Sustainability
Challenges and Opportunities

Meeting the world’s needs for a sustainable future

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1. Sustainability Challenge
2. Dimensioning the Sustainability Challenge
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4. Sustainable Urban Infrastructure: What does this Encompass?
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7. Emerging Technologies
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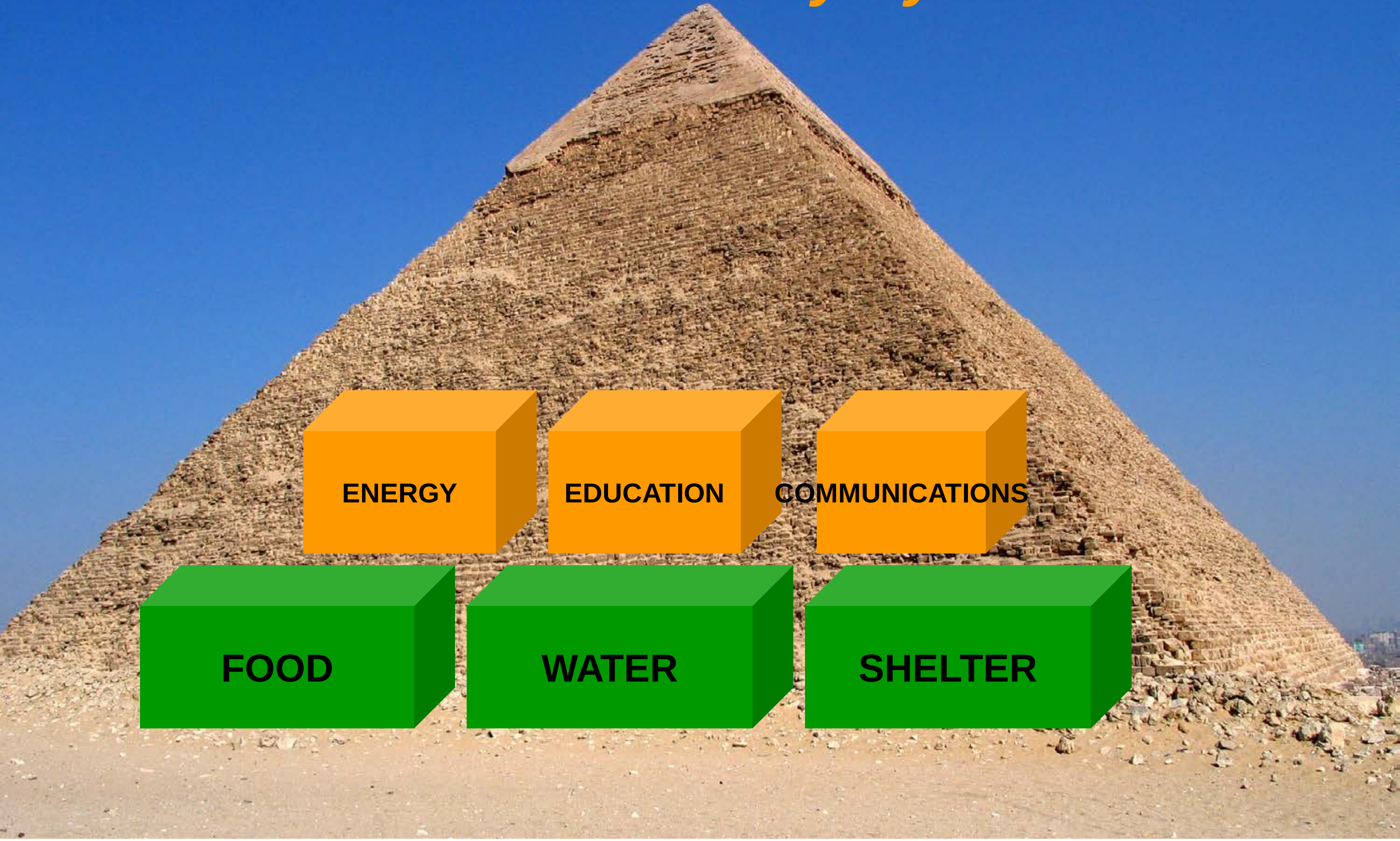
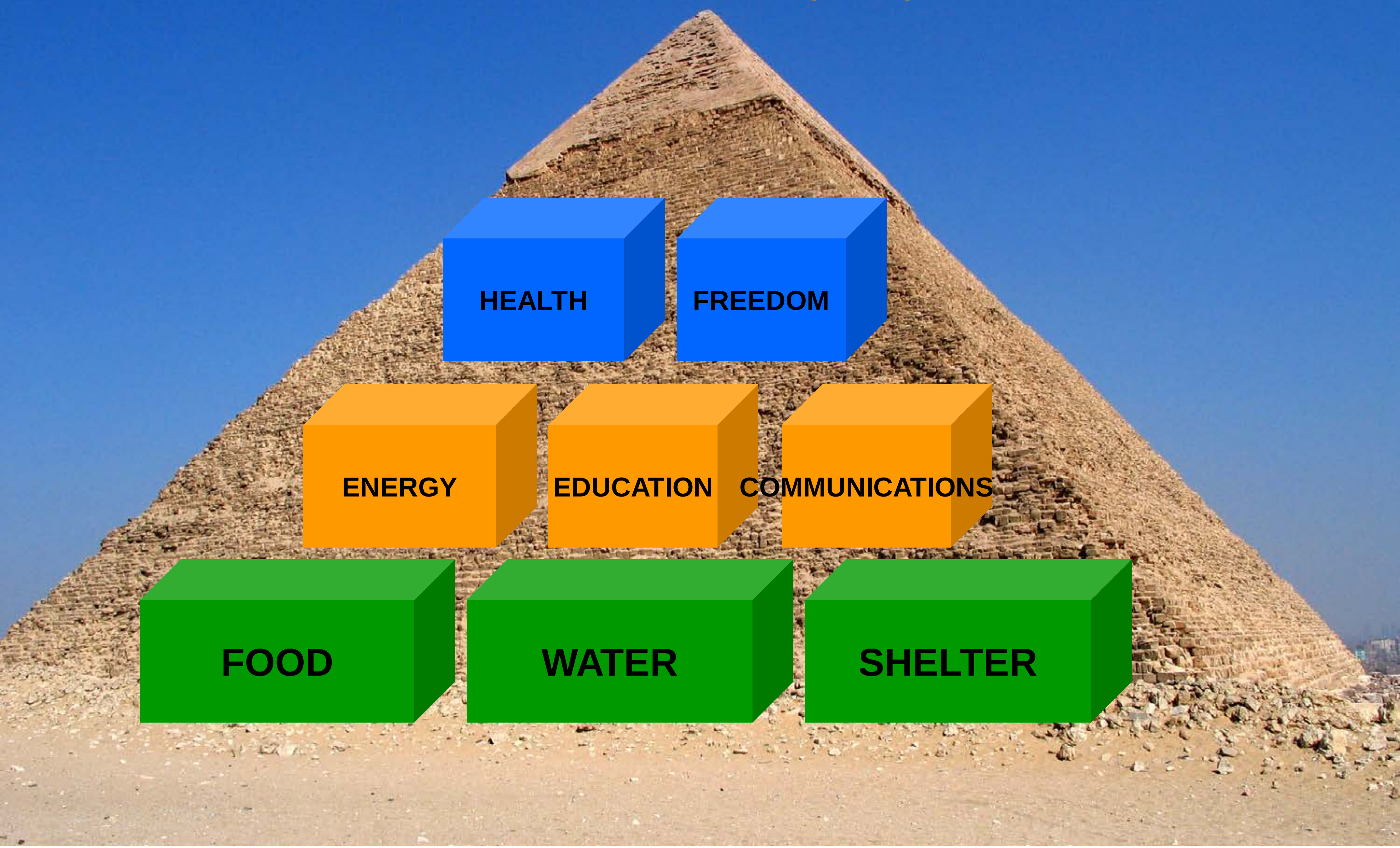
The Sustainability Pyramid

The Sustainability Pyramid



The Sustainability Pyramid



Why must we be more sustainable?





How do we become more sustainable?



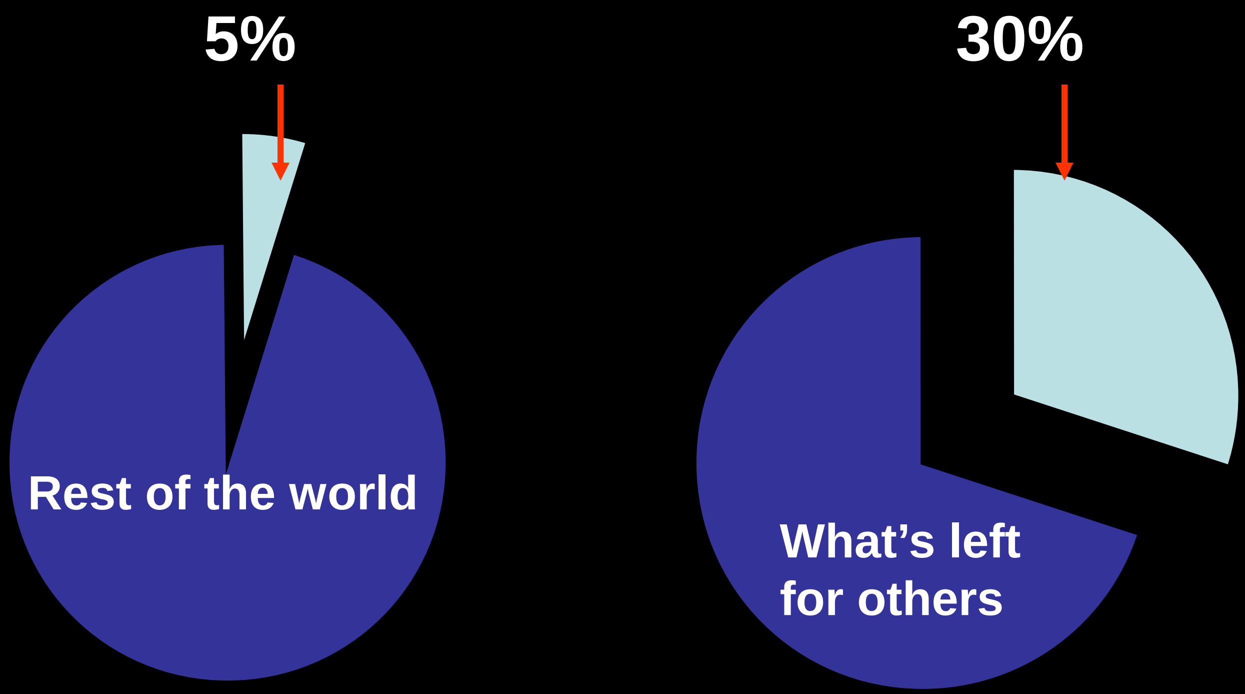







How the world might perceive our life style

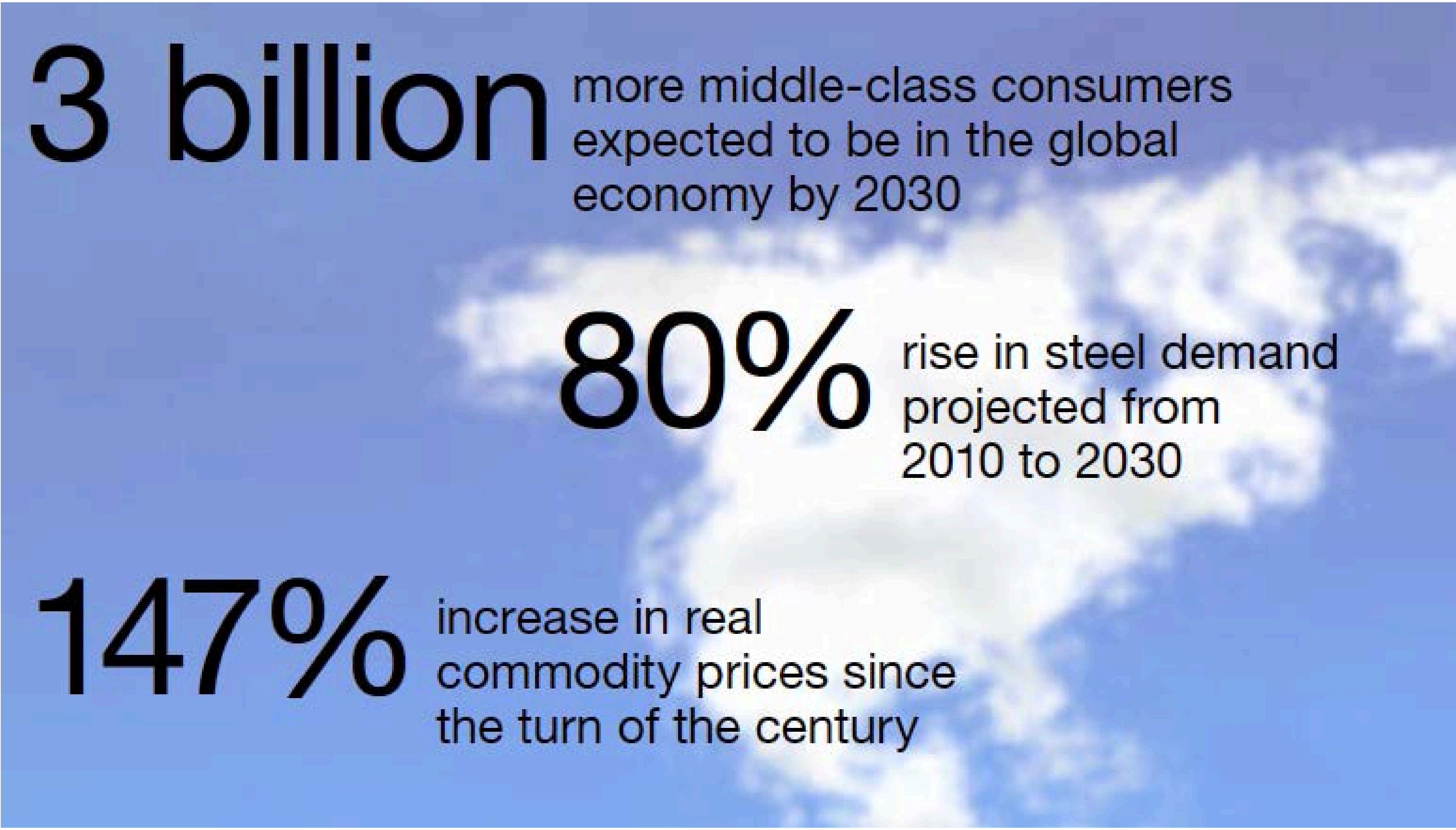
With only 5% of the global population, we use 30% of the world's natural resources (North America)



What happens if the rest of the world wants what we enjoy?


How many people in the world live

2. Dimensioning the sustainability challenge



McKinsey Global Institute

44 million

people driven into poverty by rising food prices in the second half of 2010, according to the World Bank

100% increase in the average cost to bring a new oil well on line over the past decade

Up to **$1.1 trillion**

spent annually on resource subsidies

$2.9 trillion

of savings in 2030 from capturing the resource productivity potential… rising to

$3.7 trillion

if carbon is priced at $30 per tonne, subsidies on water, energy, and agriculture are eliminated, and energy taxes are removed

70%

of productivity opportunities have an internal rate of return of more than 10% at current prices… rising to

90%

if adjusted for subsidies, carbon pricing, energy taxes, and a societal discount rate of 4%

At least $1 trillion

more investment in the resource system needed
each year to meet future resource demands

15 opportunities

deliver about 75% of total
resource productivity benefits

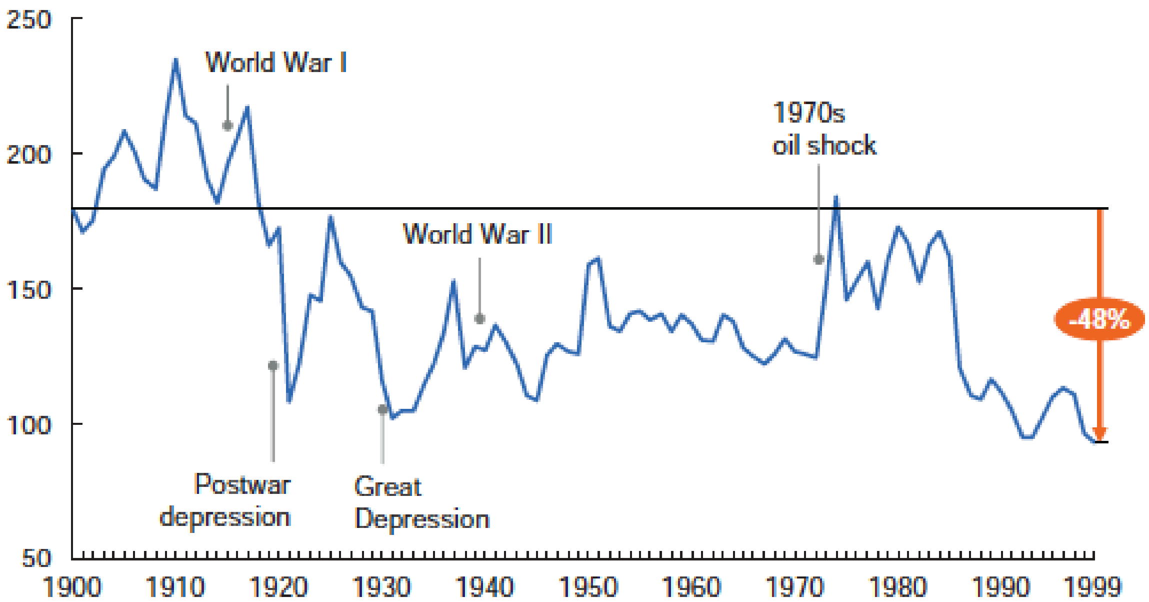
McKinsey Global Institute

Progressively cheaper resources underpinned global economic growth during the 20th century

Exhibit 1

Average commodity prices have fallen by almost 50 percent over the past century

MGI Commodity Price Index (years 1999–2001 = 100)[1]



1 See our methodology appendix for details of the MGI Commodity Price Index.

SOURCE: Grilli and Yang; Pfaffenzeller; World Bank; IMF; OECD statistics; FAO; UN Comtrade; McKinsey analysis

20th century economic growth largely driven by falling prices of natural resources - this era appears to be coming to an end

Dominant thesis of the 20th century was that the market would ride to the rescue by providing sufficient supply and productivity – largely true

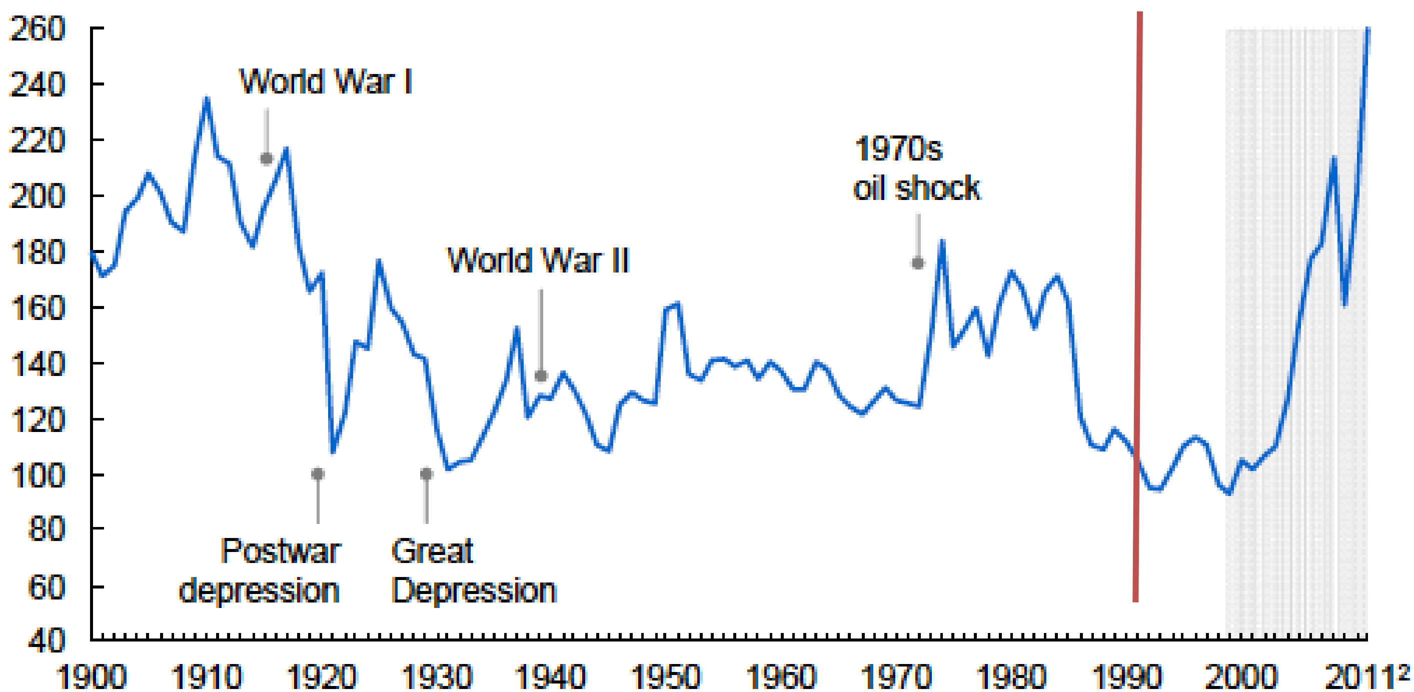
Commodity price index fell by almost half in the 20th century in real terms – in the same period, global population quadrupled and global economic output expanded roughly 20-fold

The world is now entering an era of high and volatile resource prices

Exhibit E1

Commodity prices have increased sharply since 2000, erasing all the declines of the 20th century

MGI Commodity Price Index (years 1999–2001 = 100)[1]



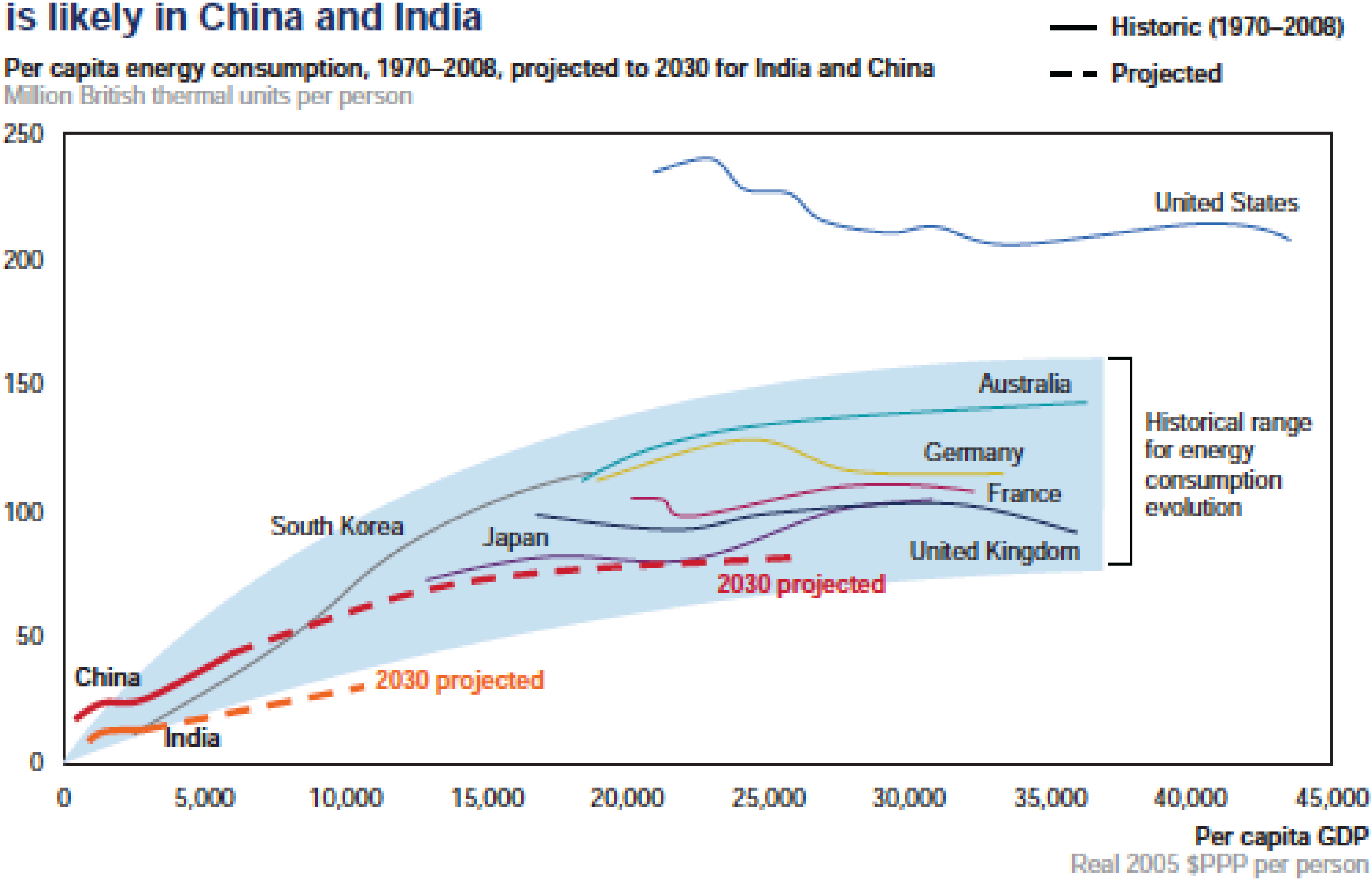
1 See the methodology appendix for details of the MGI Commodity Price Index.
2 2011 prices are based on average of the first eight months of 2011.
SOURCE: Grilli and Yang; Stephan Pfaffenzeller; World Bank; International Monetary Fund (IMF); Organisation for Economic Co-operation and Development (OECD); UN Food and Agriculture Organization (FAO); UN Comtrade; McKinsey analysis

Exhibit 10

Many countries have shown that as incomes rise, demand for resources increases—and a similar curve is likely in China and India

ENERGY EXAMPLE

Per capita energy consumption, 1970–2008, projected to 2030 for India and China
Million British thermal units per person



SOURCE: IEA; Global Insight; McKinsey analysis

Resource Challenges

- Up to 3 billion more middle-class consumers will emerge in the next 20 years – will trigger a dramatic expansion in global infrastructure, particularly in developing countries (India and China)
- Growth of India and China happening at about 10 times the speed at which UK improved average incomes during the Industrial Revolution – and at 200 times the scale
- Demand is soaring at a time when finding new sources of supply and extracting them is becoming increasingly challenging and expensive – there will be absolute shortages
- Urbanization – new and expanding cities – will displace up to 30 million hectares of the highest quality agricultural land by 2010 – 2 percent of land presently under cultivation

Water: An Increasingly Scarce Resource

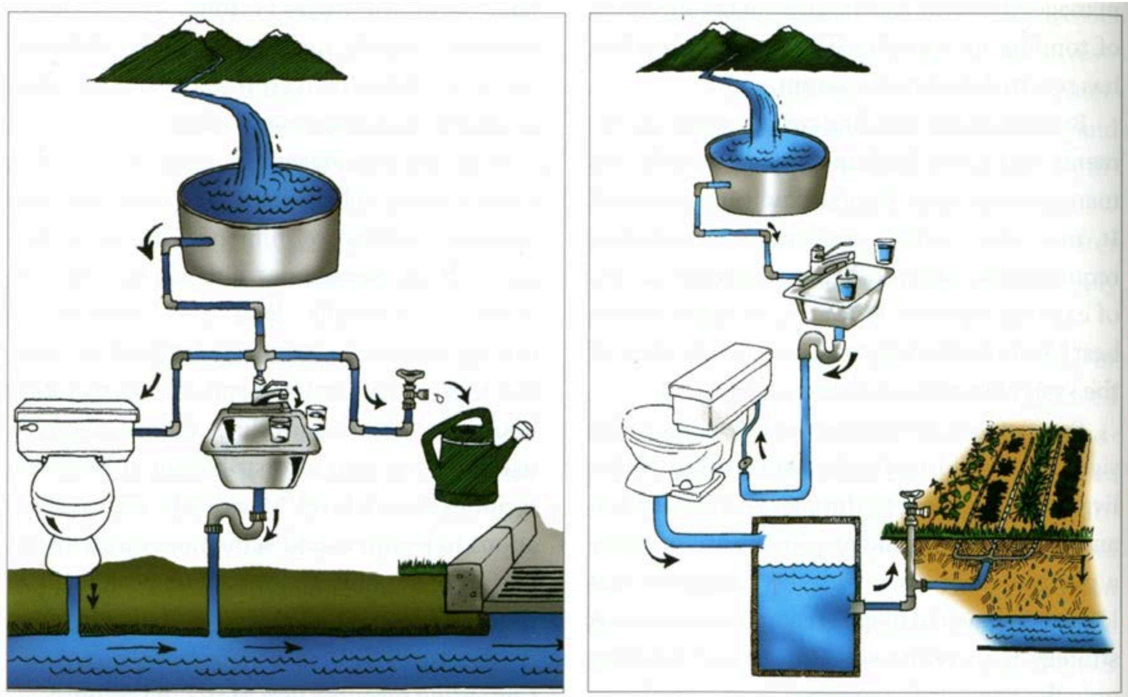


Figure 1.8 Cascading Water Use

Over 1.4 billion people currently live in river basins where the use of water exceeds minimum recharge levels, leading to the desiccation of rivers and depletion of groundwater.
Source: Human Development Report 2006

In 60 percent of European cities with more than 100,000 people, groundwater is being used at a faster rate than it can be replenished.
Source: World Business Council For Sustainable Development (WBCSD)

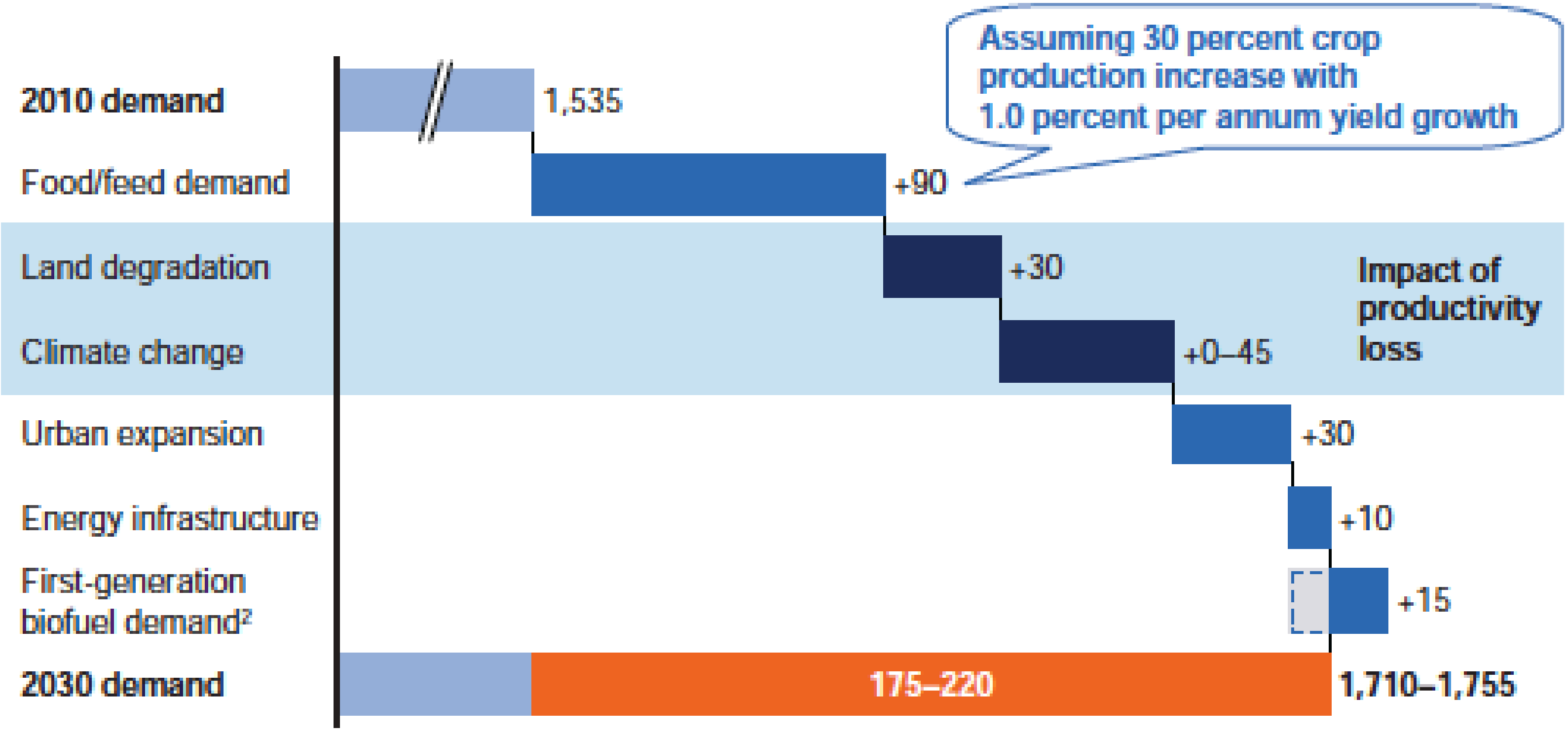
By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under stress conditions.

Exhibit 11

To meet 2030 food, feed, and fuel demand would require 175 million to 220 million hectares of additional cropland

Base-case cropland demand[1] by 2030

Million hectares



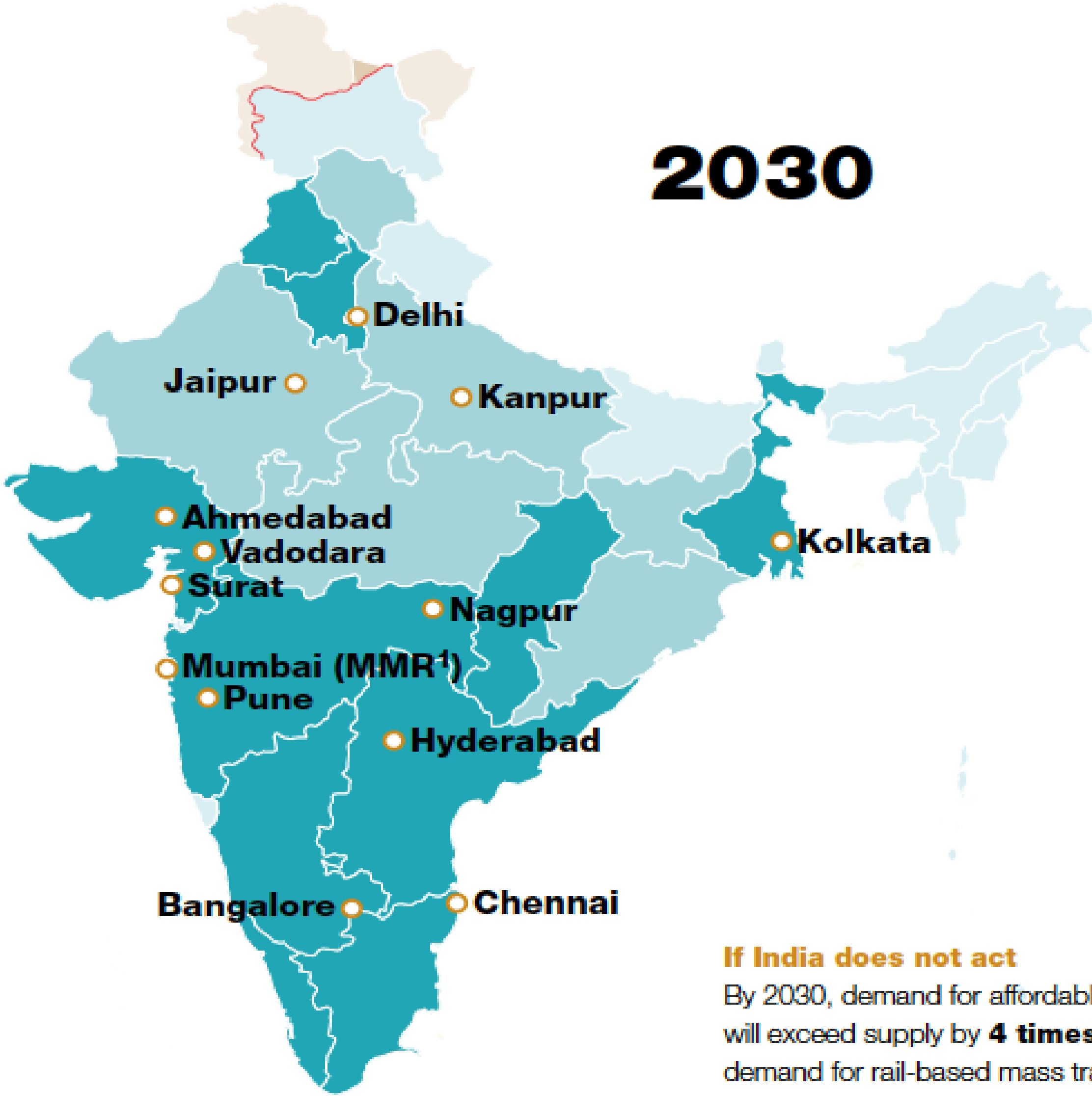
1 Defined as "arable land and permanent crops" by the FAO.

2 As 30–80 percent of biomass input for biofuel production is fed back to livestock feed, the cropland required to produce feed crops would be reduced by about ten million hectares.

SOURCE: International Institute for Applied Systems Analysis (IIASA); FAO; International Food Policy Research Institute; Intergovernmental Panel on Climate Change; Global Land Degradation Assessment; World Bank; McKinsey analysis

Rise of India’s middle class

- Indian economy, like that of China, will be dominated by mega-cities (Delhi and Mumbai) plus the 6 next-largest urban agglomerations
- By 2025 cities will command 62% of India’ spending power, up from 43% today
- Along with the shift from rural to urban, India will witness the rapid growth of its middle class – currently about 50 million or 5% of the population
- By 2025, a continuous rise in personal incomes will spur a 4x increase – 583 million people, or 41% of the population – in 20 years the shape of the income pyramid will be almost unrecognizable
- By 2025, about 75% of India’s urbanites will be middle class, compared to one-tenth today



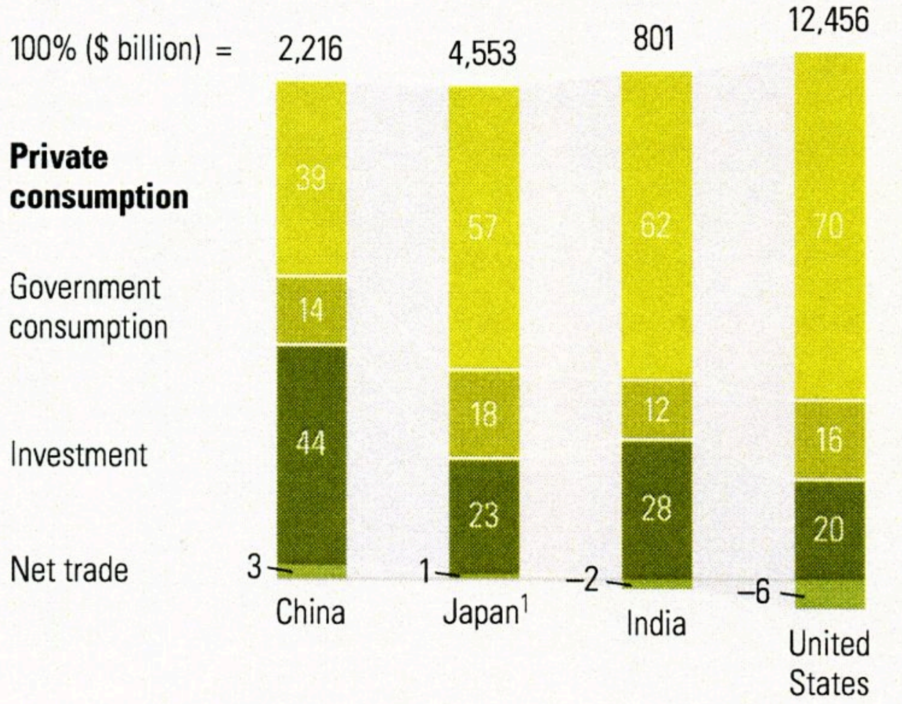
If India does not act

By 2030, demand for affordable housing will exceed supply by **4 times;** demand for rail-based mass transit will be **2.5 times the supply;** demand for private transportation will be **double the supply;** water demand will be **double the supply;** demand for sew-age treatment will be **3.5 times the supply.**

[1]Mumbai Metropolitan Region.

Private consumption: A starring role

% of GDP, 2005

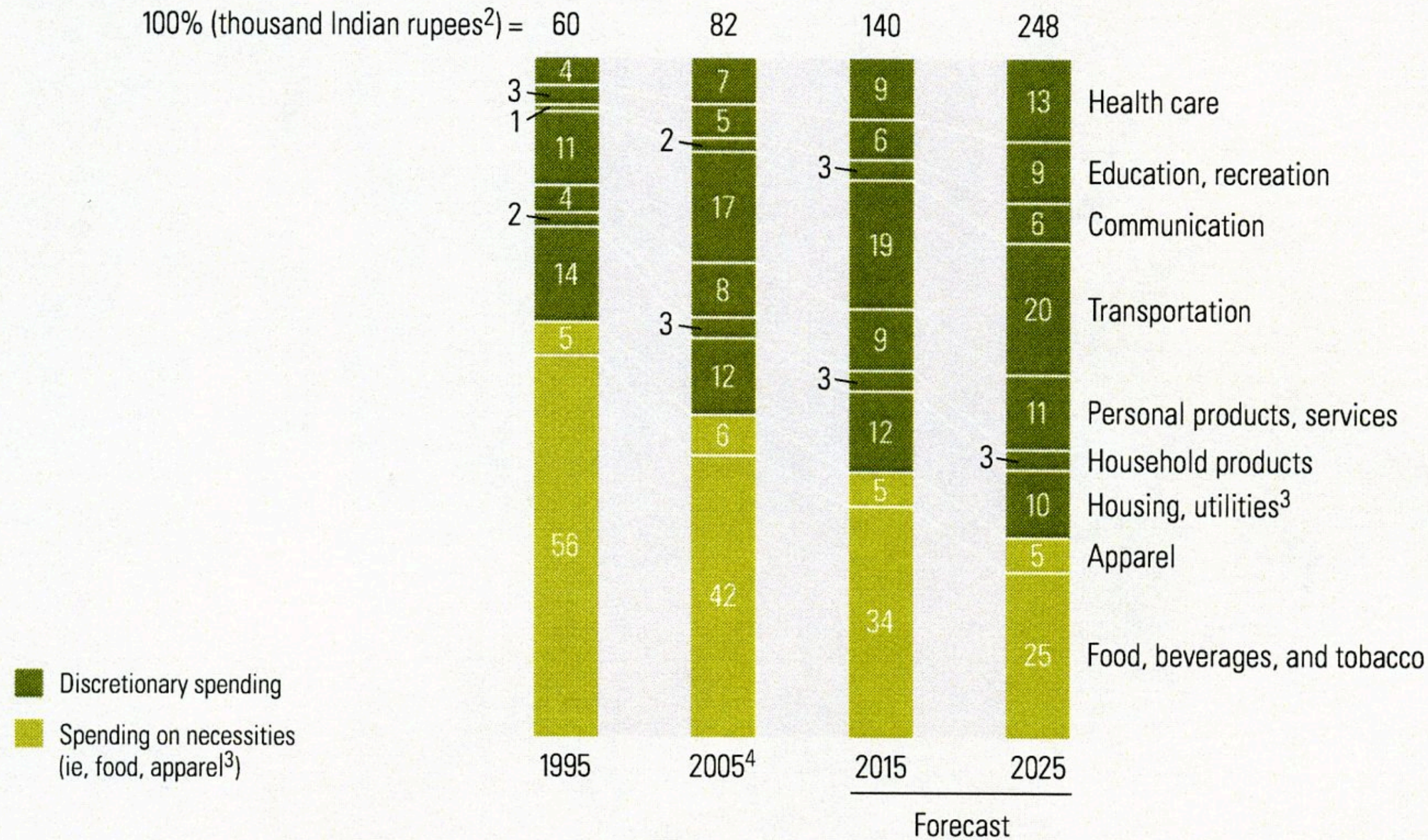


[1]Figures do not sum to 100%, because of rounding.

Source: Global Insight; McKinsey Global Institute analysis

Beyond necessities

Share of average annual household consumption, %[1]

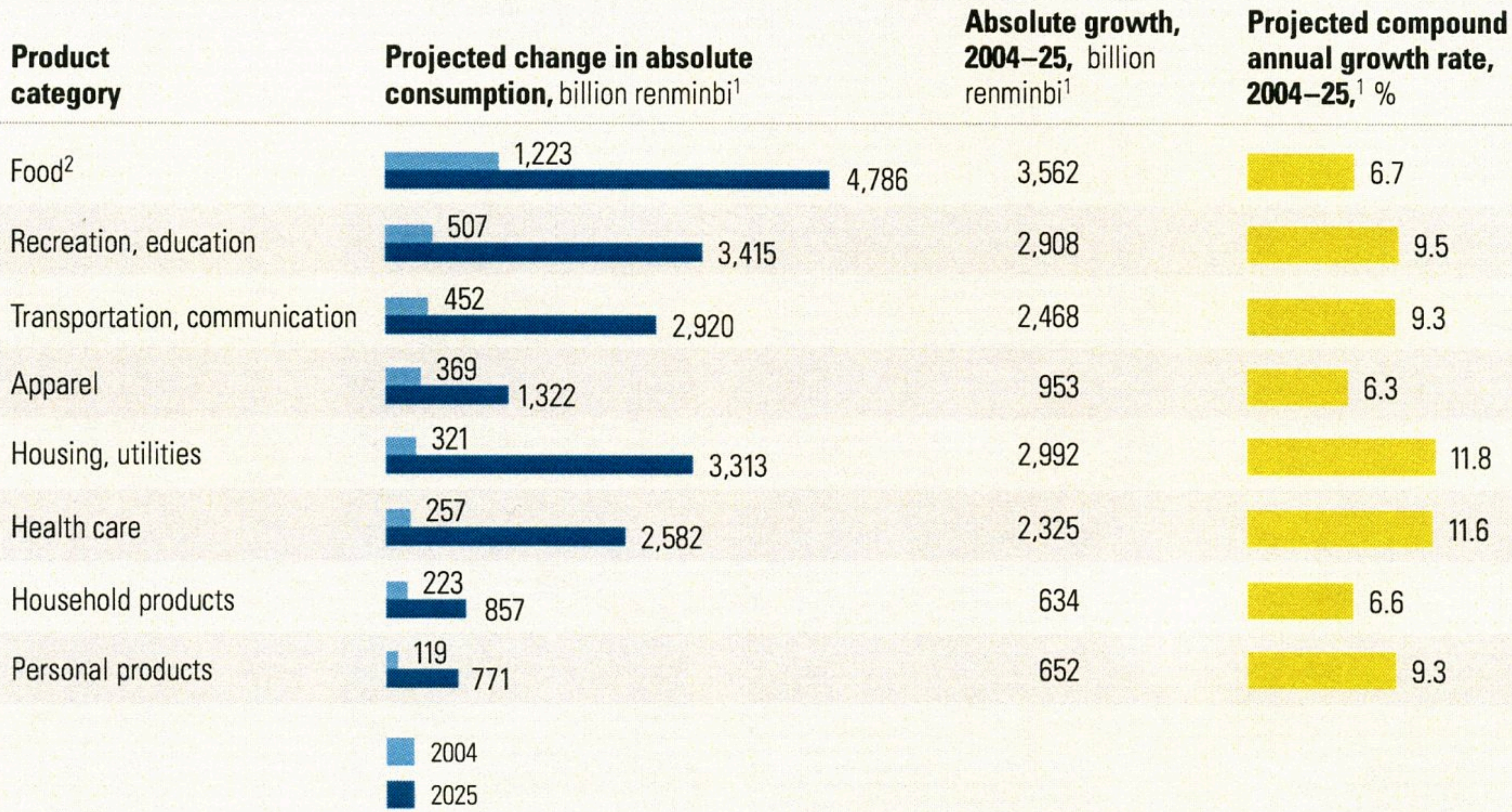


[1]Figures may not sum to 100%, because of rounding.
[2]Real 2000 rupees; 45.7 rupees = $1 in real 2000 dollars or 8.5 rupees = $1 adjusted for purchasing power parity.
[3]McKinsey Global Institute's cross-country comparisons of necessary consumption exclude housing from the category of necessity because of significant variations in national housing market structures, regulations, and measurement methodologies.
[4]Estimated.

Source: McKinsey Global Institute analysis

What will urban Chinese consumers buy?

For urban China (real renminbi, base year = 2000)



[1]Base case forecast, Q1 2006; 1 renminbi = $0.12.
[2]Figures do not sum to total, because of rounding.

Source: National Bureau of Statistics of China; McKinsey Global Institute analysis

Meeting future demand will require a large expansion of supply

Water and land are the largest challenges on the supply side – annual pace at which supply must increased over the next 20 years is 140 percent for water and 250 percent for land compared to the pace over the past two decades

Expanding supply at this rate will present significant capital, infrastructure and geopolitical challenges

Rapid expansion of supply could create both economic opportunities and challenges - potentially transform resource rich countries and adversely impact economies that are resource-intensive

Delivering on resource productivity will reduce the need to expand supply but does not eliminate it – increasing productivity is capital intensive e.g. improving urban infrastructure

3. What is Sustainability?

***A sustainable place** is a place that is designed to make it possible and easy for residents to reduce their ecological footprint and reduce their carbon dioxide emissions by specified amounts while improving their quality of life.*

Four Axis of Environmental Sustainability

- **Allocation of resources**: the optimal usage of resources that will have the least impact on the current environment and resource availability.

- **Impact on the natural world**: measures that seek to preserve and enhance ecological systems that sustain society, biodiversity and high habitat quality, as well as promote rejuvenation of degraded systems.

- **Climate change**: minimize long-term climate, resulting from human activities and infrastructure.

- **Quality of life**: to maximize the quality of life of those affected by infrastructure projects, both now and in the future

In addition to environmental sustainability, the challenge is to address social and economic factors that encourage residents to adopt sustainable lifestyles.

This means providing choices across a broad spectrum of living and work environments that will enable many lifestyle options while also addressing affordability for families, individuals, and businesses who will share a common purpose.

THE CHALLENGE

- Design Excellence
- Empower People
- Reduce Consumption
- Offer Lifestyle Options
- Innovate
- Measure Achievements




Raising the Bar

Example :

Vastra Hamnen (Western Front) Malmo, Sweden

A very high threshold of sustainability has already been achieved by a very limited number of sustainable developments in other parts of the world

Västra hamnen (or Western Harbour in English) is a neighbourhood of Malmo, Sweden - was an industrial area until 21st century when the last factory closed down.

Västra Hamnen is also known as also known as the “City of Tomorrow”, and is the first district in Europe that claims to be carbon neutral. The district uses Aquiver thermal energy to heat buildings in the winter and cool them in the summer.

The history of the Western Harbour

100 years ago, the Western Harbour did not exist. Land was gradually created using fill masses in the sea, with the final filling taking place in 1987, which created the shape of the land as it is today. Sand from Køgebukten was used to fill the large harbour basin and Scaniaparken was created.

Kockums Industries was founded in the area right back in the 1870's. Kockums built tankers longer than the Turning Torso is tall. At its peak, 6 000 people worked among docks, cranes and big industrial buildings. The decision to close the business was made in 1986.

Saab-Scania was then established in Malmö and one of Europe's most modern car manufacturers operated out of Kockums Hall, a huge building of 100 000 m² with 40 metre-high ceilings. But the plant was closed in 1996 due to a decline in profit and re-structured when Saab-Scania merged with General Motors. The land and the buildings were bought by the City of Malmö and the plant was transformed into the Malmö Exhibition & Convention Centre.

In 2001, the European Housing expo Bo01 opened, which saw the start of the Western Harbour, a new district in Malmö.

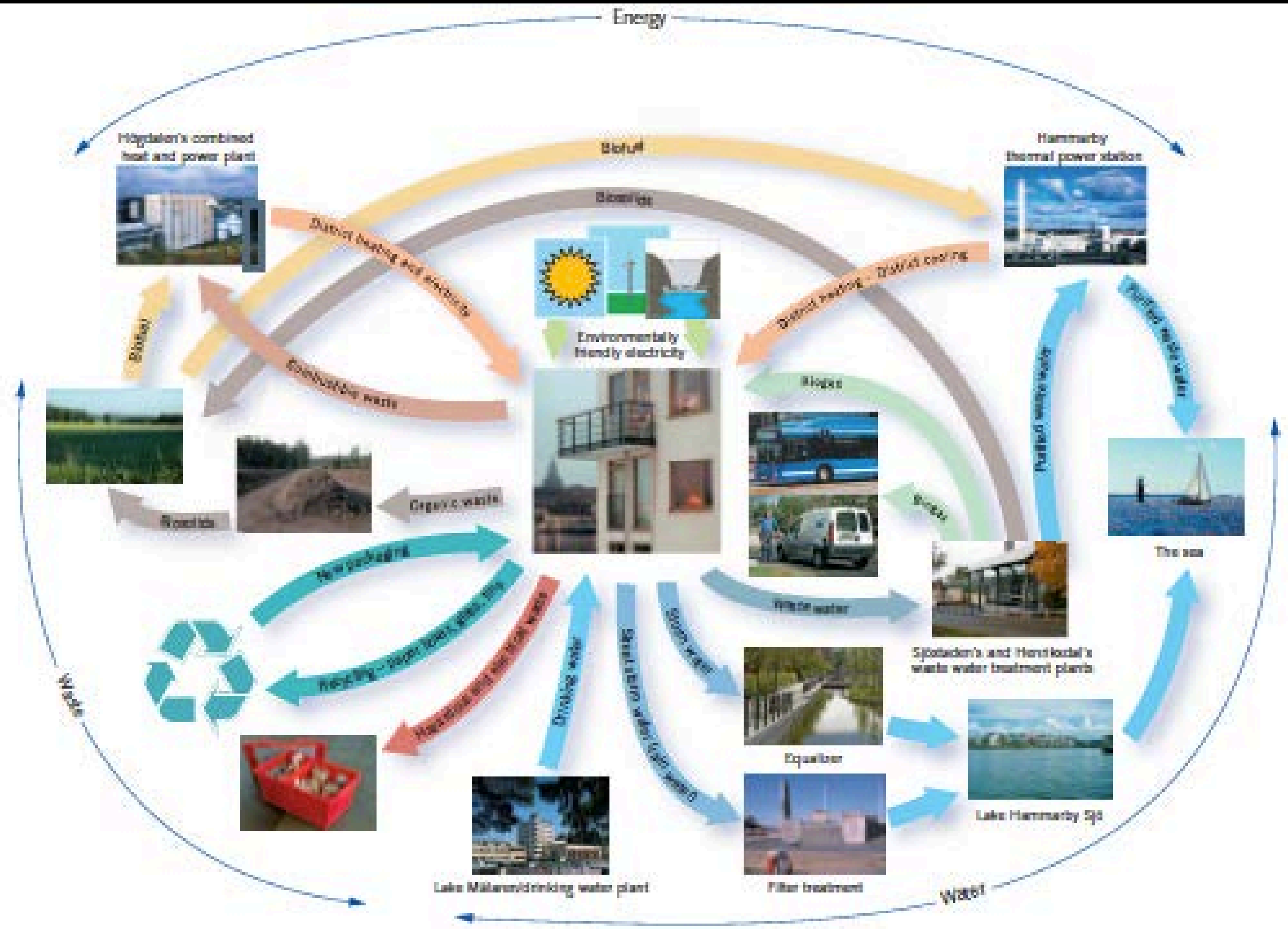
In 2009, Sveriges Television moved into the old part of Kockums, machine hall 101.


Västra Hamnen 2013
The Western Harbour in Malmö, Sweden
JOAKIM LLOYD RABOFF

HAMMARBY SJÖSTAD

Stockholm, Sweden

The Hammarby Model



The core of the environmental and infrastructural planning of Hammarby Sjöstad jointly developed by Stockholm Water Company, Fortum and the City of Stockholm Waste Management Administration can be summarised in an eco-cycle model known as the Hammarby Model.

This model shows the interaction between sewage and refuse processing and energy provision, as well as the added benefits to society of modern sewage, energy and waste processing systems.

The overall goal "twice as good as the norm" required new ideas for energy, water, waste, transport, building design, construction site logistics – all those systems that we normally take for granted in a modern city.

The 190 meter tall concrete and steel tower turns 90 degrees from bottom to top.

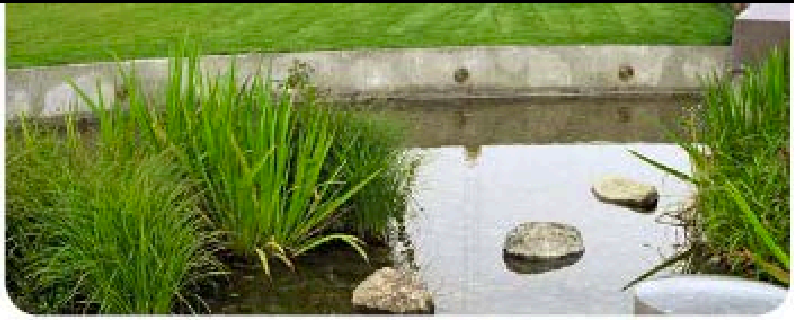
Designed for a prominent urban site on the occasion of the European Housing Expo 2001, Calatrava's residential tower for Malmö, at the city's West Harbor, is based in form on his sculpture Turning Torso. Conceived to enhance and enlarge a public area, defined by the intersection of two main roads, the "Turning Torso" building is meant to be seen as a free-standing sculptural element posed within the cityscape.

100 % locally renewable energy

Our effect on the climate means that we have to find solutions for the future. The carbon-neutral energy system of Bo01 proves that that it is possible to supply an entire city district with 100 % locally renewable energy. The district offers ways for people to live in a sustainable way, use public transport and economise on resources.

The Bo01 area is an important example for the future and the district has received a lot of international attention.

The goal of the district is to have very low energy consumption, but at the same time, the residents demand a high level of comfort. They want to live well, even if they save energy. Better ventilation and more efficient buildings have led to much less energy being used for heating than in the average home. The residents can also monitor their indoor climate individually using different IT solutions.



Open storm water-system

The rainwater, also called storm water, falling in the area does not just pour down into the sewer system like in other areas. Here, it runs into canals, ponds and fountains in the area before reaching Öresund, either directly or by passing through the salt water canals. This system is not only beautiful for the residents, but it is also good for the environment. In this way, the water is biologically cleaned before reaching Öresund. Being able to enjoy the view of running water from their houses or apartments also benefits the physical and mental health of the residents.

The open storm water system in the area is unique and very much appreciated by the residents and by visitors, especially by children. The water in the canals, ponds and the fountains offers a variety of entertainment. If the ponds dry up, they are refilled in order to maintain the biodiversity.

Measuring Consumption using Ecological Footprints

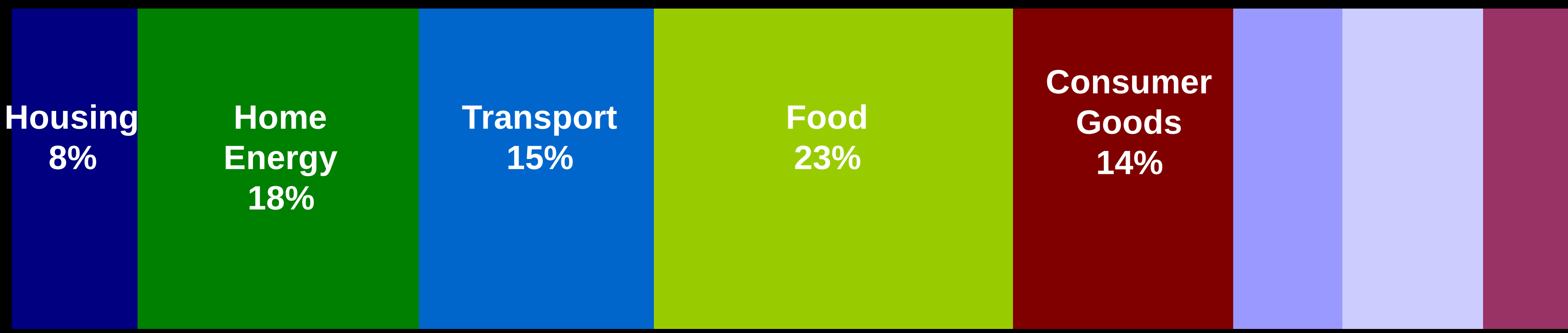
The inputs and measurement framework for determining ecological footprints vary across organizations.

What is an ecological footprint? An ecological footprint (EF) is a measure of the demands humans place on nature. The ecological footprint measures how much biologically productive land and water we occupy to produce all the resources we consume and to absorb our waste.

Ecological footprint analysis (EFA) converts the consumption of food, energy, and other materials (using personal consumption expenditure data as a proxy for physical material consumption) to the equivalent area of biologically productive land that would be required to produce the food, energy and other materials to meet human consumption demands.

Source: Federation of Canadian Municipalities, Ecological Footprints of Canadian Municipalities and Regions, 2005.

Ecological footprint of an average UK resident



78 percent fall under personal choice

This shows the importance of making everyday sustainable lifestyle choices attractive and accessible and providing appropriate education and support for residents.

In responding to these components of sustainability, it must be recognized that this new community must be a place where people choose to live and work, and where it is easy for residents to adapt to sustainable lifestyle changes.

This means that choices must be offered across all aspects of living and working and these choices need to be sustainable ones.

Determine your carbon footprint

http://www.myfootprint.org/

The key components of sustainability that must be addressed

1. Housing, Construction and Maintenance
2. Home Energy
3. Transport
4. Food and Drink
5. Consumer Goods
6. Government and Business Services and Infrastructure
7. Waste

Source: What makes an eco-town? A report from BioRegional and Cabe, 2008

Average Ecological Footprint, CO2 emissions & GHG emissions of a typical UK resident

	Ecological footprint		Carbon dioxide emissions		Greenhouse gas emissions (in CO_2 equivalents)	
	Gha/cap	Percent	Tonnes/cap	Percent	Tonnes/cap	Percent
Housing	0.46	8%	0.97	8%	1.04	8%
Home energy	1.01	18%	2.78	23%	2.94	22%
Transport	0.83	15%	2.73	23%	2.86	21%
Food & drink	1.23	23%	0.99	8%	1.64	12%
Consumer goods	0.75	14%	1.48	13%	1.70	13%
Private services	0.48	9%	1.18	10%	1.34	10%
Government	0.37	7%	0.93	8%	1.07	8%
Capital assets	0.31	6%	0.80	7%	0.84	6%
Total	5.45	100%	11.87	100%	13.43	100%

Individual Responsibility

- **Well designed and well-built sustainable communities can directly assist residents in achieving reductions in:**
  - **75 percent of their total carbon dioxide emissions impacts**
  - **76 percent of their total greenhouse gas emissions; and**
  - **78 percent of their ecological footprint**
- **By putting in place sustainable solutions for housing construction, home energy, transportation, food and goods – all areas in which people make personal choices**
- **The remainder of an individual’s ecological footprint represents a proportion of community wide infrastructure that individuals are not able reduce themselves**

Source: What makes an eco-town? A report from BioRegional and Cabe, 2008

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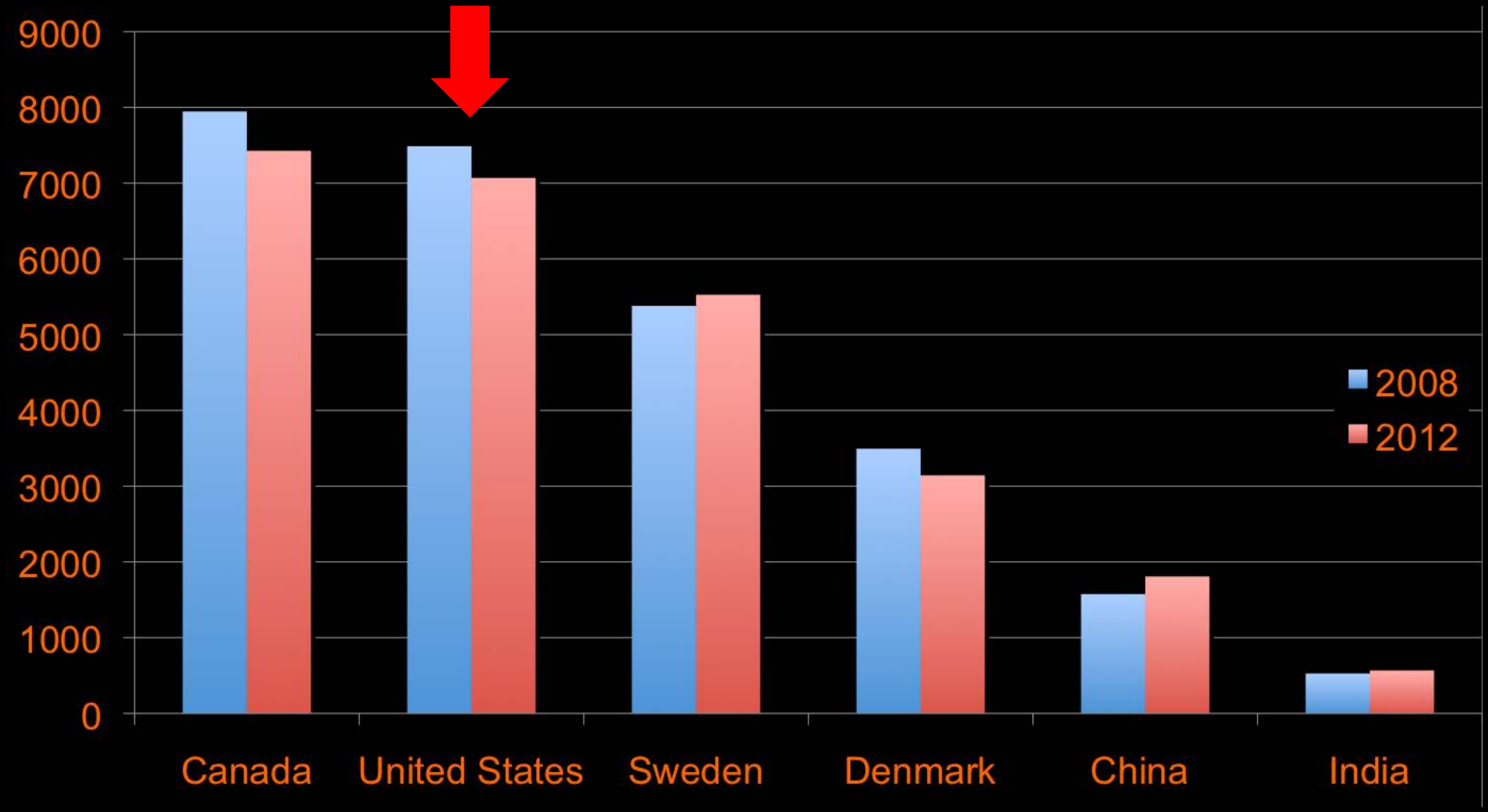
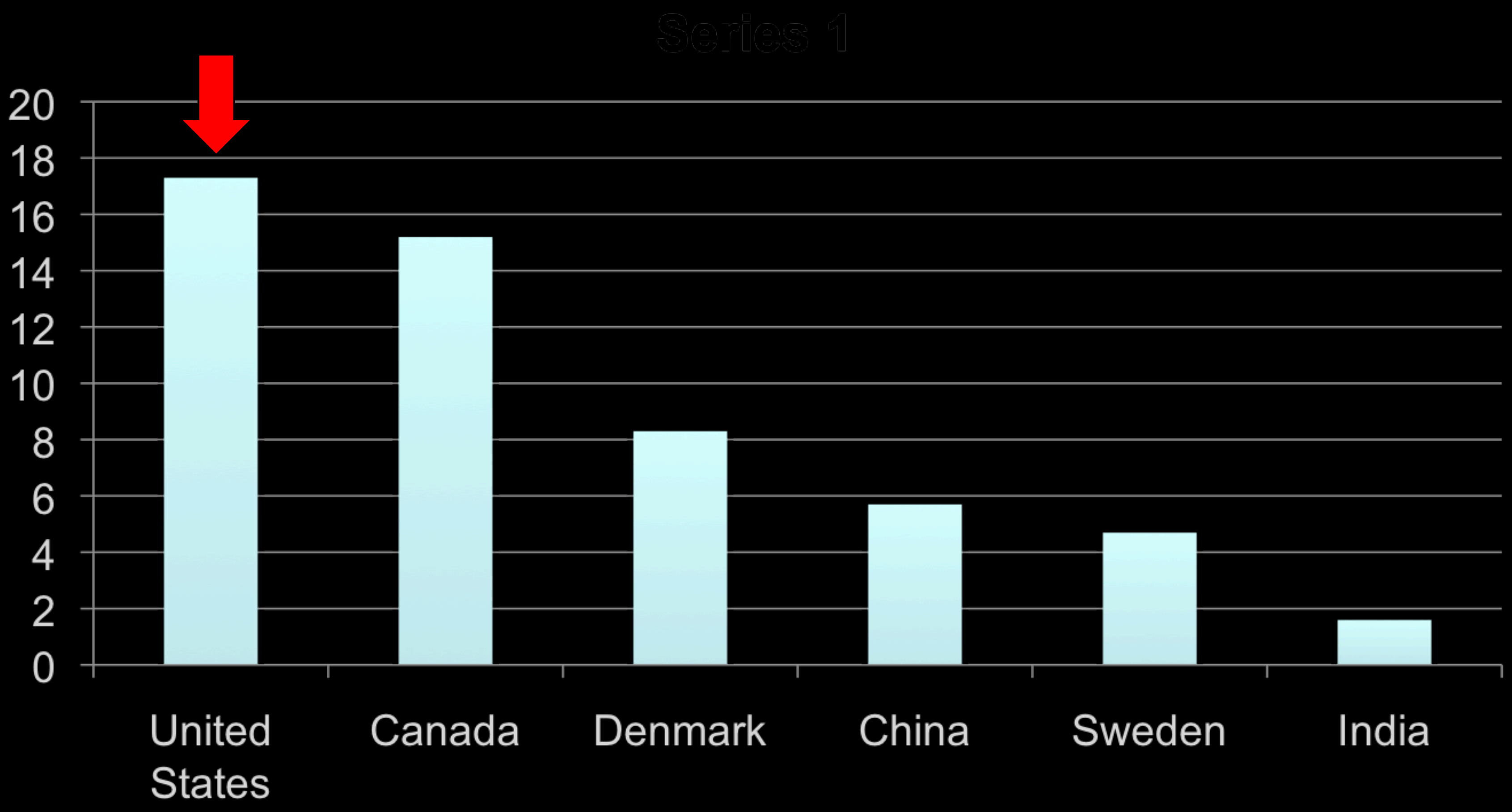
North American Energy Usage is Among the Highest in the World



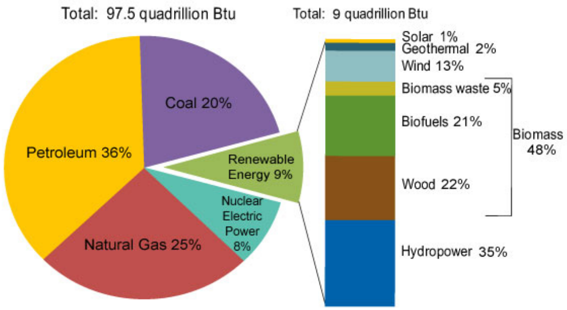
Kg of oil equivalent per person/year (World Bank, 2012)

CO2 Emissions

metric tons per person/year (World Bank, 2009)

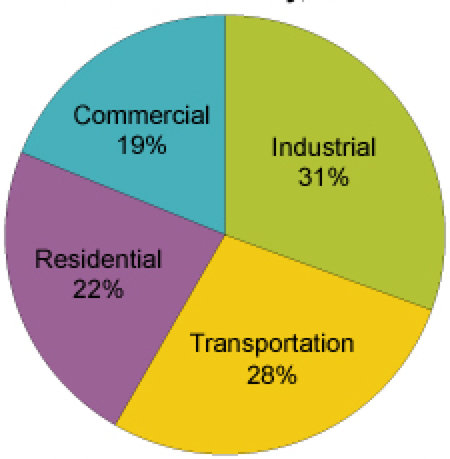


U.S. Energy Consumption by Energy Source, 2011



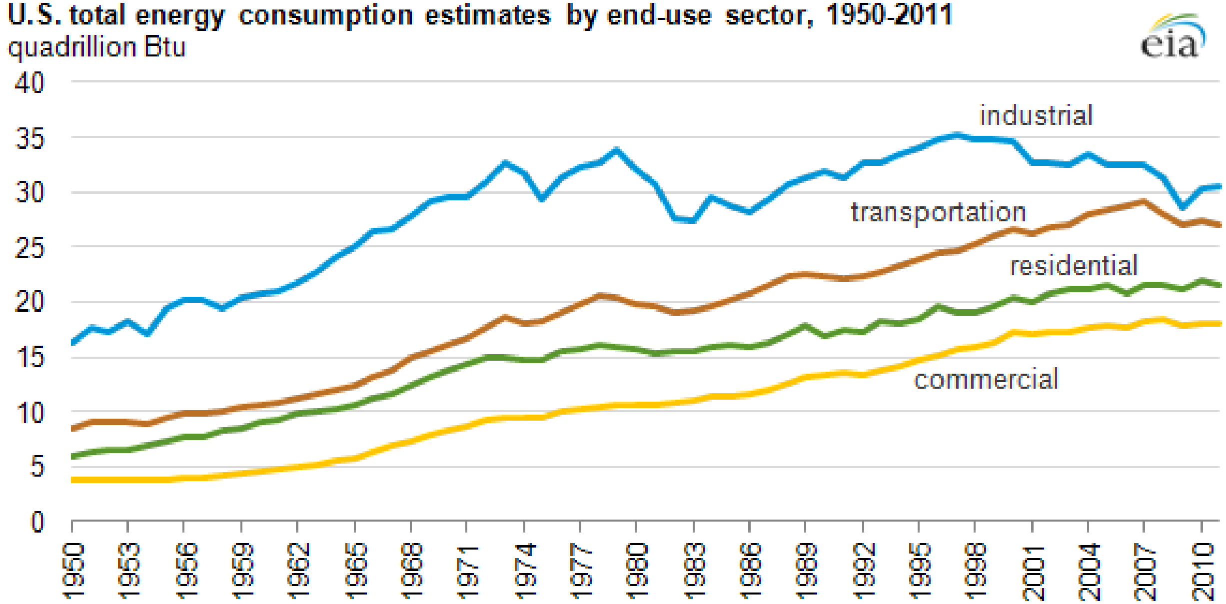
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 10.1 (March 2012), preliminary 2011 data.

Share of Energy Consumed by Major Sectors of the Economy, 2011

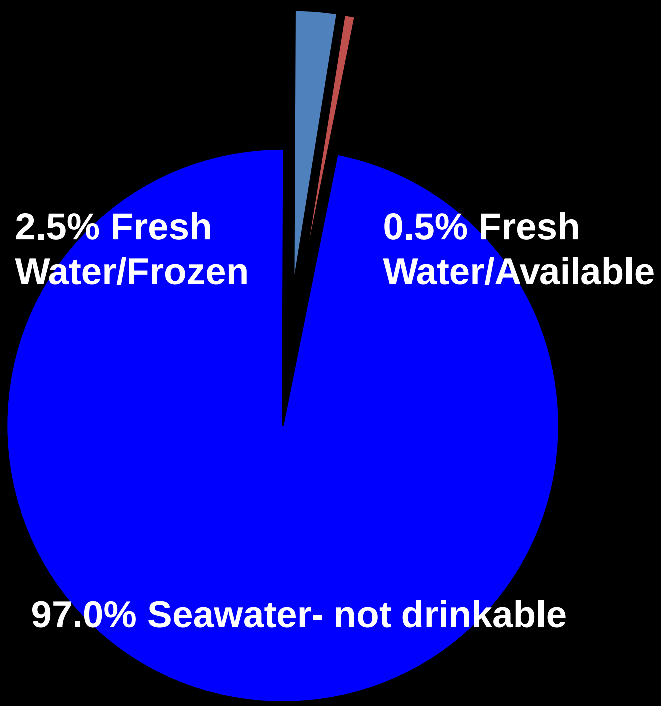


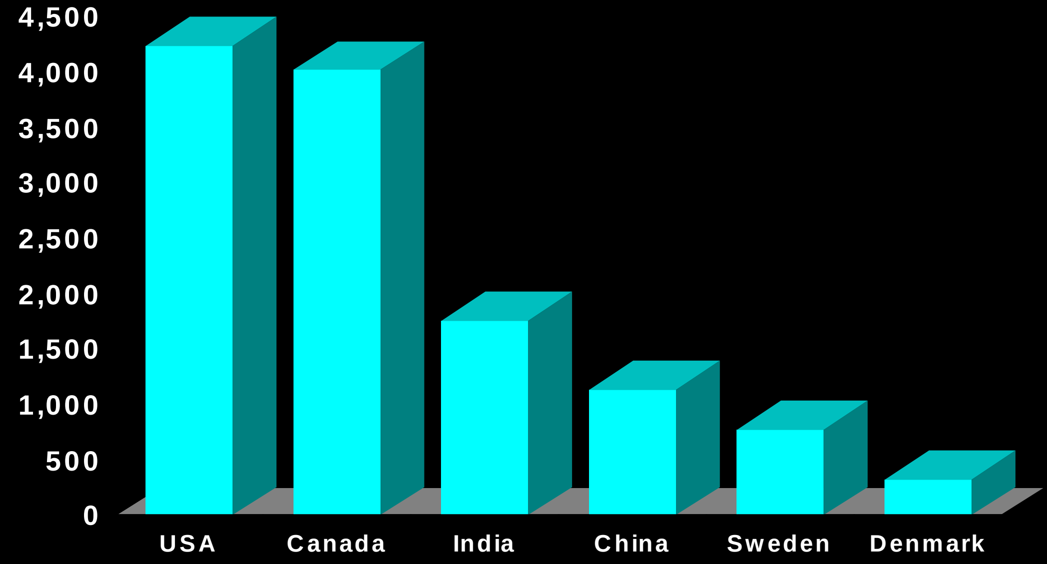
Source: U.S. Energy Information Administration, *Annual Energy Review 2011*, (September 2012).

U.S. total energy consumption estimates by end-use sector, 1950-2011
quadrillion Btu



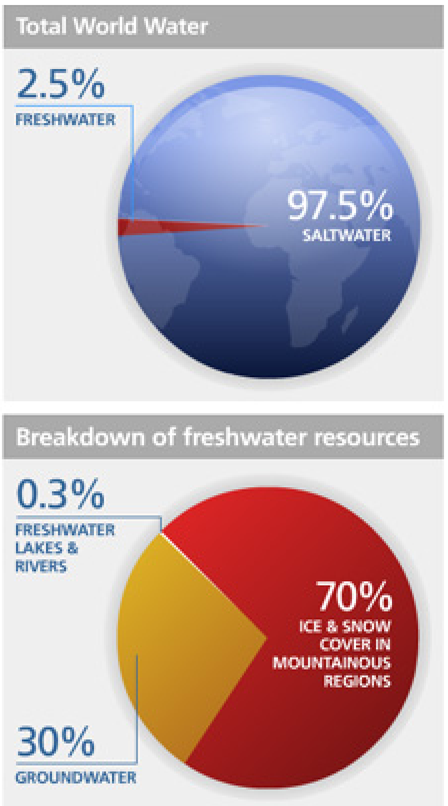
North American water usage habits are unsustainable at current rates





Total water withdrawal in litres per person per day

Water – basic necessity, scarce resource



- **Increasing water scarcity and pollution compounded by economic growth, population pressures, and increased urbanization**
- **Demand for fresh water is growing while the supply is dwindling in may regions of the world**
- **Water quality in many regions is deteriorating due to industrial discharge, municipal sewage, and overload of fertilizers and agro-chemicals**
- **Demand includes potable water, industry needs, sanitation, irrigation, river basin management, flood management, and waste water management**
- **Must distinguish between rural water, urban water, and basin water needs (integrated water resource management)**
- **Require the necessary legislative framework and technical, financial, and administrative capacity to enforce regulation**

Typical infrastructure for water distribution to residential and commercial users in Mumbia, India

Water footprint of two different diets in industrialized countries

	Meat diet			Vegetarian diet		
	Kcal/day	Litre/kcal	Litre/day	Kcal/day	Litre/kcal	Litre/day
Animal origin	959	2.5	2,375	300	2.5	750
Vegetable origin	2,450	0.5	1,225	3,100	0.5	1,550
TOTAL	**3,400**		**3,600**	**3,400**		**2,300**

Dietary habits greatly influence the overall water footprint of people. In industrialized countries, the average calorie consumption is about 3,400kcal/day (2012), roughly 30% comes from animal products.

Based on average daily portions, 1kcal of animal product requires roughly 2.5 litres of water on average. Products from vegetable origin require roughly 0.3 litresof water per day.

Producing food for one day costs 3,000 litres of water, whereas keeping all other factors equal, vegetarian diet reduces food-related water footprint to 2,300 litres per day, or a 36 percent reduction in water consumption.

Inefficient water usage is connected to a unsustainable food demand

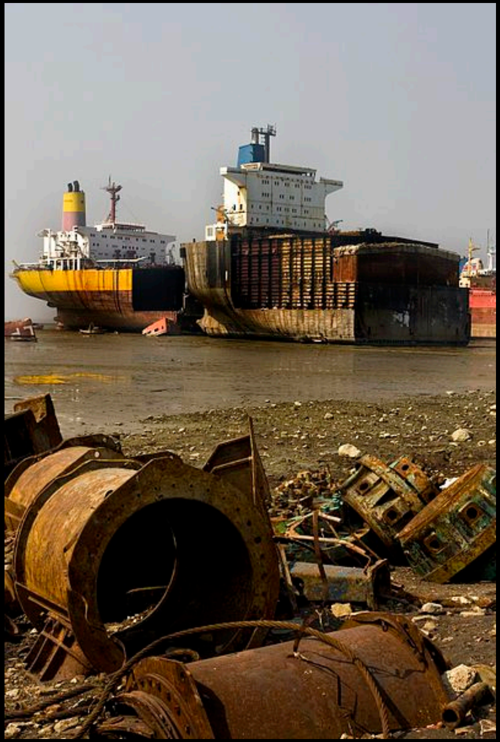
15,415 litre/kg
Meat

822 litre/kg
Apples

237 litre/kg
Lettuce

In addition to water usage, meat production accounts for a large footprint due to deforestation, desertification, the diversion of food staples as feed and the release of greenhouse gas.

It is expected that the demand for meat will increase alongside the expansion of urban populations.



Garbage – a byproduct of consumption

The recycling of waste electrical and electronic equipment in India and China generates a significant amount of pollution. Informal recycling in an underground economy of these countries has generated an environmental and health disaster. High levels of lead (Pb), polybrominated diphenylethers (PBDEs), polychlorinated dioxins and furans, as well as polybrominated dioxins and furans (PCDD/Fs and PBDD/Fs) concentrated in the air, bottom ash, dust, soil, water and sediments in areas surrounding recycling sites.




Setting Targets

The measures of ecological footprint and CO_2 emissions should be used as measures to assist in designing the community and then use ecological footprint and CO_2 emissions of individual residents as headline monitoring criteria

The UK has set the following as headline sustainability criteria and targets for individual residents:

- **An ecological footprint two thirds lower than the current national average**
- **CO_2 emissions 80 percent lower than 1990 levels**

Source: What makes an eco-town? A report from BioRegional and Cabe, 2008

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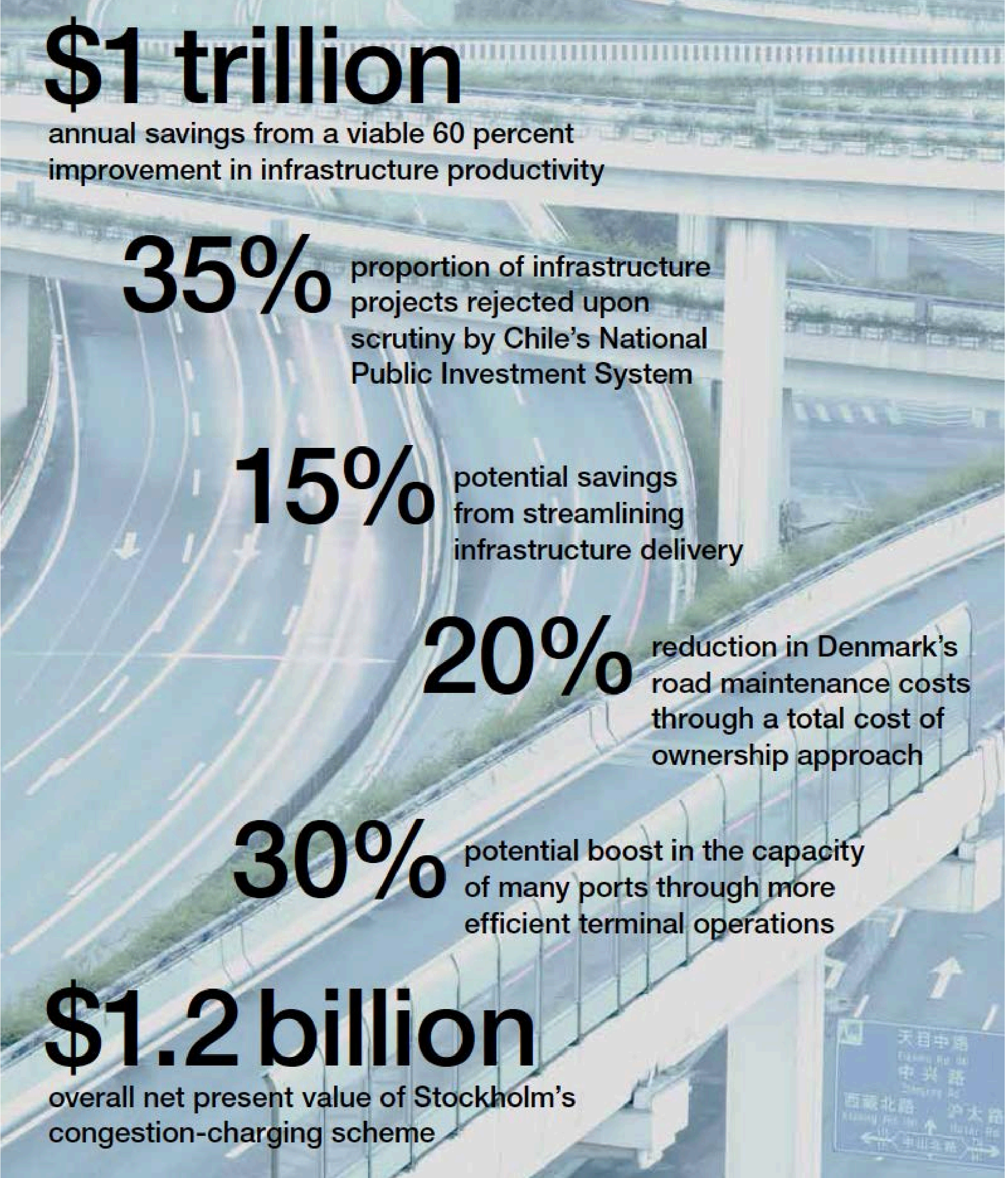
4. Sustainable Urban Infrastructure: What does this encompass?

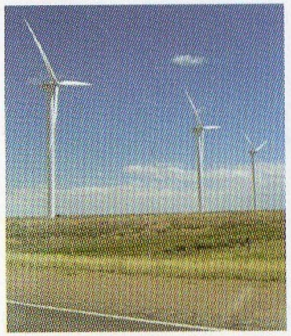
The Infrastructure Challenge



The Infrastructure Opportunity

Types of Urban Infrastructure

ENERGY



- geothermal
- hydroelectric
- nuclear
- coal
- natural gas
- oil/refinery
- wind
- solar
- biomass
- other

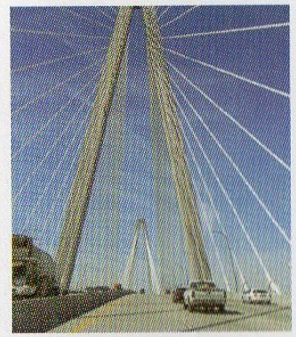
WATER

- potable water distribution
- capture and storage
- water reuse
- stormwater management
- flood control
- other

WASTE

- solid waste
- recycling
- hazardous waste
- collection and transfer
- other

TRANSPORTATION



- airport
- roads/highways
- bike/pedestrian
- railways
- public transit
- ports
- waterways
- other

LANDSCAPE

- public realm
- parks
- ecosystem services
- other

INFORMATION

- telecommunications
- internet /phone
- satellites
- data centers
- sensors
- other

16.2 Infrastructure categories

Transportation - the mobility challenge

Efficient and effective transport systems for goods and people are the backbone of sustainable economies (e.g. Industrial Revolution)

Developing countries in Asia are following the trend of inefficient transportation characteristics of developed countries by becoming increasingly dependent on resource-intensive private transportation in lieu of public transit

Transportation contributes about 25% of energy-related greenhouse gas emissions in Asia

Car ownership in India/China combined projected to rise from 19 million in 2005 to 273 million by 2035 – will represent about 45% of the total world increase in oil use through 2025

Side effects include environmental degradation, declining quality of life, inefficient urban form, inefficient allocation of land uses, limited mobility for the disadvantaged

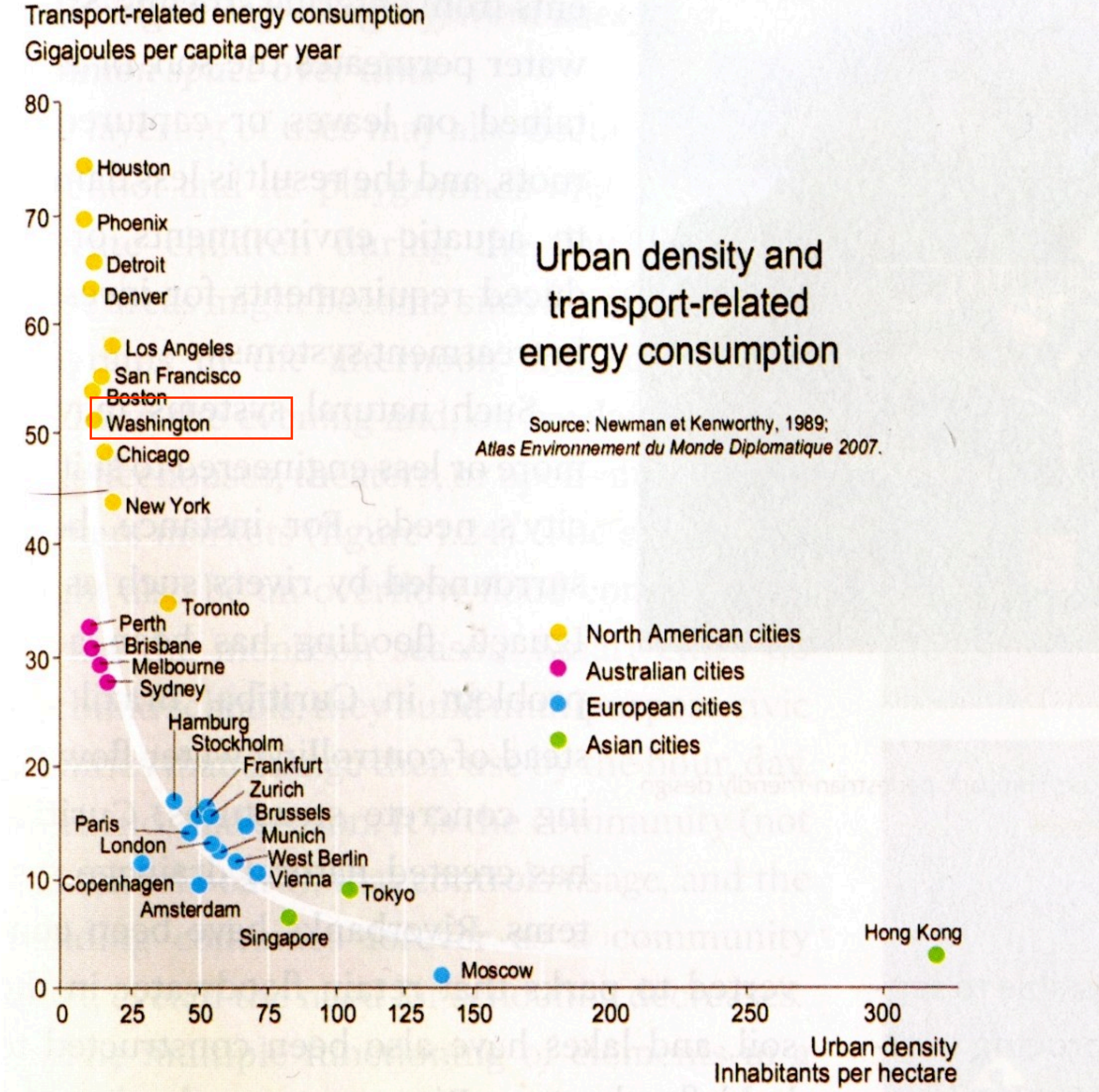
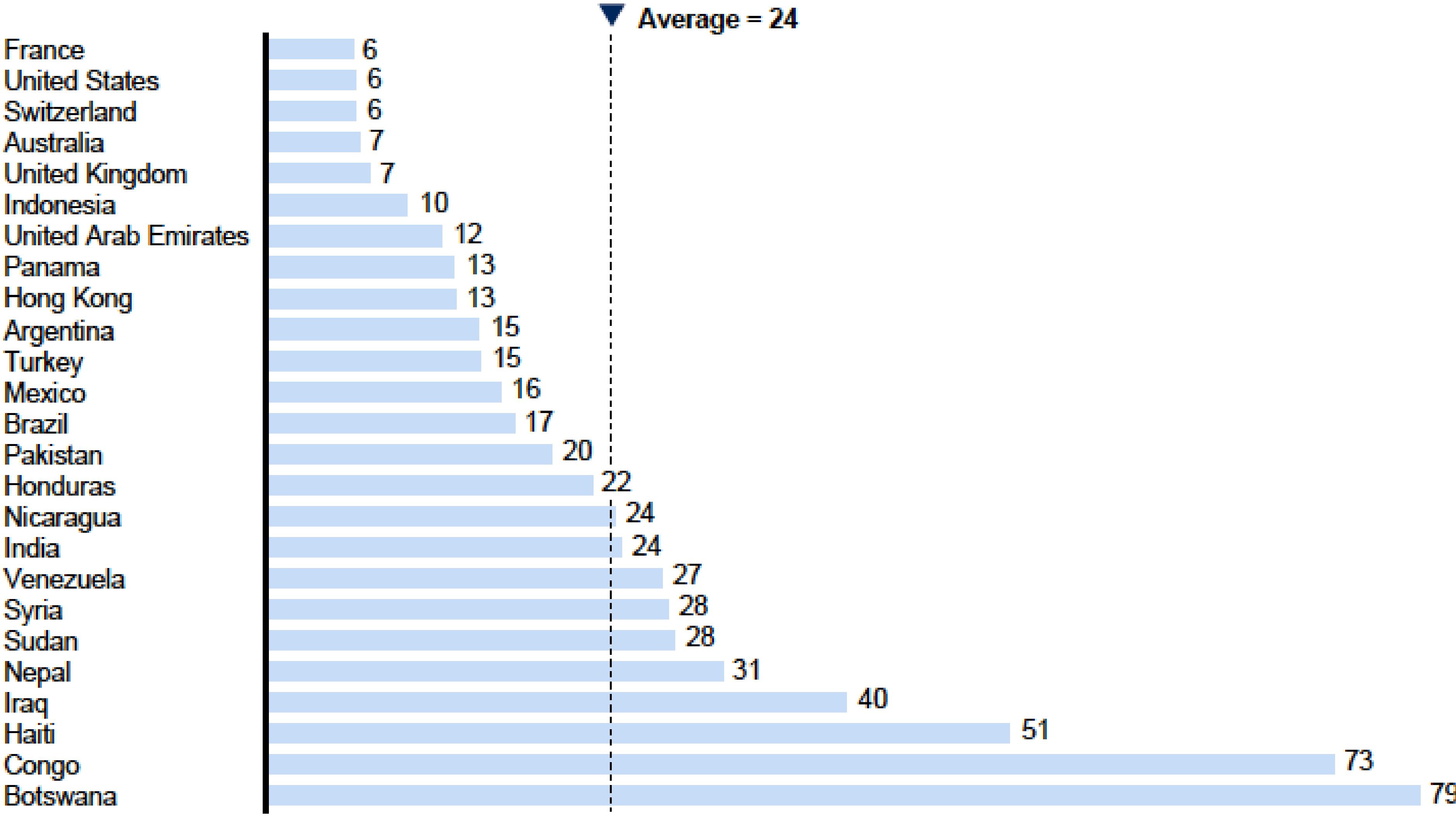


Figure 1.21 Urban Density and Transport-Related Energy Consumption

Source: Kirby (2008).

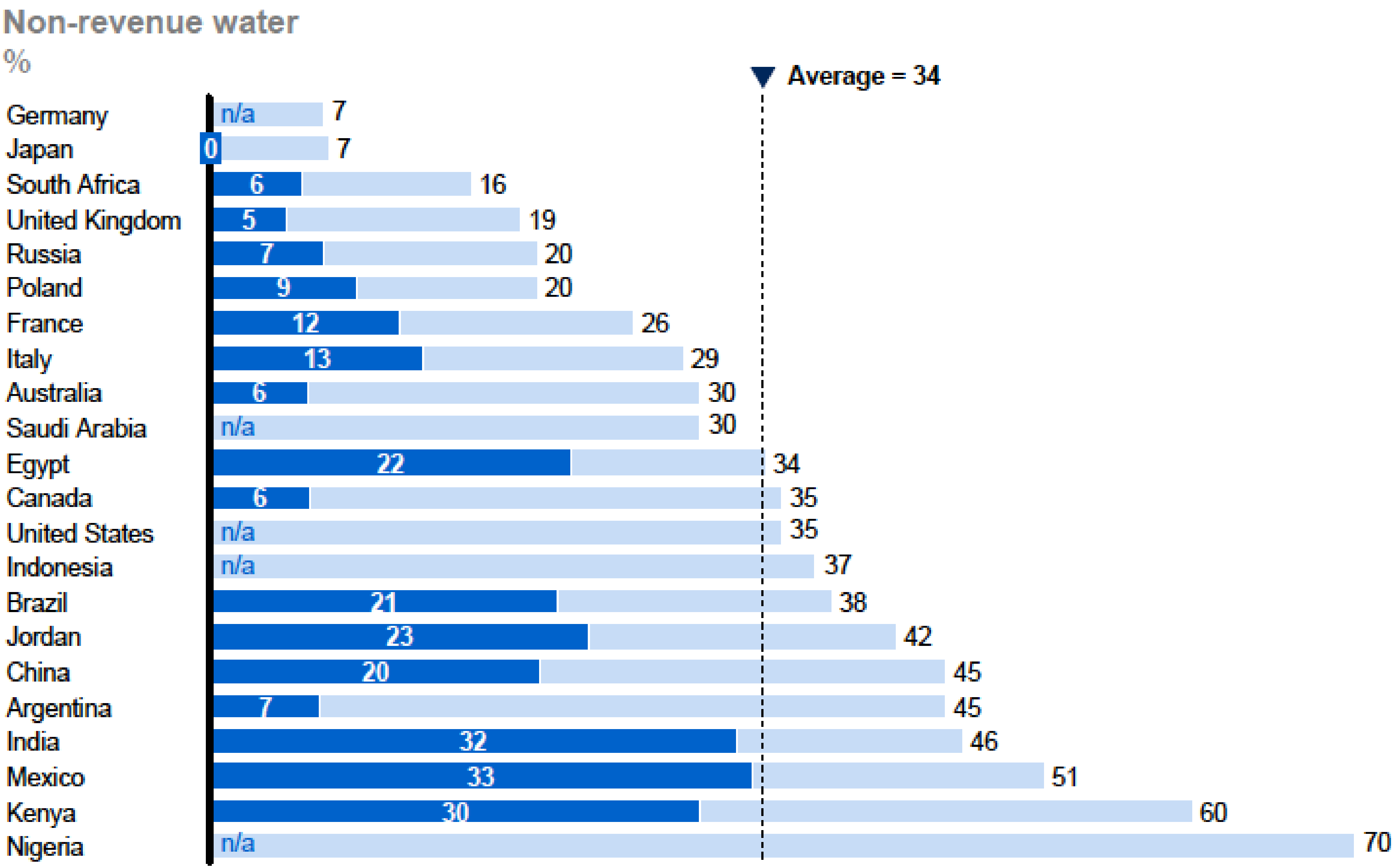
Non-revenue power is common and can account for more than 50 percent of consumption in some developing economies

Non-revenue power (unmetered or stolen usage) (%)



SOURCE: World Bank Development Indicators 2009; *Resource revolution: Meeting the world's energy, materials, food and water needs*, McKinsey Global Institute and McKinsey Sustainability & Resource Productivity Practice, November 2011; McKinsey Global Institute analysis

Non-revenue water is also a global problem, with high rates of theft in the developing world



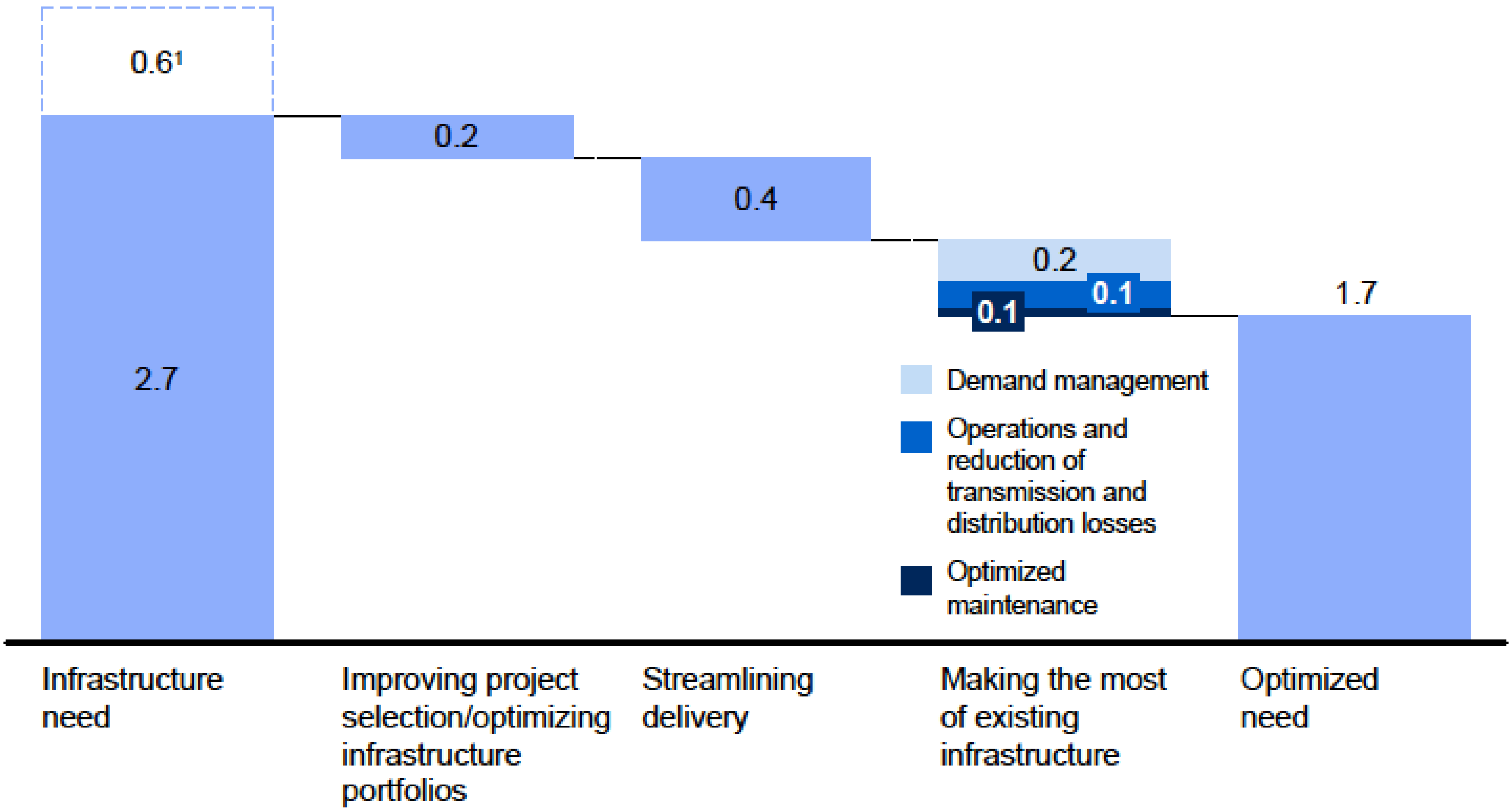
SOURCE: National statistic yearbook market report 2010; GWI 2010 dataset; World Bank Development Indicators 2010; McKinsey Global Institute analysis

The $1 trillion-a-year infrastructure productivity opportunity

Global infrastructure investment need and how it could be reduced

Yearly average, 2013–30

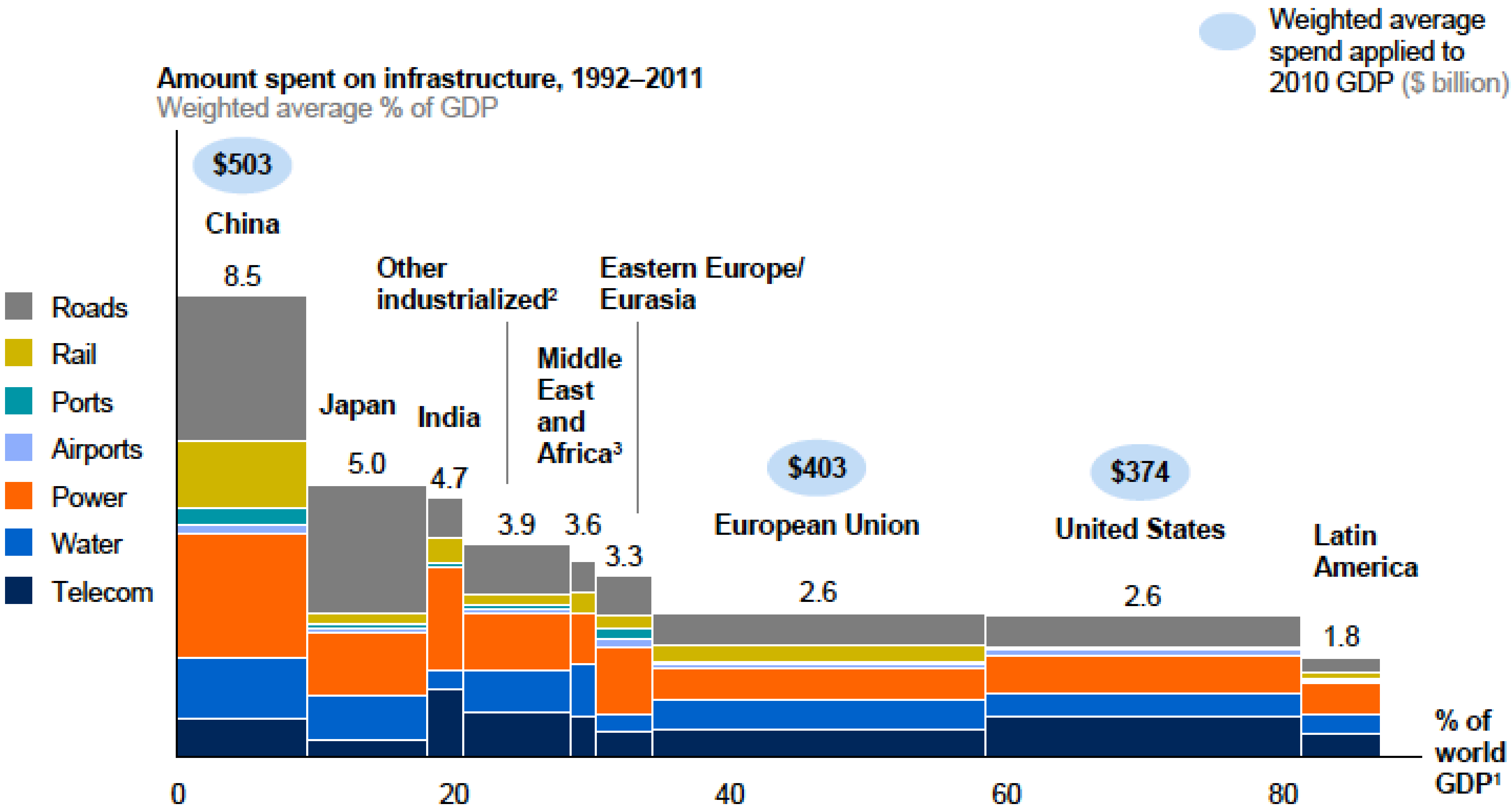
$ trillion, constant 2010 dollars



1 Telecom investment need beyond the scope of this paper.

SOURCE: McKinsey Global Institute analysis

China has overtaken the United States and the European Union to become the world's largest investor in infrastructure



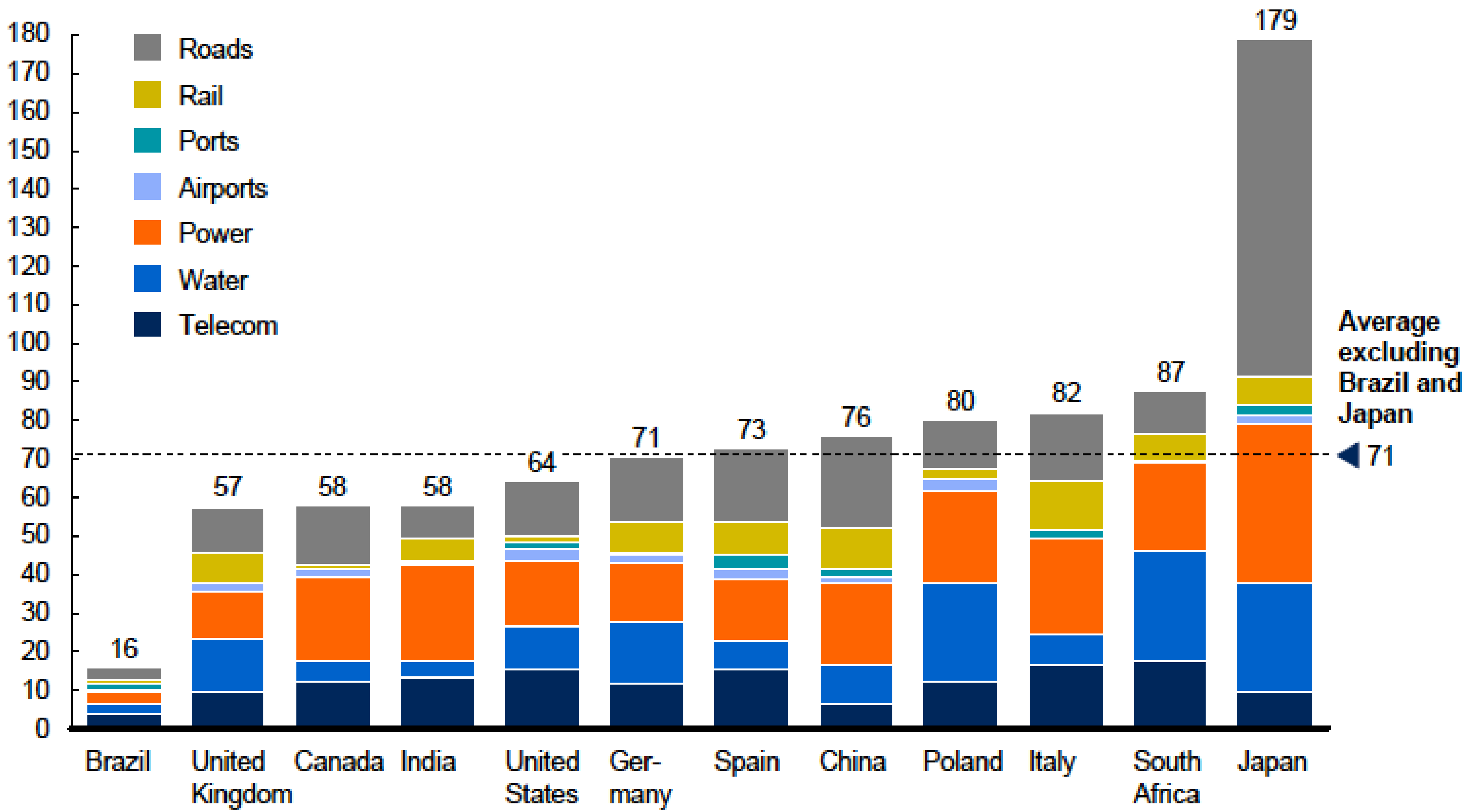
1 Percentage of 2010 world GDP generated by the 86 countries in our analysis.
2 Australia, Canada, Croatia, Iceland, Lichtenstein, New Zealand, Norway, Singapore, South Korea, Switzerland, Taiwan (Chinese Taipei), and the United Arab Emirates.
3 Excludes unusually high port and rail data for Nigeria; including these data brings the total weighted average to 5.7 percent.

SOURCE: IHS Global Insight; GWI; IEA; ITF; McKinsey Global Institute analysis

The value of infrastructure stock averages 70 percent of GDP—with significant variation across countries

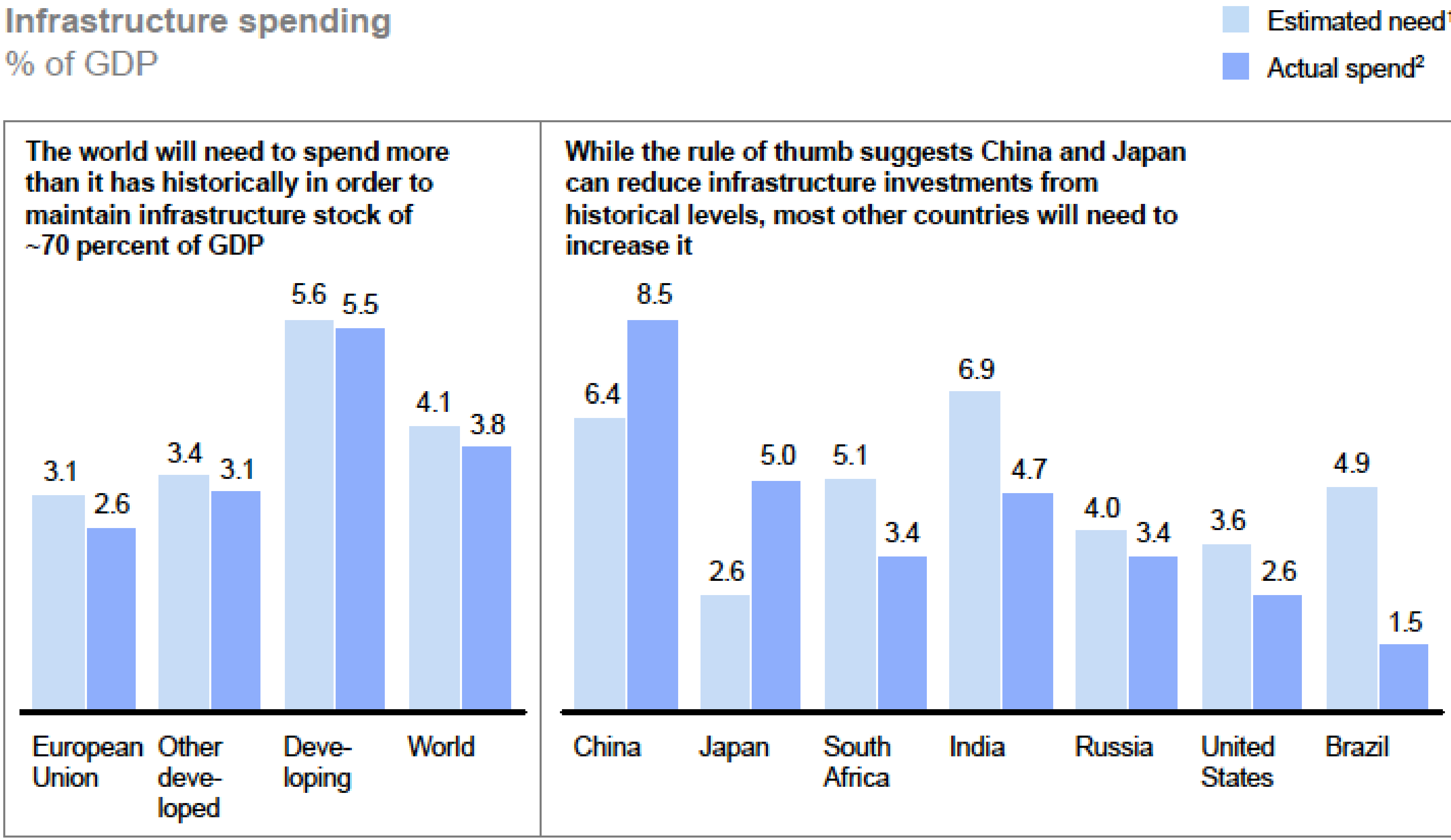
Total infrastructure stock

% of GDP



SOURCE: ITF; GWI; IHS Global Insight; *Perpetual inventory method*, OECD, 1998; McKinsey Global Institute analysis

Using the 70 percent rule of thumb, infrastructure investment would need to rise to 4.1 percent of GDP to keep pace with growth through 2030



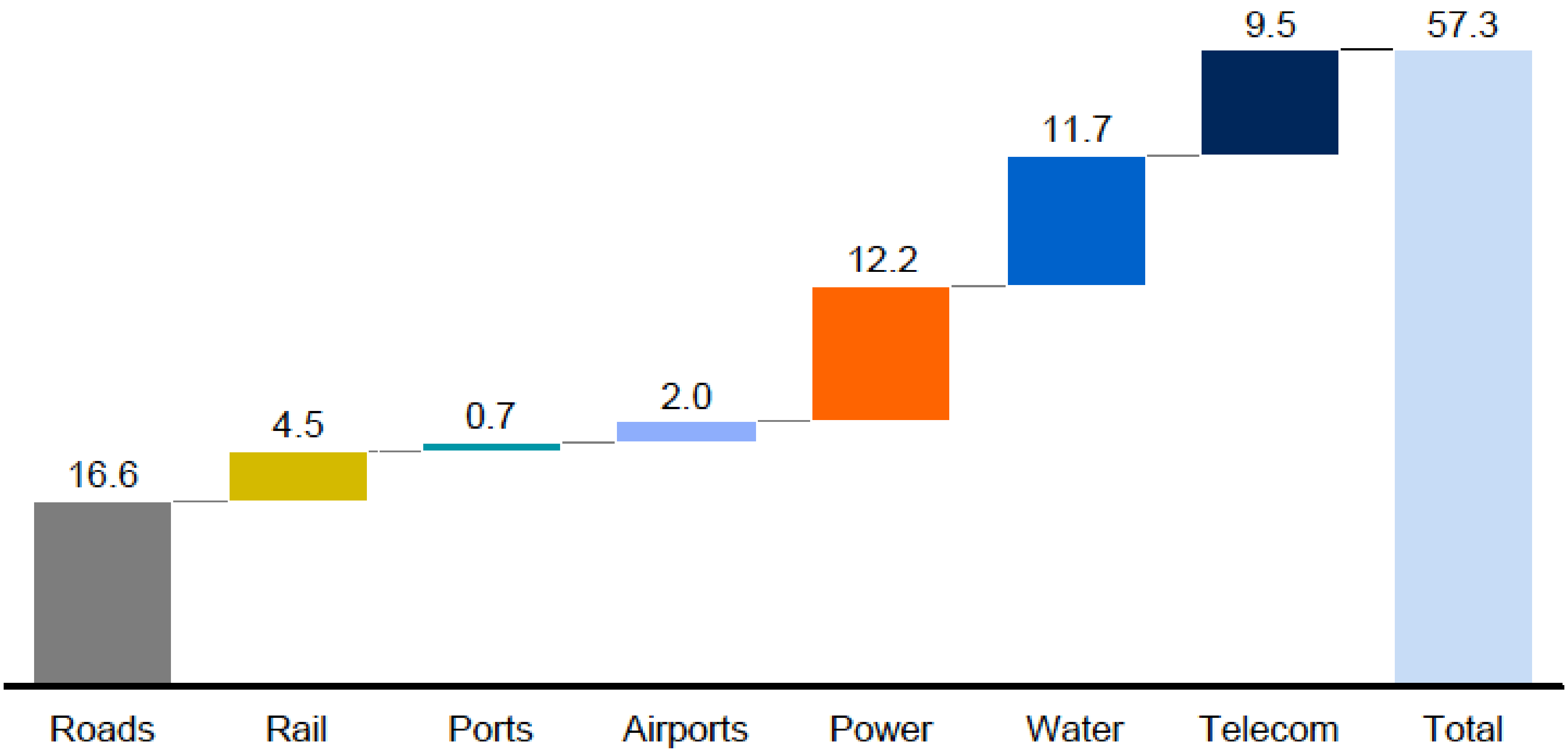
1 Estimated need based on projected growth, 2013–30.
2 Weighted average annual expenditure over years of available data, 1992–2011.

SOURCE: ITF; GWI; IHS Global Insight; *Perpetual inventory method*, OECD, 1998; McKinsey Global Institute analysis

Based on projections of demand by infrastructure segment, about $57 trillion, or 3.5 percent of global GDP, is needed through 2030

Global investment, 2013–30

$ trillion, constant 2010 dollars



1 OECD telecom estimate covers only OECD members plus Brazil, China, and India.

NOTE: Figures may not sum due to rounding.

SOURCE: OECD; IHS Global Insight; GWI; IEA; McKinsey Global Institute analysis

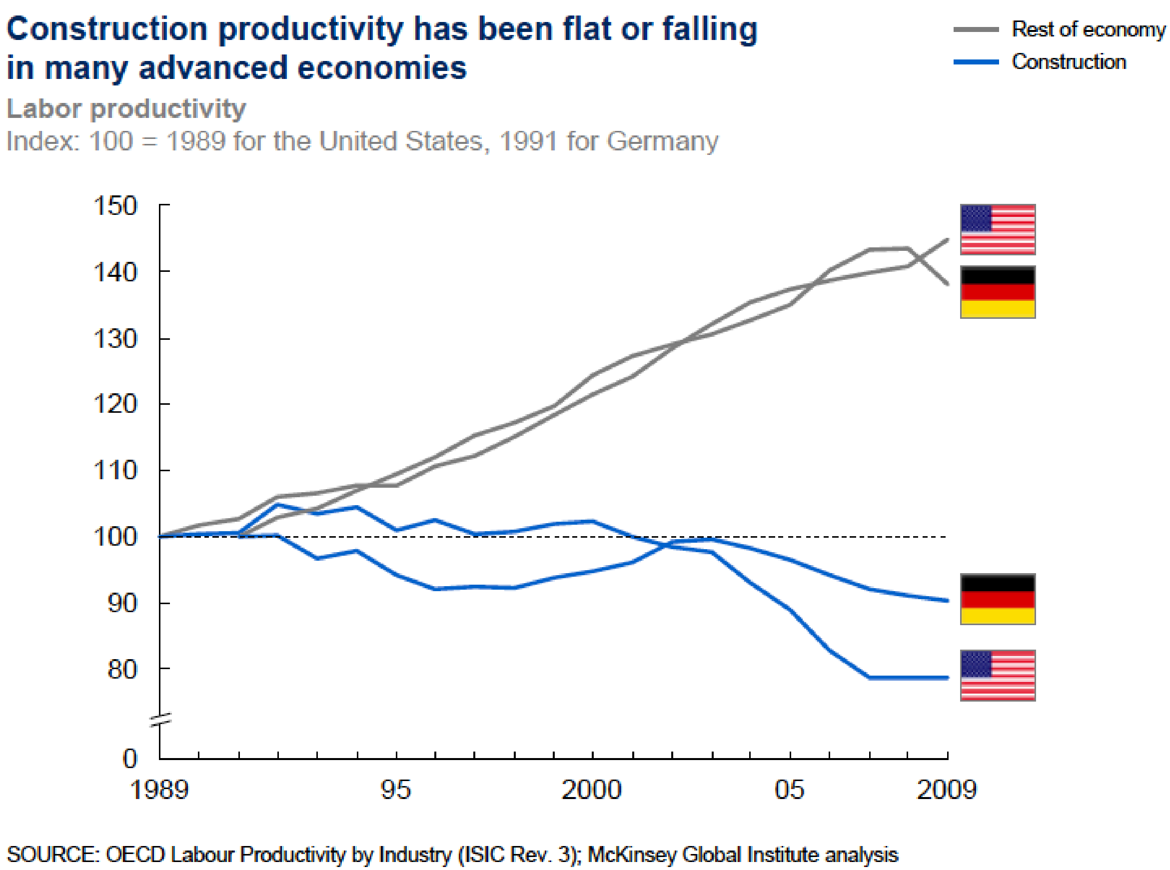
Many reasons that productivity gains in infrastructure have been so limited

Persistent biases in planning and forecasting, leading to poor project selection

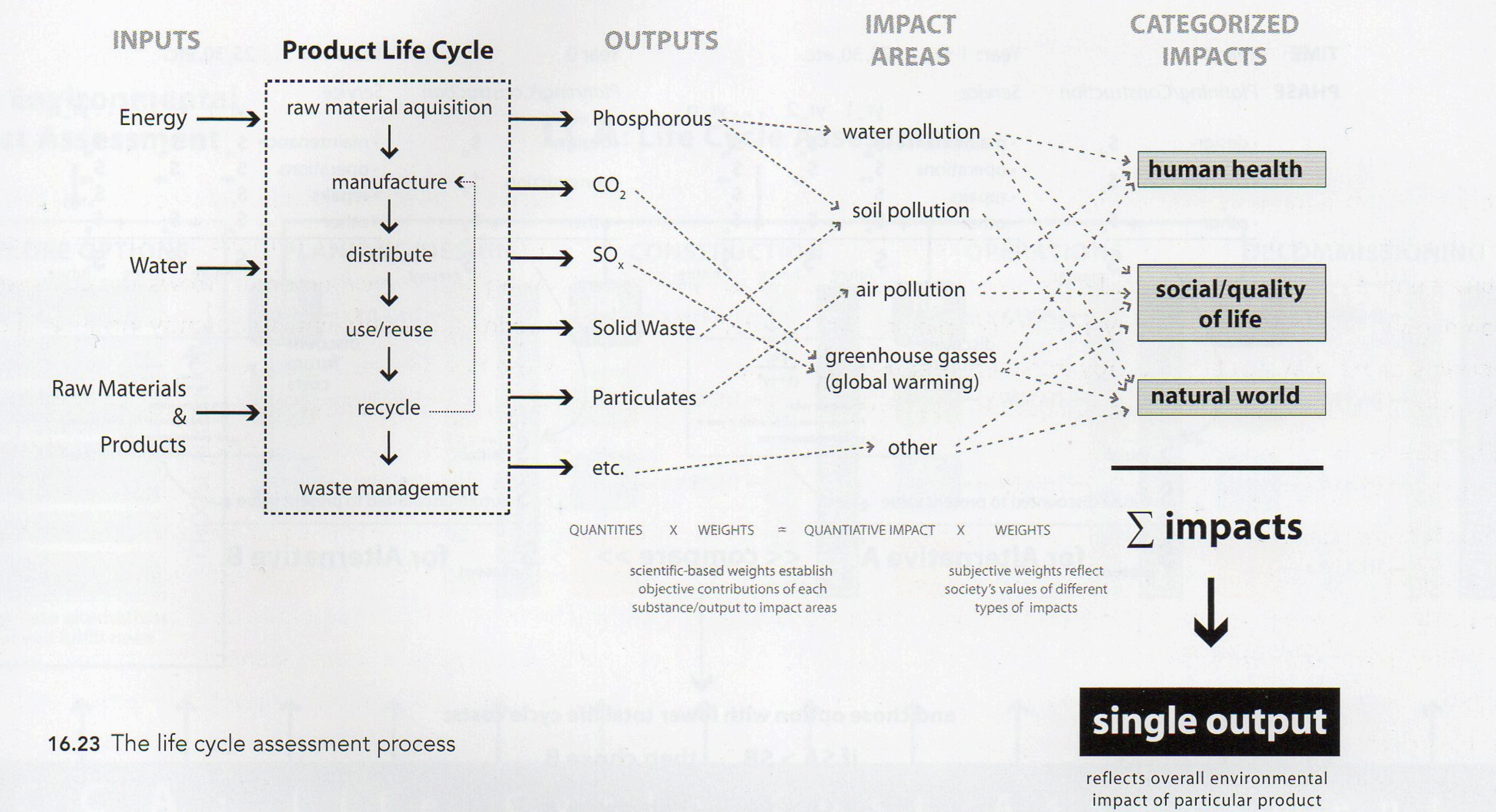
Persistent biases toward building new capacity rather then getting the most out of existing assets

Lack of performance pressure weak regulation, and informality in the infrastructure construction

Capability constraints



Need for Systemic Thinking



16.23 The life cycle assessment process

Strong commercial interests in urban infrastructure

- **IBM has been a leader in the digital infrastructure field and many of its advances apply to city-related technologies. IBM has undertaken projects across the globe under the umbrella of its "Smarter Planet" initiative, including smart grid software, working with cities on water management systems, and implementing "smart" traffic systems in major cities.**

- **Another example is technology giant Cisco's interest in the ecocity realm. Executive Vice President, Cisco Services and Chief Globalization Officer, and head of Cisco's "Smart+Connected Communities" initiative Wim Elfrink estimated that "at least $500 billion will be earmarked for instant cities over the next decade, with $10 billion to $15 billion allotted for network plumbing alone." CEO John Chambers predicted that the smart-grid market itself *"may be bigger than the whole Internet."***

- **More broadly, Cisco sees its entire Smart+Connected Communities initiative as a potential $30 billion opportunity, including revenues from installation of infrastructure—notably highways, bridges, railroads, airports, utilities, and dams—and "*selling the consumer-facing hardware as well as the services layered on top of that hardware."***

Integrating Forms with Flows: Urban Form, Land Use Mix, Density, Connectivity, and Proximity

- **The integration of spatial planning and infrastructure system design represents the most significant opportunity to enhance overall system performance. Urban form, land use mix, density, connectivity, and proximity all have effects on infrastructure performance. Yet, few land use plans are evaluated from this perspective.**

- **Planners and engineers sit in different meetings at different times and ask different questions. Seldom do infrastructure concerns influence land use plans or vice versa. Despite this disconnect, the best time to consider ways to minimize infrastructure costs is during the early stages in land development processes.**

Unfulfilled expectations of technology

Introduction of new mass technology in the last century – telegraph, railway, electrification, radio, telephone, television, automobile, air travel, -has always been accompanied by a spectacular package of promises, many yet unfulfilled

Certain level of naïveté was excusable for inventors in the 19th century – they had no way of knowing about the unforeseen consequences of their innovations

Today, we can't use that alibi – we know that new technologies have unexpected consequences, and we must anticipate their effects

Perhaps *means* and *end* have lived apart for too long – understanding *why* things change and reflecting on *how* they should change are not separate issues

To do things differently we need to perceives things differently

5. Sustainability at a Building/Neighborhood Level

Ecocity Developments

- Dongtan City in China
- Tianjin Eco-City in China
- Nanjing Eco-City in China
- Meixi Lake District in China
- Masdar City in Abu Dhabi
- New Songdo City in South Korea

New Songdo City, Korea

- **Plans for New Songdo City, located on a man-made island about 40 miles from Seoul, South Korea, began in 2000. The 1,500-acre city's anticipated population is 430,000 by 2014, and its overall development goal is "Compact, Smart and Green." Plans are to emit only one-third the greenhouse gases of a similar size city, with plans for green homes and commercial buildings developed by GE Korea.**

- **The city lies within the Incheon Free Economic Zone to attract businesses and foreign investment and aims to "position South Korea as the commercial epicenter of Northeast Asia."**

- **As of 2009, 60,000 residents and 418 companies and research centers either had relocated to New Songdo or announced plans to do so, and by 2014 the second phase of development was targeted for completion. The city plans to include 10 foreign universities, eight Korean universities, four international schools, and 17 theaters, at some point in the future.**

New Songdo City, Korea

The Saga of Songdo City

Songdo has been a financial disappointment for its developer, a joint venture of U.S. developer Gale International and POSCO Engineering & Construction of Korea. The venture has received fees and has been able to earn the equity that it put into the project which was less than $100 million. But other than that, the developer hasn't earned any profit for the 12 years of work it has put into building Songdo, which is technically part of the larger city of Incheon.

While Songdo's condominiums have sold well, about half of the commercial space in Songdo's gleaming office skyscrapers is empty because the business district has struggled to attract tenants.

The district, originally scheduled to be completed in 2014, is about half finished, with about 50 million square feet built. Officials now predict it will be finished in 2017 or 2018.

Financial returns also will be limited for Gale and POSCO because of a concession they made in 2010 during a restructuring of Songdo's debt, giving up 50% of the future profit to the city of Incheon. The restructuring and changes to the development plan were necessary partly because the cash flow of the project had fallen to the point that uncertainty was growing over repaying about $2.5 billion of debt held by a bank group led by Shinhan Bank.

http://online.wsj.com/news/articles/SB10001424052702304579404579236150341041182

Dongton City, China

- Dongtan City, China presents one of the earliest and most widely publicized sustainable urbanization project. In 2005, the Shanghai Municipal government gave a tract of land on Chongming Island to the Shanghai Industrial Investment Company (SIIC), China's state-run investment arm. Chongming Island is situated about nine miles from Shanghai's financial district and covers nearly 33 square miles—an area about three-quarters the size of Manhattan.

- The government instructed SIIC to develop a plan for the land, thus beginning the project of Dongtan City. The city's original stated goal was to be a "renewably powered, car-free, water recycling" city which could serve as a sustainable city model for the world, housing 25,000 residents by the 2010 Shanghai World Expo and 500,000 by 2050. According to SIIC, the broader idea was "to skip traditional industrialization in favor of ecological modernism."

- Delays pushed the construction start date back from 2006 to 2009. As of 2010, implementation of Arup's master plan stalled. Peter Head, a key project leader from Arup, said in an interview that to his knowledge the plans were indefinitely on hold and that SIIC had not informed Arup of the reasons for this.

- Chen Lianglu, a Communist Party leader in Shanghai, who played a large role in procuring the Chongming Island land for development by SIIC, was arrested for fraud in 2006, perhaps creating political tension that helped derail the project timeline.

http://www.dac.dk/en/dac-cities/sustainable-cities/all-cases/energy/dongtan-the-worlds-first-large-scale-eco-city/?bbredirect=true

It was nice while it lasted, but now, it seems, the dream is over. The long-awaited, much-feted eco-city of Dongtan – described by environmental campaigner, Herbert Girardet as 'the world's first eco-city' – has bitten the dust. After four years of presentations, proposals and puff, the universal praise has proven to be a little premature.

Masdar: The Shifting Goalposts of Abu Dhabi's Ambitious Eco-city

Masdar was supposed to be the world's showcase zero-impact city

Madsar City, Abu Dhabi

- **The government of Abu Dhabi began one of the most famous - and most widely criticized - ecocity projects to date. The 2.7 square-mile Masdar City, located in a desert 10.5 miles from downtown Abu Dhabi, was designed to house 40,000 residents, along with hundreds of businesses and a research university, and to serve as a clean-tech city cluster.**

- **Masdar City officials stated that the city's goal *"is to serve as a model for other sustainable urban development, assist the wider Abu Dhabi in lowering its eco footprint, contribute to Abu Dhabi's economic diversification and establish the emirate as a global hub for renewable energy and clean technology."* Initially, Masdar City had a $22 billion price tag and a projected completion date of 2016.**

- **The government originally announced that the city would aim to be zero-carbon, powered entirely by renewable energy, car-free, and produce net-zero waste. Plans for the city were later revised to achieve more modest, if still ambitious, sustainability performance indicators. These include reducing overall energy demand by 50%, embodied carbon (emissions caused by building materials and products) by 30% and operational carbon (emissions caused by the city's day-to-day operations) by 50%, compared to what Masdar City officials describe as "business as usual" in Abu Dhabi.**

Some Rethinking Needed

The city's original timeline included six development phases, beginning with development of MI, the Masdar Headquarters, and the initial residential, office and community infrastructure in the first phase. The first buildings of MI were set to open in 2009, with full build out expected by 2016.

Masdar now expects that Phase I will accommodate 7,000 residents and 15,000 commuters; at full build out in 2021 - 2025, they expect around 40,000 residents and 50,000 commuters.

Masdar project leaders scaled back some ambitions and adjusted their original timelines, facing financial challenges in 2010.4. They pushed the construction finish date back from 2016 to 2021-2025. The New York Times reported that Masdar was reconsidering its plan to generate all power on-site, and that computer-driven "personal transit pods" intended to connect the entire city might be rolled out at a more limited scope. Several directors of various aspects of Masdar left the organization.

In July 2010, Masdar's CEO Dr. Sultan Ahmed Al Jaber announced that, although delivery dates and some of the city's sustainability performance benchmarks would not be achieved immediately, the vision of Masdar City remains the same.

"it made no sense, either commercially or from an ecosustainability perspective, to insist on the original zero-carbon, zero-waste goals in the short term, when current technology would make achieving such targets enormously expensive and thus largely irrelevant to any other sustainable urban development project."




Masdar City, Abu Dhabi

A failed experiment?

100 metres from Masdar's southern-most offices, a three-storey car park stands in the sand. Five years on from when builders first set to work on it, it remains a building site. The top two floors have never been finished. They were meant to house the cars of Masdar's 40,000 commuters -- but there were never enough to fill the space.

The car park is a monument of its time: 2008. At that point, Masdar was still moving ahead with optimism. Then came the global financial crisis. A two-hour drive away, Dubai's vast state-owned investment company, Dubai World, ran up unserviceable debts of $59 billion (£39 billion). Its sister city, Abu Dhabi, had no choice but to bail out Dubai. As a result, Abu Dhabi had less to spend on its own projects -- such as Masdar. The crisis led to the Emirati housing market crashing. The city's rental-income projections collapsed overnight and, with them, any hope of finishing the site by 2015. Out went the dream of 50,000 residents and a zero-carbon settlement. "When Dubai collapsed," Geiger says, "the plug was more or less quietly pulled on six million square metres at Masdar City.“

http://www.wired.co.uk/magazine/archive/2013/12/features/reality-hits-masdar/viewgallery/330479

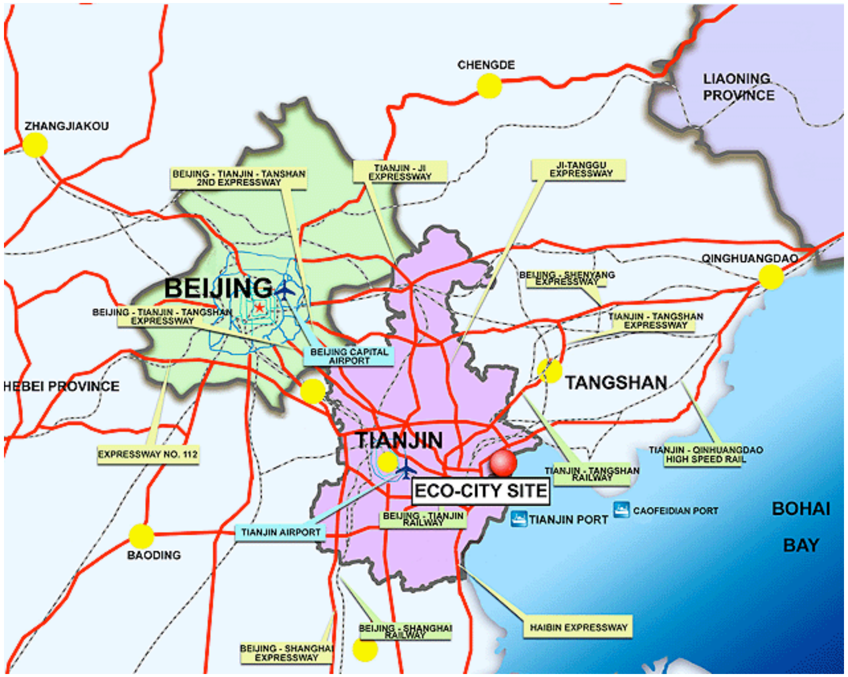
Sino-Singapore Tianjin Eco-City

In 2007, only a few years after announcing the Dongtan project, the Chinese government made plans for another ecocity, Sino-Singapore Tianjin Eco-City on a site about 25 miles from the Tianjin city center, 95 miles southeast from Beijing, and less than a ten-minute drive to the Tianjin Economic-Technological Development Area (TEDA).

The city's mission revolves around "Three Abilities" (Practicability, Scalability, and Replicability) and "Three Harmonies" (harmony with economic development, harmony with the environment, and harmony with society).

The city's plans for sustainable development include six dimensions:

1. **Intelligent city,**
2. **Clean water,**
3. **Ecology,**
4. **Clean environment,**
5. **Clean energy,**
6. **Green building**


CHENGDE
LIAONING PROVINCE
ZHANGJIAKOU
BEIJING - TIANJIN - TANGSHAN 2ND EXPRESSWAY
TIANJIN - JI EXPRESSWAY
JI-TANGGU EXPRESSWAY
QINGHUANGDAO
BEIJING
BEIJING - SHENYANG EXPRESSWAY
BEIJING - TIANJIN - TANGSHAN EXPRESSWAY
TIANJIN - TANGSHAN EXPRESSWAY
BEIJING CAPITAL AIRPORT
HEBEI PROVINCE
TANGSHAN
EXPRESSWAY NO. 112
TIANJIN
TIANJIN - QINHUANGDAO HIGH SPEED RAIL
TIANJIN - TANGSHAN RAILWAY
ECO-CITY SITE
CAOFEIDIAN PORT
BOHAI BAY
BEIJING - TIANJIN RAILWAY
TIANJIN PORT
TIANJIN AIRPORT
BAODING
HAIBIN EXPRESSWAY
BEIJING - SHANGHAI RAILWAY
BEIJING - SHANGHAI EXPRESSWAY

Some Lessons Learned

The structure of Tianjin Eco-City differs from Dongtan—hinting that the Chinese government learned from its first highly-publicized and unsuccessful ecocity experience. Tianjin Eco-City is a joint collaboration between the Chinese and Singaporean governments (2007). The groundbreaking ceremony occurred just 10 months later. The project is structured as a 50/50 joint venture between a Chinese consortium and a Singaporean consortium, called Sino-Singapore Tianjin Eco-City (SSTEC).

The Tianjin Eco-City project contemplated its first wave of residents in 2011. Completion of the initial phase of the project, about three square miles, is planned for completion within 10 to 15 years.

According to Wang Bao, a Chinese environmental activist, the Tianjin ecocity has realistic design schemes and expectations, making it China's most promising ecocity project to date. Furthermore, Bao believes that the project developers

"have scientific methods of ensuring that the development is in line with their green targets—and the Singapore leaders frequently come to check the progress."

Sino-Singapore Nanjing Eco High-Tech Island

- **Nanjing Eco High-Tech Island (Nanjing Ecocity) is another Chinese ecocity being developed by a joint partnership with Singapore. It is about two square miles in size and four miles from Nanjing, the capital of southern Jiangsu province. This ecocity's goal is *"to establish a platform for the sustainable development of high-tech, smart industries under an ecologically conscious environment;"* however, information about its projected dates and size is limited.**

- **In October 2010, the Singapore-Jiangsu Cooperation Council was renewed for three years, to promote further *"economic collaboration in urban planning and development, environmental services, logistics, commercial tourism/hospitality projects."* The council also announced in October 2010 that the official launch of housing construction for Nanjing Eco High-Tech Island had recently taken place.**


Shengquan New Town
Puxin Homeplace
Bridge Park
Waijiang
Dingpaotai
Xiaguan
Xiuqiu Park
Qiihe
Huchenghe
Qianzhou
Gulou
Drum Tower Park
Fangcao Garden
Beihekou
Jiajiang
Xuweicun
Mochouhu
Jianye
Jiyoucun
Huzhoulan
Nanhu Park
Confucius Temple
Muxiyuan
Yuhua New Village
Andemen
Huashenhu
Jiangshan Square
Jiangnan Wharf
Oil Mill Bridge
Ningwu Line
Longwangcun
Longwangshou
Tianbaocun
Shijiacun
Youfangcun
Wangyan Street
Meihuashan
Meiyuan Community
Shicun
Ningwu Line
Qinhuaixinhe
Zhujiaying Reservoir
Guojiangcun
Baijia'ao
Jingmingsi Reservoir
Jingtou Reservoir
Dijia'ao
Xianling Muyuan
Xitiansi Muyuan
Dragon Spring Temple
Qiandong
Dashihu
Jingpingh
Hanlaowa Reservoir
Tomb of Zheng He
Pixu Reservoir
Daguantang Reservoir
G42 Hu Rong
Ring Hwy
G2501 Nanjing Ring Expy
G211 Ning Wu Gao Su

Meixix Lake District, Hunan Province, China

- In February 2009, Changsha Municipal People's Government of Hunan Province and real estate developer Gale International signed an agreement to develop an ecocity called Meixi Lake District in Changsha, the capital of Hunan province in south-central China. Meixi Lake District expected to eventually house 180,000 residents in 1,675 acres.

- According to Kohn Pedersen Fox, the city's designer, Meixi Lake proposes to offer "a new model for the future of the Chinese city." It plans to focus on combining the features of a metropolis and a natural setting, and plans to feature innovative transport networks, a smart grid, urban agriculture, and waste energy recovery. Furthermore, Changsha is a booming city of over 65 million residents, so the project planners see major opportunities for the economic development of the Meixi Lake District.

- The project, in early planning stages, is expected to be completed in 2020.

But there is something about Meixi that didn't sit right with me. Changsha is not a boom town like Ordos, it lacks the kinetic atmosphere of Zhengzhou, and it just doesn't possess the economic stimulus of Shanghai. I may someday have to eat my words, but as I looked out across the lake and tried to imagine it cradled with skyscrapers I could not stop myself from saying, "New South China Mall."

http://www.vagabondjourney.com/from-farm-to-city-check-out-changshas-meixi-lake-before-the-skyscrapers/

http://www.archdaily.com/306906/kpf-releases-masterplan-for-chinese-city-built-from-scratch/

A Key Challenge: Financing

- **Financing remains one of the greatest challenges facing ecocity initiatives. Although benefits of ecocity developments may be realized over the long-term, the staggering capital requirements of such projects—estimated at $35 billion for New Songdo City—typically require both public and private sector involvement. The projects reviewed have approached this challenge in different ways.**

- **All anticipate some revenues from real estate sales, long-term leases, and office rentals, while some include technology-based royalties to offset the capital requirements. Whether these projects will secure financing in an appropriate time-frame remains uncertain; moreover, the optimal capital structure cannot be determined from data available.**

Integrating Public and Private Sectors in Partnership Arrangements

- The complexity and scale of an ecocity initiative necessitate cooperation among multiple entities, including companies of varying types, sizes, and nationalities, and government entities at the city, regional, and national levels. In most of the ecocity projects, public-private partnerships (PPPs) were initiated by governments working with companies ranging from real estate developers, architects, technology experts, financial institutions, and other service providers. The balance between the private and public sectors varies across projects.

- Projects led by single government, dual-government joint ventures, and private-sector companies—present distinct challenges. The standard PPP models common in traditional infrastructure projects, where the government recruits private companies that contribute to project development, do not work well for ecocities.

Other Challenges

- **Ecocity projects require a unique type of public acceptance to entice residents and businesses in the long-term.**
- **A completed city will require high levels of maintenance; and it is difficult to bind developers and end-users to the desired regulations for sustainability features and standards.**
- **Initiatives are also threatened by mismatched expectations, poor communication, and misunderstandings between the private and public entities**
- **Coordination between private and public entities from two different countries can result in a lack of coordination and cooperation.**
- **Coordinating a network of private companies without the institutional authority of a governmental entity at the center, and garnering sufficient financial support without the backing of a government-owned bank might prove challenging**
- **Partnership models where value is delivered through a network of collaborating companies are rare in any industry**

Real Estate as a Driver

- **Most of the ecocity projects discussed are based on a traditional real estate development model. Although many promise social and economic benefits to separate them from pure property development projects—including Masdar City's focus on becoming a global clean-tech cluster and New Songdo's free economic zone – all projects rely on real estate sales and rentals as the means for eventually repaying banks and other capital providers.**

- **Several initiatives, including Masdar City and New Songdo, also intend to offer government-based economic and tax incentives to encourage corporations to locate offices there, driving demand for both office space and residential real estate.**

Emphasis on Technology

- **A study by Booz Allen and The World Wildlife Foundation found that an up-front investment of $22 trillion dollars in green urban transportation and residential technology would save $55 trillion in future infrastructure spending. Most ecocity projects aim to realize these kinds of savings through the development of city-based technologies. However, the level of emphasis on technology R&D, in particular on the application of new "clean" and "green" technologies, varies across projects.**

- **While the success of these models and technology initiatives remains uncertain, observers have noted that interconnected systems raise serious security issues. The integration of sensors into all aspects of a city—everything from traffic signals to windows to vehicles to people—raises concerns about privacy, government surveillance, and disastrous security breaches.**

- **Sam Palmisano, CEO of IBM, acknowledged, *"Some citizens have expressed discomfort at living in not a safer society but a 'surveillance society."* While companies such as IBM and Cisco hope to resolve these issues, how citizens will react to living and working in entirely connected communities remains unknown.**

Replicability

- **These initiatives differ greatly with regard to replicability. Certain projects are intended to create a unique ecocity. Masdar City officials hope the city will provide a "model for sustainable urban development regionally and globally," and that its business model and technology will demonstrate the commercial viability of eco-cities. Although they are offering consulting services to developers, they lack plans to pursue similar projects elsewhere.**

- **On the other hand, Chinese government's involvement in over a third of the initiatives reviewed here reflects industry estimates that China needs to build 500 new cities over the next several decades—100 with populations over one million. New solutions are required.**

- **Every new city needs an economic foundation based on jobs. Not every new ecocity can be a research city whose purpose is the development of new technologies for building other ecocities. To thrive, a city requires a range of jobs, spanning multiple sectors, such as technology, financial services, retail, entertainment, education, and health care. Every ecocity similarly needs a clear economic model, as well as features that attract both businesses and residents.**

There are many challenges to developing replicable business models for sustainable urbanization. We identify four that are particularly important.

- ***One is getting access to enough land in the right location at the right price—a necessary but not sufficient condition.***
- ***A second is the great variation in how development occurs under different political systems. Lessons learned in Portugal won't translate directly to China, for example.***
- ***Third, lessons from new ecocities will need to be adjusted for projects done in existing cities or the urban retrofit market. Each setting provides its own opportunities and constraints.***
- ***Fourth, and in our view the biggest challenge of all, is establishing a new economic model for ecocities.***

Every new city needs an economic foundation based on jobs. Not every new ecocity can be a research city whose purpose is the development of new technologies for building other ecocities. To thrive, a city requires a range of jobs, spanning multiple sectors, such as technology, financial services, retail, entertainment, education, and health care. Every ecocity similarly needs a clear economic model, as well as features that attract both businesses and residents.

BBC Horizons-EcoCities

http://www.youtube.com/watch?v=bzBzcpaUlK0

6. Sustainability at a Building/Neighbourhood Level

The ECCA lands will be home to 30,000 Edmontonians living, working and learning in a sustainable community that uses 100% renewable energy, is carbon neutral, significantly reduces its ecological footprint, and empowers residents to pursue a range of sustainable lifestyle choices.

Edmonton City Centre Airport Lands

Master Plan Principles

In addition to environmental sustainability, the challenge is to address social and economic factors that encourage residents to adopt sustainable lifestyles.

This means providing choices across a broad spectrum of living and work environments that will enable many lifestyle options while also addressing affordability for families, individuals, and businesses who will share a common purpose.


Edmonton City Council – July 17th 2012

Edmonton City Centre Airport

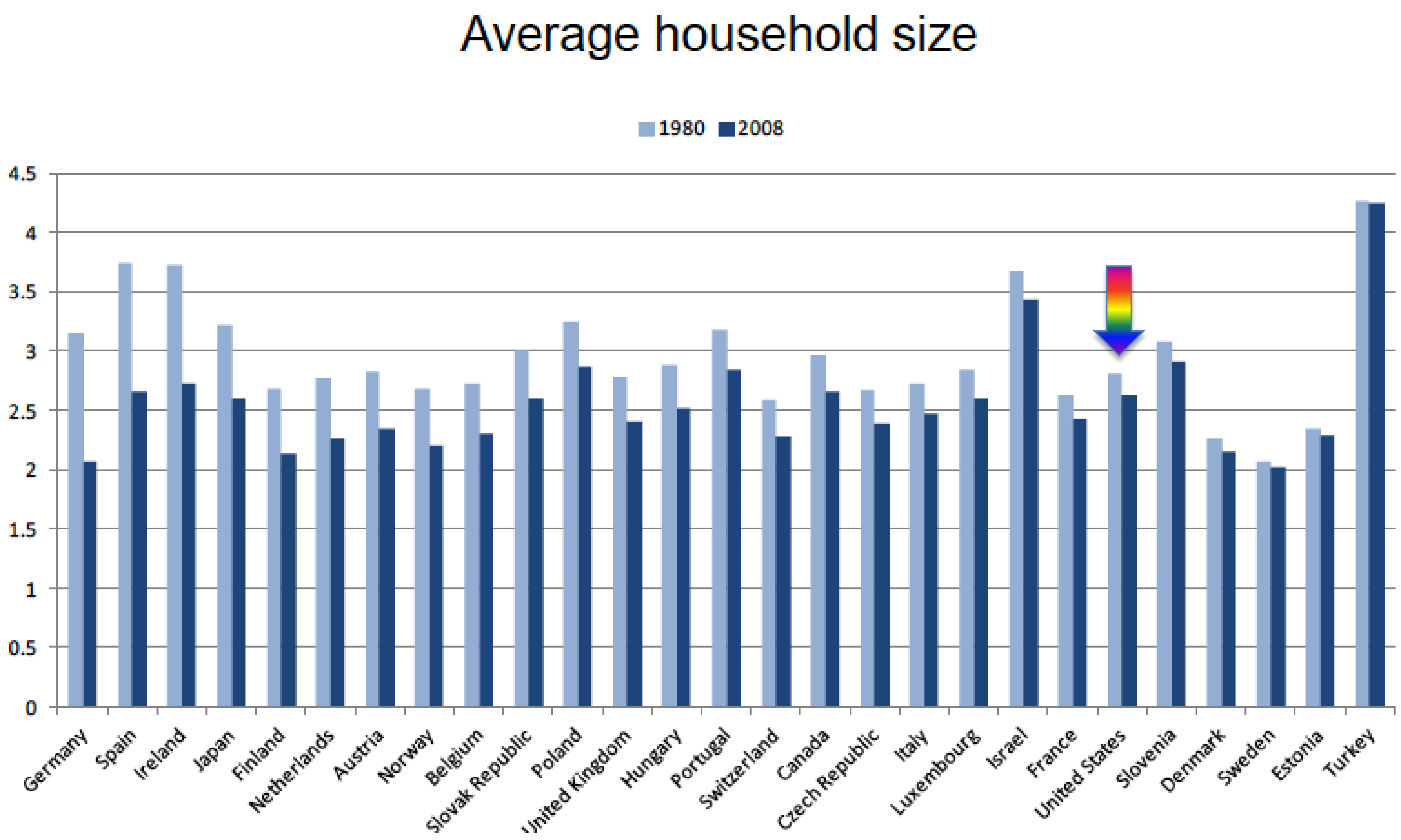
http://www.youtube.com/watch?v=w33nLGlcYZ0

http://www.youtube.com/watch?v=q-15kD8Gx0Q

Five key urban trends

1. Urbanisation and the increasing need to conserve land resources
2. The threat of climate change to cities
3. The rise in energy prices
4. The challenge of sustainable economic growth
5. Declining population, ageing and smaller households in cities

More demands for smaller houses…



...and urban living

Percentage of one-person households

6 sub-characteristics

1. shorter intra-urban travel distances
2. less automobile dependency
3. more district-wide energy utilisation and local energy generation
4. optimal use of land resources and more opportunity for urban-rural linkages
5. more efficient public services delivery
6. better access to a diversity of local services and jobs

Future Influences on Land Use

Population growth and demographic shifts

Growth will be primarily in Africa, a few Middle Eastern and South Asian countries – an aging population and low birth rates will slow growth in China and much of Europe. Immigration in Canada and the US means we are not growing old at a similar pace to that of Europe.

In the U.S., people 65 and older will make up 22% of the population in 50 years, up from about 15% now.

Advances in technology and design

Buildings will be designed and built differently with new materials that will make them last longer and be more energy efficient.

Technology may range from materials science, sensors and controls, nano-technology through modularization and computer aided design.

What is the role of good design?

Figure 1.13 Uses of a Pedestrian Pathway

Source: Rutherford (2007).

Note: A pleasant pedestrian pathway (an example in each photograph) serves the transportation needs of a walkable community, providing a quiet, safe, and cool option for moving around. At the same time, it also functions as an element in other infrastructure systems. The garden strip on both sides of the pathway is used to grow plants and flowers that help keep the city cool, reducing energy requirements for air-conditioning. The pathway is bordered by a gentle swale or depression in the earth that functions as an infiltration trench, intercepting and slowing storm water flows. The soil in the trench is enriched with composted organic waste, avoiding the need to truck such waste out of the community. The enriched organic soil is highly absorbent and, thus, needs little irrigation to stay green, helping reduce the city water budget. The subbase for the pathway is composed of ground glass and rubble from returned bottles and from industrial waste. In essence, the pedestrian pathway is a transportation facility that also serves to manage and treat storm water flows, recycle organic and inorganic waste, cool the city, and provide a water-efficient garden amenity.

http://www.urbanobservatory.org/compare/index.html

Urban Form and Sustainability

One need not look far to find a passionate argument that the compact city is the green city. Having more people in a smaller area results in less energy use for transportation purposes lower greenhouse gas emissions and greater efficiency in the use of various resources. Cramming more people into a smaller space makes our cities more sustainable.

Or does it?

New research published in the spring issue of the *Journal of the American Planning Association* (2012) finds that – unlike today's dominant narrative of the green city – urban form may actually have very little impact on energy use and other measures of sustainability.

Researchers from the universities of Cambridge, Newcastle, and Leeds looked at three English metropolitan areas of various sizes and ran them through computer models that imposed three different urban forms over the course of 30 years.

Each area was modeled as a hyper-dense city with tight restrictions on land use, an urban growth boundary and prioritized transit development, a sprawling, market-driven urban form that had few restrictions on land use, and a middle ground based on English new towns, or those planned suburban-style developments on the outskirts of larger cities.

Each urban form – compaction, dispersal, expansion – was modeled on the three areas between the years 2001 and 2031 and evaluated on the basis on 26 different measures of sustainability – from pollution levels to degradation of water systems to the energy consumption of buildings and people.

The models showed only very slight differences between the three urban forms.

"To our surprise, if you compare the compact form versus the current trend, the difference in reduced transport by automobile is very minor. And if you allow the city to expand, the increase in the use of the car is only marginal," says Marcial Echenique, a professor at the University of Cambridge Department of Architecture and one of the authors of the report.

"If you make the city more compact, it doesn't mean that people will abandon their car. Only 5 percent of people abandon the use of the car. Ninety-five percent carries on using the car, which means there are more cars on the same streets, therefore there is much more congestion and therefore there is much more pollution and no great increase in the reduction of energy.“

Echenique has been working on this research for about 4 or 5 years, and continued modeling and analysis has only backed up their findings.

"We are not very convinced of the idea that compacting cities will make very much difference in terms of environmental quality. But it will have severe consequences in terms of economics and social issues," Echenique says.

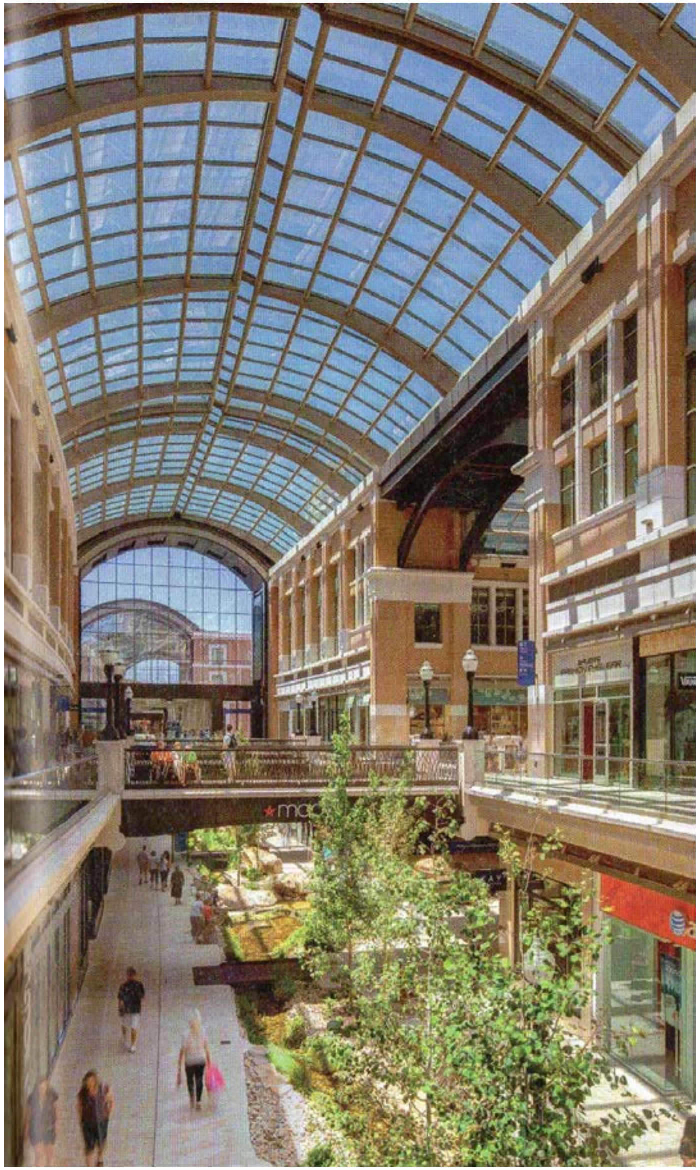
In terms of reducing the environmental impacts of human development and lifestyle, Echenique says his numbers indicate that we might be better off focusing our effort on improving technology and energy efficiency.

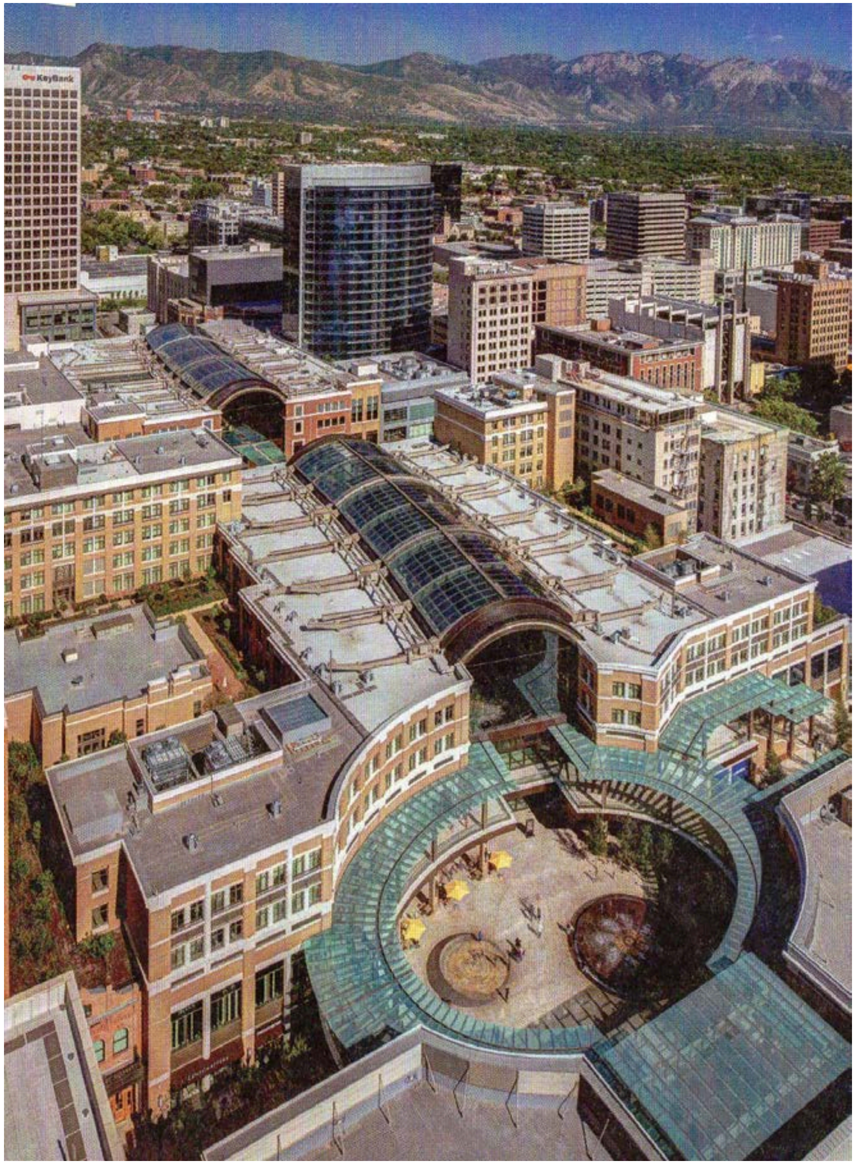
He says we'll have a much better chance of reducing the negative impacts of modern living by focusing on automobile technology and reduced energy usage in buildings. He and his team are currently working on research on the effectiveness of focusing on the technology side. Results are expected to publish later this year.

"We believe that we can reduce by 50 percent or more the use of energy in a fairly short time, within the next 20 years or so," he says. "It's much more effective than compacting or dispersing cities, because there's only a five percent difference either way.“

Echenique argues and his research indicates that greater gains can be achieved by making more efficient cars or better insulation for buildings than by trying to reshape the urban landscape. "Technology offers a much better future than trying to constrain behavior of the market," he says.

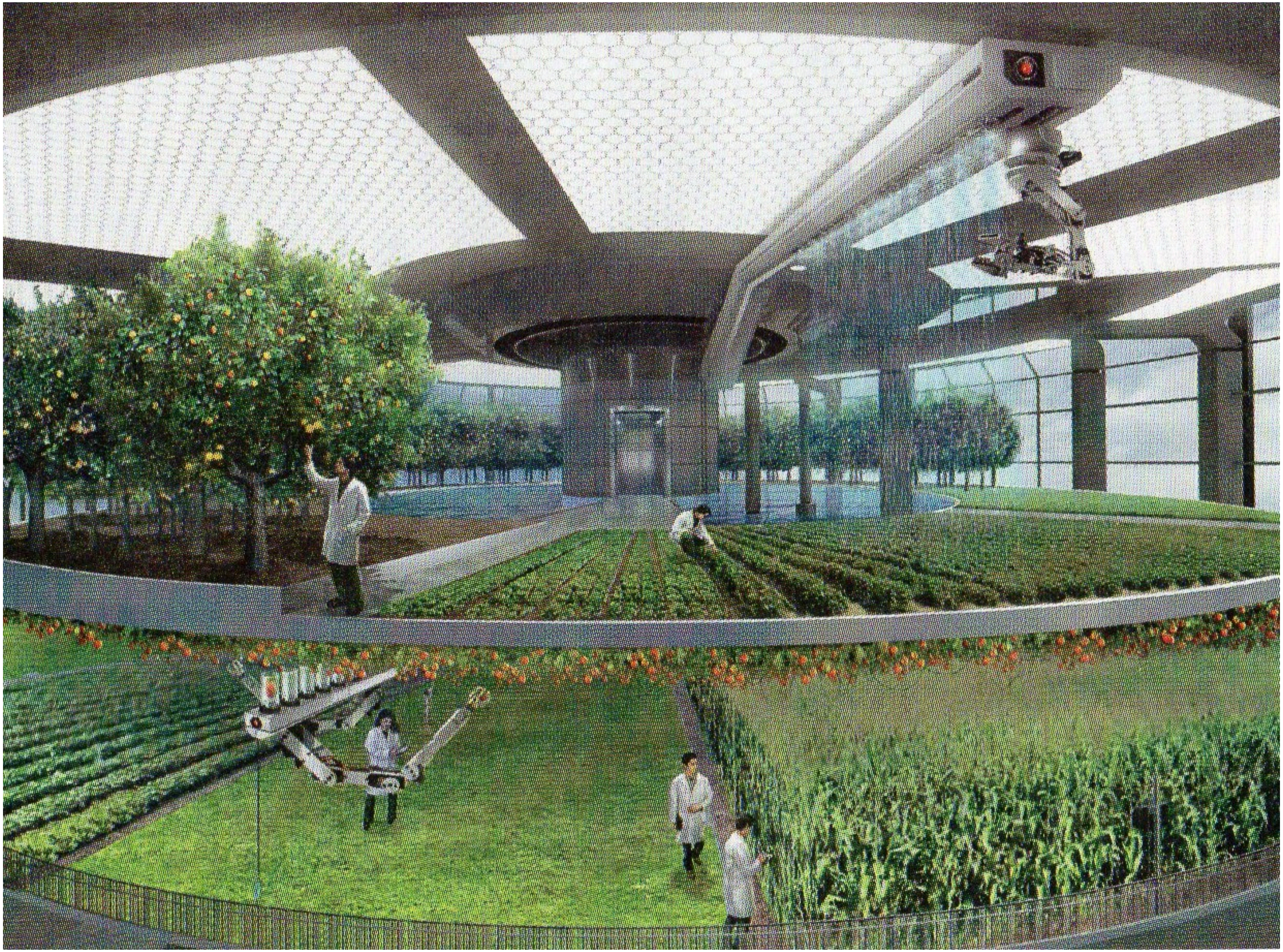
Mixed Use





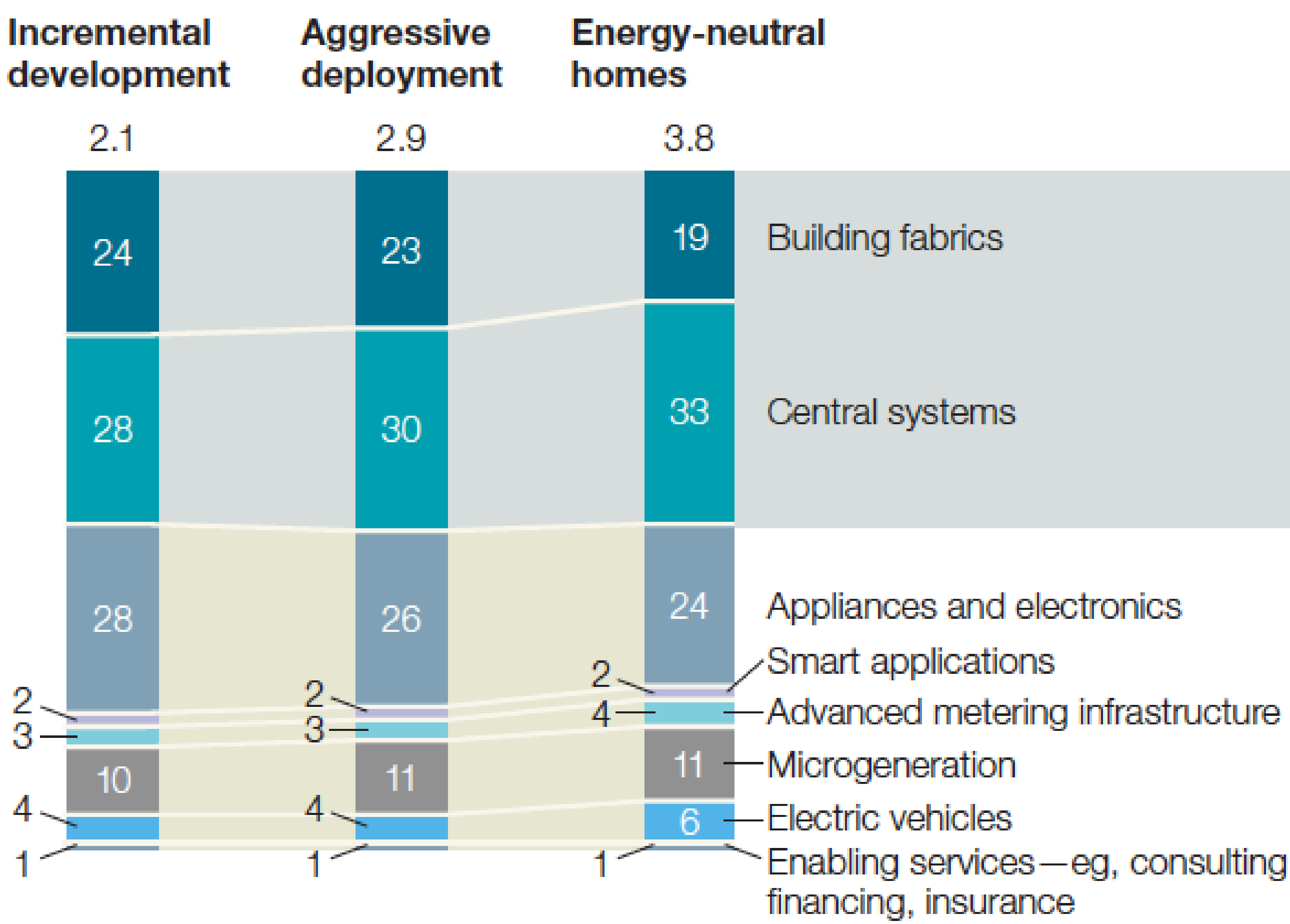
City Creek Center in Salt Lake City is the only enclosed mall built since 2006. It has a rectractable roof

Urban Farming



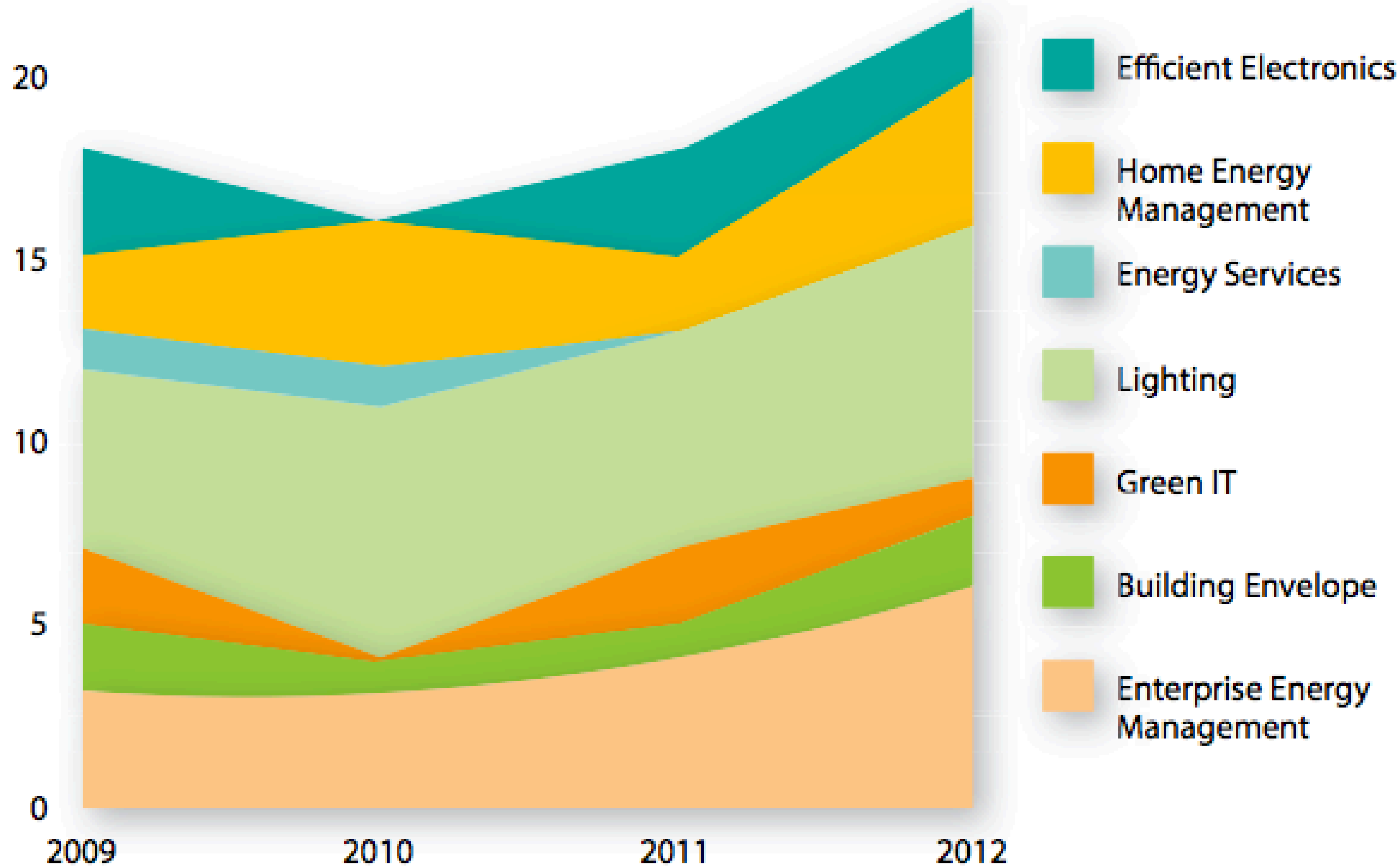
Building fabrics and central systems represent approximately half of the total value pool.

Distribution of 2020 value pool at EBIT level,[1] average of Germany, Italy, Sweden, and United Kingdom, %



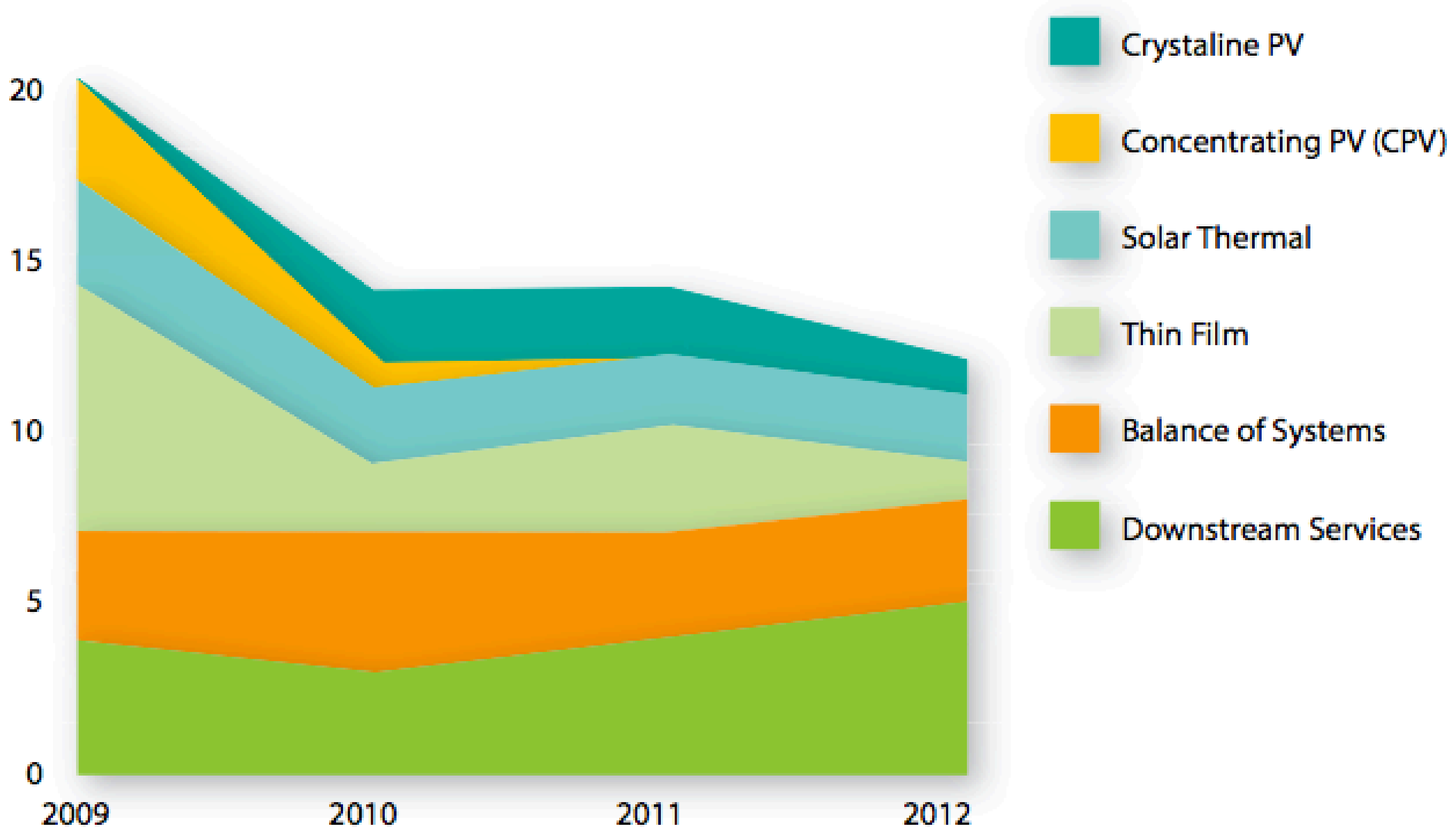
[1]EBIT = earnings before interest and taxes. Assumes same volume and mix as 2010.

Lighting has been consistently the largest sub-sector of Global Cleantech 100 energy efficiency companies. However, enterprise energy management companies are responsible for most of the sector's growth in representation since 2010. Enterprise energy management, including building energy management, is the fastest growing sub-sector of energy efficiency. The third major segment of energy efficiency companies in the Global Cleantech 100 has been home energy management (HEM).



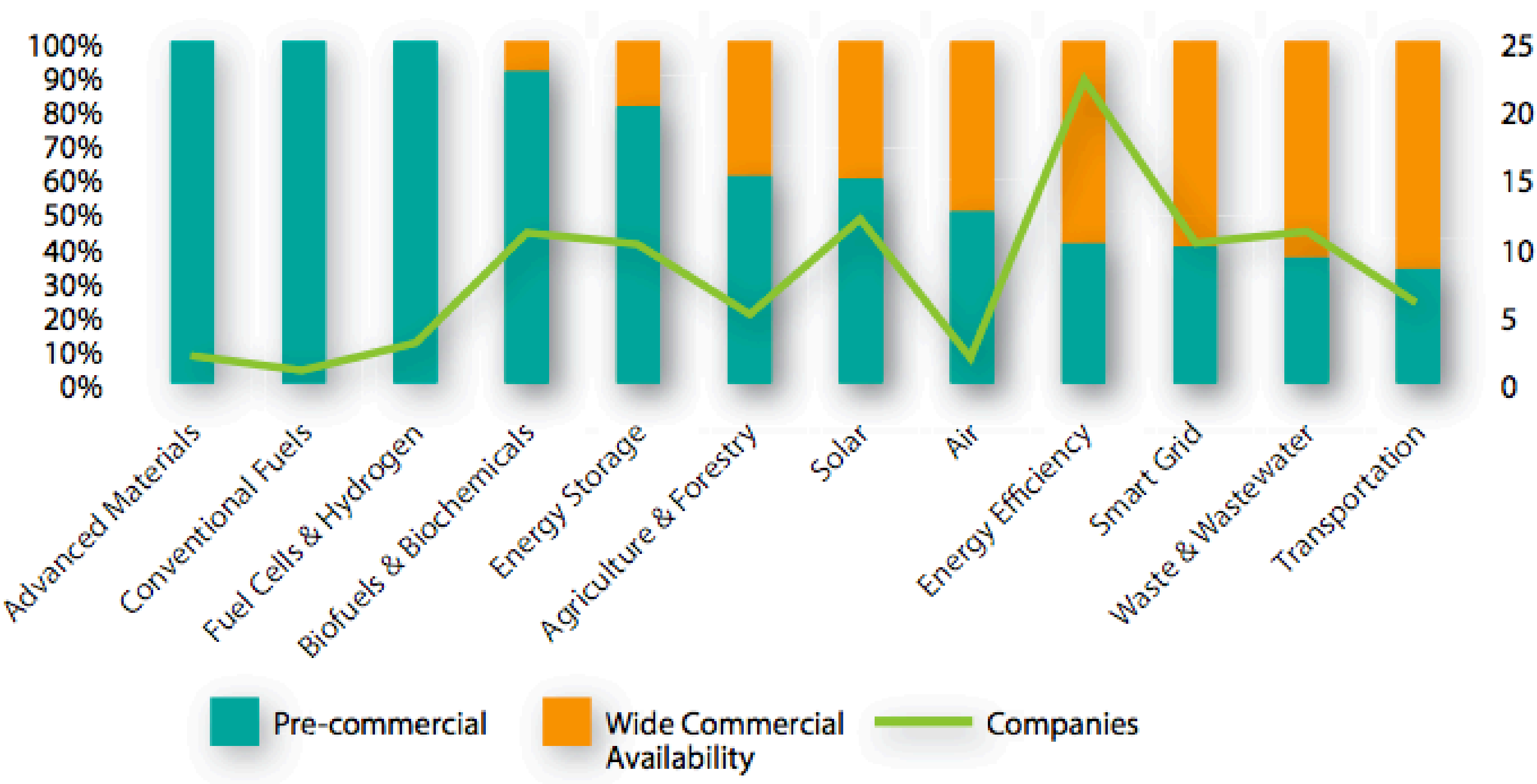
Source: Cleantech Group Analysis

Solar



Source: Cleantech Group Analysis

Development stages



Source: Cleantech Group Analysis

The residential sector

- **Residential sector, accounts for 35 percent of the end use potential for energy saving in the US. The incremental investment to make 129 million U.S. homes—and the appliances, devices, and climate control systems in those homes—more energy efficient would be $229 billion, providing present-value savings of $395 billion. Upgrading building shells and heating and cooling equipment, mostly in existing homes, represents the largest opportunity (71 percent). The rest would come from upgrading devices and appliances.**

- **Can divide U.S. homes into three clusters: a) existing homes of low-income people; b) existing homes of other Americans; and c) new homes (those built after January 1, 2009). At all income levels, energy-efficiency upgrades to shells of existing homes (for example, through insulating basements and sealing air leaks) offer the largest opportunities. Similar savings could be achieved in new homes at half the cost, but few such homes will be in place by 2020.**

Turning to the Home of the Future—Demanding Less from the Grid

- **Research indicates that if selected existing technologies were deployed to the fullest by 2020, a new home could consume around 90 percent less energy, whether gas or electricity, from the grid than it does today. The opportunity for existing homes, which form the majority of housing stock, is substantial : cuts of 35 to 40 percent could be achieved.**

- **Business as usual will not be an option for most energy utilities. To cope with this discontinuity, they must seek new sources of revenues and profits in emerging energy-related businesses. These include building fabrics (for example, roof and wall insulation), central systems (including heat pumps and lighting), appliances and electronics (energy-efficient white goods), "smart" applications (home area networks and energy storage devices), advanced metering infrastructure, microgeneration (for instance, small-scale wind turbines and solar panels), and the delivery of power for charging electric vehicles, as well as financing, insurance, and consulting services.**

- *McKinsey Quarterly: Winning the battle for the home of the future, October 2011*

Barriers to Adoption

- **The barriers are significant. Homeowners typically know little about their energy consumption or how to reduce it and end up underestimating savings from retrofits.**
- **They may also move before recouping the cost of upgrades—a barrier that undermines 40 to 55 percent of these opportunities.**
- **For most families, allocating funds for such money-saving measures is difficult: core spending absorbs 90 percent of average household budgets, so a "typical" retrofit costing $1,500 absorbs 30 percent of annual discretionary spending. If the expense isn't a deal breaker, homeowners face high transaction costs researching upgrades and finding suitable contractors.**
- **Poorly installed and operated equipment—some reports conclude that contractors install 90 percent of retrofits sub-optimally—can hike air-conditioning and heating costs by 30 percent.**

A Crowded Field

- **Developing or acquiring new capabilities will be essential for utilities as they move beyond their comfort zones. They must, for example, help customers overcome the investment barrier by providing financing options through partnerships with banks or by creating internal financial units. Many players also realize that they have to join hands with other new entrants to cover the value chain effectively.**

- **British Gas collaborates with the UK grocery retailer Sainsbury's. Under their partnership, consumers can purchase energy-management products (such as solar panels and insulation) in a supermarket and British Gas installs them. Ikea now sells solar panels in Germany.**

- **Google purchase Nest, a maker of smart residential thermostats, in January 2014 for $3.2 billion US**

- **Growth of opportunities will depend on the consumers' speed in adopting measures that reduce the consumption of energy from the grid.**

Technology

- **Don't expect truly disruptive technologies to boom over the next ten years and lead the way to the low-energy home of the future. The pace at which a wide range of relatively mature and emerging technologies develop and become commercially viable will therefore determine when we can see a critical level of consumer adoption.**

- **Many technologies already recoup their investments today, sometimes with regulatory support. These include heat pumps, double- and triple-glazed windows, energy-efficient (LED) lighting, and microgeneration products (such as solar panels).**

- **Other technologies have a largely unexploited potential, most notably heating, ventilation, and air-conditioning systems using occupancy sensors that automatically manage when and where heating and air conditioning are needed.**

- **Still other technologies, now under development, have a huge potential and could be commercially viable by the end of the decade. One example is "active windows" with coatings that block incoming light when temperatures are high.**

Regulation

- **Many European governments are pursuing a mix of supply- and demand-side measures to meet the European Union’s commitment to a 20 percent reduction in greenhouse gas emissions by 2020.**
- **On the supply side, they can increase the share of low- or no-emission power generation sources, such as natural gas, nuclear, and renewables. But there are challenges.**
- **Expect the push for low-energy homes, where energy efficiency measures reduce demand for power, to remain strong or even be reinforced through government action in some countries.**
- **Regulatory outlook for different home energy technologies varies by country, United Kingdom is introducing a “green deal” to help consumers finance energy efficiency packages.**

Consumer Behaviour

- **Consumers are positive about saving energy, according to market research in the United Kingdom. Yet they expect business and the government, not themselves, to take the lead on the journey toward the low-energy home.**

- **For most consumers, cost is the only reason to reduce energy consumption. But functionality, technological simplicity, brands, and design take priority over saving energy when people purchase appliances.**

- **Most consumers perceive low-energy products to be below par on these attributes and on performance as a whole. This finding suggests that energy-management companies must work hard to bring down costs, raise the quality of products, and educate consumers about the long-term savings they can achieve.**

- **Consumers do have a latent need to control their energy usage. They are most excited about technologies that helped them do so.**

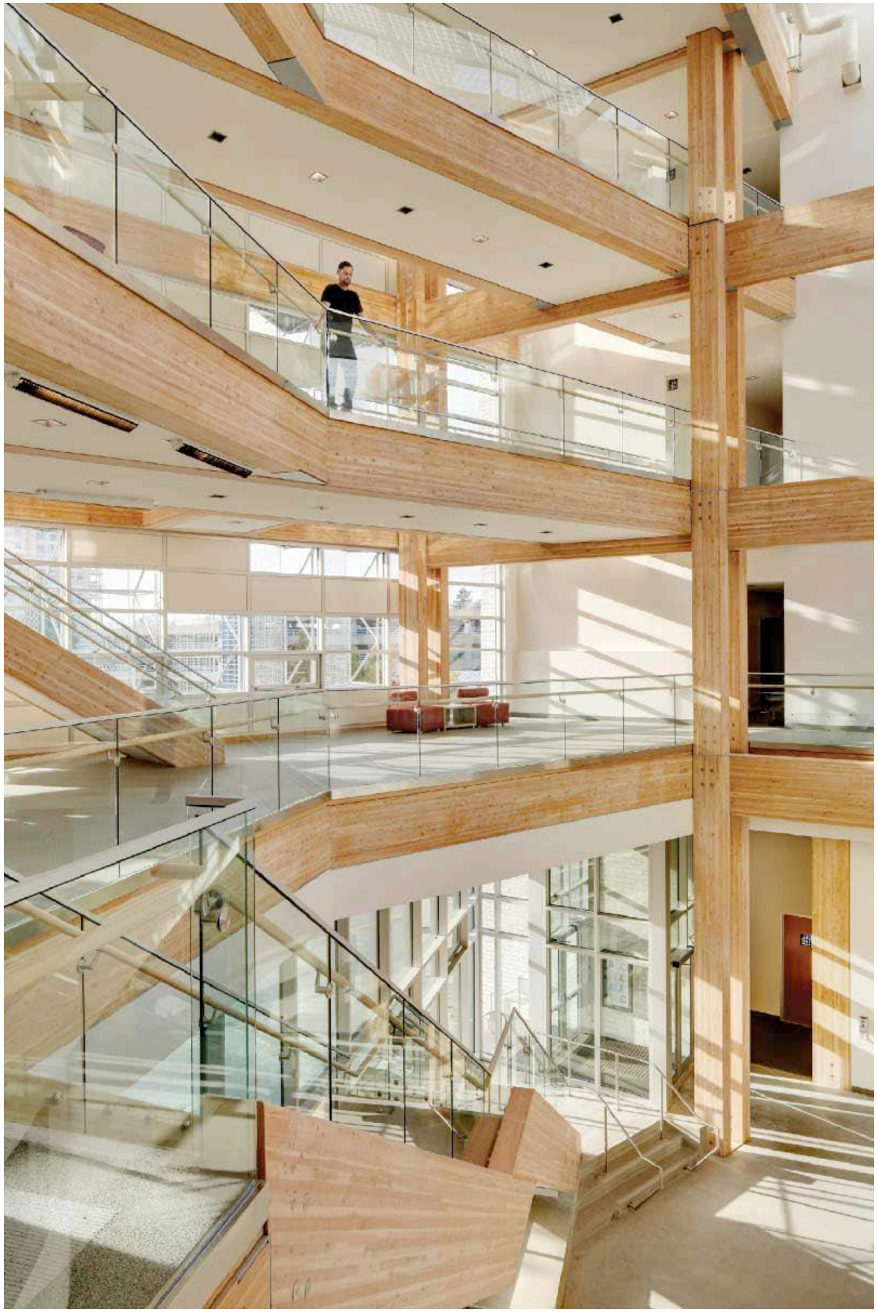
In the 2020 time-frame, low-energy homes will not be "smart homes." Building fabrics (such as roof and wall insulation) and central systems (including heat pumps) represent approximately half of the total value pool across the four countries. Appliances (such as energy-efficient white goods) represent a bit less than a third, and microgeneration around 10 percent.

While growing fast, smart applications (for instance, metering) do not represent much value. The same holds true for electric vehicles, which is seen more as a post-2020 opportunity.

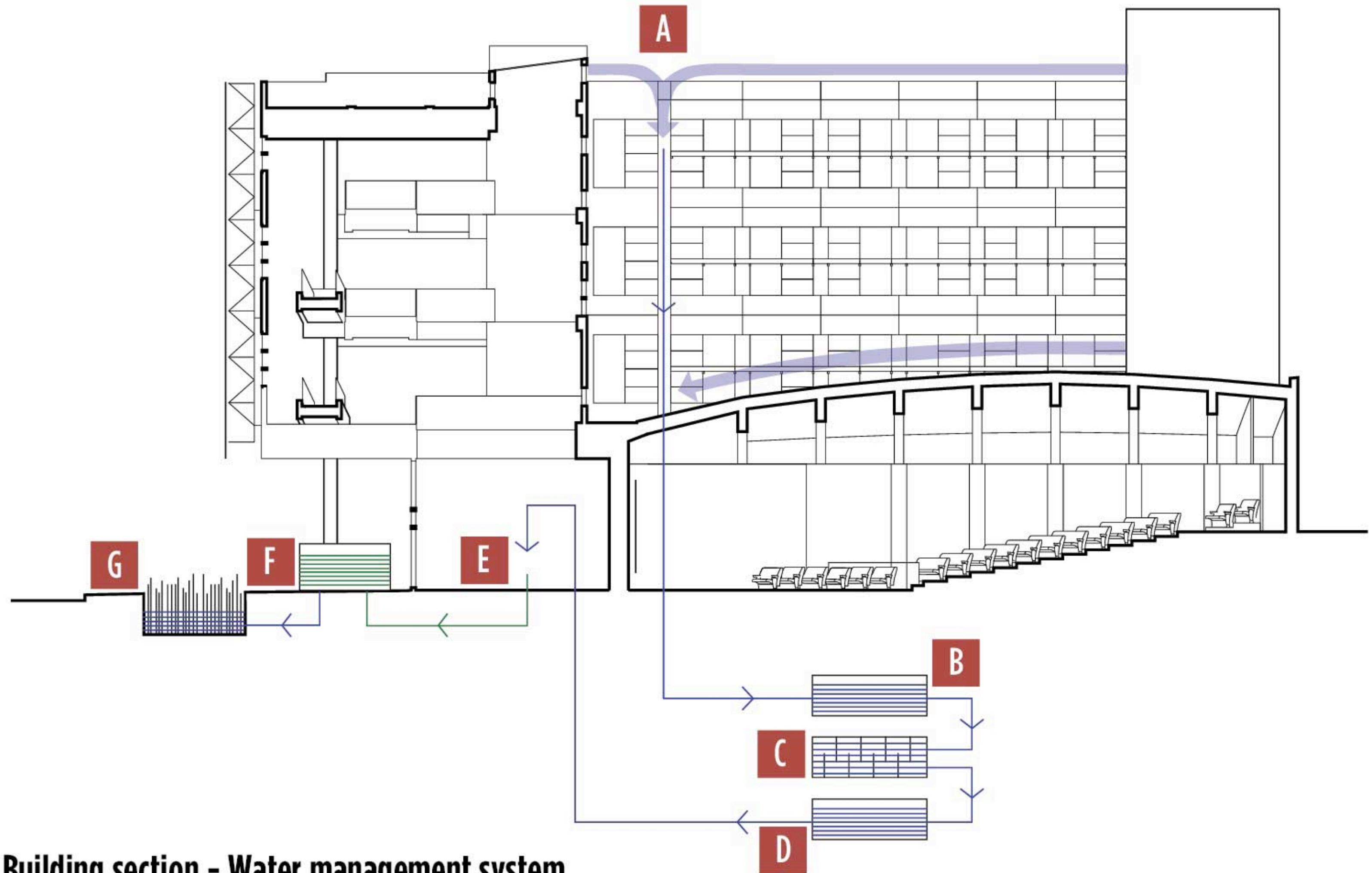
Centre for Interactive Research on Sustainability, UBC - Designed to be the most sustainable building in North America

The 5,675m2 ‘living lab’ is organized around two four-storey wings, linked by a central atrium. The atrium serves as a building lobby, entry to a day lit auditorium, and as a social and educational space from which all of the project’s sustainable strategies are visible.

Other program areas include: academic offices, meeting rooms, multiple smaller social spaces, indoor environmental quality and building simulation software labs; a Group Decision Lab that has advanced interaction technologies to engage audiences in sustainability and climate change scenarios; a building management system that shares building performance in real-time; and a cafe that uses no disposable packaging and serves local, organic food.



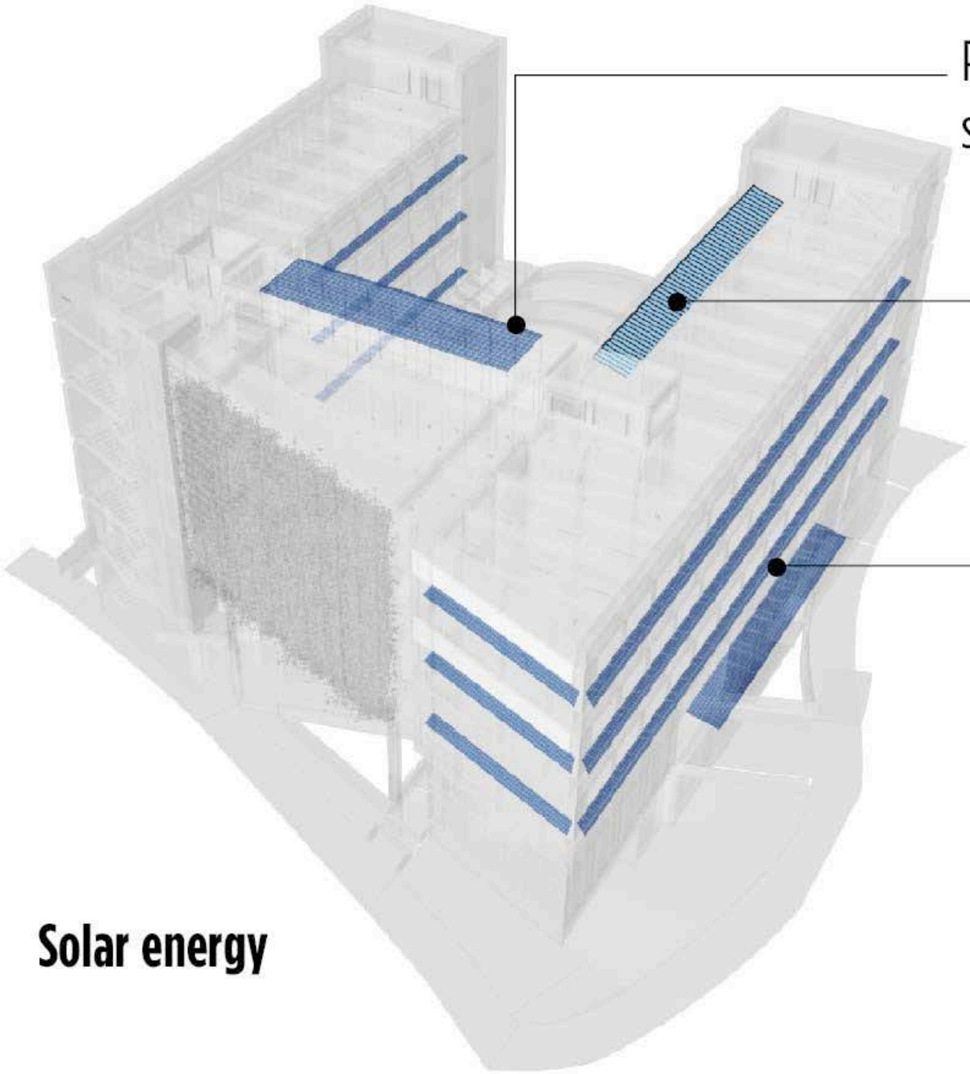
Vancouver office of Perkins+Will



Building section – Water management system

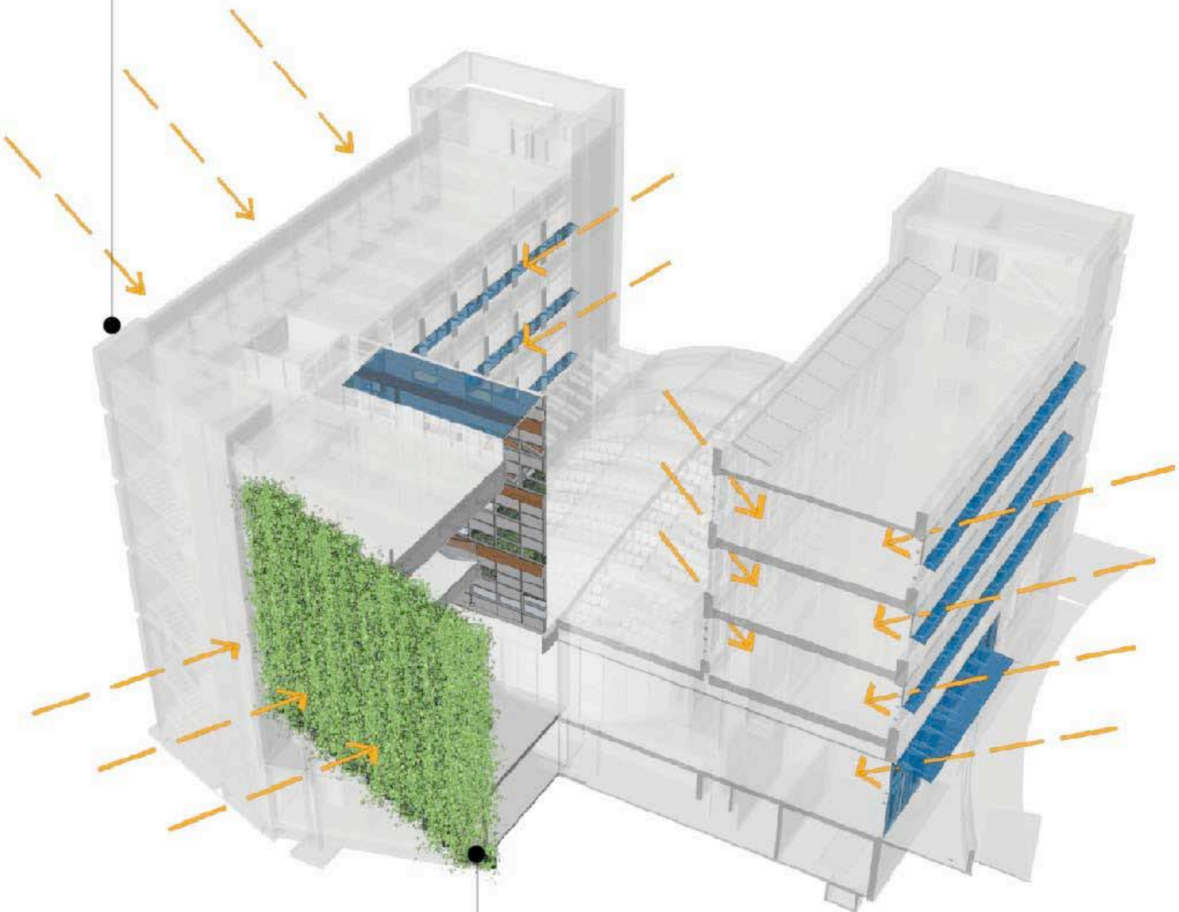
A	Rainwater collection	D	Potable water storage	F	Solar aquatic biofiltration
B	Rainwater storage	E	Domestic water use	G	Irrigation / bioswale
C	Potable water processing				


EXIT



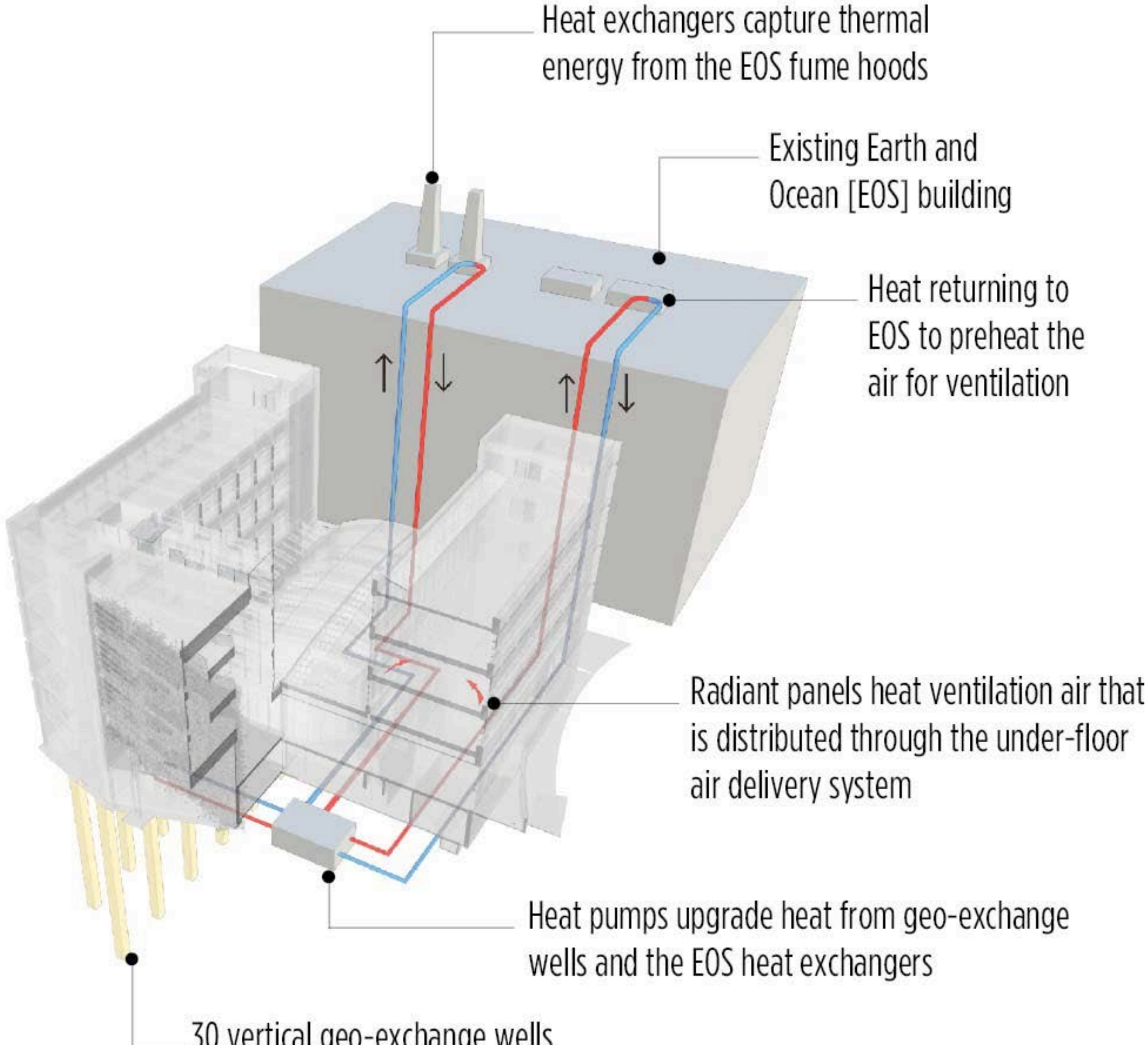
Solar energy

Narrow floorplates allows
for daylight penetration

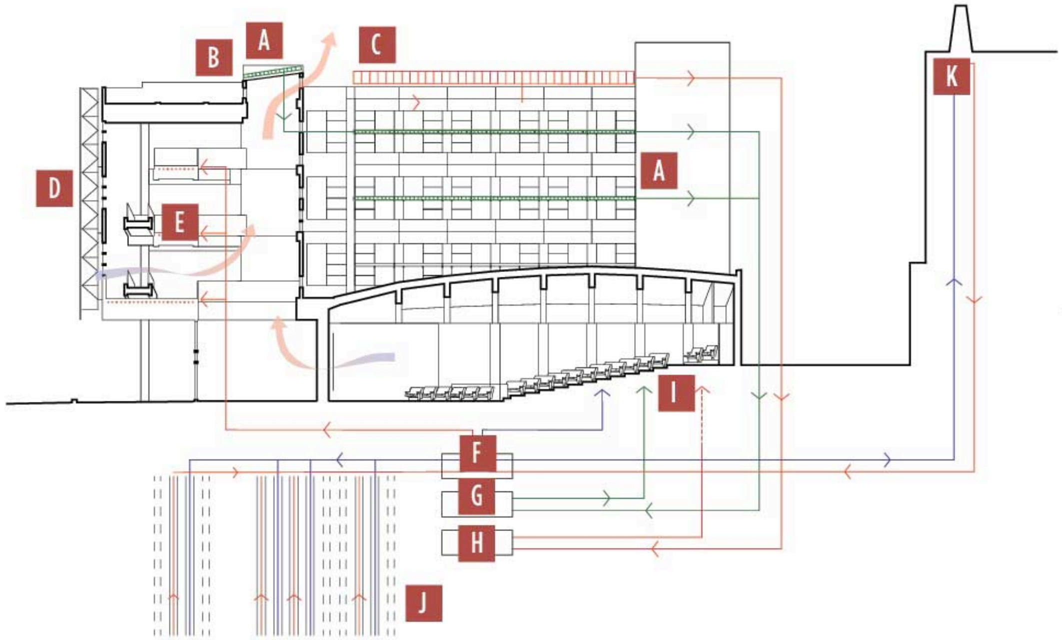


Daylighting

In the summer, the living wall shades the interior spaces from the late afternoon sunlight. In the winter the living wall drops its leafs allowing sunlight in the interior spaces.

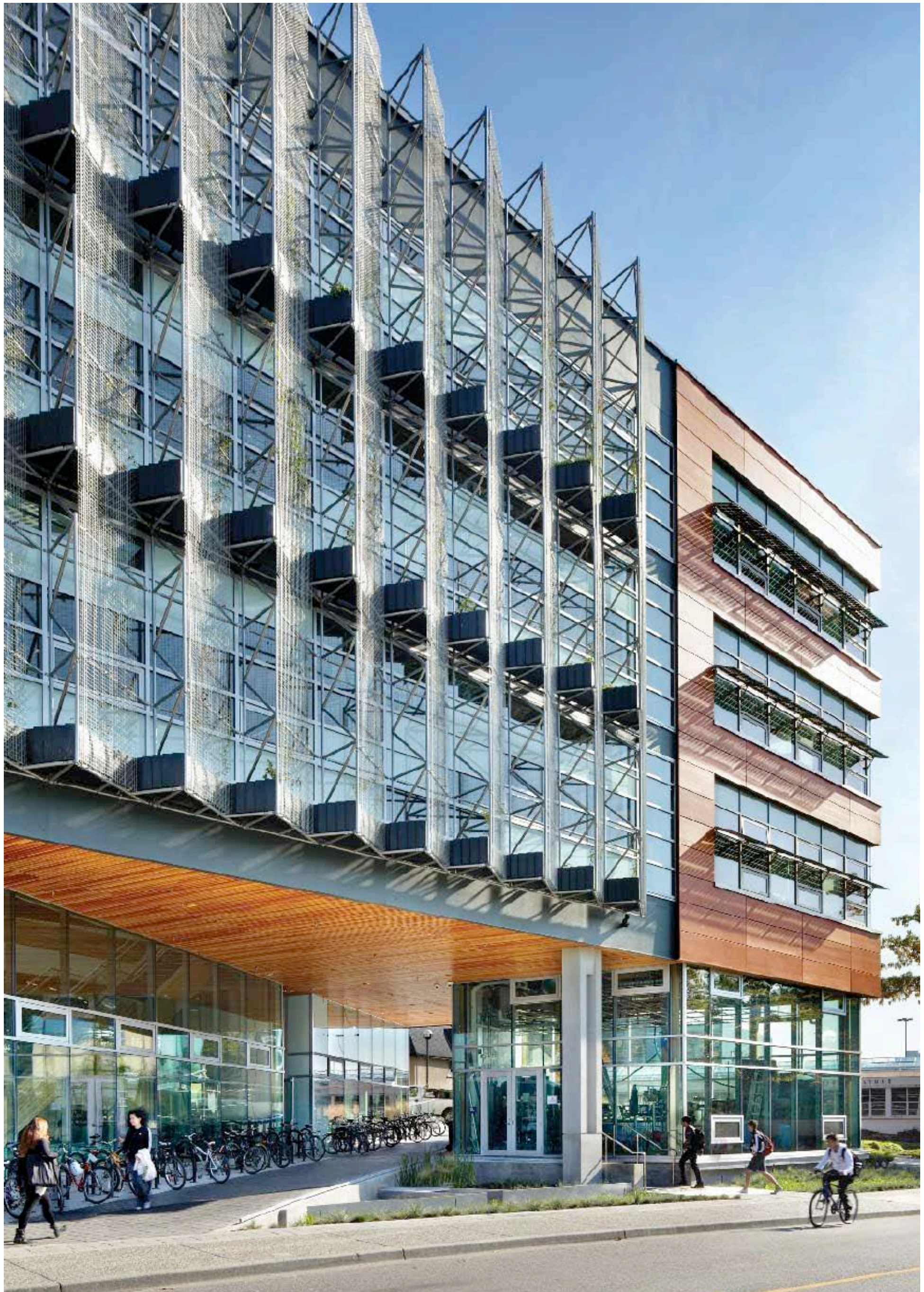


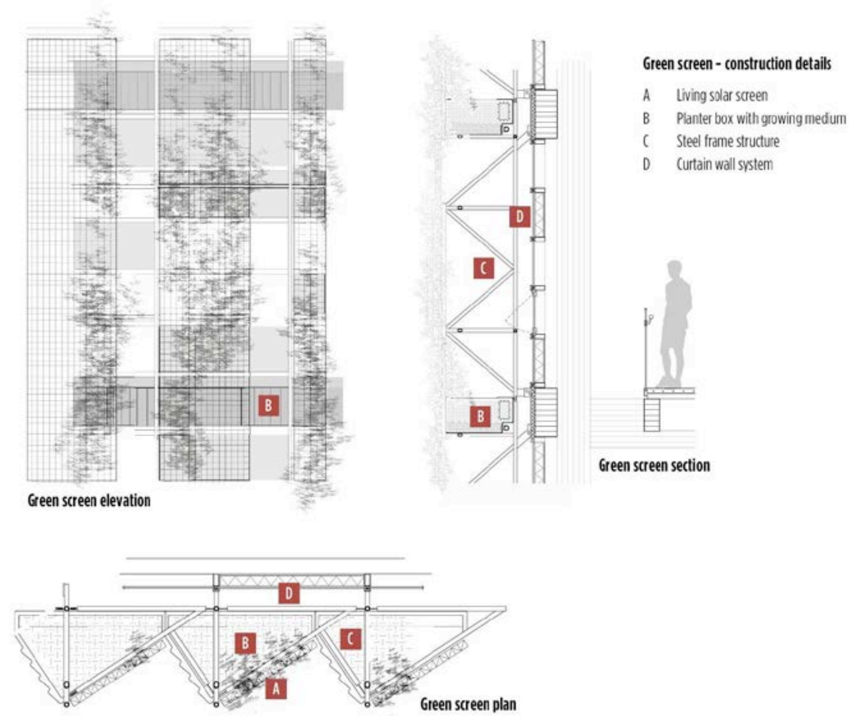
Energy exchange system



Building section – Energy management features

A	Photovoltaic array	G	Electrical inverter
B	Ventilation penthouse	H	Solar heated domestic hot water
C	Evacuated tube array	I	Domestic hot water use
D	Living solar screen	J	Geoexchange field
E	Radiant slab	K	Excess heat from UBC
F	Heat exchanger		




Green screen – construction details
A Living solar screen
B Planter box with growing medium
C Steel frame structure
D Curtain wall system
Green screen elevation
Green screen section
Green screen plan
A
B
C
D


Fall
Spring
Winter
Summer

6. Sustainability and Technology as Key Drivers

Engines of progress

Industrial Revolution was the sum of several nearly simultaneous advances in mechanical engineering, chemistry, metallurgy, and other disciplines.

Steam engine, precisely the one invented by James Watt and his colleagues in the second half of the 18th century, was perhaps the most important – ***"took several decades to unfold…it was nevertheless the biggest and fastest transformation in the entire history of the world."*** **Ian Morris, Anthropologist**

Steam started it all – harnessing steam overcame limitation of muscle power, human and animal, generated massive amounts of useful energy that led to factories, mass production, railways and transportation – laid the foundations for modern life.

Are computers and others digital advances doing for mental power what the steam engine and its descendants did for muscle power?

Dominance of 19th century thinking

Current design and planning practices still firmly rooted in thinking patterns established in the 19th century

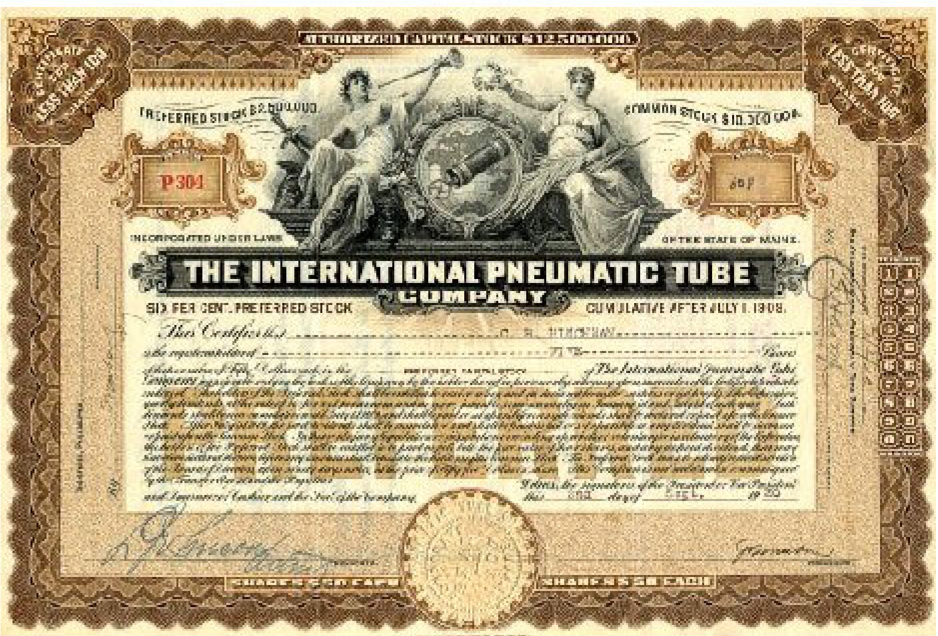
Abundance of coal, combined with new manufacturing technologies led to unprecedented increases in wealth and improvements in quality of urban life in both Europe and North America (Industrial Revolution)

This was achieved with single-purpose, centralized, supply-oriented utilities that operated in silos and capitalized on economies of scale, abundant and inexpensive resources, and open access to public goods such as water and atmosphere, reinforced by monopolists concessions (many owned by or granted by government to special interests).

These silos, once the solution, are now part of the problem – unfortunately, these silos are still integral to our professional training and institutional structures

Infrastructure Networks

- 3rd millennium BC, city north-east of Karachi, Pakistan – fresh water through clay pipe system
- Ancient Rome – 220 million gallons of fresh water each day through two aqueducts (NYC consumes more than a billion gal/day)
- 6th century BC – start on Rome's sewer system, finished in 33 BC
- Early 18th century, London – street lamps burning whale oil
- Middle of 18th century, London – start on private water lines to homes and businesses (reaction to Cholera outbreak)
- 1812, London – Light and Coke Company supplies gas to street lighting
- 1858 – London experiments with electric street lights
- 1870's - Paris, pneumatically synchronized clocks through systems of pipes below the streets to homes and businesses
- 1875 – completion of London's first sewer network
- 1882 – New York City – Edison Electric Illuminating Company with 15 miles of wire illuminating 400 street lights in a square mile



Pneumatic Mail Networks

- **1893, Philadelphia – compressed air drives two-foot long cylinders through a 6” cast iron pipe connecting two post offices – switched to automobiles in 1918**
- **1897, New York – 27 mile pneumatic loop links 27 post offices across Manhattan – remained operational until 1952**
- **1865-1963, Berlin – *Rohrpost* pneumatic mail system extends for some 400 KM**
- **Paris – pneumatic mail system used until 1983 when fax machines made the system redundant**
- **Prague –in use through 2002 and currently being restored**

Wired City

- **1879, New York's first telephone exchange – 252 subscribers**
- **Seoul, Korea – world most wired city – almost every household linked with 100 megabits (average in the UK is 4 megabits) – upgraded in 2012 to provide one gigabit per second**
- **Whole city transformed into a *Wi-Fi* hotspot and commuters can pay with radio frequency identification card (RFID)**
- **Citizens of Seoul can access real time data from sensors around the city such as air quality or traffic upgrades**
- **New Songdo City, Korea – scheduled for completion in 2015 where CISCO is implementing its vision for the smart cities of the future**

One of the first people to build a telephone exchange was Hungarian Tivadar Puskas in 1877 while he was working for Thomas Edison. George W. Coy designed and built the first commercial telephone exchange which opened in New Haven, Conn. in January, 1878. The switchboard was built from "carriage bolts, handles from teapot lids and bustle wire" and could handle two simultaneous conversations. Charles Glidden is also credited with establishing an exchange in Lowell, MA. with 50 subscribers in 1878.
Source: Wikipedia

Where we are today?

Sometime around 1750, English entrepreneurs unleashed the astounding energies of steam and coal, and the world was forever changed. The emergence of factories, railroads, and gunboats propelled the West's rise to power in the nineteenth century, and the development of computers and nuclear weapons in the twentieth century secured its global supremacy.

Now, at the beginning of the twenty-first century, many worry that the emerging economic power of China and India spells the end of the West as a superpower. In order to understand this possibility, we need to look back in time.

Social Development

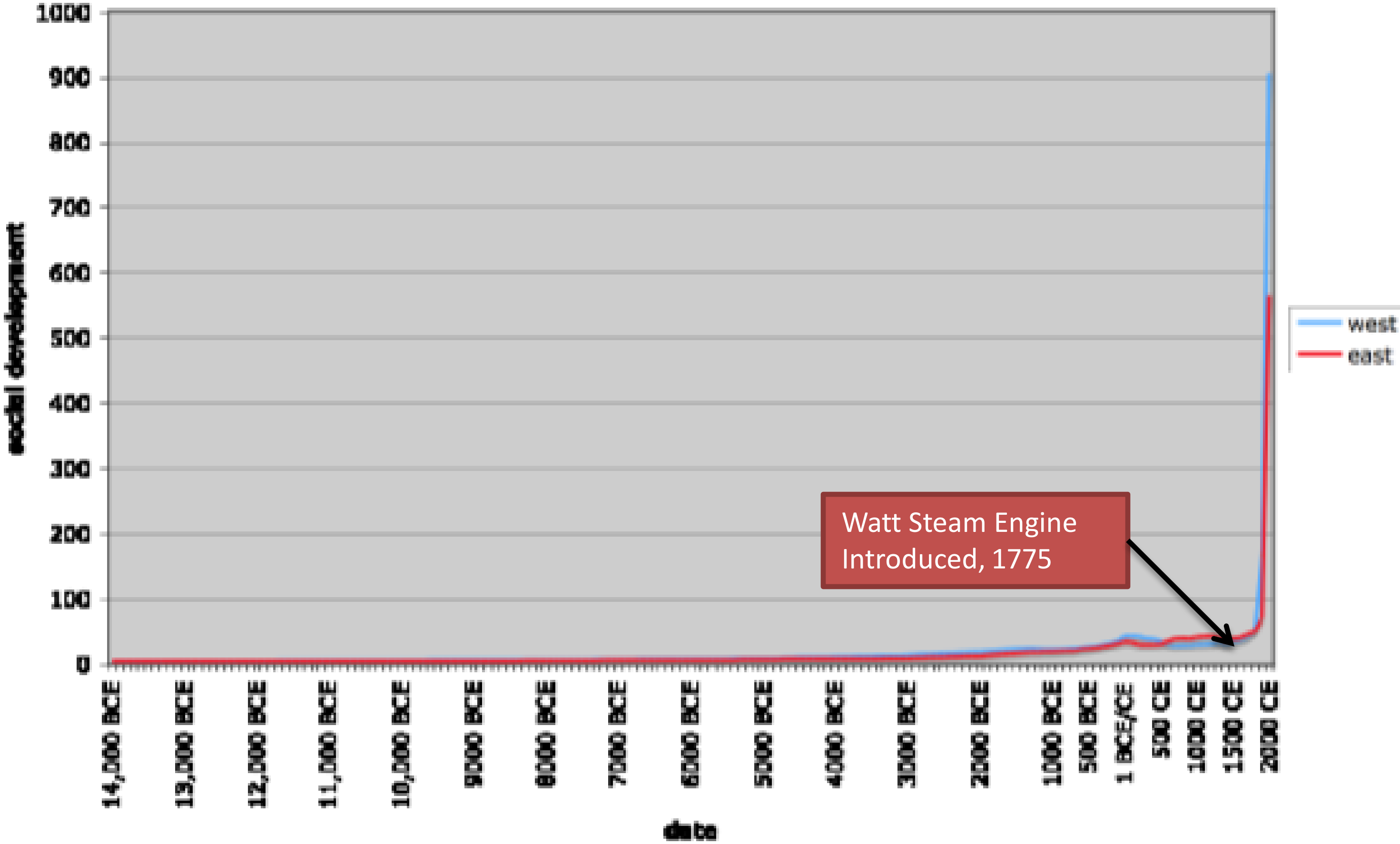
No single quantifiable trait can cover the full range of social development as defined here, but a combination of four traits — *energy capture, organization, information technology, and war - making capacity* — does seem to do so, and each of the traits performs relatively well on the criteria for adequacy.

Energy capture is the foundation of social development. **At the lowest level, insufficient energy capture (for adult humans, roughly 2,000 kilocalories per adult per day, varying with body size and activity level) means that individuals slow down, lose body functions, and eventually die. To clothe, house, and reproduce themselves, and to extend their power at the expense of other communities, however, humans have to capture more energy (in the case of the US in 2000, for instance, around 230,000 kilocalories per person per day).**

Energy capture must be the starting point for any discussion of social development.

SOCIAL DEVELOPMENT, Ian Morris, Stanford University, Oct 2010
http://ianmorris.org/docs/social-development.pdf

Eastern and Western social development scores, 14,000 BCE – 2,000 CE, shown on a linear-linear scale



SOCIAL DEVELOPMENT, Ian Morris, Stanford University, Oct 2010

Social development is the bundle of technological, subsistence, organizational, and cultural accomplishments through which people feed, clothe, house, and reproduce themselves, explain the world around them, resolve disputes within their communities, extend their power at the expense of other communities, and defend themselves against others' attempts to extend power (Morris 2010: 144).

“There was no economic growth for four centuries and probably the for the previous millennium” prior to 1750, or roughly when the Industrial Revolution started”

What does this do to expectations of a better life for future generations?

“The growth of productivity slowed markedly after 1970. While puzzling at the time, it seems increasingly clear that the one-time-only benefits of the Great Inventions and their spin-offs had occurred and could not happen again…. All that remained after 1970 were second-round improvements such as developing short-haul regional jets, extending the original interstate highway network with suburban ring roads, and converting residential America from window unit air conditioners to central air-conditioning.”

Bob Gordon, Economist

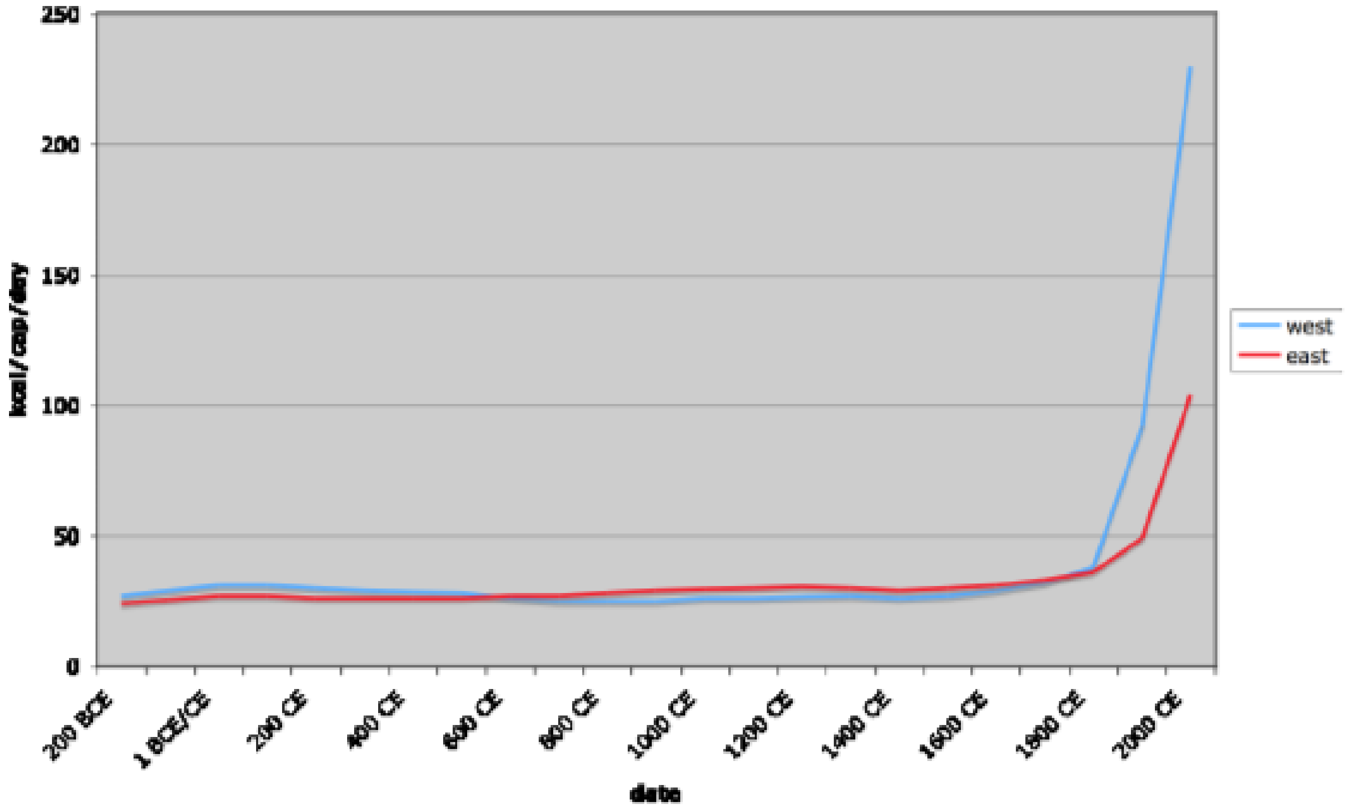
Energy Capture

All living things need to combat the forces of entropy by capturing energy from their environments. "Energy capture" describes the full range of energy captured by humans in any form whatsoever, including, but not limited to:

- **Food (whether consumed directly, given to animals that provide labor, or given to animals that are subsequently eaten)**
- **Fuel (whether for cooking, heating, cooling, firing kilns and furnaces, or powering machines, and including wind and waterpower as well as wood, coal, oil, gas, and nuclear power)**
- **Raw materials (whether for construction, metalwork, pot making, clothing, or any other purpose)**

SOCIAL DEVELOPMENT, Ian Morris, Stanford University, October 2010

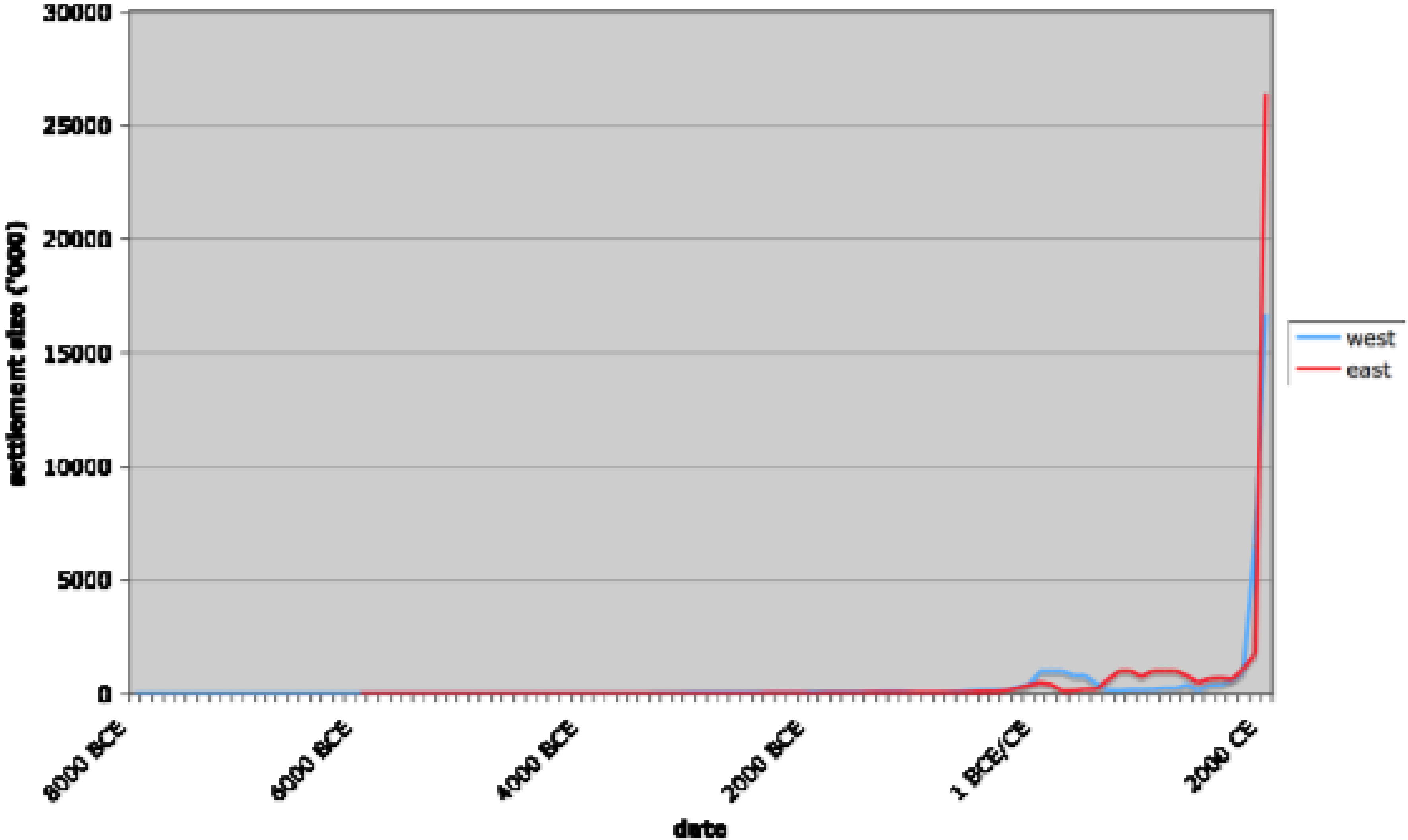
Eastern and Western energy capture, 200 BCE-2000 CE



SOCIAL DEVELOPMENT, Ian Morris, Stanford University, October 2010

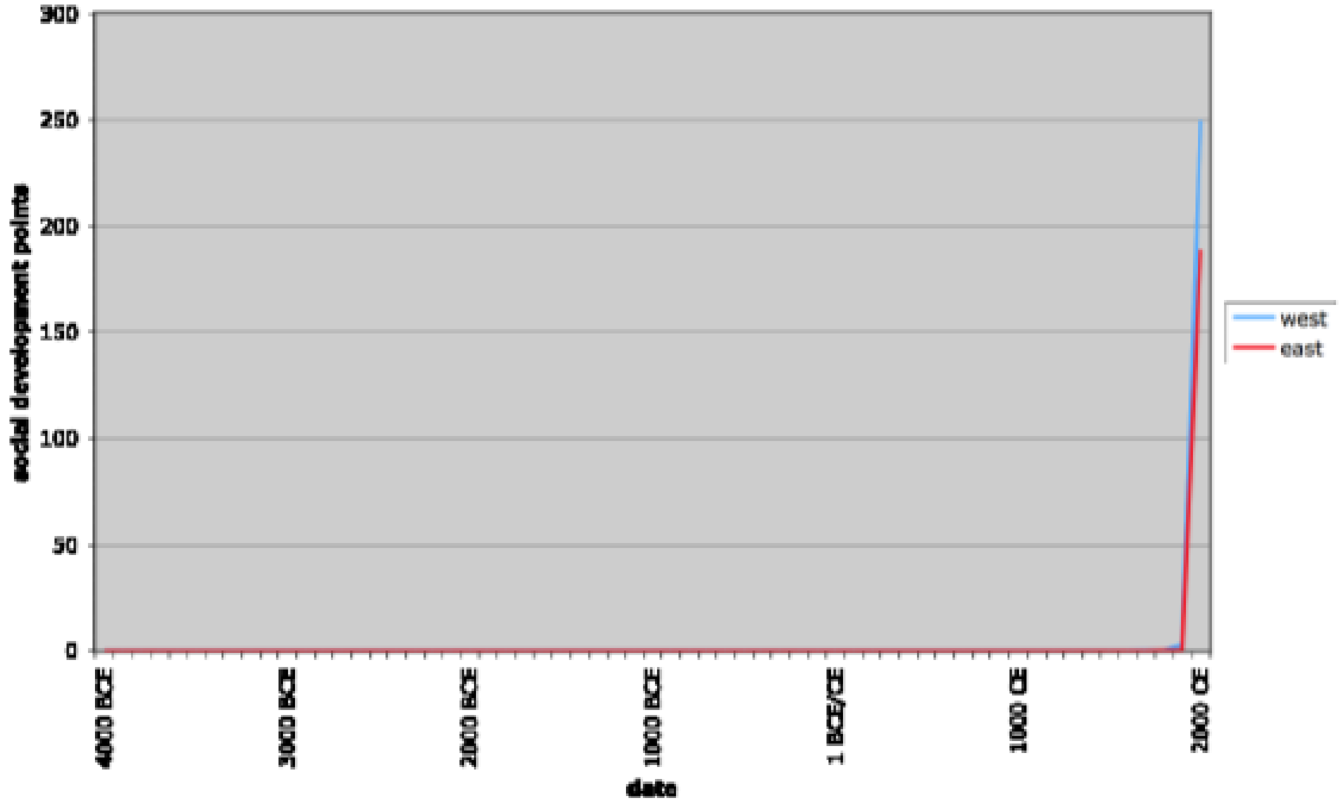
In the energy-alone graph, just like the full social development graph, the West still leads the East for 90 percent of the time since the late Ice Age; the East still overtakes the West between roughly 550 and 1750 CE; there is still a hard ceiling that blocks development around 100 and 1100 CE (at just over 30,000 kilocalories per person per day); post-industrial revolution scores still dwarf those of earlier ages; and in 2000 CE the West still rules.

Eastern and Western largest city sizes, 8000 BCE-2000 CE



SOCIAL DEVELOPMENT, Ian Morris, Stanford University, October 2010

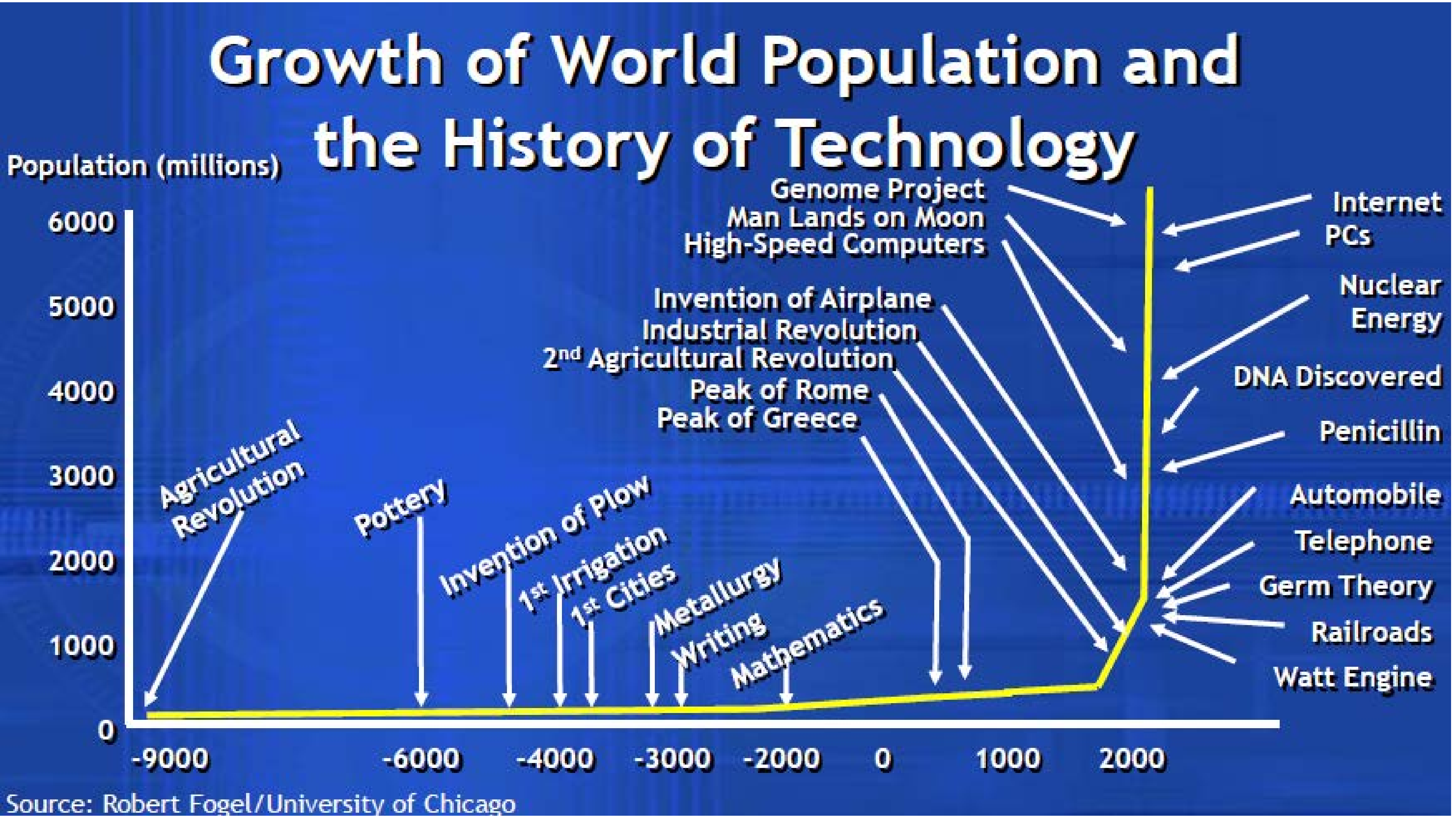
Eastern and Western information technology, 4000 BCE - 2000 CE



As in the case of war - making capacity, the greatest difficulty is not the scarcity of evidence for pre-modern times but the dramatic leap in technological sophistication during the 20th century, which makes it difficult to compare the information technology of 2000 CE with that of earlier periods.

SOCIAL DEVELOPMENT, Ian Morris, Stanford University, October 2010

8. Emerging Technologies


Growth of World Population and the History of Technology
Population (millions)
6000
5000
4000
3000
2000
1000
0
-9000
-6000
-4000
-3000
-2000
0
1000
2000
Agricultural Revolution
Pottery
Invention of Plow
1st Irrigation
1st Cities
Metallurgy
Writing
Mathematics
Peak of Greece
Peak of Rome
2nd Agricultural Revolution
Industrial Revolution
Invention of Airplane
High-Speed Computers
Man Lands on Moon
Genome Project
Internet
PCs
Nuclear Energy
DNA Discovered
Penicillin
Automobile
Telephone
Germ Theory
Railroads
Watt Engine
Source: Robert Fogel/University of Chicago

30-Year Cycles of Innovation

Year	Most Innovative Industry
1800	Textiles
1830	Railroads
1860	Chemicals
1890	Electricity
1920	Automobiles
1950	Aircraft
1980	Computers
2010	Internet
2040	??????

Source: Matt Ridley, "The Rational Optimist"

Innovation and Technology

A firms stock of technology is really is really a portfolio of its "knowledge" assets or intellectual property (IP)

At least three broad categories or sources of "know-how" (technology)

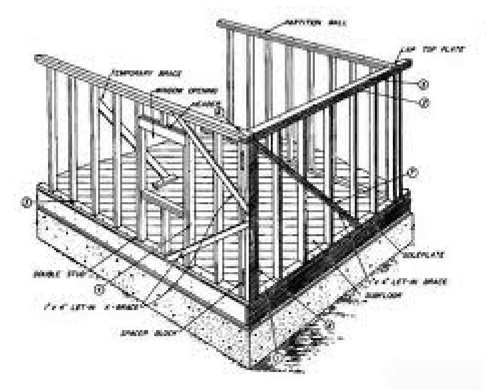
- **Product Technology** – know-how embodied in the product itself (operating system in a personal computer or microprocessor)
- **Process Technology –** know-how in the manufactures of a product or the steps necessary to combine materials to produce a product (assembly-line)
- **Management Technology** – know-how incorporated into a set of management procedures and other often "intangible" elements associated with selling a product or administering a business (information systems, branding)

Note: the term "product" equally refers to "service" in this context.

Post-WWII housing production- a new paradigm

Levittown, 1948

Suburbia, 1950



2x4 stick construction

The Levitt family began and perfected their home construction techniques during World War II with contracts to build housing for the military on the East Coast. Following the war, they began to build subdivisions for returning veterans and their families. Their first major subdivision was in the community of Roslyn on Long Island which consisted of 2,250 homes. After Roslyn, they decided to set their sights on bigger and better things. In 1946 the Levitt company acquired 4,000 acres of potato fields in Hempstead and began to build not just the largest single development by a single builder but what would be the country's largest housing development ever.

Two seemingly contradictory perspectives-push or pull?

The desire to bring genuinely new products to market (*market-driving, customers don't know what they want*)

The desire to follow a customer (market-driven) approach to product development *(give them what they want)*

"innovators dilemma" – becoming a prisoner of a once-but-no-longer successful technology due to emergence of an apparent "disruptive" newer technology (desk-top versus laptop)

The Value Proposition *Value = Benefits – Price*

Rooted in the notion that a product is nothing more than a "delivery system" for a set of benefits

Utility is a function of the underlying benefits to the customer

Must distinguish between *features* and *benefits* – features are what a firm produces and benefits are what a customer buys – what a firm makes (features) is different from what it sells (benefits)

A Transformative Framework

In a major infrastructure shift, technologies simply don't replace other technologies, rather, systems replace systems

Edison not only invented the light bulb, he invented an economically competitive network that encouraged consumers to replace kerosene with electricity as their primary source of energy

Edison mapped out an operational system that included generators, meters, transmission lines, and substations that interacted technically, and in combination created a profitable business

Edison's originality and impact lie in his ability to synthesize his ideas into a creative, coherent and commercially viable system

Too often, the focus is on the parts rather then the whole (solar panels, wind turbines, geothermal)

Transformative framework has four interdependent and mutually reinforcing components:

1. An enabling technology

for new technologies to be viable they must belong to complex, interdependent systems whose components work together in specialized ways

Internal combustion engine gave rise to the automobile, but it was Henry Ford's production process and the construction of roads, gas stations, plus financing options that gave rise to the auto era and doomed the horse and carriage

2. An innovative business model

must solve a real customer problem with the capacity to make a profit

Model consists of a the customer value proposition, the profit formula, and the key resources and processes that the company must combine

Competitive advantage is represented by the unique way in which these elements and components are integrated to create value for both the customer and the company

May require business models designed exclusively for a new technological paradigm (Google and advertising-based research)

3. A robust market-adoption strategy

New technologies like the systems they're intended to replace will likely be complicated and integration won't be clear – high degree of ambiguity may exist

Need an emergent approach where assumptions can be tested with quick, creative and inexpensive ways

Strong and obvious value proposition can promote a willingness to overlook initial shortcomings

4. Favorable government policy

Governments are usually central in advancing the development of next-generation technologies

Should not support market-ready technologies unless it is clear that they can be delivered profitably

Often the need to amend regulations that inhibit development are thwart new business models

Defining Green Technologies

Science-based applications that aim to protect the natural environment and resources by minimizing waste and toxicity, conserving energy and reducing pollution and carbon emissions

Goal is generally to advance economic, energy and climate security

Includes alternative energy sources such as solar farms, wind turbines, tidal turbines, geothermal and wave power; technologies that support conservation, regardless of power source such as "green" buildings, "clean coal" technologies, carbon sequestration; clean chemicals and other products that reduce waste or eliminate the need for waste treatment; consumer products that empower individuals to reduce their own carbon footprint, including hybrid and hydrogen powered vehicles, recycled material products and light emitting diode and compact fluorescent lamp lighting technologies that replace incandescent bulbs.

Green technologies encompass such diverse domains as water treatment/purification, recycling, materials, energy storage, power generation, infrastructure, transportation and a wide variety of support services.

Clean energy technologies

“Unless clean tech follows well-established rules of innovation and commercialization the industry’s promise to provide sustainable sources of energy will fail.”

Christianson, Talukdar, Alton and Horn

“If governments pour large subsidies into green technologies, they run the risk of backing technologies that, like ethanol, are fundamentally flawed. Solar power is a similar flawed technology if it deployed in competition with the existing power grid”

Green technologies – those that either harness power from renewable, sustainable resources or seek to reduce adverse human impact on the environment

Include - solar, wind, and geothermal power, biofuels, and smart power grids, as well as hydrogen and electric vehicle propulsion

Success – ability to deploy according to sound innovation theory

Better Place: A Systemic Model for the electric car

Shai Agassi's start-up electric-vehicle services company in Isreal aimed to make electric transport easy, reliable, and affordable as gas-powered cars

Market Adoption

Israel, given its small size and desire to minimize dependency on oil, promotes an innovative, technology-focused economy

Business Model

Batteries belong to Better Place which sells miles (electricity), and makes profit on the difference between cost/mile for gas and lower costs of electricity

Technology

Automated switching stations can swap depleted battery for fully-charged one in less time than to fill a tank with gas

Charge spots in business and residential areas – can recharge while parked

Proprietary software monitors batteries and directs driver to nearest charge spot or switching station

Policy

Import tax in Israel has dropped to 10% for electric vehicles while rising to 72% for gas-powered cars http://www.ted.com/talks/shai_agassi_on_electric_cars.html

Better Place lays off hundreds of workers, December 7, 2012

Following a difficult year, the departure of the founding CEO, and new fund raising efforts, electric car infrastructure company Better Place has been laying off hundreds of employees in Israel, 140 persons were laid off recently, and another 150 to 200 could be laid off soon, too, says Globes.

Better Place's business model is to build out battery swap stations and electric car charging stations in regions and then sell electric cars like cell phones. Customers pay rates for charging cars and for a subsidized vehicle (made by Nissan) that has a swappable battery.

However, the model isn't proven out yet, and Israel is the testing ground — and car sales have been slow there. Better Place only sold 23 cars in November, says Globes, which is "the lowest figure since it started marketing vehicles this year."

Israeli customers don't seem to be taking to the rates and plans as well as expected. Sam Jaffe, a senior research analyst with IDC Energy Insights, thinks the problem has been a marketing one. He writes in an article in October:

The Israeli car market is held hostage by a small oligarchy of leasing firms. Better Place chose to thread the needle by having those leasing firms be their distributors while at the same time not sharing enough profits with them. The leasing companies balked at becoming a middle-man, and froze Better Place out of the market. The solution to the impasse is for Better Place to either re-mold its Israel operations as a head-on competitor to the leasing companies or to renegotiate its contracts with them.

Electric Car Company Better Place Bankrupt, Burns Nearly $1 Billion, 06/9/13

"Electric cars just took a major detour, at least in Israel. Behind the company Better Place, the country had been Europe's foremost champion for electric cars, vowing to replace all gasoline-run cars with electric ones over the next few years. But after racking up massive debt over the past five years, the company has been forced to file for bankruptcy.

Two major limitations keep electric cars from going mainstream, and both center on the battery. For one, charge storage is limited. The cars produced by Better Place had a range of about 100 to 160 miles per charge, leaving many to worry about getting stranded. Another problem is the cost, as the battery is the most expensive part of an electric car.

As it turned out, Agassi's solution, so elegant on paper, didn't translate quite as well to the real world. First, it drove overhead costs extraordinarily high. Each switch station cost about $500,000 to build and, to make a network large enough for even Israel required building dozens of stations. And – the fatal drawback – even when the stations had been built, customers remained unconvinced. The company could only attract 750 drivers throughout all of Israel.

On May 26th, 2013 and citing losses totaling almost a billion dollars, Better Place filed to liquidate."

Tesla

But while Better Place screeches to a halt, the world's leading electric car maker, Tesla, continues to pick up speed. Unlike Better Place that required a vast network of swap stations to make owning the cars feasible, scaling the Model S has tracked consumer demand. The Model S can drive 208 to 265 miles on a single Supercharge. Supercharging stations provide reliable 150 mile boosts for long distance travelers, but right now there are only 12 of them. The company says they plan on installing hundreds more by 2015.

Tesla expects to deliver more than 35,000 Model S vehicles in 2014, an increase of more than 55 percent from the 22,477 it delivered last year. In the first quarter, it will deliver about 6,400 of those cars.

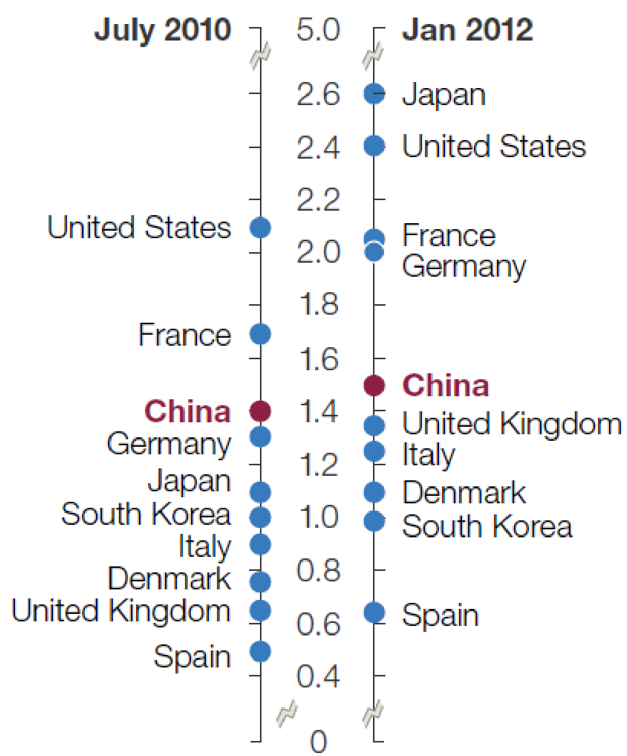
As with gasoline-powered vehicles, some electric cars will be successful, some won't. While Better Place's solution to low battery power was technologically elegant, it wasn't socially effective. As other electric cars like Tesla's growing fleet, Mitsubishi's i-MiEV, Chevrolet Volt or Nissan's Leaf compete in the electric car market, the feasibility will grow with as visibility – and the number of charger stations – spread. Hard lessons will be learned and more companies will fold.

100 percent electric and selling well – why?

Norway may seem like an odd place for electric car to survive, but Tesla Model S last month set a new single-model sales record. That's more than sales of the two next-best selling models, the Volkswagen Golf and Nissan Leaf, combined. In fact, so far this year, the Tesla Model S is the best-selling car in a cold country that has quickly warmed to electric vehicles. Sales of Model S beat out a long-standing sales record from 1986, when the Ford Sierra was top dog. The Tesla Model S trounced the sale of Volkswagen Golf, formerly Norway's favorite car, and the Nissan Leaf, which also benefits from generous tax incentives the country showers on EV buyers.

China has fallen behind other markets in electric-vehicle readiness.

McKinsey electric-vehicle index (EVI),[1]
5 = most developed, 0 = least developed



The EVI assesses a nation's readiness to support an electric-vehicle (EV) industry based on:

Supply

- EVs' forecast share of car production
- number of EV prototypes generated by national OEMs[2]
- government support for infrastructure and R&D

Demand

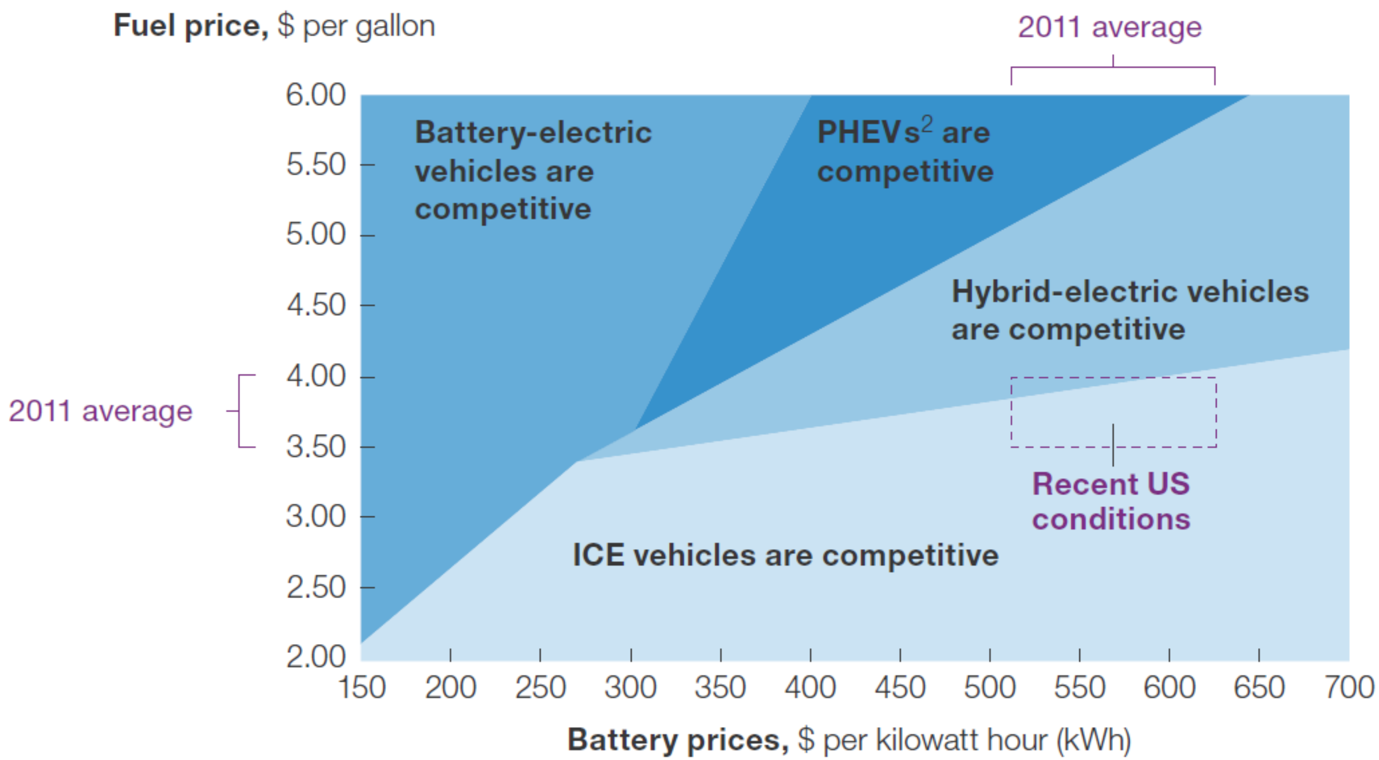
- EVs' share of car sales
- level of government subsidies
- customer driving experience

[1]Includes plug-in electric hybrids and battery EVs but not conventional hybrid EVs.
[2]Original-equipment manufacturers.

For consumers, purchase prices remain high: heavily subsidized battery-electric vehicles can cost 150 percent more than comparable cars powered by internal-combustion engines. That puts electric vehicles well beyond the reach of China's highly price-sensitive consumers.

The interaction of battery and fuel costs will determine the size of the market for electric vehicles.

Electrified vehicles' projected competitiveness with internal-combustion-engine (ICE) vehicles, based on total cost of ownership[1] (US example)



[1]Assumes 240 watt hours per mile (as may be achieved with lightweight, efficient air conditioning) compared with today's 305–322 watt hours per mile.
[2]Plug-in hybrid-electric vehicles.

Source: US Energy Information Administration; McKinsey analysis

BEV: battery-electric vehicles
PHRV: Plug-in hybrid vehicles
HEV: hybrid electric vehicles

Building technology – radiant solutions

Today, 95% of buildings in Korea and 85% of buildings in Northern China feature some form of radiant floor heating. Modern fluid-based (hydronic) systems dominate the construction industry in Europe.

By 2010 in North America, only about 5% of residential buildings were using hydronic systems. Only 7.5% of new commercial construction is specifying radiant systems, but this number is expected to double by 2014.

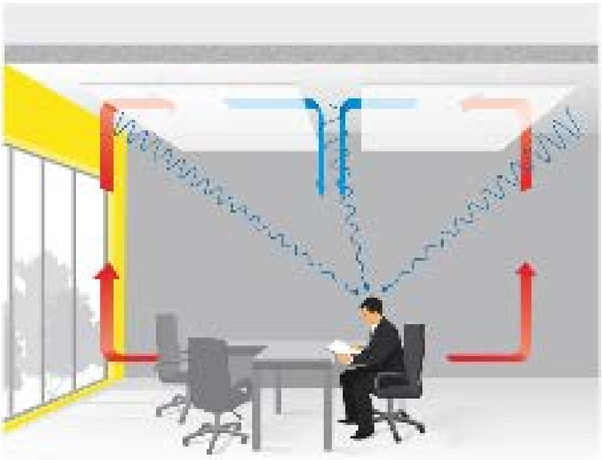
There are many different names for radiant systems within buildings: “thermal slabs”, “in-floor radiant heating”, “radiant surface heating”, “surface heating systems”, “radiant floor heating/cooling systems”, “embedded surface heating/cooling system”, and “thermally (or thermo-) activated building systems (TABS)”.

They all refer to the same concept of having a large surface that is actively heated or cooled and that exchanges heat with its surroundings. A radiant system is defined as performing at least 50% of its heat exchange by radiation and the rest by convection.

Crocker; Higgins September 5, 2012

Heat transfer by radiation

Heat transfer by natural convection



Actual heat transfer includes radiation and convection

The two main principles for providing a room with comfort cooling are to supply the room with cooled air or to reduce the temperature of one or some of the room's surrounding surfaces, e.g. ceiling and walls. In the former case, the cooling is carried out by forced convection and, in the latter, by radiation exchange with the room's warmer surfaces in addition to natural convection.

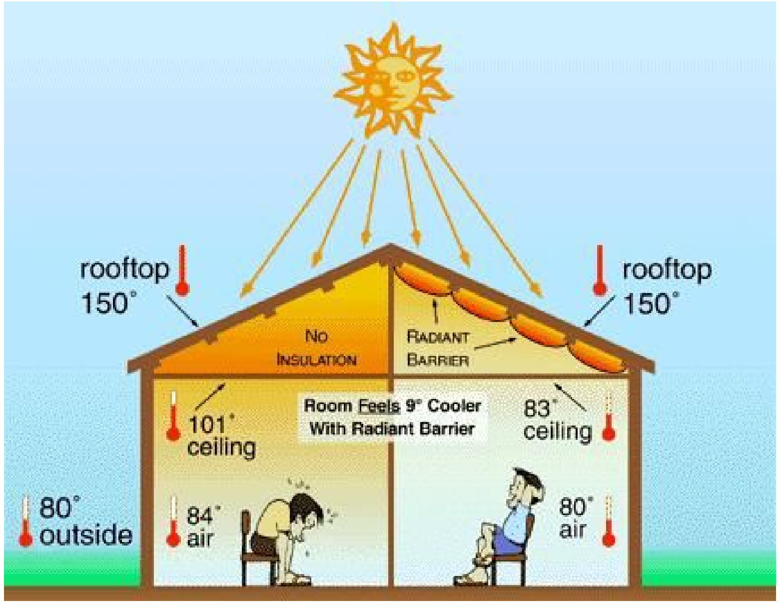
Natural convection occurs when there is a difference in density between the heavier cooled air and the surrounding, warmer air.

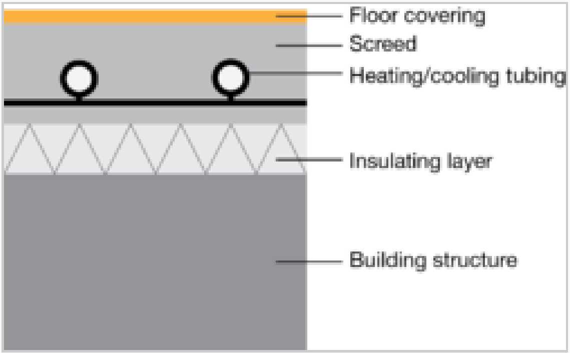
In large, modern buildings, active systems are frequently used. A system of pipes or tubing transports cold water that cools the ceiling area, this in turn has a cooling effect on the room. One advantage with this system is that a number of cooling sources can be used such as cold ground water, sea water etc. A limiting factor for the cooling capacity of an active system is that the cooling surface should not be too cold. At excessively low temperatures, there is a risk of condensation forming on the room facing surface and the difference between the temperature of the cooling surface and the rest of the room would not be pleasant for the people located in the room.

Principle of thermal radiation

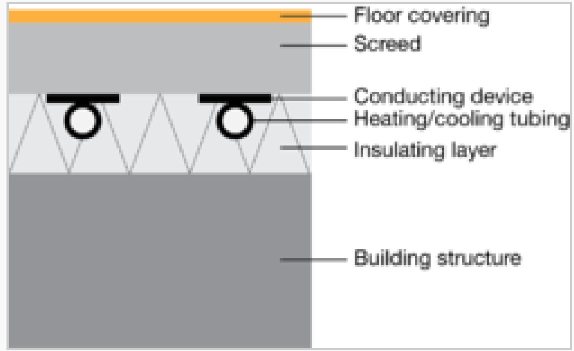
Heat radiation is the energy in the form of electromagnetic waves emitted by a solid, liquid, or gas as a result of its temperature. In buildings, the radiant heat flow between two internal surfaces (or a surface and a person) is influenced by the emissivity (the relative ability of its surface to emit energy by radiation) of the heat emitting surface and by the view factor between this surface and the receptive surface (object or person) in the room The heat transfer by radiation is proportional to the power of four of the absolute surface temperature. *Emissivity* is the value given to materials based on the ratio of heat emitted compared to a blackbody, on a scale from zero to one. A blackbody would have an *emissivity* of 1 and a perfect reflector would have a value of 0.

In radiative heat transfer, a *view factor* quantifies the relative importance of the radiation that leaves an object (person or surface) and strikes another one, considering the other surrounding objects. In enclosures, radiation leaving a surface is conserved, therefore, the sum of all view factors associated with a given object is equal to 1. In the case of a room, the view factor of a radiant surface and a person depend on their relative positions. As a person is often changing position and as a room might be occupied by many persons at the same time, diagrams for omnidirectional person can be used.

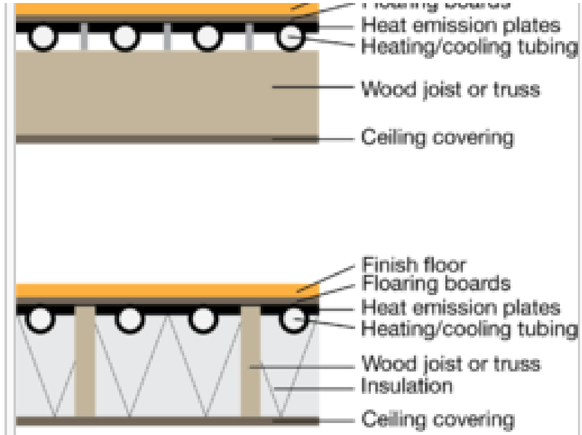




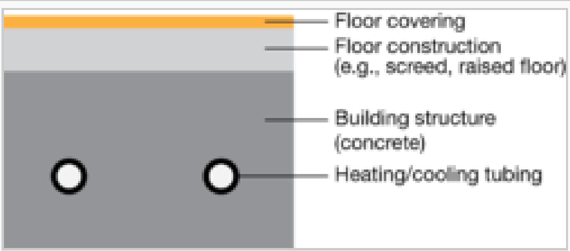
Section diagram of a radiant embedded surface system (ISO 11855, type A)



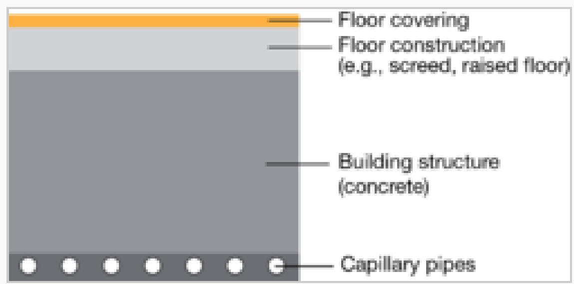
Section diagram of a radiant embedded surface system (ISO 11855, type B)



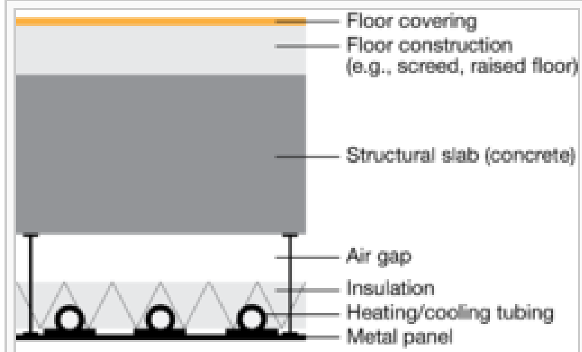
Section diagram of a radiant embedded surface system (ISO 11855, type G)



Section diagram of thermally activated building system (ISO 11855, type E)

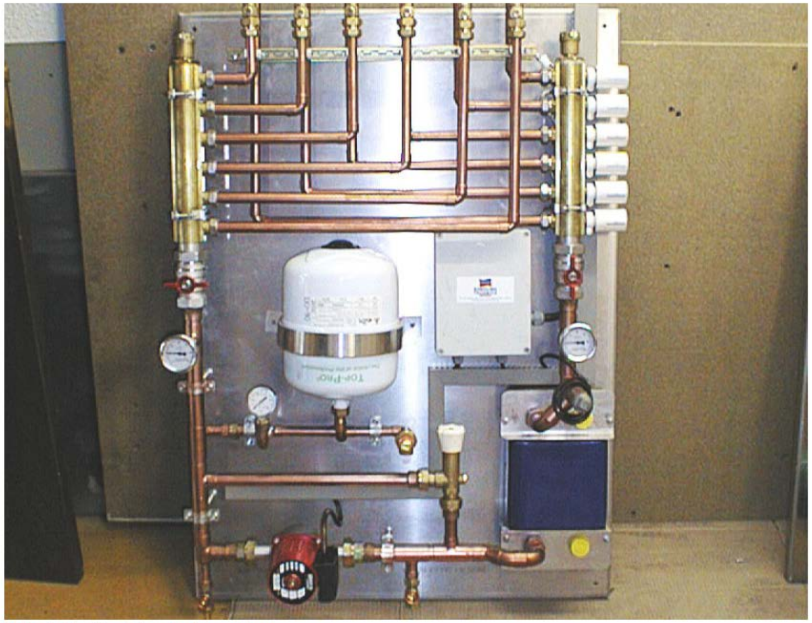


Section diagram of radiant capillary system (ISO 11855, type F)



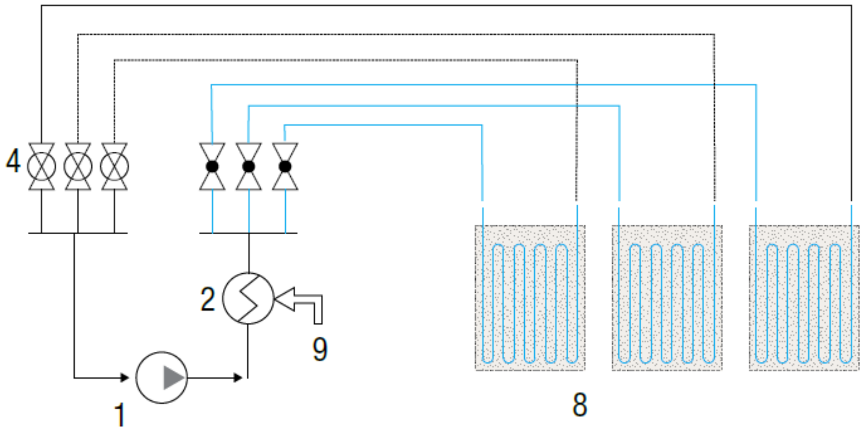
Section diagram of a radiant panel

Radiant systems are associated with low-energy systems. Low-energy refers to the possibility to utilize ‘low quality energy’). Both heating and cooling can in principle be obtained at temperature levels that are close to the ambient environment. The low temperature difference requires that the heat transmission takes place over relative big surfaces as for example applied in ceilings or underfloor heating systems. Radiant systems using low temperature heating and high temperature cooling are typical example of low-energy systems. Energy sources such as geothermal (direct cooling / geothermal heat pump heating) and solar hot water are compatible with radiant systems. These sources can lead to important savings in terms of primary energy use for buildings.


KaRo hydraulic station 2 pipes system

Control

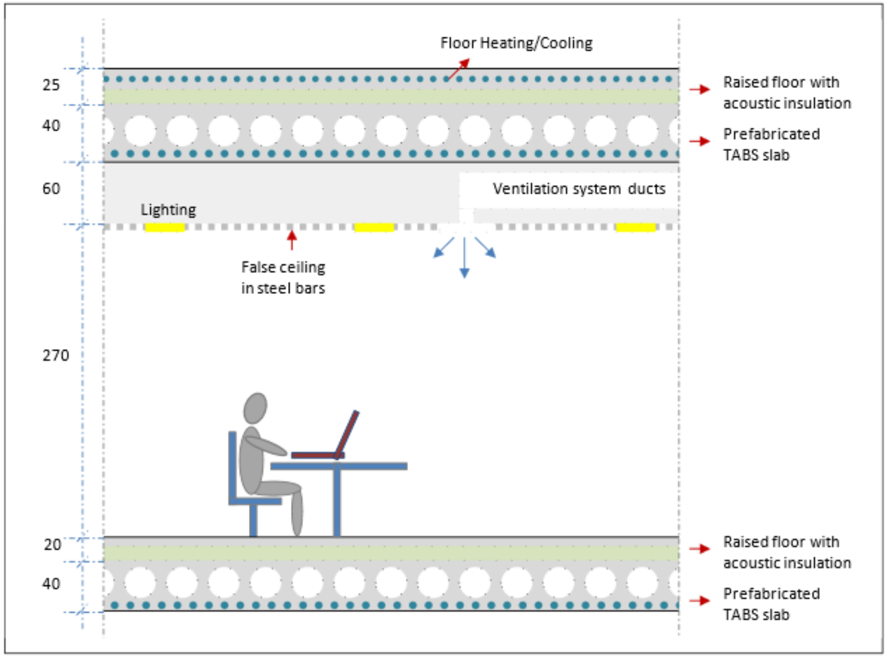
Floor station with 2 pipes system



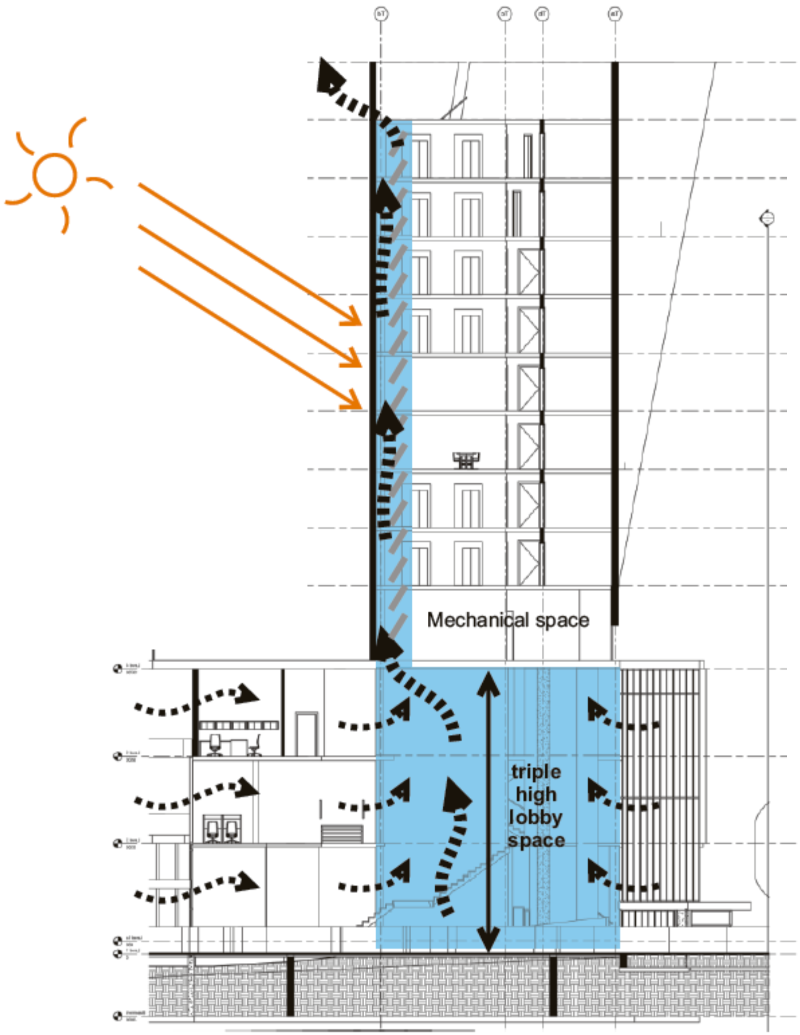
A (TABS) building situated in Denmark

In winter time heating is guaranteed by convectors, located in the floor along the façade, and balanced by mechanical ventilation. In summer a thermal active building system integrated in the ceiling, combined with mechanical ventilation, provides a cool environment. Both the floor and the ceiling slabs have raised floor with acoustical insulation, and pipes imbedded in the lower part of the concrete slab.

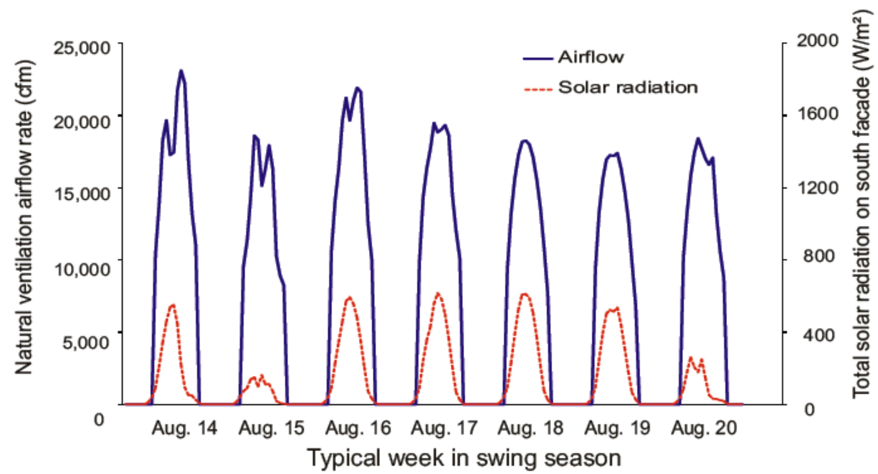
A floor heating/cooling system is situated in the upper layer of the ceiling slab, with the aim to heat/cool the room above. The lighting level is controlled by sensors of presence and the intensity of artificial light is balance with natural light. There are automatic and manual curtains for solar radiation control, and workers can open and close windows.

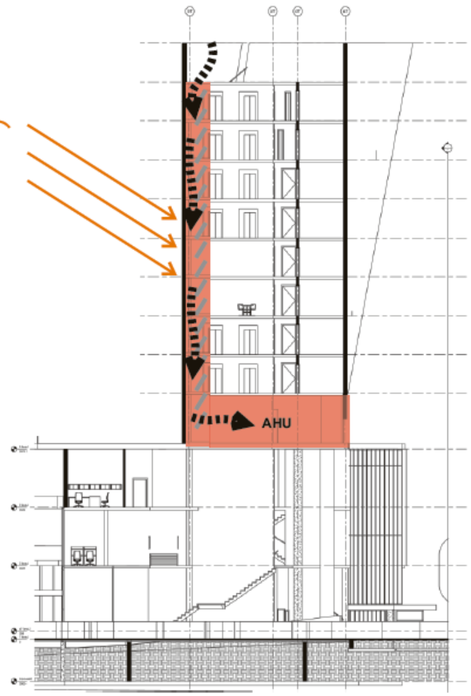


Solar Chimney

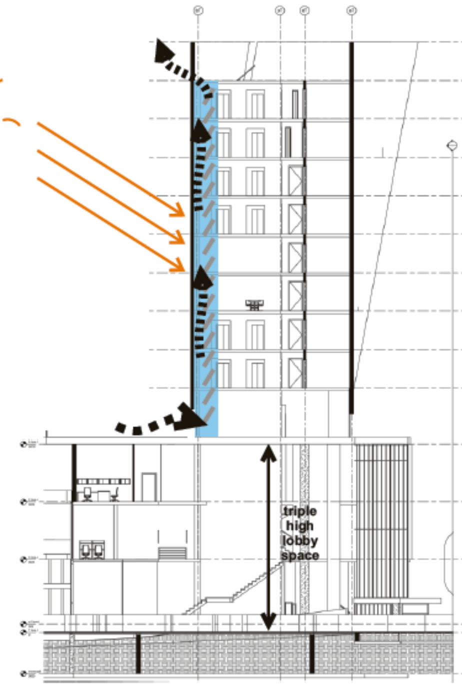


Natural ventilation mode: used during swing seasons, air is drawn from operable windows in the podium building and exhausted through solar chimney
Temperature range: 15 °C < outdoor temperature < 26 °C

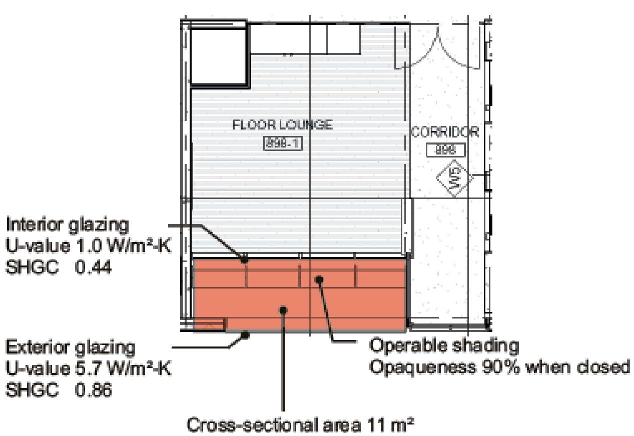




Winter preheat mode: the double-skin facade is used to to the air handling unit in winter
Temperature range: outdoor temperature < 15 °C



Summer cooling mode: air flows through the solar chimney to reduce facade glazing temperature during daytime
Temperature range: outdoor temperature > 26 °C



10 Lessons for Green Technologies

1. **Timing is everything** - bubbles and shakeouts are an unavoidable part of the natural selection process in free markets – palpable enthusiasm over potential market size and growth, multitudes of new entrants, and euphoria of the media, investment bankers and venture capitalist.
2. **Change occurs slowly** – three main obstacles to rapid adoption of emerging technologies

- ***Chicken/egg problem*** – without software, a great new hardware device has little value
- ***Cost or performance barriers*** – the electric car is plagued by the costs and poor performance of batteries
- ***Co-evolution versus pure substitution*** – on-line retail, versus "bricks-and mortar" retail

3. **Collaboration is crucial** – considering the scale, scope and complexity of most green technology markets, experience shows that collaboration can be the key to capturing new market opportunities.

4. **Innovation takes many forms** – must comprehend the full meaning of the word "innovation" – may involve changes to business models, organizational design, financial structures, or production and supply chains.

5. **Embrace uncertainty by maintaining options** – must be prepared top react to uncertain conditions, complex timing issues, and uncertain futures.

6. **Anticipate where the money will be** – success depends upon anticipation and ability to envision the future – subsidies have a shelf-life

7. **Think beyond industry boundaries** – biosciences now have wide-ranging implications fore national security, climate change, and green technologies – same with new enzymes, tissue engineering, bacteria and nano-technologies

8. Share the joint gain – diffusion of risk is especially attractive in the green technology space –networks with superior skills, experience, and market insights. Watch the periphery – two capabilities for long-term survival: organizational vigilance and ability top adapt to change – need the ability to sense, interpret and act on weak signals

10. Become ambidextrous - must balance a learning and performance culture, attend to short-term while taking the long-term view, and orient to both people and tasks, as the situation demands

8. New Strategies/New Business Models

Entrepreneurs and Global Conglomerates

Eko Financial: Banking when banking infrastructure does not exist

http://www.youtube.com/watch?v=eywlK8iBcb0

Unilever India: Marketing laundry detergent to rural populations

http://www.youtube.com/watch?v=qlGcd_5fyzI

Aravind Eye Care: Delivering affordable eye surgery to the masses

http://www.youtube.com/watch?v=3cjnNPua7Ag

Diagnostics for all

Thanks to an international group of scientists, engineers, physicians and business people, a nonprofit company with a novel business model is poised to change the way patient health is monitored in the developing world.

The company, Diagnostics For All, was founded by Harvard University Professor George Whitesides and Hayat Sindi, a scientist from Saudi Arabia, based on technology developed in Whitesides' laboratory at Harvard.

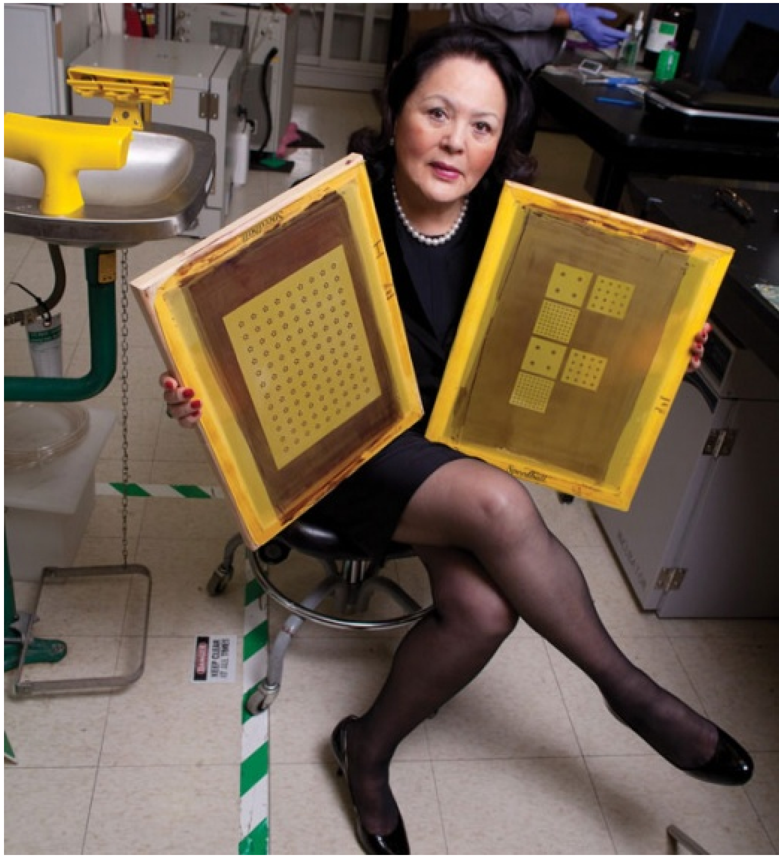
Using inexpensive and readily available paper and adhesive tape, Whitesides and colleagues developed a small, disposable device that can be used to test bodily fluids for signs of illness.

Sindi, the driving force behind commercializing the technology, assembled a team of Harvard and Massachusetts Institute of Technology students and scientists to write a business plan, which won first place in two prestigious competitions: the Harvard Business School Business Plan Competition and the MIT $100K Entrepreneurship Competition. Diagnostics For All is the first nonprofit company to win the MIT competition.

Cambridge nonprofit Diagnostics for All, which is working to create simple, low-cost, point-of-care diagnostics for use in emerging countries, particularly areas far from hospitals, has received a $100,000 grant from the Bill & Melinda Gates Foundation.

As the head of Diagnostics for All, a nonprofit founded in 2007, Una Ryan has one goal: to change the way health care is delivered in poor countries. The organization is developing paper diagnostics—cheap, portable, easy-to-manufacture tests that can be used in environments with few resources and little infrastructure.

The key to the nonprofit's success is an innovative business model. Diagnostics for All has won grants and philanthropic funding to support early development of its technology. But Ryan knows that these types of funds are inadequate for deploying new medical tests over the long term. So Diagnostics for All has created a for-profit subsidiary, Paper Diagnostics, which will partner with companies to develop tests for use in wealthy nations. After taxes, the proceeds will be invested back into the nonprofit.



Screen test: Una Ryan holds printing screens used to pattern paper diagnostics.

Narayana Hrudayalaya (NH) Hospitals, India

Narayana Hrudayalaya is Walmart meets Mother Teresa.

The organization, a complex of health centers based in southern India (*narayana hrudayalaya* means "God's compassionate home" in Sanskrit), offers low-cost, high-quality specialty care in a largely impoverished country of 1.3 billion people. By thinking differently about everything from the unusually high number of patients it treats to the millions for whom it provides insurance--and by thinking a lot like the world's largest retailer--the hospital group is able to continually lower costs.

Narayana Hrudayalaya's operations, for instance, include the world's largest and most prolific cardiac hospital, where the average open-heart surgery runs less than $2,000, a third or less what it costs elsewhere in India and a fraction of what it costs in the U.S.

In addition to cost-cutting, Narayana Hrudayalaya finds creative ways to make the economics work. The company started a micro-insurance program backed by the government that enables 3 million farmers to have coverage for as little as 22 cents a month in premiums.

Patients who pay discounted rates are in effect compensated by those who pay full price or opt for extra perks. Typically, the latter group includes foreigners for whom a $7,000 heart operation, access to an experienced specialist, and a deluxe private room is a relative bargain. The balance of patients is, in fact, crucial.

Every day, Narayana Hrudayalaya's surgeons receive a P&L statement of the previous day that describes their operations and the various levels of reimbursement. The data allow them to add more full payers, if necessary (unless urgent health issues dictate otherwise).

"When you look at financials at the end of the month, you're doing a postmortem," says Dr. Ashutosh Raghuvanshi, Narayana Hrudayalaya's CEO. "When you look at it daily, you can do something."

A 50 percent solution at a 15 percent price

50 percent solutions can become 90 percent solutions in just a few years

We may have to make "good enough" performance more acceptable –health care for example

GE V-Scan portable ultrasound scanner

Commitment to the bicycling in Copenhagen, Denmark

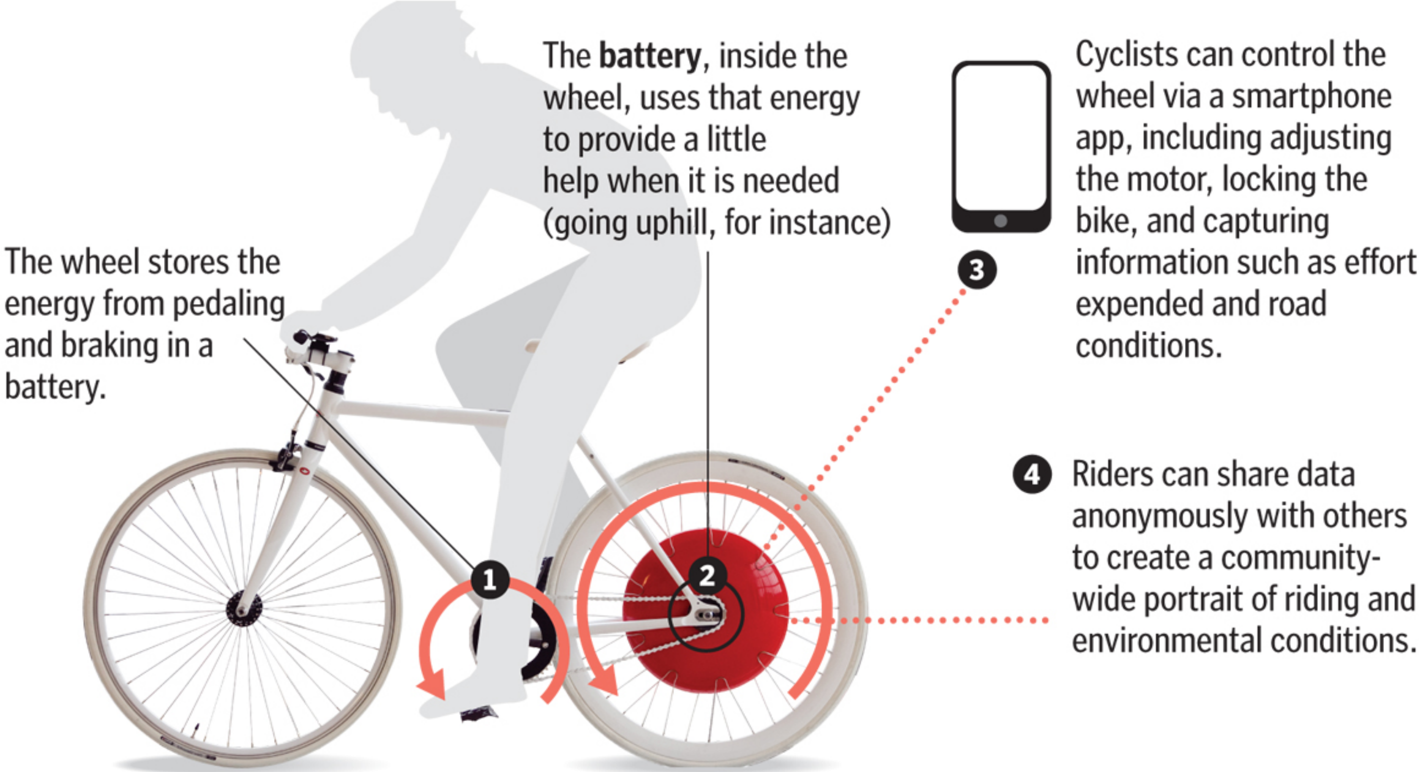
Bicycle integration in the S-train system

Typical design of bicycle facilities in Copenhagen; the cycle track runs next to the sidewalk and is separated from traffic by a curb and parked cars

Parking problem in Copenhagen

Copenhagen Wheel

www.youtube.com/watch?v=S10GMfG2NMY



SOURCE: MIT SENSEable City Lab

CHIQUI ESTEBAN/GLOBE STAFF

COPENHAGEN WHEEL

A Massachusetts startup is launching a new device that transforms almost any bicycle into an electric-hybrid vehicle using an app on a smartphone.
The device, called the Copenhagen Wheel, is installed as part of a rear hub of a bike wheel and is packed with a proprietary computer, batteries and sensors that monitor how hard a rider is pedaling and activate an onboard motor whenever support is needed. The device uses wireless connectivity to communicate with the biker's smartphone to track distance travelled and elevation gained, share with friends the number of calories burned and lock the wheel remotely as soon as the owner walks away from the bike.

Box 11. Stockholm's focus on education, enforcement, and equity has made congestion charging a success

In 2006, policy makers in Stockholm gambled on a full-scale congestion pricing trial aimed at reducing traffic in Sweden's capital, increasing accessibility to the city, and improving the environment. Vehicles entering the city center paid a variable fee of $1.50 to $3.00 during the weekday rush hour. To educate the public about the benefits, Stockholm introduced the scheme as a trial, and then briefly revoked the program to demonstrate to citizens how traffic volumes would increase again in its absence. After that, Stockholm citizens voted to make the system permanent. To enforce the rules, the city set up 18 control points with laser detectors and optical character recognition technology that immediately identified vehicle registrations; this achieved a 96 percent compliance rate. To ensure access and equity, the city has reinvested a significant portion of the revenue raised in public transport.

The scheme has been highly successful. Congestion both inside and outside the cordon fell by 20 to 25 percent during the trial period, air quality improved within a year, and the city recouped its initial investment in less than four years. The overall net present value of the scheme is an estimated $1.2 billion with a benefit-to-cost ratio of 4:1.

- **D.light co-founders on Forbes' List of Top 30 Social Entrepreneurs**
- **November 30, 2011 Forbes released a list of top 30 social entrepreneurs who are changing the world, and d.light co-founders Sam Goldman and Ned Tozun are among them!**
- **Forbes says the list known as the Impact 30 is the first of its kind in the magazine's 94-year history.**

D-Light

D.light is a for-profit company started in 2007 by Stanford MBA students Ned Tozun and Sam Goldman, whose idea for solar-powered lights was born out of a Stanford Design School course called "Entrepreneurial Design for Extreme Affordability." As a Peace Corps volunteer in Benin, Goldman had seen a young boy badly burned by a kerosene lamp. Both founders knew that more than 2 billion people in the world don't have access to reliable electricity. Venture-capital firm Draper Fisher Jurvetson, which sponsored the design contest, invested $250,000.

Tice, meanwhile, had enjoyed a more conventional business career in the consumer products industry, running the Folger's coffee business for Procter & Gamble and helping to develop new products for Dreyer's ice cream. While working with advanced nanotechnology to create stain and wrinkle-resistant fabric for a company called Nano-Tex, he decided to make a change.

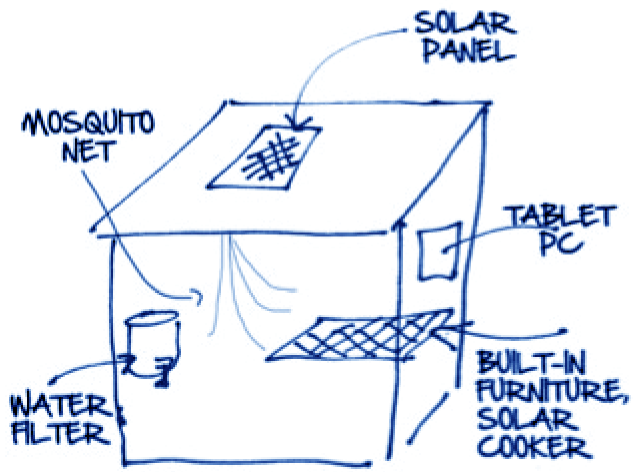
http://www.dlightdesign.com/

- About three decades ago, Donn Tice was an MBA student at the University of Michigan, studying with the late C.K. Prahalad, who was developing his argument that companies can make money and do good by creating products and services for the world's poorest people. It's an exciting notion, popularized in Prahalad's influential 2004 book, "The Fortune at the Bottom of the Pyramid"

- Today, Tice is the CEO of d.light, which sells solar-powered lanterns to the poor. He's trying to prove that his teacher was right — a fortune awaits those who can create and sell life-changing products that help the very poor.

- The company is now selling about 200,000 solar-powered lanterns and lighting systems a month in about 40 countries. By its own accounting, d. light has sold nearly 3 million solar lighting products and changed the lives of more than 13 million people. And if all goes according to plan, the company will turn profitable in 2013.

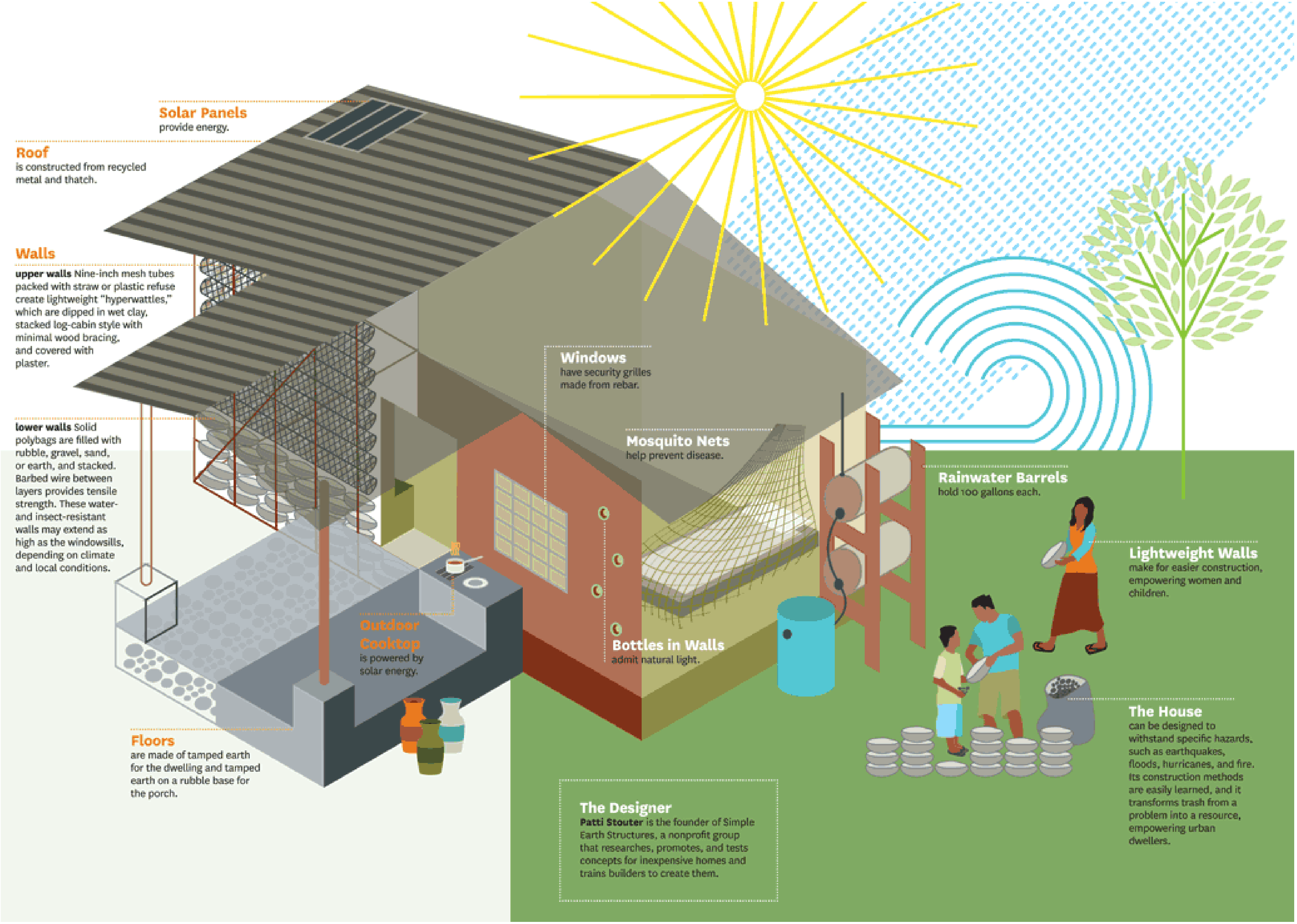
The **$300 House** was first described in a *Harvard Business Review* blog post by **Vijay Govindarajan** and **Christian Sarkar**. Initially, they just wanted to put the idea out there, but now, due to the tremendous response, they decided to see how far they can go toward making this idea a reality.

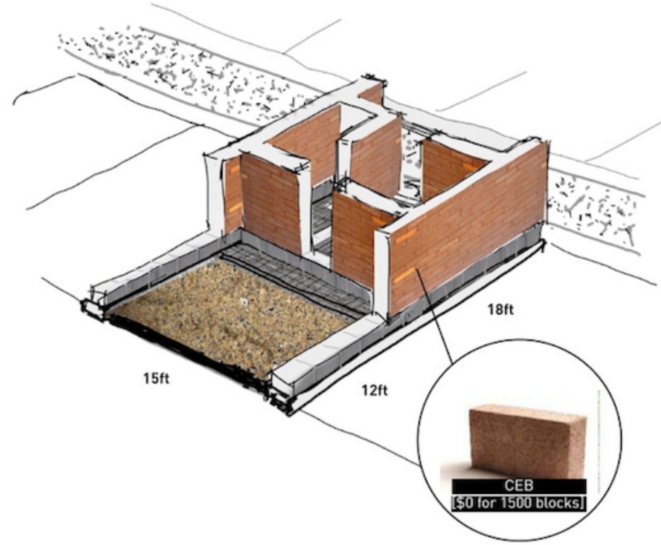


Started with five simple questions: THE $300 HOUSE

- **How can organic, self-built slums be turned into livable housing?**
- **What might a house-for-the-poor look like?**
- **How can world-class engineering and design capabilities be utilized to solve the problem?**
- **What reverse-innovation lessons might be learned by the participants in such a project?**
- **How could the poor afford to buy this house?**

“The goal is to design, build, and deploy a simple dwelling which keeps a family safe from the weather, allows them to sleep at night, and gives them a little bit of dignity. If we can give the poor a chance to live safely and build an inclusive ecosystem of services around them which includes, clean water, sanitation, health services, family planning, education, and micro enterprise, maybe we can start reducing the disease of poverty. By helping create this ecosystem, we believe companies can make money while providing services needed by the poor at an affordable cost. The poor deserve a chance, a real chance, to make it out of poverty.”


Solar Panels
provide energy.
Roof
is constructed from recycled metal and thatch.
Walls
upper walls Nine-inch mesh tubes packed with straw or plastic refuse create lightweight "hyperwattles," which are dipped in wet clay, stacked log-cabin style with minimal wood bracing, and covered with plaster.
lower walls Solid polybags are filled with rubble, gravel, sand, or earth, and stacked. Barbed wire between layers provides tensile strength. These water- and insect-resistant walls may extend as high as the windowsills, depending on climate and local conditions.
Floors
are made of tamped earth for the dwelling and tamped earth on a rubble base for the porch.
Outdoor Cooktop
is powered by solar energy.
Windows
have security grilles made from rebar.
Mosquito Nets
help prevent disease.
Bottles in Walls
admit natural light.
Rainwater Barrels
hold 100 gallons each.
Lightweight Walls
make for easier construction, empowering women and children.
The House
can be designed to withstand specific hazards, such as earthquakes, floods, hurricanes, and fire. Its construction methods are easily learned, and it transforms trash from a resource, empowering urban dwellers.
The Designer
Patti Stouter is the founder of Simple Earth Structures, a nonprofit group that researches, promotes, and tests concepts for inexpensive homes and trains builders to create them.



DVS
In its design, DVS envisions a simple house made of compressed earth blocks and a wooden frame. A corrugated metal roof is raised slightly from the house to provide air flow. What's more interesting than just the design for one $300 house is DVS' plan to build the houses together in compounds with a central courtyard, which is where activities like cooking and washing would take place.

ArchitectureCommons
The main focus of ArchitectureCommons's plan is not just a house, but a new economic system. By creating local cooperatives that make earthen bricks, AC believes the entire structure of the house could be manufactured for free. Maybe a sneaky way around the rules, but also a potentially game-changing innovation for poor communities in need of housing and industry.

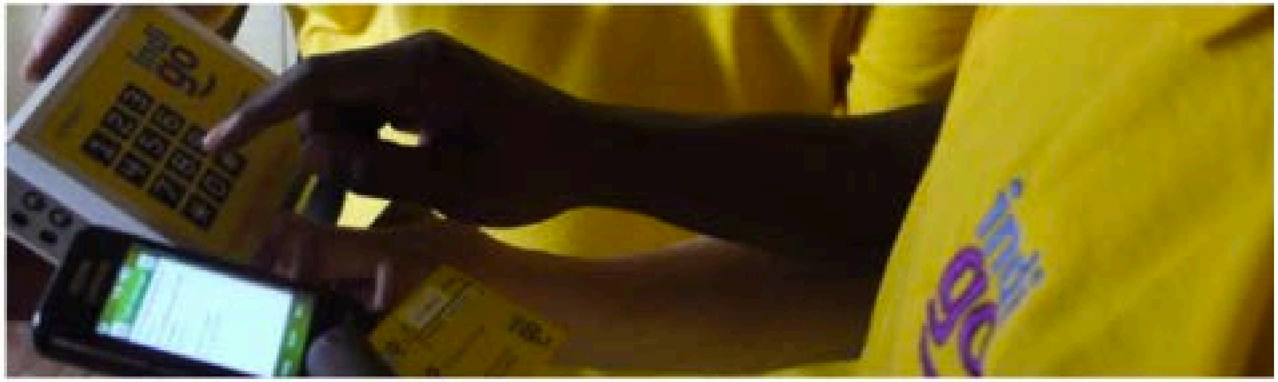
Eight 19: Indigo 'pay-as-you-go' solar

There is a common problem with most renewable sources of energy – customers are used to paying for energy as they use it but for renewables the cost is all up front in the purchase price. This puts technologies such as wind turbines or traditional solar beyond the reach of many users. Eight19 offers the Indigo Pay-As-You-Go solar solution.

Indigo combines mobile phone technology with solar technology allowing customers to buy scratchcards to pay for their energy, just as they would for their mobile phones. Customers are able to charge their mobile phone and have 8 hours of clean lighting for two rooms, whilst saving money – some of which can pay for the next Indigo scratchcard. Indigo has a transformational impact from day one. In Kenya, Indigo deployments are so cost-effective that users spend half as much on their Indigo solutions that they previously did on kerosene.

A user may purchase an entry-level Indigo system capable of lighting 2 rooms and charging one mobile phone. But over time, that person's requirements will grow. They may want more lights, to power a radio or TV or even power a sewing machine to enable them to make more money. Indigo grows with these needs allowing customers to progressively upgrade over time to grow from simple systems to full home electrification.

How IndiGo works



IndiGo is best thought of as "pay as you go" solar power.

Each IndiGo power unit has a unique serial number. To add credit to the unit, the user purchases a scratch card for a period of time such as a day, a week or a month. This scratchcard number, along with the unit serial number, is sent by SMS text message to the IndiGo server which validates the number and sends back a unique passcode. The user enters this passcode into the unit and the output is enabled for the period of the credit.

IndiGo works with any mobile phone and any mobile operator. The system enables products such as high quality solar lighting, mobile charging and other low power uses of solar energy.

http://eight19.com/overview/indigo-pay-you-go-solar

Green energy in the developed world


HYUNDAI
Fuel Cell Electric Vehicle
FCEV
Powered By Hydrogen



Nikon
COOLPIX


Rating green technologies for successful implementation

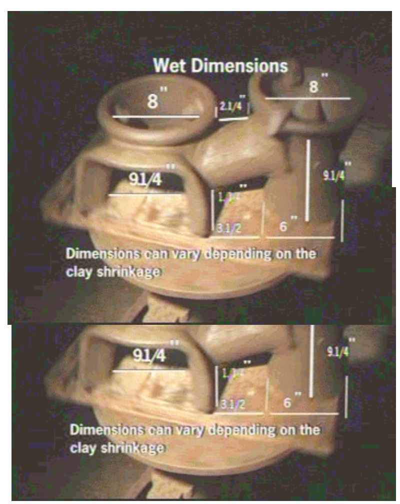
	Low technical hurdles	Compatible with existing systems	Can win head-on competition with incumbent technologies	Fills customers “job-to-be-done”
Geothermal	✔	✔	✔	✔
Plug-in hybrid vehicles	✔	✔		✔
Solar		✔		✔
Wind		✔		✔
Biofuels	✔			✔
Smart grid	✔		✔	
Fuel cells				✔
Electric vehicles		✔		

Green energy in the developing world

Technologies succeed best when the business unit responsible for developing and deploying the technology is also located where the targeted customers are located – need “good enough” products at lowest price points (e.g. hand held ultrasound machines)

Must sell a product that provides a full solution that addresses a customer need (e.g. D.light designs in India)

May need to integrate products across a wider spectrum of the value chain – sales and distribution infrastructure does not exist – may need to create a network of local entrepreneurs (e.g. D.light design)



“Anagi” Stove, Sri Lanka - “Anagi” stove is an excellent stove because it saves firewood and cooking time provided it is made to the correct dimensions. Lab tests carried out on the stove indicate a technical efficiency of 21%, and numerous field-cooking tests tell average firewood savings to be over 30%, twice as good as traditional stoves.

Why advanced technologies often fail

Generally four reasons that advanced technologies fail to gain commercial success

1. Technical challenges

- Technological approaches often prove to be unworkable or un-scalable (e.g. controlled nuclear fusion, plasmodium parasites)
- Most green energy technologies face some kind of significant technological hurdle (e.g. fuel cells, battery technology, smart grids, wind turbines, solar panels)

2. Systematic complexity

- **New technologies are rarely *"plug compatible"* with existing value chains (e.g. hydrogen powered fuel cells vs the ubiquity of gasoline filling stations)- producing hydrogen is very complex**
- **Likely success is with technologies that either work within the existing system (e.g. gas-electric or plug-in hybrid cars) or bypass it entirely (cell phone)**

3. Head on competition

In direct competition with established technologies, new technology will only be adopted if it is more cost and performance-effective in the markets where it is being used

- **New technologies have much better success rates where they are aimed initially at non-consumers – those not consuming existing products or services because of lack of wealth, experience, or access**
- **Non-consumers more willing to accept limited functionality or quality, as the product or service is superior to the alternative – no product at all e. g. the development of the transistor radio and then TV by Sony)**

4. Customers just don't want them

- **New product or service doesn't help customers do a job that needs to be done – a fundamental problem that they need to resolve, including a specific result or outcome**
- **If a technology tries to solve a job with which a customer is terribly concerned, it is likely to face headwinds (e.g. smart grids vs. digital cameras)**
- **Rise of digital photography indicated that consumers will change their behaviour in response to new technologies, but not the fundamental job they are trying to do – now consumers attach photos to emails instead of filing them in albums**
- **Smart grids enthusiasts are discovering that consumers are not as willing will to change behaviour as first thought – technology does not help them do a job they are already trying to do.**
- **The challenge is not to change consumer behavior, but change the job that consumers are trying to do (IPod)**

Green energy in the developed world

Adoption faces more daunting challenges in the developed world – already have a convenient, low-cost, and pervasive energy infrastructure in place

Green technologies must prove to be better performing at lower cost and that usually means government subsidies to bridge the gap

Electric car may address needs of customers who would actively seek a car with limited range and acceleration (e. g. second car for teenagers to go to school and visit friends)

Hybrid technologies enable incremental performance or costs advantages that can address head-on competition while remaining within existing systems of use and the production and sales infrastructure

9. Building Capacity

Why emerging markets need a clean slate approach

Developing economies are different – night and day different

Rich world has a few people who spend a lot, in the developing world there are a lot of people, each of whom spends very little, China and India are mega-markets with micro-consumers

Differences imply starkly different business challenges

May have to let go of dominant logic and what you have learned and start with humility and curiosity

1. Performance gap – need breakthrough technologies that deliver decent performance at ultralow cost – meet real needs at a realistic price – an entirely new price/performance curve
2. Infrastructure gap – rich world can leverage well-developed infrastructure, but it will constrain choice – lack of infrastructure can be an advantage in driving innovation on poor countries and where it does exist it can be cutting edge
3. Sustainability gap – only way that poor countries can sustain economic growth is with "green" solutions - consumption and production levels that are environmentally unsound will be catastrophic
4. Regulatory gap – rich economies benefit from regulatory systems that keep markets fair and consumers and work place safe, but also constrain innovation
5. Preference gap – poor countries exhibit a rich diversity of tastes, habits, and rituals and this diversity is a driver of new products and services

The Challenge
C.K. Prahalad

Doing business with the world's 4 billion poorest people — two-thirds of the world's population — will require radical innovations in technology and business models. It will require MNCs to reevaluate price–performance relationships for products and services. It will demand a new level of capital efficiency and new ways of measuring financial success. Companies will be forced to transform their understanding of scale, from a "bigger is better" ideal to an ideal of highly distributed small-scale operations married to world-scale capabilities.

In short, the poorest populations raise a prodigious new managerial challenge for the world's wealthiest companies: selling to the poor and helping them improve their lives by producing and distributing products and services in culturally sensitive, environmentally sustainable, and economically profitable ways.

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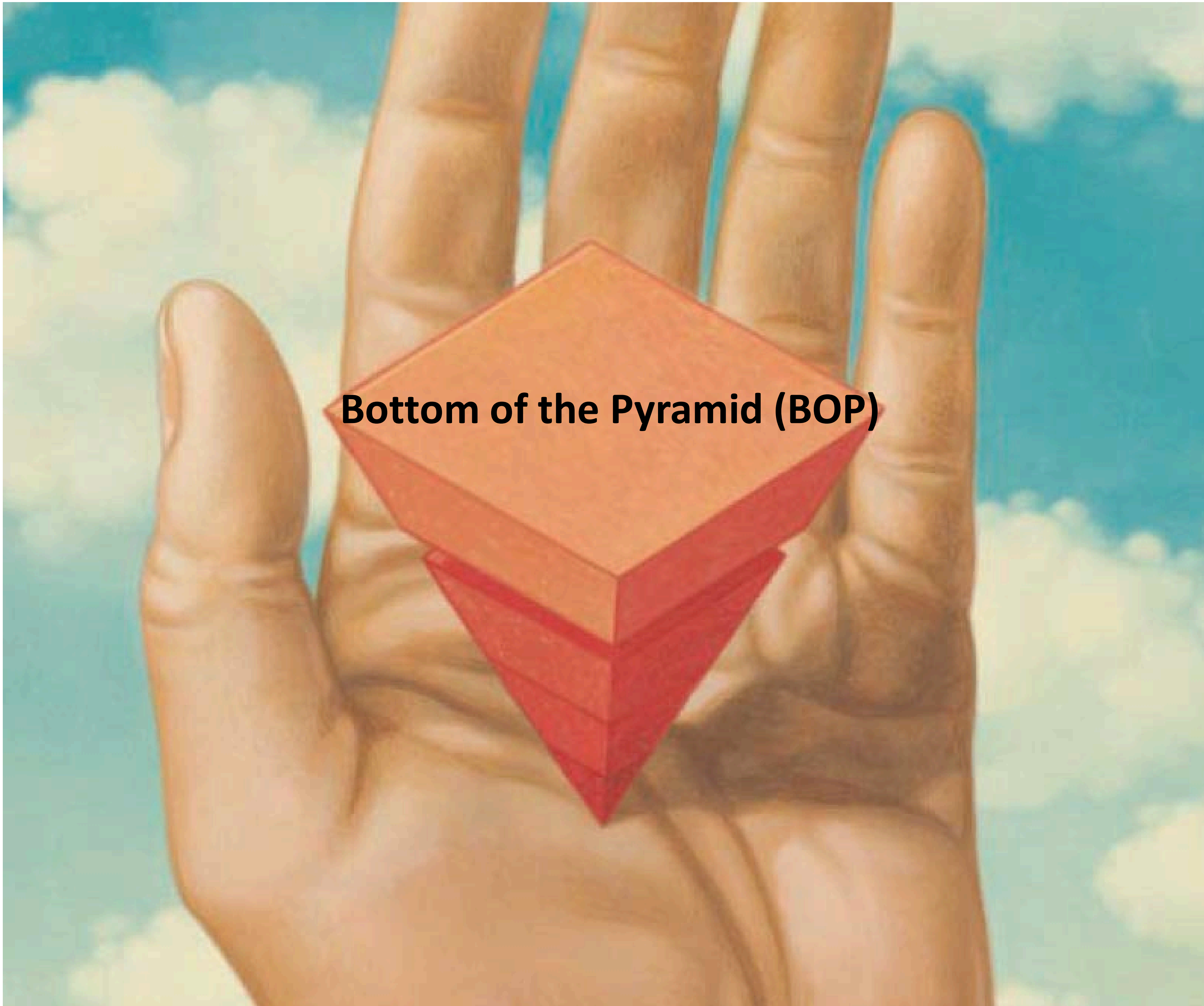
Bottom of the Pyramid (BOP)

Traditional approaches will not work for most of the world's population

Traditional thinking

PRICE = COST + PROFIT (cost structure is a given and profit is the motivating factor - this is the dominant logic of capitalism)

Challenging the dominant logic (C.K. Prahalad)

PRICE – PROFIT = COST (price is what people can afford, profit is what motivates, and cost is based upon the capacity to consume)

Exhibit 1: **The World Economic Pyramid**

Annual Per Capita Income*	Tiers	Population in Millions
More Than $20,000	1	75–100
$1,500–$20,000	2 & 3	1,500–1,750
Less Than $1,500	4	4,000

* Based on purchasing power parity in U.S.$
Source: U.N. World Development Reports

The United States with around 4% of the world's population – consume more than 25 percent of the planet's energy resources

To re-create those types of consumption patterns in developing countries would be disastrous

False Assumptions

Constraints set by widely shared orthodoxies, including:

- **Current cost structures preclude profitability in the lowest tier**
- **Poor cannot afford or have no use for products and services sold in developed markets**
- **Only developed markets appreciate or will pay for new technology – lowest tier 4 should be left to governments and non-profits**
- **Business challenges with a humanitarian dimension don't motivate managers**
- **Intellectual excitement is in developed markets**

Each of these assumptions obscures the true value at the bottom of the pyramid

12 principles of innovation for BOP Markets

1. **Focus on price performance of products and services** – must create new price-performance envelope
2. **Innovation requires hybrid solutions** – cannot be solved with old technologies - must creatively blend emerging technologies with existing and rapidly evolving infrastructures
3. **Solutions must be scalable and transportable** across countries, cultures, and languages – ease of adaptability is crucial
4. **All innovations must focus on conserving resources** – eliminate, reduce and recycle
5. **Product development must start from a deep understanding of functionality**, not just form – infrastructure constraints require a rethinking of functionality
6. **Process innovations** are just as important as product innovations – the presence of logistic infrastructure cannot be assumed

12 principles of innovation for BOP Markets

7. **Deskilling work** is critical design of products must take into account the skill levels, poor infrastructure, and difficulty of access for services
8. **Education of customers** on product/service usage is critical and often occurs in the absence of traditional approaches to education
9. **Products must work in hostile environments** – may face noise, dust, unsanitary conditions and abuse plus low quality or lack of consistency with existing infrastructure
10. **Research on interface** is critical given the nature and heterogeneity of the potential consumer population
11. **Innovations must reach the consumer** and the challenges between rural and urban markets very different
12. **Feature and function evolution** can be very rapid – must focus on the broad architecture of the systems – the platform- so that new features can be easily incorporated

Making Sustainability Profitable

In 2010, Boston Consulting Group (BCG) partnered with World Economic Forum (WEF) to identify companies with the most effective sustainability practices in the developing world – more than 1,000 firms, $25 million to $5 billion, from a wide array of markets and industries

Collectively they demonstrated that trade-offs between economic development and environmentalism aren't necessary

- **Take a systems approach – focus on the efficiency of the system as a whole, versus that of the individual parts (food production based on a balanced ecosystems approach)**
- **Take the low-tech road – instead of investing in breakthrough technologies that are often capital intensive, begin to conserve the most constrained resources with a series of minor adjustments to their operations (address leaky pipes)**
- **Take a broader view – extend sustainability efforts to include customers, their operational requirements and suppliers (FSC Wood products)**
- **Think ahead – embark on sustainability efforts long before the imperative is obvious (water neutral production systems)**

Source: Harvard Business review, March 2013

Challenges and Opportunities of Investing in Cleantech and Renewable Energy

Based on the database of the Cleantech Group, there are about 19,200 cleantech companies in the world, of which over 1/3 are based in the United States. Despite some minor setbacks, there is no doubt that cleantech has become one of the most targeted sectors for both public and private investment. A few numbers can shed light on the fact that the cleantech industry has emerged to be a fast-growing industry of great political and environmental significance:

During 2012 alone, cleantech companies around the globe raised $6.56 billion of venture capital across 732 deals

For the global Foreign Direct Investment (FDI), the cleantech sector ranked as the second largest sector after oil and gas by attracting $12 billion from the global FDI into the U.S. in 2011, making it the fastest growth sector for the past decade

Source: IGEL @ Wharton, March 8, 2013

Cleantech versus High-Tech

Intellectual property critical to both, but in different ways

Many VC-backed high-tech companies focused on value-added specialty products that could command high margins

Most cleantech companies used proprietary technology to develop commodity products that could only be profitable at scale

Silicon Valley high-tech start-ups had high market risk and often failed because users were not ready to adopt new, useful products

Cleantech companies had low market risk due to the commodity nature of energy markets

Cleantech companies tended to require more deployment and expansion capital than those in software, hardware and networking

Most difficult area for capital in cleantech might be pilots to prove the technology is rock solid

Game-changing shifts

Much harder to effect the game-changing shifts between centralized and decentralized development that characterized IT over the past 40 years

Mid 1990s convinced that the Internet was going to change the world – sooner rather then later

Have a similar strong convictions about the cleantech but it will happen over very different time periods than the Internet

VC investing in cleantech as a separate category, started around 2005 when food-based bio-fuels were all the rage

That bubble burst in 2006 just in time for solar to get everyone excited in the next big thing – thin solar film

This bubble burst with the rest of the economy in 2009 and this forced a healthy realism of cleantech opportunities

Third wave of cleantech will be governed by efficiency and demand-side management

Market Challenges

Cleantech investors generally agree that one of the key challenges for a cleantech company's IPO is the scalability of the cleantech business model and technologies. Current market conditions value the ability to scale technologies or businesses to reach critical mass and having a short and clear path to cash generation, which explains why information technology remains the most active industry among business IPOs.

Other market challenges facing the cleantech sector include lower electricity prices driven by the large-scale development of natural gas from shale, upstream profitability drying up due to over-capacity manufacturing, and a potential drop in demand due to concerns over government debt and budget deficit.

A changing landscape

By August 2010, the IPO markets for cleantech-related companies was chaotic. With few exceptions, valuations of newly public cleantech companies failed to show much hope for improved performance in the near-term

But the landscape was changing – world was coming around to the idea that we are wasteful with energy because our infrastructure is built around the idea that energy was too cheap to worry about.

Current energy infrastructure is not sustainable

What happens when we reach the end-of-oil? We know this will happen but not when it will happen

Vast majority of cleantech venture dollars to date have been spent on “supply side” innovation in power generation and renewal fuels, whereas the real opportunities for innovation will be found on the demand-side” of the energy solution

“Venture Capital Dispatch”, March 21, 2013

One of the largest enablers of clean-technology venture investing, California Public Employees’ Retirement System, is showing a negative 9.8% return on the investment that the country’s largest pension fund has made in the space over the past five years, said Joseph A. Dear, Calpers chief investment officer.

Investing in clean-tech isn’t following a J-curve, or the idea that venture funds have a couple of years of losses, followed by a big jump in returns, he said. “For Calpers,” it’s been “an L curve, for ‘lose.’”

Speaking on the opening panel at The Wall Street Journal’s ECO:Nomics in Santa Barbara on Wednesday, Dear said that the pension system invested about $460 million directly in clean-technology funds and in total invested about $900 million in the sector. So far venture firms returned one-tenth of the money they got from the pension fund, he said.

Those words didn’t lie well with the venture investors present in the room, including Alan Salzman, chief executive and managing partner at Vantage Point Capital Partners , one of the largest venture funds that invested in clean-tech, and in which Calpers is a limited partner.

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