

Smart Buildings

Leveraging ICTs for Smart Sustainable Cities (SSC)
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What's Really Happening?



www.amjaindell.com

Key Elements of a Smart City



Buildings ...

- Where we spend 90% of our lives
- Where we spend 70% of our electricity
- Where we spend 50% of our energy
- Where we spend 40% of our CO2 emissions
- *Natural counterbalance to fluctuating renewables*
- where we spend a lot of our \$'s
- 2/3rds of the occupants are uncomfortable

} 1/2 Wasted



The need for progress is clear

2

Real estate is the second largest expense on the income statement for most companies.

3

In most organizations the real estate portfolio is on the balance sheet as the third most valuable or expensive single asset.

30 percent

Facilities investments and operating costs can be more than 30% of corporate annual spending.

2025

By 2025, buildings worldwide will become the top energy consumers.

42 percent

Worldwide, buildings consume 42% of all electricity – up to 50% of which is wasted.

1

Buildings are the number 1 contributor to global CO2 emissions.

Source : IBM



Buildings Consume 50% of the World's Energy

Transportation
25%

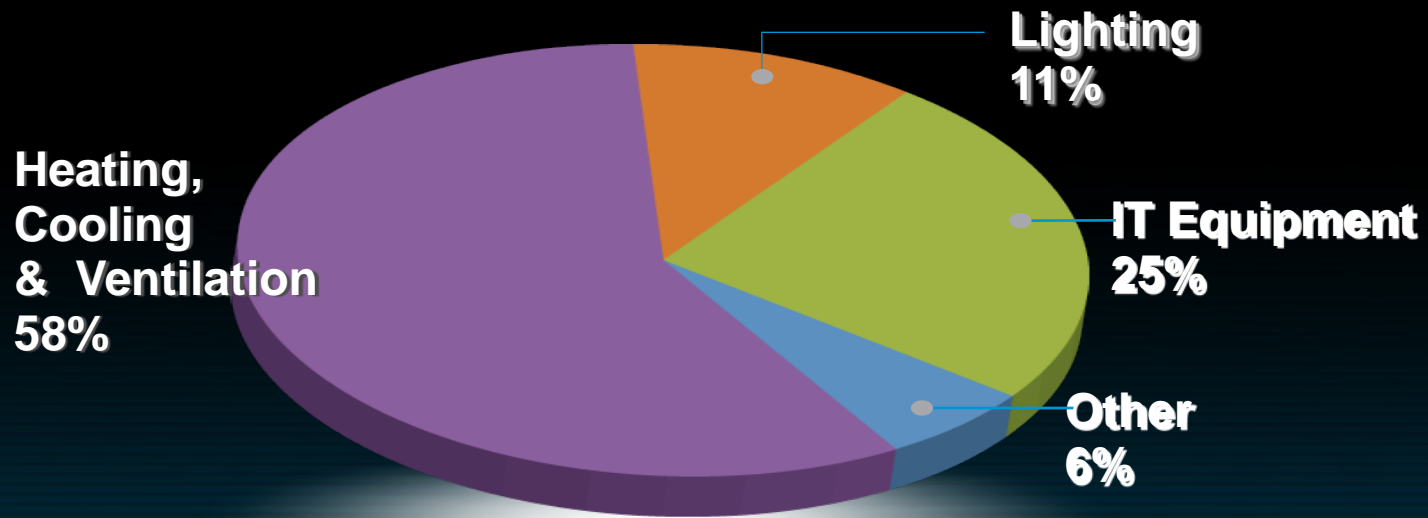
Manufacturing
25%



Buildings
50%

The Energy Consumption of IT Equipment in Buildings is Increasing Significantly

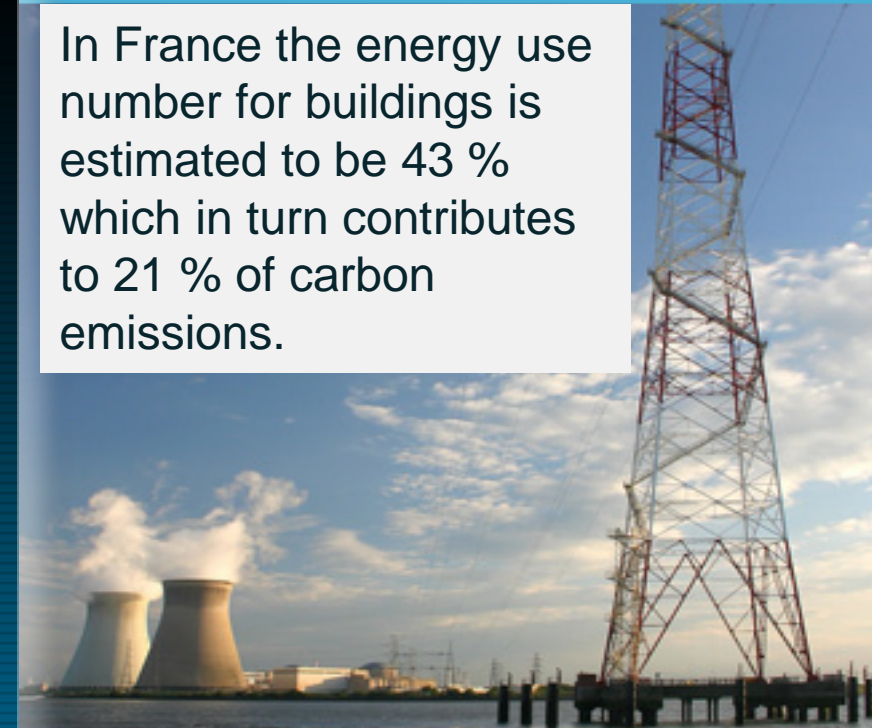
Building Energy Usage



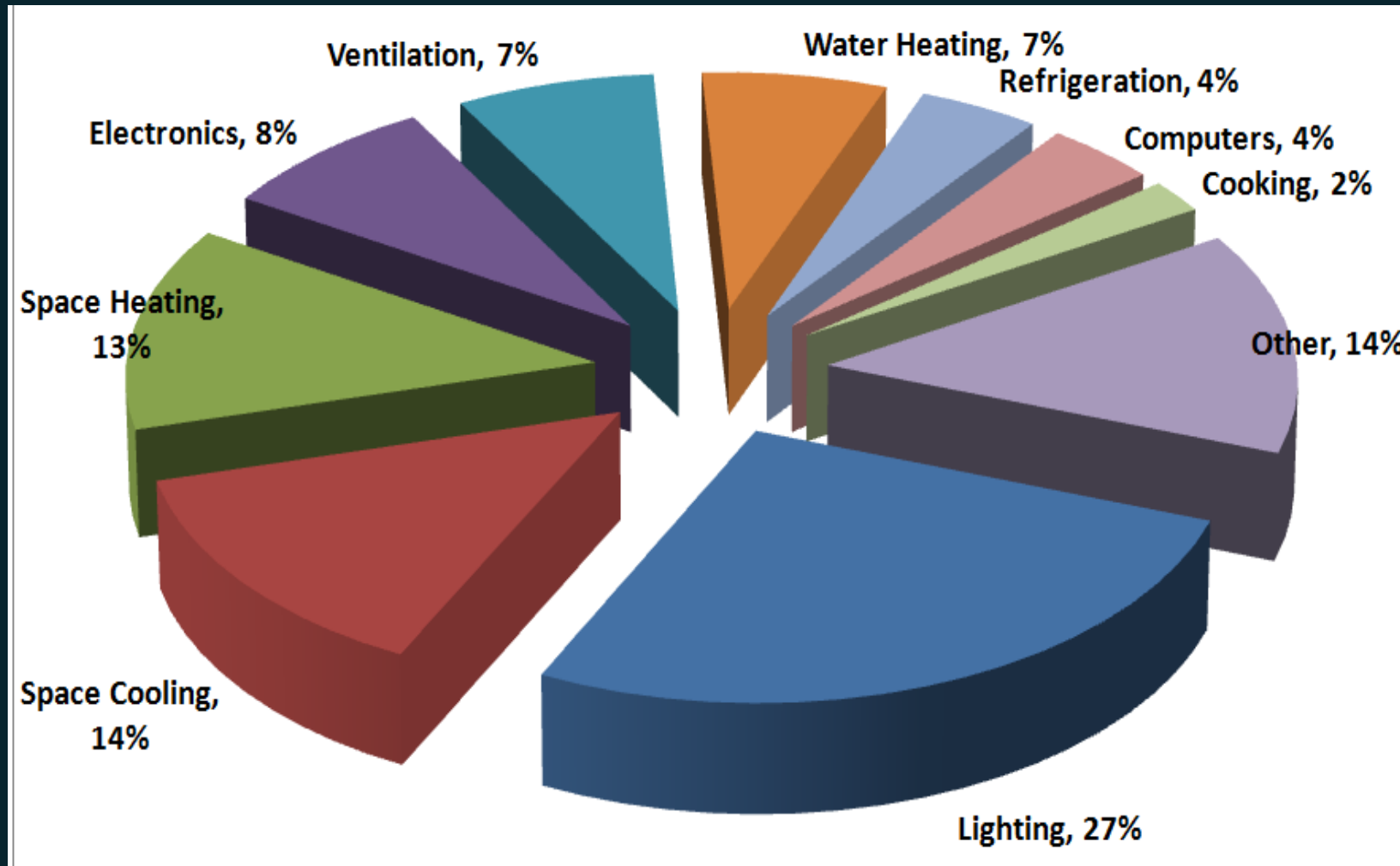
It is estimated that by 2025, buildings will be the number **ONE** consumer of energy in the world.

“... it takes twice as much energy to remove the heat generated ... as it takes to run the equipment.”

In France the energy use number for buildings is estimated to be 43 % which in turn contributes to 21 % of carbon emissions.

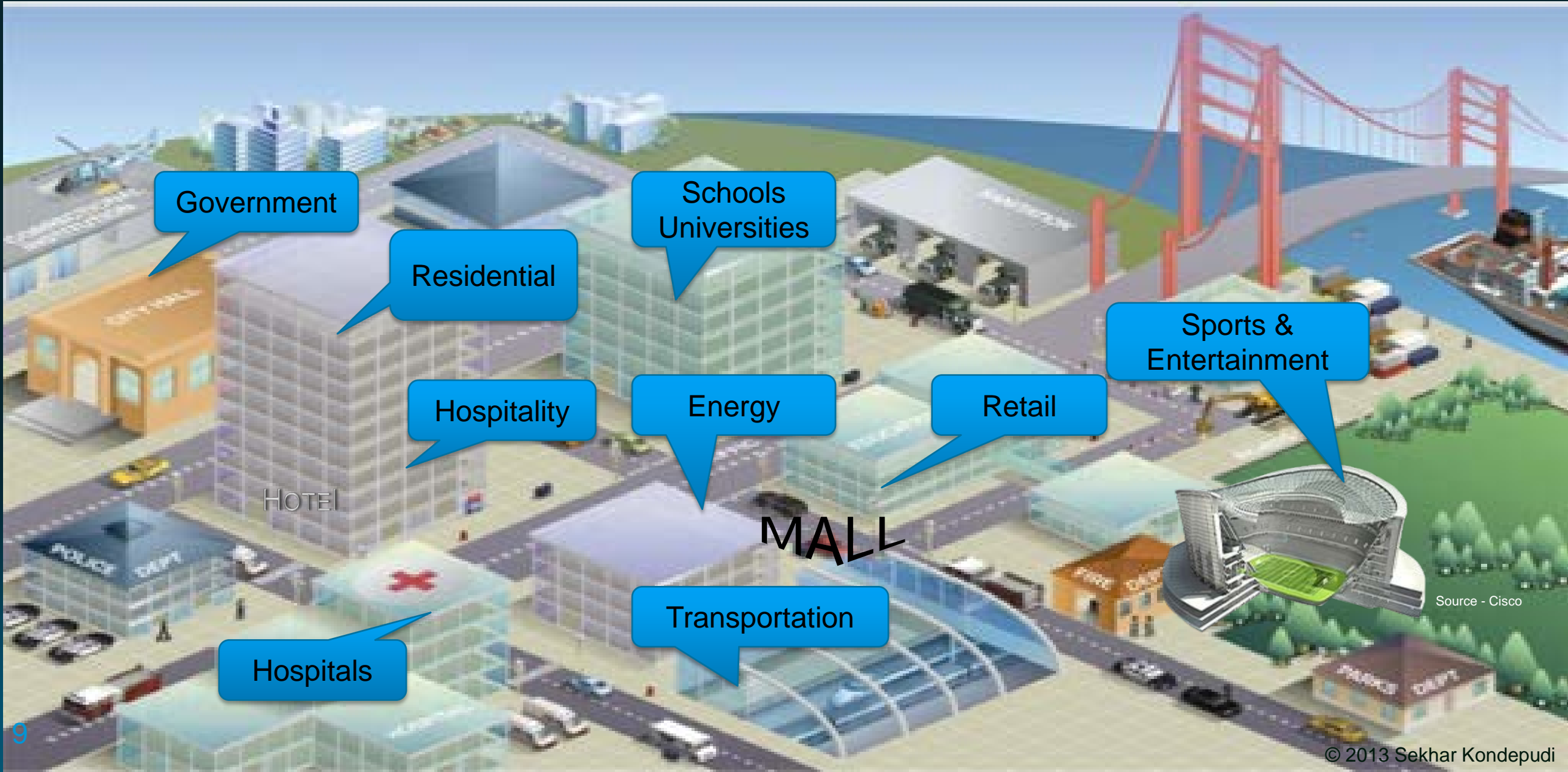


Commercial Buildings Energy Usage



EIA 2008

City / Community = Σ Buildings



Source - Cisco

User Experiences

Home/Residential

Imagine having quick and easy access to the information and government services you need to enhance your personal and professional life



Office

A building that knew when you arrived and left, automatically turned business applications on and off, sends a security alert when an unidentified package is left, or notifies you about peaking energy use



Shopping

Reserve and pay for parking before leaving home; receive real-time sales incentives on your mobile device upon entering the store; real-time video surveillance system



Transportation

Road, railway, and air transportation is the heart of any community. Where transportation services are smart, safe, energy efficient. Where you could access real-time transit information



Sports

Connecting fans with their favorite teams--and each other--in entirely new ways with more immersive, interactive, and personalized experiences



School

Imagine a school where learning extends beyond classroom walls, students are exposed to a wider world of information and experience, and people can collaborate in real time,



Wellness

Receive services from best-in-class healthcare organizations that provide an enhanced patient experience, privacy, and safety.



Government

Imagine a government experience that is engaging, where you can access the information you need to live, work, learn and play in that community



Typical Systems in Buildings

Mechanical Systems

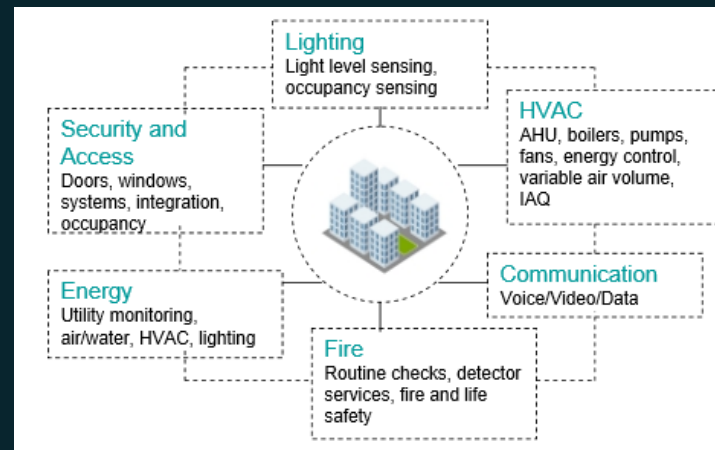
- Heating
- Ventilation
- Air-Conditioning
- Lighting
- Power
- Water
- Elevators
- Metering
- Thermal storage, CHP

Safety & Security

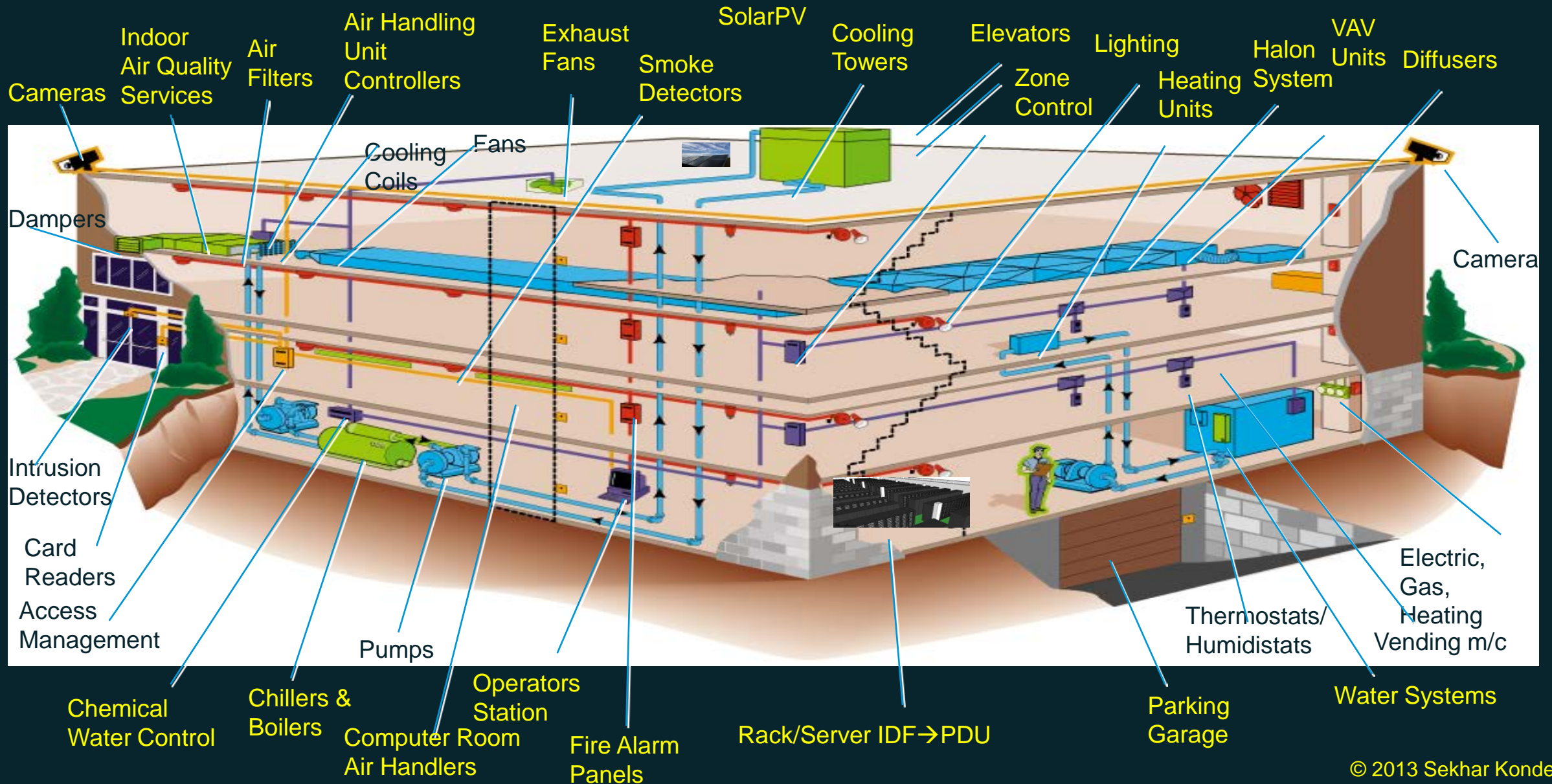
- Alarms
- Fire Detection & Suppression
- Intrusion
- Access Control
- Video Surveillance
- Scanning
- Evacuation
- IAQ – Smoke, CO2, CO

Communication & Networks

- High Speed Internet
- Common Network Infra
- Wireless Mobility - WiFi
- Remote Site Mobility -VPN
- IP Telephony - VoIP
- Audio -Video Conferencing
- Visitor Management
- Interactive Media / Signage



A Building = Σ Many Devices & Sub-Systems

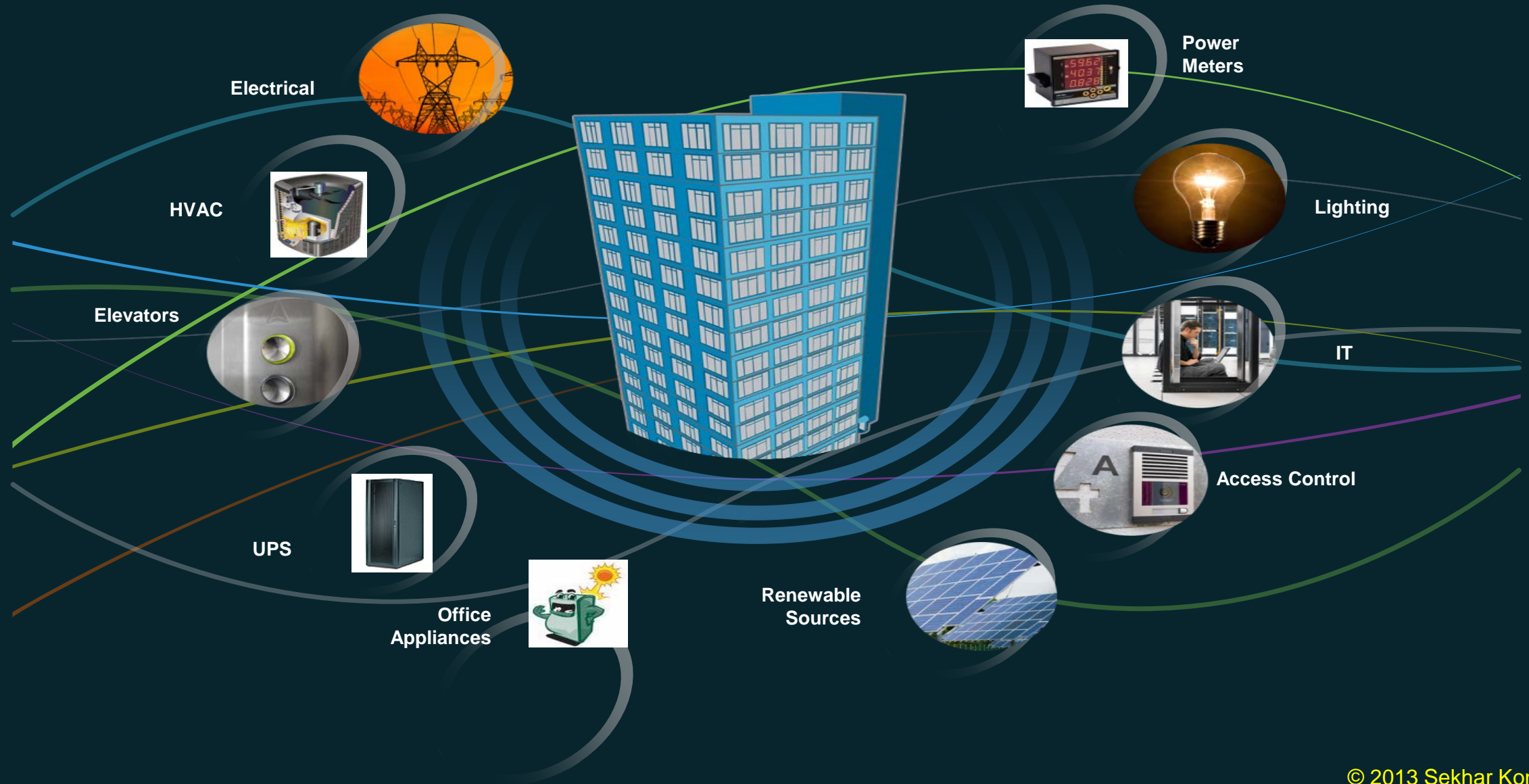


Building Services

- **Physical Services** (Building Systems HVAC, Lighting, Elevators etc)
- **Infrastructural ICT Services** (Pagers, Information System, Trouble Ticketing, Server farm, Office Systems, E-Mail, VoIP, VoD, Space-Management, Telecommunications)
- **Security Services** (Fire Alarm, Intrusion, Inundation, CO, CO2, Nox, Access Control, Asset Tracking, CCTV)
- **Enterprise Services** including CRM, ERP, Business and Financial Applications.

Energy and Facility Management

Today's Disparate Building Systems



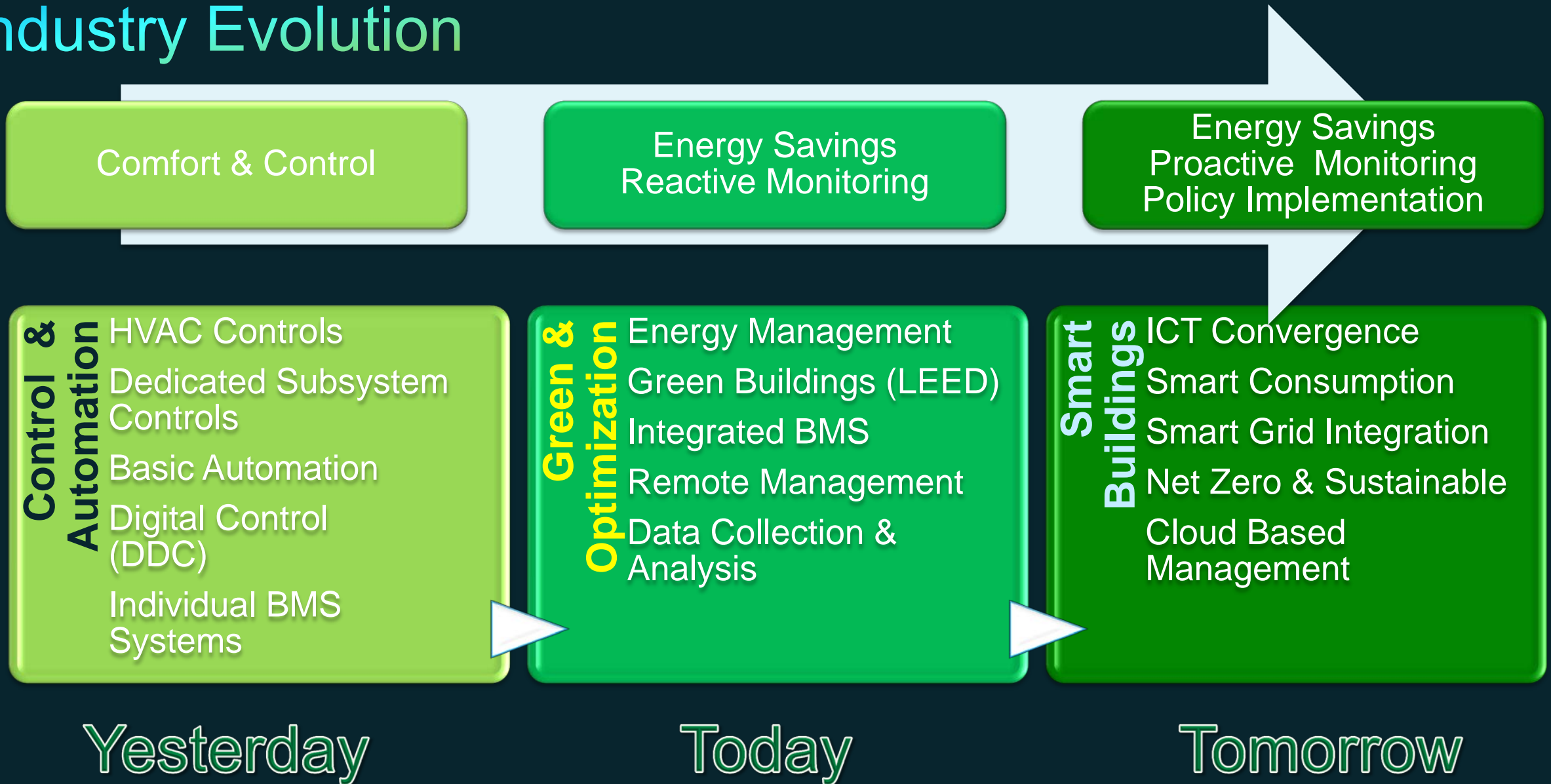
Siloed Systems in a Building

Integrating Across Silos							
Power	HVAC	Lighting	Access	Video Security	Life Safety	IT	Network
Power Monitoring Control Systems	Building Automation Systems	Lighting Control	Active Access Control Biometrics	Network Digital Video Recorder Video Analytics	Life Safety Systems	White Space IT Apps	Network Mgmt Systems
Emergency Power Supply Utilities	Chillers Boilers Air Handlers	Lighting	Locks Doors Gates Man-traps	Cameras Housings	Fire & Smoke Detectors, Sprinklers	Servers Computers Wiring Closet	Routers Switches Phones

Convergence



Industry Evolution

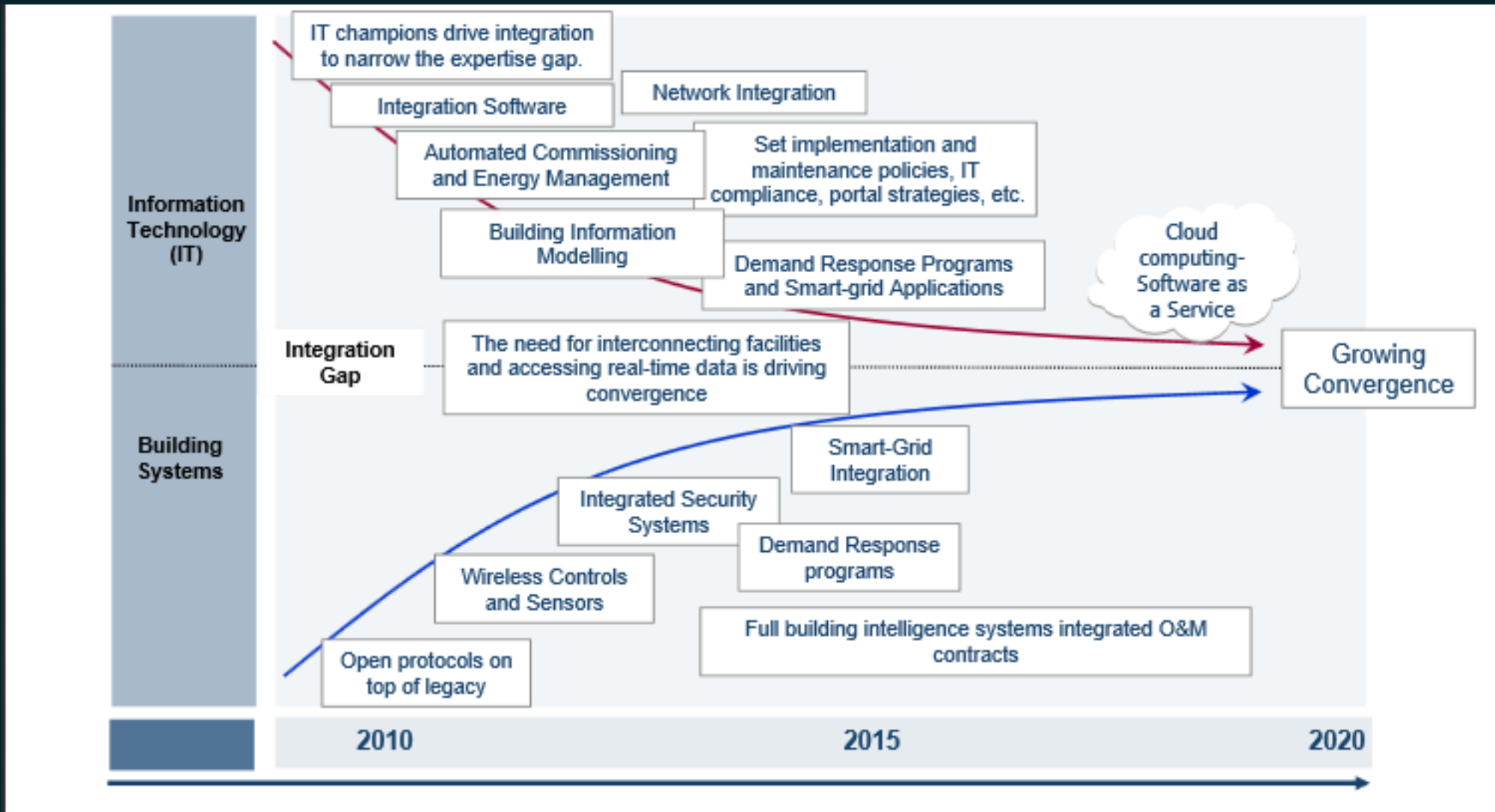


Yesterday

Today

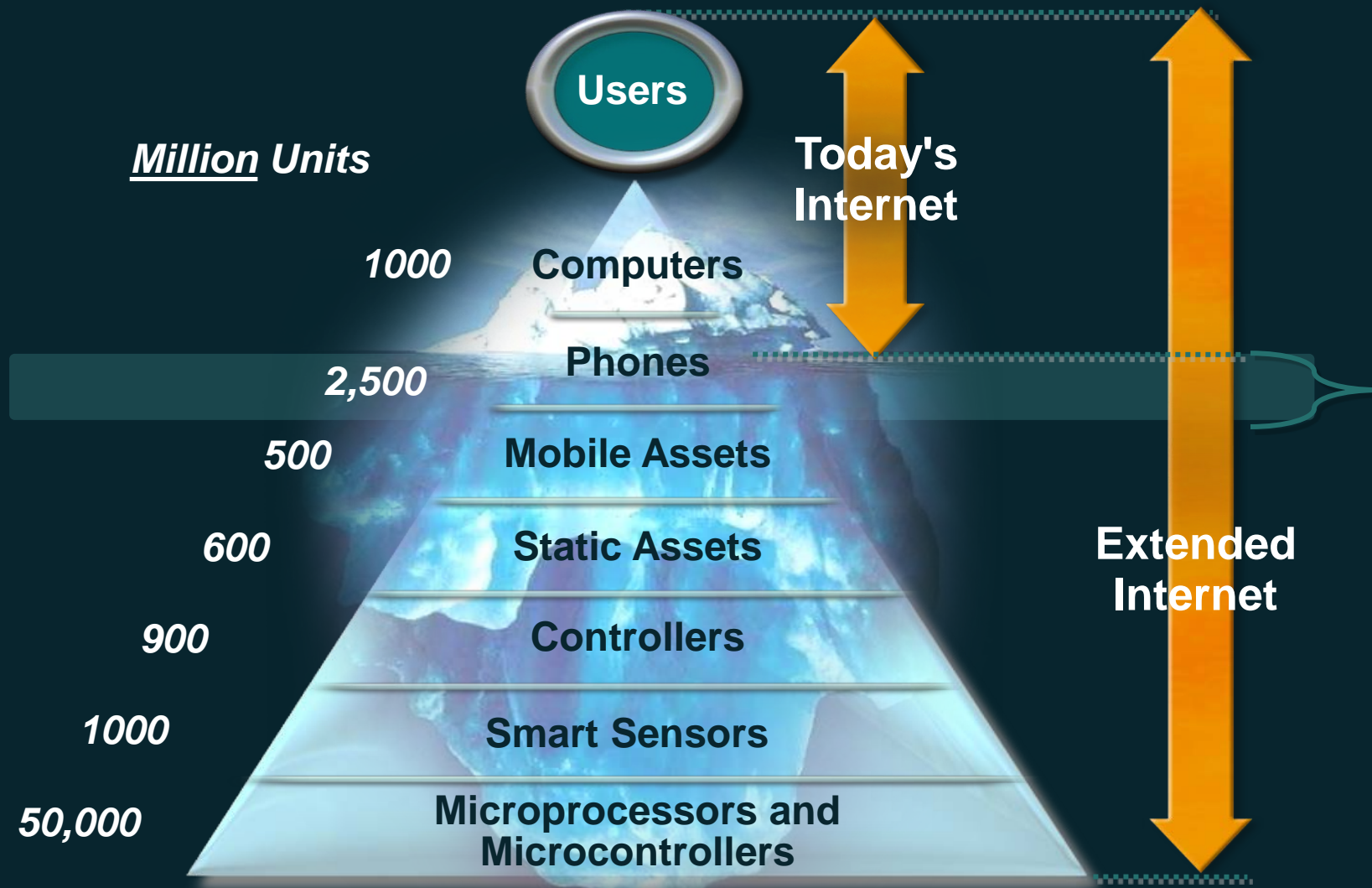
Tomorrow

Convergence Between Traditional Building Systems & IT Systems



Source : Frost & Sullivan

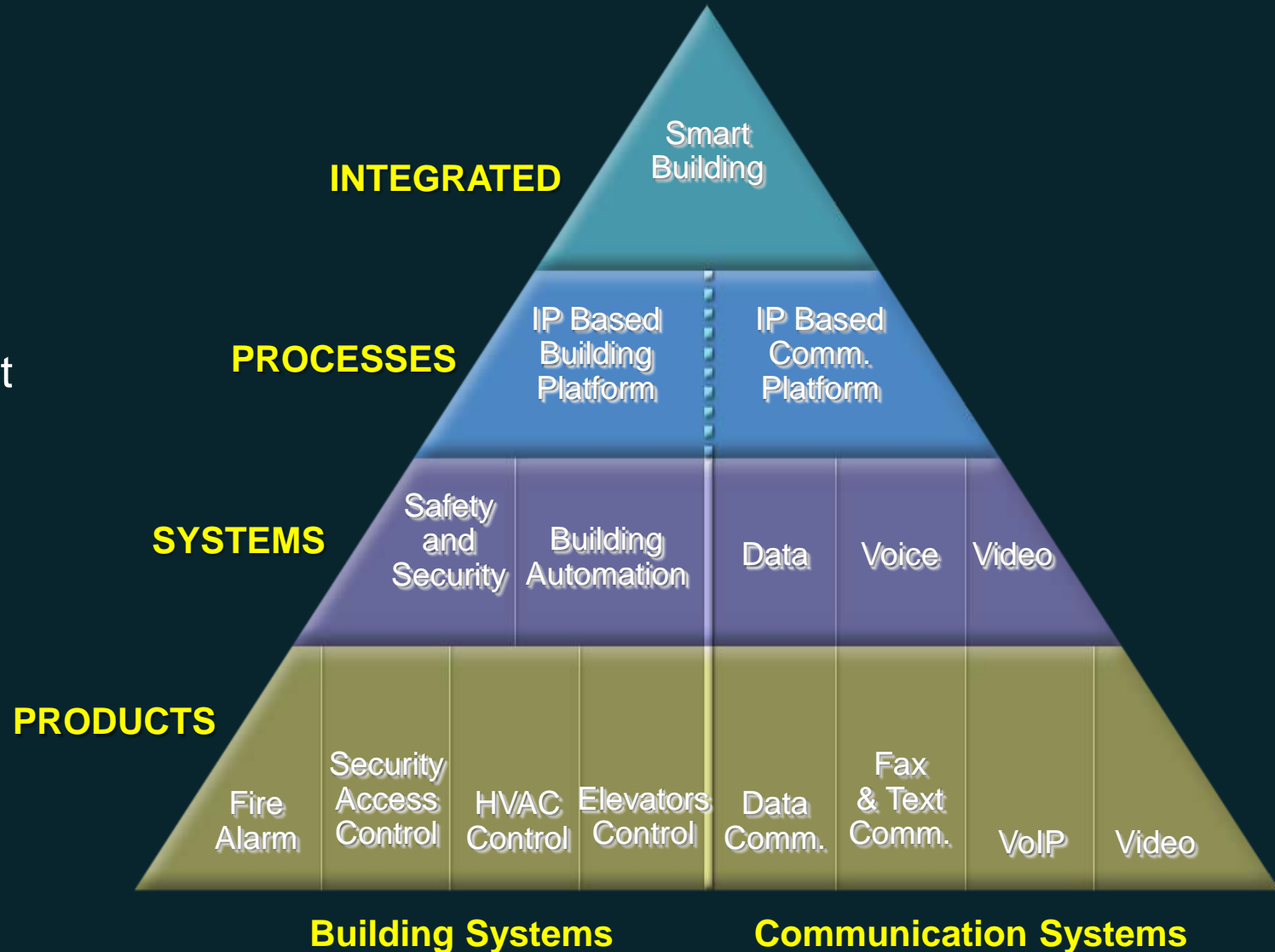
Proliferation - Buildings will have Billions of New Devices



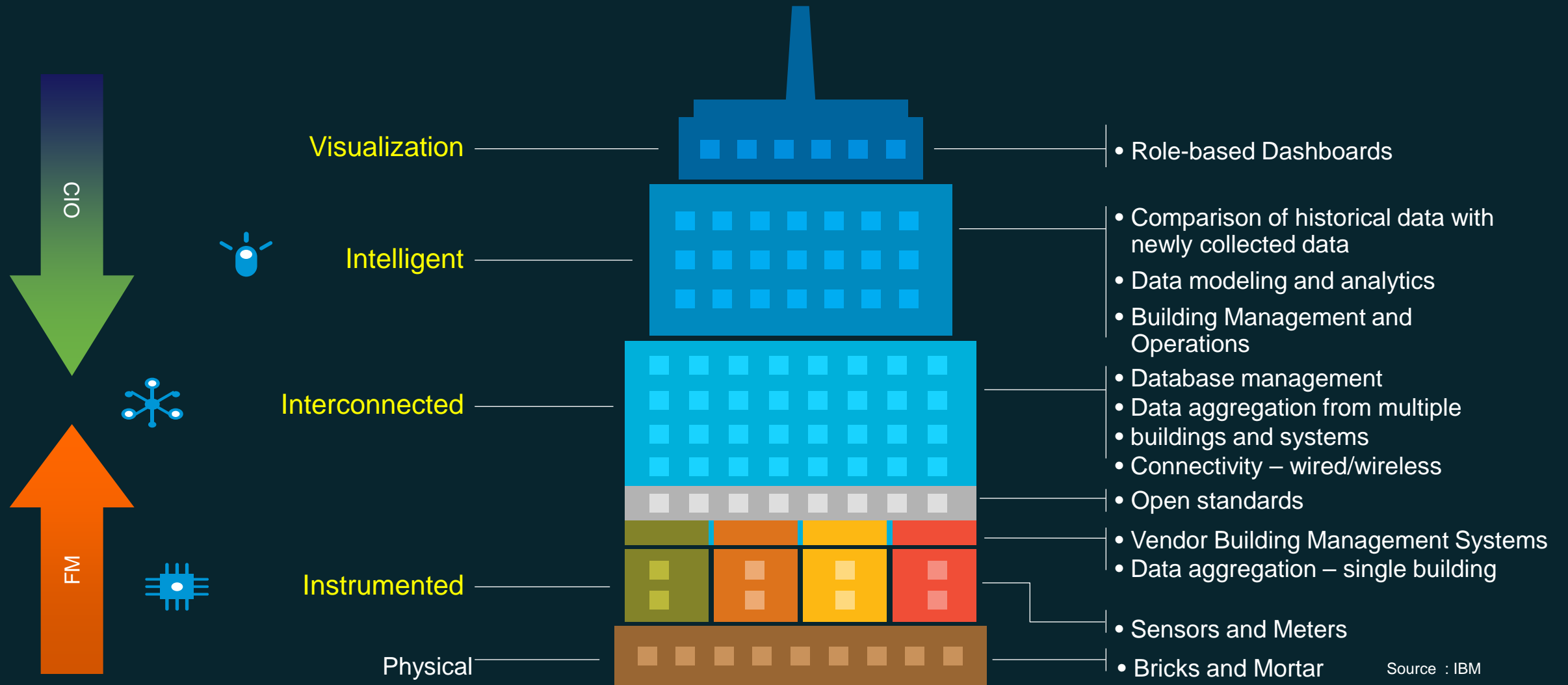
Extrapolated from Harbor Research, Forrester Research,

Convergence & Network Infrastructure

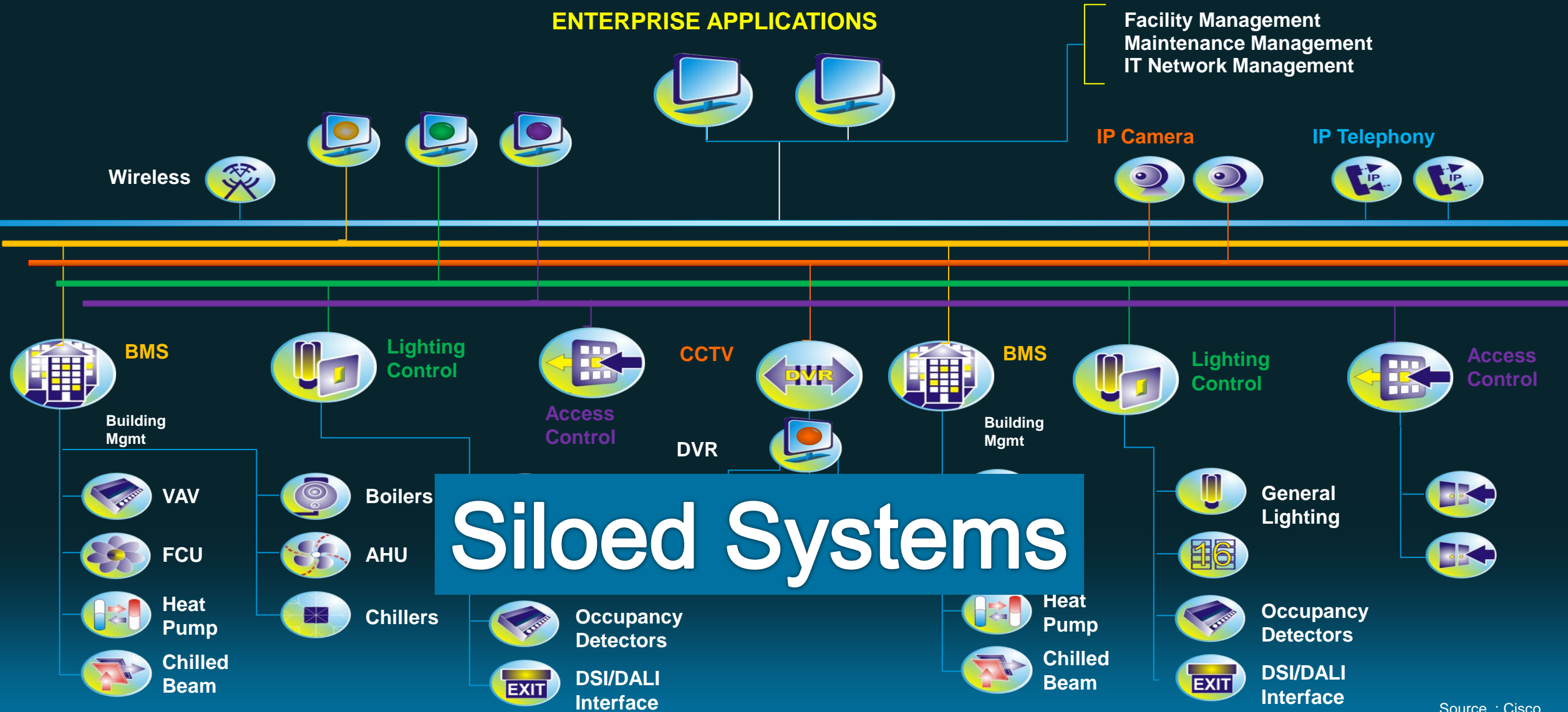
- Convergence is about gathering information and making decisions based on it.
- Without a good, robust network centric infrastructure, buildings can't do that.
- The fundamental objective is to get at all the data in a consistent manner.
- Plumbing – Facilities
- Control – Network .



Convergence creates a smarter building



Before Convergence



Source : Cisco

After Convergence

Middleware Server

Disparate Protocols to Common Format + ICT Integration

ENTERPRISE APPLICATIONS

- Energy Management
- Building Management
- Facility Management
- Security Management
- Maintenance Management
- IT Network Management

Wireless

IP Camera

IP Telephony

Energy & Power Metering

BMS

Lighting Control

UPS Monitoring

CCTV

Access Control



VAV

FCU

Heat Pump

Chilled Beam

Fire Alarm System



Boilers



AHU



Chillers



Smoke Sensor

Break Glass



Sounder



General Lighting



DVR



Channel Controllers



Occupancy Detectors



DSI/DALI Interface



Door Controllers



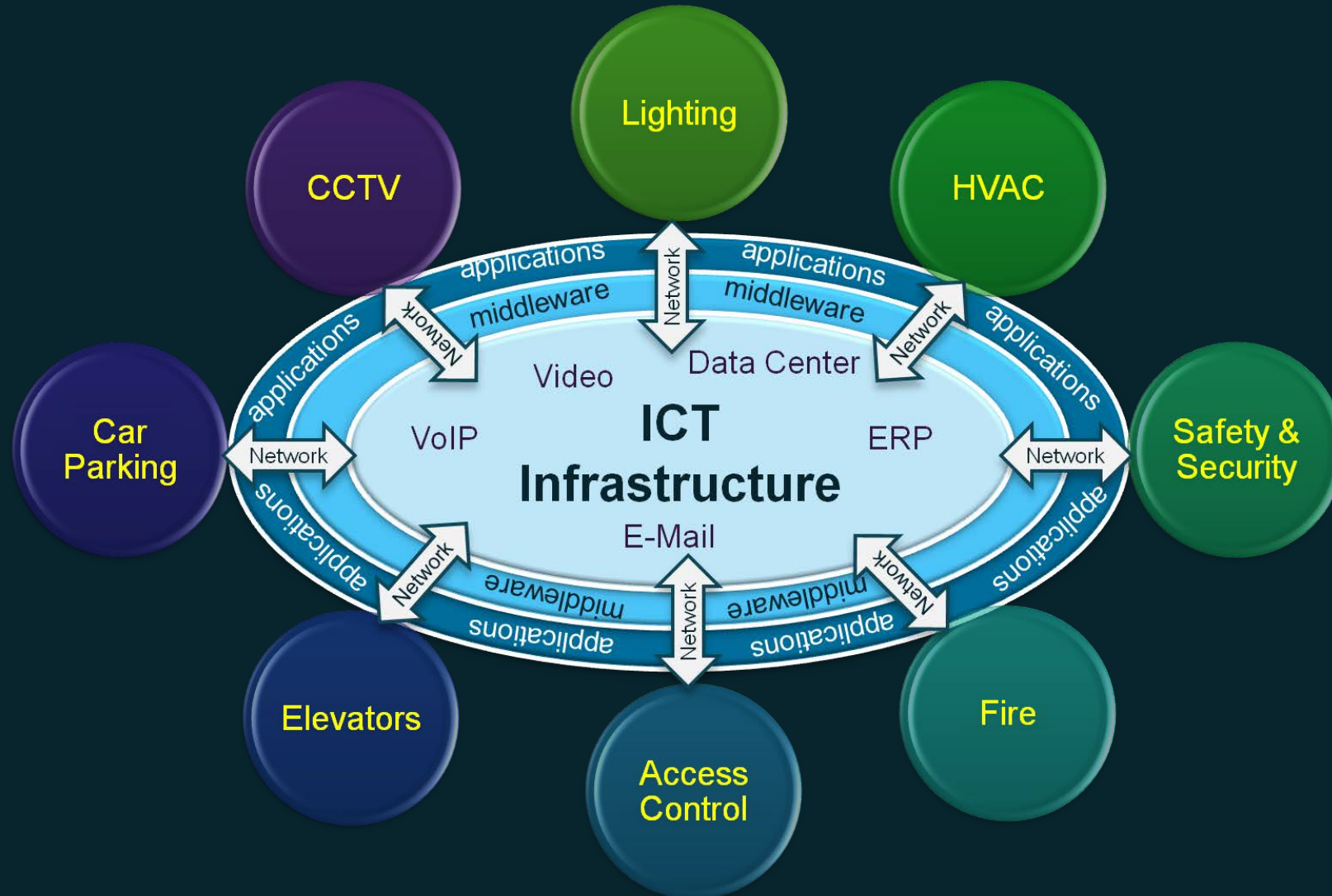
Reader Technology



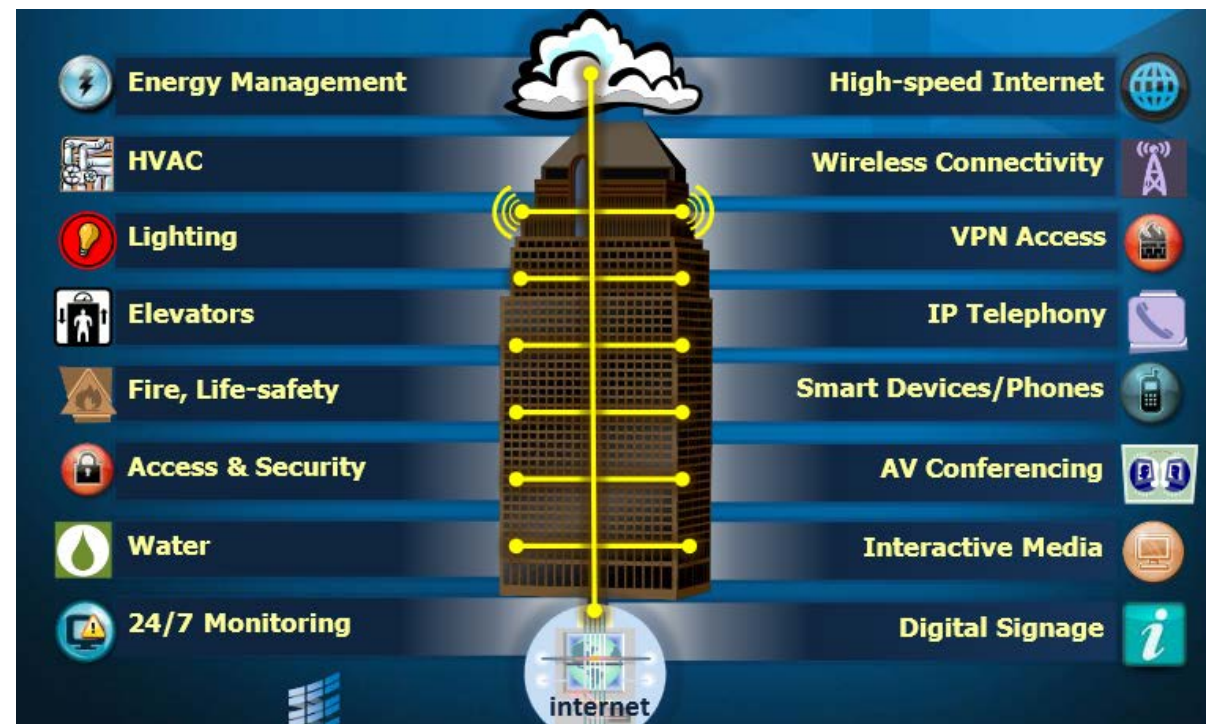
Intruder Panels

Source : Cisco

ICT AT the CORE



Smart Buildings



'Intelligent' Building Definition

- An intelligent building is a *dynamic and responsive* architecture that provides every occupant with *productive, cost effective and environmentally* approved conditions through a continuous interaction among its four basic elements: *places* (fabric; structure; facilities); *processes* (*automation; control; systems;*) *people* (services; users) and *management* (maintenance; performance) and the *interrelation* between them.
- CIB Working Group 1995
- "Intelligent buildings are buildings that through their physical design and IT installations are responsive, flexible and adaptive to changing needs from its users and the organisations that inhabit the building during its life time. The building will supply services for its inhabitants, its administration and operation & maintenance. The intelligent building will accomplish transparent 'intelligent' behaviour, have state memory, support human and installation systems communication, and be equipped with sensors and actuators."
- Per Christianson (2000)
- "Intelligent buildings should be sustainable, healthy, technologically aware, meet the needs of occupants and business and should be flexible and adaptable to deal with change"
- Clements-Croome (2007)
 - be *flexible* and *responsive* to different usage and environmental contexts
 - be able to *change state* (with long and short term memory)
 - support *human communication*
 - accomplish *'intelligent' behaviour* and *transparent intelligence*
 - *Integrate* the different systems in a building to form a holistic system

What is a Smart Building?

Smart Buildings are well managed, integrated physical and digital infrastructures that provide optimal occupancy services in a reliable, cost effective, and sustainable manner.



- It is a building that is managed comprehensively from design to demolition
- it is equipped with the right instruments and systems to enable monitoring and optimal operations
- it is integrated with the utility smart grid to take advantage of time-of-use electric rates, and to minimize consumption during peak hours
- it is capable of producing at least part of its energy needs; it might even capture rainwater, and minimize wastewater; and most importantly
- it has user interface tools to keep the occupants aware of the real time parameters of the building and empowers them to impact those parameters.

Source : IBM

Smart Buildings

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

Building Management System

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

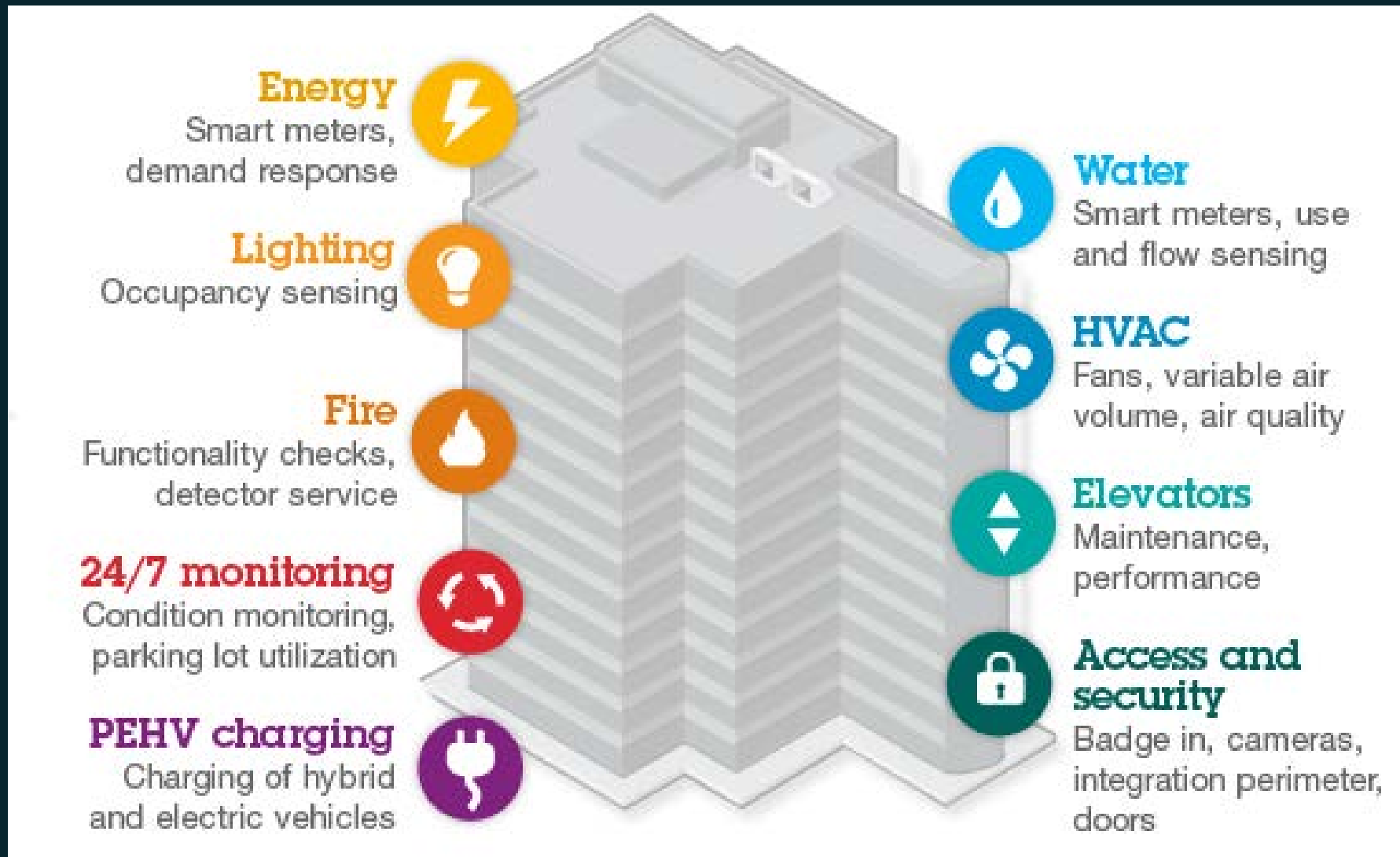
electricity storage
electricity grid

combined heat and power system
ev-charging poles

UPS

Multiple Sub-Systems

Systems in a Smart Building



Source IBM

How does a Building Become Smart?

Building Portfolio

Asset Mgmt

Energy Use

Maintenance

Occupancy

Facilities

Waste Management

Carbon Compliance

Vertical Aspects

Analytics and Optimization



Water
Smart Meters,
Use / Flow Sensing



Energy
Smart Meters,
Demand response



Elevators
Maintenance,
Performance



Fire
Functionality
checks,
Detector service



HVAC
Fans, Variable Air Volume,
Air Quality



24/7 Monitoring
Condition Monitoring, Parking Lot
Utilization



Access/Security
Badge in,
Cameras, Integration
Perimeter, Doors,
Floors, Occupancy



Lighting
Occupancy
Sensing

External Integration

Weather

Public Safety

Utilities

Citizen / Social

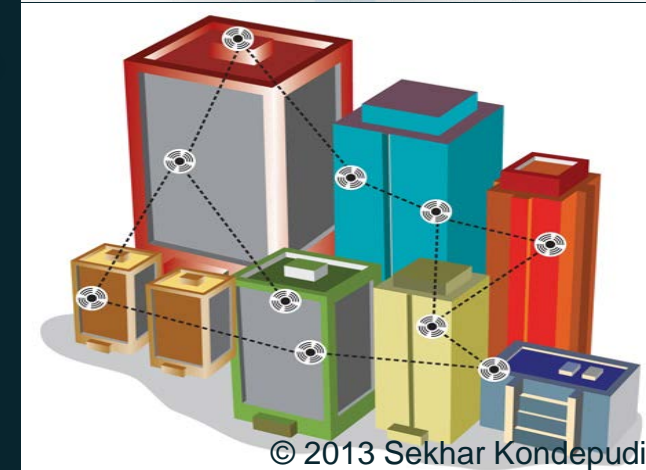
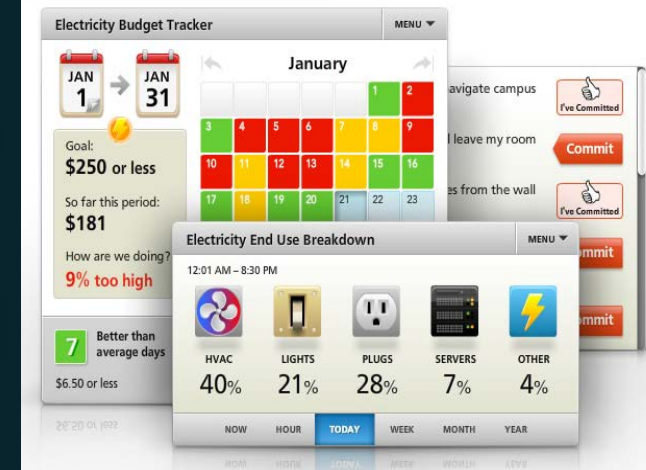
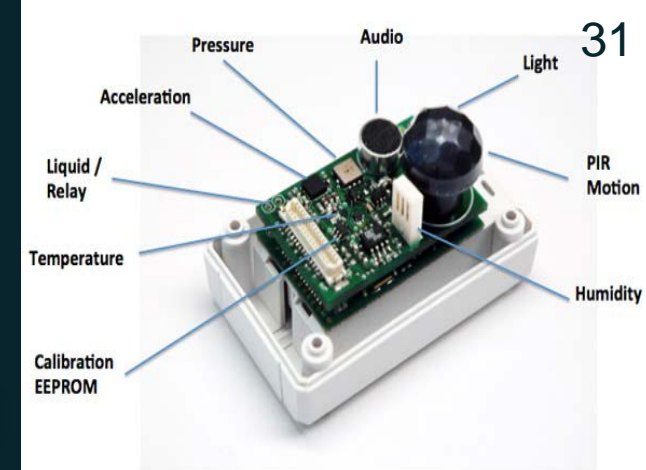
Advertising

Voice / Video / Data

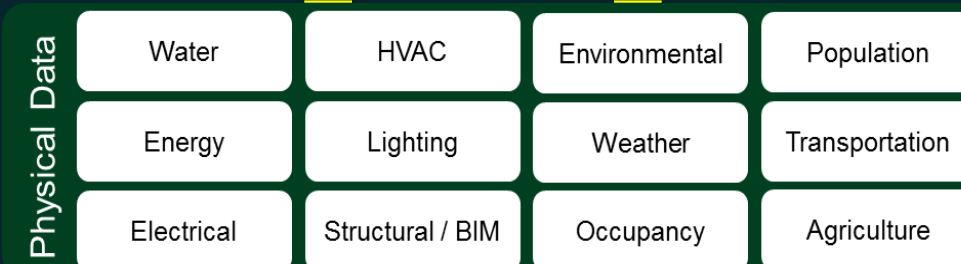
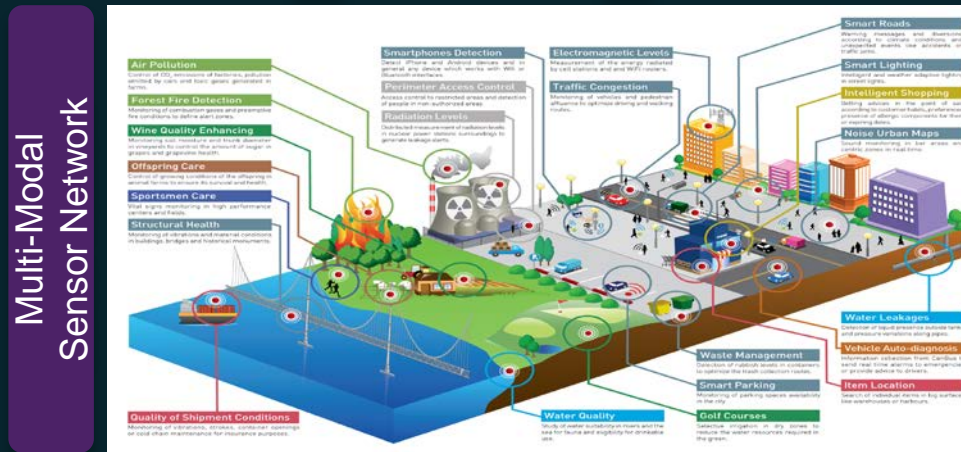
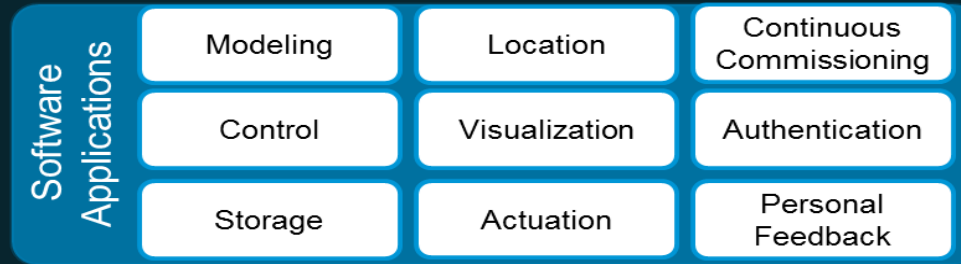
Adapted / Modified from IBM

Analytics, Informatics & Dashboards

- **Wireless Sensor Networks**
- **Energy & Environmental Data**
View, Compare, Share
- **Analytics**
Prediction
Energy Savings Strategies
Operational Optimization
- **Real-time Information / "Pulse"**



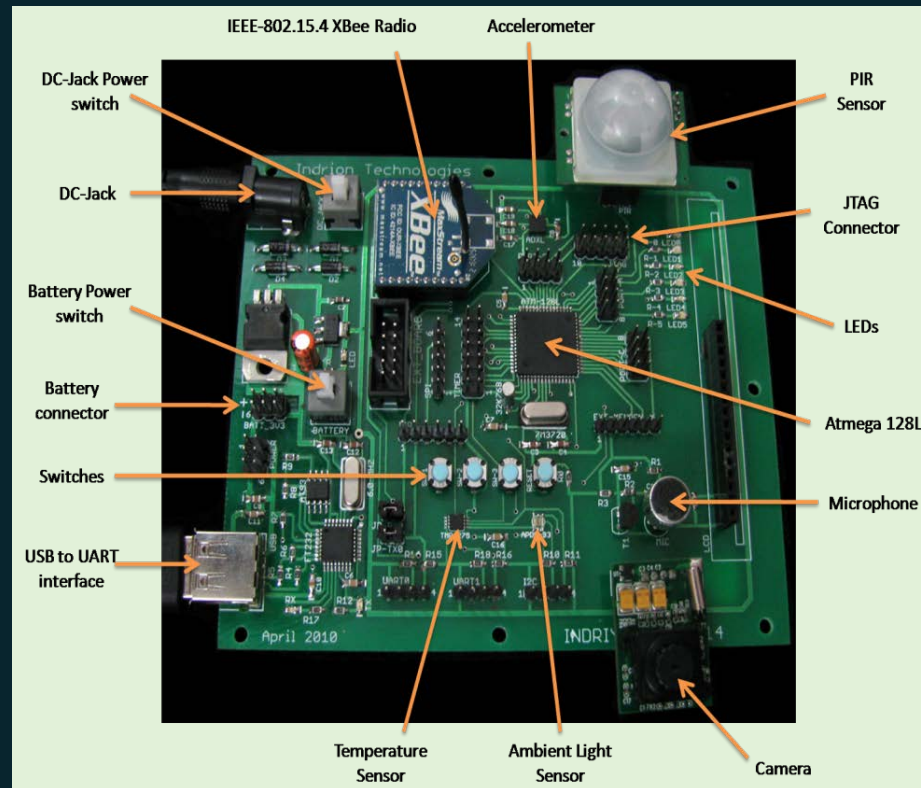
Leverage ICT / Devices To Achieve Sustainability



Concept Adapted from sMAP, UC Berkeley, Libelium

Wireless Smart Devices for the Built Environment

- Plug Load
- Temperature
- Humidity
- Air Flow
- Light
- Noise
- Motion
- Visual



In-Line Power



Temperature



Power Adapter



Light (Lux)

Wireless Building Energy Solution

Measure, Monitor, Analyze, Optimize Control

3

ICT & Device Scale (Micro)
Internet of Things

Current

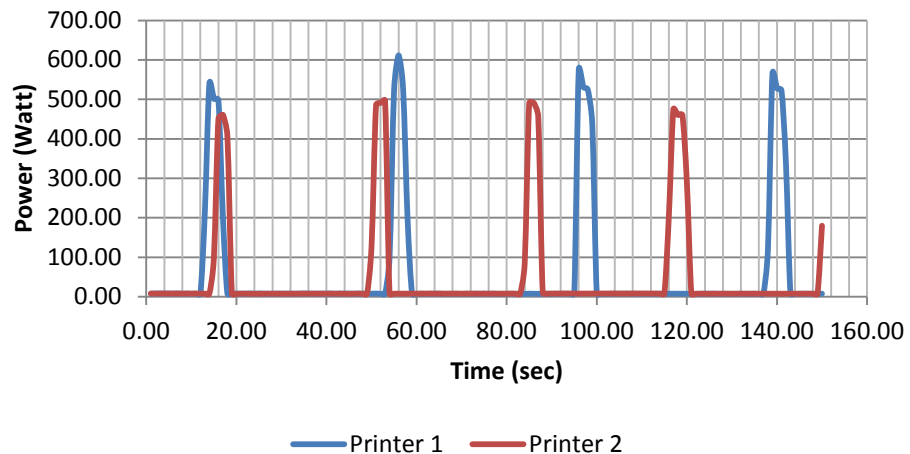
- Integrated solution for
 - Automated Indoor / Outdoor Lighting Management
 - Desktop & Connected Devices Power Management
 - Integration with Access Control (early stage)
 - Cooling/Heating Systems (next stage)
- Technologies
 - Wireless Sensor & Control network
 - Over the Air Real-Time Updates
 - Cloud / Mobile Command & Control
 - Support for CFL as well as LED lighting
 - Anytime, Anywhere Access
- Real Time Analytics
 - Facility wide data @ different level of granularity
 - Conference Room Utilization data



- User Comfort & Optimization
 - Scenes & Schedules for different zones
- Completely Automated Solution
 - Avoids manual interventions & errors
 - Almost switch-less environment
- Providing benefits for
 - Retrofit / Brownfield Sites
 - Energy Savings
 - Efficient utilization of resources
 - Productive & Comfortable work environment
 - Ease of Installation/Maintenance

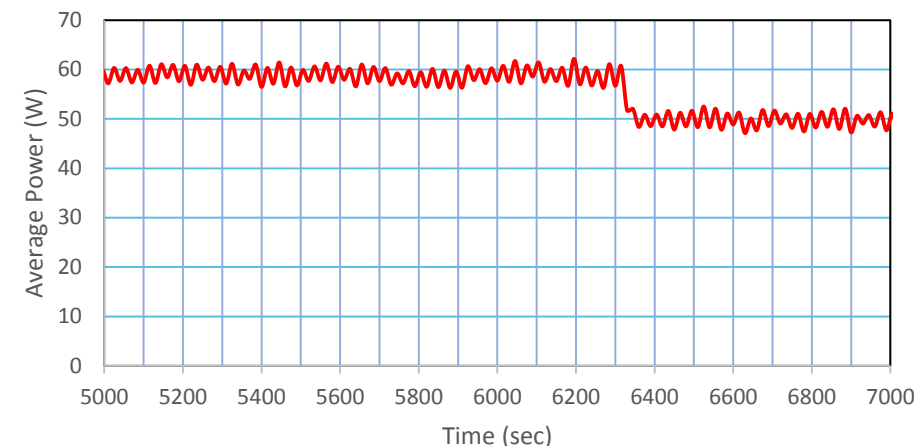
MFD Printers (Desktop, Monochrome)

Printer (MFD) - Idle State



Spike every 40 seconds (keep the drum warm ?)
Spike lasts for 7-8 seconds
Consumes up to 500W during that small timeframe
Trend similar with Other MFD printer

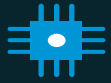
Printer (MFD) - Idle State



Snapshot of Field Data
Captured at 15 sec intervals over multiple weeks
Range between 50 and 60 W
Energy Consumption Consistent with Detailed Per Second Data

Assume 50 W for 12 hours a day X 365 Days X \$ 0.25 / Kwh ~ \$ 55.00 / year / printer
At least 3000 such printers on NUS Campus = \$ 165,000 savings annually

What does it mean to become Smarter?



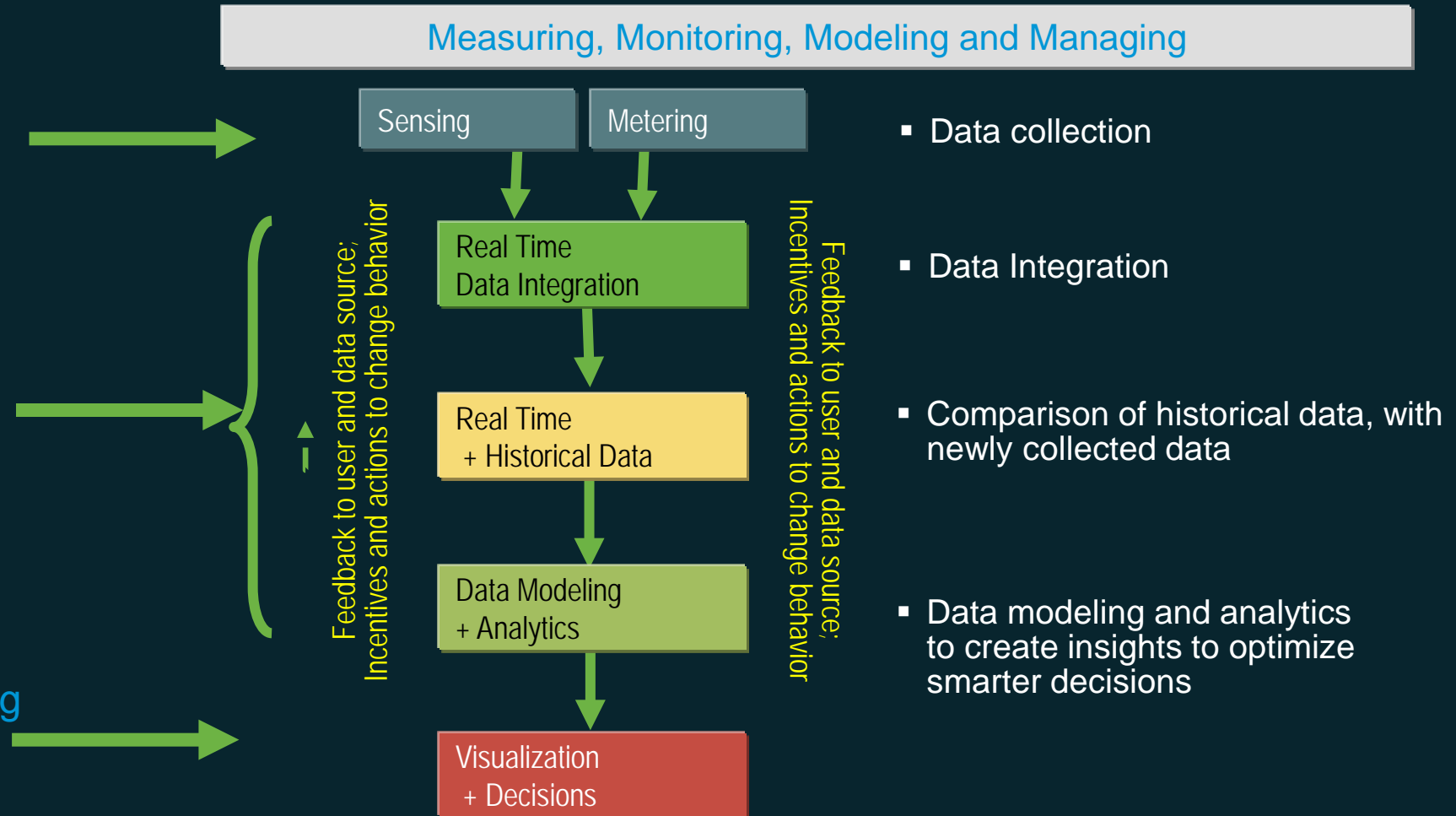
Our world is becoming
INSTRUMENTED



Our world is becoming
INTERCONNECTED



Virtually All things are becoming
INTELLIGENT

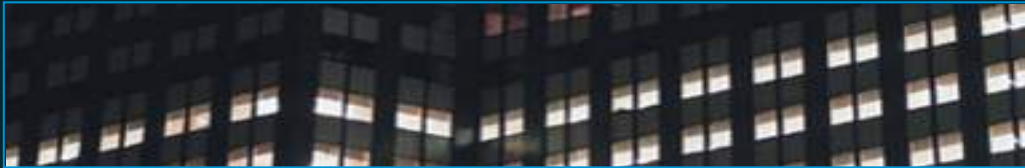


Source: IBM

What Does it Mean to be a Smarter Building ?

The interconnection of physical assets and information technology can optimize efficiency, production and consumption in many types of buildings.

Smarter Commercial Building



- Provides integrated facilities operations information for owners/operators in order to optimize energy usage and services based on tenant's needs.

Smarter Cell Tower



- Integration of active and passive management enables optimized operations to reduce truck rolls.

Smarter Data Center



- Integrated facilities and IT insight to energy efficiency of datacenter and the correlation of IT and facilities information.

Smarter Campus

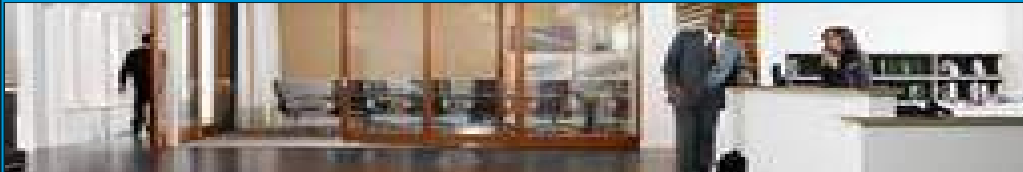


- Intelligent infrastructure platform and tools to manage plug-in electric vehicle stations, buildings, badging, central utility plant

What Does it Mean to be a Smarter Building ?

The interconnection of physical assets and information technology can optimize efficiency, production and consumption in many types of buildings.

Smarter Hotel



- Integration of all the guest subsystems of hotel that welcome guest according to their preferences and adds to convenience during stay.

Smarter Airport



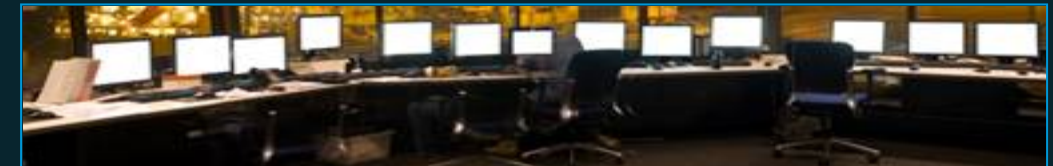
- Provides efficient passenger and cargo services, climate control, wi-fi access, track maintenance tasks and help achieve security and safety compliance

Smarter Hospital



- Sensor instrumentation used in real-time for asset location and automated workflows such as medical equipment maintenance.

Smarter Government Building



- Utilize fully serviced office hubs and mobility tools to improve public services. Match occupancy levels with portfolio wide estates data to optimize building utilization.

In Summary





Smart Real Estate & Buildings

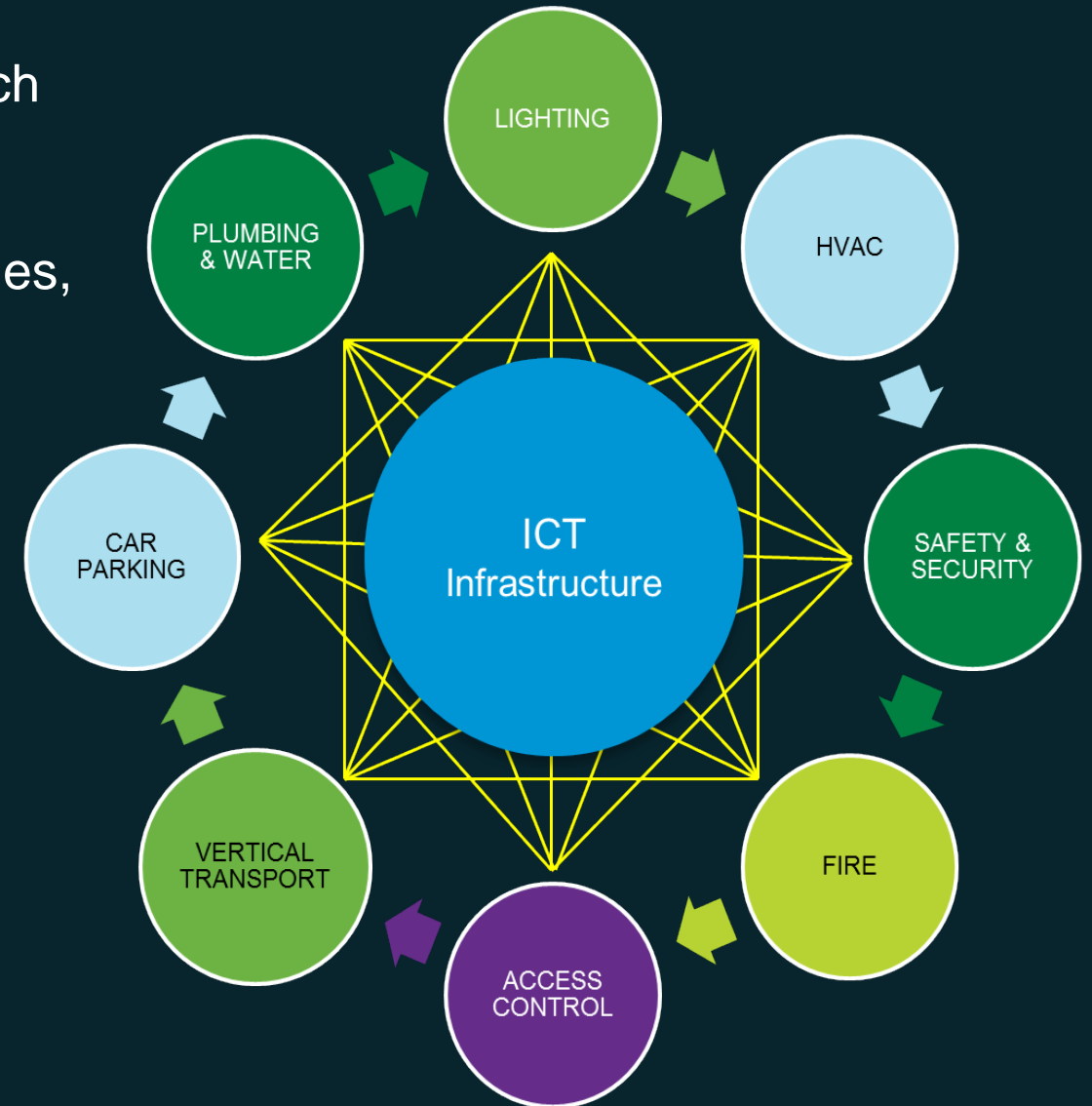
- ... solutions that turn buildings into living organisms: networked, intelligent, sensitive and adaptable ...
- ... synergies between energy efficiency, comfort and safety and security
- Building as a Network – Integration of Multiple Technologies (HVAC, Lighting, Plug Loads, Fire, Safety, Mobility, Renewable, Storage, Materials, IAQ etc)
- Software – Efficiency, Automation & Control , Analytics & (Big ?) Data Management
- Integration with Smart Grid
- Distributed Energy
- Coexist with Productivity, Efficiency, CSR, Sustainability and GHG reduction goals

The Building as a Network

- Variety of Building Functions / Sub-Systems all of which coordinate with one another
- Sub-systems, components & devices which have nodes, end points and behave like a network in terms of their end use characteristics and interactivity with other nodes.
- “System of Systems” or a “network of networks”
- “Internet of Things” (IoT) for Buildings.
- This is completely analogous to an IT or Data Communications network

Example : Car Parking & Ventilation

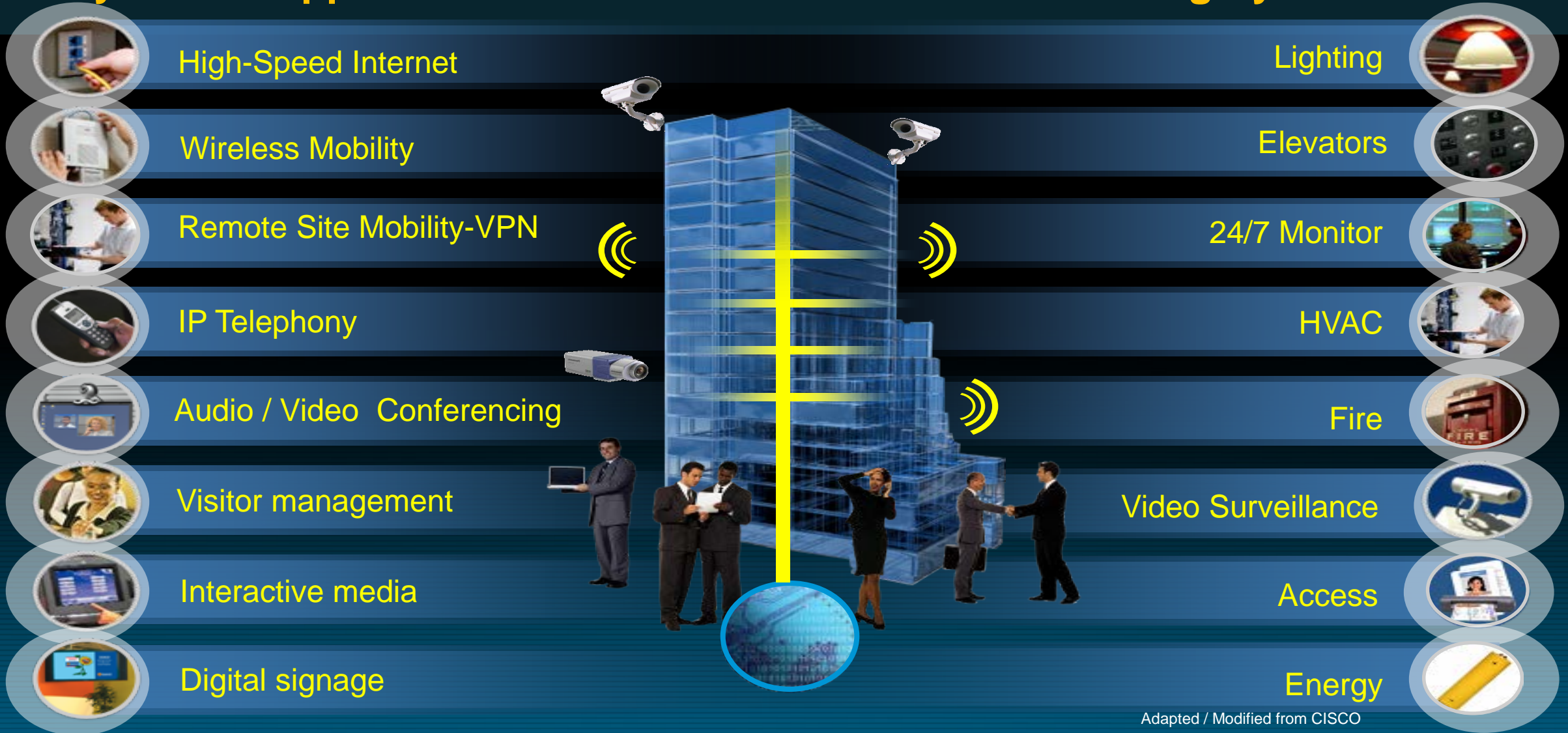
Example : Car Parking, Security, Access Control Lighting



Converged "Smart" Building

IT Systems / Applications

Building Systems



Adapted / Modified from CISCO

Smart Buildings – Analogous to the Human Body

“The Skin”

Dense sensor network on building surface and embedded in the systems and materials

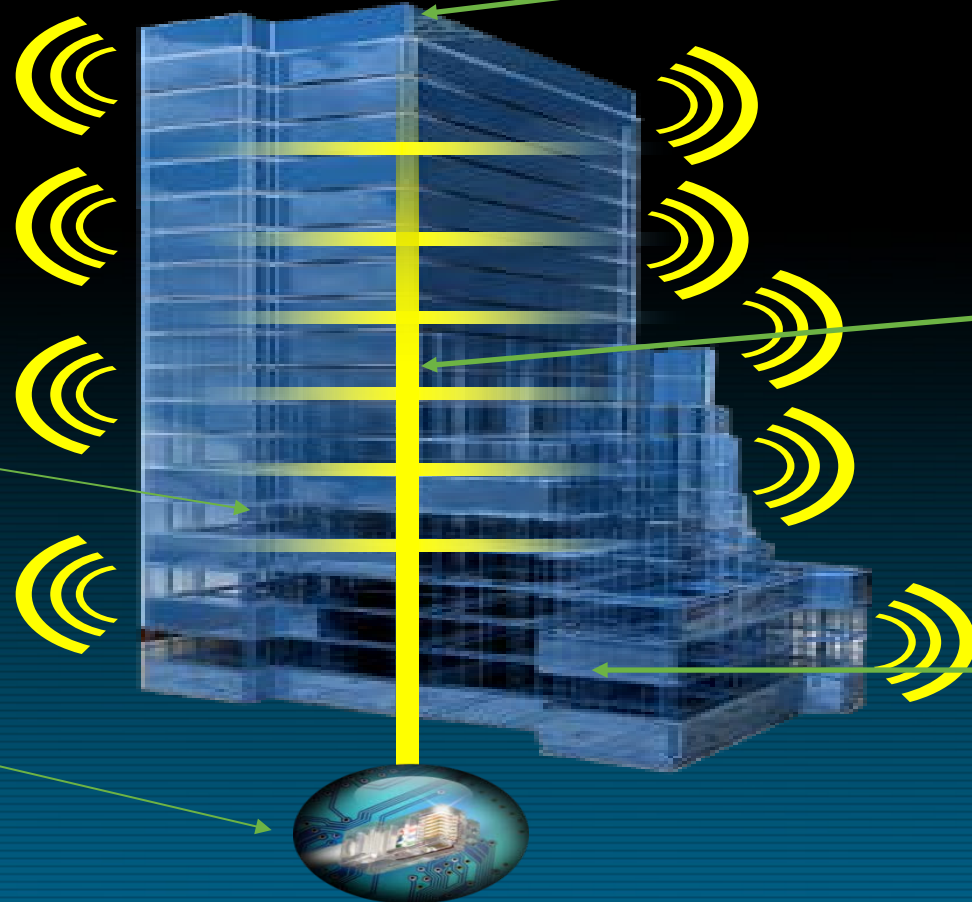
“The Circulatory System”

The electrical system

“The Brain”

A policy engine at the center of the information systems

The Living Building



“The Skeleton”

The physical bricks and mortar of the building

“The Nervous System”

The IP Network

“The Muscles”

The devices and subsystems attached to the network

Data Secure Buildings

greentech**efficiency:**



◀ PREV

Nest Labs Acquires
MyEnergy to...

EFFICIENCY:
Energy Management

NEXT ▶

Why Your Energy
Dashboard May Be...



Hackers Penetrate Google's Building Management System

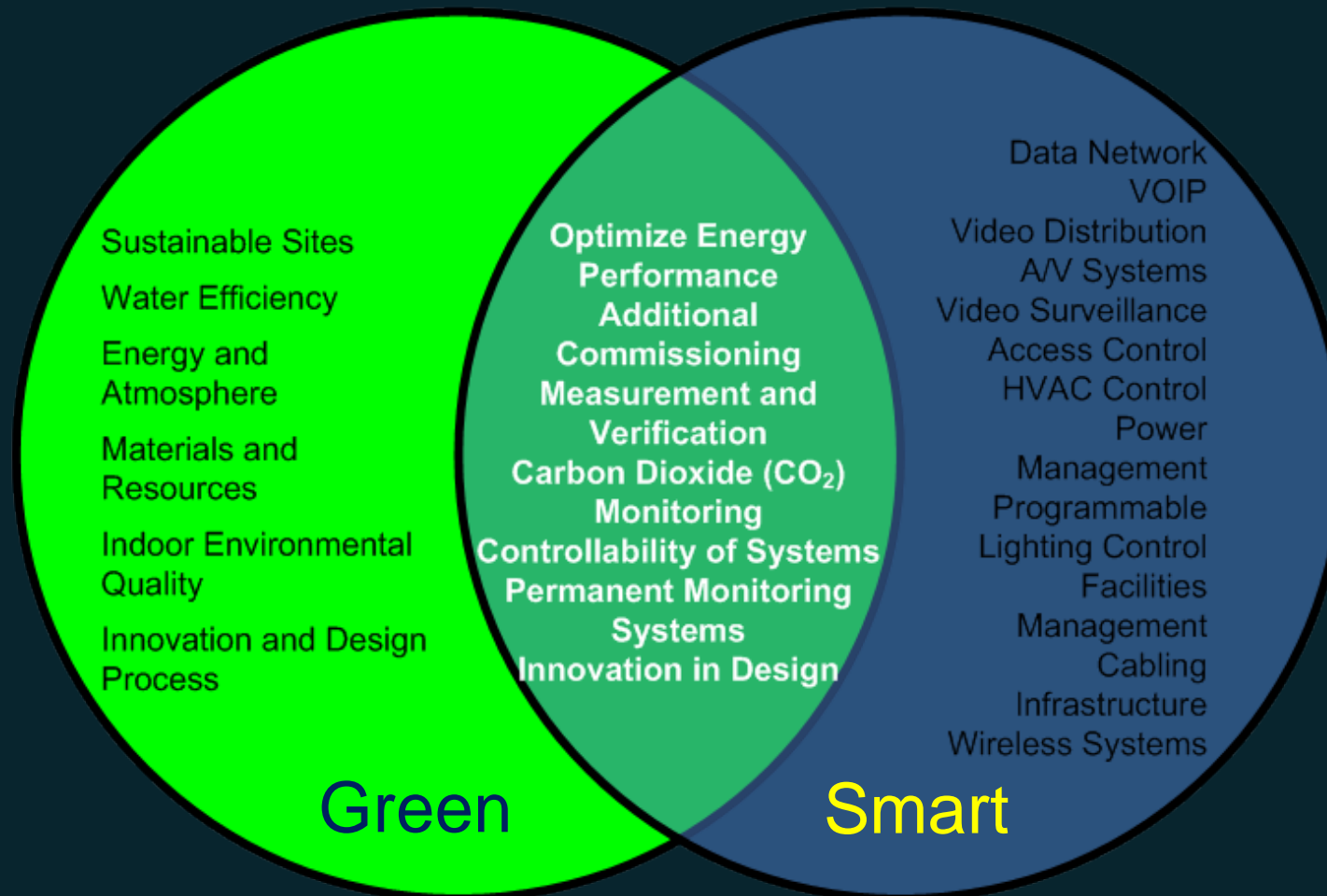
The downside of smarter buildings: "If Google can fall victim, anyone can."





Smart Green Buildings

- Smart building technologies can improve buildings' energy efficiency and indoor environmental quality.



Begin !!



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