



*IP to market*

CORINIUM INNOVATION

# Key Issues and Opportunities for Innovation in the Global Water Sector – a Perspective

Dr Gerald Jones



---

*“The only true wisdom is in knowing  
you know nothing”*

Socrates



- 
- Key issues and priorities:
    - EU, China, US
    - WaterAid
  - Major sector issues:
    - Mining
    - Agriculture
    - Energy
  - Case studies:
    - Water utility
    - Manufacturer
  - Role of scientific understanding:
    - Material science
    - Microbiology
  - Strategic innovation:
    - Water policy
    - Strategic investments



- 
- **Key issues and priorities:**
    - EU, China, US
    - WaterAid
  - Major sector issues:
    - Mining
    - Agriculture
    - Energy
  - Case studies:
    - Water utility
    - Manufacturer
  - Role of scientific understanding:
    - Material science
    - Microbiology
  - Strategic innovation:
    - Water policy
    - Strategic investments

# Key issues and priorities: EU, China, US



## EU

- Population 503 million – 2012
- Projected population 517 million – 2060
- 41% live in urban regions
- 35% in intermediate regions
- 24% in rural regions



# Key issues and priorities: EU, China, US



## China

- Population 1.3 billion – 2010
- Projected population 1.4 billion – 2050



# Key issues and priorities: EU, China, US

---



## US

- Population 316 million – 2011
- 80% live in cities and suburbs
- Projected population 439 million - 2050



# EU Innovation Partnership

## EU (EIP Water)

---



- Headline target for 2020
- Identify, test, scale up, disseminate and stimulate the uptake of innovative solutions
- For 10 major water related challenges

*Brussels – end 2012*



# EU Innovation Partnership

## EU (EIP Water)

---



*“Markets alone are not always capable of delivering the appropriate innovation at the right time”*

*“EU water sector relatively risk averse”*

*“For EU industry sectors such as process industries where water is a key resource, efficiency gains are hindered by a lack of suitable innovations”*

# EU Innovation Partnership

## EU (EIP Water)

---



*“Time to market needs to be shortened”*

*“Procurement rules do not always favour innovation”*

*“Europe is very strong on research but fails to turn the knowledge into added value for society and markets”*

# EU Innovation Partnership

## EU (EIP Water)

---



### Priority areas:

- Water re-use and recycling
- Water and wastewater treatment, including recovery of resources
- Water and energy nexus
- Flood and drought risk management
- Ecosystems services
- Also cross-cutting priorities
  - Water governance
  - Decision-support systems and monitoring
  - Financing for innovation

Generalised reference to “Smart Technology”

# EU/UK Perspective

---



## UK

Ofwat: economic regulator for private water utility sector in England and Wales

Innovation priorities:

- Reducing leakage
- Adapting infrastructure to a changing climate
- Economic regulatory reform to incentivise markets and innovation
- Environmental pollution protection
- Sustainable drainage

# EU/UK Perspective

---



- Increasing efficiencies in treatment processes and waste management
- Promoting end-user education
- Reducing water consumption and promoting sustainable disposal
- Reducing water supply interruptions
- Comprehensive underground asset mapping
- Smart metering
- Sustainable abstraction
- Strategic connections for water-stressed areas

# China



- China covers roughly same geographic area as United States
- Population is nearly five times greater
- China has rugged mountains in the West and vast deserts in central area. Population is concentrated in a relatively small area
- Urban population exceeded rural population in 2012
- Projected urbanisation 70% by 2050
- Projected urban population increase 300-700 million (cf London 8 million, Dublin 1.2 million)

# China



- Planned spend of \$850 billion in next decade
  - \$650 billion on rural water projects 2011-2020
  - \$200 billion on clean-up projects
- Environment Ministry says 43% of monitoring locations in 2011 showed water 'unfit for human contact'. This is despite spending \$112 billion on water infrastructure in period 2005-2010.
- Zhou Lei (Nanjing University) considers a key problem is pressure on local water resources resulting from three decades of blistering economic growth. He estimates a shortfall of 50 billion cubic metres/annum to feed growing energy and agricultural demand.



- The high costs suggest that treatment rather than prevention remains the strategy.
  - On top of the 10 year rural water plan, a further \$20 billion has been allocated to treat small and medium-sized rivers over the next 2 years. This is in addition to spending by:
  - Local governments
    - This spending is primarily to upgrade from:
      - Grade V: ‘no human contact’ to
      - Grade IV: ‘industrial use only’
- The intention is to make more water usable by industry.





## Water consumption

- 4-10 times more water/unit of GDP as other competitive economies
- Largest proportion of industrial use is devoted to energy
- Mining, processing and consuming coal accounts for 20% of all water consumed nationally

## Southern China

- 90% withdrawal from surface water in 2010
- 25% not usable by industry less than 50% found to be drinkable

# China



- Chen Lei (Ministry of Water Resources): 2/3 Chinese cities face increased water scarcity
- ¼ of China's rural population, 320 million, don't have access to safe drinking water
- Exploitation of groundwater is increasing, leading to dramatic drop in groundwater tables
- 100-300 metres in Beijing
- 90 metres in other parts of China
- Major implications of land subsidence already being felt

# China



- Political and social stability in China is dependent on finding solutions to these problems
- There remains a tendency to conceive major infrastructure projects as a potential solution
- The reality for the future is likely to require a balance between appropriate investment in major infrastructure, institutional and policy reform and a greater focus on innovative solutions
- China recognises the problems – it now has to conceive and deliver the solutions!



## Ageing infrastructure

- 90% water utilities state-owned. Privatisation not popular. Significant proportion of water is not metered

## Pressures on public funding:

- Water \$7 investment to \$1 revenue
- Wastewater \$8 investment to \$1 revenue

cf electric power industry:

- \$1.6-1.7 to £1 revenue

Challenge to maintain/improve/serviceability of existing assets

## Ageing workforce

- 37% water utility and 31% wastewater utility are eligible to retire by 2018
- Projected that employment needs to grow by 45% in coming years
- Pool of skilled technical workers is shrinking

## Challenge

- Knowledge capture and transfer
- Reducing labour intensity through automation

## Innovation

- Need is recognised **but** sector is traditional and innovation has not been part of culture
- EPA regulates eg VOC pharmaceuticals
- Cost of regulation?
- CSO's                                  how?                                  cost?

# US



---

## Role of EPA

### Water technology

- Equipment and chemicals
- \$3.9 billion trade surplus

### Total market

- \$319 billion environmental industry
- Water equipment/chemicals largest component



## EPA

### 'Top ten'

#### 1. Energy reduction and recovery of drinking water and wastewater facilities

- 150,000 drinking water facilities
- 15,000 wastewater facilities
- 4% of national electricity consumption
- Significant scope energy reduction
- Potential for some energy production

#### 2. Nutrient recovery for wastewater N&P reduction to reduce nutrient pollution

Potential N&P recovery



---

## 3. Improving and ‘greening’ the nation’s infrastructure

- Rehabilitation need for water and wastewater infrastructure estimated at \$650 billion ‘green’ infrastructure for stormwater management.
- Decentralised approaches to reduce pumping and treatment costs.

## 4. Water re-use

- 15,000 wastewater treatment plants.
- 9.5 trillion gallons wastewater/year
- Much greater scope for water re-use





## **5. Improved and less expensive monitoring**

- Less than 30% of nation's surface water bodies are assessed by EPA
- Focus on smart sensor technology, remote sensing (drones, satellite imagers)
- Integration with telemetry and IT

## **6. Improved reliability of small drinking water systems**

- Over 90% of 150,000 public water systems are small, serving fewer than 3,000 people.
- Need improved technology and operational controls to protect public health at less cost and with greater reliability.



---

## 7. Technology evaluation & performance

Barriers to entry and take up of new technologies from pilot testing to market

Calls for improved technology evaluation by independent 3rd parties.

## 8. Reducing water impacts from domestic energy production

Using new technology to alleviate water quality and quantity issues associated with energy production.



## 9. Resilience of water infrastructure

- Dealing with extreme weather events
- How to rebuild existing and build new infrastructure to achieve greater resilience

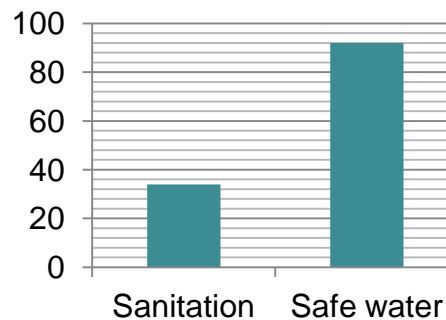
## 10. Improving water quality in oceans, estuaries and watersheds

- Less than half of nation's surface waters achieve their intended use (eg potable water supply, swimming, fishing)
- Groundwater is also vulnerable to pollution
- Need innovative approaches to protect and rebuild ecosystems and restore watersheds

- 
- 783 million people don't have access to safe water; 1 in 10 of the world's population
  - 2.5 billion people don't have access to sanitation. Almost  $2/5^{\text{ths}}$  of the world's population
  - Around 700,000 children die every year from diarrhoea caused by unsafe water and poor sanitation – almost 2,000 children/day.

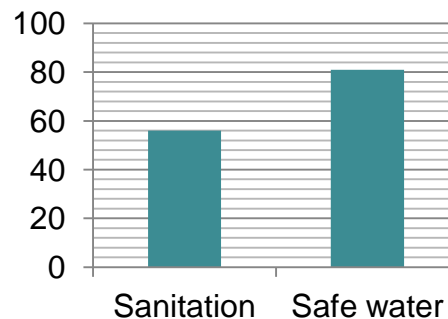
## WaterAid works in 27 countries

- India



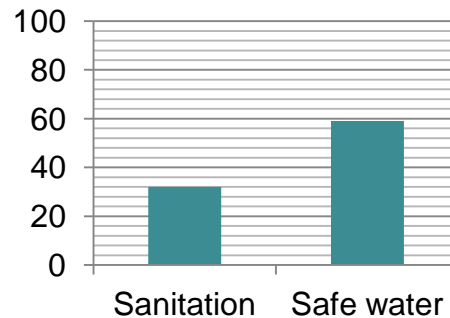
700 million people have no access to toilets  
100 million have no safe water

- Bangladesh



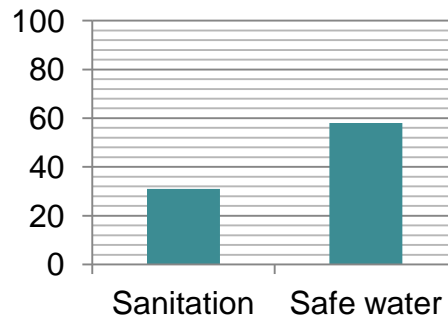
Monsoon flooding, cyclones and arsenic in water sources are among challenges

- Kenya



Water and sanitation coverage remains dangerously low, despite progress

- Nigeria



Africa's most populous country; almost half have no safe water and around 70% have no sanitation



- 
- Key issues and priorities:
    - EU, China, US
    - WaterAid
  - Major sector issues:
    - Mining
    - Agriculture
    - Energy
  - Case studies:
    - Water utility
    - Manufacturer
  - Role of scientific understanding:
    - Material science
    - Microbiology
  - Strategic innovation:
    - Water policy
    - Strategic investments

# Mining



## Gold

Most gold-mining operations use cyanide to extract gold from surrounding rock



eg in 2000 a breach in a mine tailings dam at a gold mine in Romania released 100,000 cubic metres of cyanide-rich waste into the watershed. Nearly all aquatic life died. Drinking water cut off for 2.5 million people.

US regulations don't require mine operators to monitor cyanide and its breakdown compounds in nearby groundwater and water bodies





## Alternative technologies exist:

Haber Gold Process: a non-toxic extracting system. Tests show more gold recovery over a shorter period than cyanidation.

YES Technologies – biocatalyzed leaching process said to be 200 times less toxic than cyanide

**but** cyanidation is established and entrenched in the sector.

Weak or non-existent regulation

# Agriculture & Horticulture



## Tomatoes

Israel – Arava region & southern Negev desert: 300 tons/hectare/year



- No fertile soil
- Limited water

600 families

8 settlements

3000 people

Produce 150,000 tons of vegetables/year in greenhouses.

# Agriculture & Horticulture

---



**Israel** is a pioneer in drip-feed irrigation

- Economy in water
- Economy in fertiliser
- Fertigated crops are earlier maturing, higher yield and better quality
- Better pest and disease resistance
- Better drought tolerance
- Plant breeders continually developing new varieties to improve plant genetics
- Multi-disciplinary innovation in agriculture

# Agriculture & Horticulture

---



## Greece and Holland

- Greece produces twice as many tomatoes as Holland
- Greece exports very little
- In summer months, Greece imports tomatoes from Holland
- Greece can't grow a crop during the hottest time of the year
- Holland employs high tech greenhouses
- Greece has two harvests a year – poor weather, poor harvest
- Holland has temperature-controlled greenhouses
  - Holland – 70 kg/m<sup>2</sup>/year
  - Greece – 7 kg/m<sup>2</sup>/year

## Shale oil extraction

Hydraulic fracturing and water resources issues:

- Chemicals in the fracturing fluids and the risk of groundwater contamination
- Water requirement for fracking in potential conflict with other water needs such as agriculture and ecosystems
- Potential methane contamination of drinking water wells
- Storing, transporting, treating and disposing of wastewater



# Energy



- Some indications that hydraulic fracturing modifies the mobility of chemical contaminants bound up in natural strata
- “More and better research is needed to clearly assess the key water-related risks associated with hydraulic fracturing and develop sound policies to minimise those risks” (Pacific Institute)
- Lack of disclosure of chemicals used citing commercial confidentiality and competitiveness issues
- Regulatory process appears inadequate – eg exemptions from Clean Water Act for oil and gas companies
- Polarisation between oil and gas producers and lobby groups



- 
- Key issues and priorities:
    - EU, China, US
    - WaterAid
  - Major sector issues:
    - Mining
    - Agriculture
    - Energy
  - **Case studies:**
    - **Water utility**
    - **Manufacturer**
  - Role of scientific understanding:
    - Material science
    - Microbiology
  - Strategic innovation:
    - Water policy
    - Strategic investments

# Water Utility:



---

## Thames Tideway Tunnel

- Major new sewer
- Tackles problem of CSO discharges into the river Thames for at least the next 100 years
- Enables EU environmental standards to be met
- Overcomes capacity problems with existing mainly Victorian sewer system
- Special purpose company (SPC)/private investors
- Major objections from Hammersmith & Fulham council – disruption and excessive cost - £4.2b - £80/yr for foreseeable future
- Final decision expected Autumn 2014



# Water Utility:



---

## Thames Tideway Tunnel - Real-time control

- Problem of storm overflows from combined sewer system into the river Seine during heavy rainfall
- Began to implement RTC of sewer system in 1996. Subsequently EU Sprint programme applied state-of-the-art techniques of modelling and control
- This implementation showed that an 80% reduction of flows into the Seine could be managed by RTC system

# Water Utility:



## Thames Tideway Tunnel

- The proposed tunnel is between 6.5 and 7.2 metres in diameter
- 66 metres at its deepest point
- 25.1 km long
- One of the largest and deepest tunnels in London
- SUDS option considered and rejected
- No specific mention of RTC option or integrated SUDS and RTC option

# Water Utility:



---

## Thames Tideway Tunnel – Observation

- The existing sewer system in London is a ‘dumb’ or ‘passive’ system
- The proposed tunnel is a ‘dumb’ or ‘passive’ system
- The tunnel is a conservative rather than an innovative solution
- Are Thames Water customers getting value for money?

# Manufacturer:



- Ingolstadt production plant produces 500,000 vehicles/year
- 4.9 cubic metres water/car in 1988
- 1.5 cubic metres water/car in 2007
- Collects rainwater from an area of 450,000 square metres
- By end of 2014, 97% of water will remain within the plant circulation system
- Drinking water is used for drinking and showers



# Manufacturer:



- 
- Service water is used for everything else
  - Implementing MBR (Membrane BioReactor) technology to treat wastewater
  - Reducing freshwater consumption by 40% saving 500 million litres/annum
  - Reducing proportion of wastewater by 50% and hazardous wastes by 20%
  - Enables recycled wastewater to be used for industrial production
  - MBR enters service mid 2014



- 
- Key issues and priorities:
    - EU, China, US
    - WaterAid
  - Major sector issues:
    - Mining
    - Agriculture
    - Energy
  - Case studies:
    - Water utility
    - Manufacturer
  - Role of scientific understanding:
    - Material science
    - Microbiology
  - Strategic innovation:
    - Water policy
    - Strategic investments

# Graphene

---



## Manchester University:

- Andre Geim and Konstantin Novoselov: Nobel Prize in Physics 2010
- ‘Ground-breaking experiments regarding the 2-dimensional material graphene’
- Thinnest known material
- Strongest material ever measured
- Crystalline but elastic (can stretch up to 20% of its length)
- Very efficient electrical conductor

# Graphene

---



- Can sustain current densities up to six orders of magnitude higher than copper
- Best thermal conductivity of any material
- Most impermeable material ever discovered



# Graphene

---



## Earliest mention in a patent – 1994

- 3011 patents published – 2011
  - UK 54 patent applications
  - China 2,204
  - US 1,754
  - South Korea 1,160
  - Samsung 407
  - IBM 134

# Graphene

---



- Water sector emerging applications eg MIT
- Desalination:
  - Graphene as a potential filtration material
  - Potential to be far more efficient and possibly less expensive than existing membrane systems

# Antibiotics



Dame Sally Davies (UK Government Chief Medical officer):

Threat posed by antibiotic resistance:

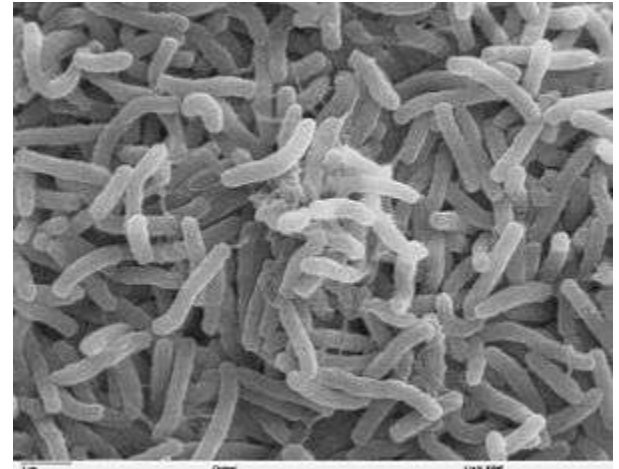
- ‘ticking time bomb’
- ‘as important as climate change’
- ‘should be ranked alongside terrorism on list of threats to the nation’
- No incentive for pharmaceutical industry to produce new drugs
- Progressively increasing resistance to currently available antibiotics
- Discovery void since 1987

# Cholera



- No longer a threat in developed countries
- E1 strain of *vibrio cholerae*
  - 535,000 cases
  - 7,000 deaths

## Resilience and robustness of disinfection



# E coli



- Walkerton, Canada, 2000
- Population < 5,000
- 2,300 fell ill, 7 died
- Breakdown in water system
- Surface water leaked into well water
- Inadequate/poor management
- Economic impact \$155m
- Need vigilance?





- 
- Key issues and priorities:
    - EU, China, US
    - WaterAid
  - Major sector issues:
    - Mining
    - Agriculture
    - Energy
  - Case studies:
    - Water utility
    - Manufacturer
  - Role of scientific understanding:
    - Material science
    - Microbiology
  - **Strategic innovation:**
    - **Water policy**
    - **Strategic investments**

# Climate change

---



- 4° Turn Down the Heat, World Bank report
- 4° scenarios are devastating
- *'A 4°C warmer world can and **must** be avoided'*.

Dr Jim Yong Kim  
President, World Bank Group



# Climate change

---



The Stern review published in 2006 pointed to a 75% chance that global temperatures would rise between 2 and 3°C above the long term average.

*'I got it wrong, on climate change – it's far, far worse'*

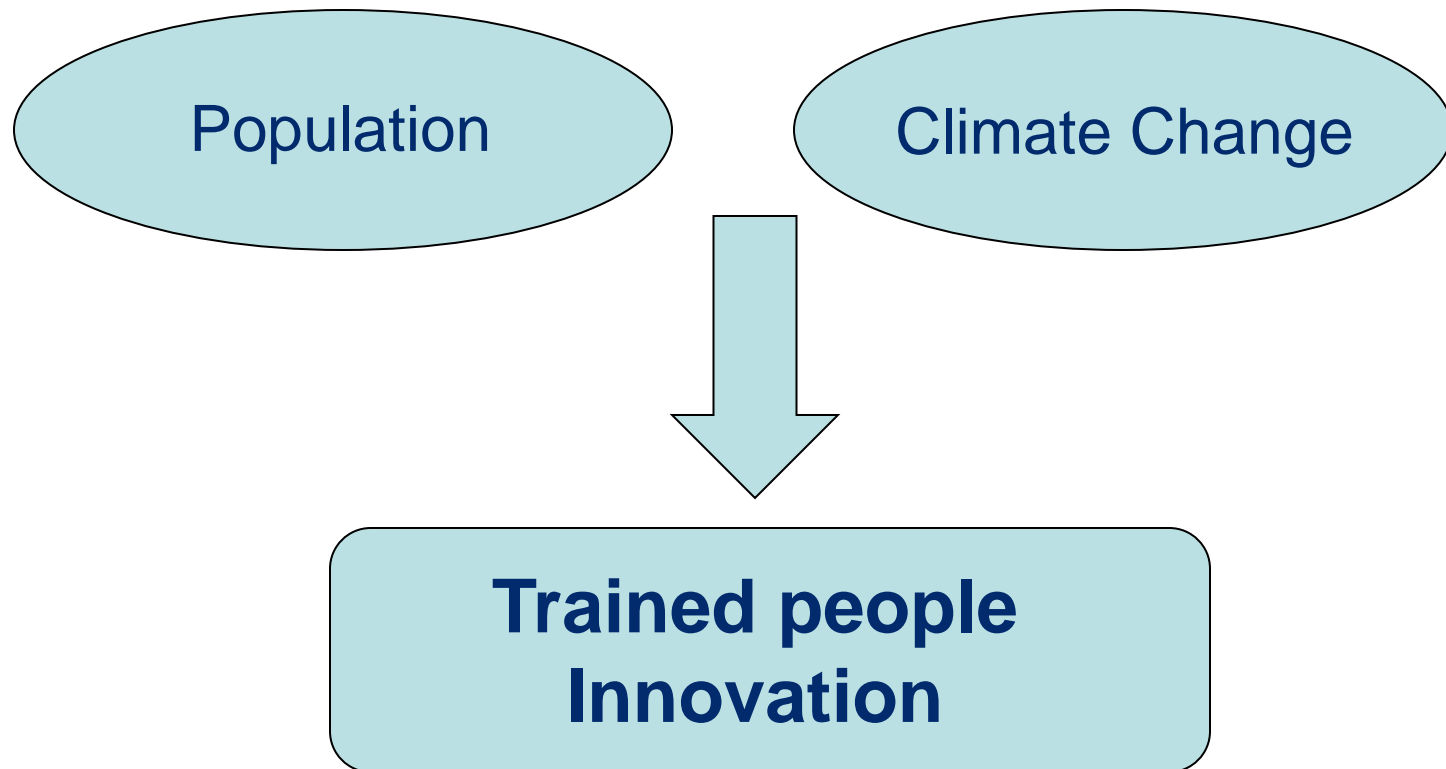
*'Planet on track for 4°C rise'*

(Stern, Davos 2013)



# Global Water Sector

---




# Global Water Sector



- Time to end complacency and the 'status quo'
- Time to innovate and invest



Risk of innovating  Risk of not innovating