# Big, Smart, and Everything: Data, Technology, Buildings, Cities, and the IoT

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FASHRAE, BEMP, FIBPSA, AIA
Bentley Systems, Inc.
20 March 2023

ASHRAE Cleveland Chapter
AIA Cleveland

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**Big, Smart, and Everything:**
**Data, Technology, Buildings, Cities, and the IoT**
**Approved for 1 LU/HSW by AIA, course Crawley03**

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EDUCATION PARTNER

Big, Smart, and Everything: Data, Technology, Buildings, Cities, and the IoT

By Drury B. Crawley

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General CE hours

LEED GREEN ASSOCIATE ☐
LEED AP BD+C ☐
LEED AP HOMES ☐
LEED AP ID+C ☐
LEED AP ND ☐
LEED AP O+M ☐

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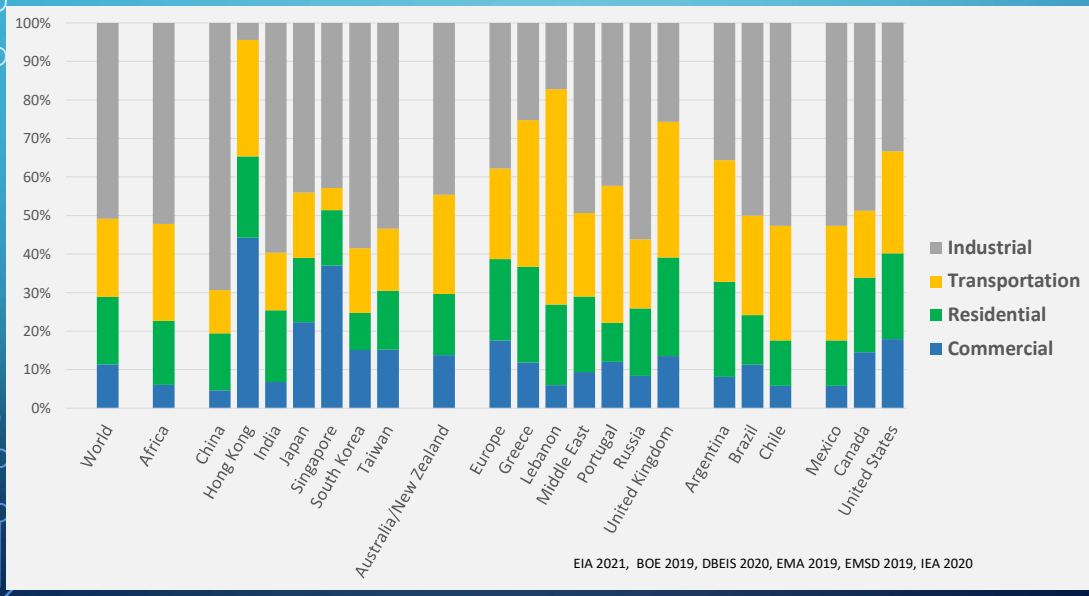
## BUILDING ENERGY USE WORLDWIDE

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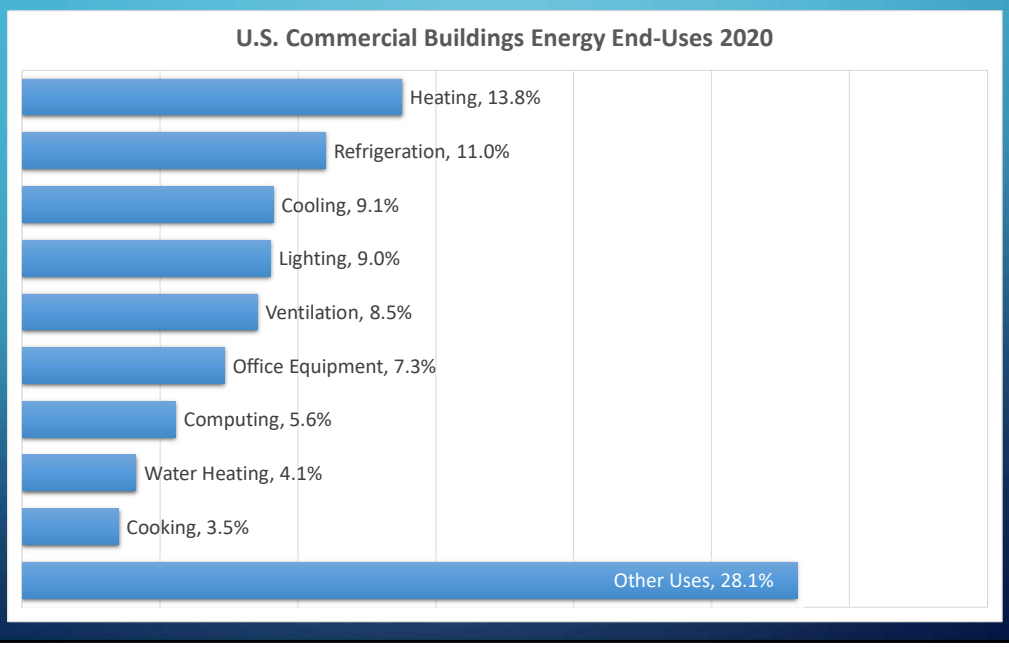
# U.S. BUILDINGS ENERGY USE

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# BUILDING INDUSTRY TRENDS

- Centralization of Ownership (large chains, owners)
- Climate change mitigation / ~~carbon regulation~~
- Green/sustainable/living buildings
- BIM /digital modeling
- Benchmarking/data!
- NZEB/NZEC
- Resilience
- IoT/Smart everything

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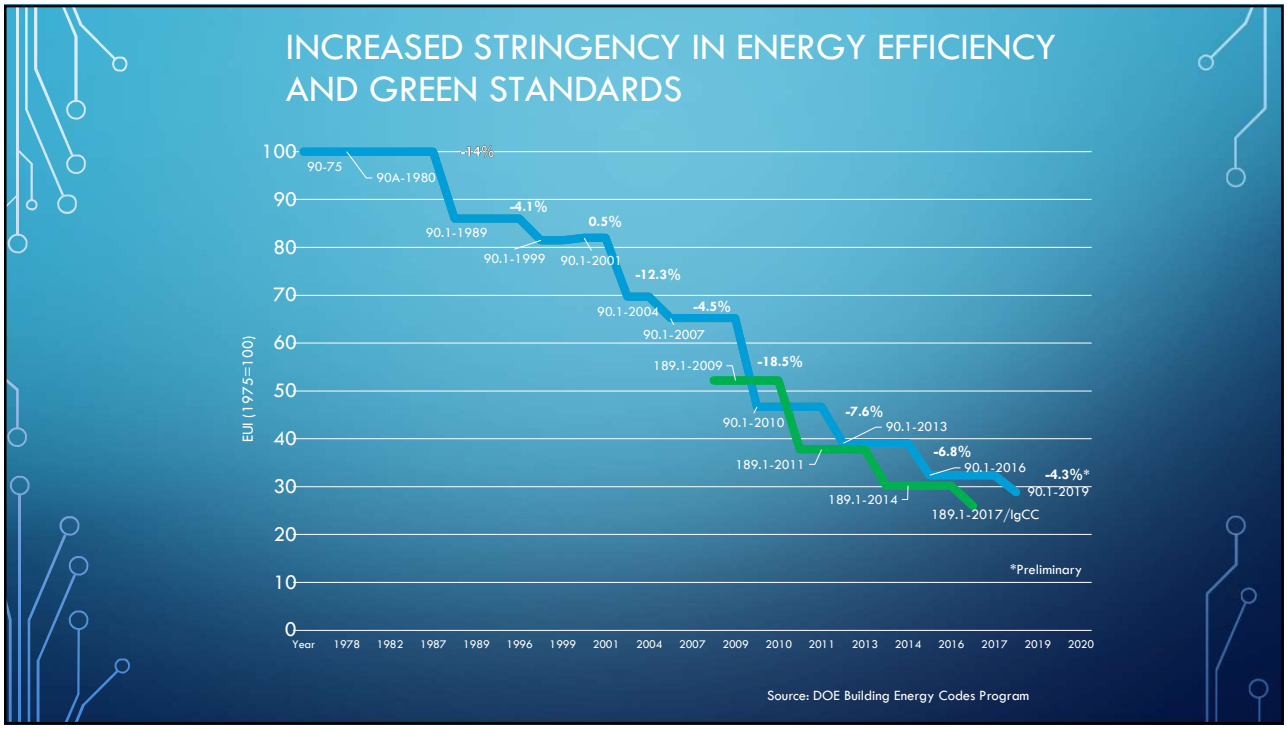
INCREASED STRINGENCY IN ENERGY EFFICIENCY AND GREEN STANDARDS
EUI (1975=100)
100
90
80
70
60
50
40
30
20
10
0
90-75
90A-1980
-14%
90.1-1989
-4.1%
90.1-1999
0.5%
90.1-2001
-12.3%
90.1-2004
-4.5%
90.1-2007
189.1-2009
-18.5%
90.1-2010
-7.6%
90.1-2013
189.1-2011
-6.8%
90.1-2016
189.1-2014
-4.3%*
90.1-2019
189.1-2017/IgCC
*Preliminary
Year
1978
1982
1987
1989
1996
1999
2001
2004
2007
2009
2010
2011
2013
2014
2016
2017
2019
2020
Source: DOE Building Energy Codes Program

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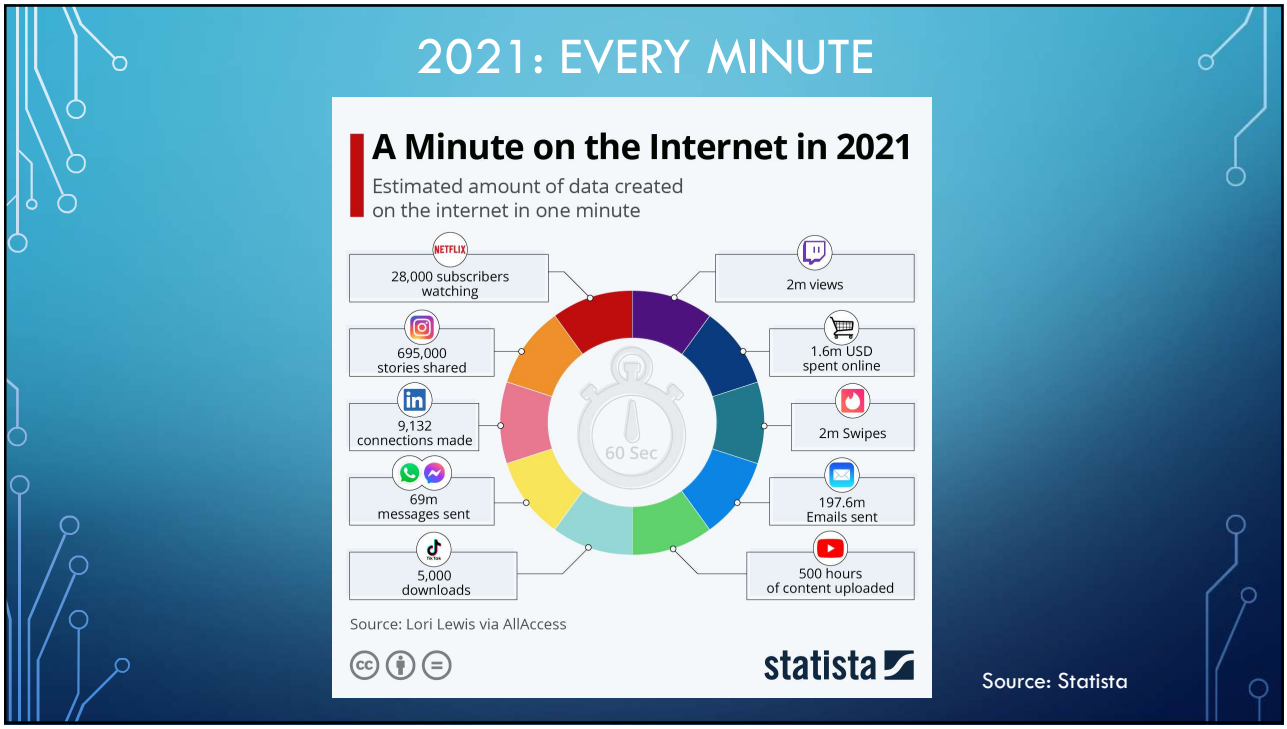
2021: EVERY MINUTE
A Minute on the Internet in 2021
Estimated amount of data created on the internet in one minute
28,000 subscribers watching
695,000 stories shared
9,132 connections made
69m messages sent
5,000 downloads
2m views
1.6m USD spent online
2m Swipes
197.6m Emails sent
500 hours of content uploaded
60 Sec
Source: Lori Lewis via AllAccess
statista
Source: Statista

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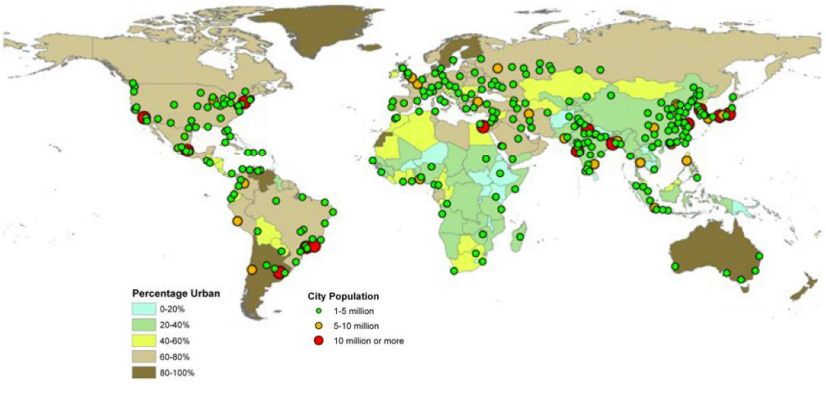
# Urbanization

## Global Pattern 1995




Source: "World Cities report 2016"
United Nations Habitat

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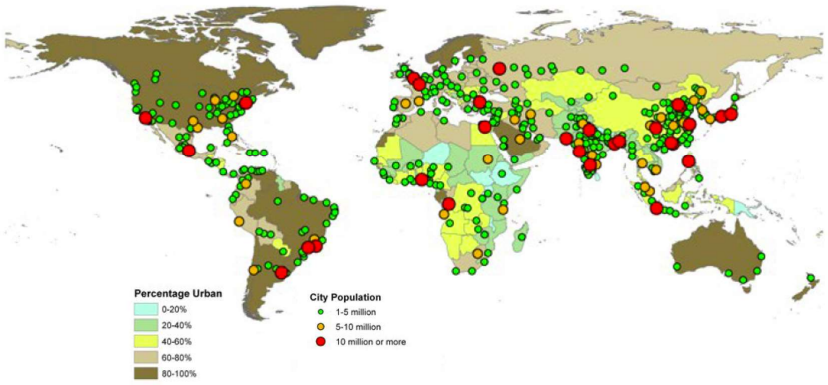
# Urbanization

Global Pattern 2015




Source: "World Cities report 2016"
United Nations Habitat

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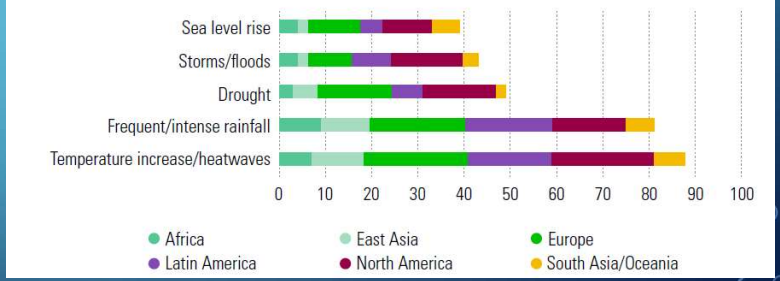
# Decarbonization

**Figure 5.2: Risks from climate change, as reported by 110 cities to the Carbon Disclosure Project (CDP)**

*Source: Based on data from https://www.cdp.net/CDPResults/CDP-Cities-2013-usage-summary.pdf.*




Source: "World Cities report 2016"
United Nations Habitat

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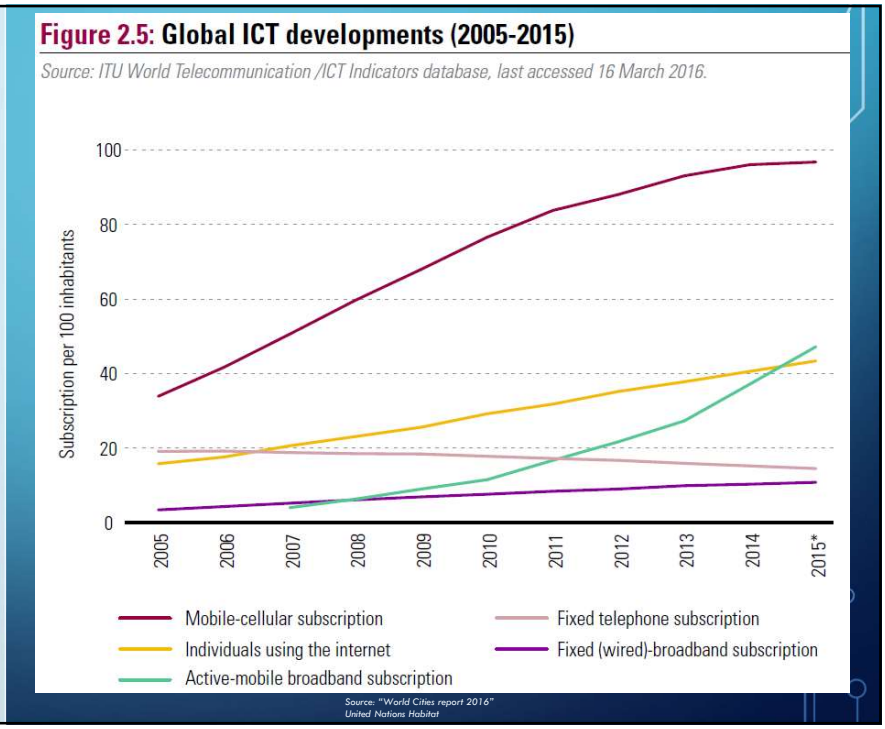
# Digitalization

Global Pattern 1995

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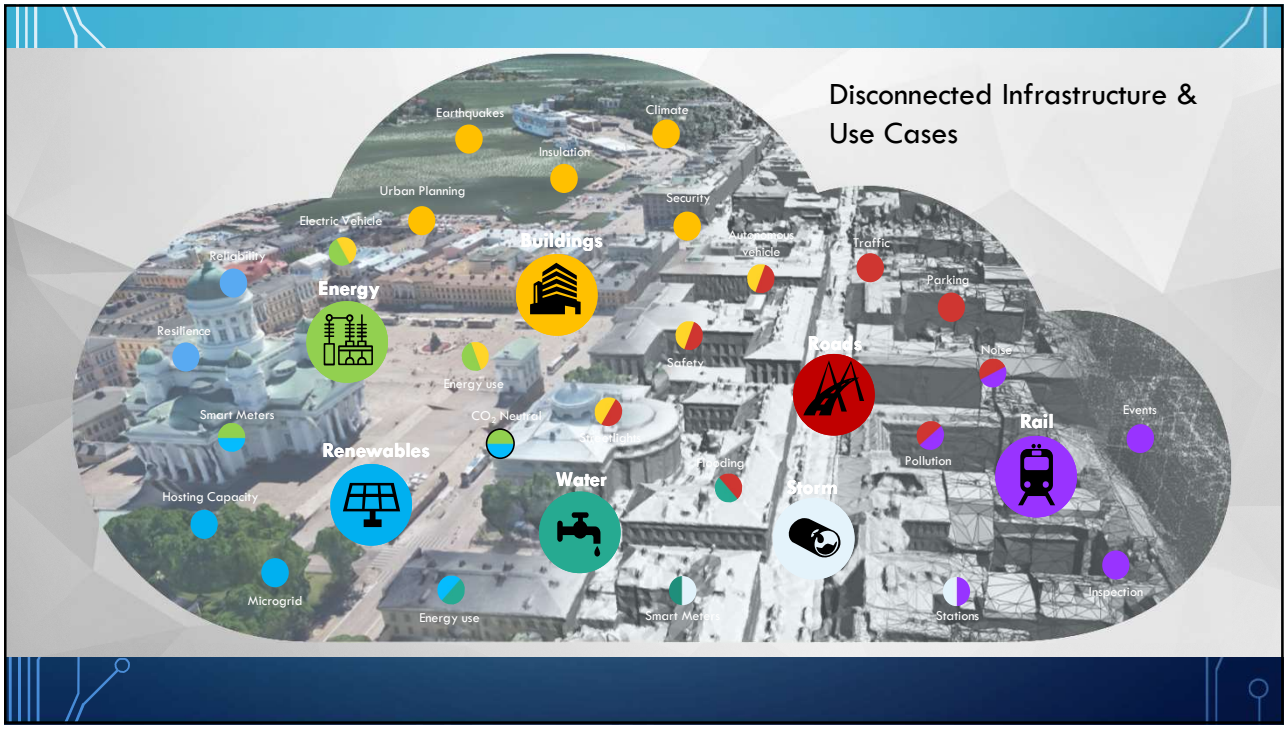


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# DIGITAL TWINS

Virtual replicas of a physical product, process, or system—bridge physical and digital worlds.

Early Uses:

- Infrastructure
- Modeling
- Transportation
- Cities/Urban Planning

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**digital twin**

/ dig·i·tal twin /

*noun*

1. A Digital Twin is a virtual representation of real-world entities and processes, synchronized at a specified **frequency** and **fidelity**.

Source: Digital Twin Consortium®

digitaltwinconsortium.org

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# DATA AND ANALYTICS

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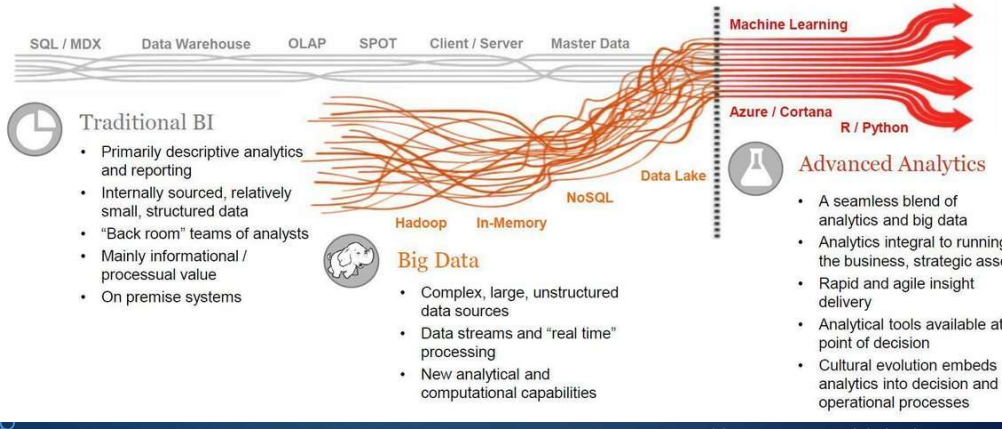
The field of Data & Analytics is evolving fast, driven by the large amount of data available as well as technological quantum leaps




**Traditional BI**

- Primarily descriptive analytics and reporting
- Internally sourced, relatively small, structured data
- "Back room" teams of analysts
- Mainly informational / processual value
- On premise systems

**Big Data**

- Complex, large, unstructured data sources
- Data streams and "real time" processing
- New analytical and computational capabilities

**Advanced Analytics**

- A seamless blend of analytics and big data
- Analytics integral to running the business, strategic asset
- Rapid and agile insight delivery
- Analytical tools available at point of decision
- Cultural evolution embeds analytics into decision and operational processes

PwC 2016 *Strategy & Global Industry 4.0 Survey*

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# ARTIFICIAL INTELLIGENCE?

- Artificial intelligence – the techniques used to teach computers to learn, reason, perceive, infer, communicate and make decisions similar to or better than humans
- Comprising:
  - **Machine Learning** – science of getting computers to act intelligently without being explicitly programmed
  - **Neural Networks and Deep Learning** – Neural Networks automatically learn about the features of a specific object based on large amounts of training data and power Deep Learning
  - **Adversarial Networks** – AI systems embedded with multiple neural networks that compete with each other, a path towards unsupervised learning

Wall Street Journal Pro 2018 *Advances in Technology Push AI Into the Mainstream*

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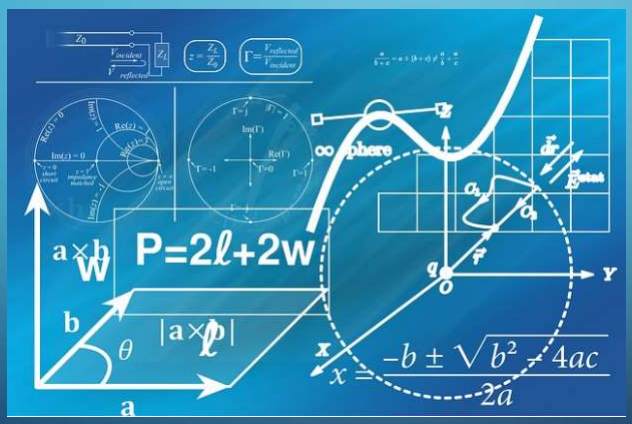
# MACHINE LEARNING … JUST MATH, STATS, DATA




The New Stack 4-7-2017*Machine Learning Is Not Magic: It's All About Math, Stats, Data, and Programming*

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# AI ADOPTION COULD CREATE TRILLIONS IN VALUE

- Tech giants spent an estimated $20 billion to $30 billion on AI in 2016
- In 2017, $15.2 billion was invested in AI startups around the world, and nearly half (48 percent) of that total went to China; 38 percent was invested in the United States.
- AI could potentially deliver additional global economic activity of around $13 trillion by 2030

Wall Street Journal Pro 2018 *Advances in Technology Push AI Into the Mainstream*

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# SMART TECHNOLOGY, BUILDINGS, CITIES

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# SMART CITY?

"Smart cities put data and digital technology to work with the goal of improving the quality of life"

"Smart cities add digital intelligence to existing urban systems, making it possible to do more with less."

"Smart cities use data and technology to make better decisions."

McKinsey Global Institute 2018 *Smart Cities: Digital Solutions for a More Livable Future*

"Using digital technology to solve the timeless problems of cities."

Anthony Townsend 1-14-2019 Architect Magazine Q+A: *What is a Smart City?*

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***"Smart infrastructure provides the foundation for all of the key themes related to a smart city…"***

United Nations - Economic and Social Counsel
Report of the General Secretary – February 2016

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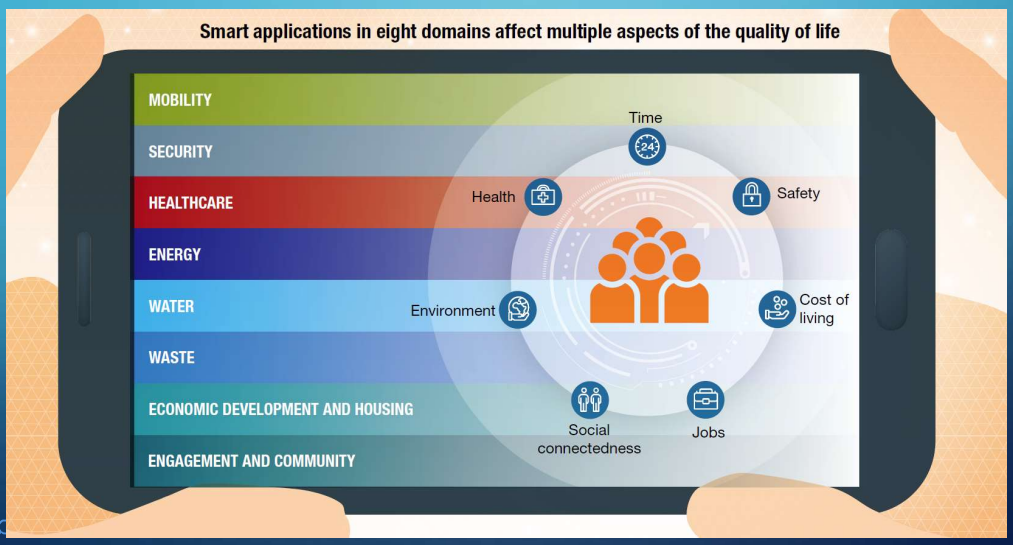
# DOMAINS OF SMART CITIES




McKinsey Global Institute 2018 *Smart Cities: Digital Solutions for a More Livable Future*

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# THE GOAL

McKinsey Global Institute 2018 *Smart Cities: Digital Solutions for a More Livable Future*

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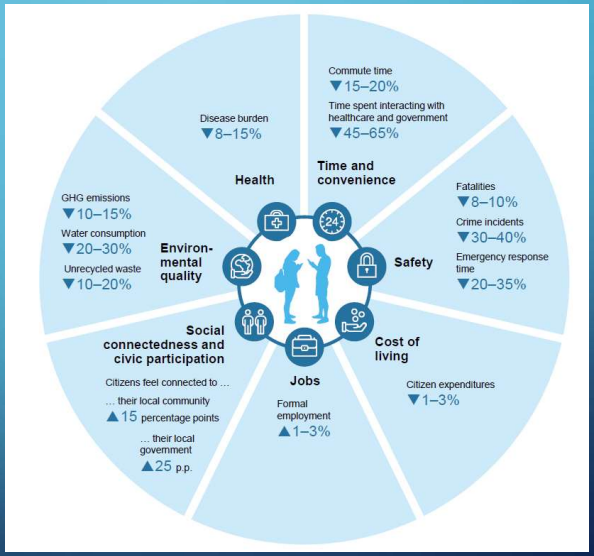
# POTENTIAL IMPACT OF SMART CITY APPLICATIONS




McKinsey Global Institute 2018 *Smart Cities: Digital Solutions for a More Livable Future*

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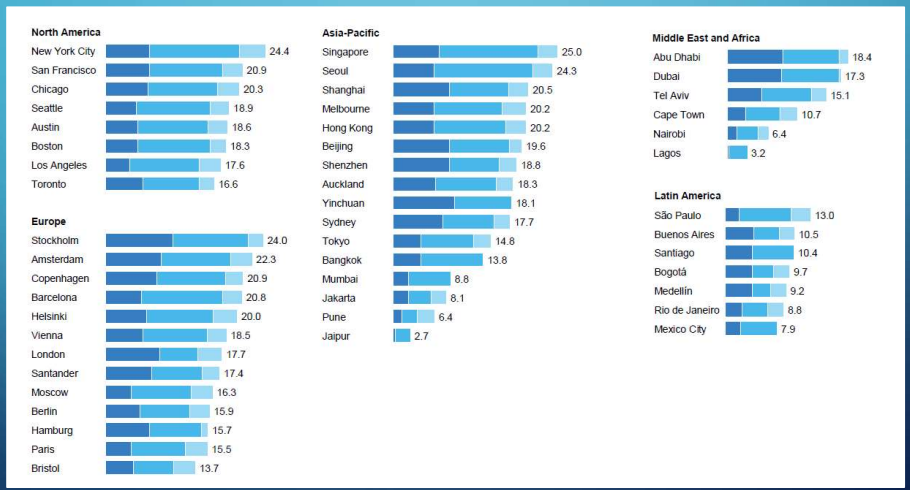
# CITIES WITH MOST DEVELOPED SMART CITY TECHNOLOGY BASES




McKinsey Global Institute 2018 *Smart Cities: Digital Solutions for a More Livable Future*

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# SOME FORECAST BENEFITS OF SMART CITIES/INFRASTRUCTURE

- Enhance urban mobility
  - Public transit fare, toll and parking management
  - Traffic/transit optimization
- Smarter infrastructure
  - Citizen reporting
  - Service management
- Strengthen public safety
  - Improved safety, reporting, evidence collection
  - Digital hearings – speeding tickets
- Improve citizen and social care
  - Streamlined application process – govt interaction
  - Improved government services
  - Improved social care

2019 Microsoft *Bringing smart living to your city*

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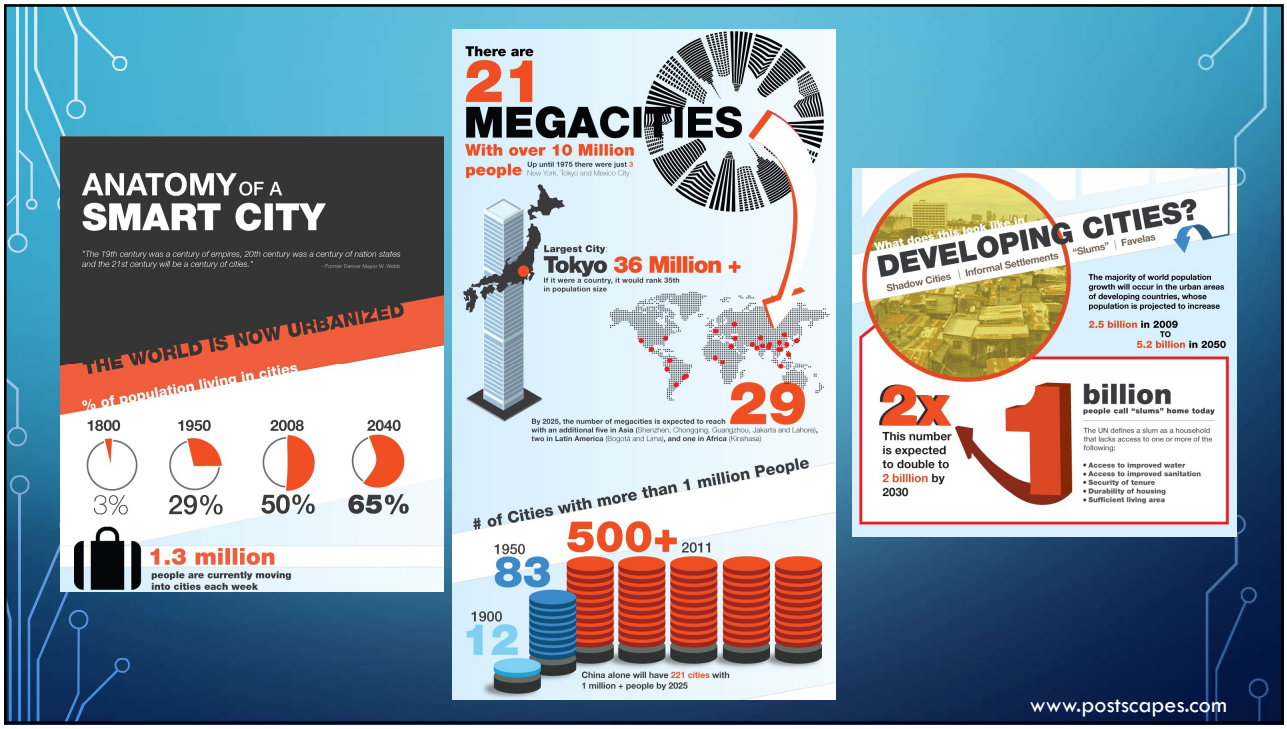


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ECONOMIC INFLUENCE
The top 600 urban centers generate
60%
of global GDP
In the developing world, as much as 80% of future economic growth will occur in cities
ENVIRONMENTAL IMPACT
Cities use
60%-80%
of the world's annual energy needs
Lighting alone represents 19% of the world's total electricity consumption
All OF THE ABOVE
The need for
SMARTER
CITIES
DRIVEN BY:
Sensors
Networks
Engagement
RESULTING IN:
REAL-TIME
URBAN INFORMATICS
With the combination of low power sensors, wireless networks, and web and mobile-based applications, Smart Cities have arrived.
DEVELOPED CITIES
MEASUREMENT: Your city as a platform
ENVIRONMENT
SAFETY
TRANSPORATION
UTILITES
BUILDINGS

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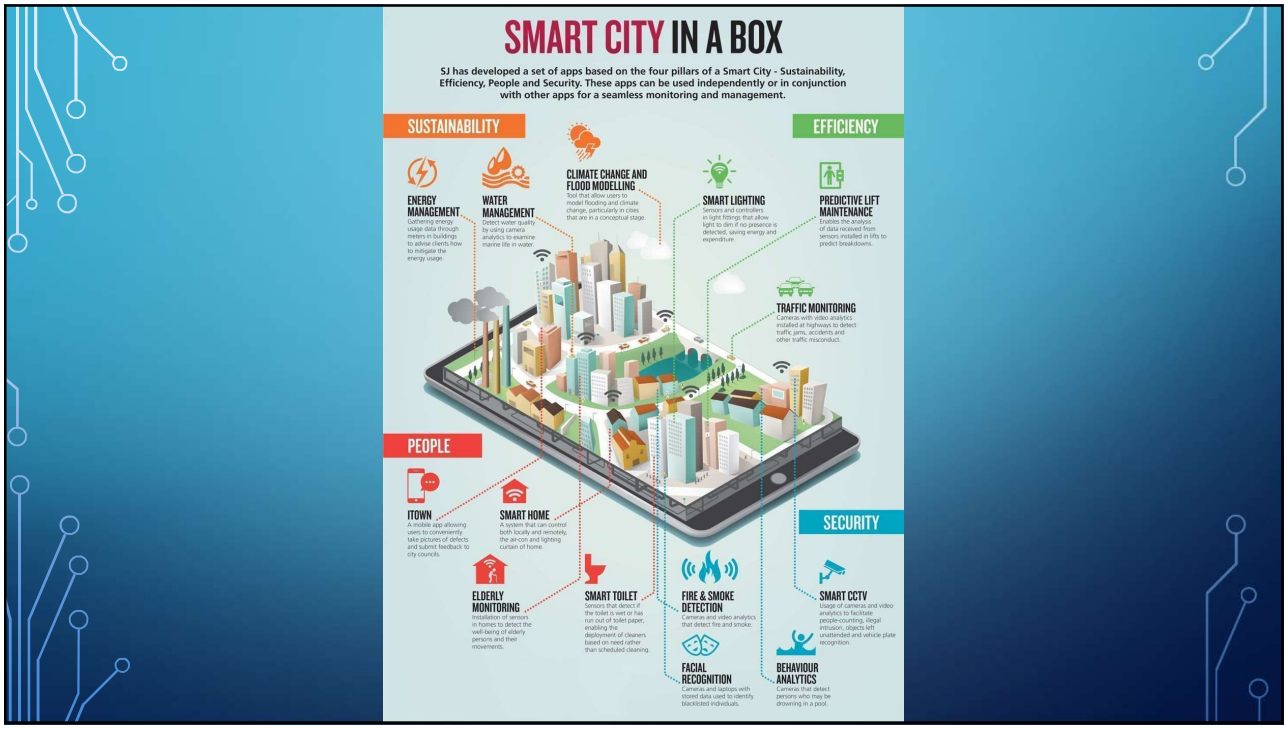
SMART CITY IN A BOX
SJ has developed a set of apps based on the four pillars of a Smart City - Sustainability, Efficiency, People and Security. These apps can be used independently or in conjunction with other apps for a seamless monitoring and management.
SUSTAINABILITY
EFFICIENCY
ENERGY MANAGEMENT
WATER MANAGEMENT
CLIMATE CHANGE AND FLOOD MODELLING
SMART LIGHTING
PREDICTIVE LIFT MAINTENANCE
TRAFFIC MONITORING
PEOPLE
SECURITY
ITOWN
SMART HOME
ELDERLY MONITORING
SMART TOILET
FIRE & SMOKE DETECTION
SMART CCTV
FACIAL RECOGNITION
BEHAVIOUR ANALYTICS

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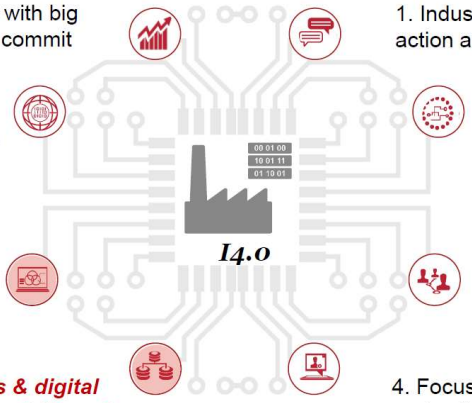
# SMART MANUFACTURING

8. Big investments with big impact: It's time to commit

1. Industry 4.0 - From talk to action and implementation

7. Industry 4.0 is accelerating globalization, but with a distinctly regional flavor

2. Digitization drives quantum leaps in performance




*6. Robust, enterprise-wide data analytics capabilities require significant change*

3. Deepen digital relationships with more empowered customers

*5. Data analytics & digital trust are the foundation of transformation*

4. Focus on people and culture to drive transformation

PwC 2016 *Strategy & Global Industry 4.0 Survey*

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PwC 2016 *Strategy & Global Industry 4.0 Survey*

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# INTERNET OF EVERYTHING -- IOT

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# INTERNET OF EVERYTHING

With 5G wireless and ubiquitous data sensors becoming available, every device that collects data can share it – supporting real-time decision-making for controls, utility grids, buildings, traffic, and transportation. Imagine dozens of sensors ensuring our comfort in our workplaces while optimizing energy efficiency and sustainability

Benefit of 5G is not **high bandwidth** (transmission capacity) but **low latency** (delay before data transfer begins following transfer request)

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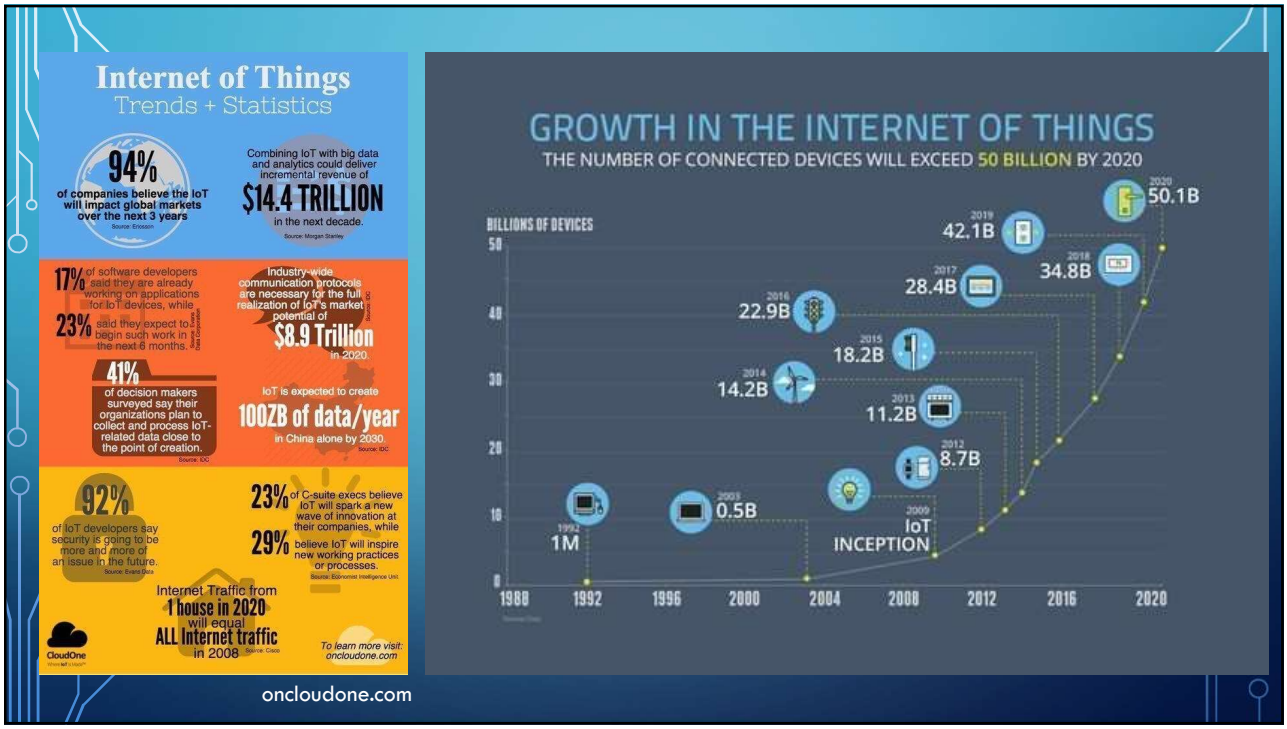
Internet of Things
Trends + Statistics
94%
of companies believe the IoT will impact global markets over the next 3 years
Combining IoT with big data and analytics could deliver incremental revenue of
$14.4 TRILLION
in the next decade.
17% of software developers said they are already working on applications for IoT devices, while
23% said they expect to begin such work in the next 6 months.
Industry-wide communication protocols are necessary for the full realization of IoT's market potential of
$8.9 Trillion
in 2020.
41%
of decision makers surveyed say their organizations plan to collect and process IoT-related data close to the point of creation.
IoT is expected to create
100ZB of data/year
in China alone by 2030.
92%
of IoT developers say security is going to be more and more of an issue in the future.
23% of C-suite execs believe IoT will spark a new wave of innovation at their companies, while
29% believe IoT will inspire new working practices or processes.
Internet Traffic from
1 house in 2020
will equal
ALL Internet traffic
in 2008
To learn more visit:
oncloudone.com
CloudOne
GROWTH IN THE INTERNET OF THINGS
THE NUMBER OF CONNECTED DEVICES WILL EXCEED 50 BILLION BY 2020
BILLIONS OF DEVICES
1992 1M
2003 0.5B
2009 IoT INCEPTION
2012 8.7B
2013 11.2B
2014 14.2B
2015 18.2B
2016 22.9B
2017 28.4B
2018 34.8B
2019 42.1B
2020 50.1B
0
10
20
30
40
50
1988
1992
1996
2000
2004
2008
2012
2016
2020
oncloudone.com

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THE STATE OF IoT SECURITY
90% OF CONSUMERS LACK CONFIDENCE IN THE SECURITY OF IOT DEVICES
The majority of businesses and consumers support government-mandated IoT security regulations
90%
96% of businesses and 90% of consumers believe there should be IoT security regulations
54% of consumers own an average of four IoT devices, but only 14% believe that they are extremely knowledgeable on IoT device security
Only 33% of businesses believe they have complete control over the data that their IoT products/services collects as it moves from partner to partner, potentially leaving data unprotected at some stages of its journey
65% of consumers are concerned about a hacker controlling their IoT device while 60% are concerned about data being leaked
Only 57% of businesses encrypt all of the data that they capture or store via IoT devices
61% of businesses feel IoT regulations should include who is responsible for securing data at each stage of the journey
gemalto

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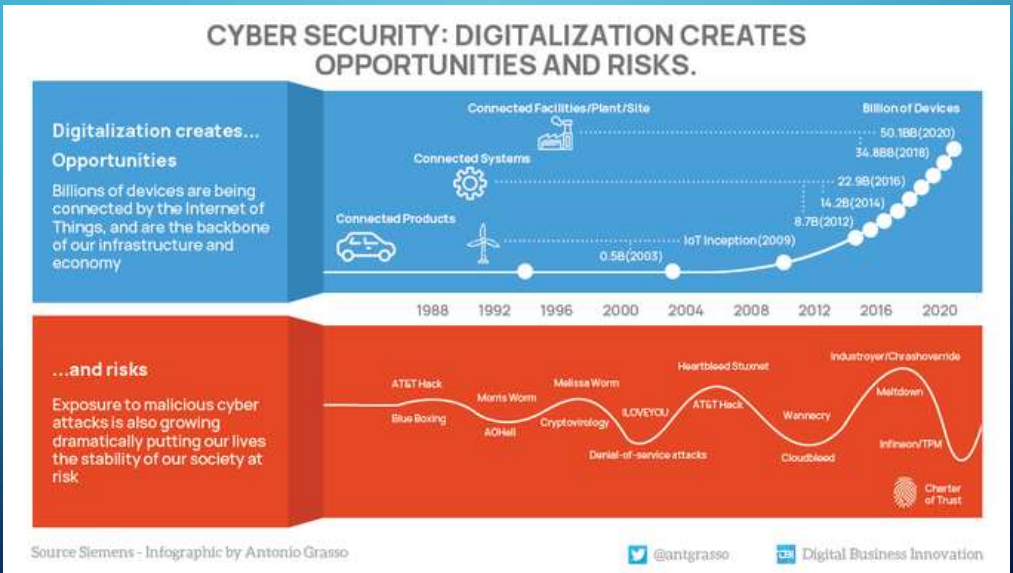
# IOT REQUIRES CYBER SECURITY

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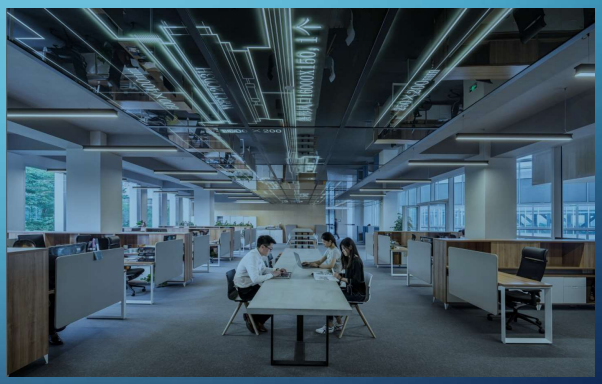
# IOT CHANGING DESIGN AND OPERATION

- Data collection to analyze use of spaces
- Sharing information and knowledge



Archipreneur 1-29-2019

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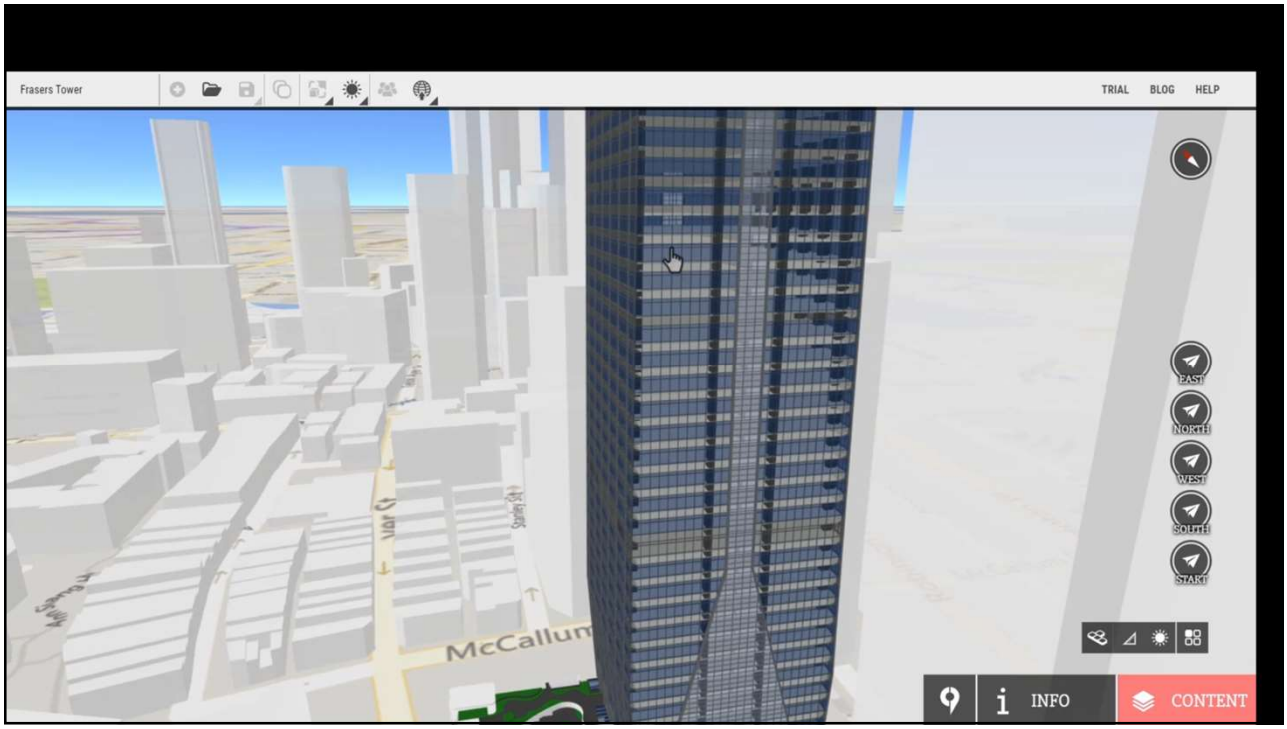


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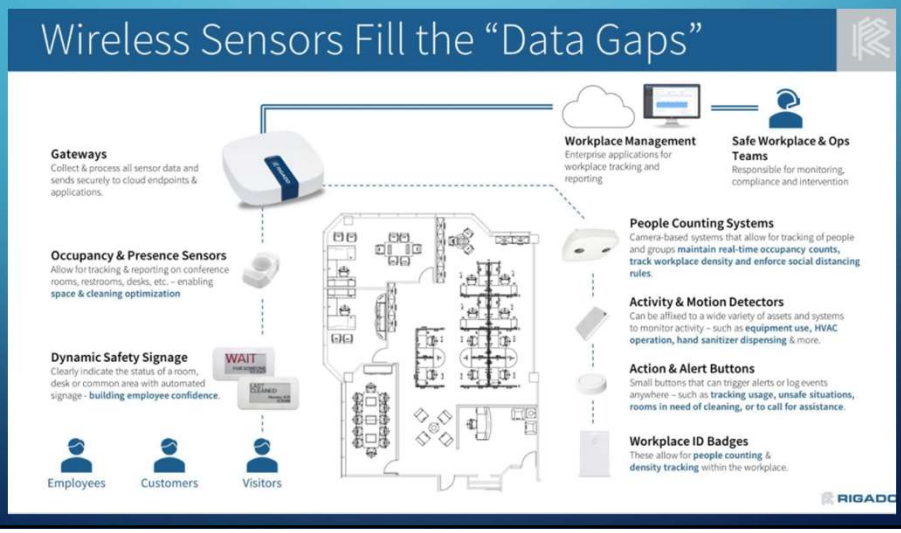
# IOT AND WIRELESS

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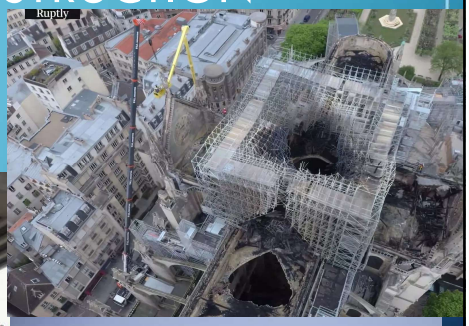
# IOT ALREADY CHANGING CONSTRUCTION INDUSTRY

- Drones
- Worker Safety
- 3D modelling and precision measurement (digital twin)
- Asset Tracking
- Predictive Maintenance
- Augmented Reality
- Computer-integrated Manufacturing



BIM Today 1-8-2019 *Modern technology in the construction industry*

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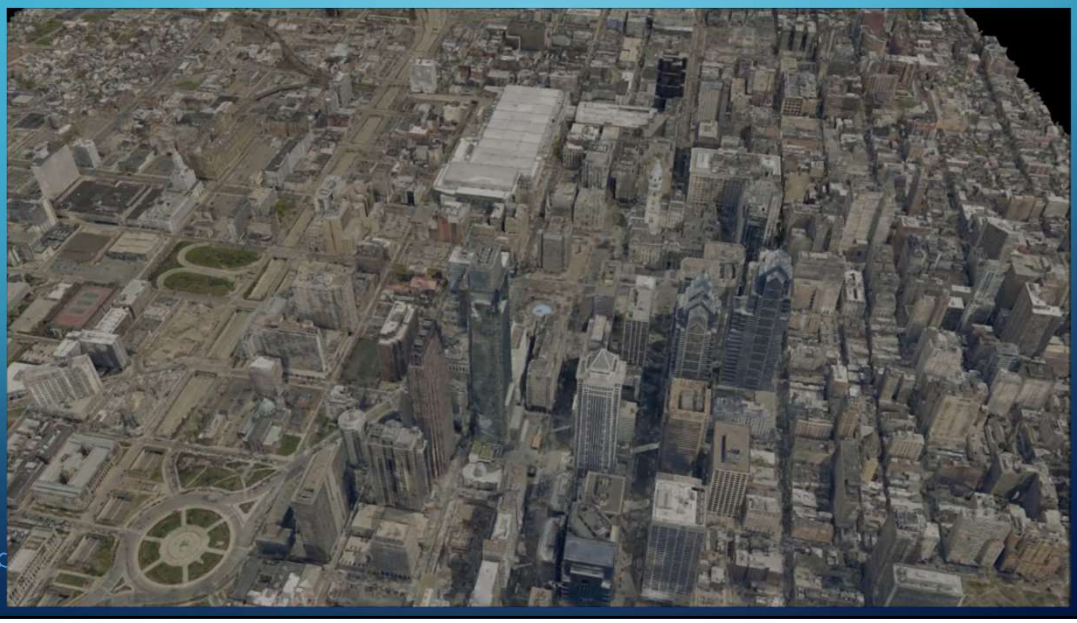
# ENERGY AND WATER



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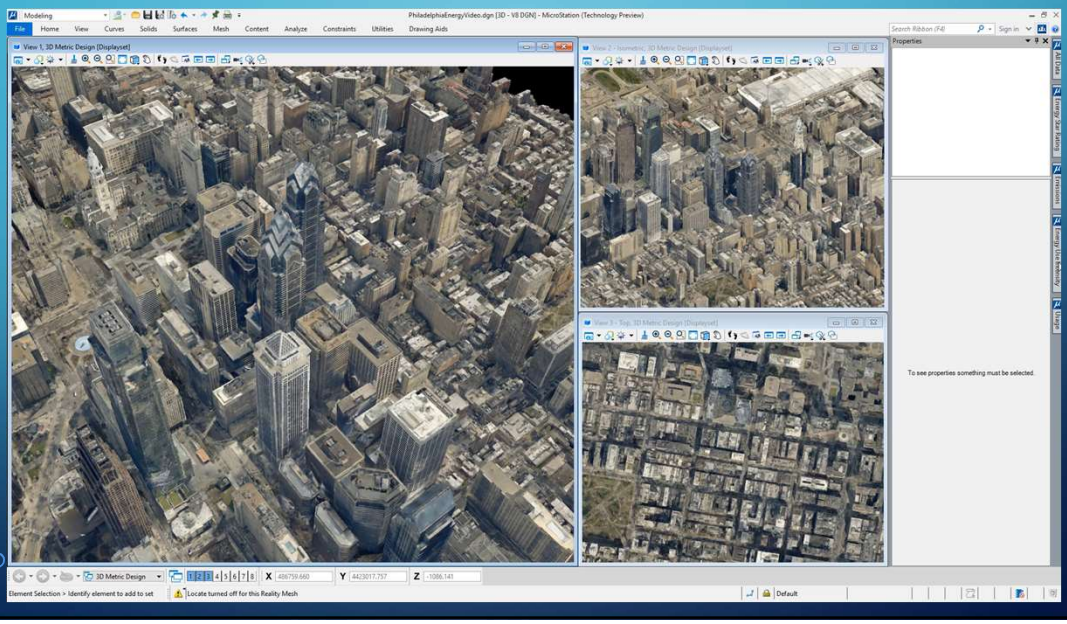
# EXPLORING BUILDING DATA WITHIN THE URBAN MODE



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Flood model -
Helsinki, Finland

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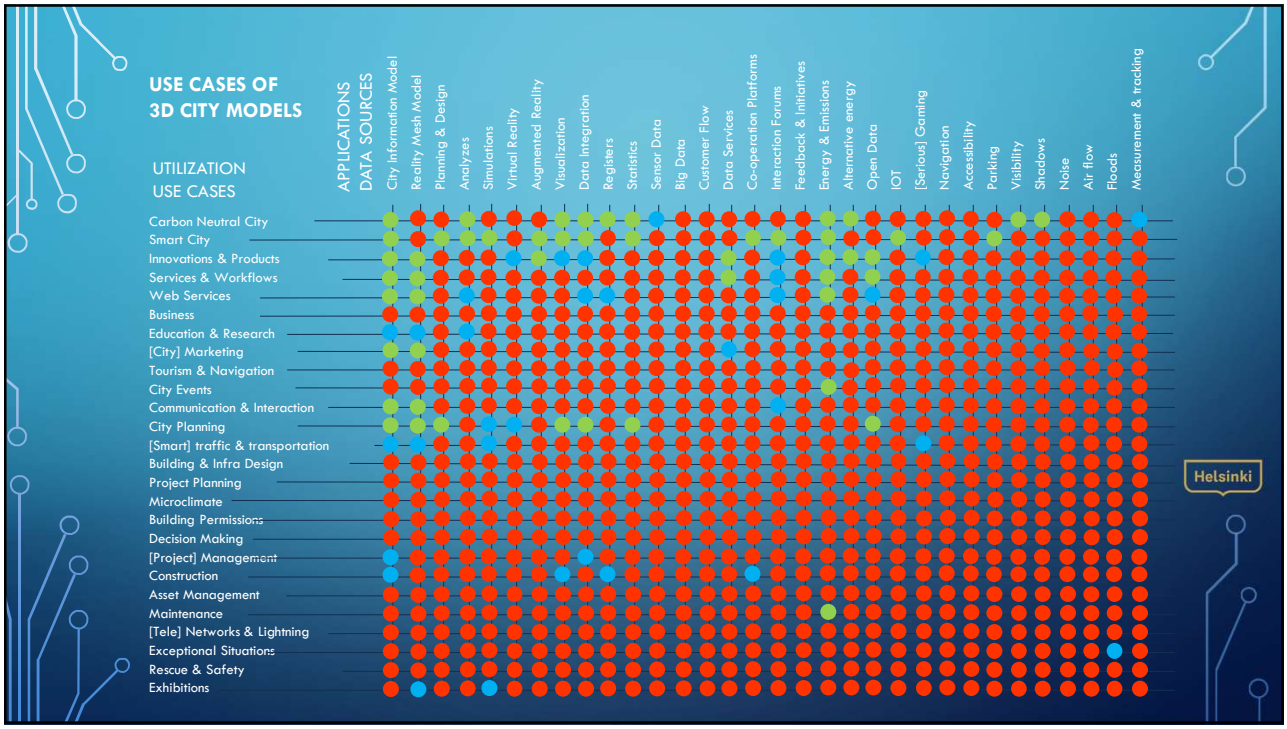
USE CASES OF
3D CITY MODELS
APPLICATIONS
DATA SOURCES
UTILIZATION
USE CASES
City Information Model
Reality Mesh Model
Planning & Design
Analyzes
Simulations
Virtual Reality
Augmented Reality
Visualization
Data Integration
Registers
Statistics
Sensor Data
Big Data
Customer Flow
Data Services
Co-operation Platforms
Interaction Forums
Feedback & Initiatives
Energy & Emissions
Alternative energy
Open Data
IOT
[Serious] Gaming
Navigation
Accessibility
Parking
Visibility
Shadows
Noise
Air flow
Floods
Measurement & tracking
Carbon Neutral City
Smart City
Innovations & Products
Services & Workflows
Web Services
Business
Education & Research
[City] Marketing
Tourism & Navigation
City Events
Communication & Interaction
City Planning
[Smart] traffic & transportation
Building & Infra Design
Project Planning
Microclimate
Building Permissions
Decision Making
[Project] Management
Construction
Asset Management
Maintenance
[Tele] Networks & Lightning
Exceptional Situations
Rescue & Safety
Exhibitions
Helsinki

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FUTURE?
Digital Twin
Connected Infrastructure
Earthquakes
Climate
Insulation
Urban Planning
Security
Electric Vehicle
Buildings
Autonomous vehicle
Traffic
Reliability
Energy
Parking
Resilience
Safety
Roads
Noise
Energy use
$CO_2$ Neutral
Smart Meters
Streetlights
Rail
Events
Renewables
Flooding
Pollution
Water
Storm
Hosting Capacity
Microgrid
Energy use
Smart Meters
Stations
Inspection

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Climate
Insulation
Earthquakes
Security
Urban Planning
Autonomous vehicle
Buildings
Safety
Energy use
Streetlights
Rail
Events
Water
Storm
Hosting Capacity
Microgrid
Energy use
Smart Meters
Stations
Inspection

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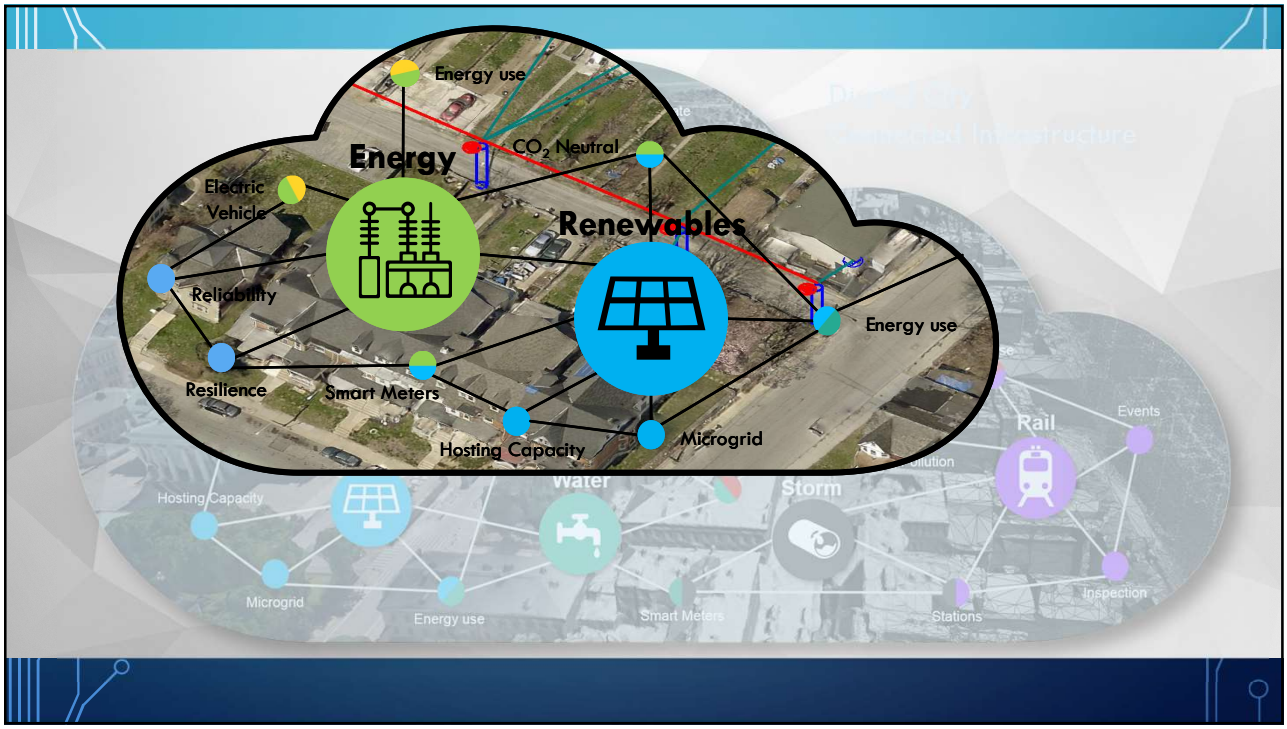
Energy use
Energy
$CO_2$ Neutral
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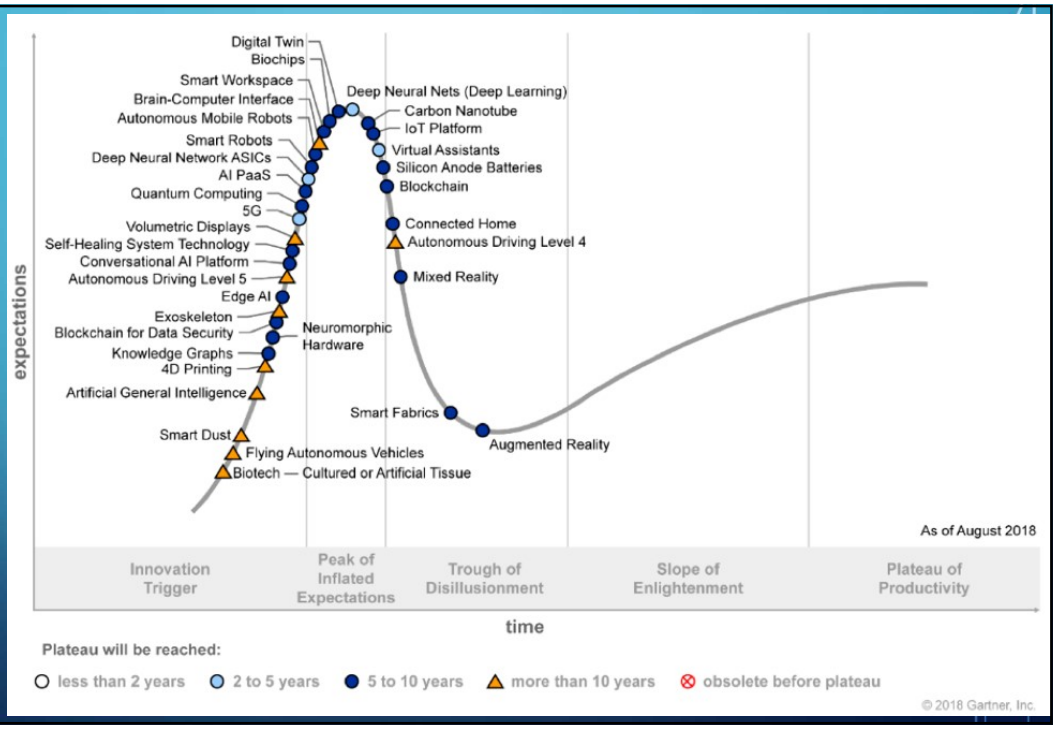
# WHERE ARE WE ON THE HYPE CURVE?

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# SUMMARY

- 3-D digital models (digital twin) make it easier to understand our buildings, communities, and their interactions with environment
- Sensors becoming ubiquitous in our lives
- Security, privacy and data ownership become critical components
- With 5G deploying, data connectedness makes Smart Cities possible – powerful tool for policymaking or building owners
- Anything that is measured locally now will be connected in future – Smart Buildings → IoT → Smart Cities
- Data analytics (BI, machine learning, AI) allows us to find trends and causes not clear from our limited data today
- Much of what is described for IoT, Big Data, AI, Smart today … a lot of hype

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## CHALLENGE: PROVIDE CLIENTS WITH MULTIPLE METRICS

Energy
Demand
Cost
Water
IEQ
Carbon

Business model
(sales, student, occupied room,
business unit: barrel of beer, case of wine)

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## THANK YOU!

## QUESTIONS?

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ASHRAE Cleveland Chapter

AIA Cleveland

**GBCI Approved | 1 CE Hour** | 920020229
**AIA Approved | 1 LU/HSW | CRAWLEY03**

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