



Intelligent and Smart Buildings



Ir Dr. Sam C. M. Hui

Department of Mechanical Engineering

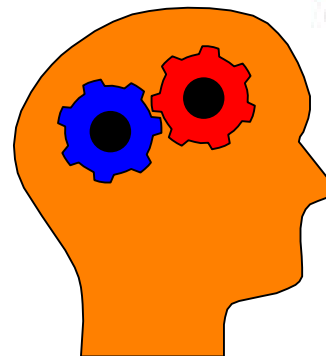
The University of Hong Kong

E-mail: cmhui@hku.hk

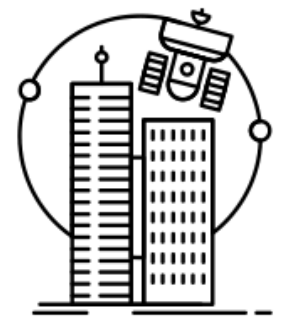
Contents



- Intelligent building (IB)
- Basic principles
- Smart & green building
- Smart cities
- Smart office & home



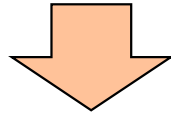
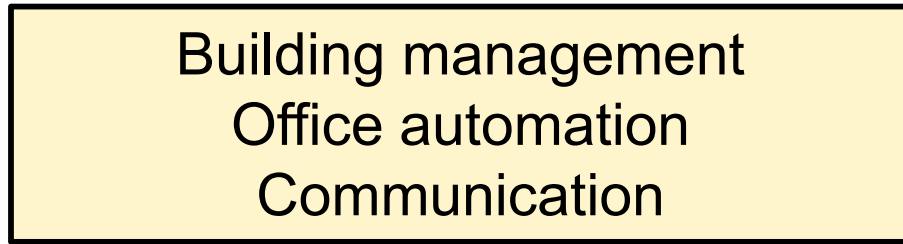
Intelligent building (IB)



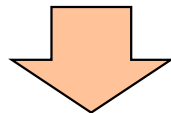
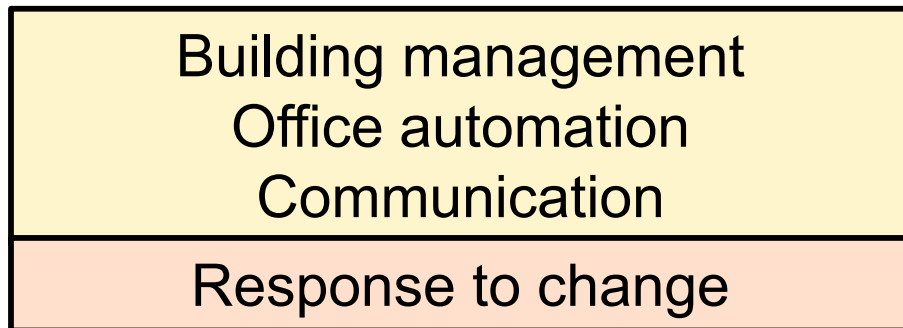
- Intelligent building (IB)
 - First coined in USA in early 1980s; its definition/model is changing/evolving
 - Automated buildings (1981-85)
 - Responsive buildings (1986-91)
 - Effective buildings (1992-)
 - Intelligent/Smart buildings (2000-)
 - Development of IB
 - Closely linked with computers & information communication technology (ICT); high-tech related
 - But, IB \neq high-tech building

智慧型大廈
智能建築

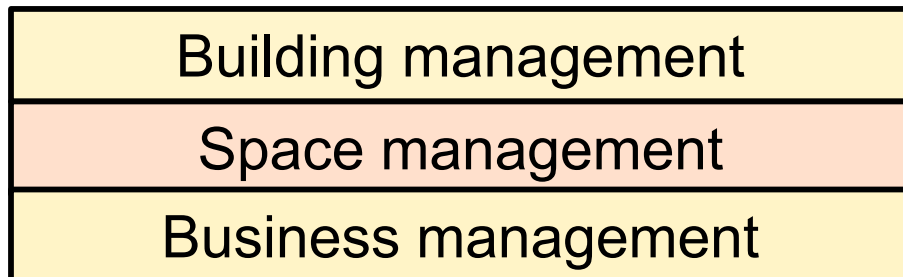
Automated buildings (1981-1985)



Responsive buildings (1986-1991)



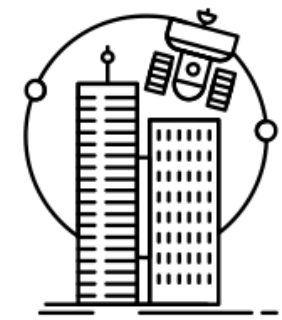
Effective buildings (1992-)



An intelligent building is a collection of innovative technologies

An intelligent building is a collection of technologies able to respond to organizational change over time



An intelligent building provides a responsive, effective & supportive environment within which the organization can achieve its business objectives. The intelligent building technologies are tool that help this to happen.



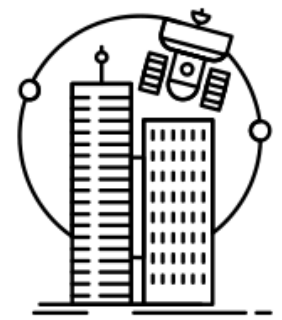
Intelligent building (IB)

- Building management:
 - Building automation & the physical environment
- Space management:
 - Building's internal space & operating costs
 - Capabilities & flexibility of the building to accommodate changes, personal moves & connectivity
- Business management
 - Management of the organization's core business

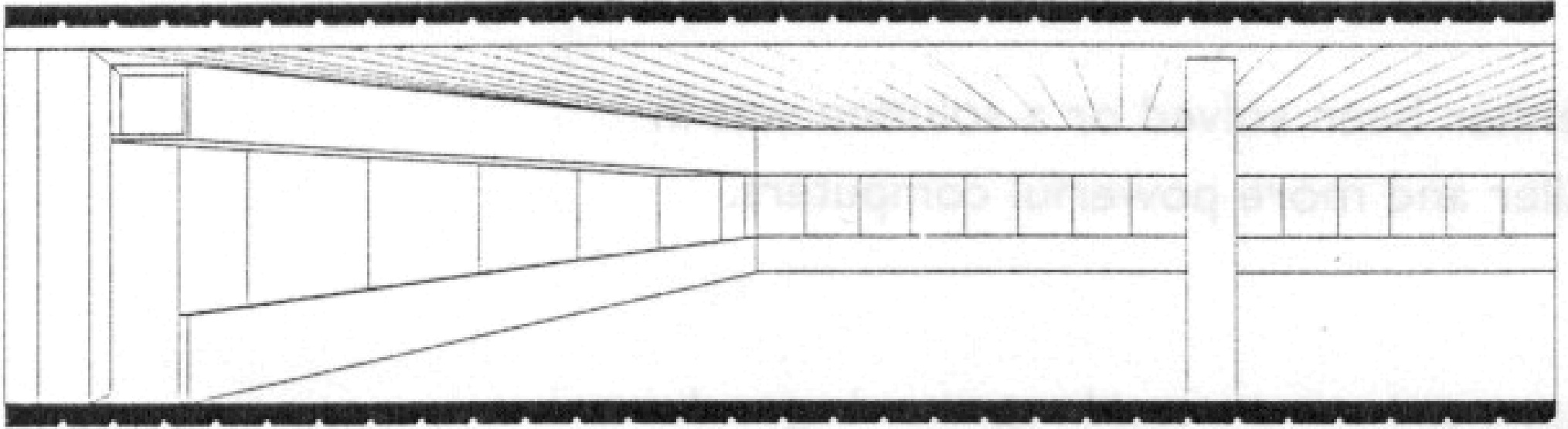
The Intelligent Building

IB Goals	IB Tasks	IB Attributes	
Building management	Environmental control of building 	Design strategies and building shell attributes Facility management strategies	Building Automation systems (BA)
	User control of building systems		
Space management	Management of change (capacity, adaptability, flexibility, manageability) 		Computer Aided Facility Management systems (CAFM)
	Minimization of operating costs		
Business management	Processing of information		Communications
	Storage of information		
	Presentation of information		
	Internal communications		
	External communications		
		Office automation	
		Audiovisual systems	
		Business systems	

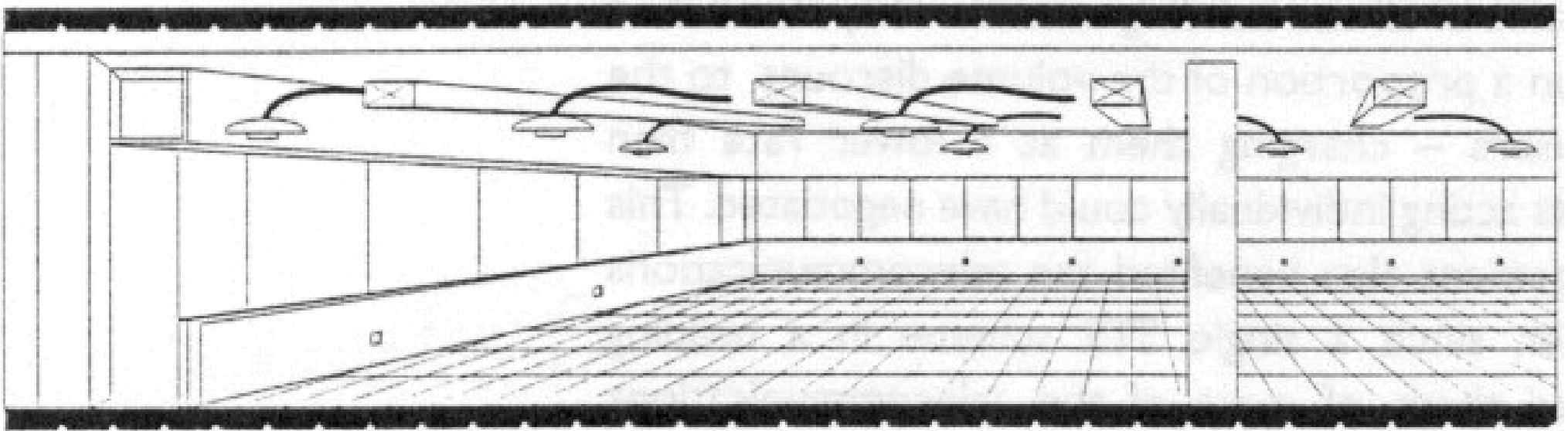
Intelligent building (IB)



- Intelligent Buildings Institute (IBI)(1989):
 - Optimization of its four basic components - **structure, systems, services & management** - and the interrelationships between them
- IB in Europe study (early 1990s):
 - IB “... provides a responsive, effective & supportive intelligent environment within which the organization can achieve its business objectives.” -- DEGW (1992)

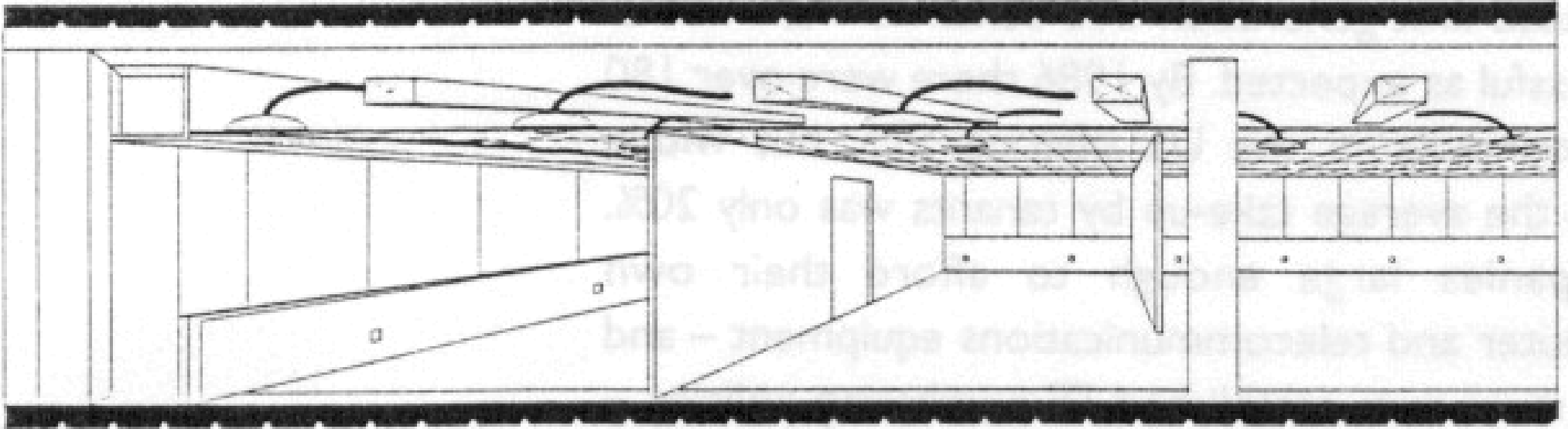


Building shell: 50-75 years (structure cladding)

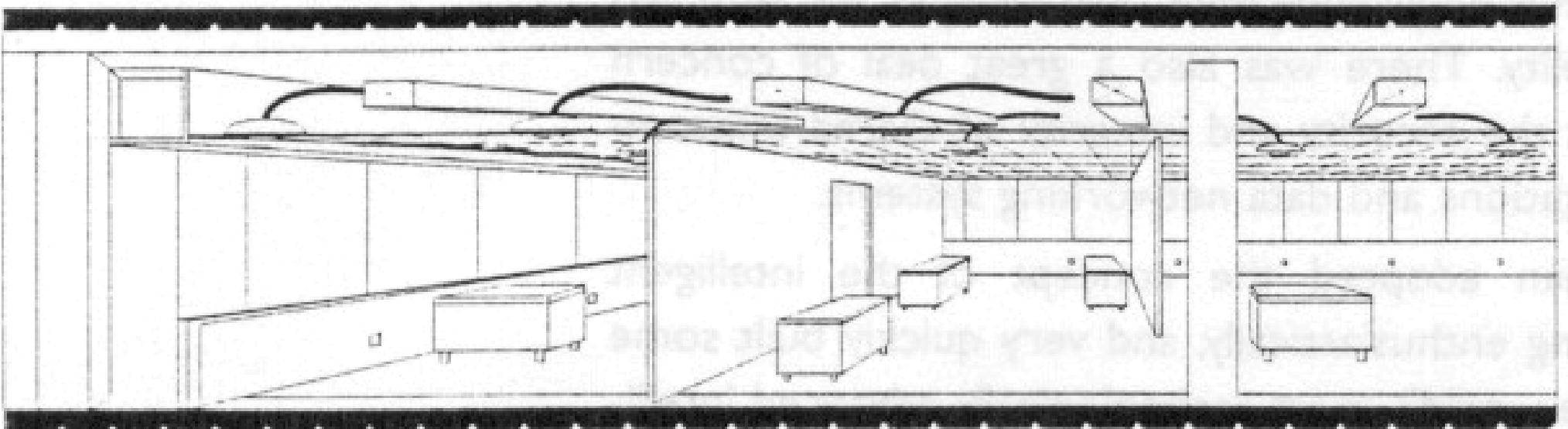


Building services: 15 years (HVAC, light, power)

[Source: Harrison A., Loe E. & Read J., 1998. *Intelligent Buildings in South East Asia*]

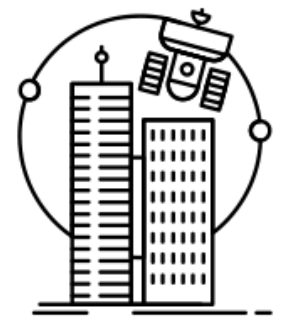


Fitting-out elements (scenery): 5 years (fixed interior elements, ceiling, partitions, finishes, IT equipment)



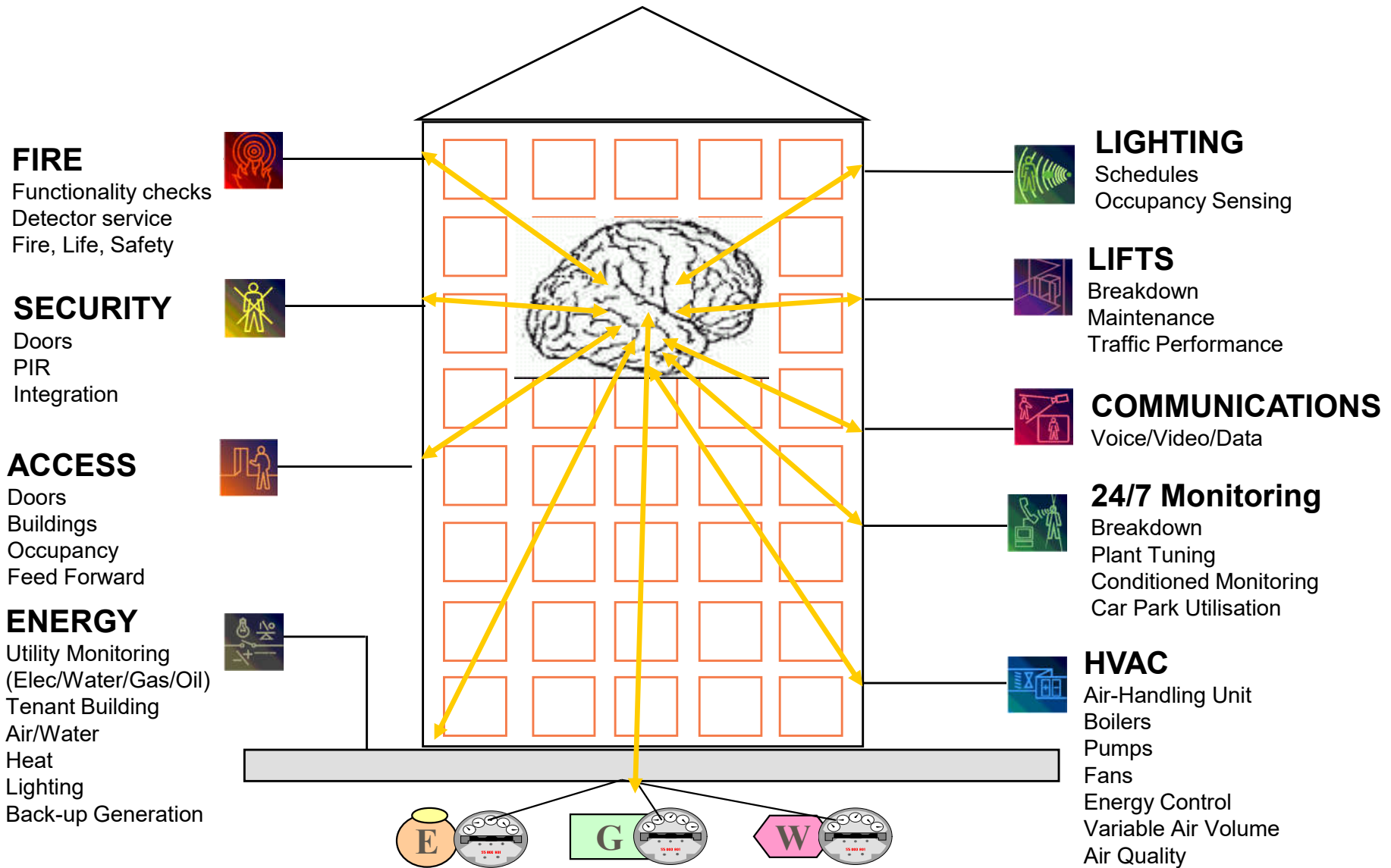
Office furnishings (settings): day-to-day rearrangement

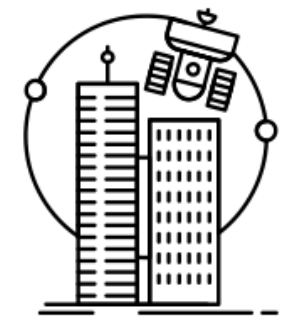
Intelligent building (IB)



- Definitions of Intelligent Building (IB)
 - By Continental Automated Buildings Association (CABA)
 - IB uses both technology & process to create a facility that is safer & more productive for its occupants & more operationally efficient for its owners
 - By European Intelligent Building Group (EIBG)
 - IB creates an environment that maximizes the effectiveness of the building's occupants, while at the same time enabling efficient management of resources with minimum lifetime costs of hardware & facilities

Major elements of intelligent buildings



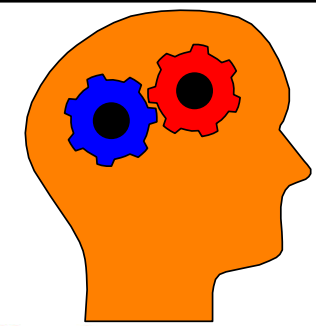


Intelligent building (IB)

- Definition of IB (from AIIB)
 - An intelligent building is designed & constructed based on an appropriate selection of quality environment modules to meet users' requirements by matching the appropriate building facilities to achieve long-termed building value
 - The needs of the building developer/owner/occupants & the enabling technologies
 - IB will generate measurable long-termed building values (productivity, market value, energy conservation, environmental friendliness & high working efficiency)

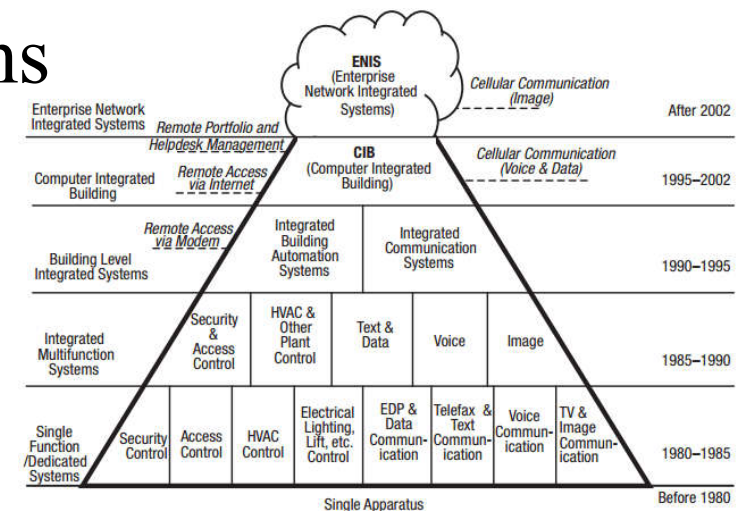
Intelligent building technology



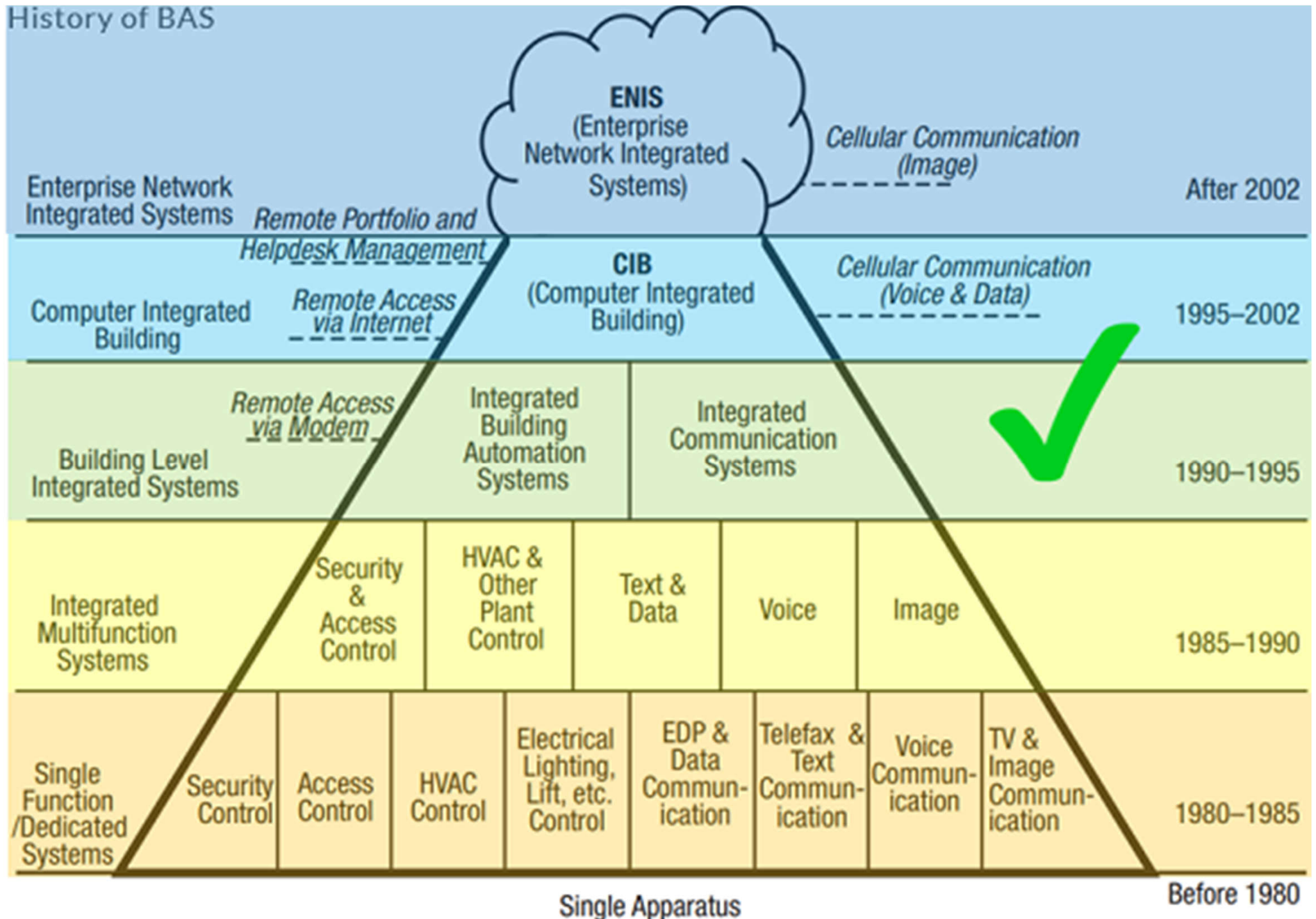


Basic principles

- Major IB features
 - Automatic reactions (adjust internal conditions)
 - Effective communication & IT management
 - Responsiveness to changes
- Integrated IB pyramid
 - Single function/dedicated systems
 - Multifunctional systems
 - Integrated systems
 - Computer integrated building

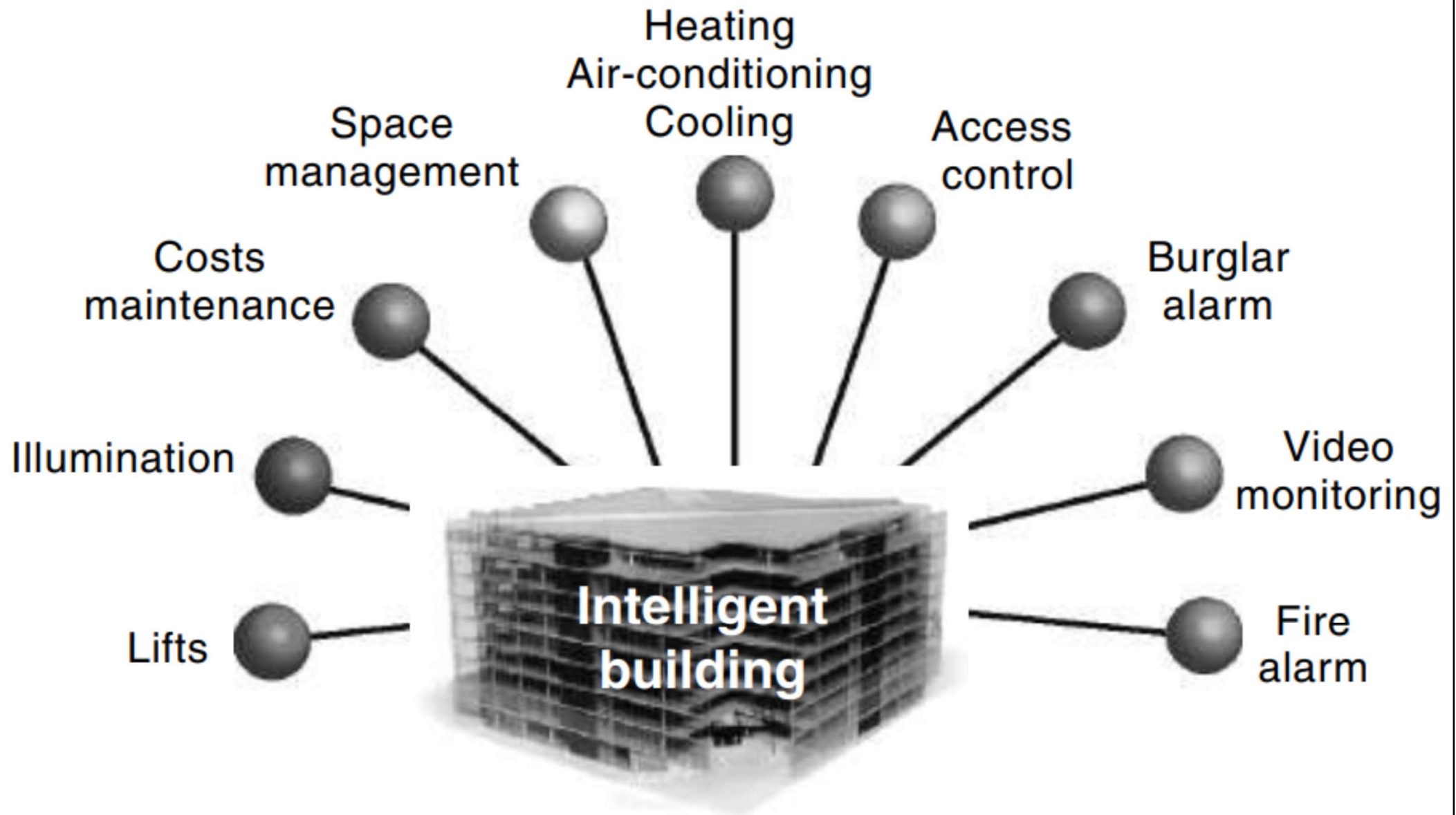


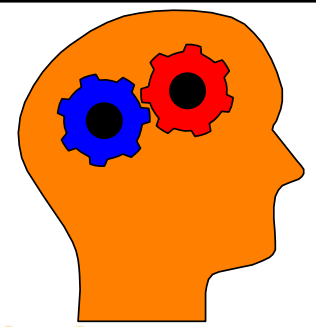
Intelligent building pyramid



(Source: Wang S., 2010. *Intelligent Buildings and Building Automation*, Spon Press, London & New York.)

System integration of intelligent building

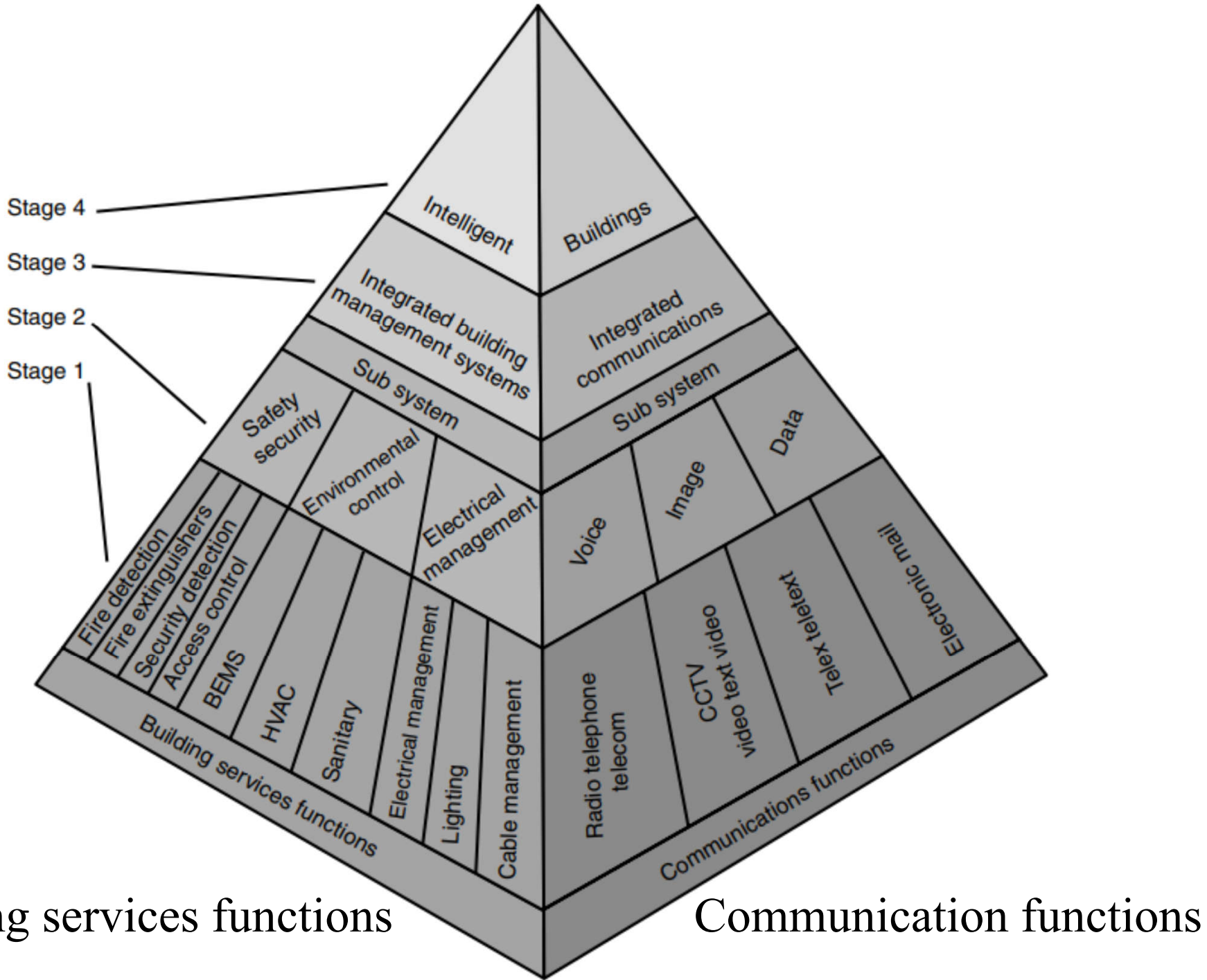




Basic principles

- Integration of various building systems
 - Energy management system
 - Lighting management system
 - Security systems & fire safety
 - Telecommunications & office automation
 - Local area networks (LANs)
 - Cabling management
 - Intelligent maintenance mgt. system (IMMS)
 - Computer aided facility management (CAFM)

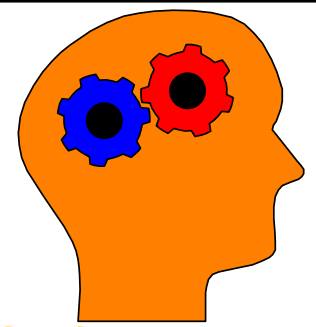
Building services & communication integration of intelligent buildings



Building services functions

Communication functions

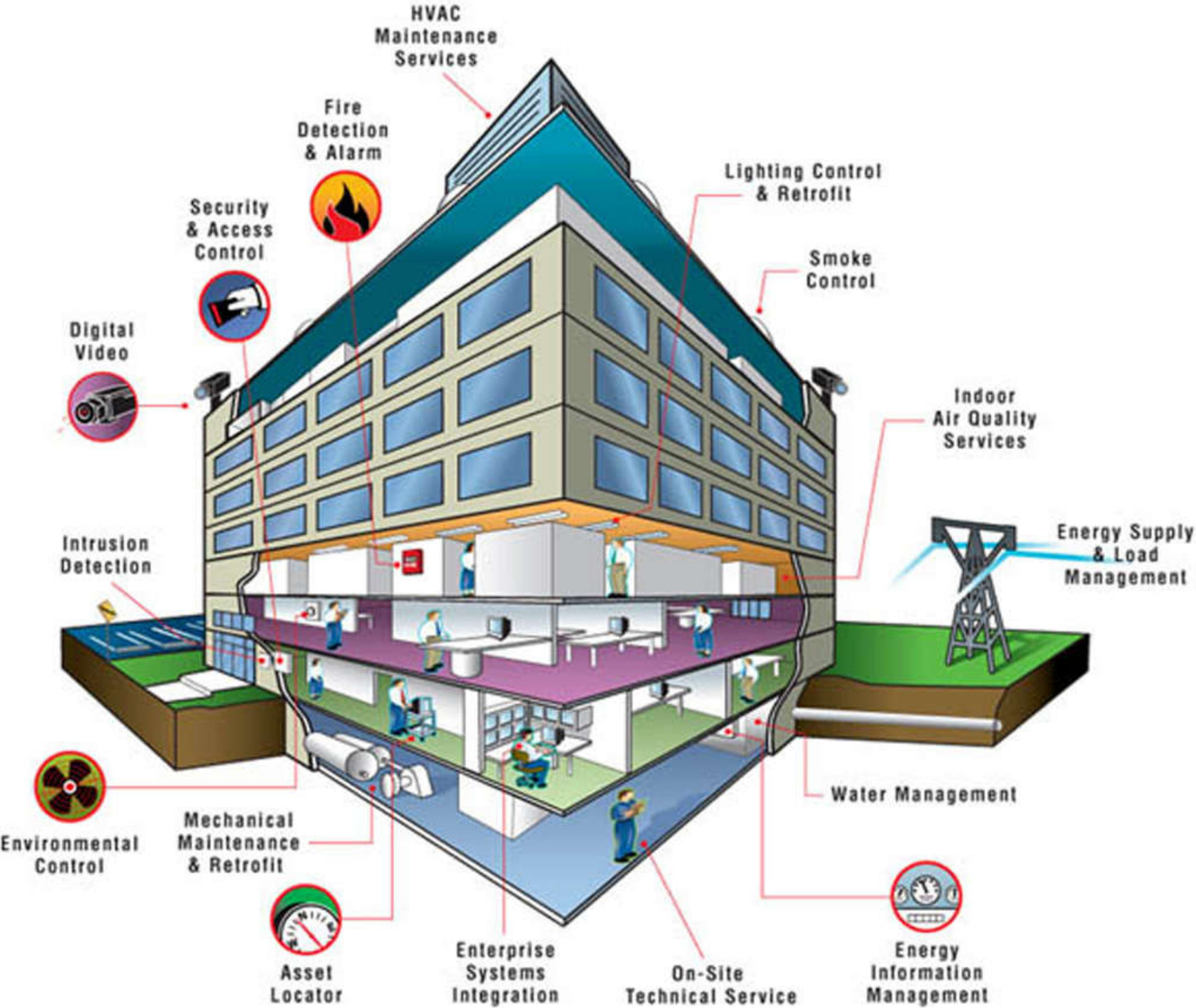
(Source: Clements-Croome D. (ed.), 2004. *Intelligent Buildings: Design, Management and Operation*, Thomas Telford Publishing, London.)

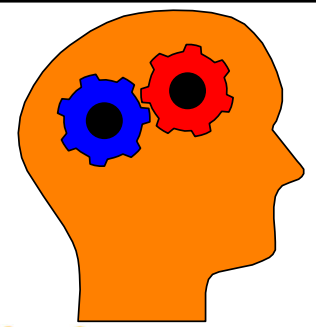


Basic principles

- Major categories:
 - Energy efficiency
 - Energy management & control
 - Lifesafety systems
 - Fire alarm & security
 - Telecommunications systems
 - PABX telephone, videotext, cablevision, e-mail
 - Workplace/Office automation
 - Data processing, word processing, computer-aided design (CAD), information services

Building automation systems (BAS) for intelligent buildings

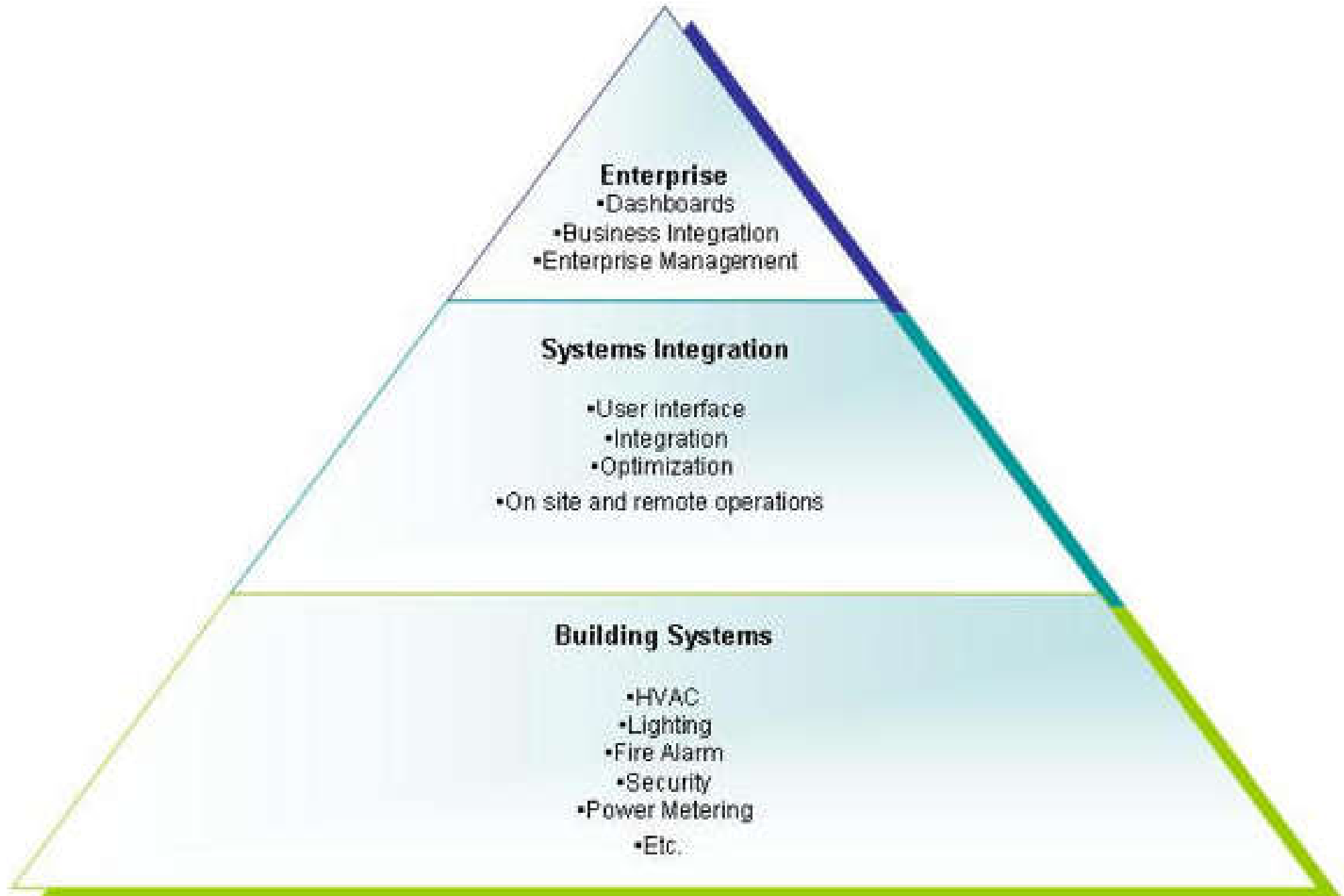




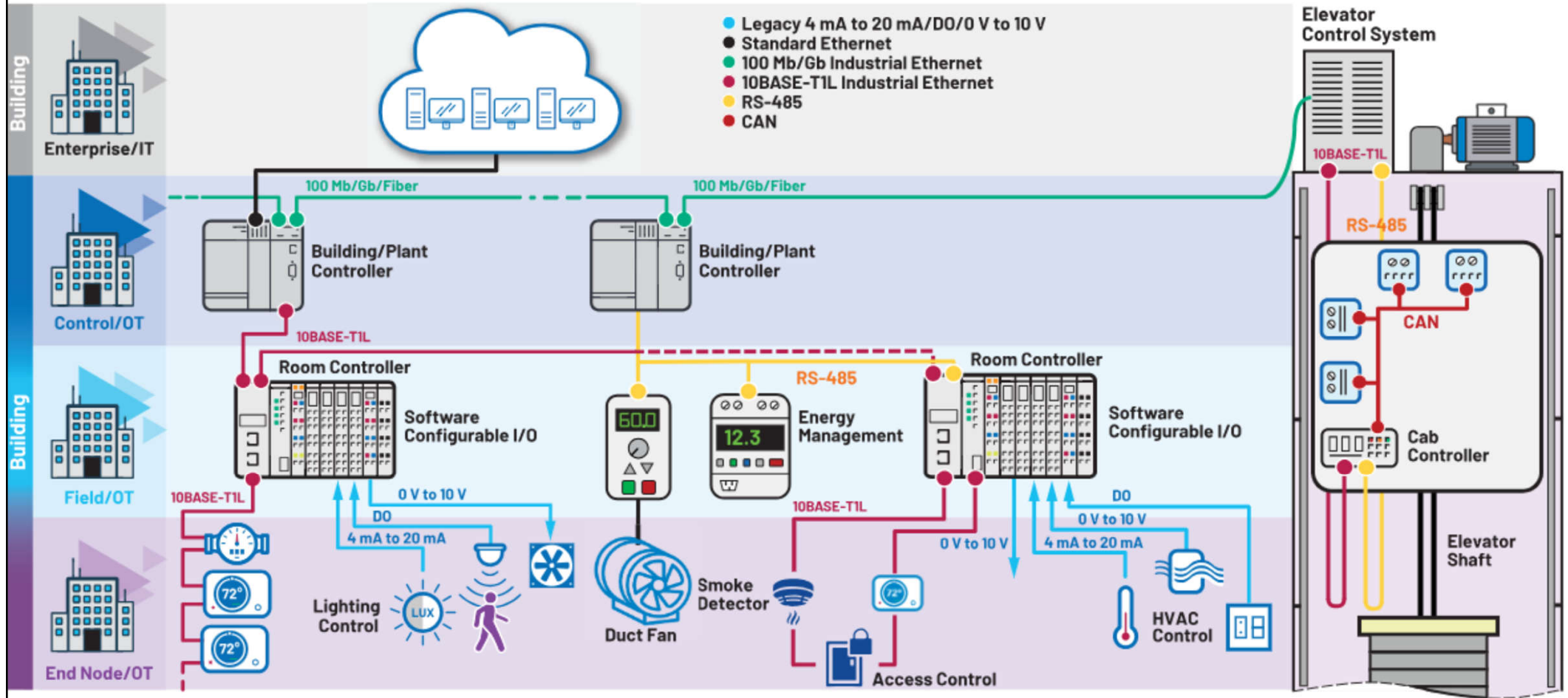
Basic principles

- Four main aspects:
 - **Facility management**
 - Take care & maintain various functions for occupant comfort & operation
 - **Information management**
 - Office automation (OA), LAN, wiring
 - **Communication**
 - Tel/Fax, e-mail, Internet, video telecommunication
 - **Control**
 - Building automation system, direct digital control

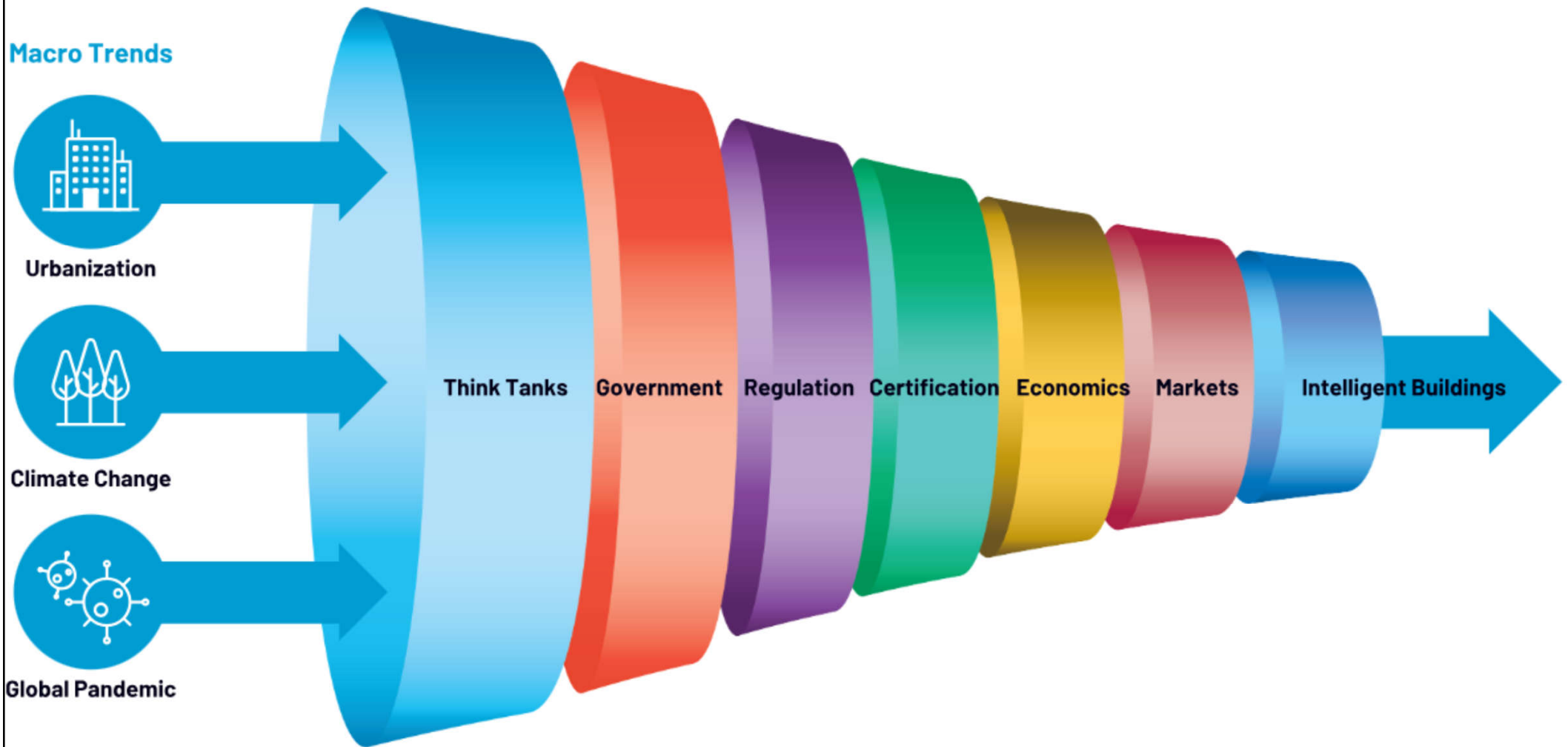
Intelligent building model to improve building systems control, system operational efficiency and facility assessment & optimization

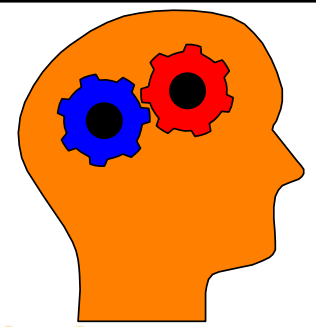


Intelligent building infrastructure (an example of how multiple technologies & communications protocols could transform a legacy BAS system into an intelligent building)



The funnel of influence for intelligent buildings (macro trends & key aspects affecting the development & evolution of intelligent buildings)





Basic principles

- Late 1990s & 2000s
 - IB definition: tilted towards **energy efficiency** & **sustainability** with the introduction of green building assessment methods (e.g. BREEAM & LEED)
 - Driving forces: urbanization & climate change
 - Increasing convergence of intelligence & sustainability: “**Bright Green Buildings**”
 - Buildings that are **both intelligent & green**

Convergence of intelligent and green buildings

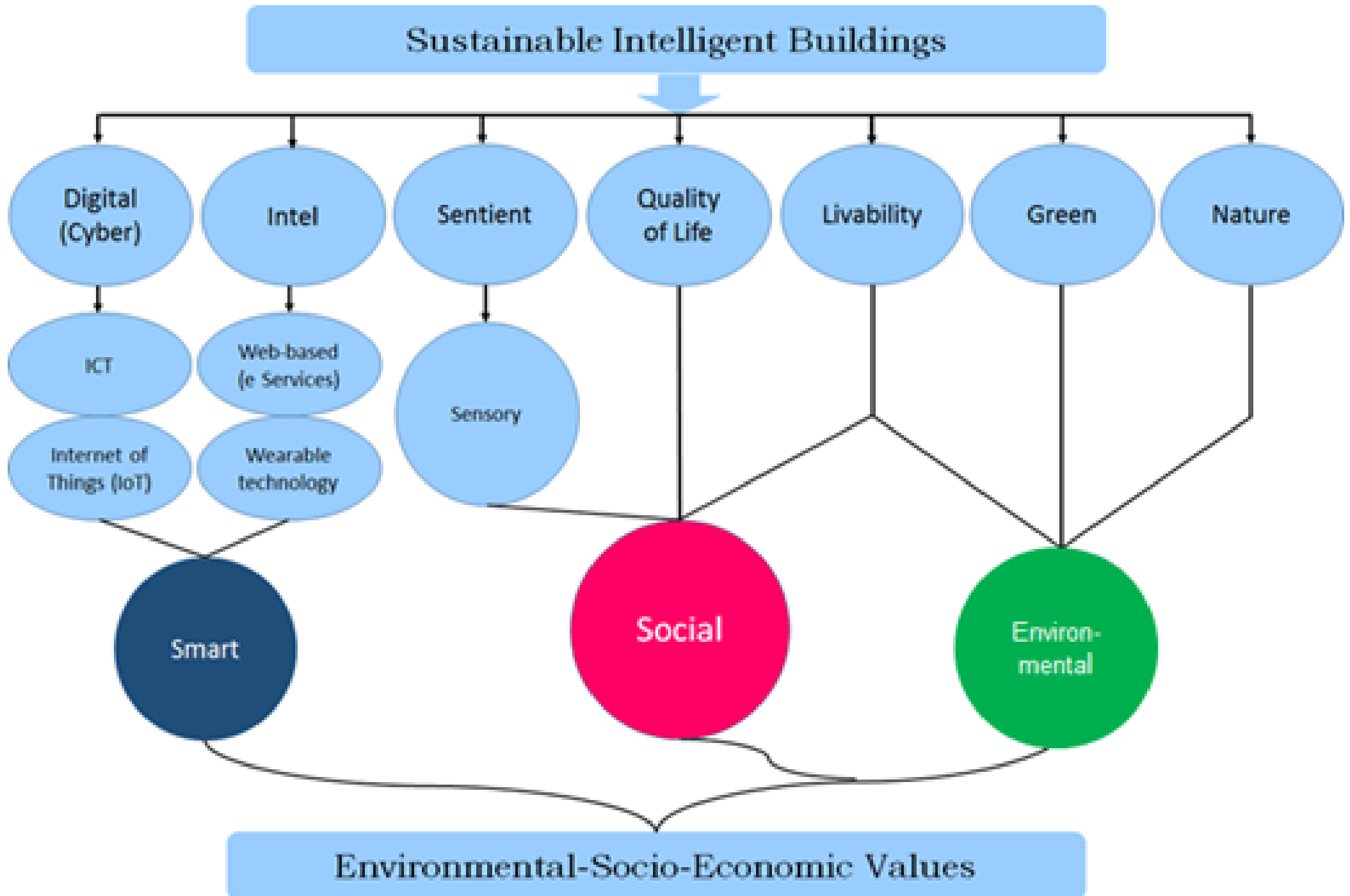


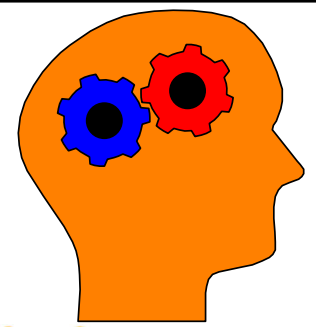
Source: Frost & Sullivan

(Source: Ma Z., Billanes J. & Jørgensen B. N., 2017. A business ecosystem driven market analysis: The bright green building market potential, In *the 1st Annual International Conference of the IEEE Technology and Engineering Management Society*, Santa Clara, California USA, 2017.

https://www.researchgate.net/publication/318890442_A_business_ecosystem_driven_market_analysis_The_bright_green_building_market_potential)

Basic concepts of sustainable intelligent buildings





Basic principles

- Current understanding of IB
 - Address both intelligence & sustainability issues by utilising computer & intelligent technologies to achieve the optimal combinations of overall comfort level & energy consumption
 - Intelligent buildings combine & leverage 5 key aspects of building management:
 - Enhanced financials, operational efficiency, occupant experience, energy conservation, sustainability

Intelligent + Green

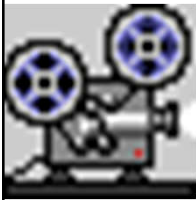
5 key aspects of intelligent building management

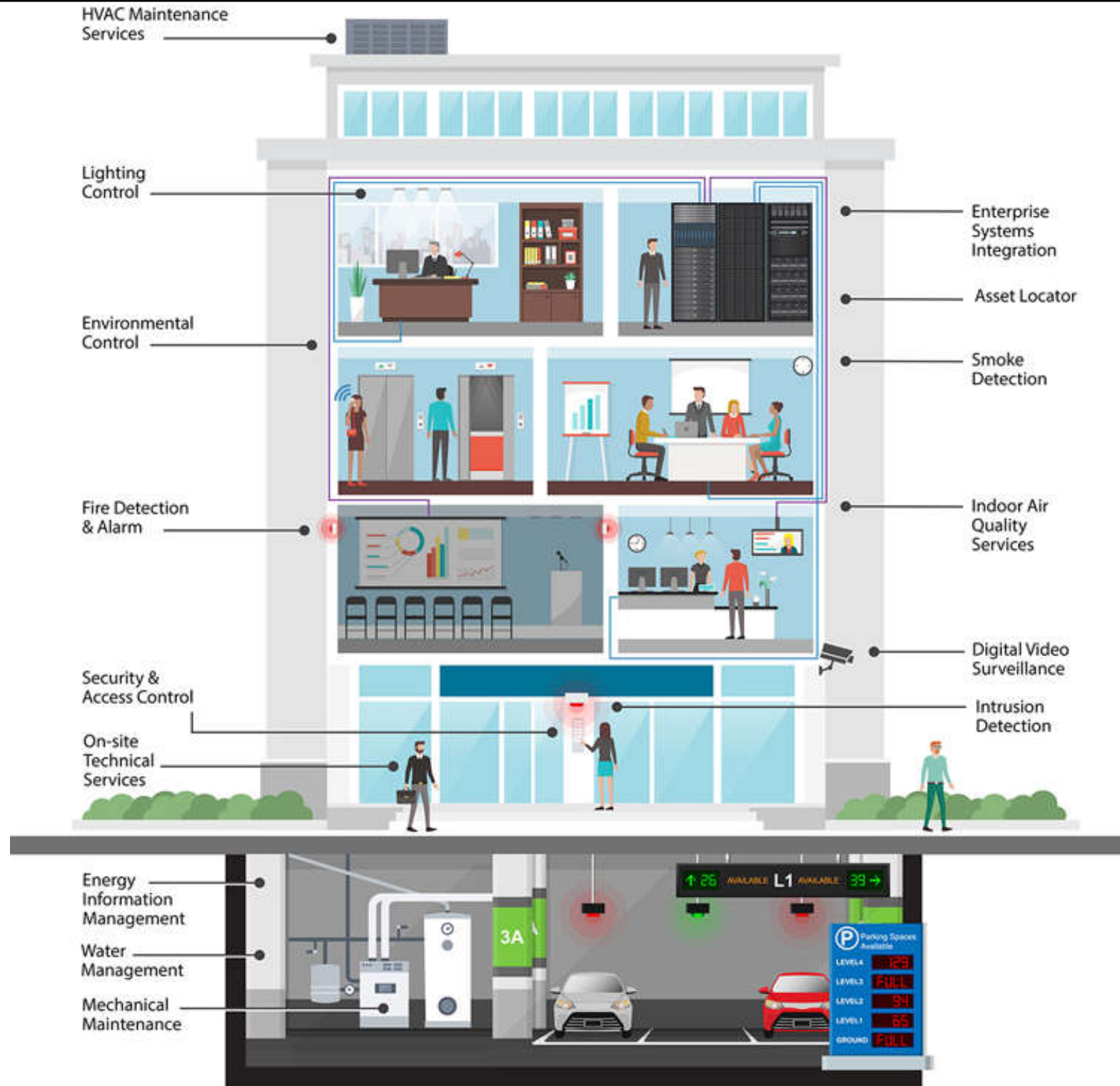


Smart & green building



- Smart building:
 - Use data & technology to improve the efficiency of its operation and the experience of the people who use the building
 - Improve the quality of the built environment
- Future outlook:
 - Smart buildings - the future of building technology (7:26) <http://youtu.be/gCuPx9shWT0>
 - Can you identify all the technologies in the video?





The essential technologies that make a building smart

Smart building is a new class of buildings that are secure, healthy & sustainable



Benefits of smart buildings

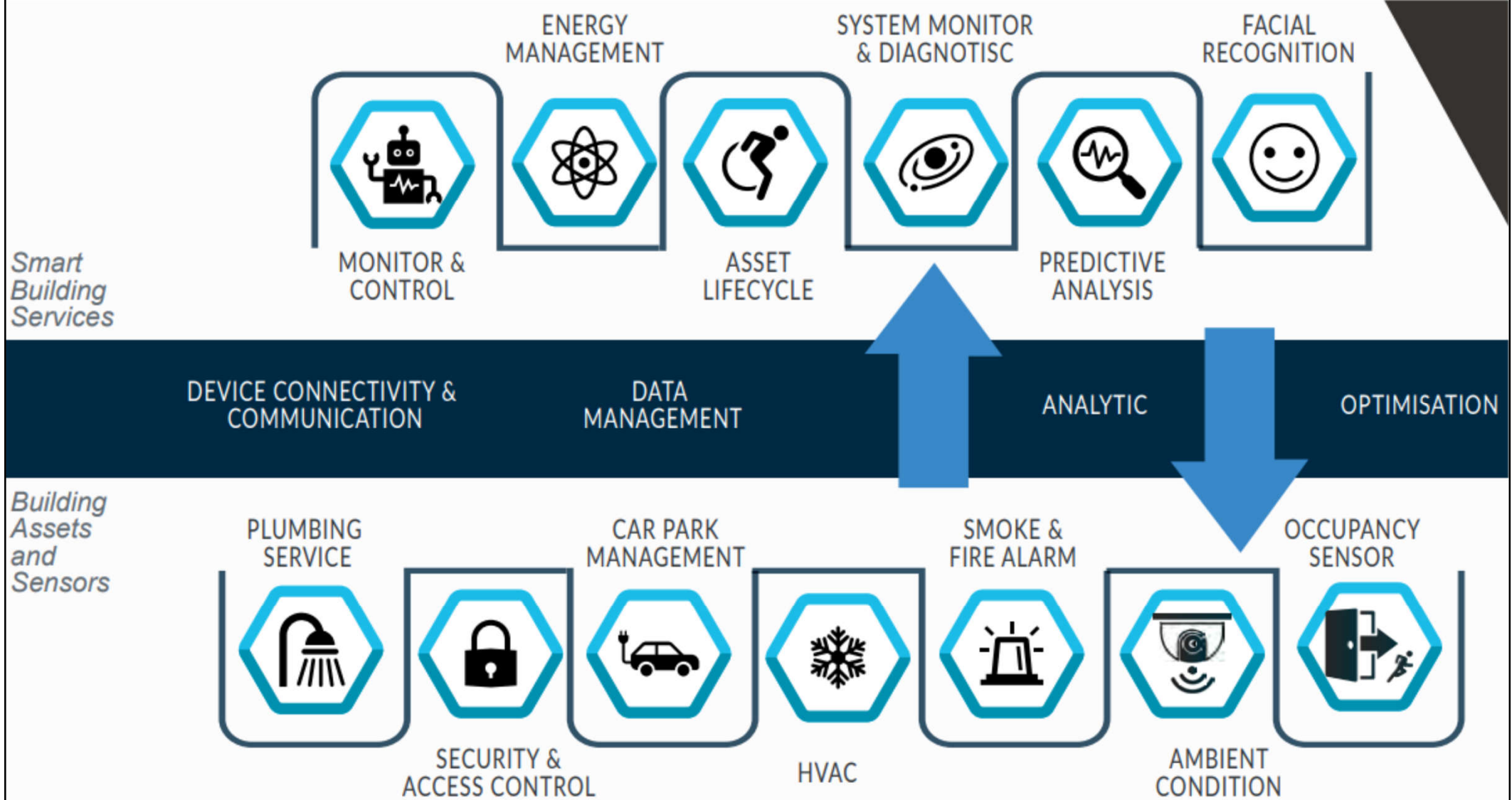


Smart & green building

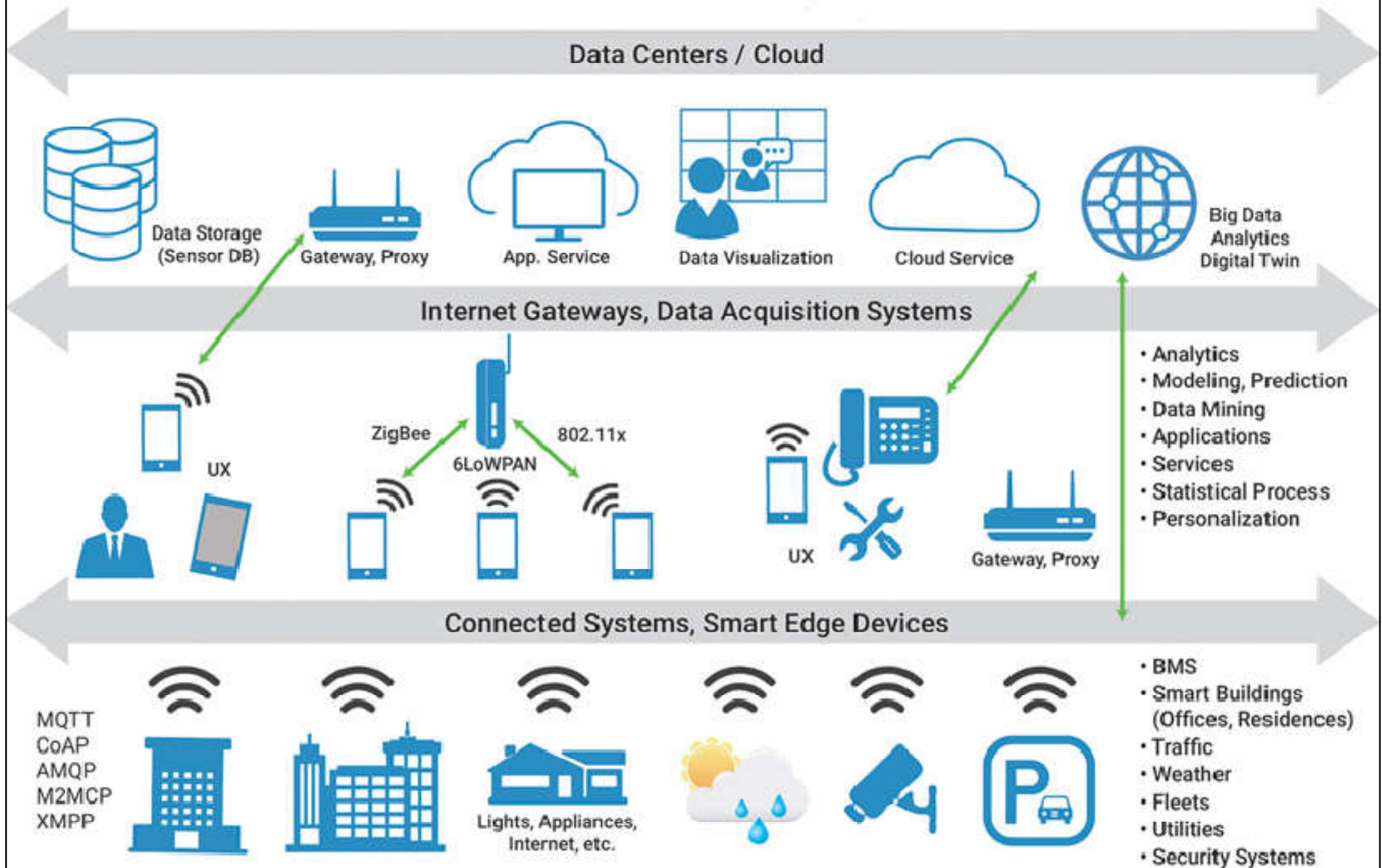


- A smart building uses its intelligence to collect actionable data from user devices, sensors, systems & services on the premises
 - Apply that data using artificial intelligence & machine learning (AI/ML) makes the building both programmable & responsive to the needs of the users & the building manager
 - Use predictive analysis, analytics, big data for optimization of building performance

Examples of smart building services



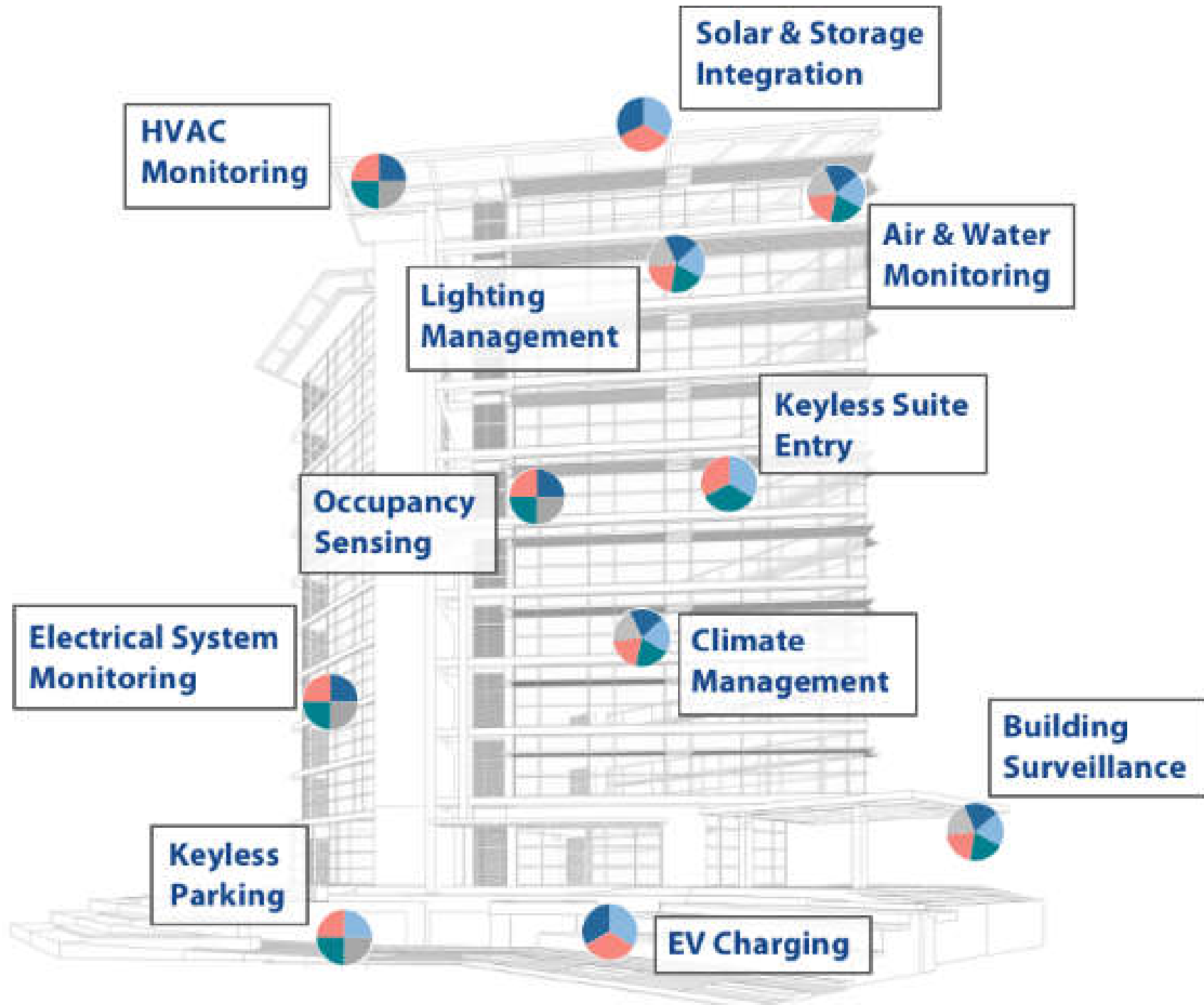
Smart building architecture



Common smart building functions

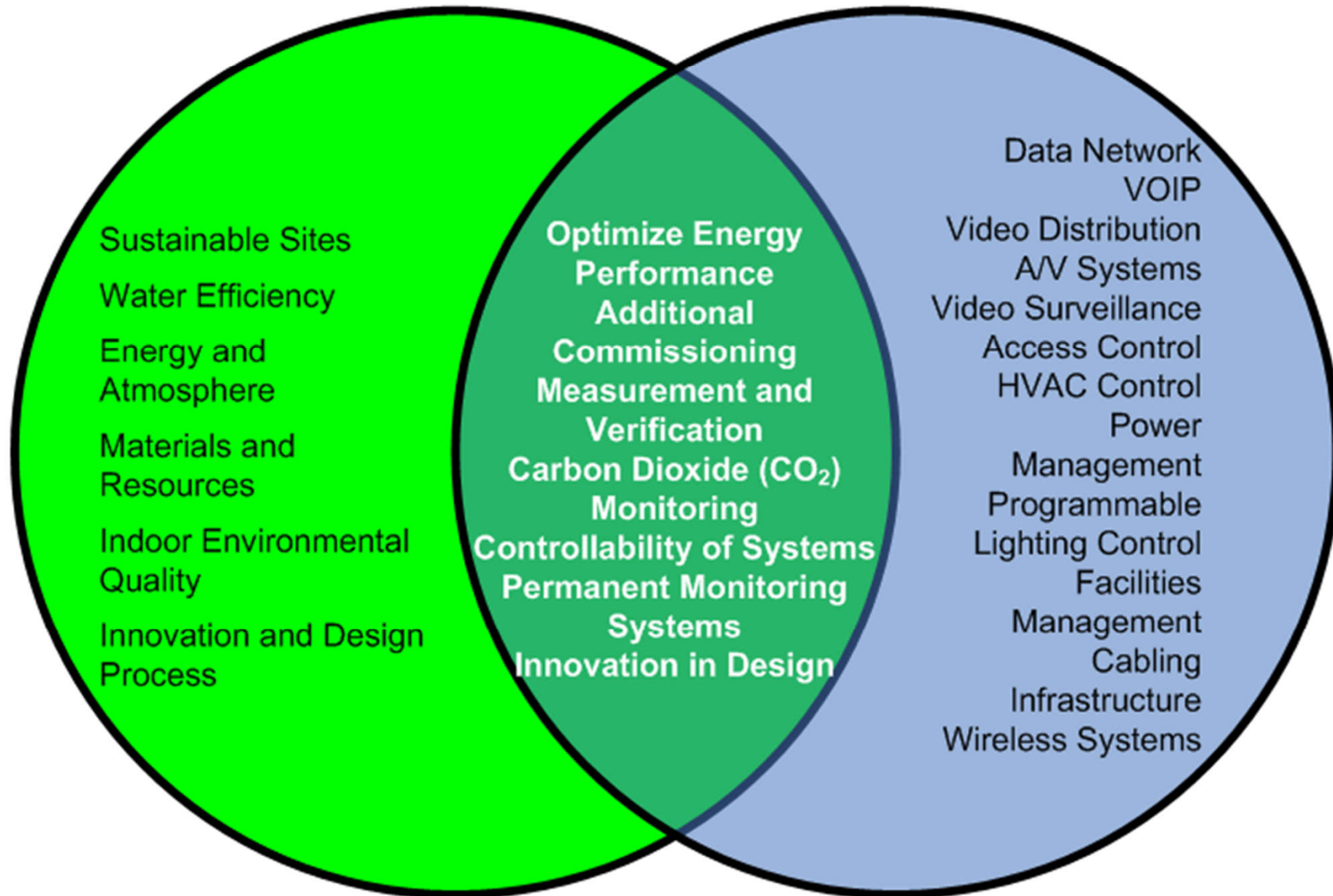


Smart building automation system



THE COMMONALITY OF SMART AND GREEN BUILDINGS

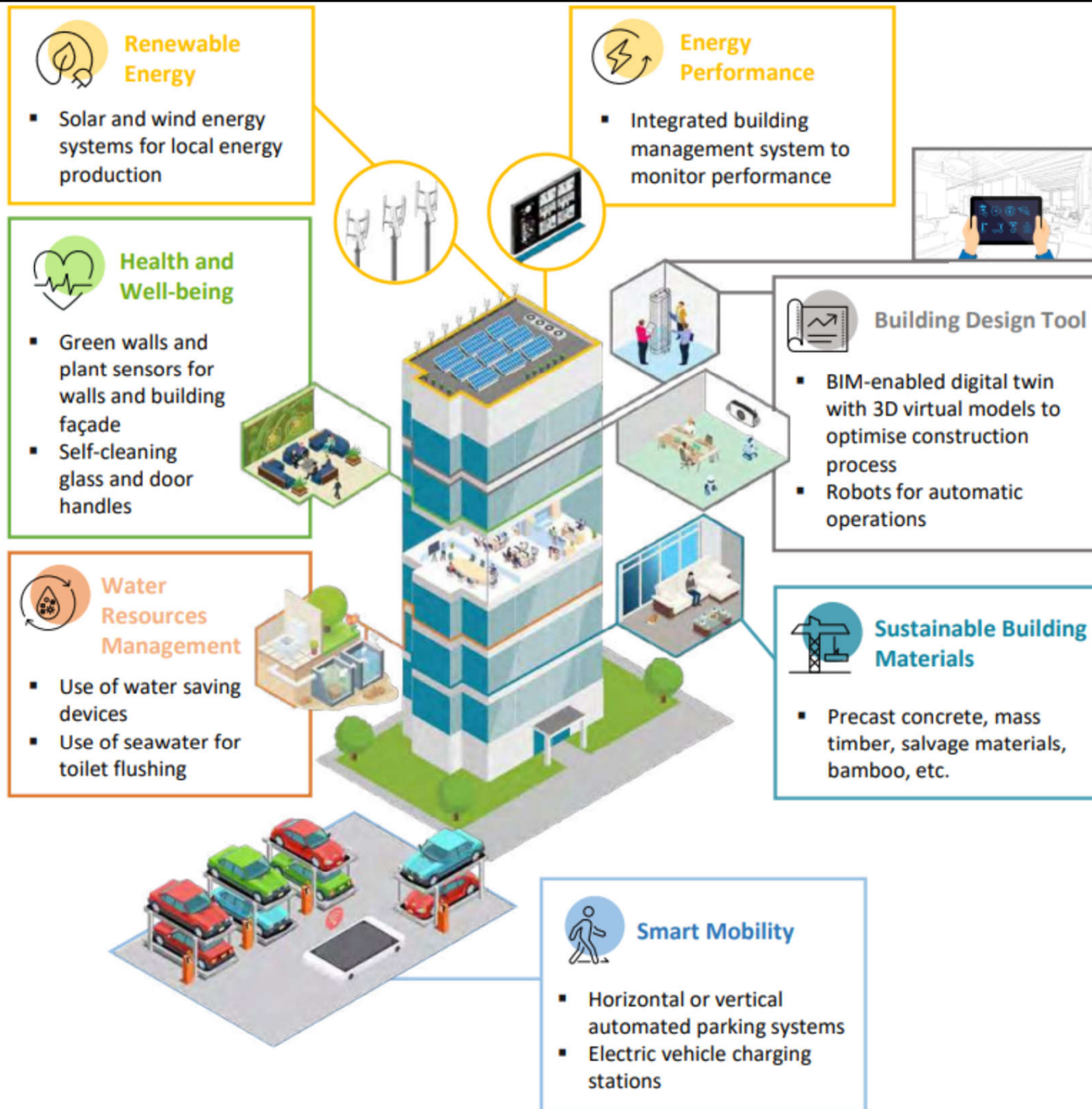
GREEN BUILDINGS



Redefining the interface between smart and green buildings



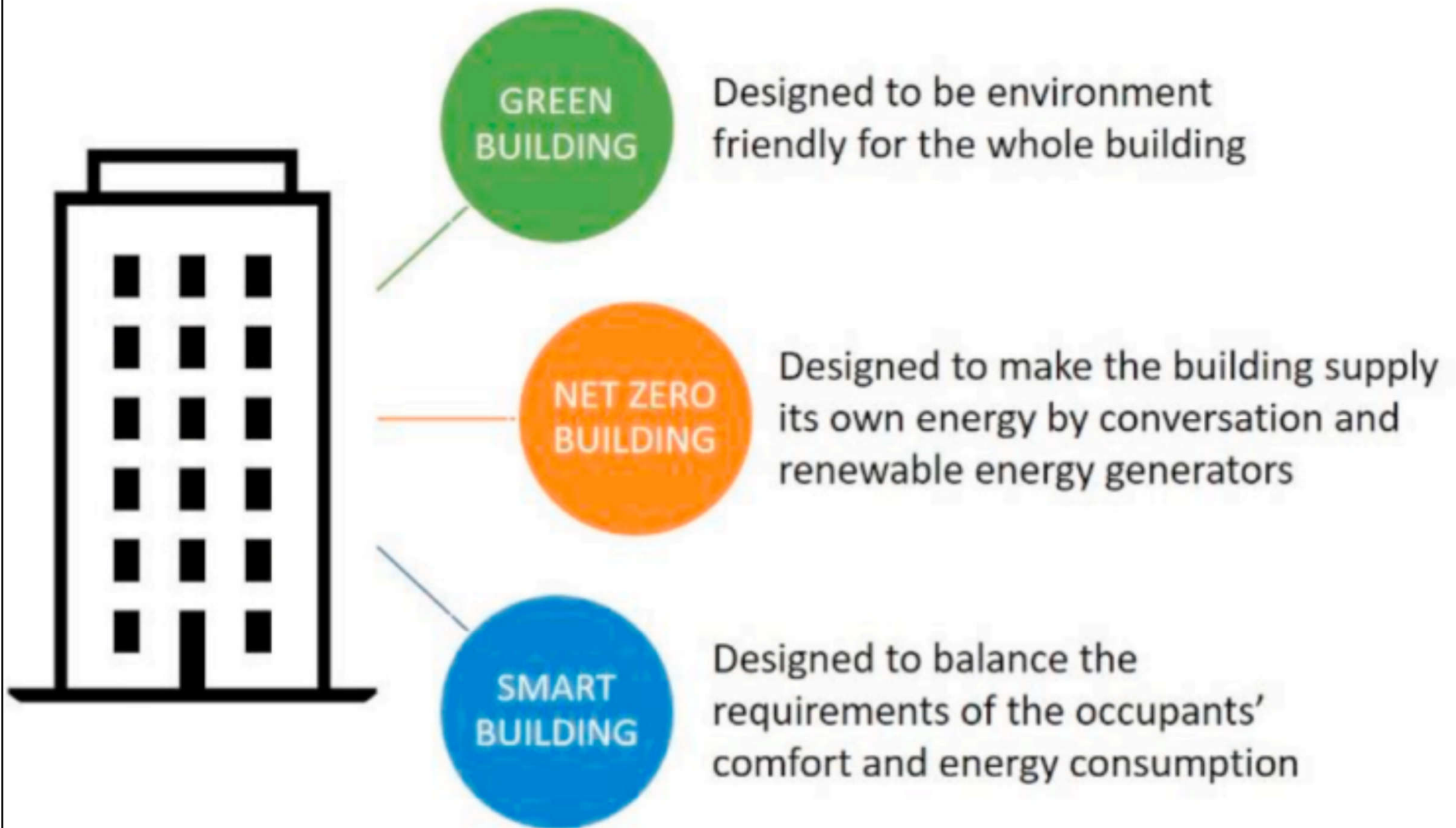
(Source: HKGBC, 2021. *Hong Kong Smart Green Building Design Best Practice Guidebook*, Hong Kong Green Building Council Limited (HKGBC). https://www.hkgbc.org.hk/eng/resources/publications/Files/HKGBC_Smart-Green-Building-Design-Best-Practice-Guidebook.pdf)



Smart green building technologies & features

(Source: Arcadis Hong Kong, 2023. Discover new ideas and business opportunities in Hong Kong - The City of Smart Green Buildings, Invest Hong Kong. <https://innotech.investhk.gov.hk/en/explore-opportunities-hong-kong-s-it-sector/discover-new-ideas-and-business-opportunities-in-hong-kong-the-city-of-smart-green-buildings/>)

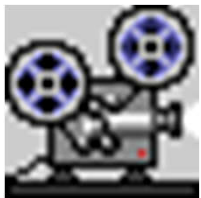
Types of buildings concepts based on design goals



Smart cities

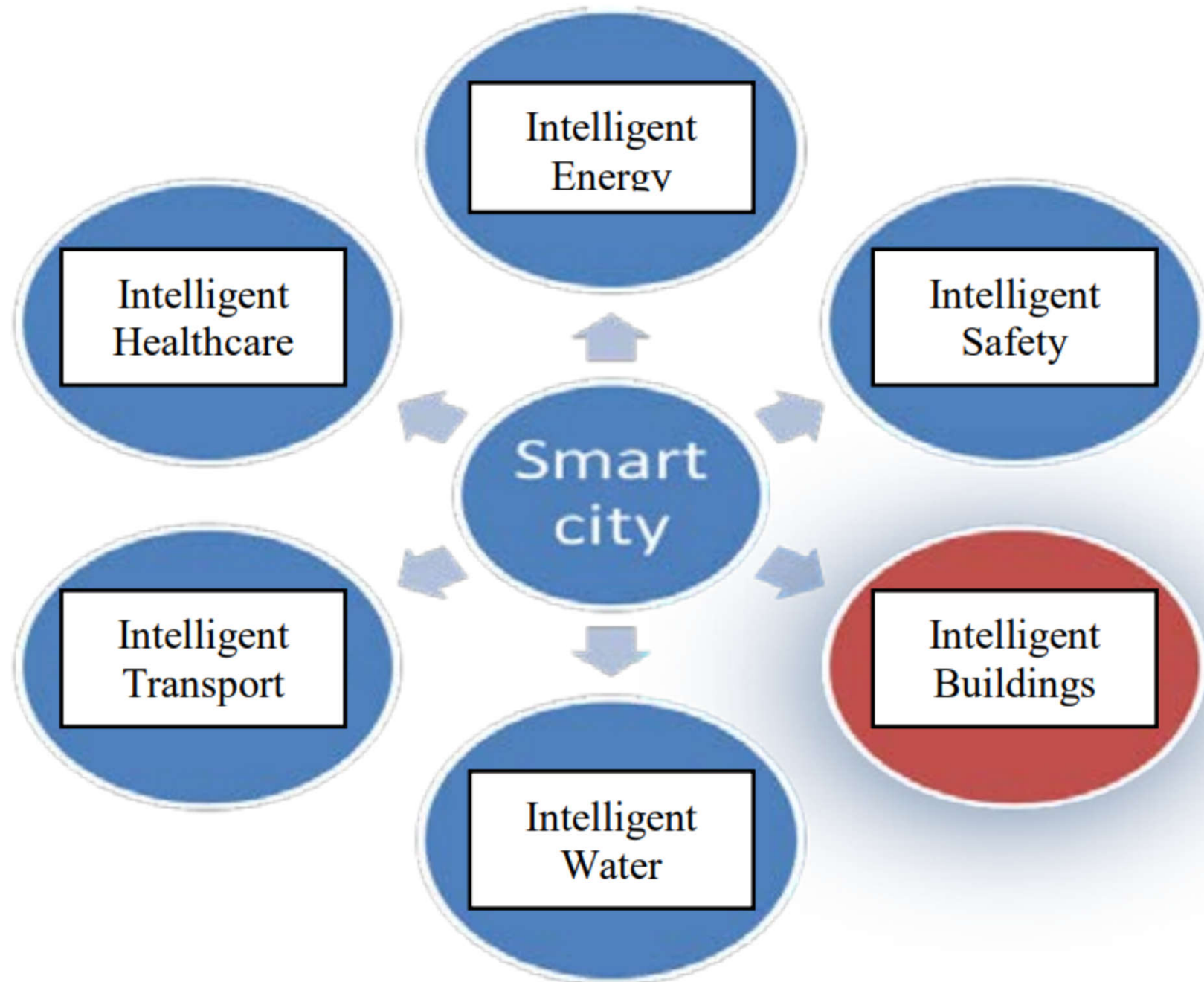


- Intelligent (Smart) buildings are part of an increasingly integrated built environment
 - Smart homes, smart offices, smart cities, smart electricity grid, intelligent transport



Video: What is a smart city? | CNBC Explains (3:30) <https://youtu.be/bANfnYDTzxE>

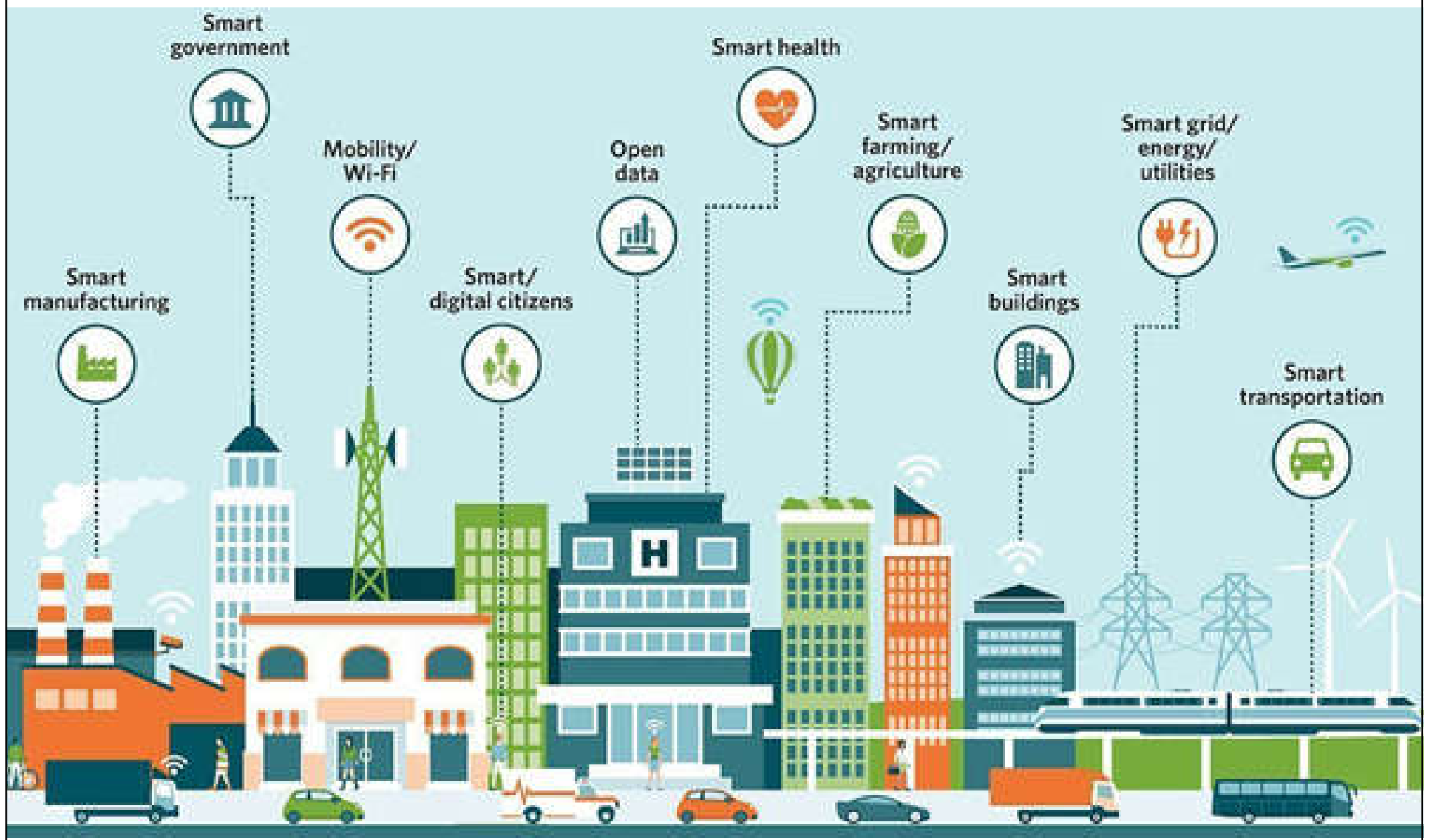
The smart city concept



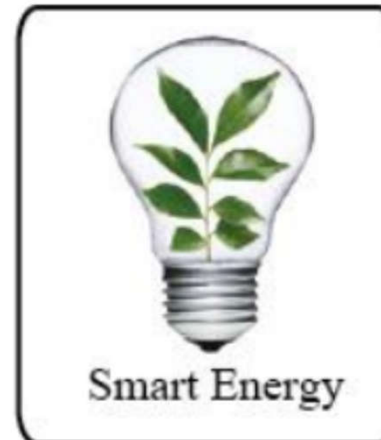
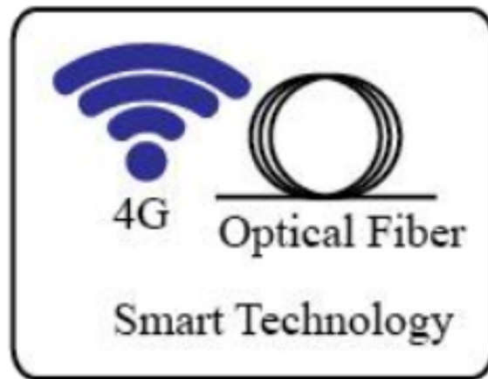
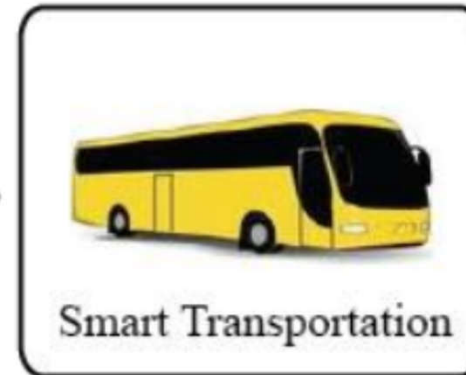
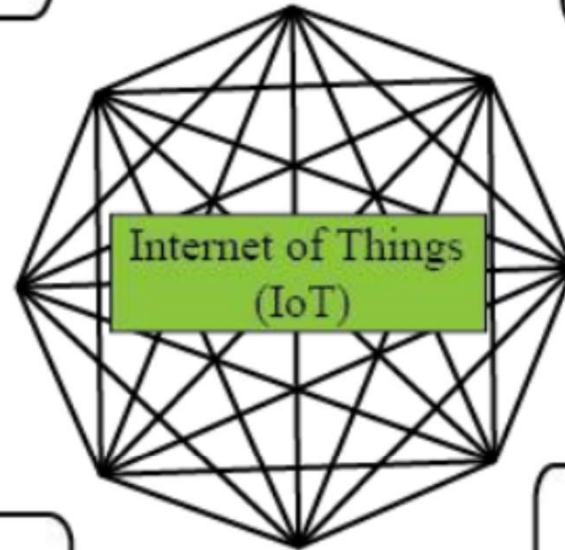
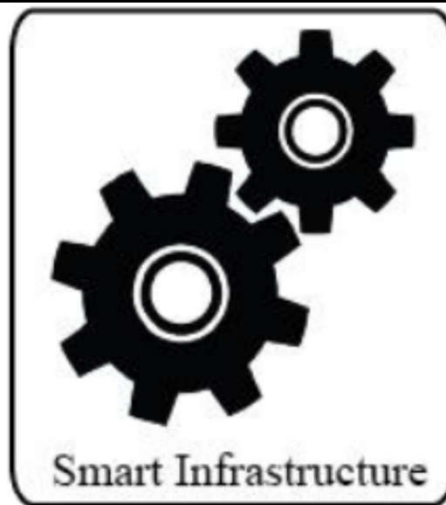
(Source: Popescu D. E. & Prada M., 2013. Some aspects about smart building management systems - solutions for green, secure and smart buildings, Conference: *Recent Advances in Environmental Science*, Lemesos, Cyprus, Volume 7, p. 126-132.

<https://doi.org/10.13140/RG.2.1.3057.8644>)

Smart city – elements, features & technologies

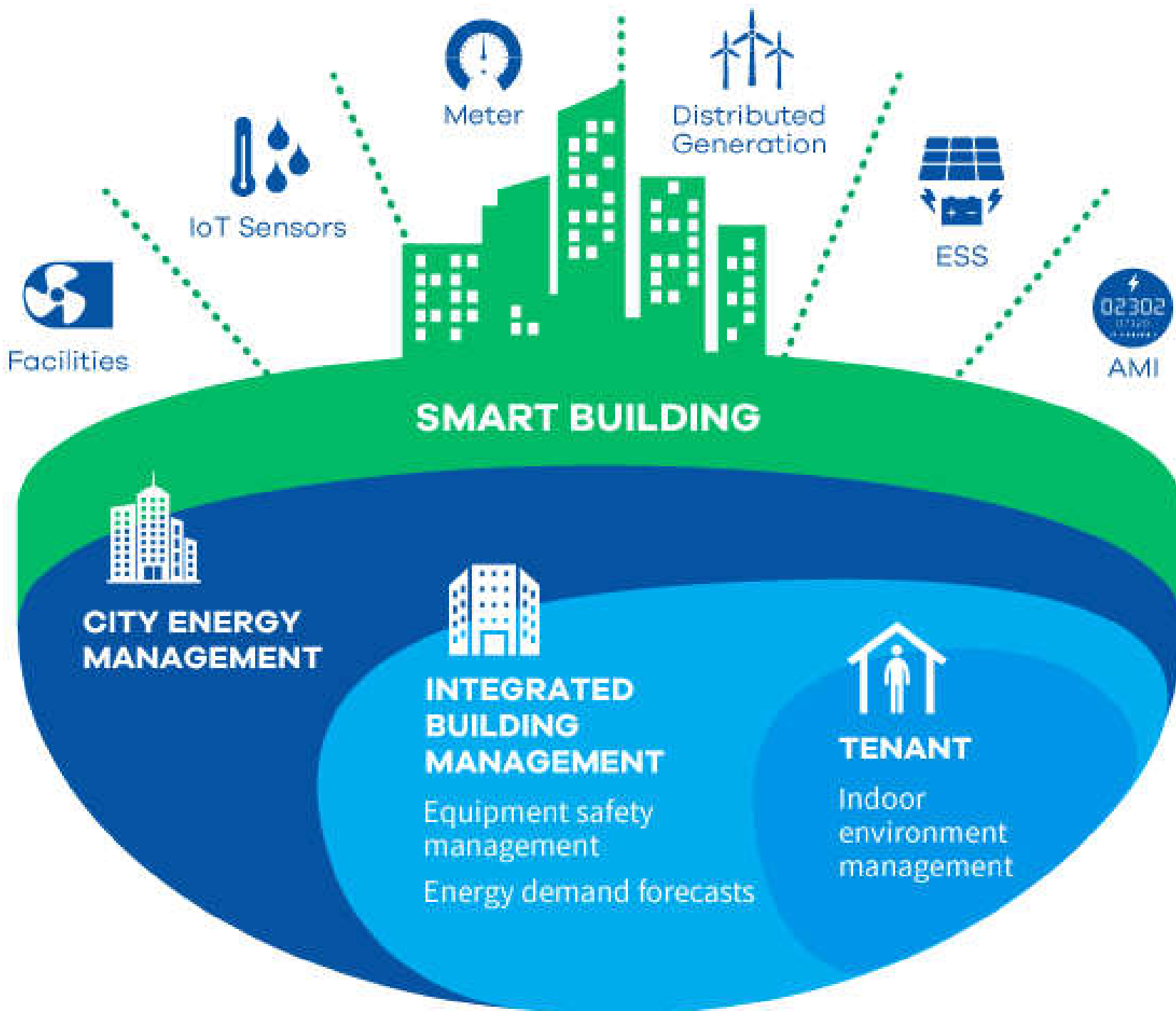


(Source: <https://constrofacilitator.com/smart-city-elements-features-technology-and-govt-approach/>)



A broad
overview of
smart city
components

Smart building for city, building owners & tenants



The most important factors in the formation of smart city infrastructure



(Source: Habibi S., 2020. *Building Automation and Digital Technologies*, Woodhead Publishing, Cambridge, MA & Kidlington, UK.

<https://doi.org/10.1016/C2019-0-03708-9>)

SMART BUILDINGS CONNECTED BY A SMART GRID

Benefits of increased building performance

- cost savings
- comfort optimization
- increased flexibility in energy demand
- CO₂ reduction

Smart Sensors

- humidity
- temperature
- light
- CO₂ level
- occupancy

SMART BUILDING

personal comfort and increased building performance

Room Control

sun blinds
building properties
ventilation

air conditioning
heating
lighting
power consuming devices

combined heat and power system

ev-charging poles

Building Management System

- real time energy prices
- load occupancy forecasts
- weather forecast anticipation
- demand response signals
- insight in energy usage of devices

SMART GRID

bi-directional energy and communication flows

district heating

gas network

water supply

thermal (heat and cold) storage

uninterruptible power supply
meters and sub-meters

electricity storage

electricity grid

solar panels

industrial area

sub station

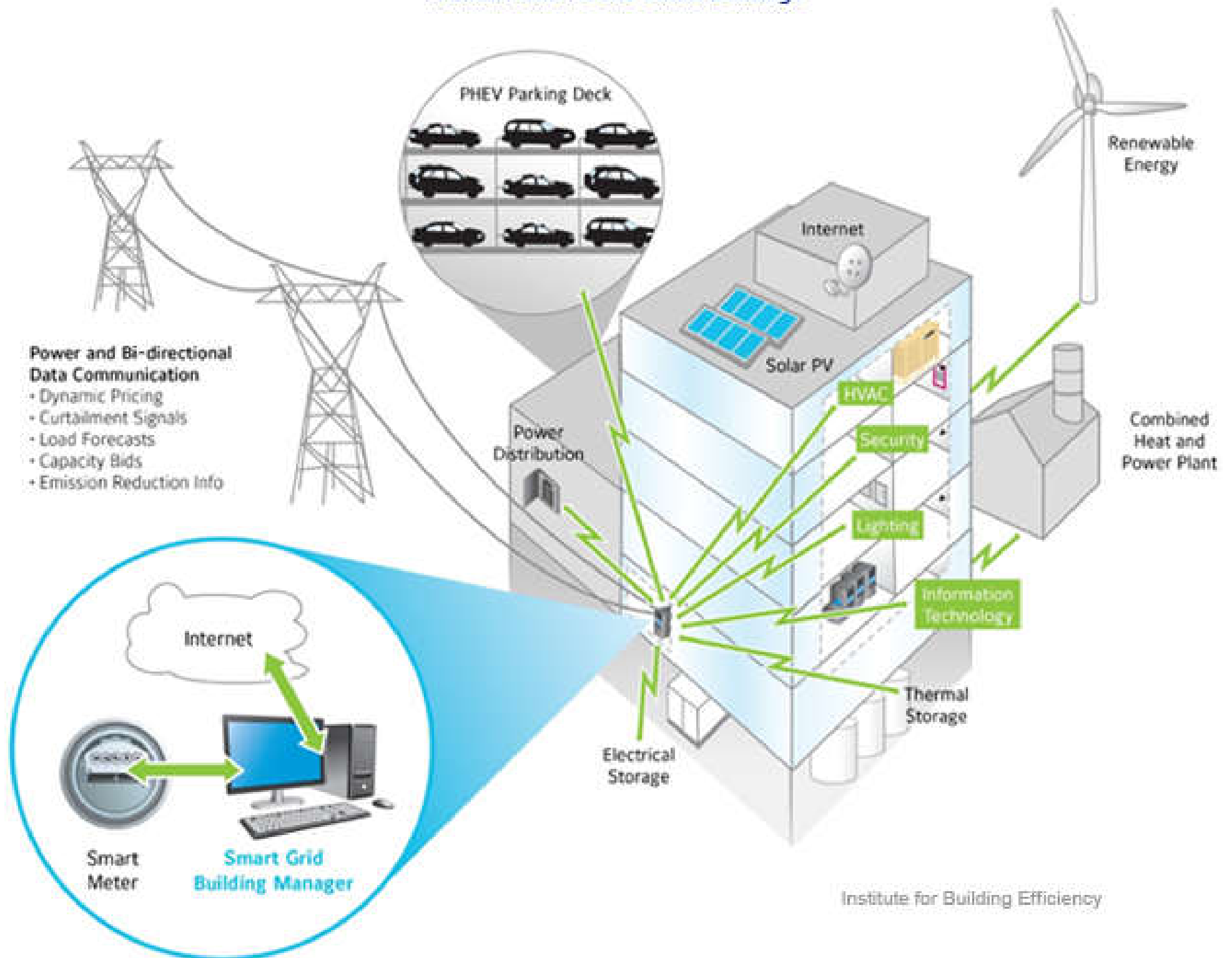
wind turbine

residential area

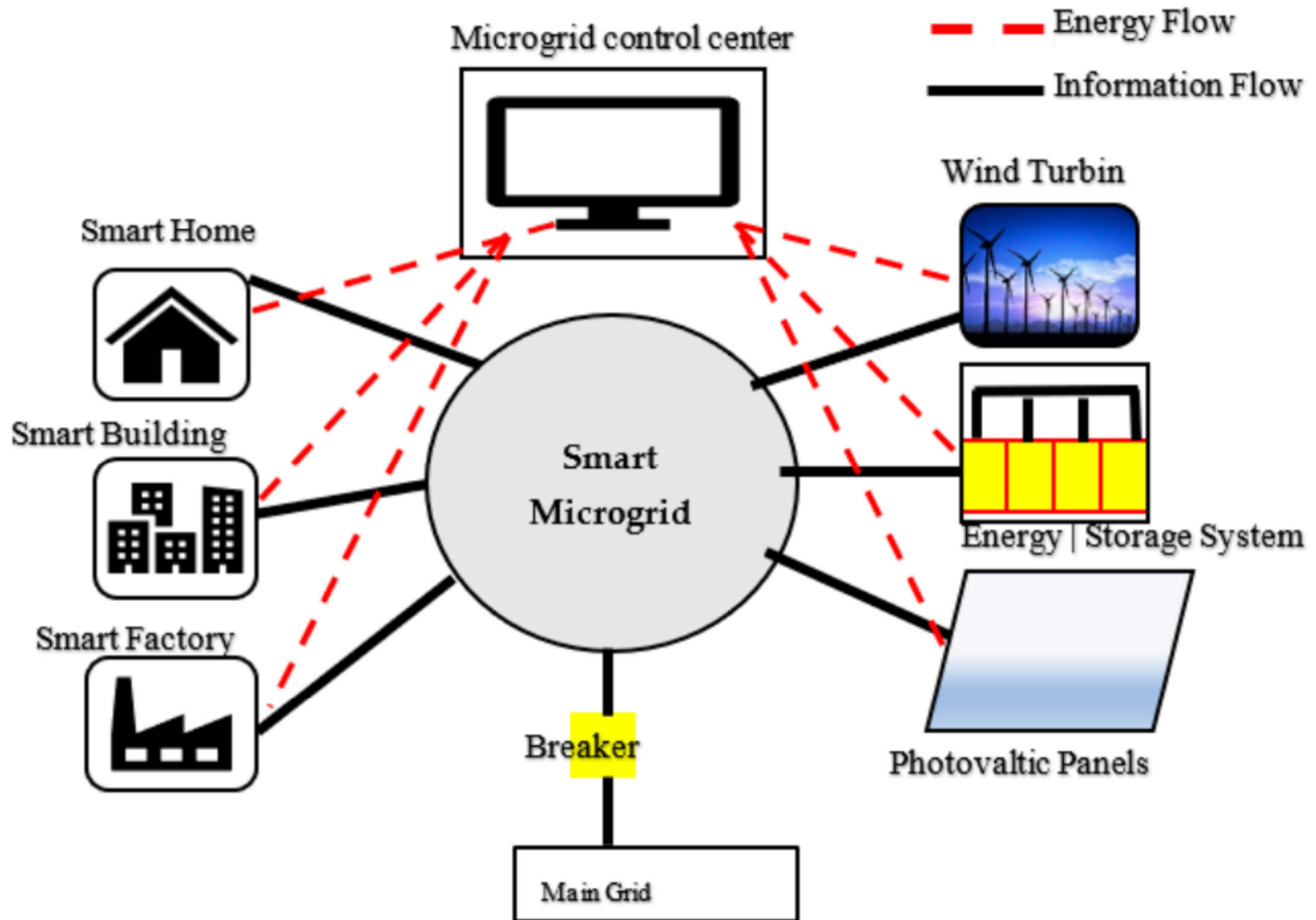
greenhouse



A Smart Grid Needs Smart Buildings



Advanced control of smart microgrid for smart buildings



(Source: Krishnan P., Prabu A. V., Loganathan S., Routray S., Ghosh U. & AL-Numay M., 2023. Analyzing and managing various energy-related environmental factors for providing personalized IoT services for smart buildings in smart environment, *Sustainability*, 15 (8) 6548.

<https://doi.org/10.3390/su15086548>)

Smart office & home

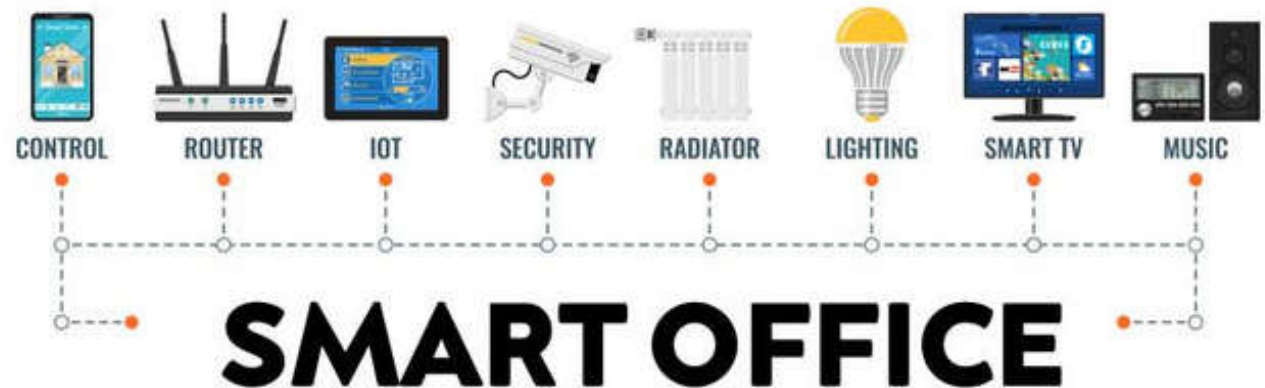


- Office space & commercial buildings
 - Such as speculative high-tech offices
 - Organizational/functional requirements
 - Impact of IT & business strategy
- Objectives
 - Responsive (to user needs / to climate)
 - Efficient (building design & systems)
 - Effective (operation & management)
 - Better integration (with IT & within systems)

Smart office & home



- Major systems for smart offices
 - Building automation system (BAS)
 - Office automation system (OAS)
 - Communication automation system (CAS)
- Criteria
 - Business value/benefits
 - Efficiency
 - Effectiveness



The Building Information Network



Tenant Services

- High Speed Internet
- Wireless
- Unified Communications
- Interactive Media
- Digital Signage
- IP Telephony

Dashboards



Building Services

- Lighting
- Elevators
- 24/7 Monitoring
- HVAC Sensors
- Fire Control
- Video Security
- Energy Management
- Maintenance Management



Smart office & home

- IB + IoT (Internet of Things)
 - Video: Smart Buildings with Internet of Things Technologies (2:58) <http://www-ssl.intel.com/content/www/us/en/smart-buildings/overview.html>
 - The Internet of Things for Smart Buildings (5:07) <https://youtu.be/N-I0vr-bEuE>
- Major impact of building intelligence
 - Modern & flexible space design, improved comfort, productivity & pervasive connectivity



Smart office & home



- Current & future development of smart offices
 - New ways of working
 - More interaction
 - More collaboration (physically or electronically)
 - More individual autonomy
 - New patterns of space use
 - More group spaces
 - More shared spaces
 - More space for concentration
 - More intermittent space use



Workflow in a smart office

A day in a smart office.
When the office space works for you.

SIEMENS
Ingenuity for life



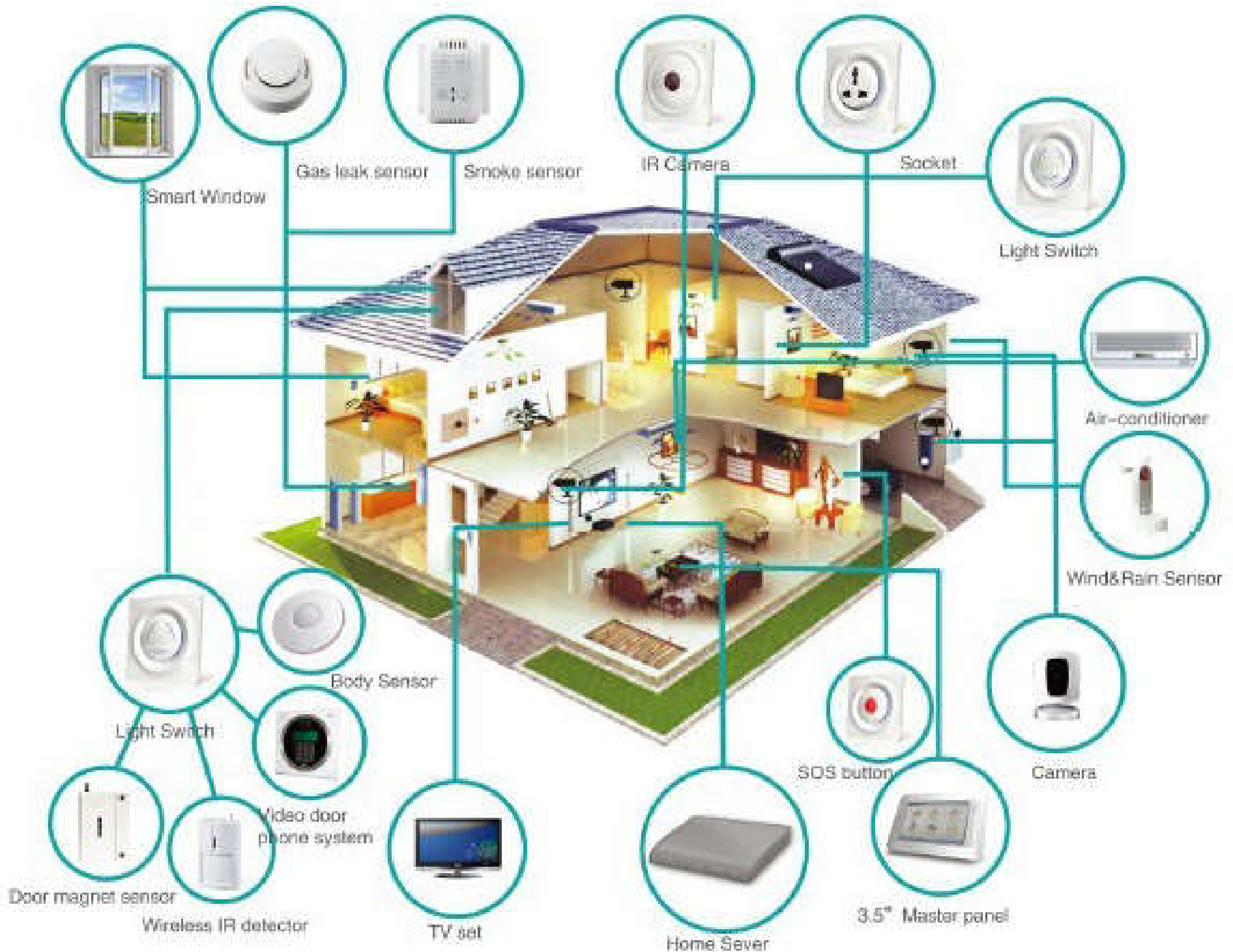
[siemens.com/smart-office](https://www.siemens.com/smart-office)

Smart office & home

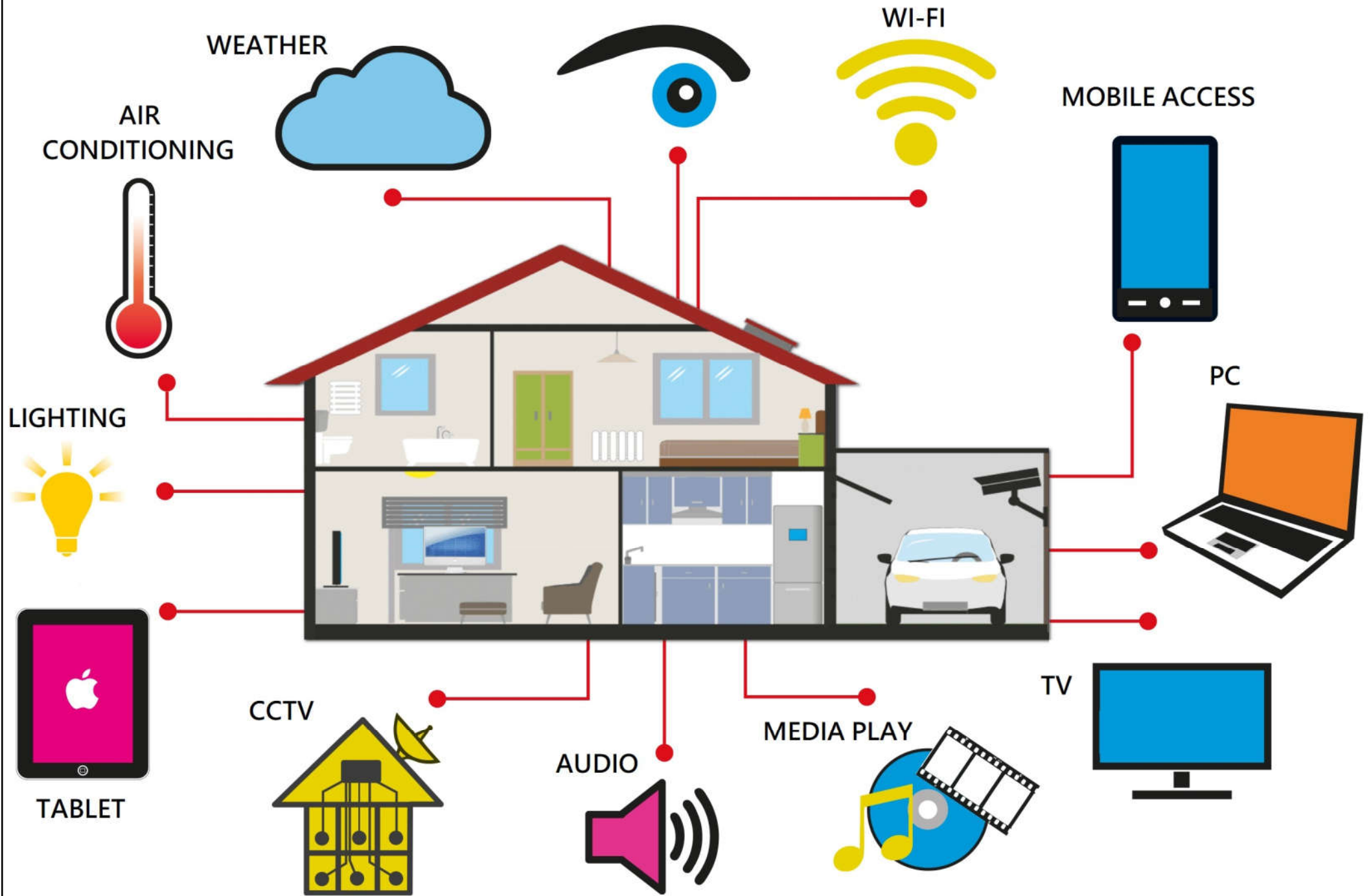


- Basic concepts of smart home:
 - 1. Automation: capable of using automatic devices or carrying out automatic functions
 - 2. Multi-functionality: capable of conducting different tasks or creating various outcomes
 - 3. Adaptability: capable of learning, predicting & meeting the wants of users
 - 4. Interactivity: capacity to provide & allow communications among users
 - 5. Efficiency: conveniently and save time & costs

Intelligent home/house



Smart home systems



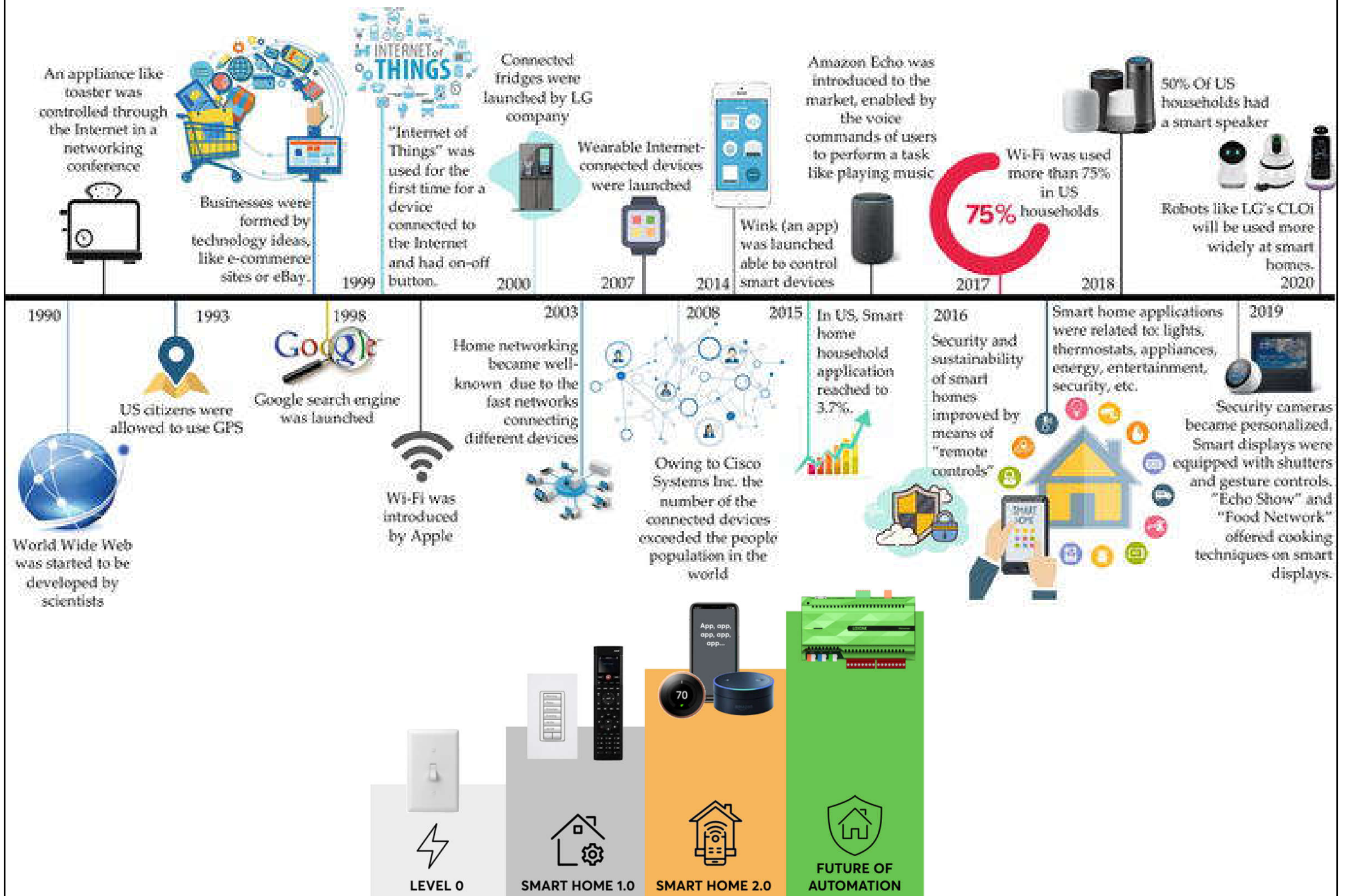
Smart office & home



- Home automation
 - Climate control & energy management
 - Home networking
 - Home theatre
 - Integrated lighting control
 - Multi-room A/V systems
 - Residential gateways
 - Safety & security
 - Structured wiring
 - Whole house automation



Smart home evolution timeline



(Source: <https://www.intechopen.com/chapters/74934>, <https://www.loxone.com/int/blog/home-automation-evolution/>)

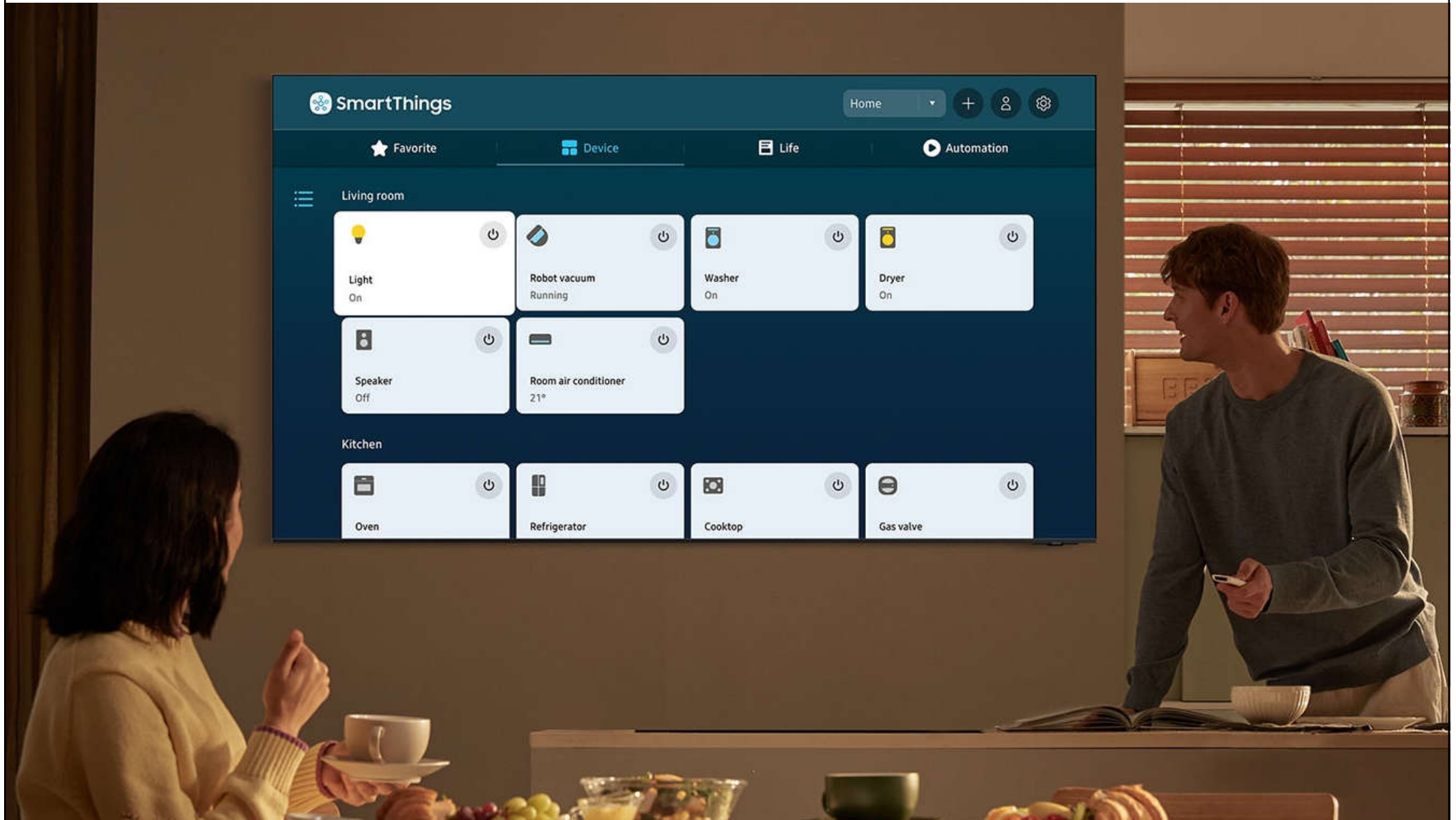
Smart office & home



- Examples of smart home technologies:
 - Smart TVs (e.g. on-demand video/music, voice or gesture recognition)
 - Smart lighting systems (with sensors & automation)
 - Smart thermostats (users schedule, monitor and remote control)
 - Smart door locks & openers
 - Smart security cameras & systems
 - Smart kitchen appliances & monitors



Smart home devices connected to a Smart TV



Smart office & home



- Future smart home features:
 - Smart HVAC – automatically adjust temperature based on personal biometrics
 - Safety sensor – alert when a hazard is detected
 - Smart cooking – track cooking time & temperature to avoid overcooking & power off automatically
 - Smart refrigerator – track & order refills for low stock items & monitor use by date
 - Health & biometric monitor – monitor vitals & alerts medical authorities if needed



Further Reading

- Defining Today's Intelligent Building
<http://www.commscope.com/Blog/Defining-Todays-Intelligent-Building/>
- Smart Buildings vs. Intelligent Buildings: Why Intelligent Buildings Are the Better Choice
<https://www.analog.com/en/thought-leadership/smart-buildings-vs-intelligent-buildings.html>
- Smart Buildings: A Comprehensive Guide
<https://www.zenatix.com/smart-buildings-a-comprehensive-guide/>