IT and Sustainability

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National University of Ireland Maynooth

Presentation Outline

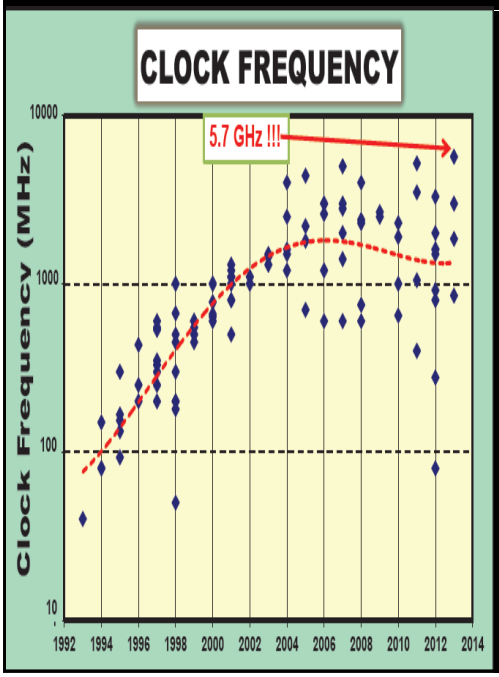
- IT and Energy ✓
- IS and Energy
- Smart Cities
- Conclusions

The maximum speed at which a physical system can commute from a state to another is proportional to the energy of the system.

$$E \geq \frac{h}{4} f$$

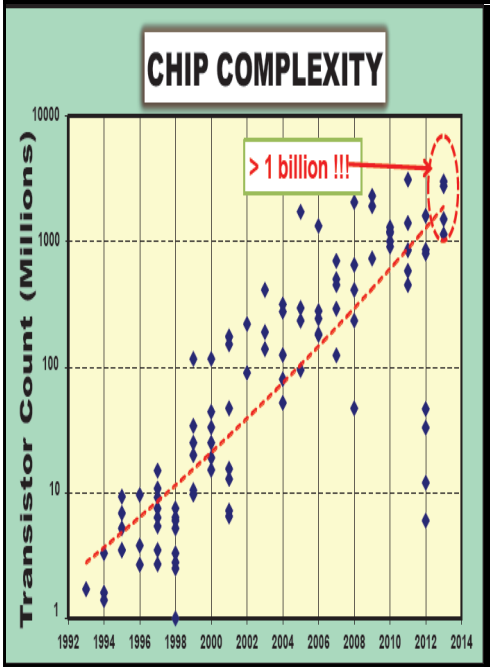
- E = energy to commute 1 bit
- h = Planck's constant $6{,}626 \cdot 10^{-34}$ J·s
- f = commutations per second
- To commute 1 bit at 1 GHz *at least* 10^{-25} J are needed.

2



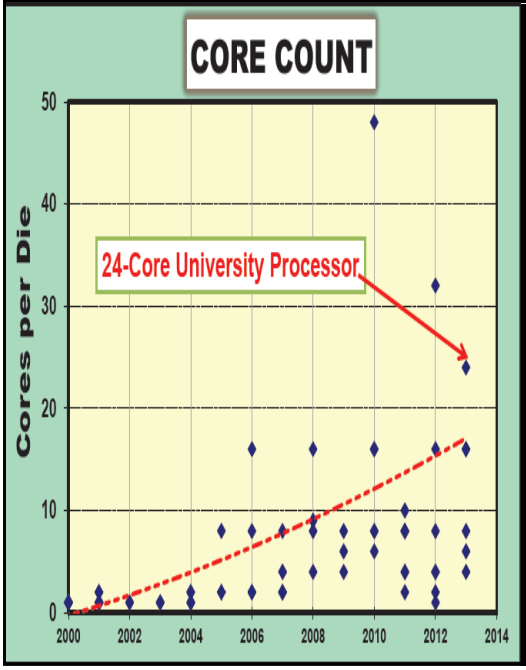
Lowering leakage and managing voltage, variability and aging, has bolstered the continuing reduction in total power dissipation. This is helping rein in the increase in energy demands from PCs, servers, and similar systems. As power reduction becomes mandatory, the trend towards maintaining near constant clock frequencies also continues as shown in frequency trends plot. This will yield solutions with less cost and cooling demands, resulting in greener products in the future.

3



The relentless march of process technology brings more integration and performance. IBM's System z processor leads the charge at ISSCC 2013 clocking in at 5.7GHz and with 2.75B transistors.
The chip complexity chart shows the trend in transistor integration on a single chip over the past two decades. While the 1 billion transistor integration mark was achieved some years ago, we now commonly see processors with beyond 2B transistors on a die.

4



Processors are choosing to trade off performance by lowering supply voltage. The performance loss of reduced voltage and clock frequency is compensated by further increased parallelism. Processors with more than 8 cores are now commonplace. This year at ISSCC 2013, a 24-core processor from Fudan University will be presented as noted in the core count trend chart.

5

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Energy Efficiencies

	1978	2008	Energy-efficiency Improvement
Automobiles	14.3 miles per gallon of gas	20.0 miles per gallon of gas	40 percent
Passenger Airlines	22.8 revenue passenger miles per gallon	50.4 revenue passenger miles per gallon	121 percent
Agriculture	0.63 units of output per unit of energy use	1.46 units of output per unit of energy use	132 percent
Steel Manufacturing	63 pounds of steel per MBtu	167 pounds of steel per MBtu	167 percent
Lighting	Incandescent light bulb— 13 lumens per watt	Compact flourescent bulb— 57 lumens per watt	339 percent
Computer Systems	1,400 instructions per second per watt	40,000,000 instructions per second per watt	2,857000 percent

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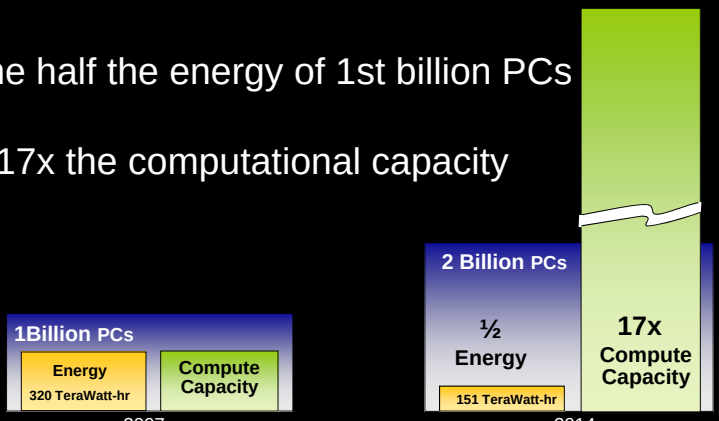
Compared to the 1st Billion PC's Installed The 2nd Billion Will…

…consume half the energy of 1st billion PCs

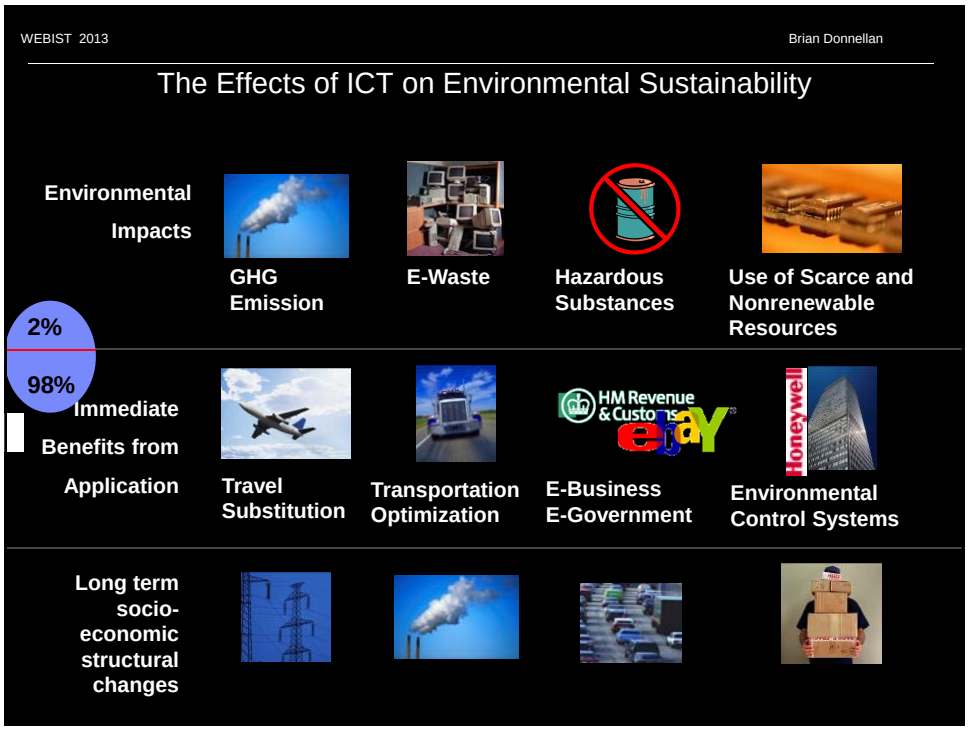
…deliver 17x the computational capacity



2007
1 Billion PCs Installed Base

2014
2 Billion PCs Installed Base

Source: Intel Microprocessor Marketing and Business Planning, and Intel iAG/PCCA Power Initiative team, PBCA-PPM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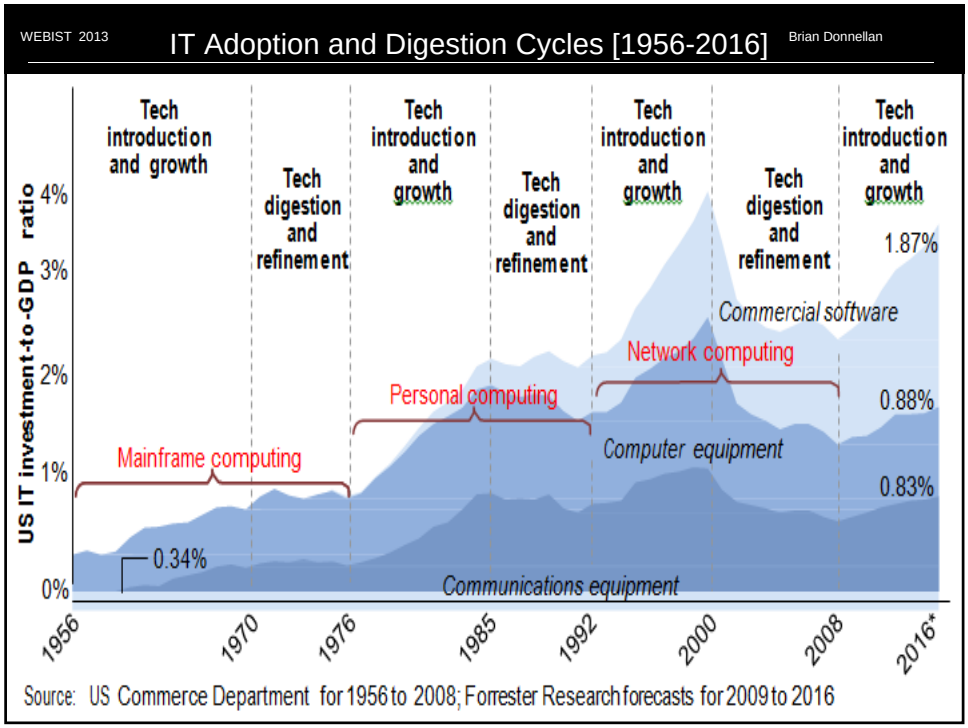
The Effects of ICT on Environmental Sustainability
Environmental Impacts
GHG Emission
E-Waste
Hazardous Substances
Use of Scarce and Nonrenewable Resources
2%
98%
Immediate Benefits from Application
Travel Substitution
Transportation Optimization
E-Business E-Government
Environmental Control Systems
Long term socio-economic structural changes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IT Adoption and Digestion Cycles [1956-2016]
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US IT investment-to-GDP ratio
4%
3%
2%
1%
0%
Tech introduction and growth
Tech digestion and refinement
Tech introduction and growth
Tech digestion and refinement
Tech introduction and growth
Tech digestion and refinement
Tech introduction and growth
1.87%
Commercial software
Network computing
Personal computing
Mainframe computing
0.88%
Computer equipment
0.83%
0.34%
Communications equipment
1956
1970
1976
1985
1992
2000
2008
2016*
Source: US Commerce Department for 1956 to 2008; Forrester Research forecasts for 2009 to 2016

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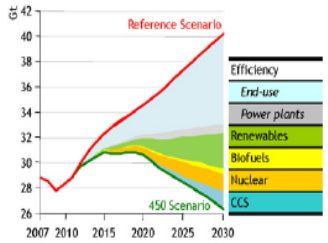
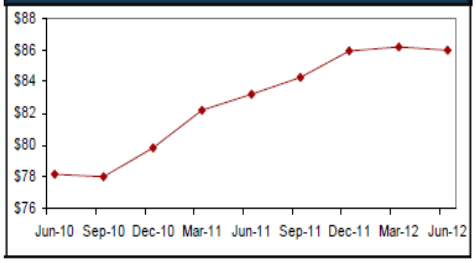
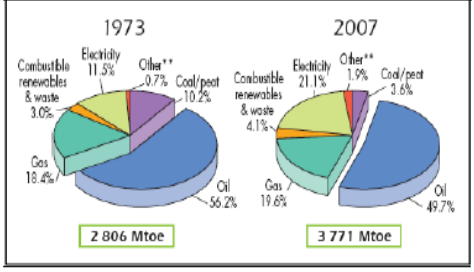
Worldwide CO_2 Emissions



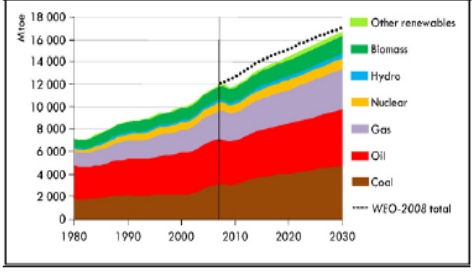
Energy Prices (Oil)



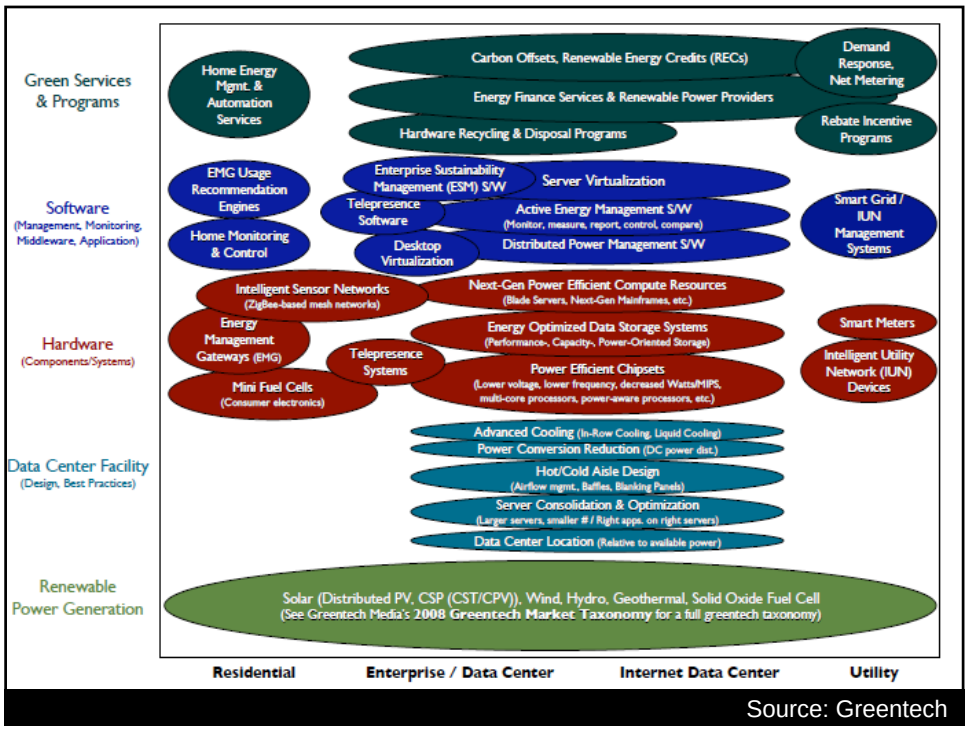
Worldwide Energy Consumption



Worldwide Energy Demand



Sources: International Energy Agency (IEA) and Consensus Economics, 2009



Source: Greentech

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Dominant Logics (Watson et al)

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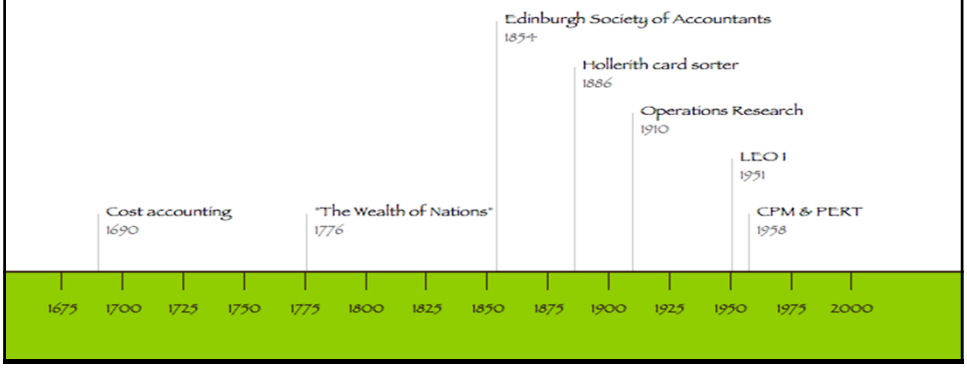
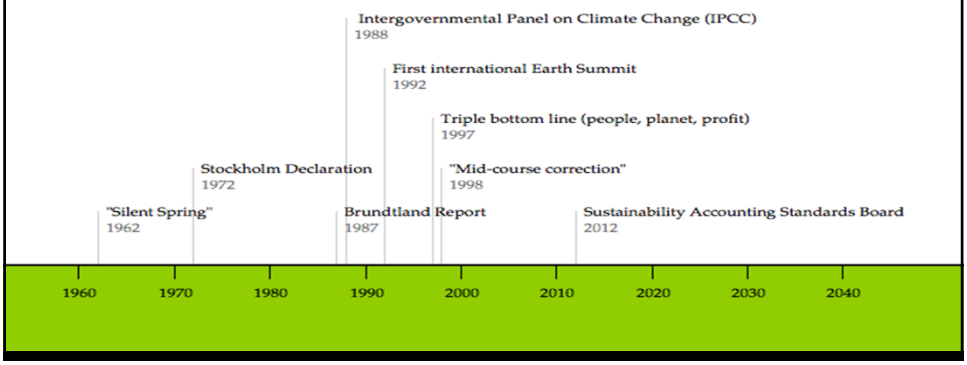
Question	How to survive?	How to farm?	How to manage resources?	How to create customers?	How to reduce environmental impact?
Dominant issue	Survival	Production		Customer service	Sustainability
Key information systems	Gesture Speech	Mathematics Writing Calendar Money Measures	Accounting Economics ERP Project management Digital computers	Ecommerce CRM Business analytics	Sensors Simulation Optimization Design Flow analysis

Dominant Logic – Industrial Era (Watson et al.)



Dominant Logic – Sustainability (Watson et al.)



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Distribution of the U.S. labor force by sector 1840-2010

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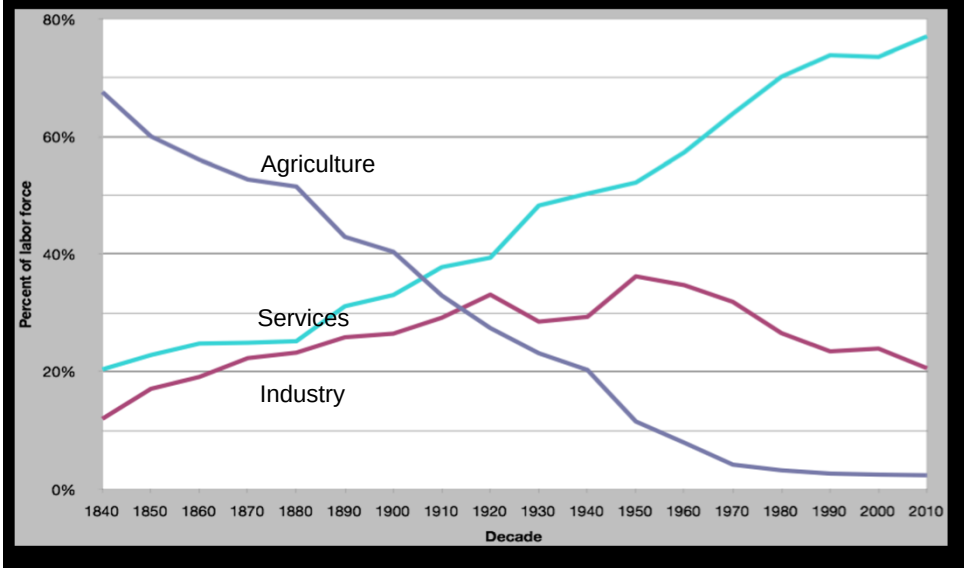

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Implications for IS (Watson et al)

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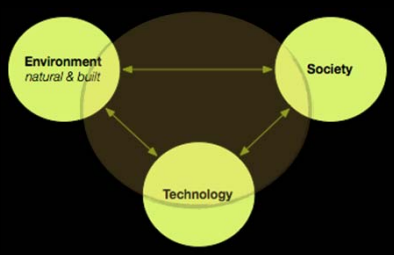
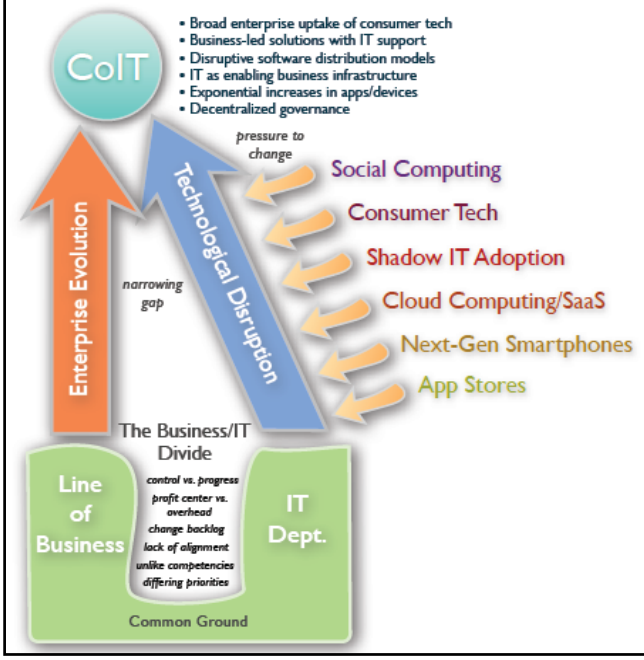
- Reassess the socio-technical model to include natural systems as well as built
- Flow network analytics
- Big data from vast sensor networks
- Symbiotic physical and informational modeling and simulation
- The impact of information on consumer environmental behavior





- Consumerization of the workplace
- Rise of shadow IT (10% ten years ago, nearly a 3rd today)
- SaaS makes enterprise cloud apps just a URL away
- Smartphones the new "IT dept in your pocket"
- Tech savvy business users leading the charge with their own vision

Source: Dachis

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WEBIST 2013 — Smart Cities as a Platform for IT — Brian Donnellan

Non-community services

- Finance
- Workplaces
- Persuasive information

Community services

- Healthcare
- Education
- Recreation & Commerce
- Travel & Transport
- Security & Safety
- Living Environment

Infrastructure Services

- Energy Electricity
- Water
- Buildings
- Transport Infrastructure
- Waste
- Data- & Tele-Communication

Services applicable for ICT solutions.

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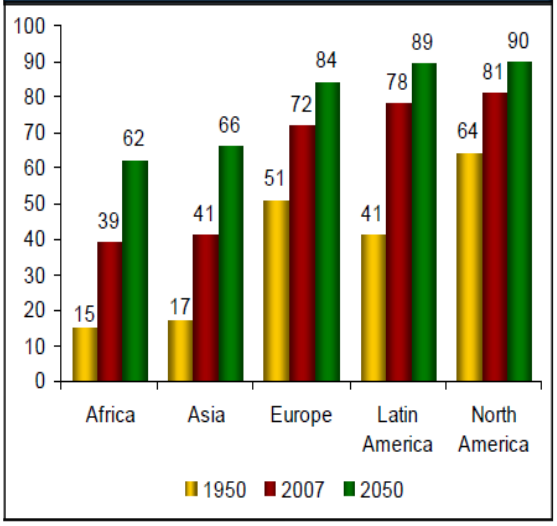
The Percent of the Population Living in Urban Areas is Projected to Rise Rapidly in the Less Developed Regions—Asia, Africa and Latin America



"The 19th century was a century of empires, the 20th century was a century of nation states, the 21st century will be a century of cities"
– Wellington Webb, former Mayor of Denver

- People living in cities:
  - Are more economically successful
  - Are better educated
  - Are generally healthier
- However, urban citizens also:
  - Use more energy
  - Consume more goods and services
  - Create more pollution and waste

Source: UN Population Division, *World Urbanization Prospects: The 2007 Revision, Executive Summary (2007)*

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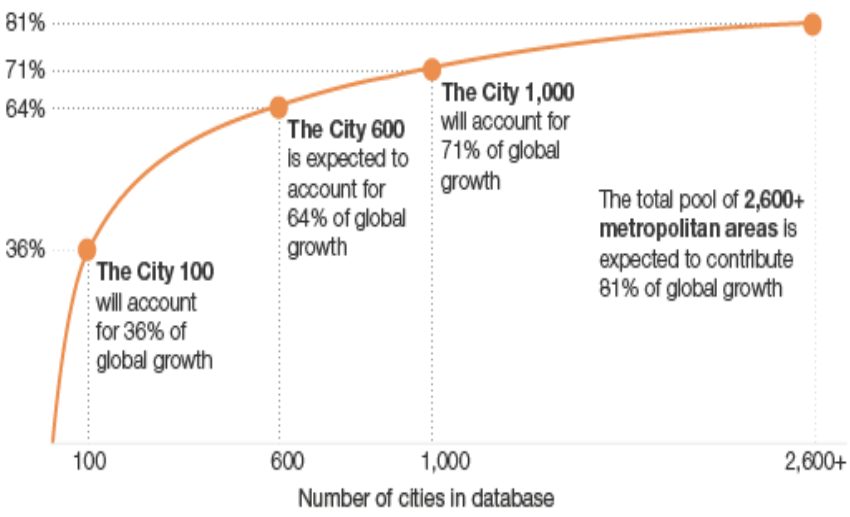
Projected Cumulative Contribution to Global GDP growth



[1]Predicted real exchange rate.

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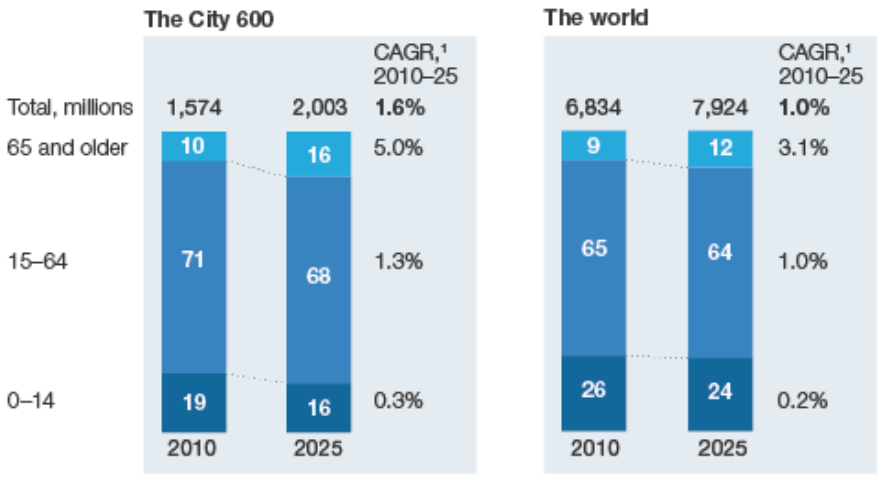
Top 600 cities will grow 60% faster than World Population



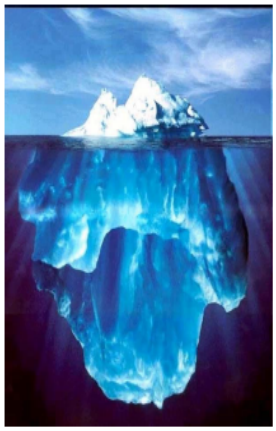
[1]Compound annual growth rate.

What Citizens May Expect from Wired Cities: Examples of Typical Goals and Technological Features Implemented in Wired Cities

Electronic applications for ...	The city as ...		
	Political arena	**Service provider**	**Community**
Information retrieval	More transparency through searchable electronic archives, webcasting of meetings	Easier access to city services through service catalogues, quality checks	Mutual citizen awareness through e-catalogues of civic groups
Communication	Better informed deliberations through web forums, issue-specific discussion groups	Better targeted services through e-complaints procedures, online satisfaction surveys	More civic interaction through online meetings
Participation	More extensive	More quality through	Enhancement of

Examples for a city of 1 million people		
Smart metering	600,000 smart meters	$120 million opportunity
Electric vehicle charging infrastructure	45,000 electric vehicles	$225 million opportunity
Remote patient monitoring (diabetes)	70,000 people w/diabetes	$14 million opportunity
Smart retail establishments	4,000 stores	$200 million opportunity
Smart bank branches	3,200 PTMs	$160 million opportunity

Note: These are high level estimates – not to be used for formal market sizing



Total Worldwide ICT Opportunity ≈ $200 Billion

IDC Analyze the Future

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Systematic Literature Review "Sustainable Connected" Cities

Domains Aggregated view	Type of source	Energy	Water & Waste	Utilities	Environment	Smart Living	Mobility	Built Environment	Healthcare	Economy & Commerce	Government / Municipality	Social Capital	Community	Education and Culture	Entertainment	Shopping	Communication	Smart Living & Public Safety	Education	Research / Universities	Agriculture	% of domains covered
References																						
[Abdulrahman, 2012]	Academic Papers	x	x	*	*	x	x	x	x													40.00%
[Caragliu et al. 2011]								x		x	x	*	x	x	x			*	*			45.00%
[Dedgaon et al. 2011]		x	x	*	*		x			x	x	x	*				x	*	*			60.00%
[Leonhardt et al. 2012]		*	*	*	x				*	x	x	x	*					x	*			55.00%
[Naphade et al. 2011]		x	x	*			x		x		x							x	x			40.00%
ARUP [2010]	Consultancy Reports	x	x	*	*	x	x															30.00%
IBM [2009]		x	x	*	*	x				x		x	*				x	*	*			55.00%
CISCO [2012]		x	x	*	*		x	x			x								*			45.00%
OVUM [2011]		*	*	*	x			*	x	x	x	x	x						*				55.00%
IBM [2011]		*	*	*	x		*	x		*	x	x	*						*				55.00%
EU [2011]							x	x	x		*			x	x	x	x	x	x			55.00%
SIEMENS [2007]		*	*	*	x		x		*	x	x	x	*		*				x	*			65.00%
FIRE4ALL [2012]		*			*		*	x	*	*	x			*					*	*			50.00%
THINK! [2010]		*	*	*	x		x		*	x	x	x	*		*				x	*			65.00%
FORRESTER [2010]		*	*	x	x		x	x	x		x	*							x	x			55.00%
ALCATEL [2012]		*	*	x	x		x	x	x		x	*							x	x			55.00%
PURPOSE [web]		x	x	*	*		x	x	x		x	*							x	x			55.00%
SCHNEIDER [web]		x	x	*	*		x	x			x												35.00%
ROBINSON [web]		*	*	x	*		x		x	x	x			x					x	x			60.00%
PIKE [web]		*	*	x	*		x	x															35.00%
IOD5 [web]		*	*	x	*			*		x									x				40.00%
HITACHI [web]		x	x	*	*		x			x				x				x			x	x	50.00%
NETWORKS [web]		*	*		x		x		*	x	x	x	*		*				x	*			60.00%
[Alawadhi et al. 2012]	Conference Papers	*	*	*	x			x		x	x	*	x											45.00%
[Augusto, 2009]		x	x	*	*		x		x		*								x				40.00%
[Chourabi et al. 2012]		*	*		x			x		x	x	*	x						*				45.00%
[Giffinger et al. 2007]		*	*	*	x		x		*	x	x	x	*	*					x	*			65.00%
[Lee, 2012]			*		*			x			x	*	x										30.00%
[Nam et al. 2011]											x	x	*										15.00%
[Steinert et al. 2011]								x			x	*	x						x				25.00%
[Schaffers et al. 2011]		x	*	*	x				x		x	x	x					x	x				50.00%
INTEL - DCC		x	x	*	x		x	x	x	x	x		x					*	x				60.00%
% considered		87%	87%	73%	87%	60%	87%	67%	67%	67%	87%	67%	87%	67%	67%	13%	67%	73%	67%	33%	33%	

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Sustainable Connected City

…is an urban area that leverages its technological and social infrastructure implementing people-private-public partnerships supported by an innovative governance (in terms of policies, leadership and proper on-going management principles), to enable smart information services, aiming at improving its critical capabilities.

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SCC - Capability Maturity Framework

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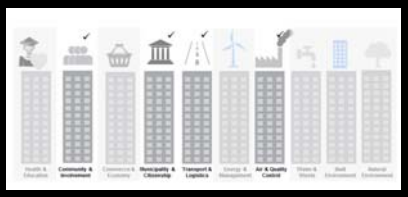
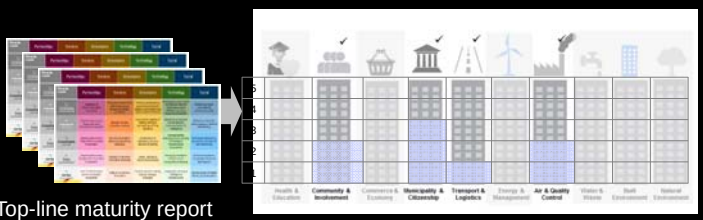


1. Target Domains for evaluation

2. Top line services and KPIs within domains for evaluation

3. Evaluate with key stakeholder workshops + citizen survey



4. Top-line maturity report

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Dublin - Urban Themes

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Economy & Innovation

Community & Citizenship

Culture and Entertainment

Movement & Transport

Urban Places & Spaces

Environmental Practices

Technologically enabled innovation for resource efficiencies and city quality of life

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SMART CITY DOMAINS

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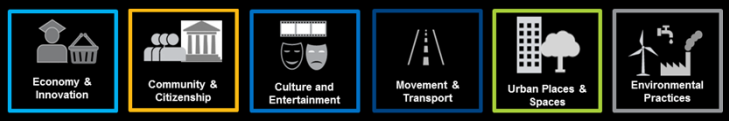

Economy and Innovation, that includes: Knowledge Activities (Education and R&D), Connectivity, Overall Competitiveness, Employment, FDI (Foreign Direct Investment), International Benchmarking, Shopping and Commerce, Tourism, Entrepreneur Support and Development.

Community and Citizenship, that includes: Governance and Participatory Democracy, Inclusive Access to Services, Community Engagement and Volunteering, Crime-Perception and Incidence, Public Safety, Housing, Poverty, Population, Healthcare, Third Sector and NGO Collaboration, Sports and Active Recreation.

Urban Places and Spaces, that includes: Existing Buildings, Outdoor Lighting, Public Space, Sustainable Use of Land, Planning, Urban Food Production, Urban Sprawl and Density of Development, Regeneration Activities.

Culture and Entertainment, that includes: Facilities Capacity and Attendance, Events and Festivals, Entertainment, Accessibility and Family Friendly, Nightlife, Support for the arts.

Movement and Transport, that includes: Air Travel, Sea Travel, Movement in the city, Use and Proximity to Public Transport, Quality of Road Network, Capacity for Public Transport, Cycling and Walking.

Environmental Practices, that includes: Water, Energy, Climate Adaptation, Noise Pollution, Waste Management, Air Quality, Biodiversity.

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Smart City Matuirty Model

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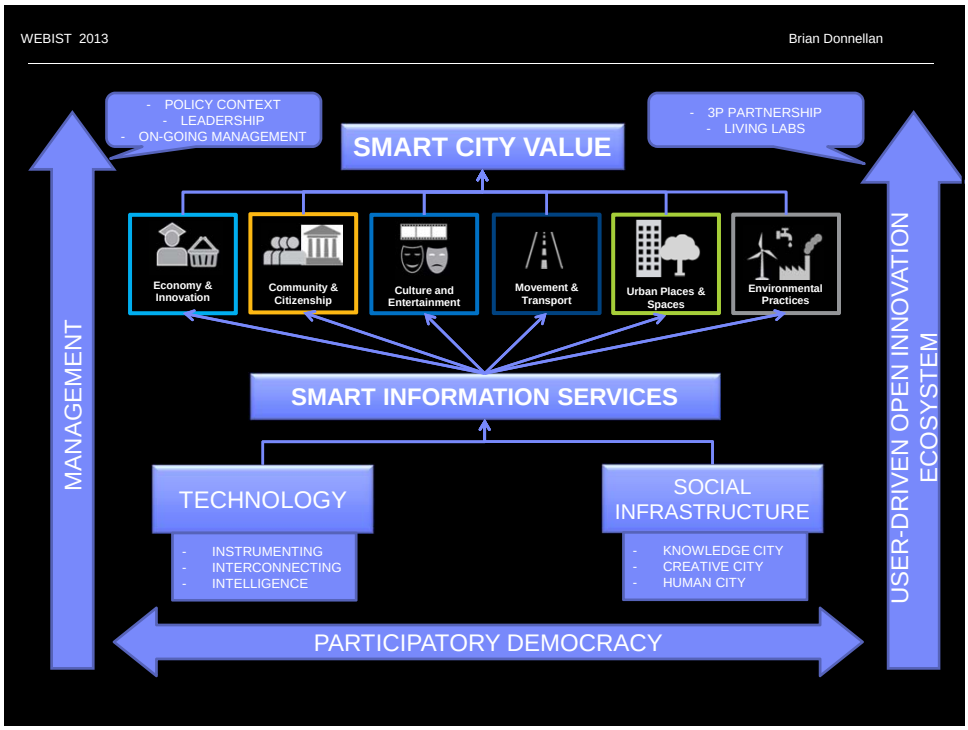
Maturity Levels	Partnerships	Services	Governance	Technology	Social
5. Optimising (Transformational)	Symbiotic & User-driven Open Innovation	Integrated, adaptive & collectively aware service innovation portfolios	Virtuous participatory governance between leaders (centralised) and citizens (decentralised)	Anticipate & solve needs via Massive, Open & Online Data-marts (MOODs) spanning diverse ecosystems	Bottom-up social innovation & entrepreneurship
4. Advanced (Proactive)	Shared-value across Quadruple-helix Innovation Ecosystem	Dynamic service innovation markets	Governance capable of making decisions anticipating shifting dynamics	Ubiquitous ecosystem connectedness, instrumentation & intelligence	Behaviours become highly-adaptive, skilled & self-learning
3. Intermediate (Essential)	Shared-value across Triple-helix Innovation Ecosystem:	Services innovation delivery programmes emerging	Mgmt. interoperability emerging across city domains. Governance of regulatory, privacy, security & sharing.	Interoperability emerging across sensing & intelligent infrastructure ecosystems	Anticipated behaviours becoming consistent & self-reinforcing
2. Basic (In-development)	Shared-value across Double-helix Innovation	Pockets of services	Vision, policies &	Sensing & intelligent infrastructure ecosystems	Active involvement, knowledge sharing & ide… ture
1. Ad Hoc (Sub-standard)	Lack of shared-value across innovation ecosystem	Little or no service innovation	Tactical decision-making, lacking strategic foresight	Inadequate sensing & intelligence Infrastructure	Varying levels of digital literacy & participation

Triple Bottom Line - sustainable social, economic, and environmental city living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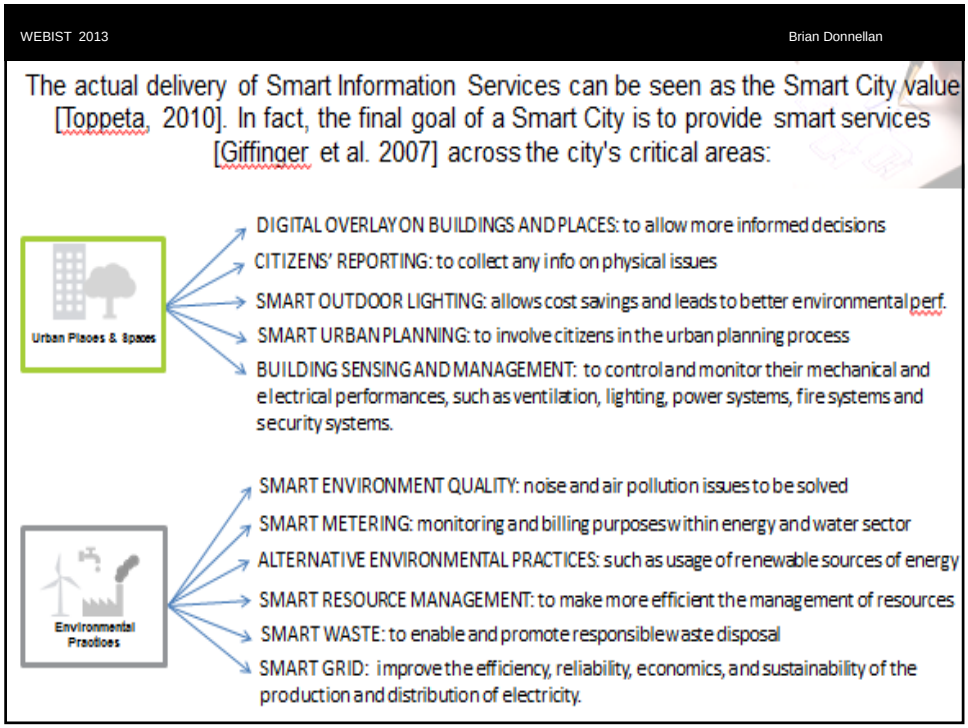
- POLICY CONTEXT
- LEADERSHIP
- ON-GOING MANAGEMENT
SMART CITY VALUE
- 3P PARTNERSHIP
- LIVING LABS
Economy & Innovation
Community & Citizenship
Culture and Entertainment
Movement & Transport
Urban Places & Spaces
Environmental Practices
MANAGEMENT
USER-DRIVEN OPEN INNOVATION ECOSYSTEM
SMART INFORMATION SERVICES
TECHNOLOGY
- INSTRUMENTING
- INTERCONNECTING
- INTELLIGENCE
SOCIAL INFRASTRUCTURE
- KNOWLEDGE CITY
- CREATIVE CITY
- HUMAN CITY
PARTICIPATORY DEMOCRACY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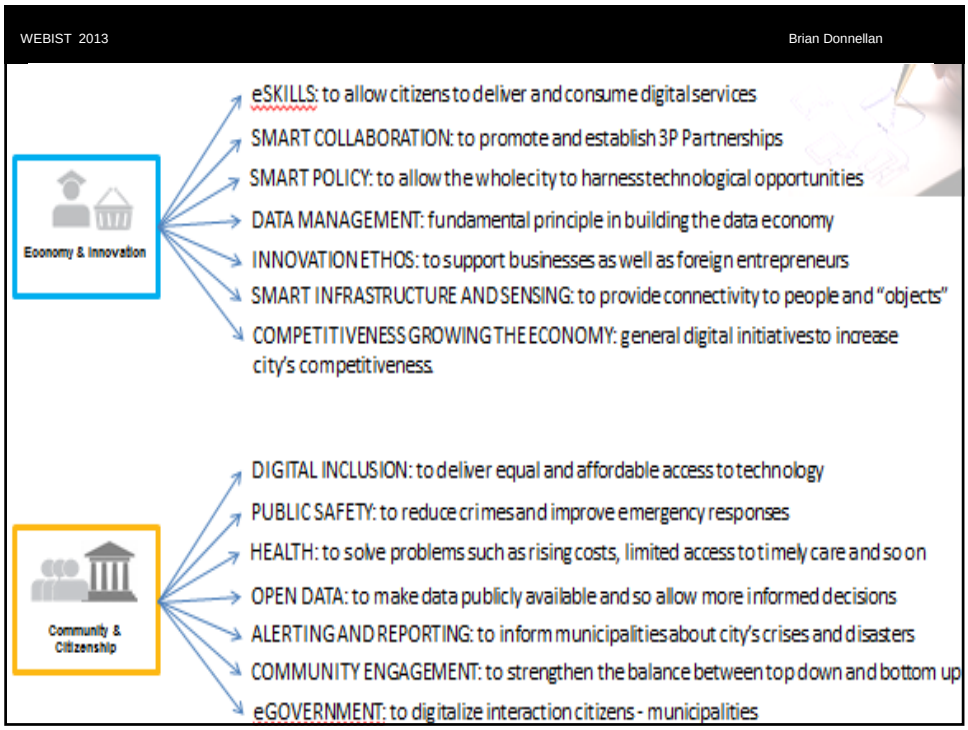
The actual delivery of Smart Information Services can be seen as the Smart City value [Toppeta, 2010]. In fact, the final goal of a Smart City is to provide smart services [Giffinger et al. 2007] across the city's critical areas:
Urban Places & Spaces
DIGITAL OVERLAY ON BUILDINGS AND PLACES: to allow more informed decisions
CITIZENS' REPORTING: to collect any info on physical issues
SMART OUTDOOR LIGHTING: allows cost savings and leads to better environmental perf.
SMART URBAN PLANNING: to involve citizens in the urban planning process
BUILDING SENSING AND MANAGEMENT: to control and monitor their mechanical and electrical performances, such as ventilation, lighting, power systems, fire systems and security systems.
Environmental Practices
SMART ENVIRONMENT QUALITY: noise and air pollution issues to be solved
SMART METERING: monitoring and billing purposes within energy and water sector
ALTERNATIVE ENVIRONMENTAL PRACTICES: such as usage of renewable sources of energy
SMART RESOURCE MANAGEMENT: to make more efficient the management of resources
SMART WASTE: to enable and promote responsible waste disposal
SMART GRID: improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.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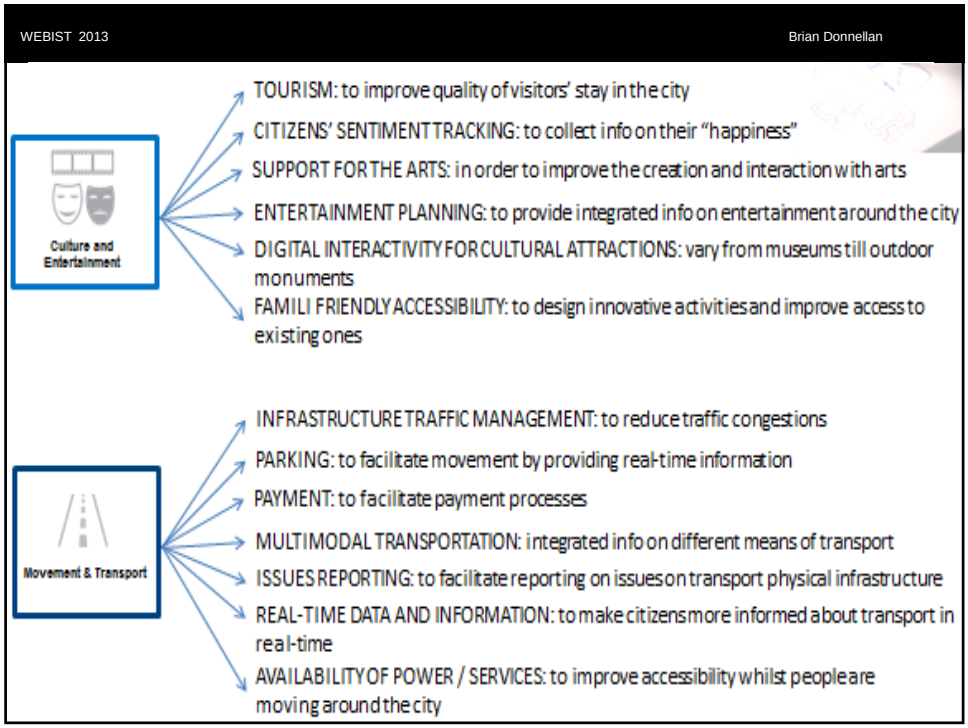
Economy & Innovation
eSKILLS: to allow citizens to deliver and consume digital services
SMART COLLABORATION: to promote and establish 3P Partnerships
SMART POLICY: to allow the whole city to harness technological opportunities
DATA MANAGEMENT: fundamental principle in building the data economy
INNOVATION ETHOS: to support businesses as well as foreign entrepreneurs
SMART INFRASTRUCTURE AND SENSING: to provide connectivity to people and "objects"
COMPETITIVENESS GROWING THE ECONOMY: general digital initiatives to increase city's competitiveness
Community & Citizenship
DIGITAL INCLUSION: to deliver equal and affordable access to technology
PUBLIC SAFETY: to reduce crimes and improve emergency responses
HEALTH: to solve problems such as rising costs, limited access to timely care and so on
OPEN DATA: to make data publicly available and so allow more informed decisions
ALERTING AND REPORTING: to inform municipalities about city's crises and disasters
COMMUNITY ENGAGEMENT: to strengthen the balance between top down and bottom up
eGOVERNMENT: to digitalize interaction citizens - municipalities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Culture and Entertainment
TOURISM: to improve quality of visitors' stay in the city
CITIZENS' SENTIMENT TRACKING: to collect info on their "happiness"
SUPPORT FOR THE ARTS: in order to improve the creation and interaction with arts
ENTERTAINMENT PLANNING: to provide integrated info on entertainment around the city
DIGITAL INTERACTIVITY FOR CULTURAL ATTRACTIONS: vary from museums till outdoor monuments
FAMILI FRIENDLY ACCESSIBILITY: to design innovative activities and improve access to existing ones
Movement & Transport
INFRASTRUCTURE TRAFFIC MANAGEMENT: to reduce traffic congestions
PARKING: to facilitate movement by providing real-time information
PAYMENT: to facilitate payment processes
MULTIMODAL TRANSPORTATION: integrated info on different means of transport
ISSUES REPORTING: to facilitate reporting on issues on transport physical infrastructure
REAL-TIME DATA AND INFORMATION: to make citizens more informed about transport in real-time
AVAILABILITY OF POWER / SERVICES: to improve accessibility whilst people are moving around the city

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Presentation Outline

- IT and Energy
- IS and Energy
- Smart Cities
- Conclusions ✓

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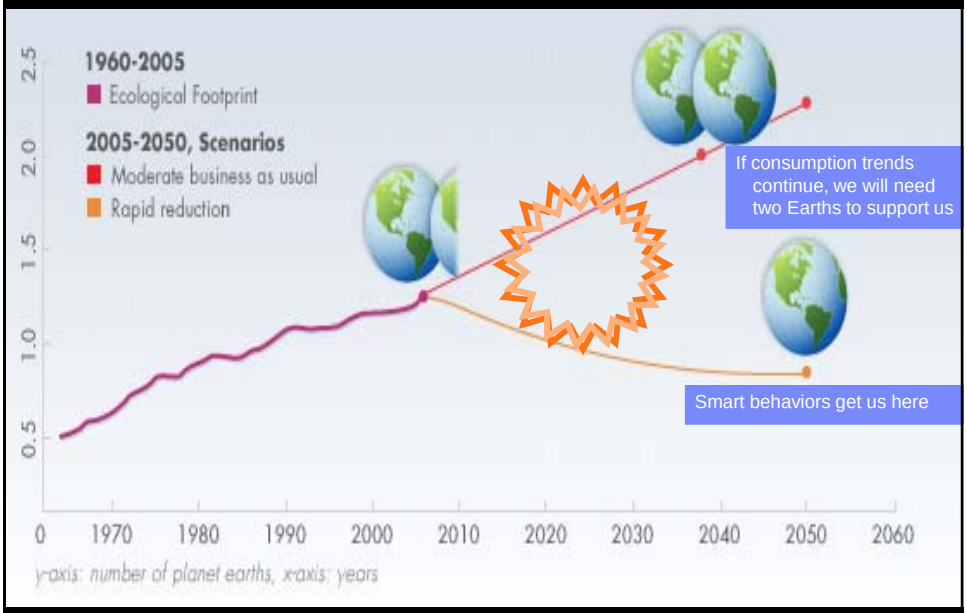
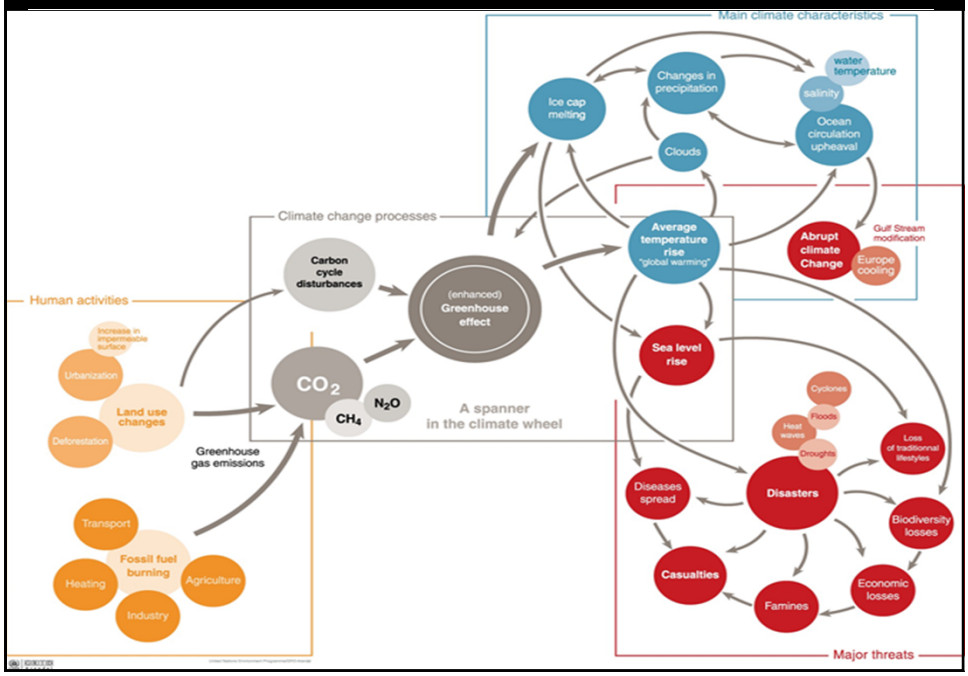


Source: Global Footprint Network



Conclusions

- The emergence of the City as a “platform”: opportunities and challenges.
- We are missing a comprehensive, systematic and holistic approach to the challenge of IT and Energy.
- Big business/government approaches to urban resilience and sustainability assumes underlying logics, ideology, production and consumption, but can we really plan out, technically solve, and alter in small increments individual behaviour which will make society sustainable?
  - Governance and leadership
  - Modes of consumption and lifestyle
  - Social relations and formations

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