

# Civil Infrastructure for Water, Sanitation, and Improved Health: Existing Technology, Barriers, and Need for Innovation

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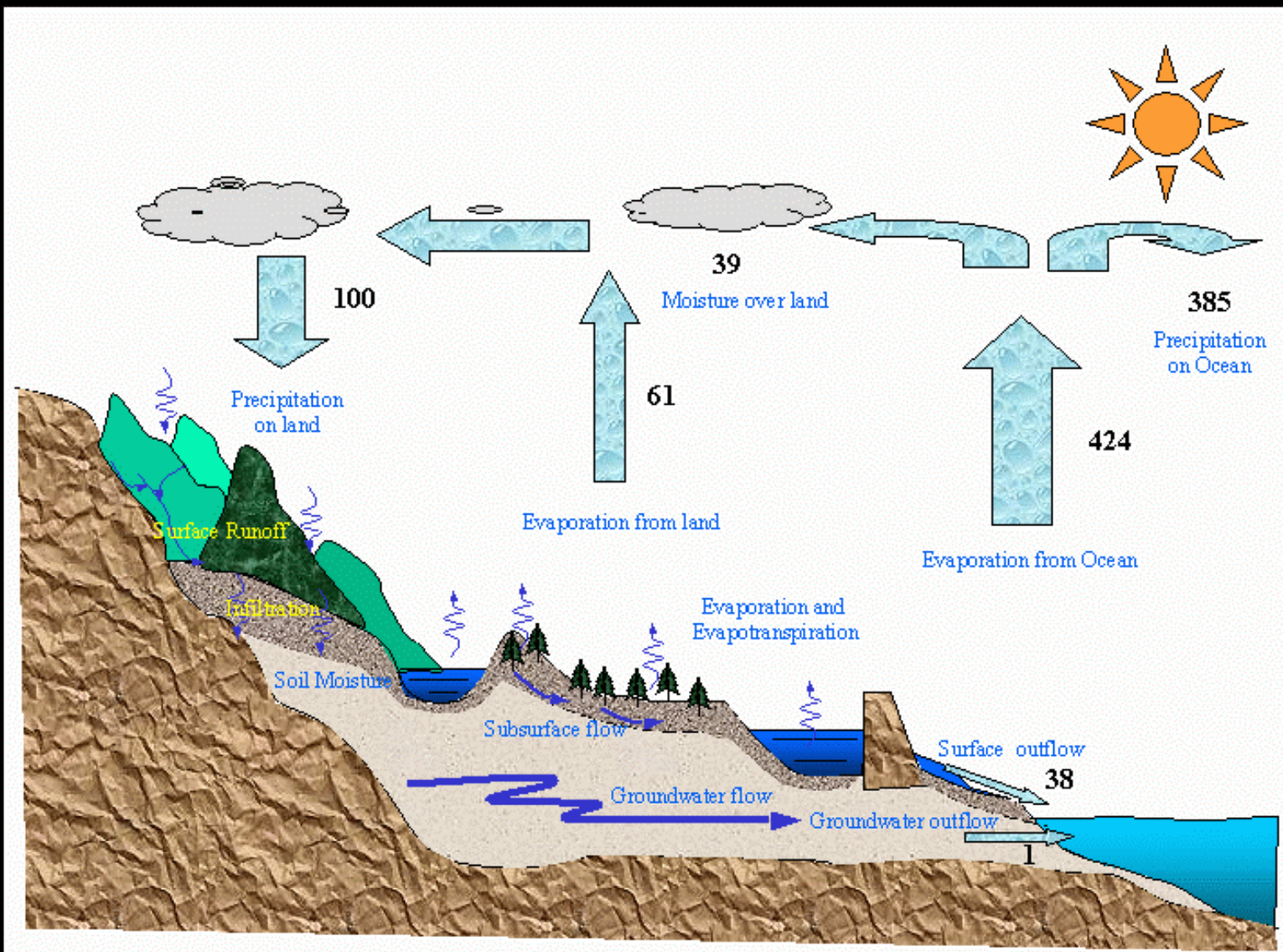
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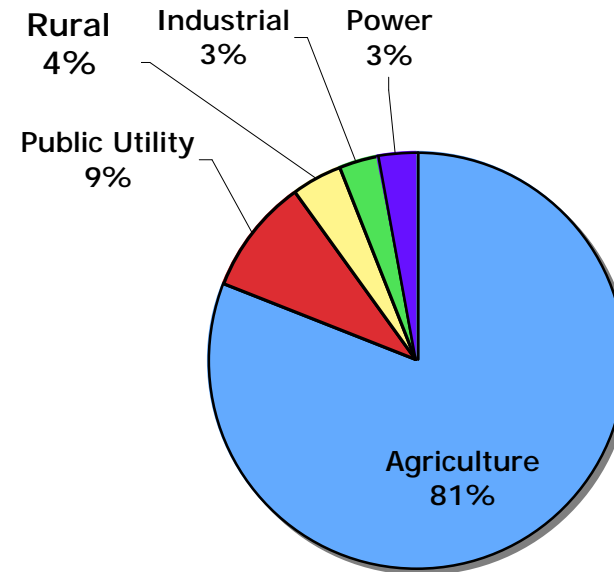
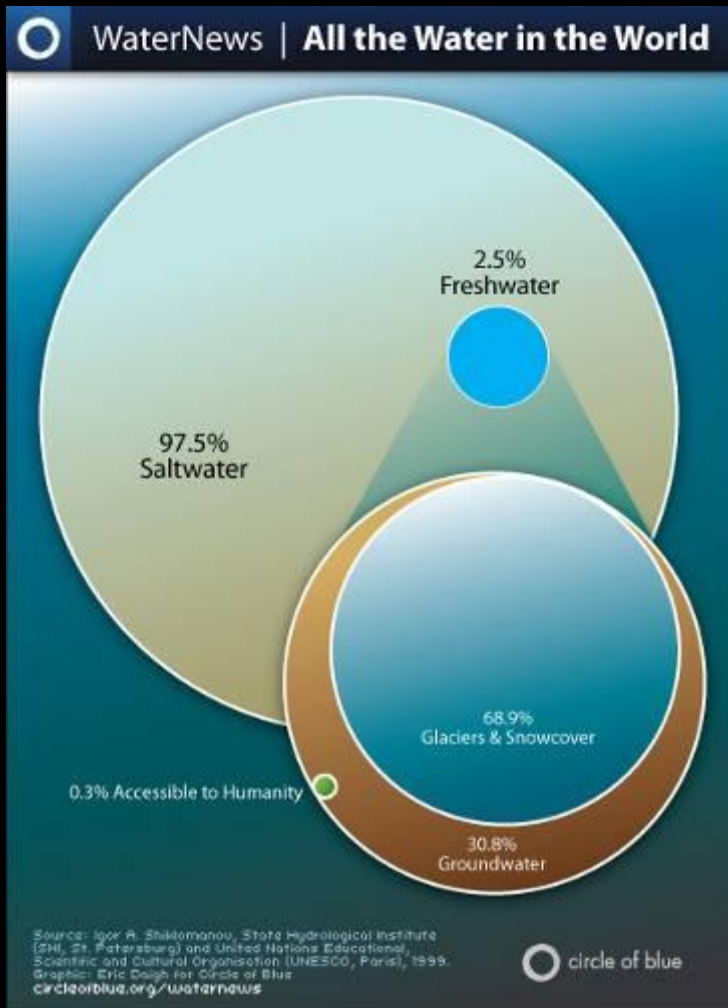
Atlanta, GA



# The Hydrologic Cycle



# Water Distribution and Use

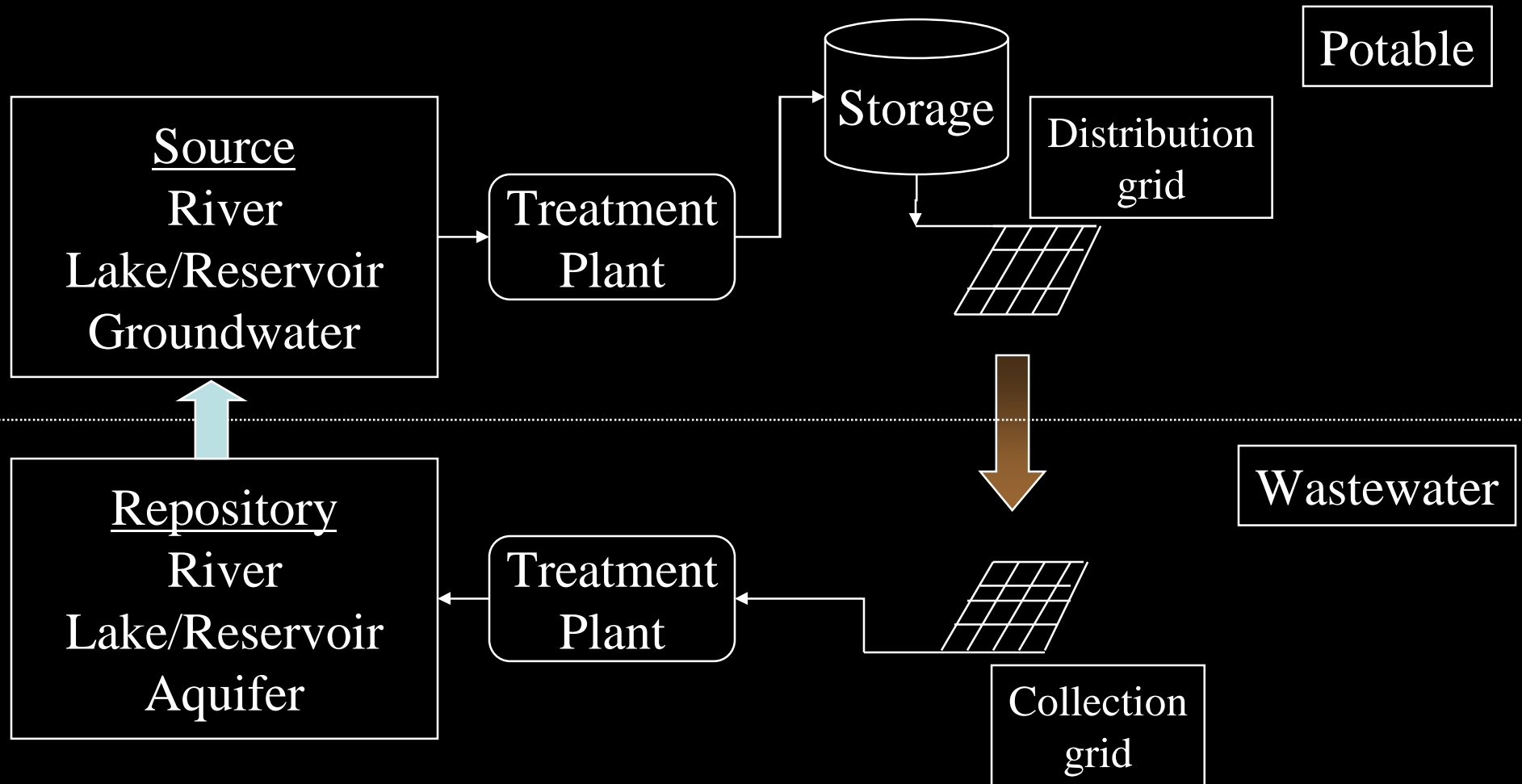


Consumptive Use in the U.S.

# Common U.S. Civil Infrastructure

- Create water supply
  - Reservoirs, intake structures, well fields
- Resource protection
  - Wastewater treatment, landfill placement, hazardous waste management, well head protection, aquifer remediation, preventing salt water intrusion
- “Heavy” Infrastructure
  - Potable water treatment plant, wastewater treatment plants, conveyance systems, above ground storage, residuals management

# Engineering the Hydrologic Cycle for Improved Health



# Improved Health and Water Quality Parameters

- Potable Water
  - Pathogens
  - Nitrate
  - Fluoride
  - Arsenic
  - Heavy metals
  - Synthetic chemicals
  - Secondary concerns
- Wastewater
  - Oxygen demand
  - Nutrient removal
  - Sludge disposal
  - Suspended solids
  - Heavy metals
  - Synthetic chemicals
  - Secondary concerns

# Essential Elements of U.S. Water Infrastructure

- Water supply
- Resource protection
- “Heavy” infrastructure

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- Energy
- Chemicals
- Subsidies
- Regulatory frameworks
- Available capital
- Property ownership
- Social Acceptance

Most are lacking  
in the developing  
world and all are  
needed to translate  
our model...

# Barriers

- Water supply
  - Shallow groundwater is limited
  - Urbanization focuses water demand and waste production
  - Increasing demand on surface water for drinking, and for wastewater discharge
  - Agriculture and energy
- Resource protection
  - Externalization of water resources during development
  - Groundwater contamination from poor sanitation and agriculture
  - Coastal development and salt water intrusion

# Barriers

- Energy
  - Energy is the largest operational cost in water and waste water treatment
    - Water and wastewater conveyance requires pumping
    - Wastewater treatment is energy intensive (aeration)
    - Residuals management can be energy intensive
    - Desalination
  - Energy demands have the greatest influence on modifications of water resources globally
  - Growth in energy production projected to be highest in water poor regions





# Barriers

- Chemicals
  - Flocculants
  - Disinfectants
- Subsidies
  - Requires that government considers clean water and appropriate sanitation in the public interest
  - Subsidies for agriculture impact water availability

# Barriers

- Regulatory frameworks
  - Particularly important for sanitation
  - Wastes are inherently low value, why spend money them?
  - Public trust for safe water
- Available capital
  - Typically financed by public sector
- Property ownership
  - Access, planning, and distribution systems
  - Knowledge of users, and ability to bill for services

# Barriers

- “Heavy” Infrastructure
  - Population growth and changing demographics
  - Implementation timetables are long
    - Reservoir development
    - Construction
    - Public acceptance
  - Operations and maintenance costs
  - Cost ineffective for small communities

# The Technology Spectrum



Large, interconnected  
complex systems

*Are intermediate  
solutions in water  
and sanitation  
possible?*

Small, distributed  
simple solutions

*Can these  
be improved?*

# The Innovation Challenge

- Most water and sanitation technologies were mature decades ago
- Research focus in U.S. universities has been on advances to our water and sanitation approach
- No clear, sustained, funded mandate for innovation to existing NGO's
- The need for “different solutions” has not changed
- What is new that changes the solution domain?

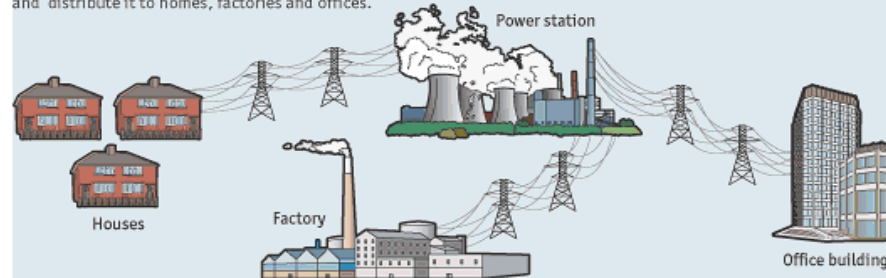
GE-in 26 years,  
nine generations of innovation in health care;  
one in power systems

*Jeffrey Immelt, GE Chairman and CEO*

# Distributed Power

## Conventional electrical grid

Centralised power stations generate electricity and distribute it to homes, factories and offices.

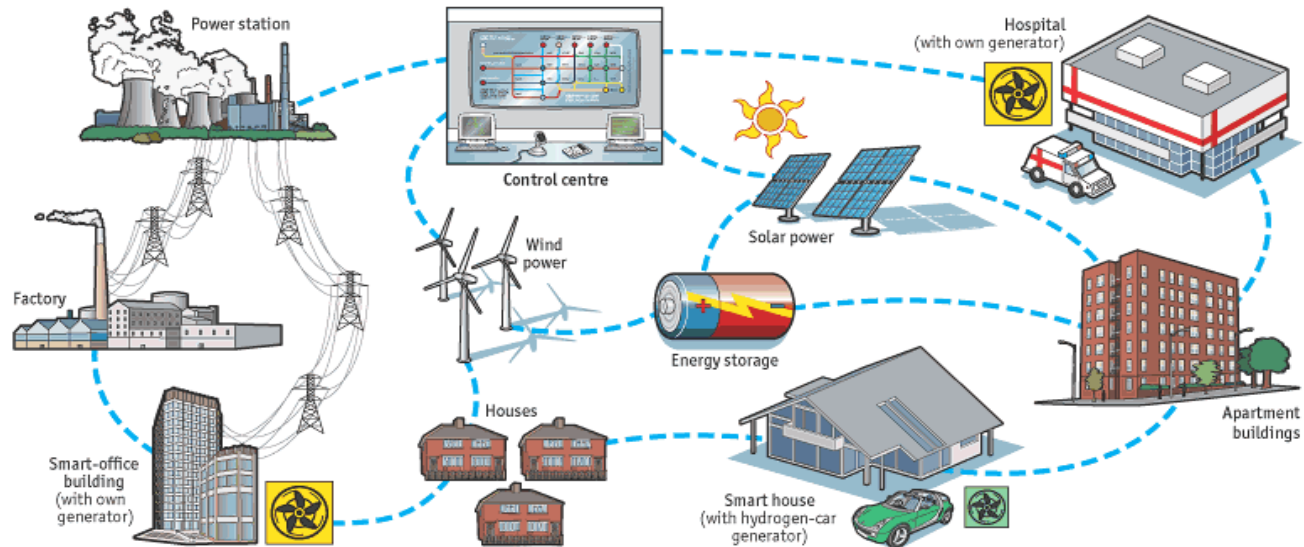


## Energy internet

Many small generating facilities, including those based on alternative energy sources such as wind and solar power, are orchestrated using real-time monitoring and control systems.

Offices or hospitals generate their own power and sell the excess back to the grid. Hydrogen-powered cars can act as generators when not in use. Energy-storage technologies smooth out fluctuations in supply from wind and solar power.

Distributing power generation in this way reduces transmission losses, operating costs and the environmental impact of overhead power lines.



Sources: The Economist; ABB

"Give a man a fish, he'll eat for a day.  
Give a woman microcredit, she, her husband, her children  
and her extended family will eat for a lifetime."

*Bono*

Together

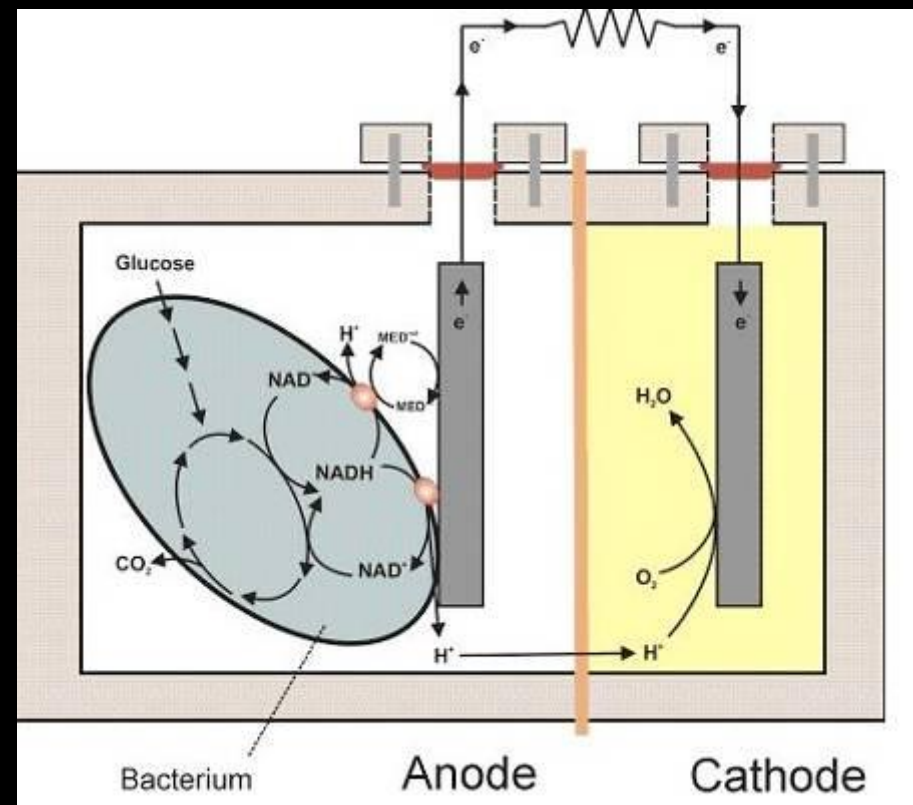
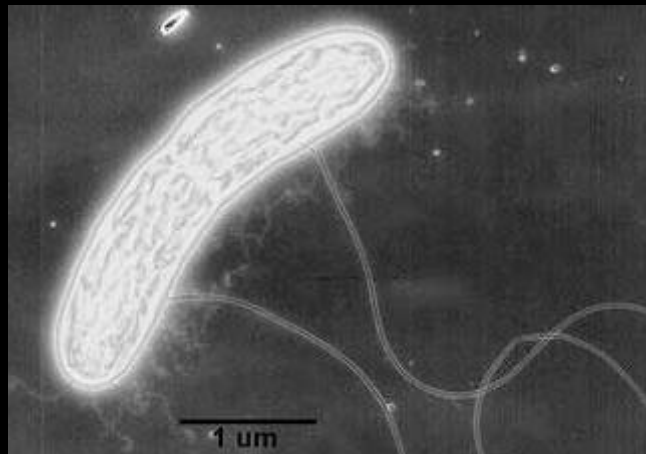
Power + Money = Opportunity

# Distributed Coupled Systems



QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

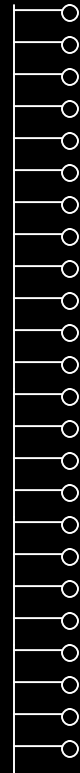
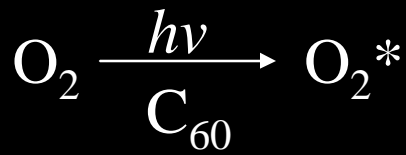
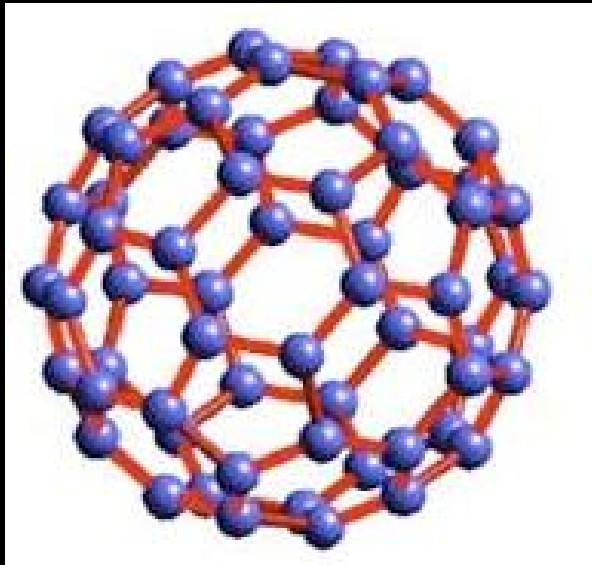
# Waste to Electricity



# Direct Electricity from Waste

- Advantages
  - Very simple and could work on small (pit latrine) to intermediate scales
  - Increase waste decomposition rates
  - Creates a valuable product
- Questions
  - Durability, design, and scale
  - How to create business model

# Materials Advances



# Innovation and Scaling

- What scale creates a useful business model?
- How rapidly can innovations be deployed?
- Can solution(s) be useful universally, or will they be region specific?
- What educational requirements will be needed?

# Summary

- “Heavy” infrastructure model possesses many barriers for solving needs in the short term
- Increasing demands from agriculture and energy are a serious threat to water security
- Advances in energy systems, materials, biology, and micro-finance show promise for innovation in water and sanitation fields
- Business models need to be integrated early in solution formulation
- Scaling factors need to be better understood