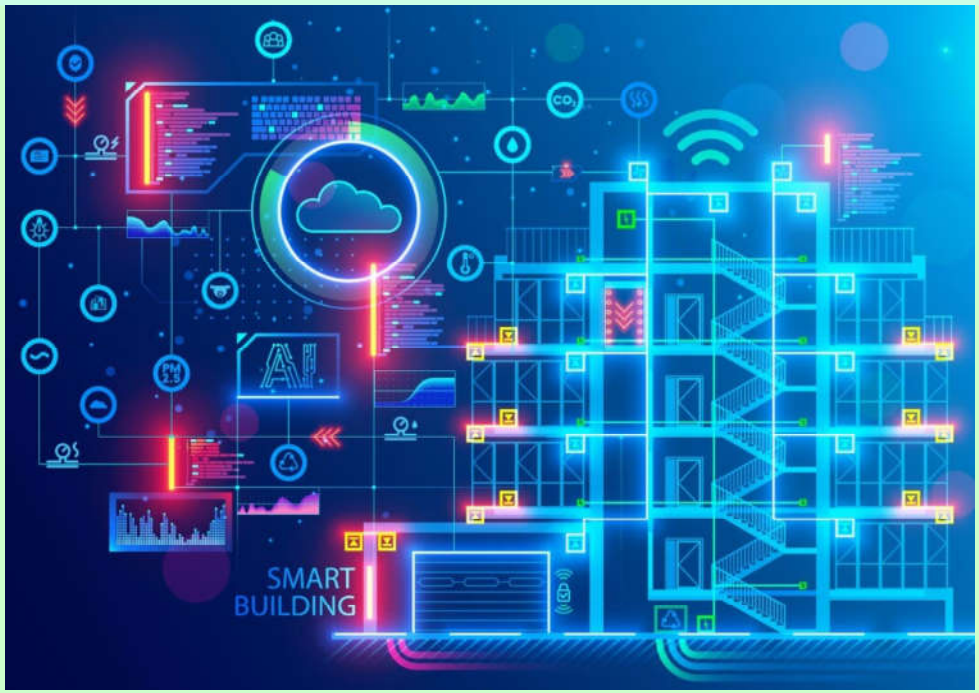
IDAT7219 Smart Building Technology

http://ibse.hk/IDAT7219/



Basic Concepts

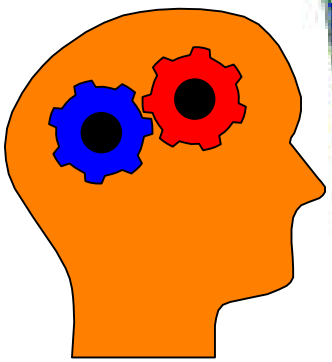
智能大廈科技

Ir Dr. Sam C. M. Hui
Department of Mechanical Engineering
The University of Hong Kong
E-mail: cmhui@hku.hk

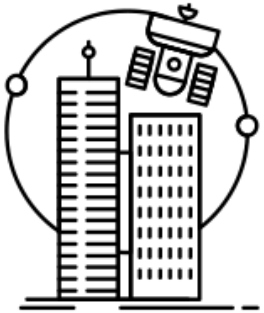
Aug 2025

Contents

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



Intelligent building (IB)

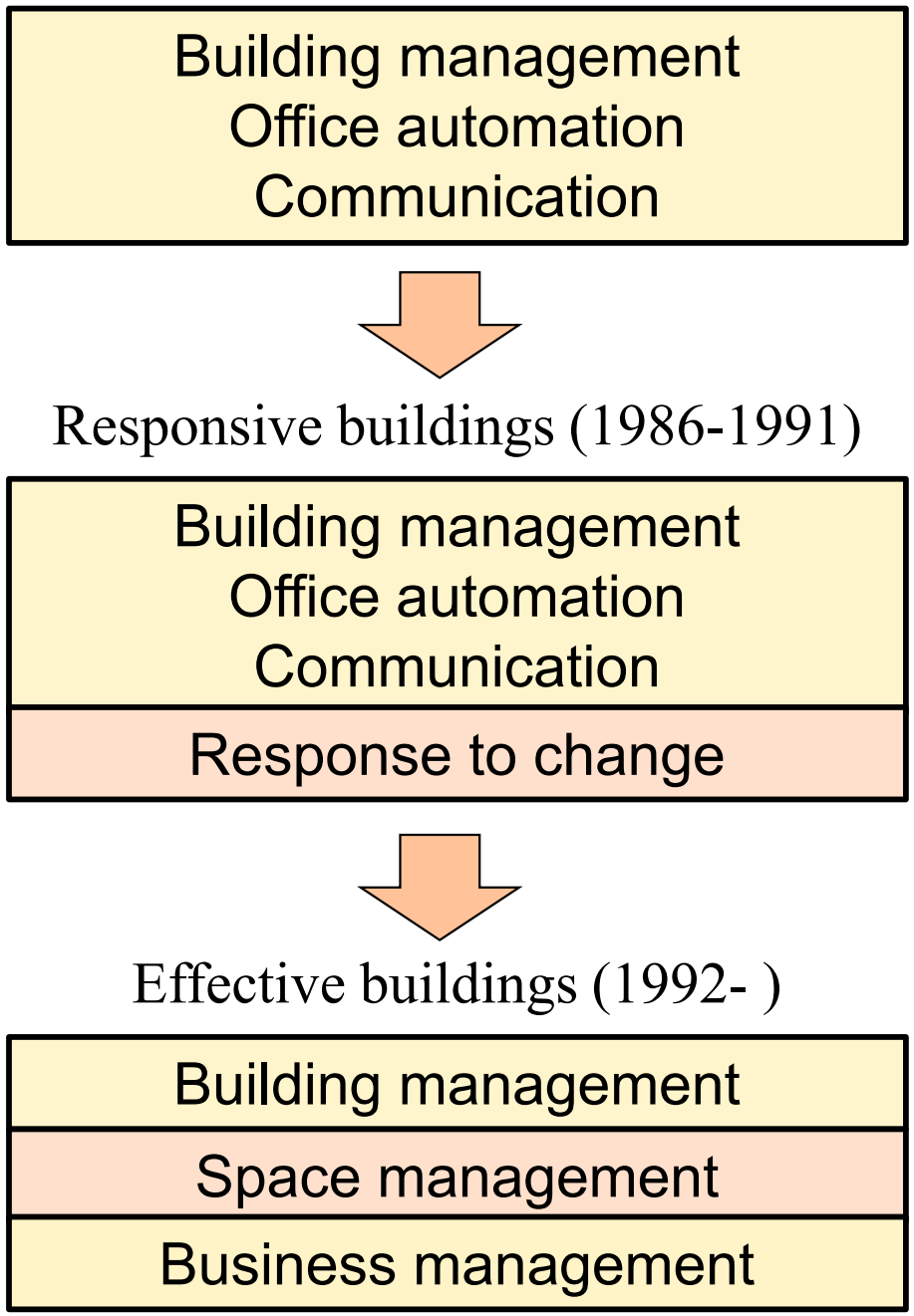


- Intelligent building (IB)
  - First coined in USA in early 1980s; its definition/model is changing/evolving
    - Automated buildings (1981-85)
    - Responsive buildings (1986-91)
    - Effective buildings (1992-)
    - Intelligent/Smart buildings (2000-)
  - Development of IB
    - Closely linked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

智能建築

智慧型大廈

Automated buildings (1981-1985)



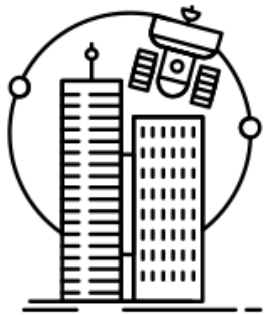
An intelligent building is a collection of innovative technologies

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

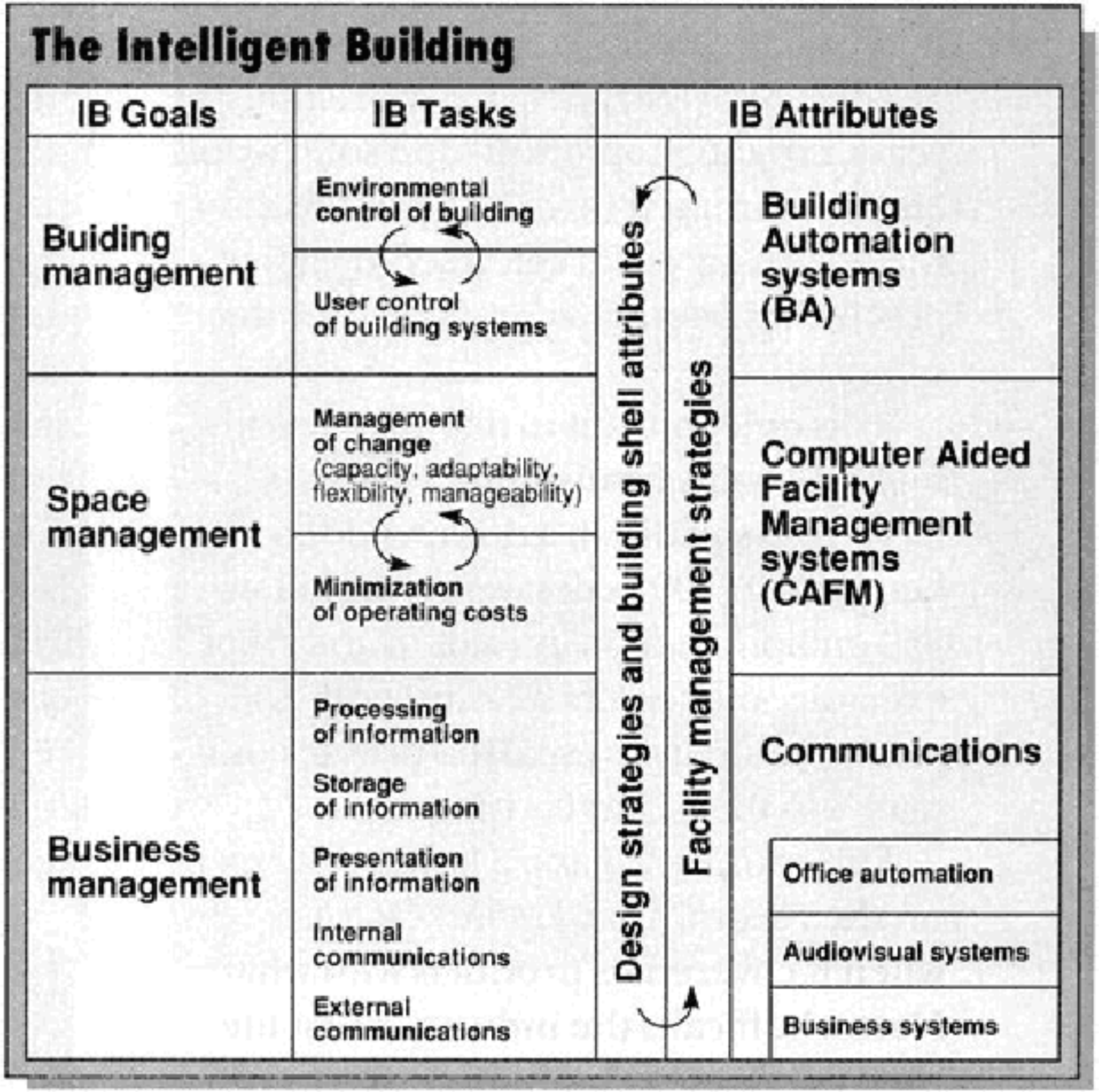
An intelligent building provides a responsive, effective & supportive environment within which the organization can achieve its business objectives. The intelligent building technologies are tool that help this to happen.

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

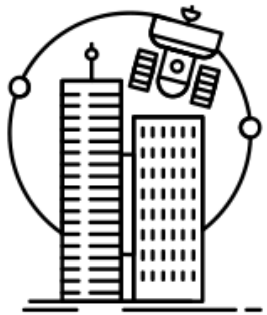
Intelligent building (IB)



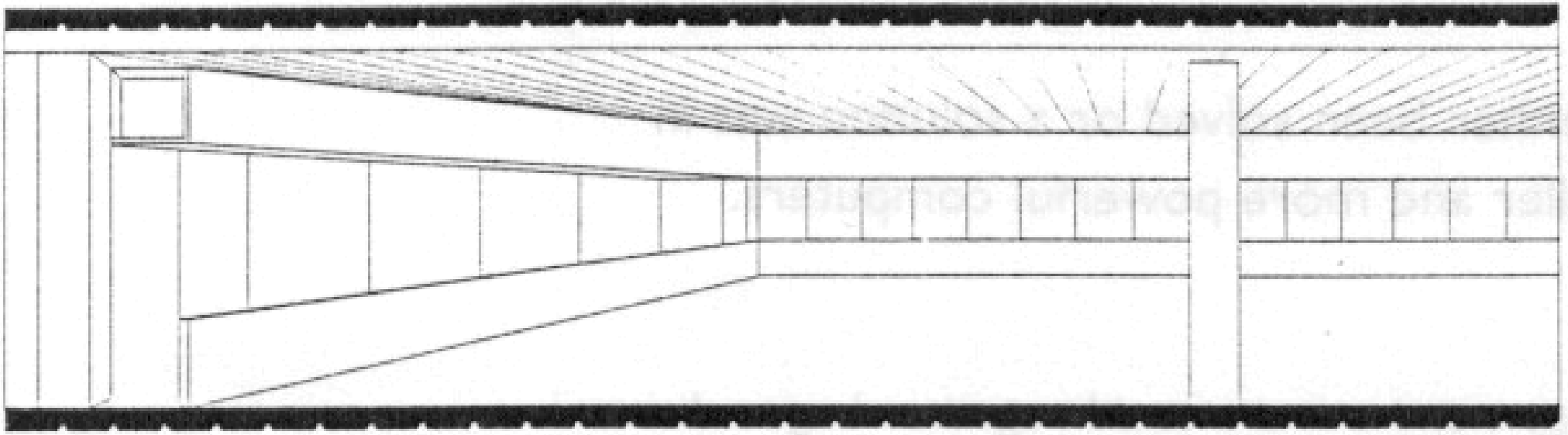
- Building management:
  - Building automation & the physical environment
- Space management:
  - Building's internal space & operating costs
  - Capabilities & flexibility of the building to accommodate changes, personal moves & connectivity
- Business management
  - Management of the organization's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


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

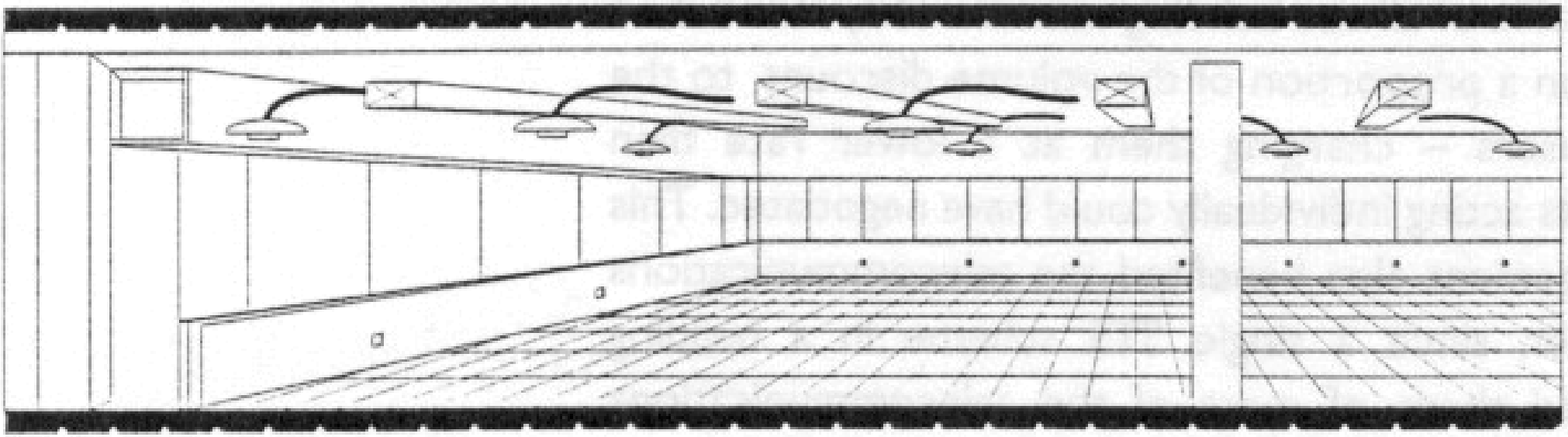
Intelligent building (IB)



- 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)

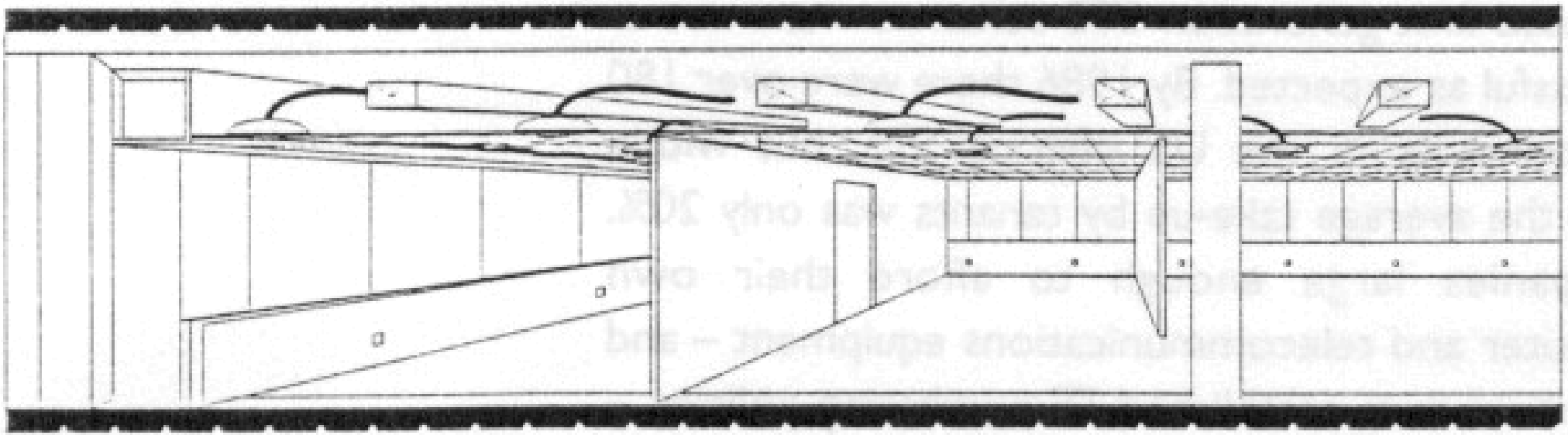


Building shell: 50-75 years (structure cladding)

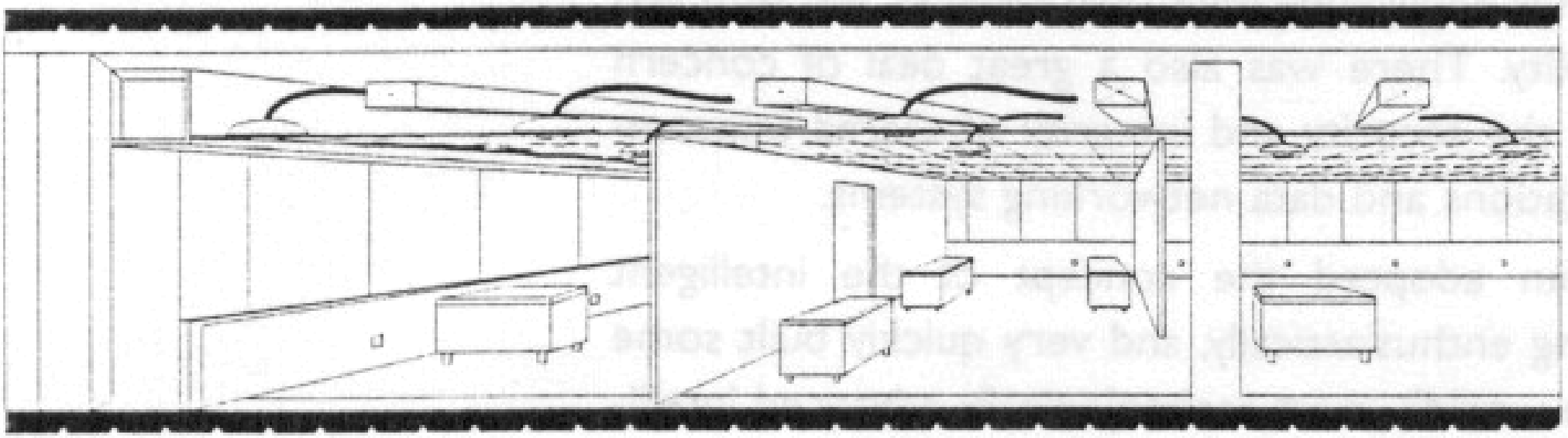


Building services: 15 years (HVAC, light, power)

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



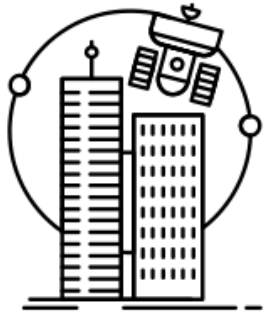
Fitting-out elements (scenery): 5 years (fixed interior elements, ceiling, partitions, finishes, IT equipment)



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

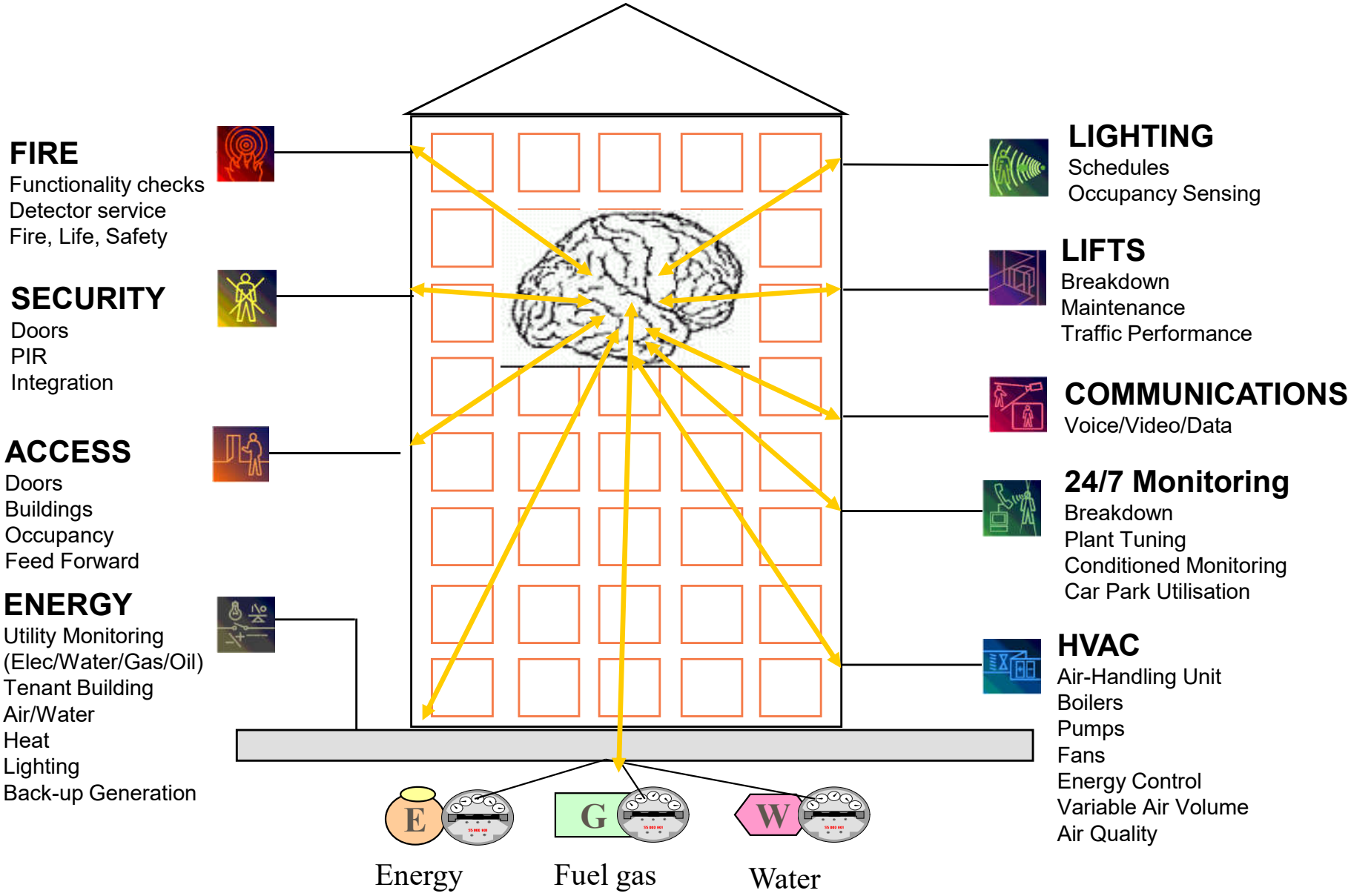
[Source: Harrison A., Loe E. & Read J., 1998. *Intelligent Buildings in South East Asia*]

Intelligent building (IB)



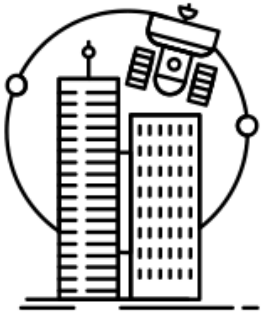
- Definitions of Intelligent Building (IB)
  - By Continental Automated Buildings Association (CABA)
    - IB uses both technology & process to create a facility that is safer & more productive for its occupants & more operationally efficient for its owners
  - By European Intelligent Building Group (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



(Source: Continental Automated Buildings Association (CABA) www.caba.org)

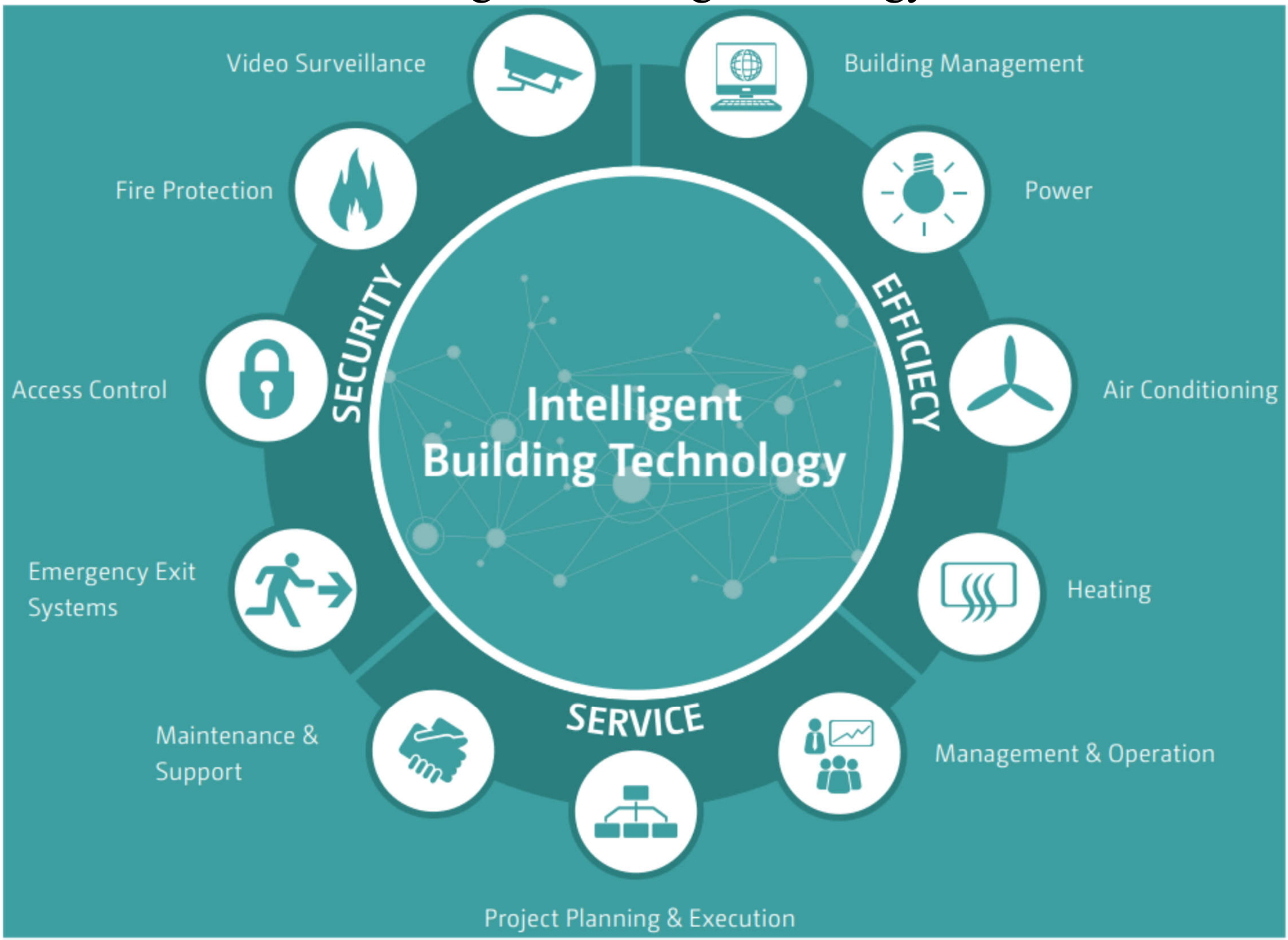
Intelligent building (IB)



- 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-term building values (productivity, market value, energy conservation, environmental friendliness & high working efficiency)

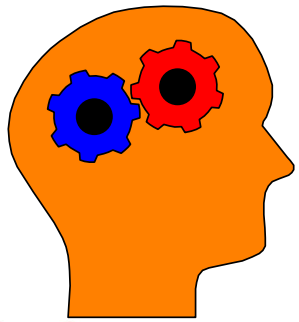
[Source: Asian Institute of Intelligent Buildings (AIIB) https://www.aiib.net/]

Intelligent building technology

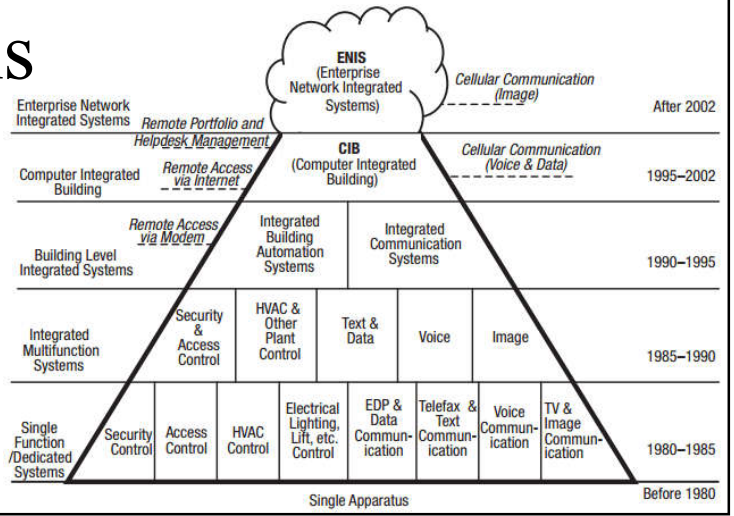


(Source: https://www.microsens.com/fileadmin/files/Brochures/MICROSENS_BuildingAutomationOfTheFuture_EN_web.pdf)

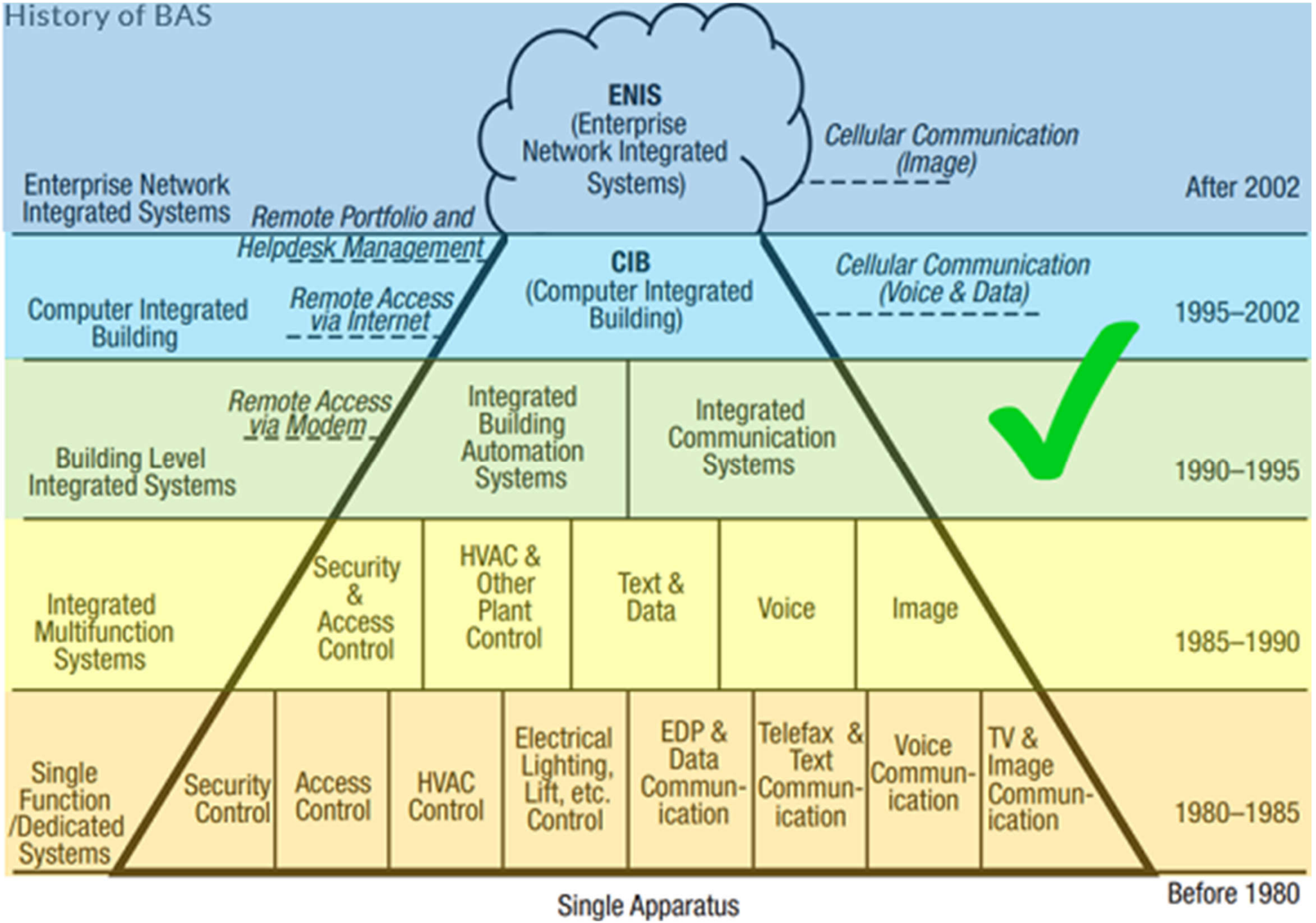
Basic principles



- 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

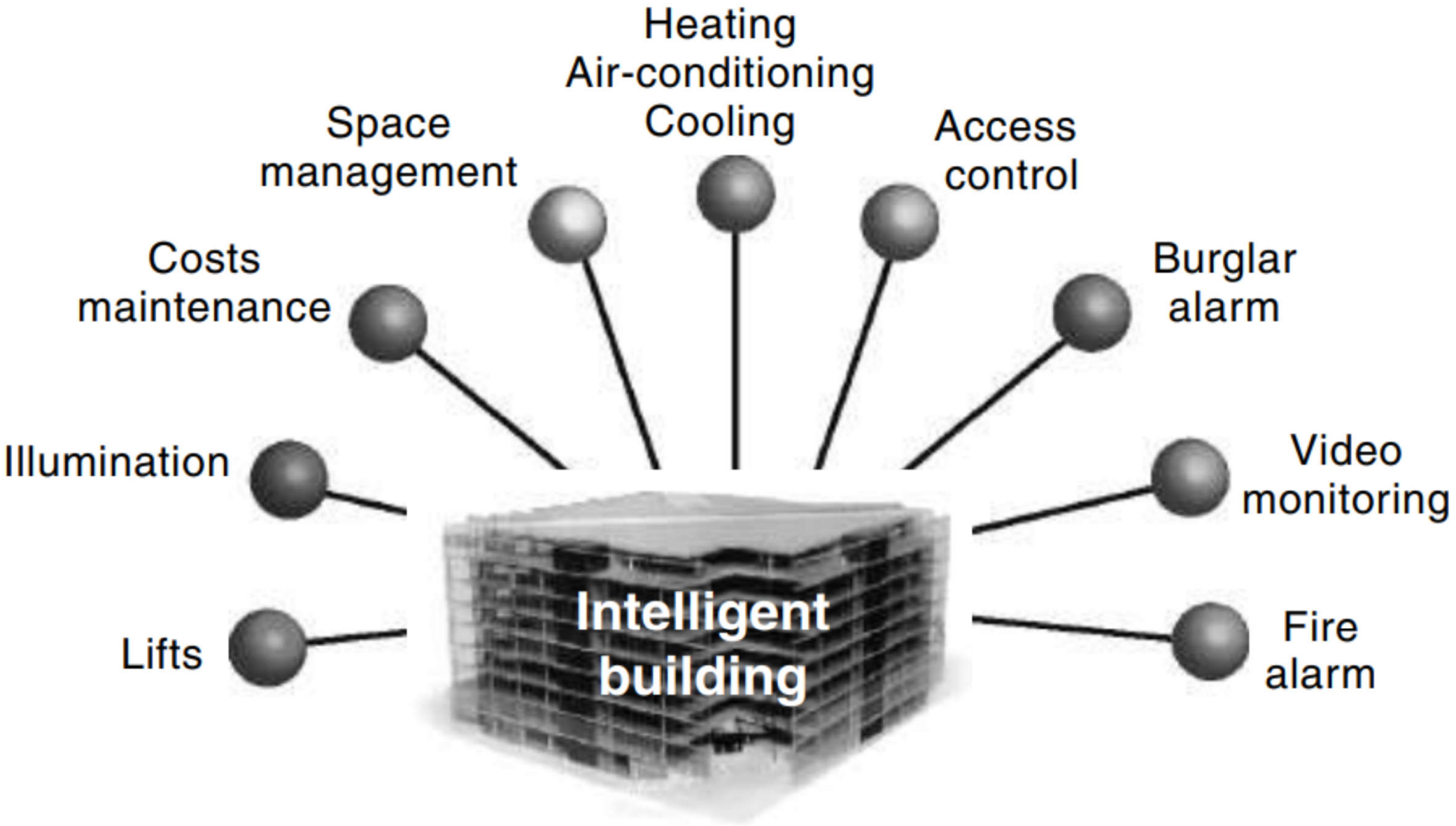


Intelligent building pyramid



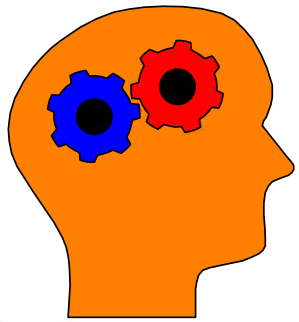
(Source: Wang S., 2010. *Intelligent Buildings and Building Automation*, Spon Press, London & New York.)

System integration of intelligent building



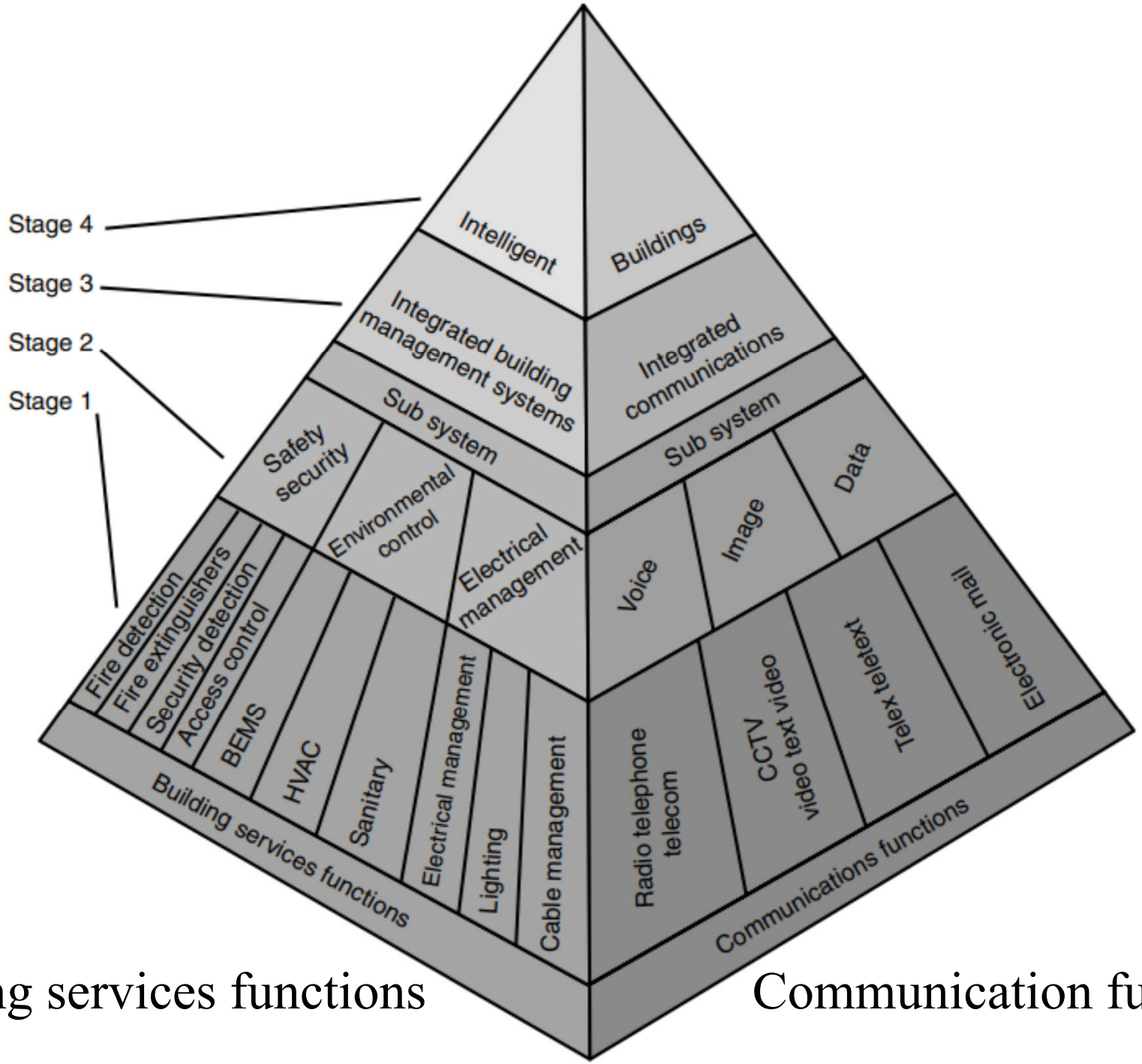
(Source: Clements-Croome D. (ed.), 2004. *Intelligent Buildings: Design, Management and Operation*, Thomas Telford Publishing, London.)

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

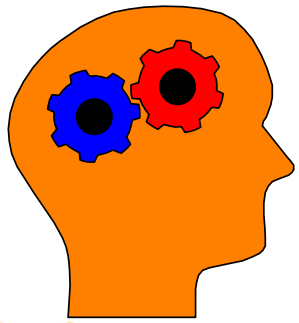


Building services functions

Communication functions

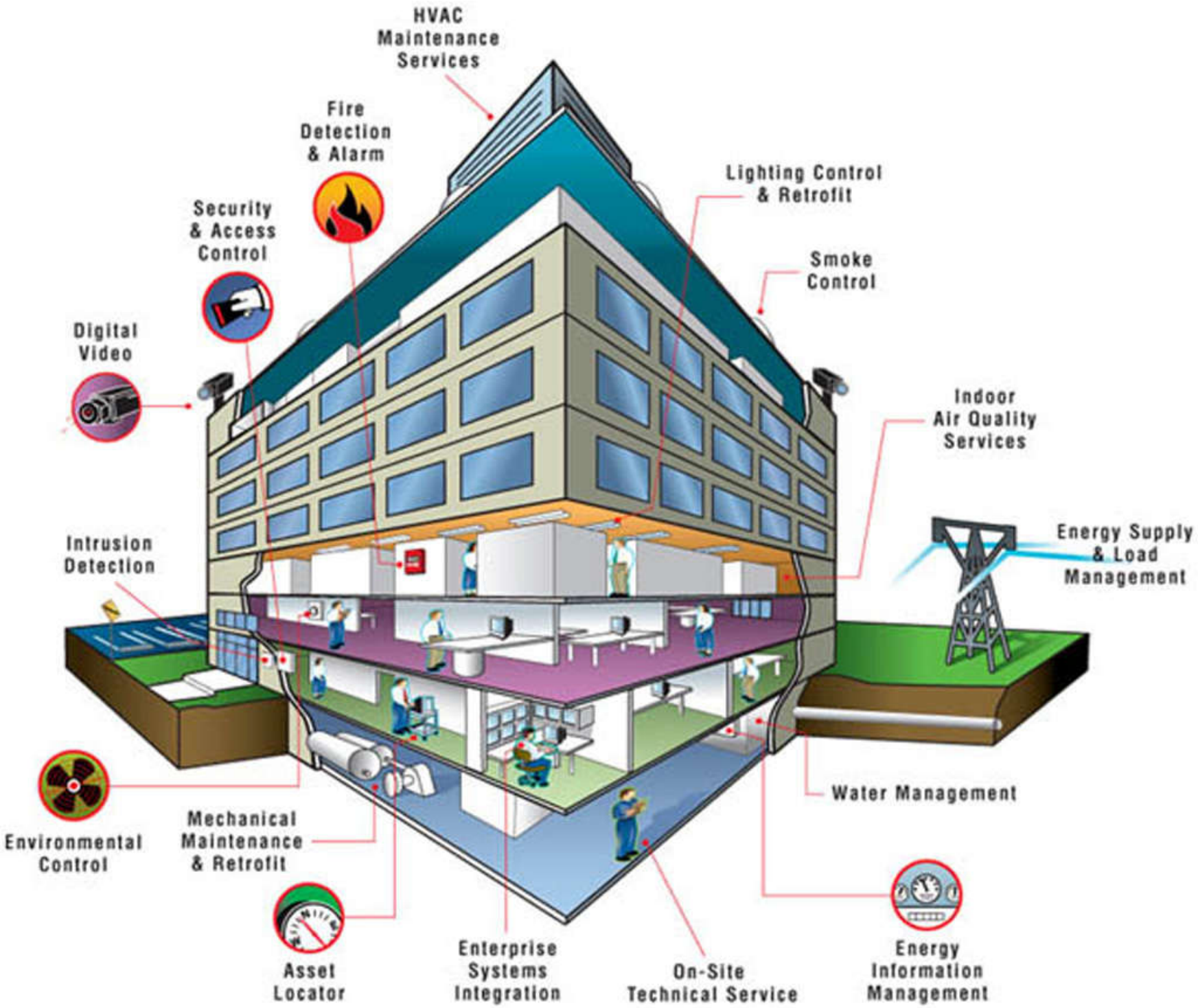
(Source: Clements-Croome D. (ed.), 2004. *Intelligent Buildings: Design, Management and Operation*, Thomas Telford Publishing, London.)

Basic principles

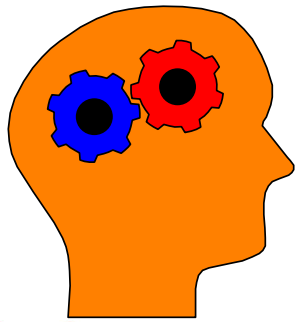


- Major categories:
  - Energy efficiency
    - Energy management & control
  - Lifesafety systems
    - Fire alarm & security
  - Telecommunications systems
    - PABX telephone, videotext, cablevision, e-mail
  - Workplace/Office automation
    - Data processing, word processing, computer-aided design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

Building automation systems (BAS) for intelligent buildings

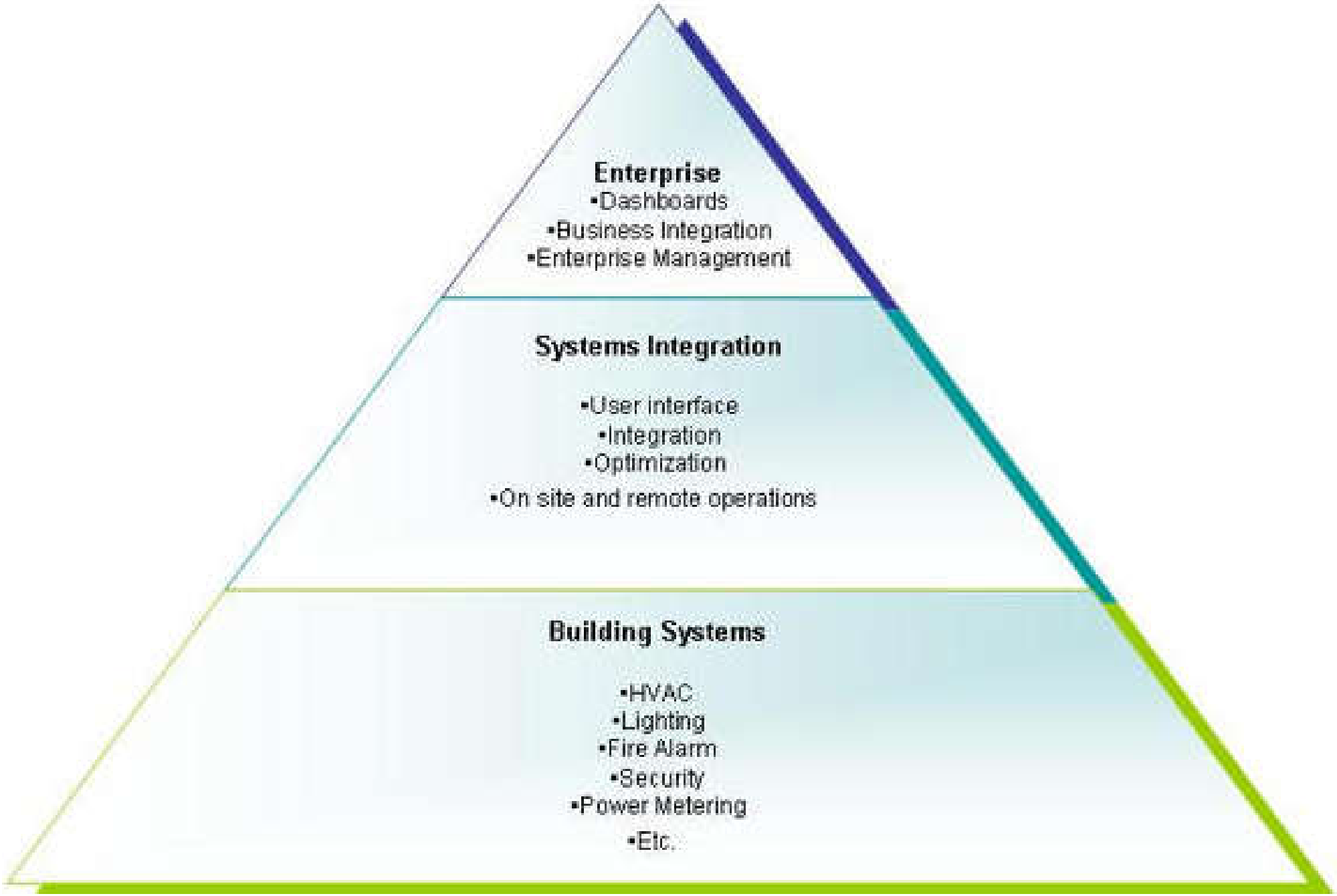


Basic principles



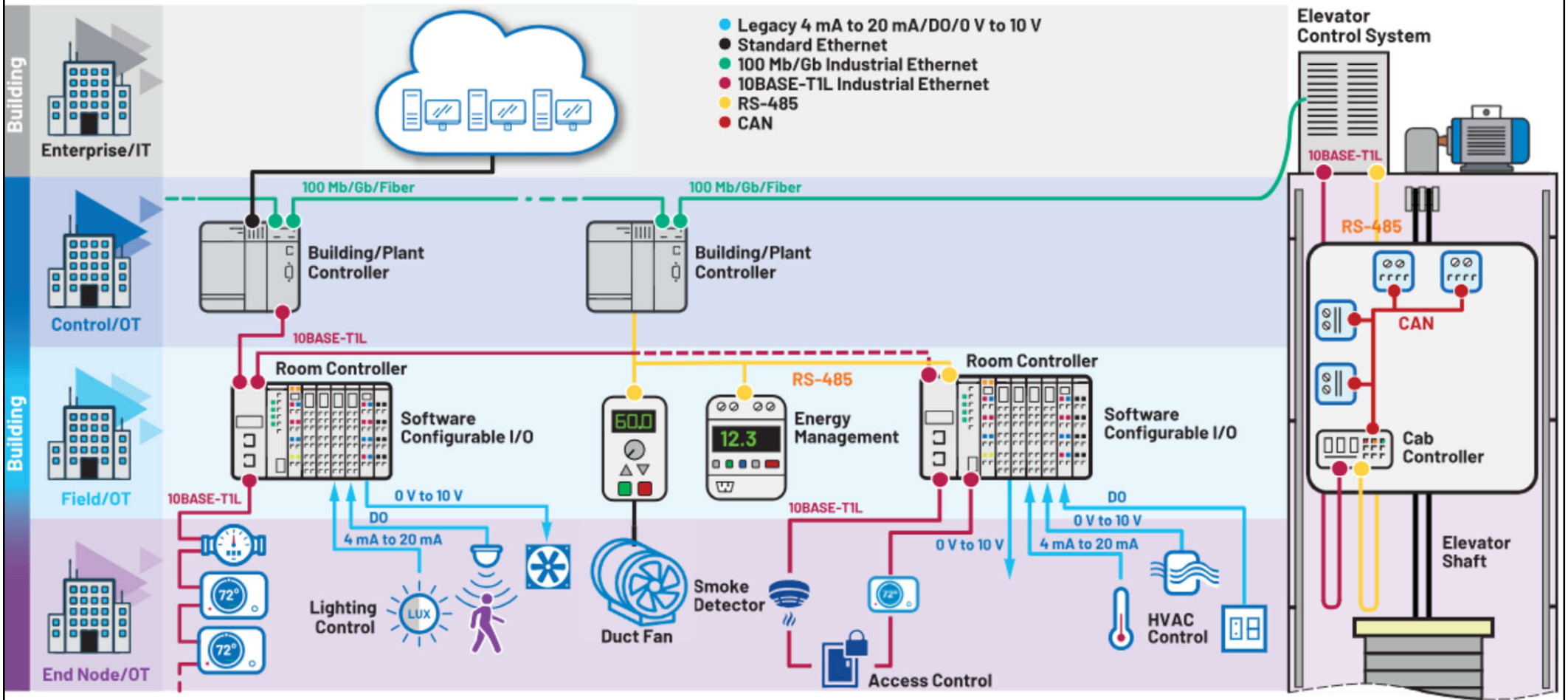
- Four main aspects:
  - Facility management
    - Take care & maintain various functions for occupant comfort & operation
  - Information management
    - Office automation (OA), LAN, wiring
  - Communication
    - Tel/Fax, e-mail, Internet, video telecommunication
  - Control
    - Building automation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

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



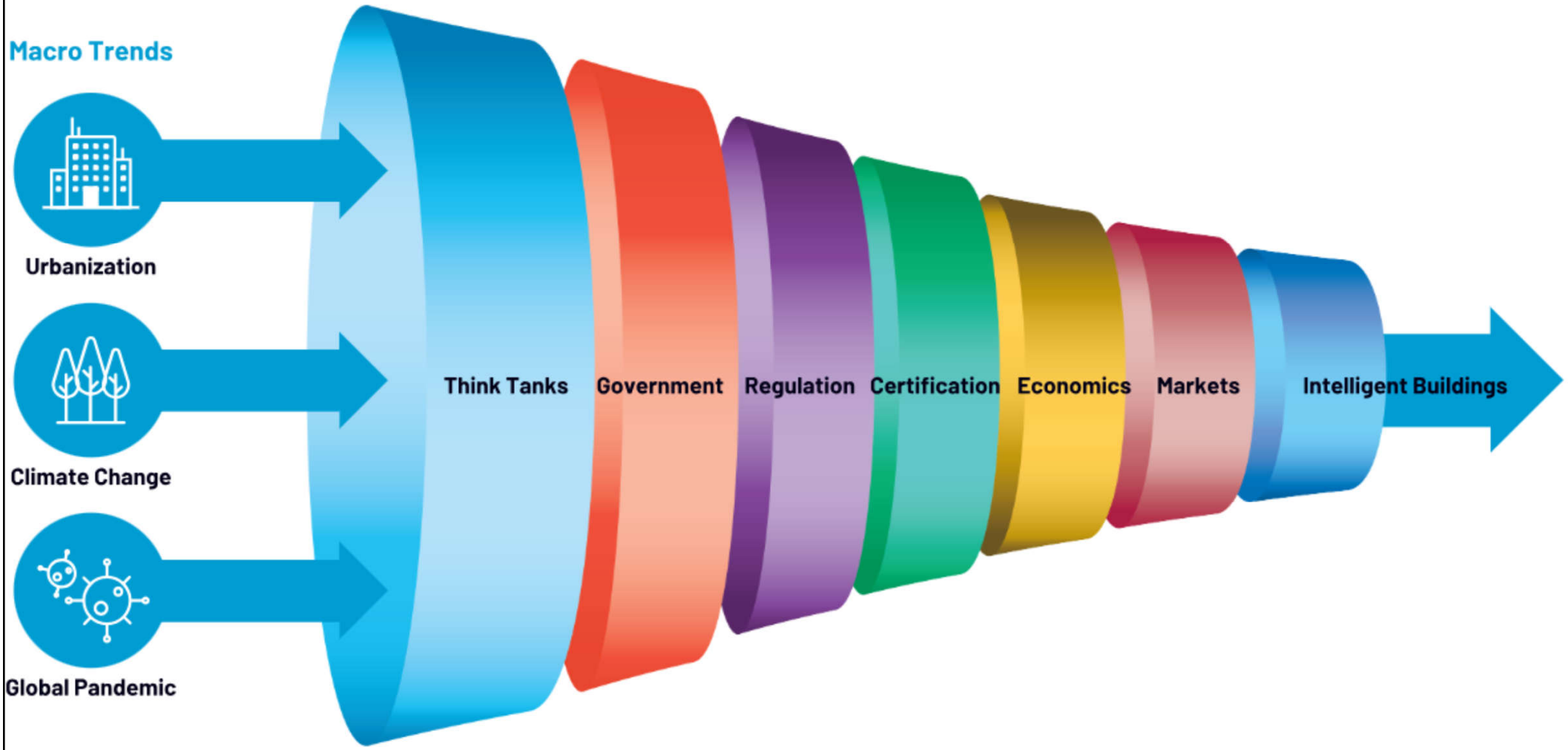
(Source: https://www.automatedbuildings.com/news/sep08/columns/080826110909big.htm)

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



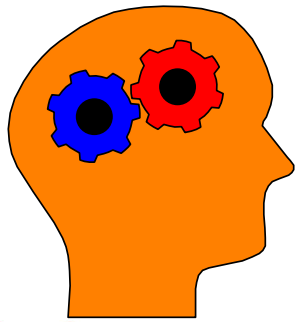
(Source: https://www.analog.com/en/thought-leadership/smart-buildings-vs-intelligent-buildings.html)

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



(Source: https://www.analog.com/en/thought-leadership/smart-buildings-vs-intelligent-buildings.html)

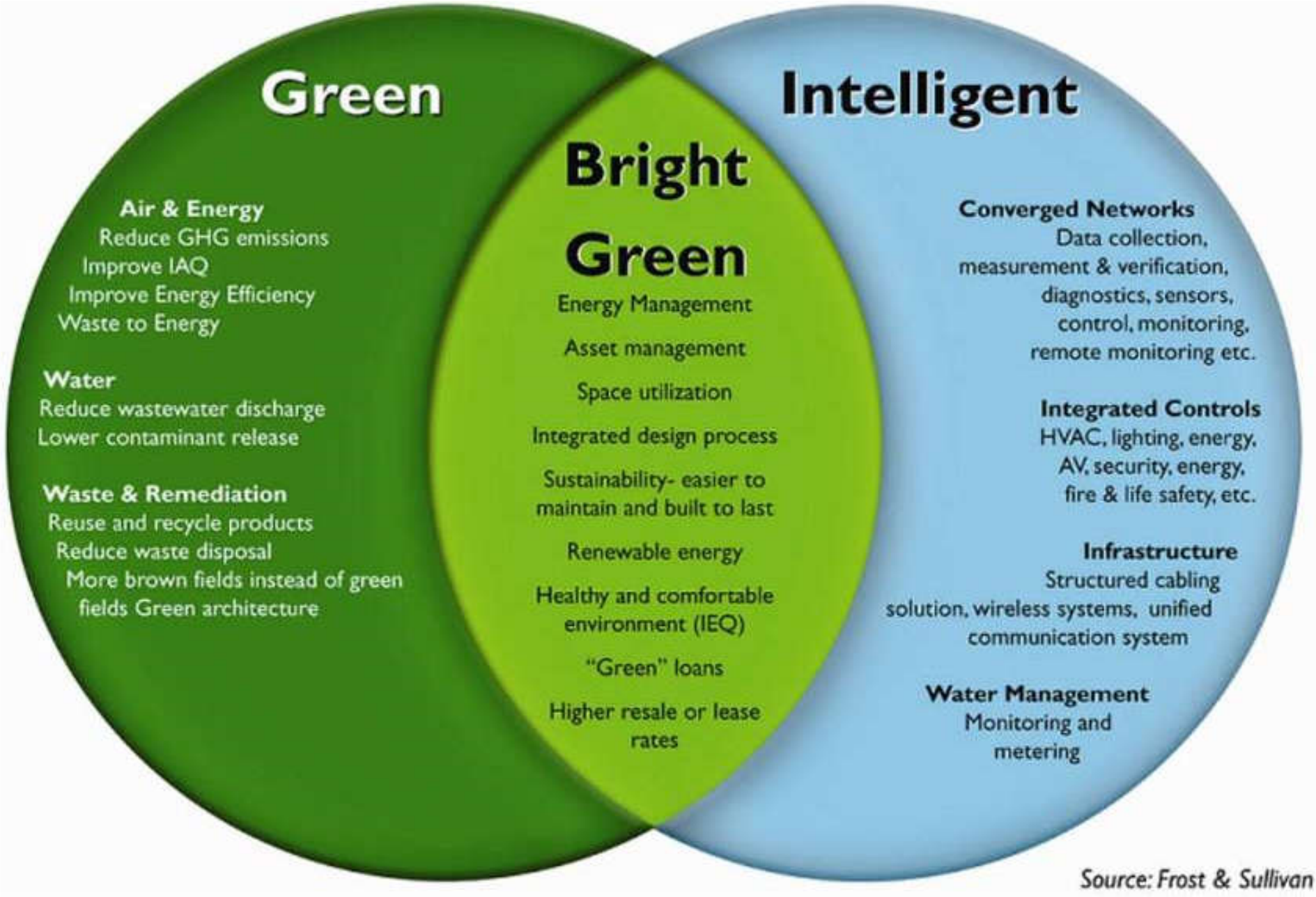
Basic principles



- 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

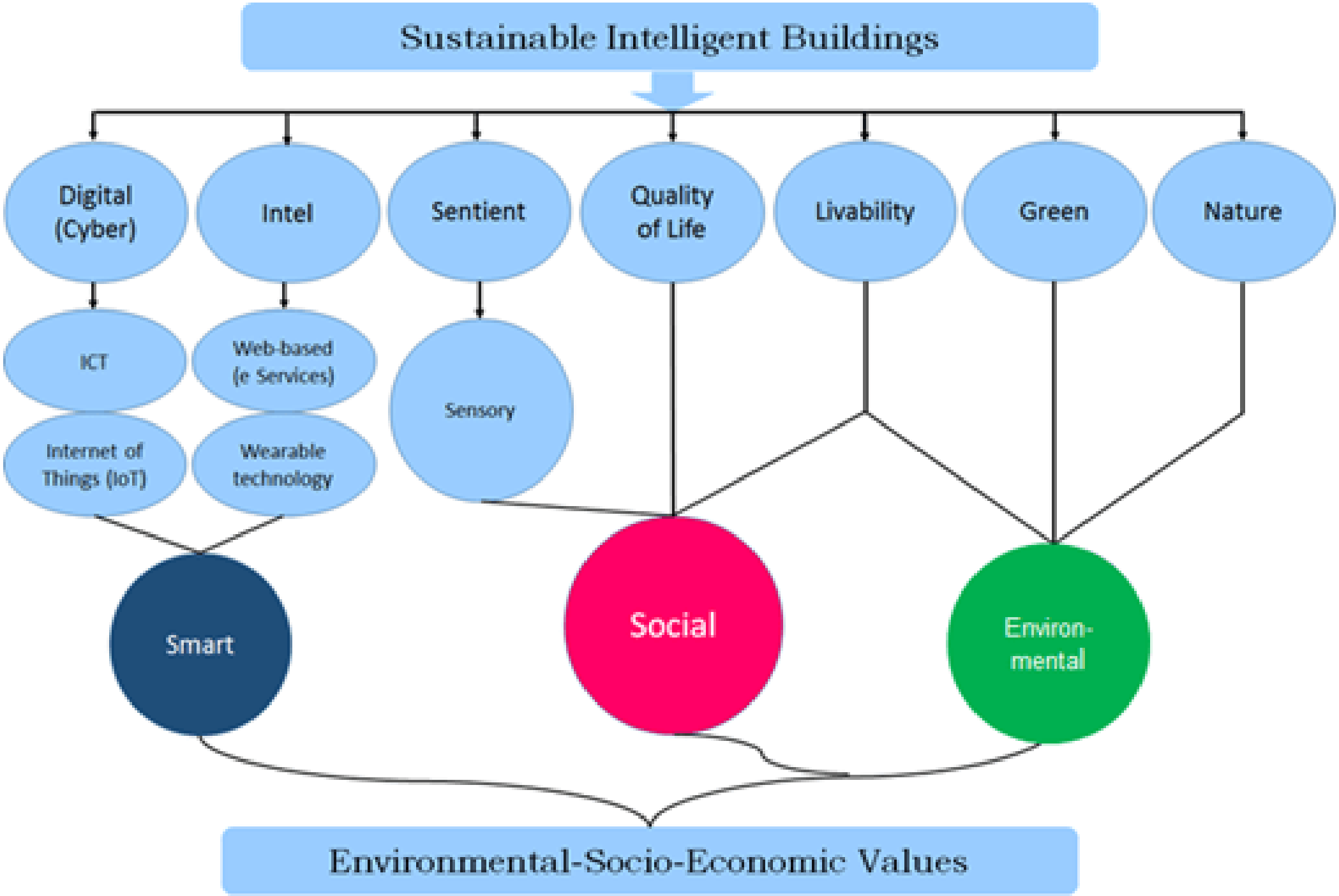
(*See also: Defining Today's Intelligent Building http://www.commscope.com/Blog/Defining-Todays-Intelligent-Building/)

Convergence of intelligent and green buildings



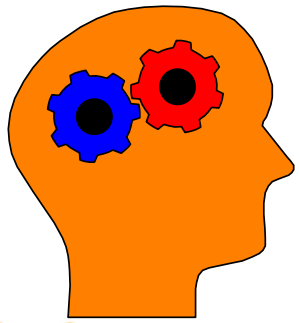
(Source: Ma Z., Billanes J. & Jørgensen B. N., 2017. A business ecosystem driven market analysis: The bright green building market potential, In *the 1st Annual International Conference of the IEEE Technology and Engineering Management Society*, Santa Clara, California USA, 2017. https://www.researchgate.net/publication/318890442_A_business_ecosystem_driven_market_analysis_The_bright_green_building_market_potential)

Basic concepts of sustainable intelligent buildings



(Source: https://www.cibse.org/get-involved/special-interest-groups/intelligent-buildings-group)

Basic principles



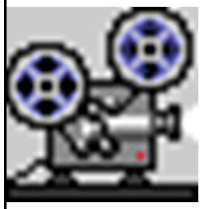
- Current understanding of IB
  - Address both intelligence & sustainability issues by utilising computer & intelligent technologies to achieve the optimal combinations of overall comfort level & energy consumption
  - Intelligent buildings combine & leverage 5 key aspects of building management:
  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

Intelligent + Green

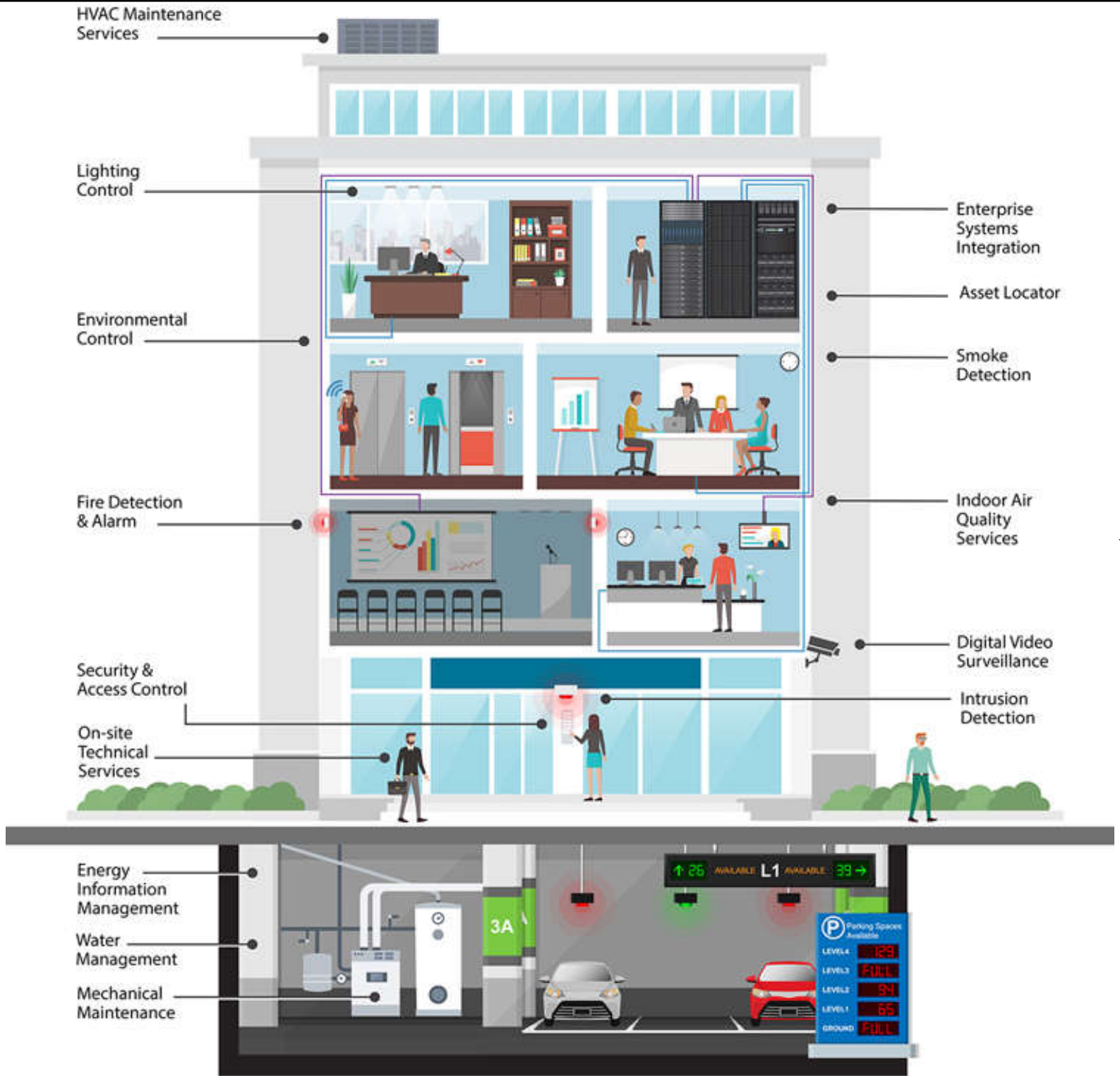
5 key aspects of intelligent building management

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?



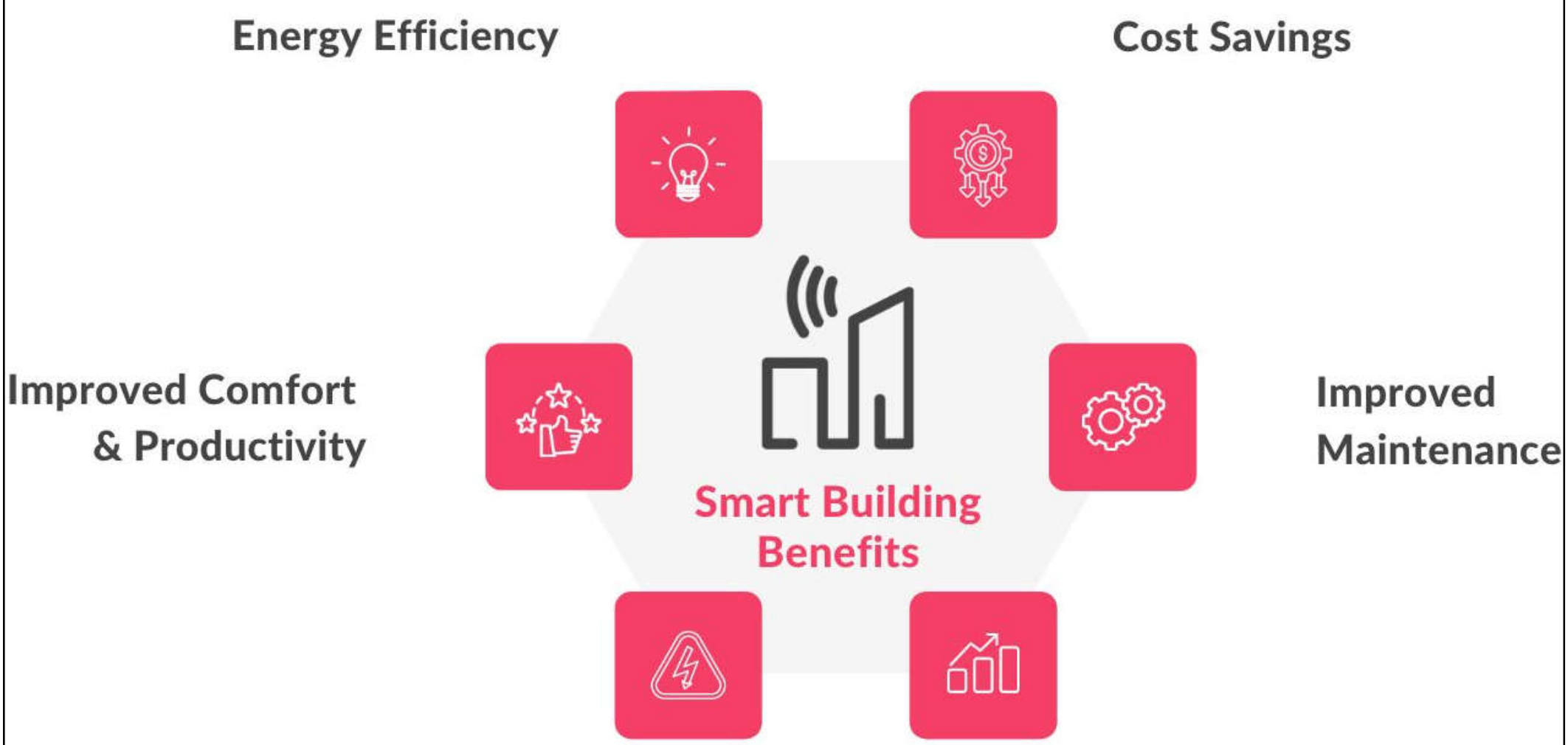
The essential technologies that make a building smart

(Source: https://www.powersystemsdesign.com/articles/the-essential-technologies-that-make-a-building-smart/34/17001)

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

(Source: https://www.johnsoncontrols.com/)

Benefits of smart buildings

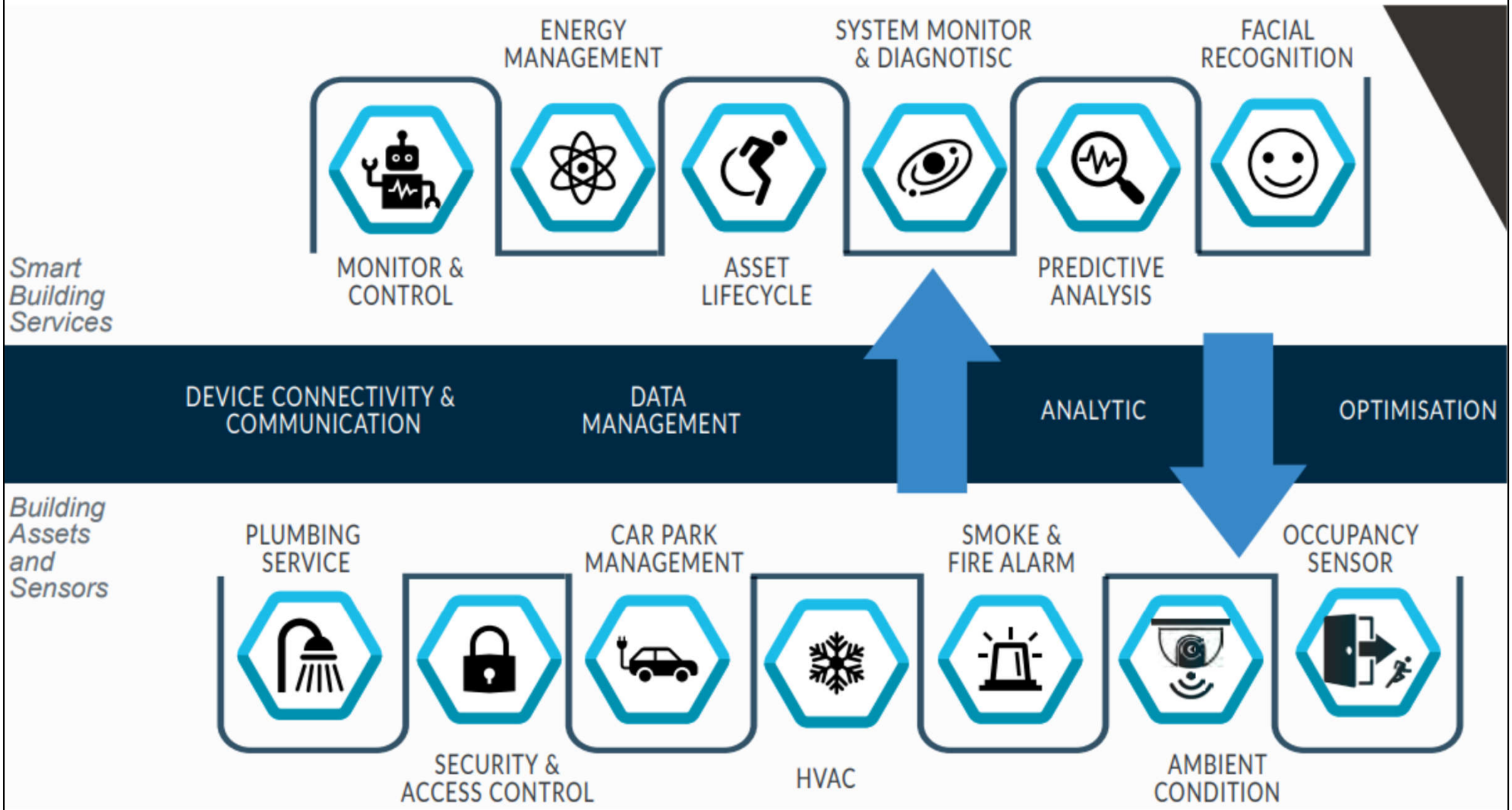


(Source: https://www.zenatix.com/smart-buildings-a-comprehensive-guide/)

Smart & green building

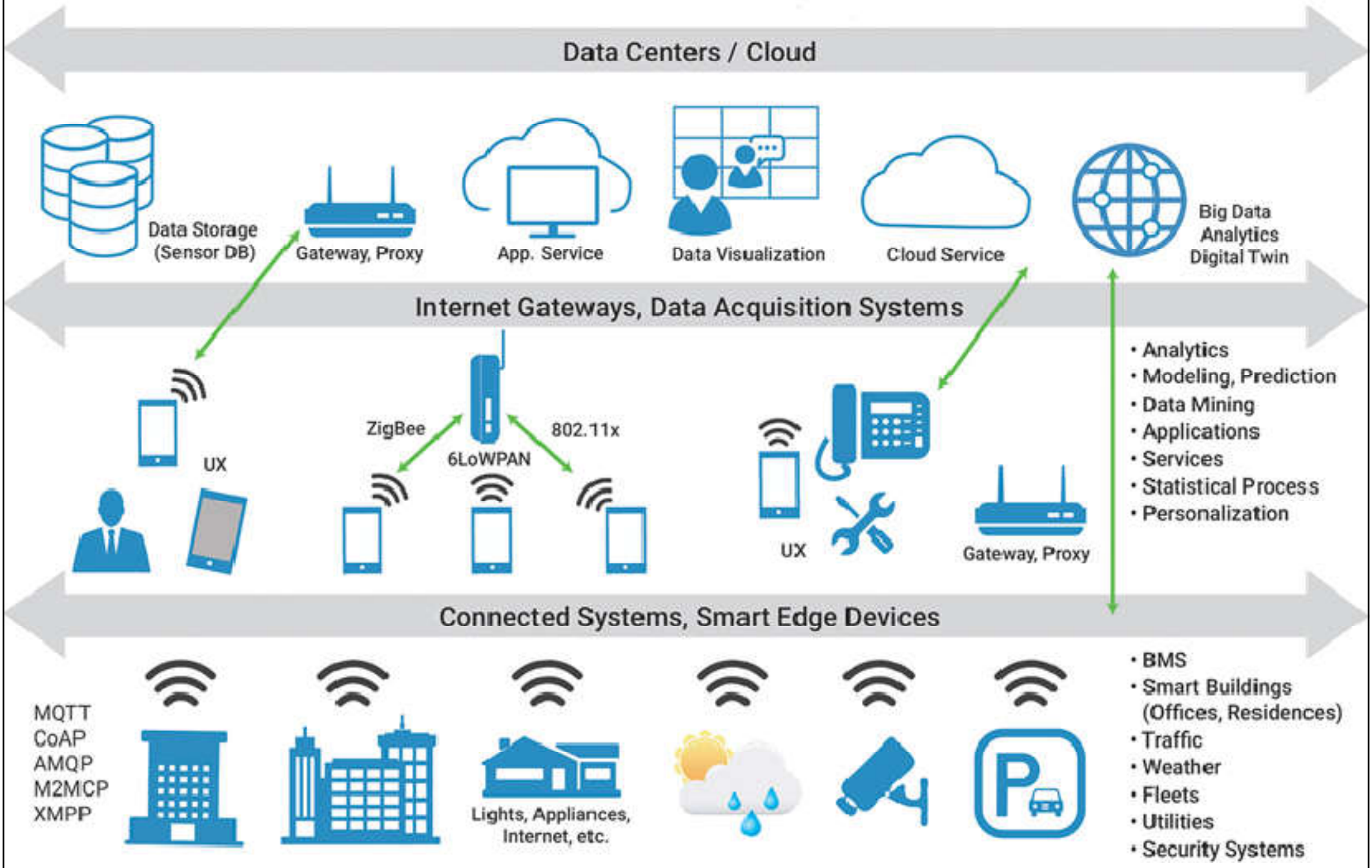
- A smart building uses its intelligence to collect actionable data from user devices, sensors, systems & services on the premises
  - Apply that data using artificial intelligence & machine learning (AI/ML) makes the building both programmable & responsive to the needs of the users & the building manager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

Examples of smart building services



(Source: http://www.adftech.com.my/wp-content/uploads/2019/08/E-Book-1.-All-About-Building-Automation-System.pdf)

Smart building architecture

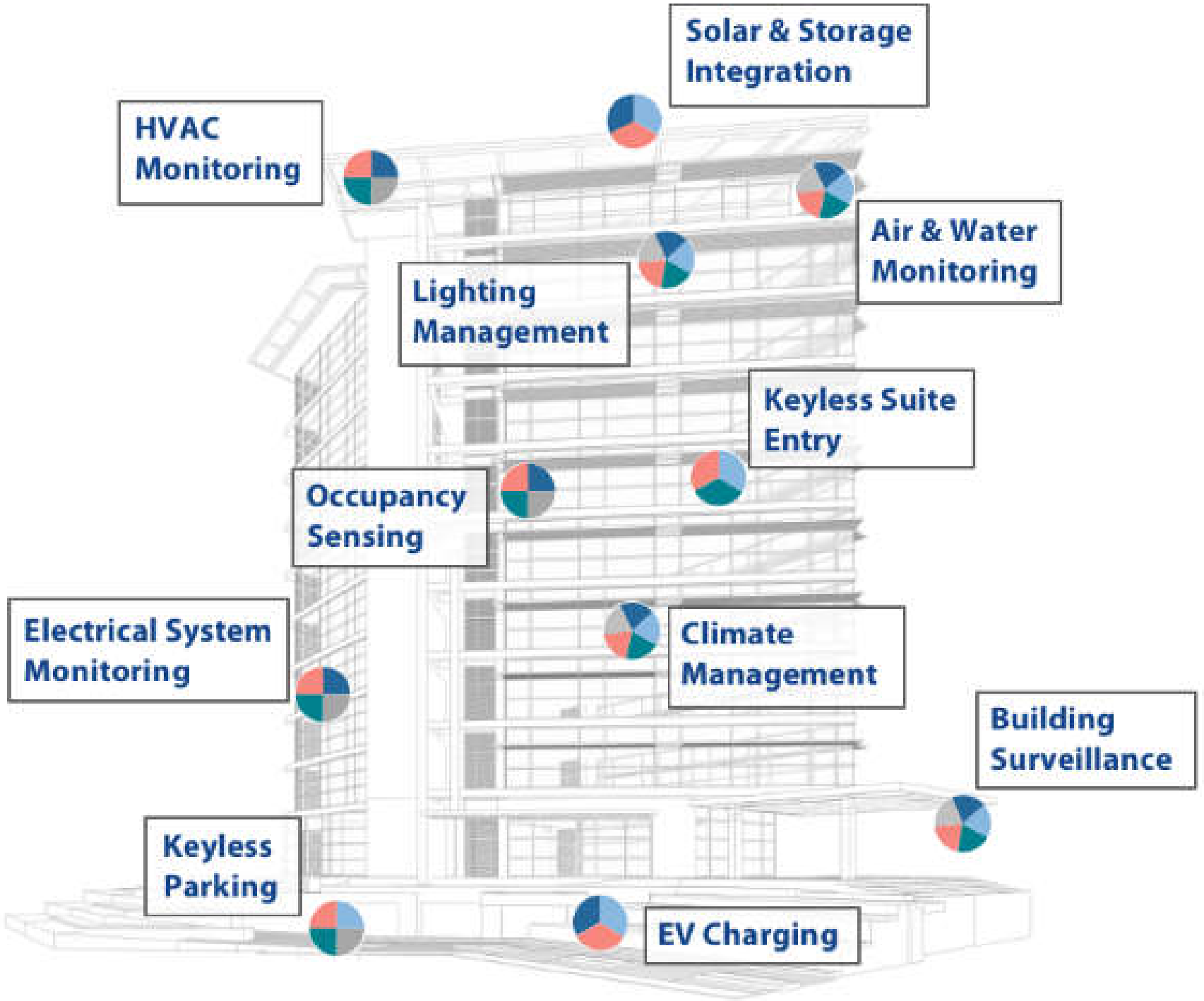


(Source: https://www.powersystemsdesign.com/articles/the-essential-technologies-that-make-a-building-smart/34/17001)

Common smart building functions

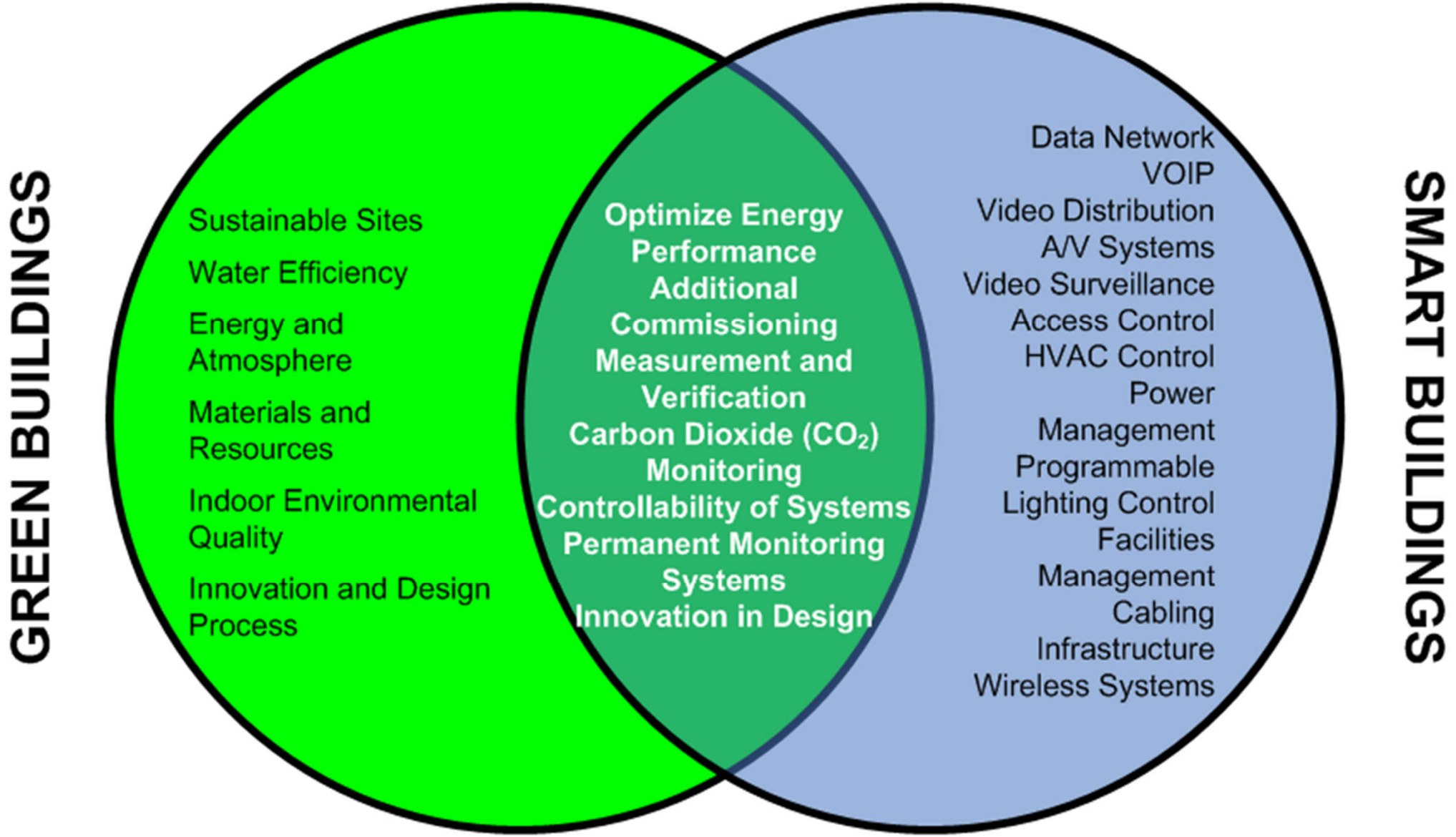
(Source: https://www.zenatix.com/the-rise-of-smart-buildings-leveraging-iot-automation-for-building-performance-optimization/)

Smart building automation system



(Source: https://gemvietnam.com/internet-of-things/smart-building-automation-system/)

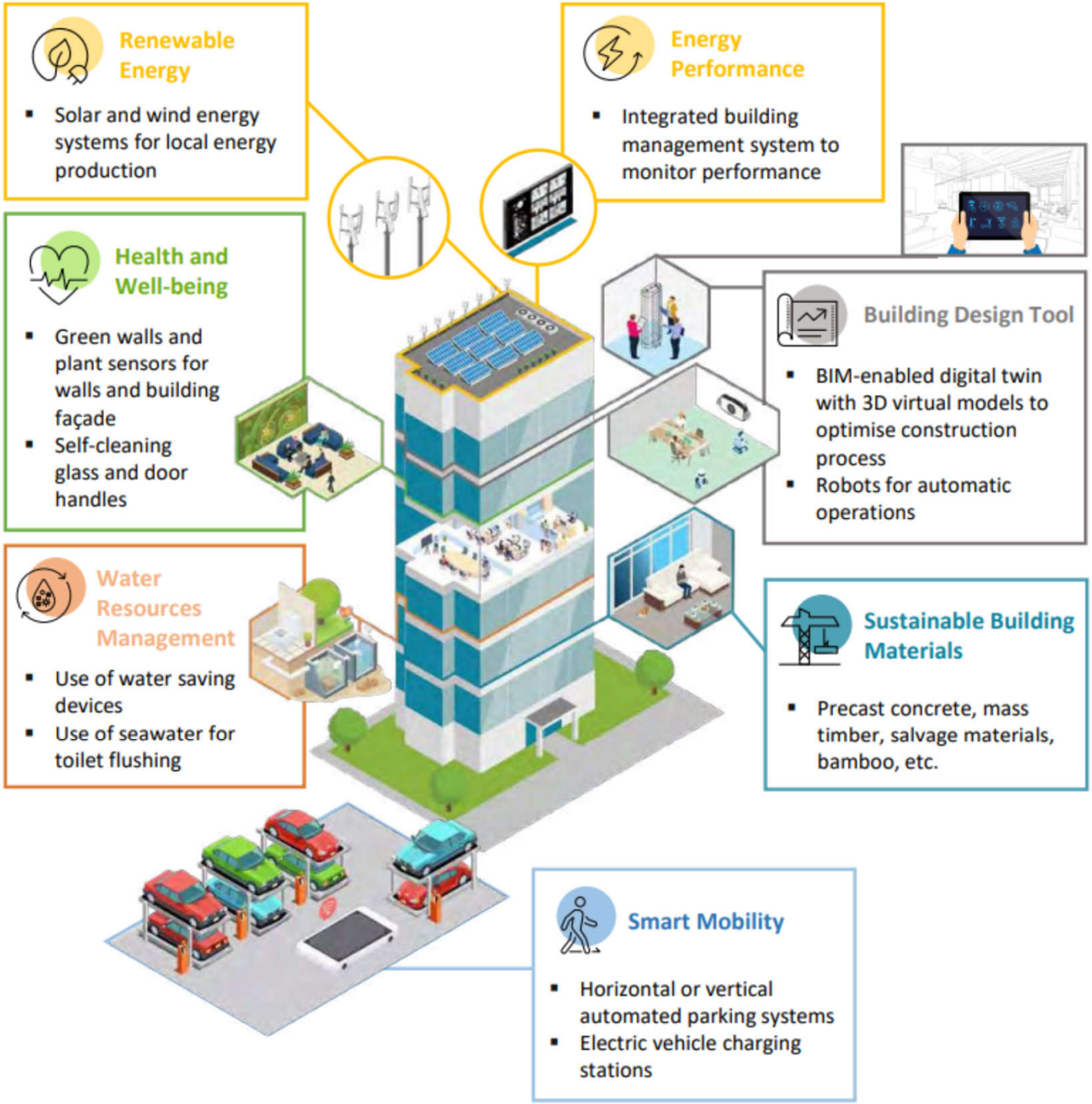
THE COMMONALITY OF SMART AND GREEN BUILDINGS



[Source: http://www.smart-buildings.com/]

Redefining the interface between smart and green buildings

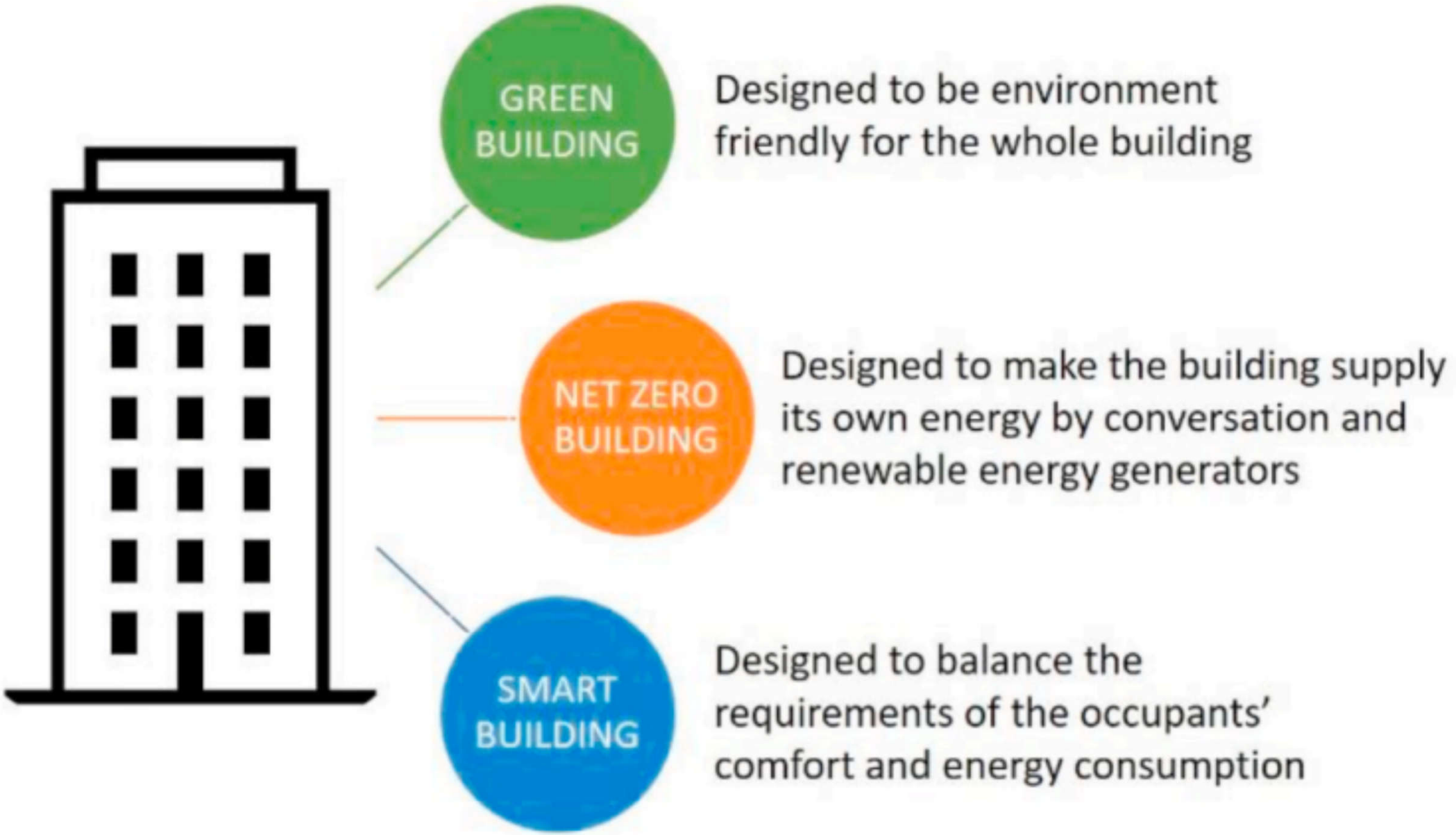
(Source: HKGBC, 2021. *Hong Kong Smart Green Building Design Best Practice Guidebook*, Hong Kong Green Building Council Limited (HKGBC). https://www.hkgbc.org.hk/eng/resources/publications/Files/HKGBC_Smart-Green-Building-Design-Best-Practice-Guidebook.pdf)



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/)

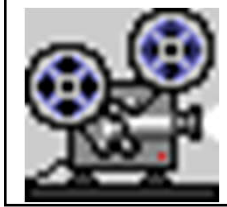
Types of buildings concepts based on design goals



(Source: Mariano-Hernández D., Hernández-Callejo L., Zorita-Lamadrid A., Duque-Pérez O. & García F. S., 2021. A review of strategies for building energy management system: Model predictive control, demand side management, optimization, and fault detect & diagnosis, *Journal of Building Engineering*, 33: 101692. https://doi.org/10.1016/j.jobe.2020.101692)

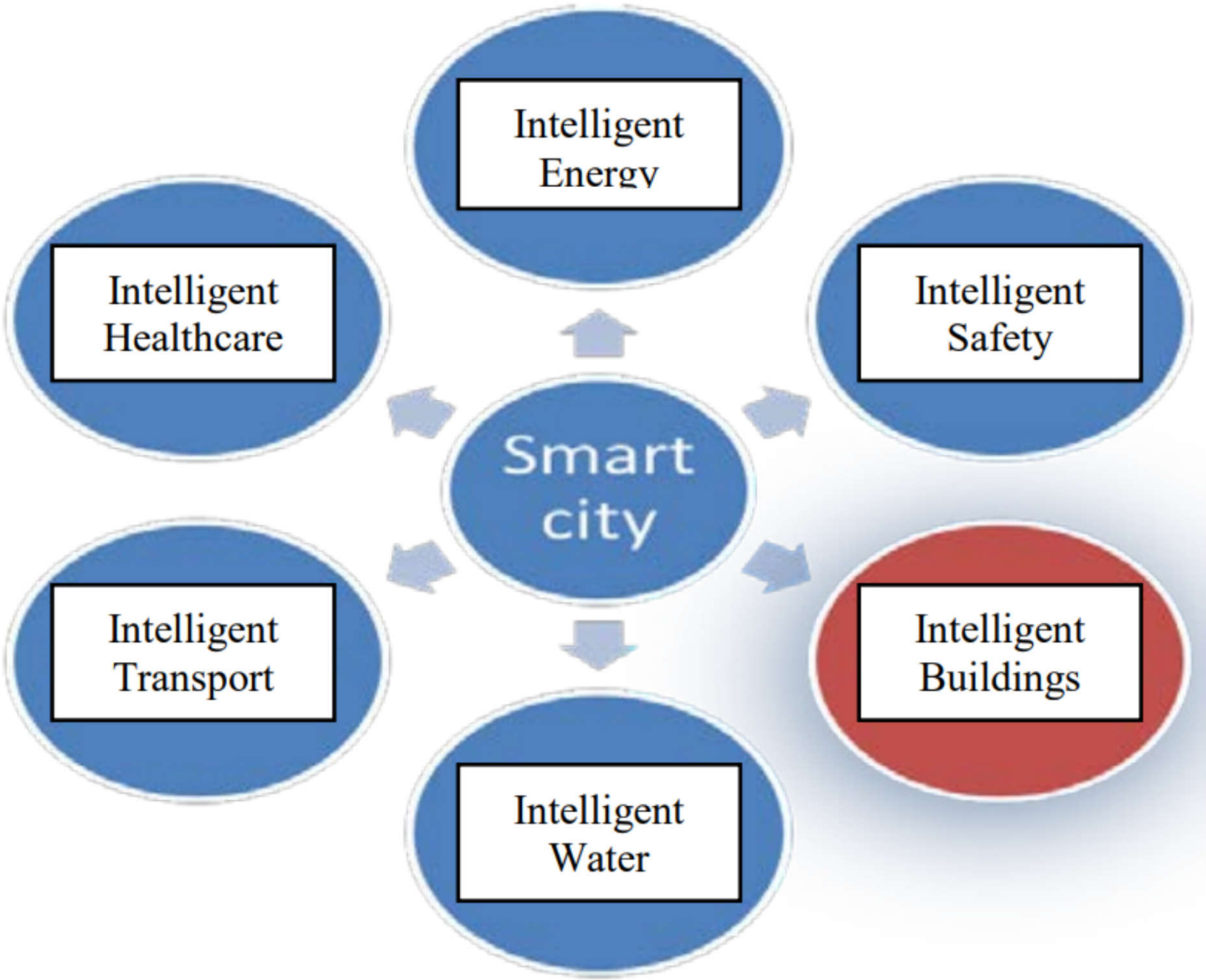
Smart cities

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



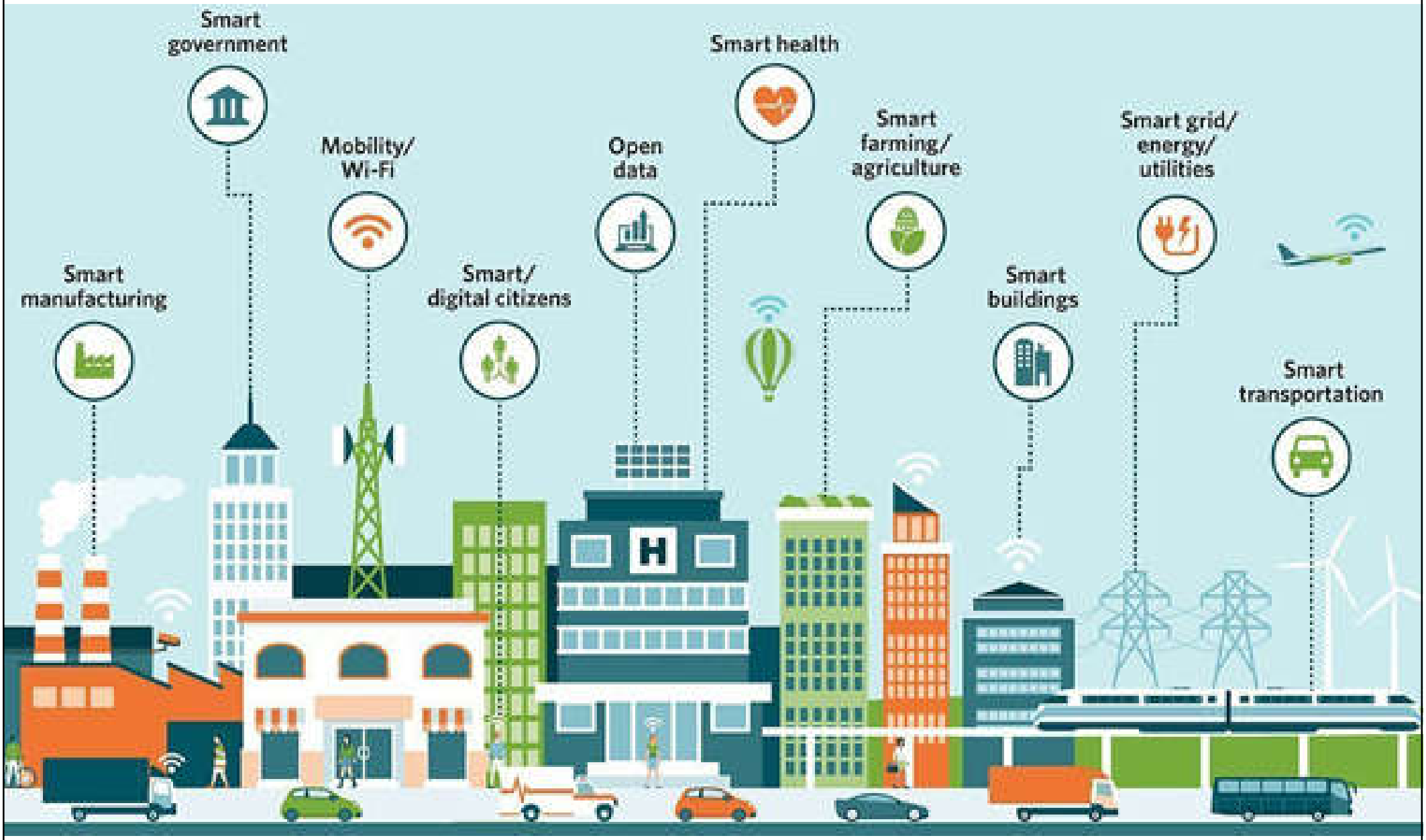
Video: What is a smart city? | CNBC Explains (3:30) https://youtu.be/bANfnYDTzxE

The smart city concept

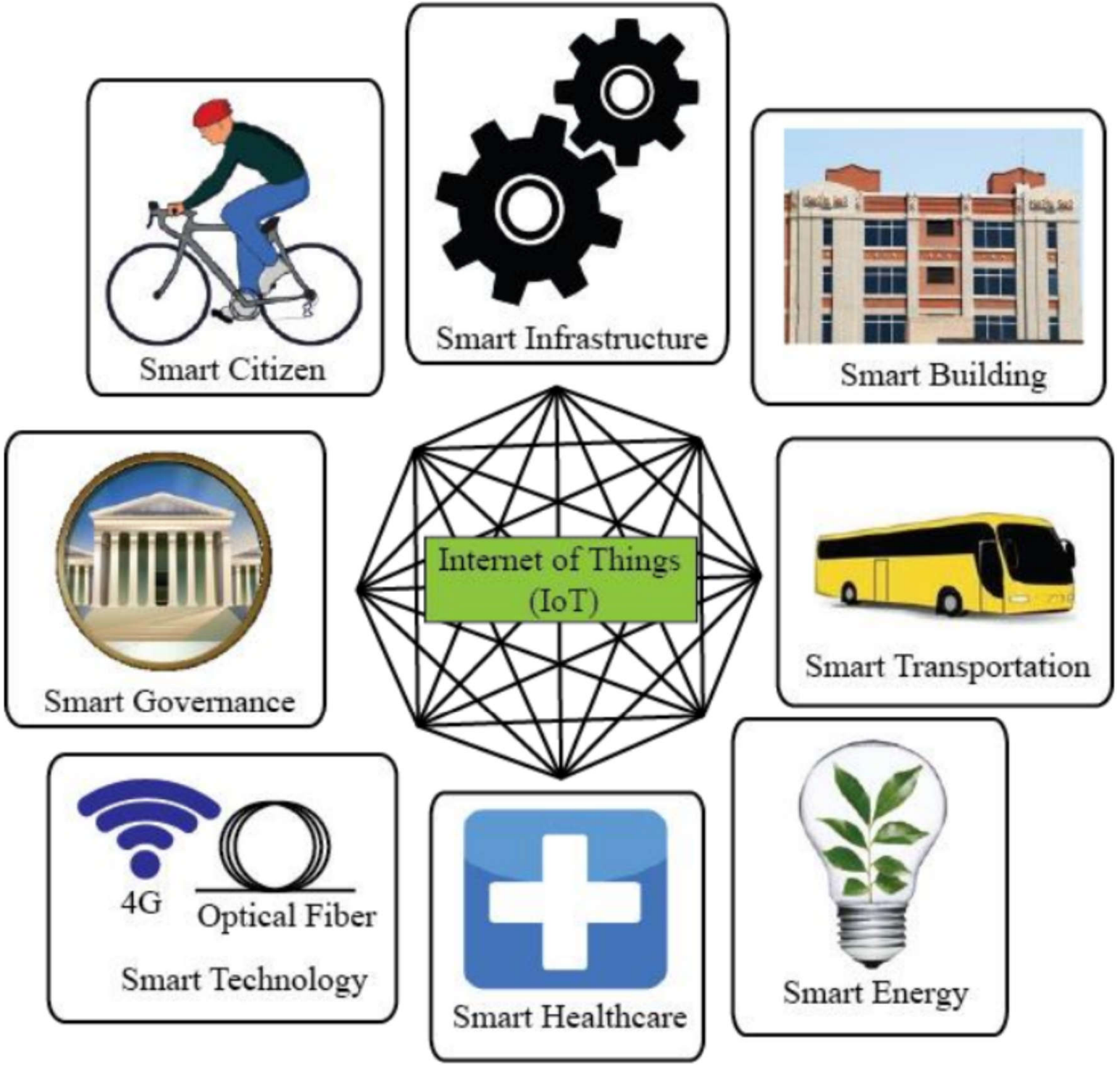


(Source: Popescu D. E. & Prada M., 2013. Some aspects about smart building management systems - solutions for green, secure and smart buildings, Conference: *Recent Advances in Environmental Science*, Lemesos, Cyprus, Volume 7, p. 126-132. https://doi.org/10.13140/RG.2.1.3057.8644)

Smart city – elements, features & technologies



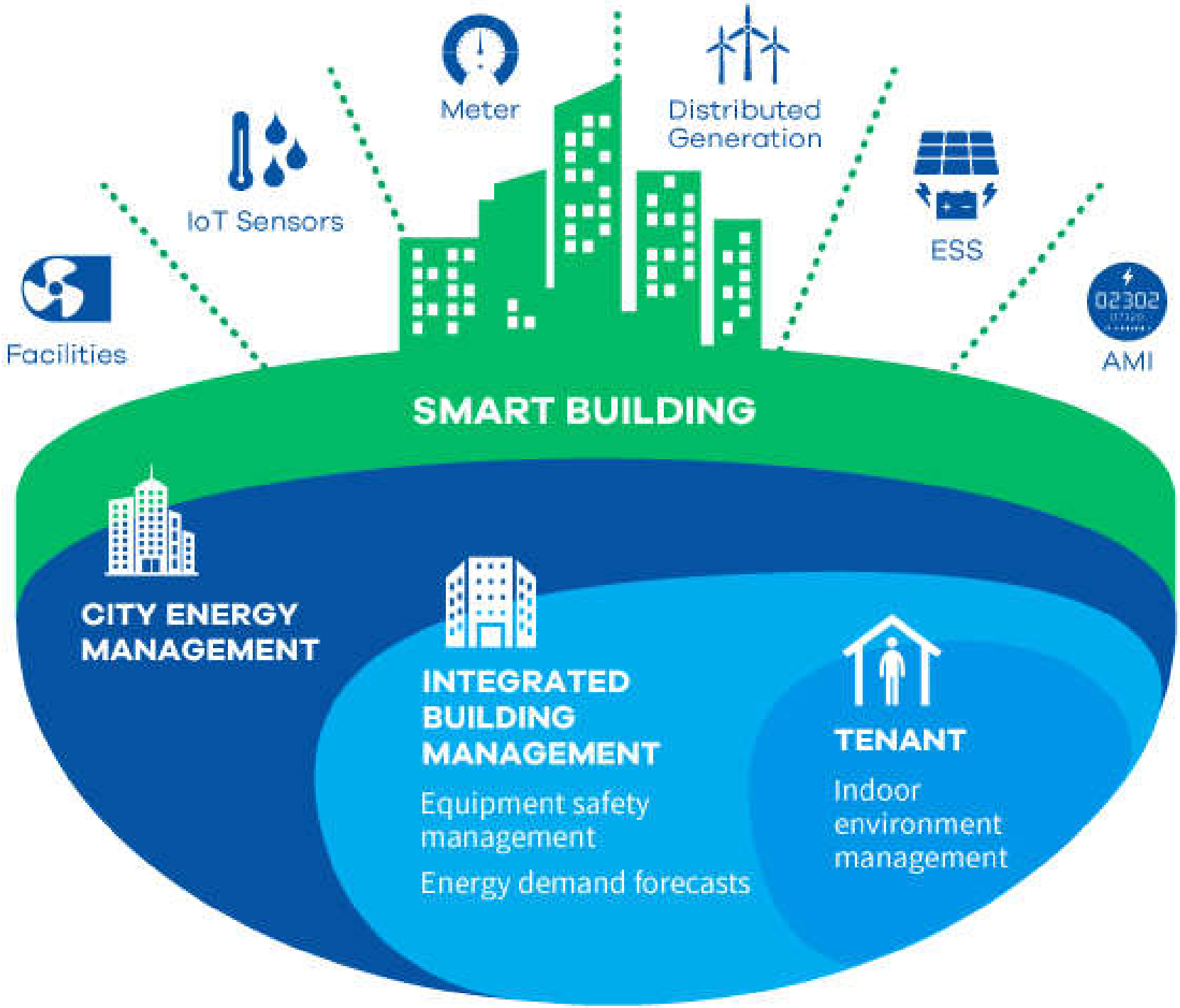
(Source: https://constrofacilitator.com/smart-city-elements-features-technology-and-govt-approach/)



A broad overview of smart city components

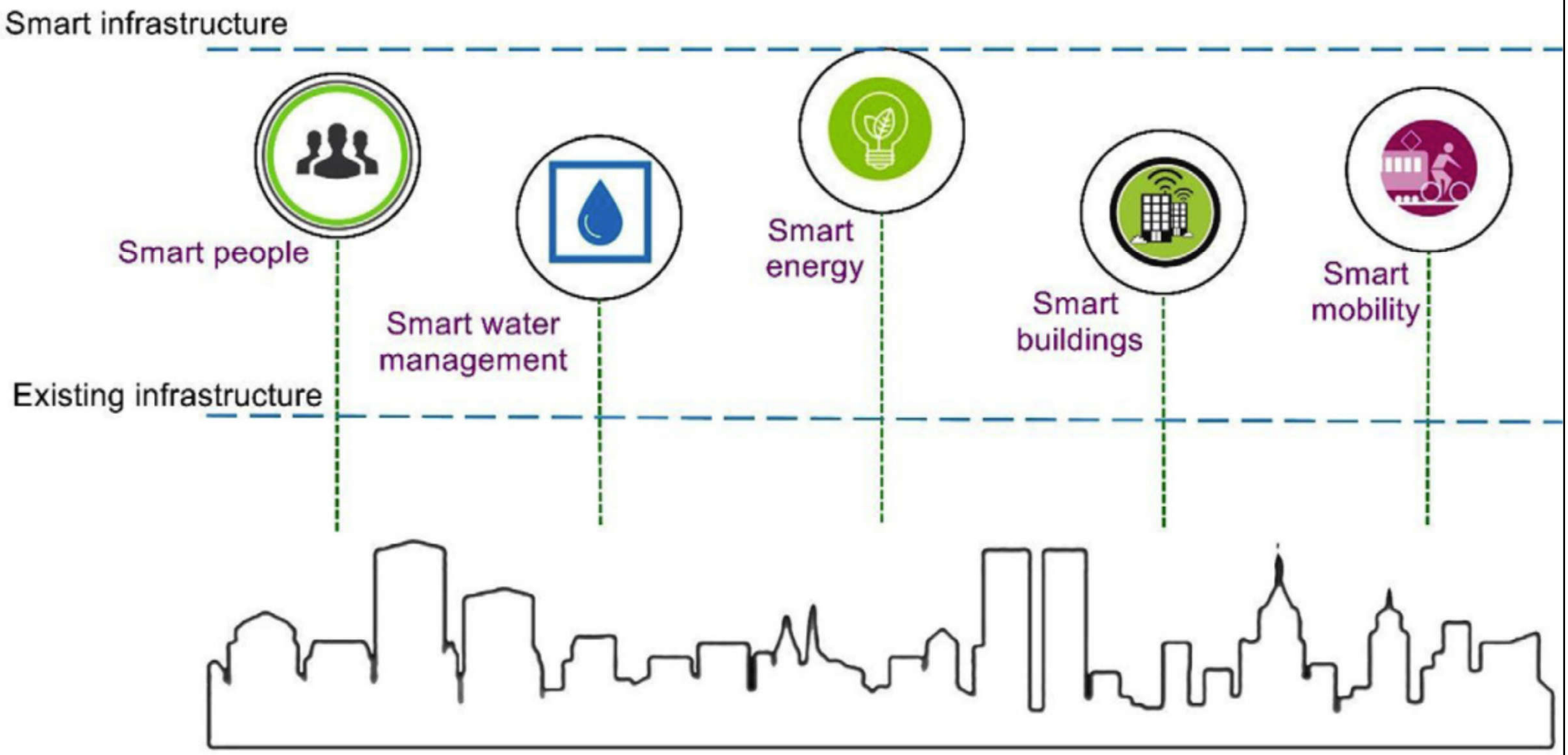
(Source: Mohanty S. P., Choppali U. & Kougianos E., 2016. Everything you wanted to know about smart cities, *IEEE Consumer Electronics Magazine*, 5 (3) 60-70. https://doi.org/10.1109/MCE.2016.2556879)

Smart building for city, building owners & tenants



(Source: https://gemvietnam.com/internet-of-things/smart-building-automation-system/)

The most important factors in the formation of smart city infrastructure

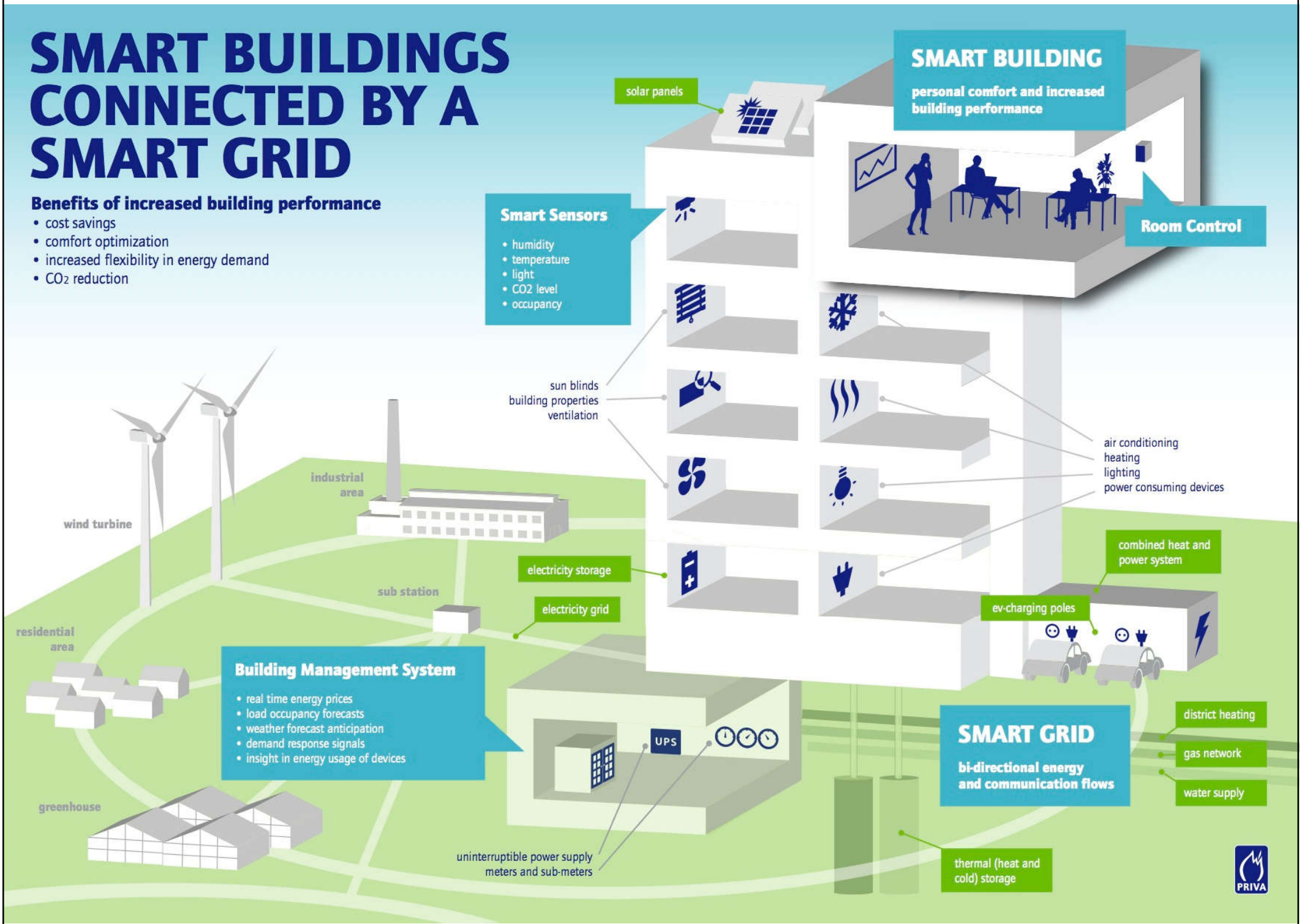


(Source: Habibi S., 2020. *Building Automation and Digital Technologies*, Woodhead Publishing, Cambridge, MA & Kidlington, UK. https://doi.org/10.1016/C2019-0-03708-9)

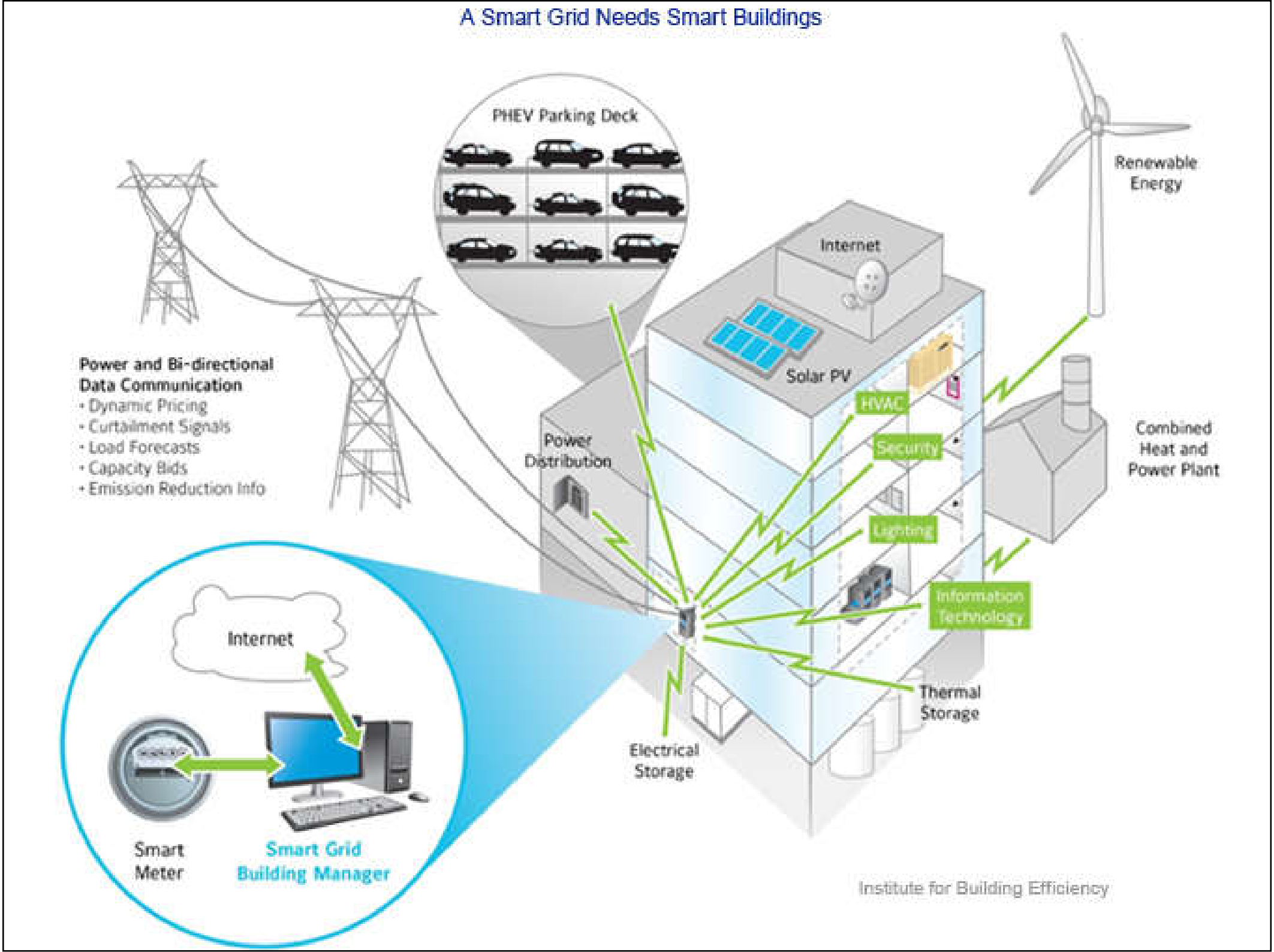
SMART BUILDINGS CONNECTED BY A SMART GRID

Benefits of increased building performance

- cost savings
- comfort optimization
- increased flexibility in energy demand
- CO_2 reduction

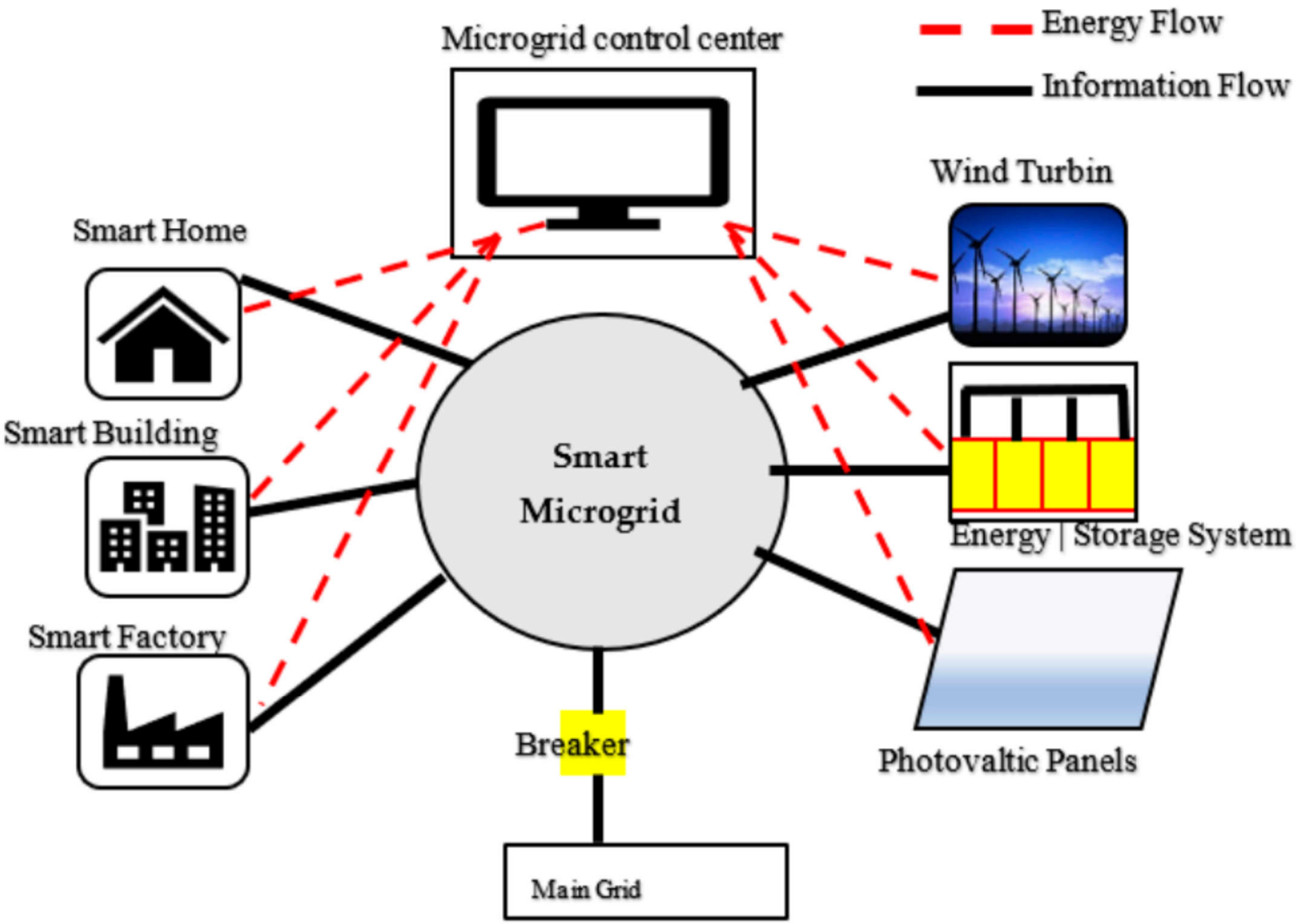


A Smart Grid Needs Smart Buildings



Institute for Building Efficiency

Advanced control of smart microgrid for smart buildings



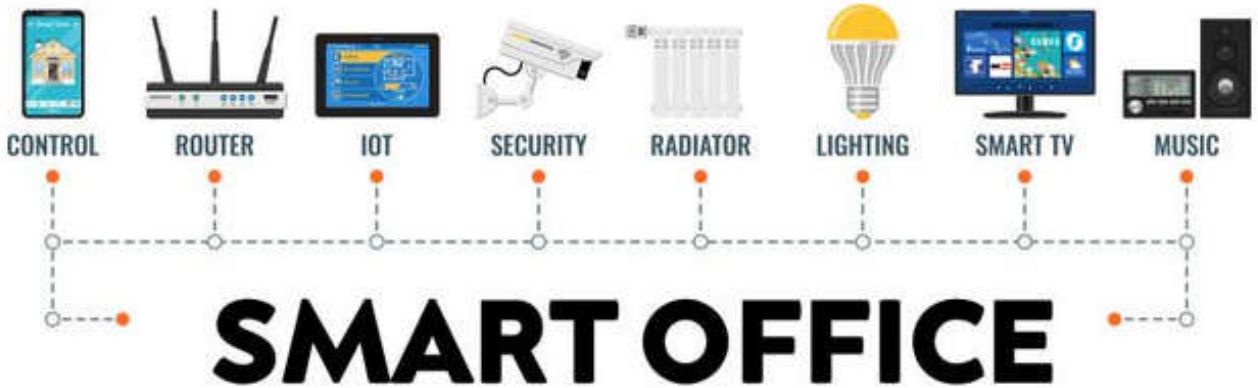
(Source: Krishnan P., Prabu A. V., Loganathan S., Routray S., Ghosh U. & AL-Numay M., 2023. Analyzing and managing various energy-related environmental factors for providing personalized IoT services for smart buildings in smart environment, *Sustainability*, 15 (8) 6548. https://doi.org/10.3390/su15086548)

Smart office & home

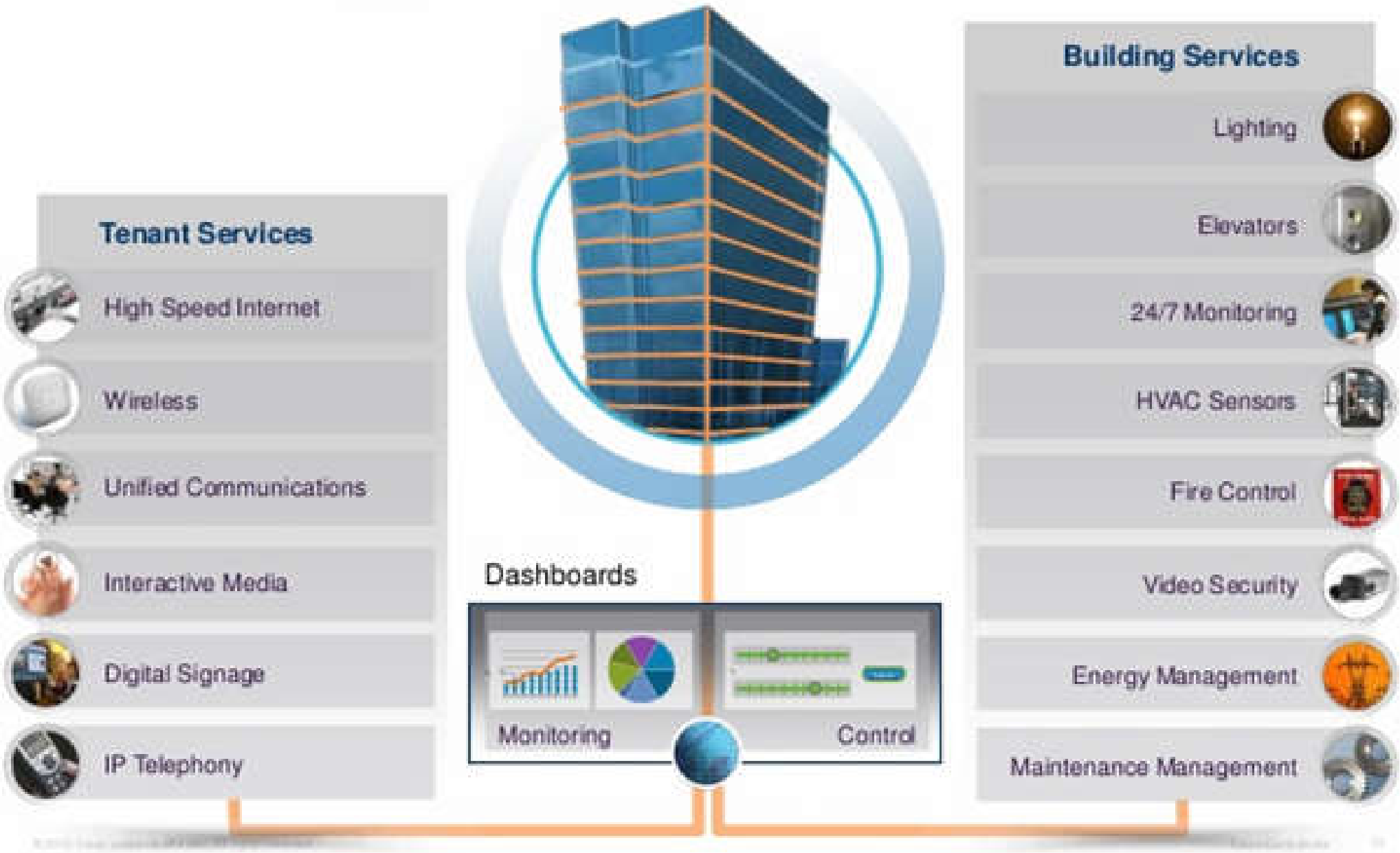
- Office space & commercial buildings
  - Such as speculative high-tech offices
  - Organizational/functional requirements
  - Impact of IT & business strategy
- Objectives
  - Responsive (to user needs / to climate)
  - Efficient (building design & systems)
  - Effective (operation & management)
  -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



The Building Information Network



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

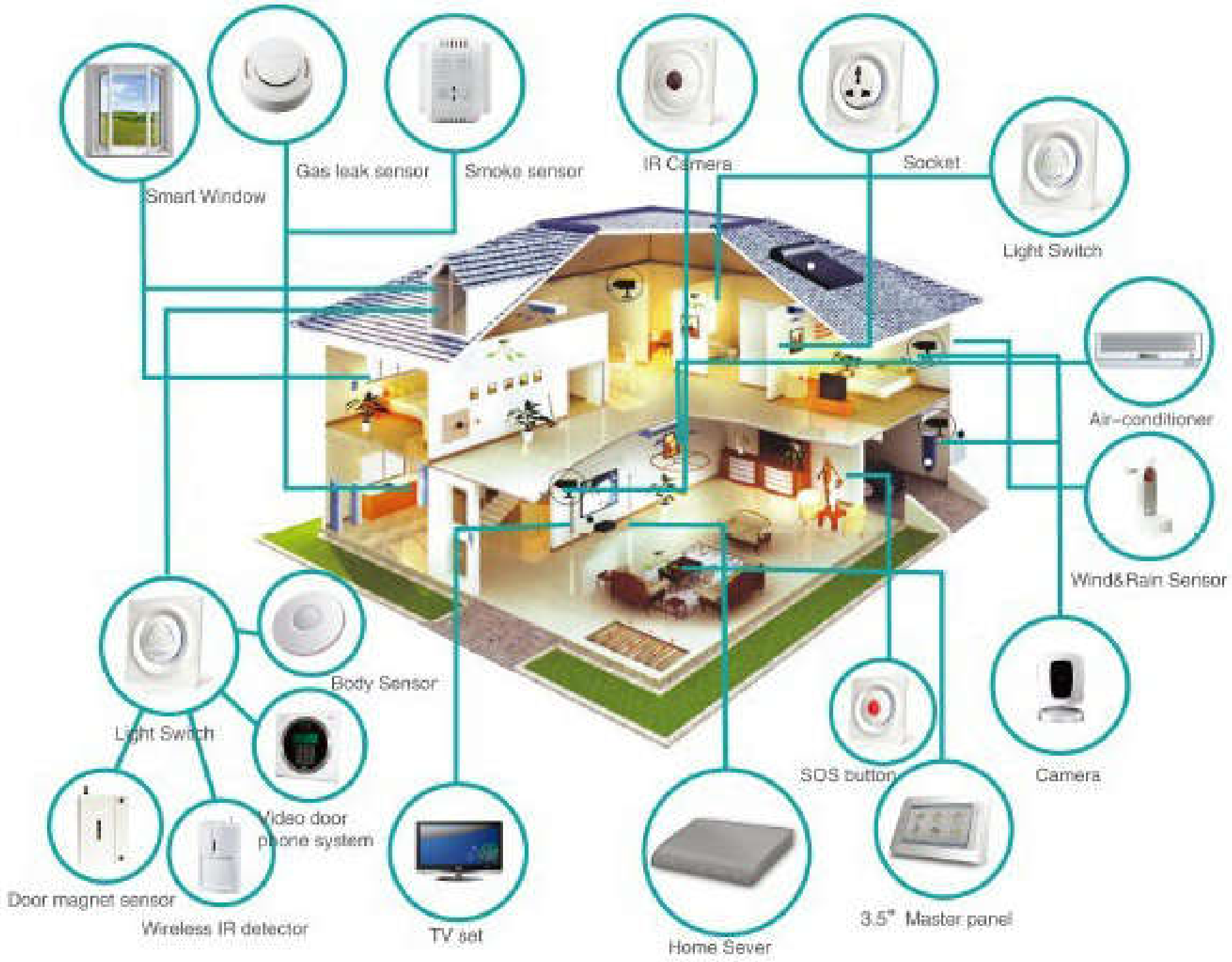
Workflow in a smart office

(Source: https://sid.siemens.com/v/u/A6V11788140)

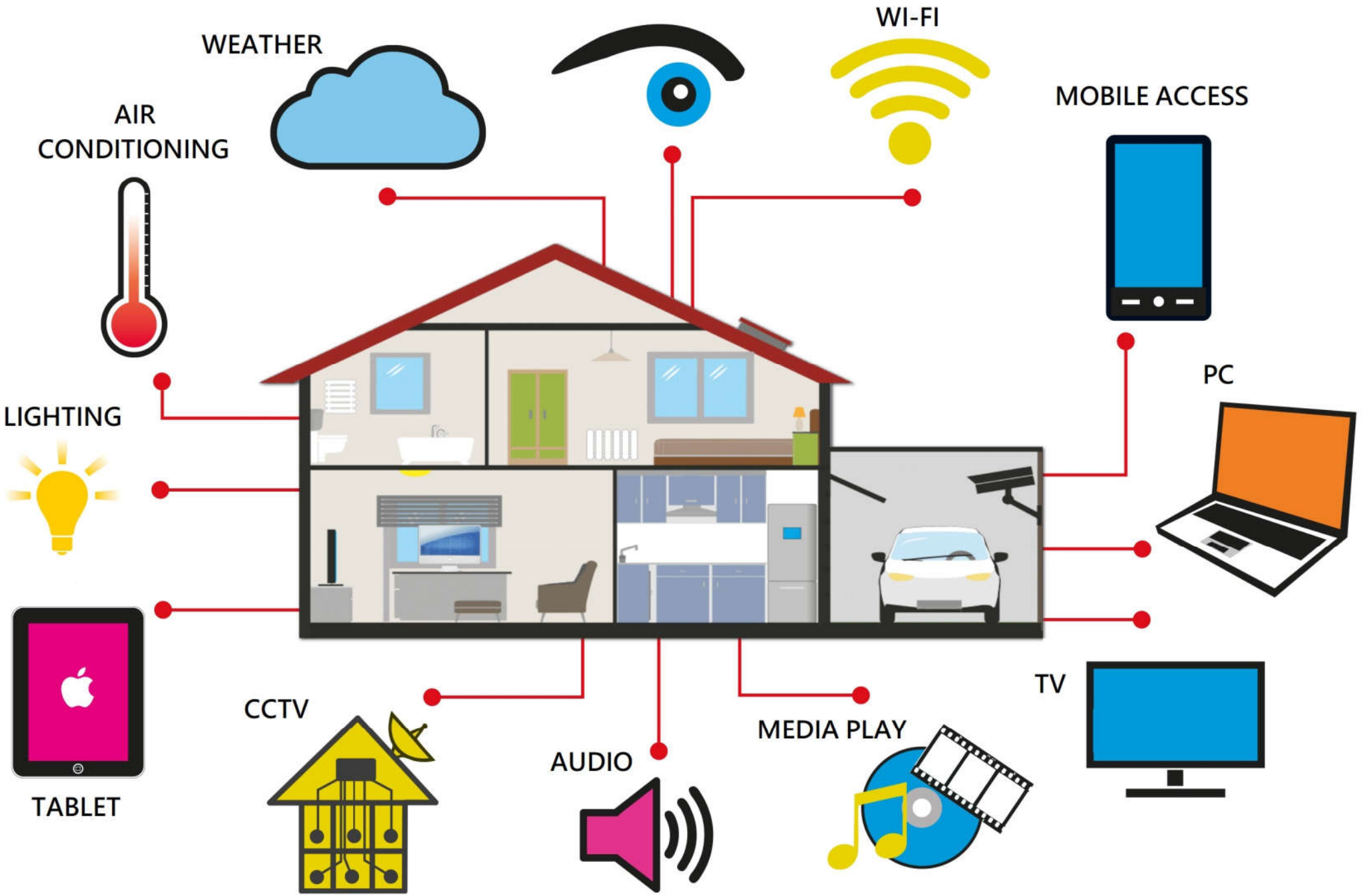
Smart office & home

- 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



(Source: http://visioforce.com/smarthome.html)

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

1990 — World Wide Web was started to be developed by scientists

1993 — US citizens were allowed to use GPS

1998 — Google search engine was launched

1999 — Businesses were formed by technology ideas, like e-commerce sites or eBay.

1999 — "Internet of Things" was used for the first time for a device connected to the Internet and had on-off button.

1999 — An appliance like toaster was controlled through the Internet in a networking conference

1999 — Wi-Fi was introduced by Apple

2000 — Connected fridges were launched by LG company

2003 — Home networking became well-known due to the fast networks connecting different devices

2007 — Wearable Internet-connected devices were launched

2008 — Owing to Cisco Systems Inc. the number of the connected devices exceeded the people population in the world

2014 — Wink (an app) was launched able to control smart devices

2015 — In US, Smart home household application reached to 3.7%.

2016 — Security and sustainability of smart homes improved by means of "remote controls"

2017 — Wi-Fi was used more than 75% in US households

2018 — Amazon Echo was introduced to the market, enabled by the voice commands of users to perform a task like playing music

2018 — Smart home applications were related to: lights, thermostats, appliances, energy, entertainment, security, etc.

2019 — 50% Of US households had a smart speaker

2019 — Security cameras became personalized. Smart displays were equipped with shutters and gesture controls. "Echo Show" and "Food Network" offered cooking techniques on smart displays.

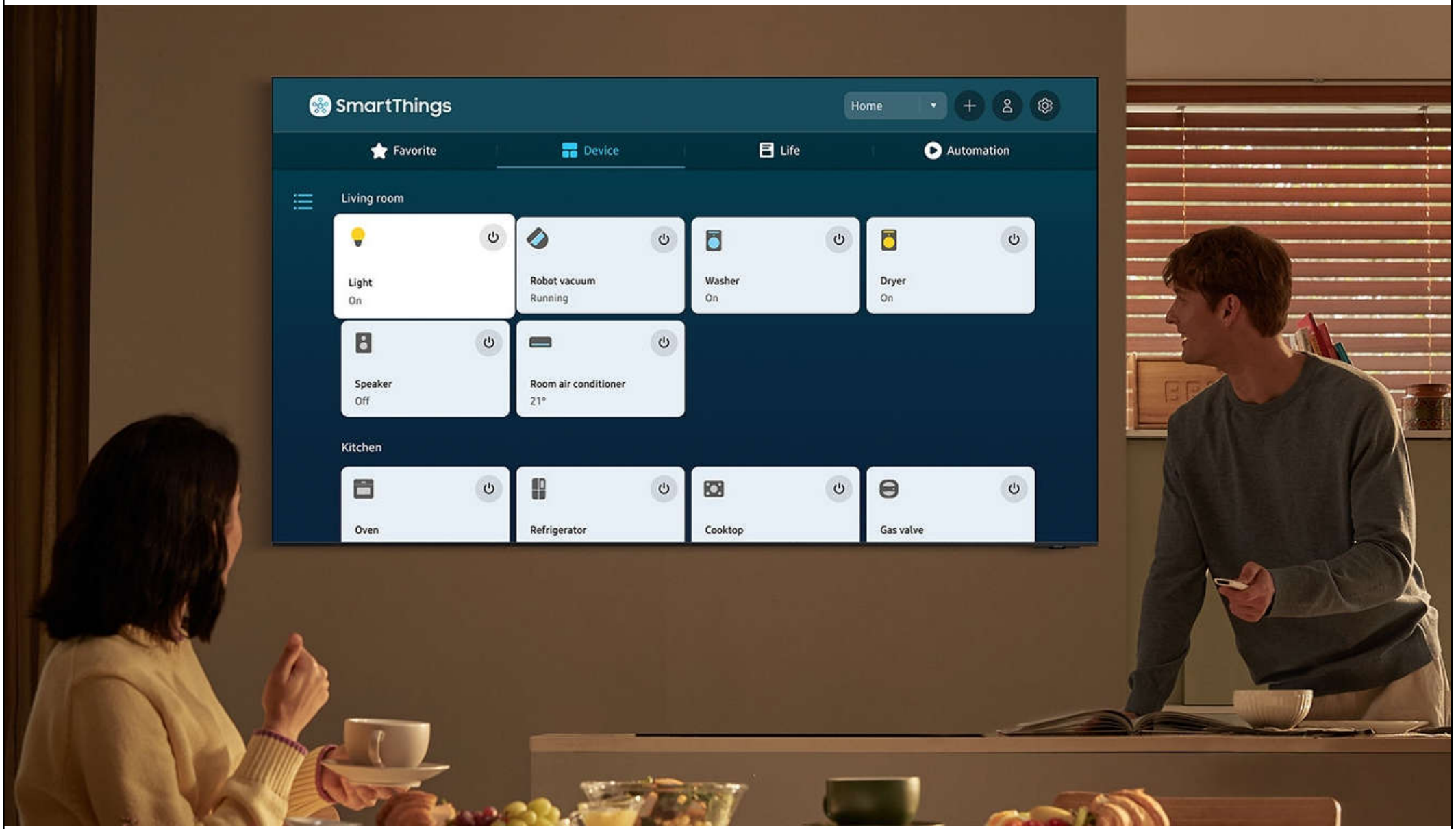
2020 — Robots like LG's CLOi will be used more widely at smart homes.

(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



(Source: https://www.samsung.com/hk_en/tvs/smart-tv/smart-home/)

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/