15.992 S-Lab: Laboratory for Sustainable Business
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Sustainable Infrastructure and International Markets

Prof. Sarah Slaughter
S-Lab (15.992)
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Infrastructure Systems

Core Enabling Systems for Civil Society and Commerce

- **Water**
- **Wastewater**
- **Stormwater**
- **Solid Waste**
- **Energy**
- **Telecommunications**
- **Transportation**

(**RED**: Usually publicly owned and operated)

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Basic Statistics

- **Construction expenditures ~$5 trillion per year worldwide**
- **Infrastructure construction expenditures ~ $1.6 trillion/yr**
- **Expected Rate of Infrastructure Expenditure Growth**
  - Czech Republic – 16% in 2007
  - India – 14%/yr (projected)
  - China –9%/yr (projected)
  - Brazil – 6%/yr (projected)

(Source: Business Monitor International, 2008)

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UN Millennium Development Goals

- **By 2015:**
  - Goal 1: Eradicate Extreme Hunger and Poverty
  - Goal 2: Achieve Universal Primary Education
  - Goal 3: Promote Gender Equality and Empower Women
  - Goal 4: Reduce Child Mortality
  - Goal 5: Improve Maternal Health
  - Goal 6: Combat HIV/AIDS, Malaria and other diseases
  - Goal 7: Ensure Environmental Sustainability
  - Goal 8: Develop a Global Partnership for Development

(Resources: www. Un.org/millenniumgoals/, www.mdgmonitor.org)

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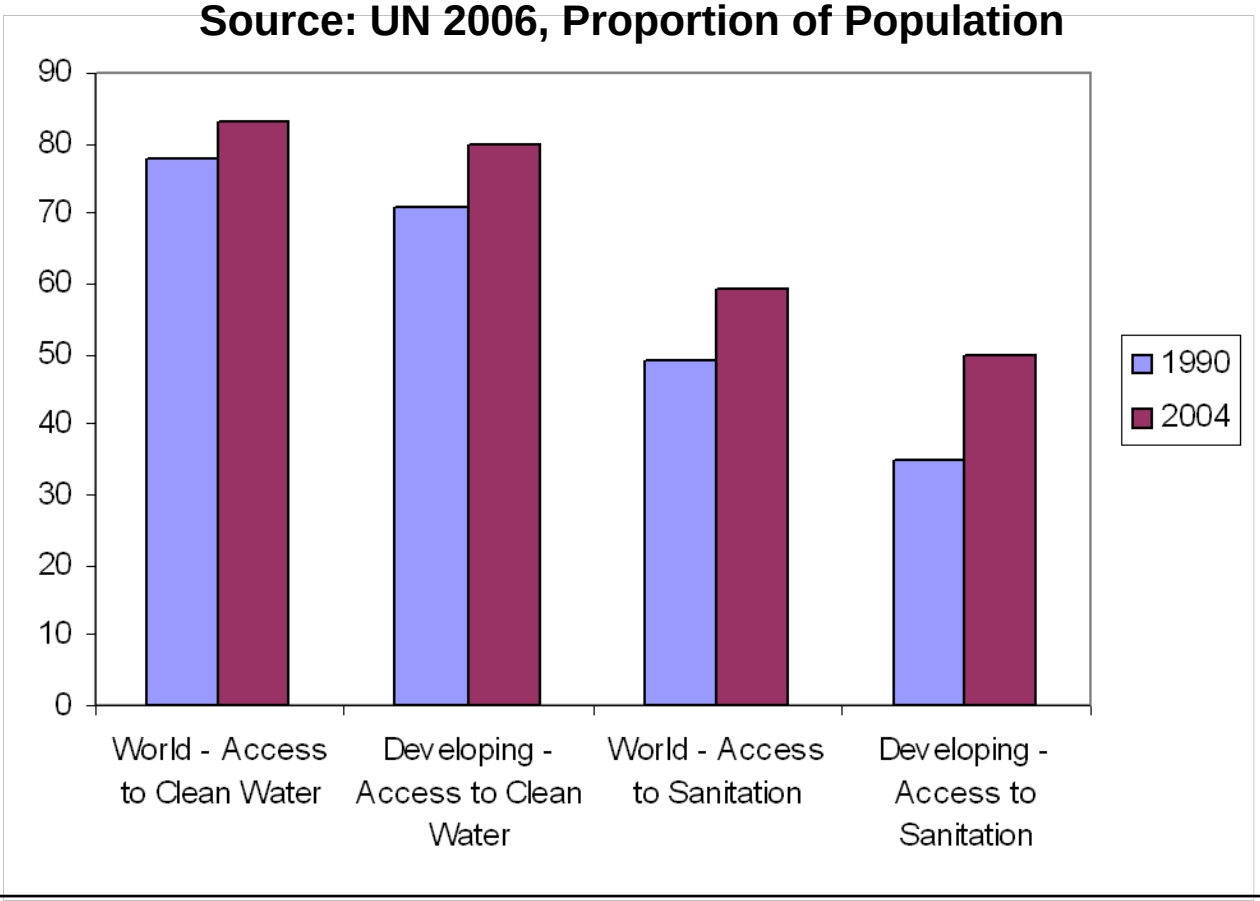
Goal 7, World Wide Access to Water and Sanitary Services

Over 1 billion people lack clean drinking water (Source: UN, 2006)



UN Millennium Development Goal 7:Halve Proportion without improved drinking water, Halve proportion without sanitation

Global Drought Monitor (Nov 07)

Image removed due to copyright restrictions. World map with drought locations by Dr. Benjamin Lloyd-Hughes and Professor Mark Saunders.
Updated map available at http://drought.mssl.ucl.ac.uk/

Population under current exceptional drought:
58,140,000

Drought Areas

- **Australia (Science News, 10/27/07, p. 266-268)**
- **United States**
  - Southwest (NYT Magazine, 10/21/07, p. 68-77, 104, 154-155)
  - Southeast (WSJ, 10/26/07, p. 1)
  - Northwest (Idaho, Montana)
- **South America (Venezuela, Peru, Southern Chile)**
- **Africa (Algeria, Southern Africa, Somalia)**
- **Mediterranean (Turkey, Russia)**

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IPCC Projected Worldwide Temperature Trends

Image removed due to copyright restrictions.

Source: "Projected Temperature Changes, 2000 to 2100 Scenario." By UNEP/GRID-Arendal.

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Water Shortage Causes

- **Weather Changes**
  - El Nino, La Nina
  - Global Climate Warming
- **Land Use Changes**
  - Forest clearing
  - Landscaping (non-native)
- **Human Water Use**
  - Increased irrigated agriculture
  - Increased population
  - Increased industrial use
  - Increased household use

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Water Shortage Impacts

- Economic
  - Agriculture
  - Industry
  - Tourism and recreation
  - Energy
  - Financial
  - Transportation
- Environment
  - Animal/Plant
  - Wetland
  - Water quality
- Social
  - Stress and health
  - Nutrition
  - Recreation
  - Public Safety
  - Cultural Values
  - Aesthetic Values

http://www.drought.unl.edu/mitigate/mitigate.htm, "How to Avoid Drought", 1998

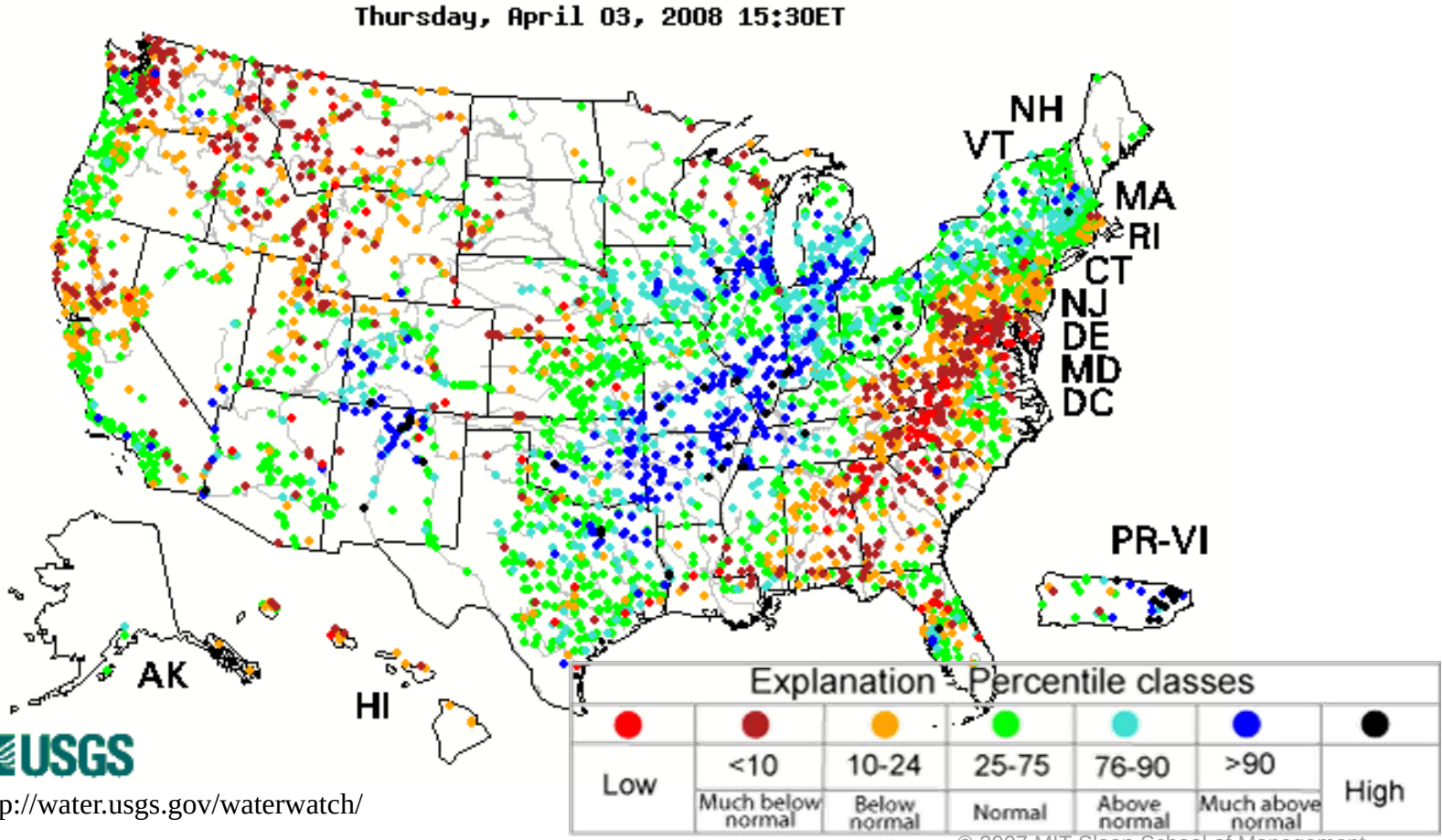
IPCC Projected Rising Sea Levels

Image removed due to copyright restrictions.

Source: "Coastlines Under Threat." By UNEP/GRID-Arendal.

US Stream Flow

Real-time vs historical streamflow for the day of the year



USGS

http://water.usgs.gov/waterwatch/

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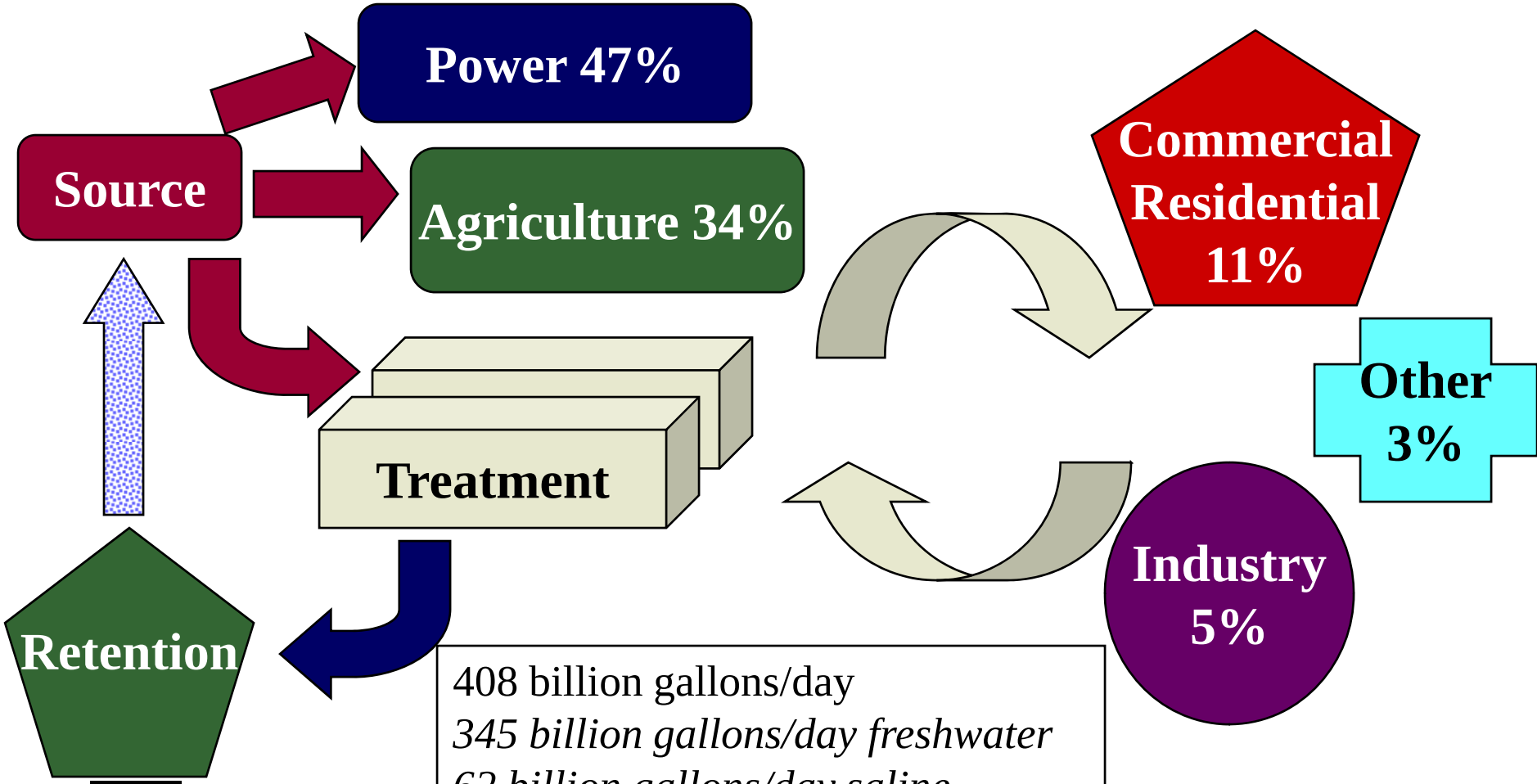
Water and Wastewater



408 billion gallons/day
345 billion gallons/day freshwater
62 billion gallons/day saline
Source: USGS, 2000

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US Municipal Solid Waste, 2005

Source: EPA, 2005

Products	Weight Generated (tons)	Percent Recovered	Solid Waste (tons)	Proportion of Total
Containers and Packaging	76.7	40%	46.2	28%
Other Wastes	65.0	32%	44.5	27%
Nondurable Goods	63.7	32%	43.3	26%
Durable Goods	40.3	19%	32.8	20%
Total	245.7	32%	166.8	

In the US, each person generates 720 kg per year.
In Mexico, each person generates less than 300 kg/yr
(Source: US Census, 1997)

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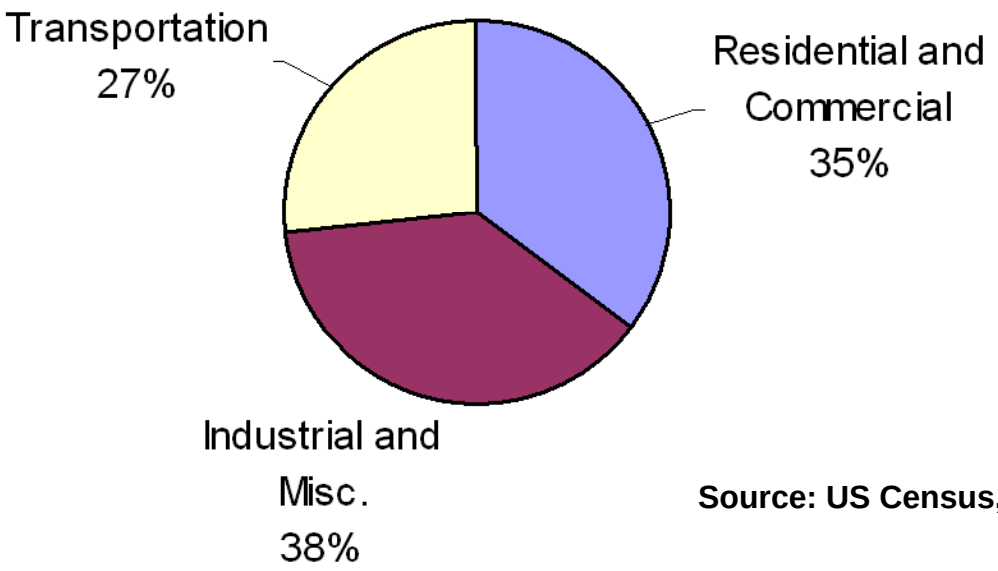
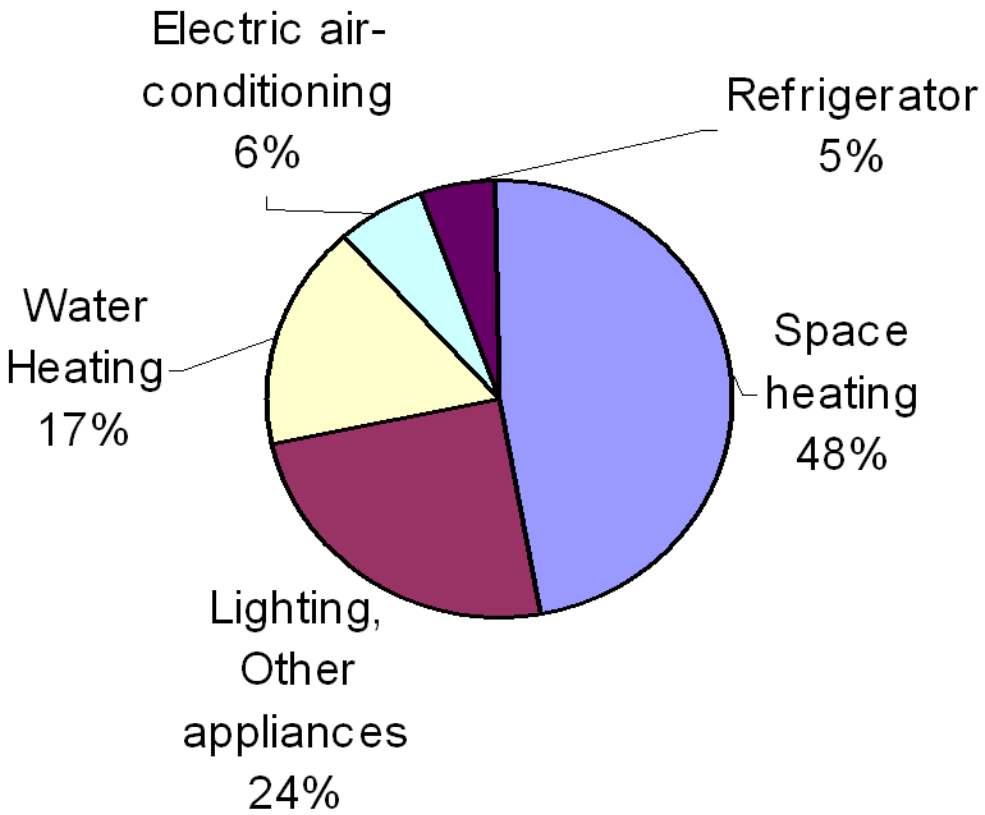
US Energy Consumption by I/BE: 97 Quad Btus in 1999

In Asia and Pacific Region, over 800 million people are without access to electricity or clean energy (UN, 2005)



Source: US Census, 1999

US Residential Energy Use: 9.9 Quad Btus in 1999



Source: US DOE, 2001

US Transportation Modes: CO2 Emissions and Energy Use

Mode	CO2 lbs/ Pass/mile (1)	BTU/ Pass-mile (2)
SUV	1.6	
Average Car	1.1	3496
Jet	1.0	3959
Economy Car	0.6	
Intercity Train	0.5	2760
Carpool	0.4	
Mass Transit (3/4 full)	0.3	2750

(1) www.sightline.org
(2) US DOT, Transportation Energy Data Book, 2007

Boston to London RT is 6,507miles and generates 2,538 lbs of CO2
Boston to Tokyo RT is 13,414 and generates 5,232 lbs of CO2

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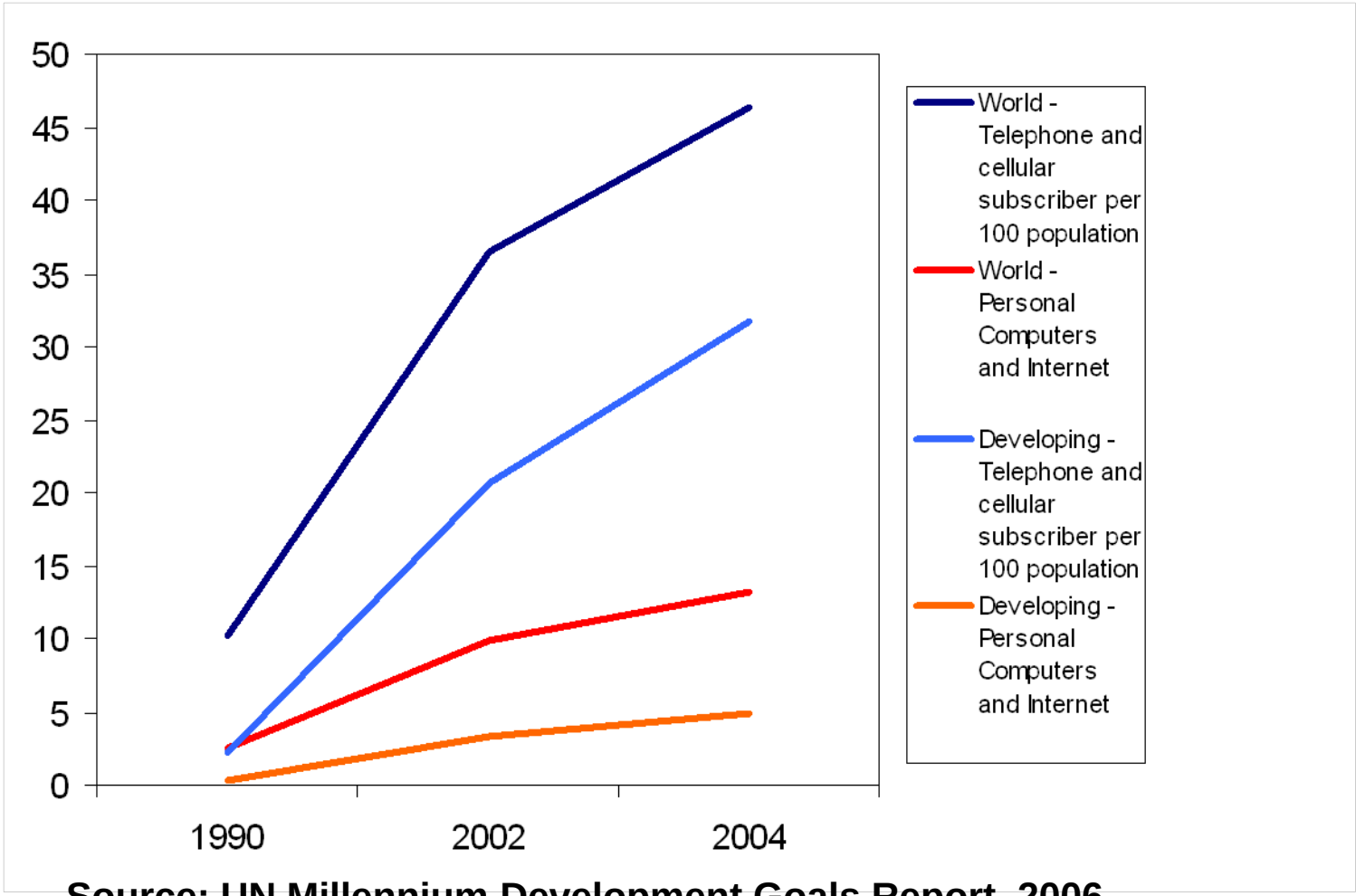
Telecommunications Infrastructure



Source: UN Millennium Development Goals Report, 2006

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Boston Area Infrastructure

Infrastructure System	Cambridge	Boston	Lenox, MA
Water			
Sewage			
Solid Waste			
Last Major Transport			
Green Buildings			

Boston Area Infrastructure

Infrastructure System	Cambridge	Boston	Lenox, MA
Water	**Fresh Pond Reservoir**	**MWRA, Quabbin Reservoir**	**Wells, Local reservoir**
Sewage	**MWRA, Deer Island**	**MWRA, Deer Island**	**Septic tanks, Local treatment**
Solid Waste	**Trucked to western Mass**	**Trucked to western Mass.**	**Burn barrel, Local dump**
Last Major Transport	**Red Line to Alewife**	**Central Artery, Third Harbor Tun**	**Highway improvements**
Green Buildings	**All city bldgs and major renov**	**All city, major construct, renov**	**MTC Cities for Climate Protect Plan**

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Opportunities

"30% of California urban water use can be reduced using existing technologies, to avoid or delay new reservoirs and other water sources." (Pacific Institute, 2003)

- **Major Actions**
  - Eliminate Waste
  - Increase Efficiency
  - Reconsider Resource Use
  - Re-Use Resource
  - Develop New Sources

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Example Community: Fort Lewis, US Army, WA

- **Fort Lewis covers 87,000 acres in Washington State**
- **Yakima Training Center covers 324,000 acres.**
- **25,000 soldiers and civilian workers, with 120,000(+) retirees and more than 29,000 family members living both on and off post.**
- **Adjacent to McChord Air Force Base**

Fort Lewis, WA

Drivers for Sustainability:

- **2000 – New Requirements for Environmental Management**
  - The Senior Environmental Leadership Conference (SELC), March 2000, mandated that installations establish an integrated strategy
  - Executive Order 13148, Leadership in Environmental Management, 22 Apr 2000.
- **2002 Base Workshop to develop Installation Sustainability Program**
  - Environmental groups and regulation agencies
  - Community
  - Army HQ and Installation

Fort Lewis, WA

- **Installation Sustainability Program Goals (2002)**
  - Air Quality – Reduce Emissions by 85% by 2025
  - Energy/Infrastructure – On-site energy generation and Platinum LEED for all buildings by 2025
  - Material Mgt – Zero net waste by 2025
  - Sustainable Training Lands – Regenerate all lands and species by 2025
  - Water Resources – Zero wastewater and 75% reduction in water use by 2025

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Fort Lewis, WA

- **2005-2006 Progress (Selected examples)**
  - Air Quality
    - 40% on-installation vehicles are alternate or dual fuel
    - 190 Rideshare participants
    - Switched boiler fuel to reduce stationary emissions
  - Energy/Infrastructure
    - Buildings upgrades with 5-30% energy use reductions
    - Targeting overall reduced energy use of 2% by 2007
    - 10% Green power purchased, target +5% by 2007
    - Rainwater harvesting cistern completed in barracks project

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Fort Lewis, WA

- **2005-2006 Progress (Selected examples – cont'd)**
  - Products and Material Management
    - Biosolid composting facility completed
    - 9,100 tons recycled asphalt, concrete (savings $340k/y)
    - 97 illegal dump sites cleaned (pot. savings $350k/y)
    - Cradle-to-cradle Hazardous Materials delivery service
  - Sustainable Training Lands
    - Cooperation with The Nature Conservancy on habitat restoration and species reintroduction for 127 acre prairie preserve
    - Cleared 1581 acres of invasive nonnative plants

Fort Lewis, WA

- **2005-2006 Progress (Selected examples – cont'd)**
  - Water Resources
    - On-site remediation of contaminated groundwater site (ahead of schedule)
    - Grey water reclamation in all barracks
    - Extensive replacement of water mains and connectors to reduce leakage

Example New Community: Noisette, SC

- **Master Plan for North Charleston – 3,000 acres with 400 acres Decommissioned Navy Yard (2004)**
  - Sustainable land use patterns
  - Natural systems restoration
  - Ecological storm water management
  - Highly-connected transportation design
  - Network of recreational elements
  - Schools as centers of community
  - Integration of art throughout community
  - Training/rebuilding local community

(Source: Harry Gordon, CEO, Burt Hill, 2007, http://www.noisettesc.com)

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Noisette, SC

- **Water/Wastewater (Stormwater)**
  - Direct through street bioswales into central pond
- **Reconstruct Natural Waterways**
  - Noisette Creek with 200 acre preserve
- **Renovation of existing buildings and construction of new buildings to sustainability guidelines (LEED)**
- **New businesses focused on sustainability**

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Noisette, SC

- **Current Progress (Selected examples)**
  - 101 EarthCraft-certified homes under contract, with 400 preserved trees and innovative features like recycled building materials.
  - Green Buildings: construction and renovation of older buildings, with green roofs and geothermal climate control.
  - 1 LEED Platinum
  - Prisoner Re-Entry Training Program – green building techniques

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Noisette, SC

- **New companies located:**
  - Southeast Biodiesel, which produces alternative fuels for marine vessels and automotive markets.
  - Coast Brewing Company, a microbrewery producing beers made with organic grains, utilizing recycled equipment and eco-friendly manufacturing processes.
  - Lowcountry Local First which supports local, sustainable businesses.
  - Fisher Recycling
  - The Verdi Company, green homebuilder

Source: http://www.noisettesc.com/index.html

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New Company Example: Water Health

- **New technology – filtration with proprietary UV treatment**
- **New Business Model:**
  - Provide community financing
  - Design and build turnkey modular units
  - Train local community to operate, maintain
  - Scalable as community develops
  - Community education and containers for health and hygiene
  - Franchised “water stores”

Water Health

Progress to date:

- **India**
  - 50 WaterHealth Centres installed in the state of Andhra Pradesh
- **Philippines**
  - Over 50 urban water store franchises across metropolitan Manila
- **Ghana**
- **Sri Lanka (after tsunami)**
  - Installed capacity to provide safe drinking water for least 21,500 survivors

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Example Next Generation Technologies: Microbial Fuel Cell

- **Waste water (including sewage) as fuel, creates electricity and water and compost**
- **Pilot plant: Brewery in Australia, brewery wastewater is used as feed.**
  - Carbon fibre anodes and cathodes are used, based on a brush design.

Source: http://www.microbialfuelcell.org/, Jeremy Patten, The University of Queensland

New Company Example: Ecochlor

- **New international regulations to reduce invasive aquatic organisms**
- **Treatment of Ballast Water in Ships**
  - Chlorine Dioxide kills organisms (including in saltwater)
  - Nontoxic after rapid degradation

New Company Example: Sterecycle

- **New technology – Steam Autoclave**
- **New Business Model:**
  - Finances, builds, owns, and operates recycling facility
  - Can recycle and recover ~80% of domestic waste
  - Can be used before traditional systems