based on closed resource cycles, understanding materials as a service.

Table 13: Digital Roadmap for Materials & circular systems

Digital Roadmap for Sustainable energy transition

Short term developments	Mid-term developments	Long term developments
In the short term, buildings generate enough energy to meet their energy demand through integrated electrical and thermal energy solutions based on renewable energy. • Electrical and thermal grids evolve, allowing storage of decentralised renewable energy produced by buildings and balancing supply and demand.	In the mid-term, direct current (DC) systems allow the use of PV electricity through energy-efficient in-house grids and the increasing amount of shared sustainable electricity storage solutions on all scales for buildings and mobility. • Energy storage systems are increasingly affordable using new materials and technologies such as flow batteries and graphene-	In the long term, bidirectional integrated grids and affordable storage solutions allow genuinely sustainable energy systems. Grids are interoperable, creating mixed thermal, electrical, water and gas networks within a single energy-management system. The growing affordability and availability of sustainable energy solutions, based on a mix of decentralised small-scale and large-

• Renewable energy technologies evolve towards more efficient and sophisticated integrated systems, e.g. advanced solar solutions such as photovoltaic thermal collectors for building integration or small-scale co-generation power solutions based on renewable fuels such as biogas or biofuel. • Large-scale renewable energy installations such as wind and solar parks are used widely throughout the territory. • All available exterior building surfaces are used to harvest solar energy through integrated energy solutions such as flexible and translucent photovoltaic or thermal collector facades.	based solutions. • Affordable seasonal heat/cold storage is shifting the season-to-season availability of harvested thermal energy through large-scale natural or artificial storage options such as aquifers and water storage tanks	scale installations, produce abundant renewable energy in the long term.

Table 14: Digital Roadmap for Sustainable energy transition

Digital Roadmap for Energy sharing

Short term developments	Mid-term developments	Long term developments
In the short term, energy resources at the town and district level are mapped and managed efficiently, allowing supply and demand matching between producers and consumers of electricity and heat, with individual buildings as contributors to efficient city-wide	• Energy grids are self-healing and bidirectional, with many interconnected decentralised production facilities for renewable energy and mechanisms to ensure grid stability and continuity of service in case of failure. • District storage	In the long-term district, energy performance is optimised through innovative approaches such as 'swarm' technologies, connecting appliances to self-learning and self-balancing networks and other city-wide solutions such as superconducting networks.

solutions. • Existing energy grids with an increasing share of decentralised renewable energy generation are stabilised at district levels by peak shaving measures and sufficient storage and generation capacity. • Sustainable energy generation and consumption are regarded as community assets, through which people share corresponding rights and obligations, collectively increasing the total amount of renewable energy in a district. • Energy performance is evaluated at the district level. New buildings with higher energy standards and renewable energy production compensate for the older building stock with a negative energy balance	systems are used to balance fluctuations in elect	

Table 15: Digital Roadmap for Energy sharing

Digital Roadmap for ICT & Building Management Systems

Short-term developments	Mid-term developments	Long term developments
In the short-term, ICT & Building Management Systems are evolving. This allows increasing generation and use of data	In the mid-term, building and home management systems allow building energy performance and operation to be optimised	In the long term, open energy and data systems allow interoperability of networks resulting in performance

for energy optimisation and management in buildings and grids based on precise control through smart meters. • ICT technologies allow the creation and control of smart networks at the local level to share electrical and thermal energy among neighbours. • Right from the design phase, building information management systems allow building energy performance simulation. This enables their lifecycle to energy balances to be optimised and their contribution at the district level to be determined	using public (e.g. weather forecasts) and private (e.g. individual users' consumption pattern) data. • Detailed real-time data is available on energy use and building performance, as well as on user comfort and behaviour, to improve and optimise building operation. This allows the creation of users' profiles, with adaptive systems that can be adjusted to match users' personal preferences	improvement through mutual learning. This is based on new standards and protocols to enable the connection of systems. • Buildings are active and self-learning, communicating and sharing experiences on sustainable performance through learning algorithms and artificial intelligence. • ICT contributes to the creation of extended smart grids, e.g. a super-Europe smart grid that connects Europe, North Africa and Asia, unifying super-grid and smart grid capabilities.

Table 16: Digital Roadmap for ICT & Building Management Systems

Digital Roadmap for Values, Motives and Behavioural change

Short-term developments	Mid-term developments	Long term developments
Behavioural change depends significantly on the availability of reliable data. In the short term, the transparency of data is increasing. This makes the actual energy costs visible, including externalised or hidden costs such as those relating to the environmental impact of fossil fuels. This supporting information helps to drive system transformation and	In the mid-term, information is increasingly transparent, ensuring that citizens have clear and transparent access to data on aspects like energy costs, individual lifestyles and behaviour, and the related environmental impact. This information allows individuals to take evidence-based decisions.	In the long term, personal environmental accountability drives individual behavioural change, avoiding 'rebound' effects. This personal accountability is based on citizens' unique use of goods and services and considers embodied energy, CO_2 emissions and other environmental and social impact indicators.

behavioural change. • Incentive strategies encourage people to change their behaviour towards more sustainable lifestyles, motivating through financial and non-financial rewards for individual or collective efforts towards overall societal sustainability. • Experience and experimentation through pilot projects and living labs promote public discussion and awareness of new building methods and lifestyles. This helps to create acceptance for sustainable buildings and positively influences the aesthetic perception of sustainable architecture. • New social intervention mechanisms such as energy ambassadors, specific educational programmes and neighbourhood energy competitions promote dialogue with citizens and increase their awareness of and interest in sustainability. • Cities can make evidence-based decisions as their access to knowledge increases and changes, with independent entities providing information and supporting municipalities.	• Strategies like 'Gamification' solutions make energy efficiency and related lifestyle changes fun. For example, these use personalised apps and competitions between citizens, allowing comparisons of personal performance and changes towards sustainability. • Lifestyle coaching by experts helps citizens to optimise their personal use of resources relating to their lifestyles. This is based on personalised advice found in the available real-time data	

Table 17: Digital Roadmap for Values, Motives and Behavioural change

Digital Roadmap for Innovative business models

Short term	Mid-term	Long term
New financing schemes promote investments, for example, in energy upgrading and renovation of the existing building stock. This includes new revenue mechanisms based on the 'truth of costs', a long-term holistic evaluation of costs and benefits for society. • The 'community manager' emerges to deal with the complexity of communities. This role is defined for match-making in districts. To optimise the use of resources, the community manager matches people's energy needs - taking into account their behaviour - with the available technical solutions in the district and legislation. • New investment models allow the creation of win-win situations based on combined public, private and company investments. These allow inclusive solutions, for example, in renewable energy installations. • An inclusive value system makes existing monetary systems and mechanisms more coherent. Value criteria for the actual environmental impact of products and services are included, for example, through taxes and incentives. • Market mechanisms	New mechanisms such as personal energy budgets allow personalised energy consumption. This could be based on energy credits (similar to mobile phone credits), enabling higher consumption at extra cost and discounts for sustainable behaviour.	New business models are based on flexible pricing schemes. This encourages people to contribute to overall grid stability and energy efficiency through flexibility in their energy use in response to dynamic pricing. • Contributing to the circular economy, business models are based on a holistic and systemic approach. This considers the total value of products and services, including their societal, environmental and economic value at different scales.

balance the energy system, allowing peak shaving and increasing overall energy efficiency.		

Table 18: Digital Roadmap for Innovative business models

Case Study: Smart Singapore Town Framework

Plans and designs to embark on the development of the Smart HDB Town, leveraged on Information and Communication Technology to make HDB towns and estates more liveable, efficient, sustainable and safe for residents.

The “Smart HDB Town Framework” maps out how HDB intends to introduce the “Smart” element in HDB towns and estates by focussing on four key dimensions:

i) Smart Planning

ii) Smart Environment

iii) Smart Estate

iv) Smart Living

Smart Planning

Good planning and designs are instrumental in creating a conducive environment in HDB towns. Smart planning will augment current efforts and enhance HDB's expertise, providing residents with well-designed homes in a green and sustainable town. Using computer simulation and data analytics will enable HDB to improve how it plans and designs its towns, precincts and buildings and derive optimal and cost-effective solutions to achieve sustainability goals.

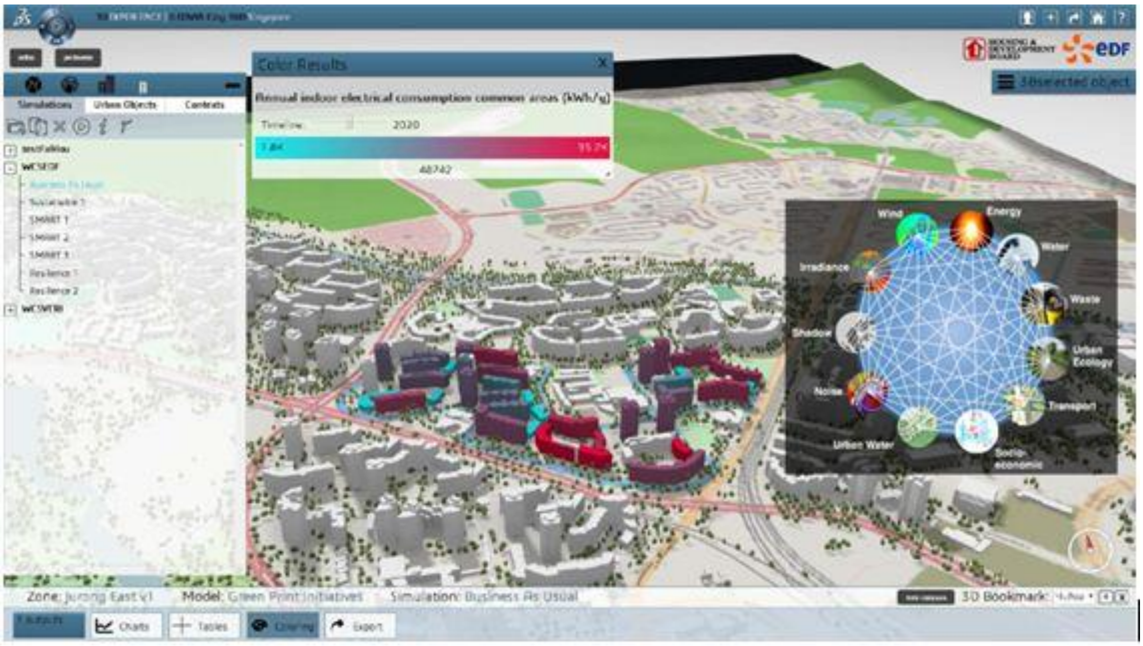


Figure 5: Real-time data is integrated into simulation models to derive the optimal and most cost-effective solutions for urban design technologies in HDB towns.

Some Smart planning technologies include:

a) Complex Systems Modelling Tool

It is a `decision-making tool' that helps planners understand the trade-offs when introducing new sustainable features into HDB towns. For example, the tool enables HDB to assess the effectiveness of various initiatives (e.g. LED lighting, solar energy, skyrise and vertical greenery, rainwater harvesting, recycling, and pneumatic waste collection) and decide on the best combination of these to achieve sustainability goals cost-effectively. The tool, which had its prototype unveiled in June 2014 at the World Cities Summit, will be employed to plan sustainability features in Punggol Northshore.

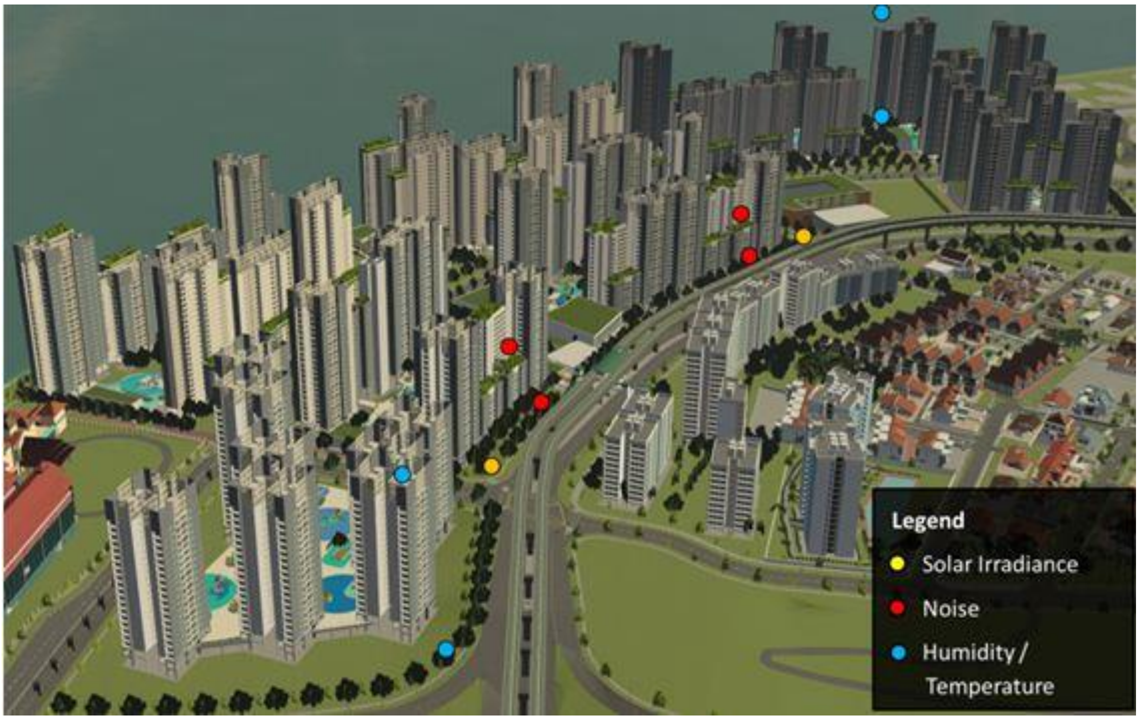
b) Smart Car Parks

Each car park will have an intelligent parking demand monitoring system that automatically increases the number of available lots during non-peak hours for visitors, as residents with a season parking ticket (SPT) are out. Conversely, it will also reduce the number of available spaces for short-term parking visitors in the evening to ensure sufficient parking spaces are reserved for residents with SPT returning home.

Figure 6: The Smart Carpark monitors and avails unutilised season parking lots to visitors.

Smart Environment

HDB looks into linking estates with a network of sensors to create a "Smart environment". These sensors will capture real-time information on environmental factors such as temperature and humidity. Innovative solutions can then be found to create a more pleasant environment for residents.



Innovative solutions respond to real-time environmental conditions and help to maintain a comfortable living environment for residents.

Figure 7: Realtime data feedback on the condition of roads and residences in the smart township

For example, smart fans located in common areas can be triggered when certain thresholds of temperature and humidity are reached. The fan speed can be regulated to improve the thermal comfort level for residents while reducing energy consumption.

Figure 8: Smart fan. Activated by human traffic, temperature and humidity, Smart fans will improve thermal comfort levels for residents.

Smart Estate

To improve estate services, HDB leverages Smart technologies to collect and analyse data which helps to optimise maintenance cycles and pre-empt problems. For example, with data collected by sensors, one can better understand the usage patterns of standard amenities, such as lifts and lights. Changes in these patterns could signify potential problems. These facilities or fittings can then be checked, and any issue identified can be resolved promptly, with minimal disruption to services.

Figure 9: Timely detection of maintenance issues in an estate enables prompt resolutions with minimal disruption to services for residents' safety and convenience

Some of the technologies that HDB looks into test-bedding include:

a) Smart Lighting with sensors

Lighting fitted with sensors installed in the common areas can help HDB understand human traffic patterns and optimise lighting. The lighting in common areas with little or no human traffic detected could be reduced to 30%, potentially reducing energy usage by as much as 40%.

b) Smart Pneumatic Waste Conveyance System

A Smart Pneumatic Waste Conveyance System will be adopted in new HDB developments. One can monitor waste disposal patterns and volume by fitting this facility with sensors. By analysing the data, one can improve the design of the waste bins and vary the frequency of waste collection based on the volume of waste collected. This can help to optimise the deployment of resources needed for waste collection. The first housing projects in Bidadari, Tampines North and Punggol Northshore incorporate this Smart feature from the onset.

Figure 10: Waste level patterns are studied to optimise the waste collection processes.

Smart Living

HDB provides the digital infrastructure in flats to pave the way for intelligent homes. With such infrastructure in place, residents can tap on Smart home applications developed by commercial companies that can enhance energy savings and enable them to access services like healthcare in the comfort of their homes.

Figure 11: Smart home appliances pave the way to intelligent homes.

Some potential applications that commercial companies can develop for Smart homes include:

a) Smart Elderly Alert System

With the digitally enabled infrastructure in the home, commercial firms can develop Smart Elderly Alert Systems for families who may wish to monitor elderly relatives to keep them safe. Sensors placed in the flat can help to monitor the movements of the elderly, and caregivers will be alerted should irregular movements be detected (e.g. if no activities are caught for some time). The system can also include a panic button so that the elderly can quickly alert caregivers and family members in need.

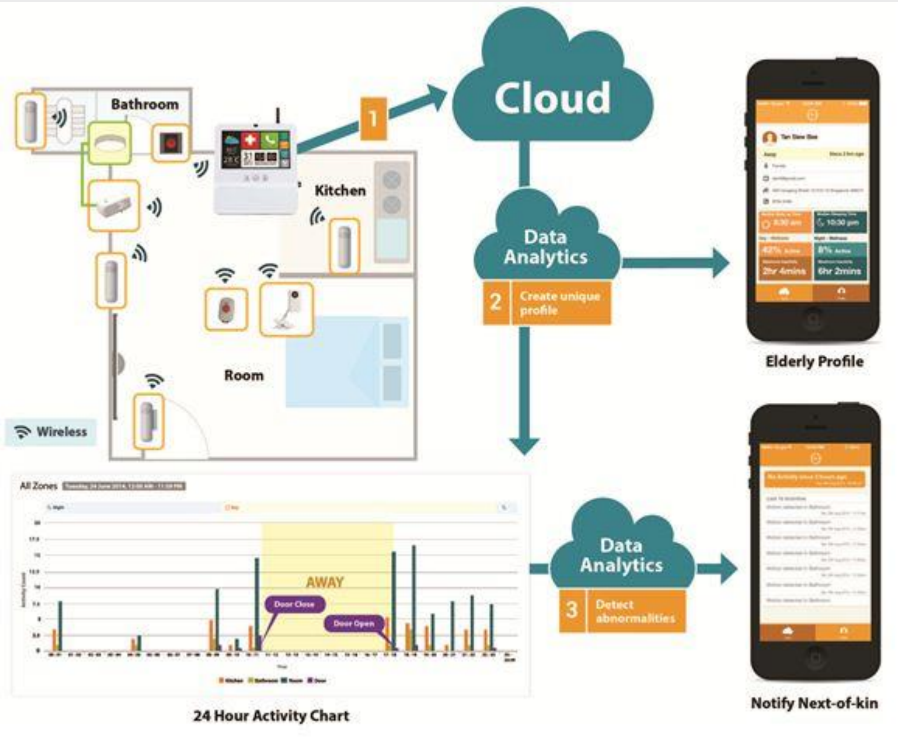


Figure 12: The Smart Elderly Alert System learns the living habits of the elderly at home and enables timely alerts to their caregiver when irregular patterns in behaviour are detected.

b) Smart Home Energy Pilot

Using new technologies, HDB, together with the Energy Market Authority (EMA) and Panasonic, explores a suite of household energy choices and solutions. The feasibility study for establishing a Smart Home Energy Pilot in Yuhua commenced in June 2014.

c) Home Energy Management System

Residents can monitor their energy consumption patterns, manage their home appliances in real time, and possibly reduce their energy usage. A year-long pilot conducted in Punggol in 2013 showed that this system helped to reduce residents' monthly energy consumption by 20%.

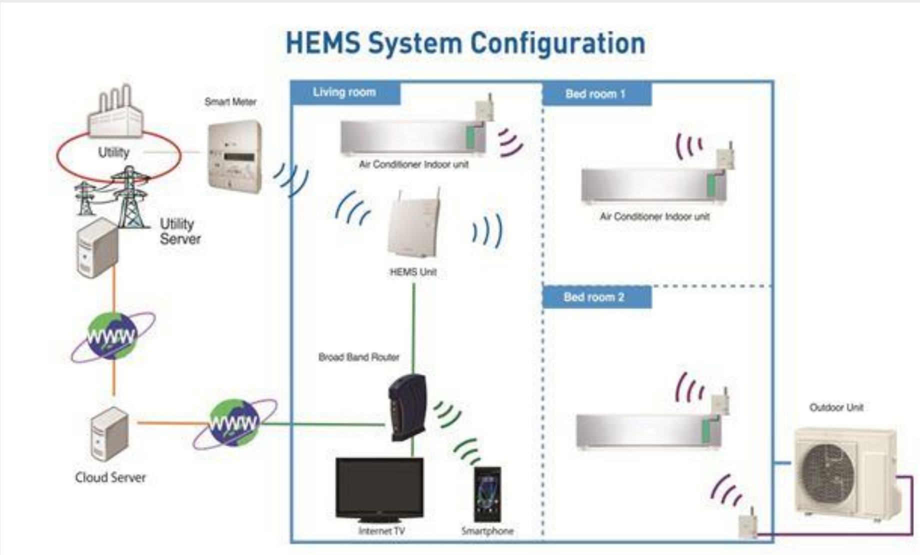


Figure13: This system allows residents to track and manage their energy consumption and control their home appliances through this management system.

HDB works closely with the relevant agencies and industry players to study the design of the ICT infrastructure in HDB homes so that residents can enjoy convenience and savings when using Smart devices and appliances.

Pilot-Programme of Smart technologies in Punggol NorthShore, Singapore

In line with Punggol Northshore's vision to be "A Smart and Sustainable District", HDB will be test-bedding suitable Smart technologies in the first four housing projects in the district, which was launched in 2015.

Smart technologies to be test-bedding in Punggol Northshore, Singapore	
Smart Planning	Smart Car park Complex Systems Modelling Tool
Smart Environment	Smart Fans
Smart Estate	Smart Lighting Smart Pneumatic Waste Conveyance System
Smart living	Smart Enabled Homes to facilitate solutions like: a) Elderly Alert System b) Home Energy Management System

Table 19: Smart technologies to be test-bedding in Punggol Northshore, Singapore

Smart HDB Town Framework details were unveiled at the HDB PEAK (Professional Engagement and Knowledge-Sharing) Forum. The Forum is an annual gathering of building professionals. It provides a platform for sharing new ideas and best practices in the building industry and aims to raise industry standards in design and construction excellence.

The theme for the Forum is “Road to Better Homes – Sustainability & Greenery”. Besides exploring how “Sustainability and Greenery” may be exemplified in public housing developments, the Forum also explores the development of Smart Towns as a new initiative for the next phase of public housing developments.

Going forward, HDB will pilot selected Smart initiatives in Punggol Northshore to assess their viability and suitability before extending them to other HDB estates.

Conclusion

Summary of Digital Roadmap on Smart Township in Malaysia

<table>
<tr><th>Basic</th><th>Intermediate</th><th colspan="2">Advanced</th></tr>
<tr><td>Wi-Fi, Mobile Phone</td><td>Wi-Fi, Mobile Phone, Sensors</td><td colspan="2">Wi-Fi, Sensors. RFID, IOT, AI</td></tr>
<tr><td rowspan="4">Smart Planning
Smart Living
Smart Home Safety
Smart Home Security
Smart Transport
Smart Parking
Smart Water Management</td><td rowspan="4">Smart Energy Sharing
Smart Streets
Smart Traffic Management
Smart Building Management
Smart People Mobility Management
Smart Healthcare</td><td colspan="2">Smart technologies to be test-bedded</td></tr>
<tr><td>Smart Planning</td><td>Smart Car park
Complex Systems Modelling Tool</td></tr>
<tr><td>Smart Environment</td><td>Smart Fans</td></tr>
<tr><td>Smart Estate</td><td>Smart Lighting
Smart Pneumatic Waste Conveyance System</td></tr>
</table>

Smart Waste Management Smart Energy Management		Smart living	Smart Enabled Homes to facilitate solutions like: a) Elderly Alert System b) Home Energy Management System

Table 20: Summary of Digital Roadmap on Smart Township in Malaysia

Basic Level

For the Basic Level, the minimum digital requirements are Wi-Fi and a mobile phone with a minimum data of 4G. Primarily this level focuses on a single home or individual home. All smart features are built-in to the home, the smart features are connected to the owner via Wi-Fi, and the owner can access the smart devices via the smart mobile phone with internet connection.

Intermediate Level

This level covers a larger area than a house, home, or building. The main connectivity requirement for this level is Wi-Fi, cloud data and a mobile smartphone with a data connection. The surroundings are equipped with sensors at strategic locations such as parking lots, streets, buildings, and public amnesties. The sensor will detect the presence of a resident in the town, and through a database stored in the Cloud, the system will give the resident options for parking space or other needs.

Advanced Level

At this level, the coverage is broader. A township is connected through Wi-Fi, the other connection technologies are using IOT, RFID, Artificial Intelligence (AI) and the database of each resident is stored in the Cloud. The smart town management system will assign each resident's unique identity. On top of the individual connection to assist the move about of the resident, the town will also have smart features such as smart planning, smart living, smart environment, smart estate, and smart wellbeing.

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