Water - Energy Linkages and Technology Challenges

Gustaf Olsson
Lund University, Sweden

In Search of Sustainable Well-Being
Tokyo
Sep 12-13, 2008

Mother Earth -- our home

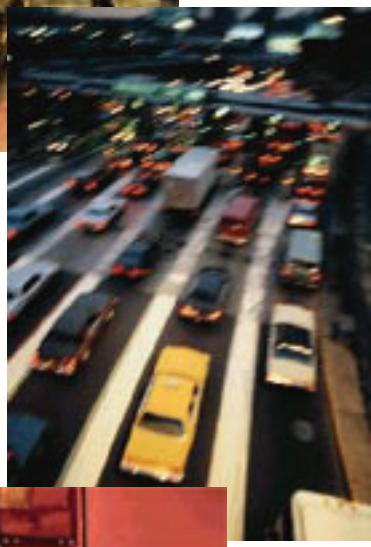
It has water, oxygen and a hospitable climate

Energy - Environment - Economics

Content

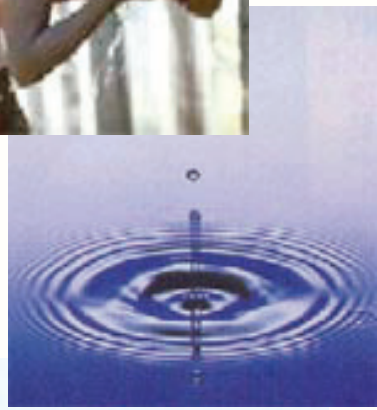
- **Water – there are no substitutes**
- **The water – energy linkage**
- **Energy in the water industry**
- **Monitoring**
- **Energy to produce clean water**
- **The systems approach**

The Challenge: Sustainable Energy



Gustaf Olsson, Lund, Sweden

In Search of Sustainable Wellbeing, Tokyo, Sep. 2008



Industrial Electrical Engineering and Automation

The Challenge: Water Security

Gustaf Olsson, Lund, Sweden

In Search of Sustainable Wellbeing, Tokyo, Sep. 2008

Impact - Human Systems

Sensitive Systems

- Water resources
- Agriculture, forestry, fisheries
- Human settlements
- Industry, energy, financial services

Vulnerabilities

- Food and water security
- Incomes and livelihoods
- Human health
- Infrastructure

The Growing Water, Energy and Sanitation Crisis

1.2 billion (10^9) people do not have water within 15 minutes walk

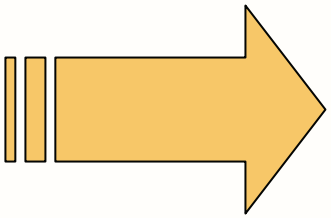
The weight of water that women in Africa and Asia carry on their heads is commonly 20 kg

Water Demand Increasing
Water Supply Decreasing

- **Europe - precipitation**
  - **Precipitation has decreased 20% 1900 - 2000**
  - **Additional 1% reduction every 10 years expected**
  - **Summer rains decreasing 5%**
- **Desalination**
  - **Mediterranian area - 18 % annual increase**
  - **Saudi Arabia - 17% annual increase**

The ”Drivers”

- **Climate change**
- **Infrastructure is aging and deteriorating**
- **Globalisation and population growth**
- **Drives towards sustainability**

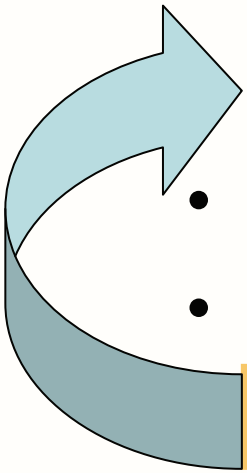


The growing water and sanitation crisis

Svante Arrhenius
(Swedish physicist, Nobel Prize winner) 1919

”Until the outbreak of the (first) world war (1914-1918) we lived in a time of feverish development. During ten years we burnt as much coal as during all the previous years of mankind, some 100 000 years. There is a similar fact about a large number of other raw materials. Therefore it has been questioned how all of this will end up if we continue like this. Like mindless wasteful humans we destroy what we have inherited from our parents. Our children will judge us since we have wasted what should belong to them.”

The main Focus of World Leaders



- **Fresh water**
- **Renewable energy**

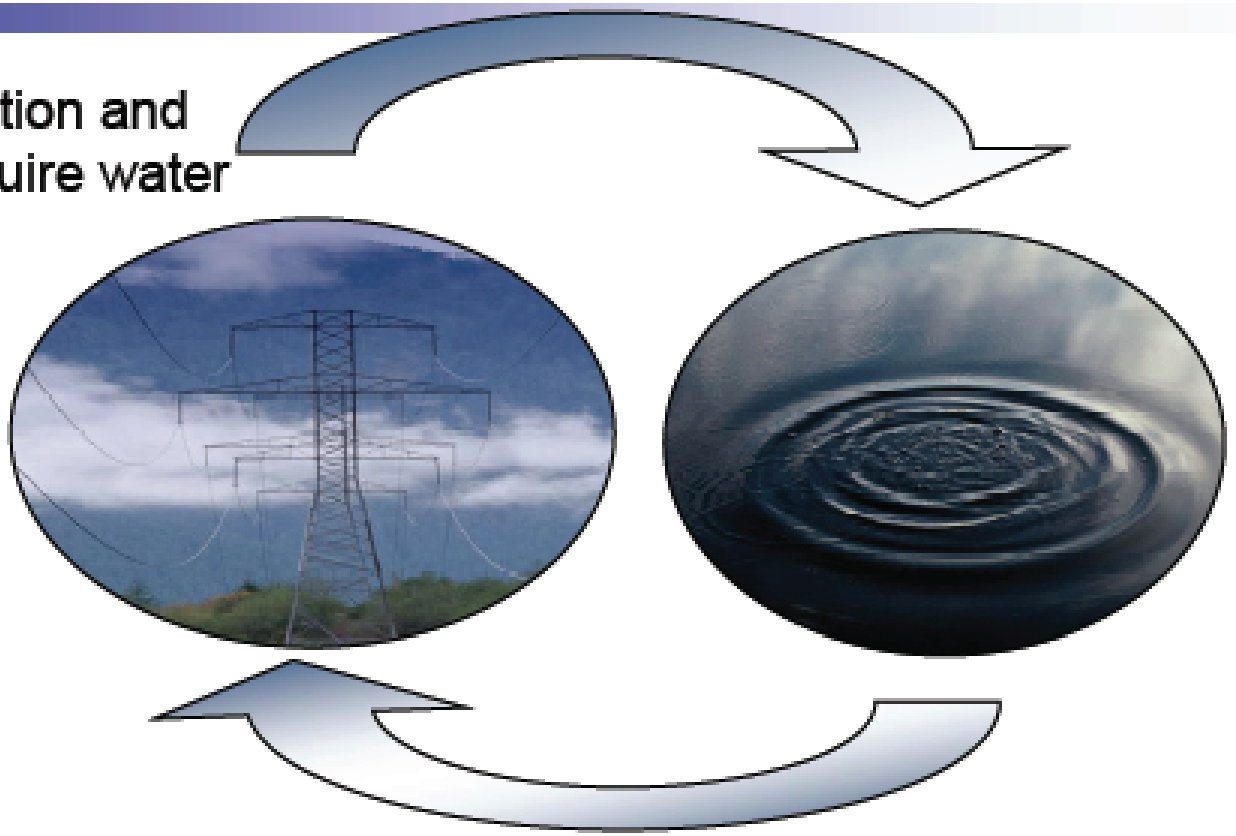
Poverty

Content

- Water – there are no substitutes
- The water – energy linkage
- Energy in the water industry
- Monitoring
- Energy to produce clean water
- The systems approach

Energy and Water are Inextricably Linked

Energy production and generation require water



Water pumping, treatment, and distribution require energy

Water to get Energy

We eat 2000-3000 kcal
each day to get energy

To get the food
2000 – 3000 liters are needed

Energy for Water – a key Challenge

- having the energy to extract water from underground aquifers
- transport water through canals and pipes
- manage and treat impaired water for reuse

Desalinate
brackish and sea water to provide new fresh water sources.

Water for Energy Production

Depending on the availability of water:

- **Hydropower**
- **Cooling of thermal power plants**
- **Fossil fuel production and processing**
- **Hydrogen economy**

Energy to Pump and Clean Water

Example Sweden

1% of all *electric* power consumption
is used for
water supply and wastewater treatment

With more advanced water treatment
we need more energy

Water/Energy – Indirect Linkages

- **Energy production - potential contamination of underground and surface water supplies**
- **Competing water uses - limit use of waterways – water for cooling**
- **Water and energy are the critical elements of sustainable economic development – we need both**

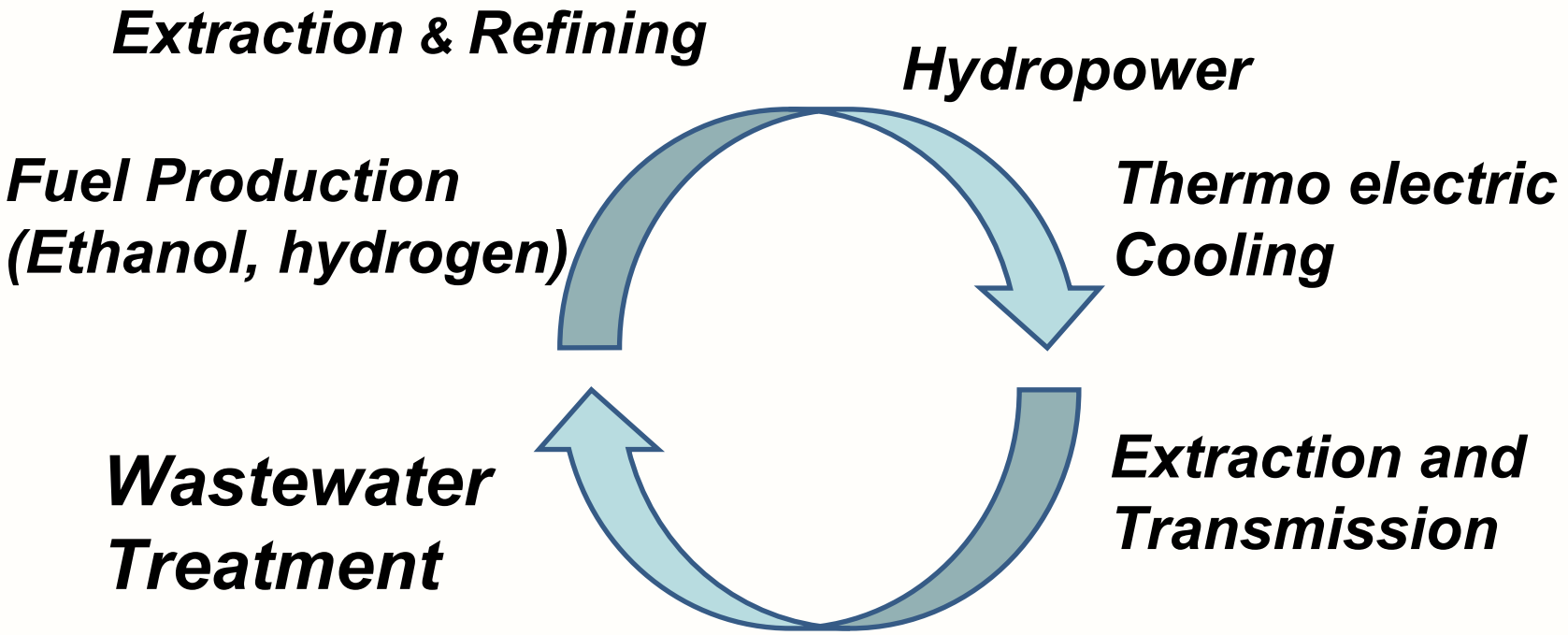
Dr. Allan R. Hoffman
U.S. Department of Energy

Water/Energy – Other Linkages

- On a global basis, neither water nor energy are in short supply
- What is in short supply is energy and water at a price that people can afford to buy
- Priority #1 is wise, efficient use of available supplies
- Then, focus on new supplies that meet sustainability and environmental requirements

Dr. Allan R. Hoffman
U.S. Department of Energy

WATER FOR ENERGY



ENERGY FOR WATER

Gustaf Olsson, Lund, Sweden

Content

- Water – there are no substitutes
- The water – energy linkage
- Energy in the water industry
- Monitoring
- Energy to produce clean water
- The systems approach

Clean Water Requires Energy!

- **Pumping**
  - **Having efficient pumps for adequate flows**
  - **Operating at dynamically changing flows and pressures**
- **Aeration in wastewater treatment**
  - **Controlling the air flow for variable loads**

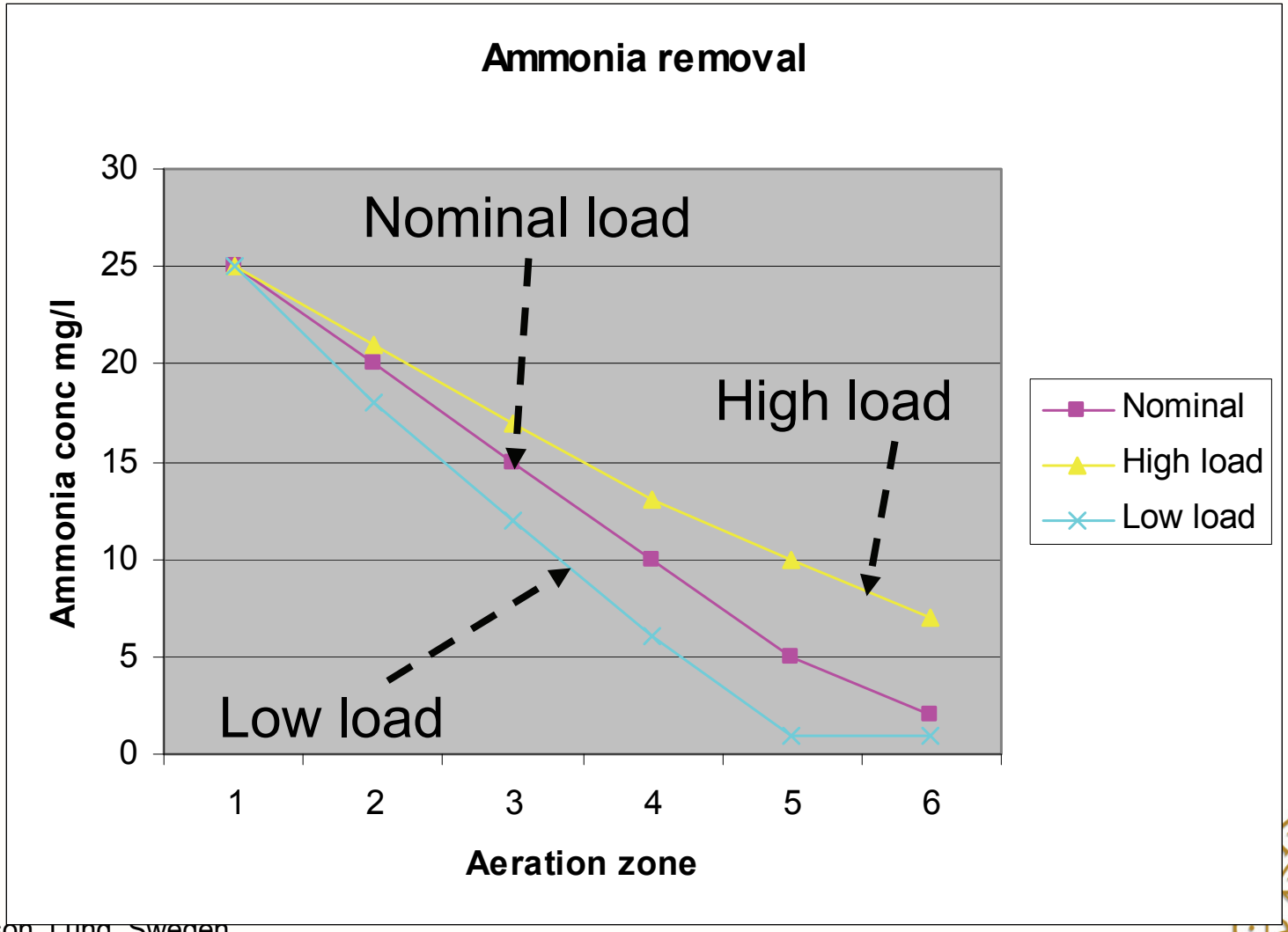
Water Reclamation Plant

Biogas production

Biological reactors

Gustaf Olsson, Lund, Sweden

Biological nitrogen removal
Controlling oxygen



Sustainability – Technology Challenges

- Saving energy
  - By more efficient equipment
  - By better control
  - By better coordination of many unit processes
- Saving chemicals
  - By better control
- Producing more biogas energy
  - By better control

Sustainability – Technology Challenges

- Detect leakages
- Detect pollutants and pathogens
- Integrated water management
  - Supply, sewers, treatment, receiving water

Sustainability is a business opportunity

Water Reuse

Wastewater treatment ought to become facility for

Water Reuse and Energy Recovery

- **Water reuse**
- **Saving energy consumption**
- **Maximizing energy production**

Anaerobic Digestion – Making Biogas

- **AD uses only 20% of the energy content of the sewage**
- **AD often perceived as being unstable**
- ***Traditional*: operate at low capacity**

- ***With close monitoring and control*: better use of capacity – better stability – handling of disturbances**

European Project - WSSTP

Water Supply and Sanitation Technology Platform

”Water for people”

The WSSTP Strategy

- Do not address singles issues in isolation
- Adopt a systems approach
- Develop integrated solutions
- Interdisciplinary!

Research Needs (1)

- **Water saving techniques**
  - **Early detection of leakages**
- **Water quantity should be controlled**
  - **Smart irrigation**
- **Smarter & lower cost treatment of alternative water resources**
- **Storage - aquifer storage & recovery**
- **Decision support systems**

Research Needs (2)

- Improved (automatic, on-line) monitoring and management of the effects of water supply and sanitation
- Reduced inputs and wastage
- Efficiency in power and chemical use
- Better re-use and recovery of materials from water and wastewater treatment

Research Needs (3)

- Relationships between level of service, costs and willingness to pay
- Benchmarking tools and framework for referencing costs
- Monitoring and integrated control of processes and activities
- Systems adaptability

Content

- Water – there are no substitutes
- The water – energy linkage
- Energy in the water industry
- Monitoring
- Energy to produce clean water
- The systems approach

Monitoring (1)

- Using on-line instrumentation
- “The computer is awake all the time”
- Check all around the clock
  - water quality
  - water quantity

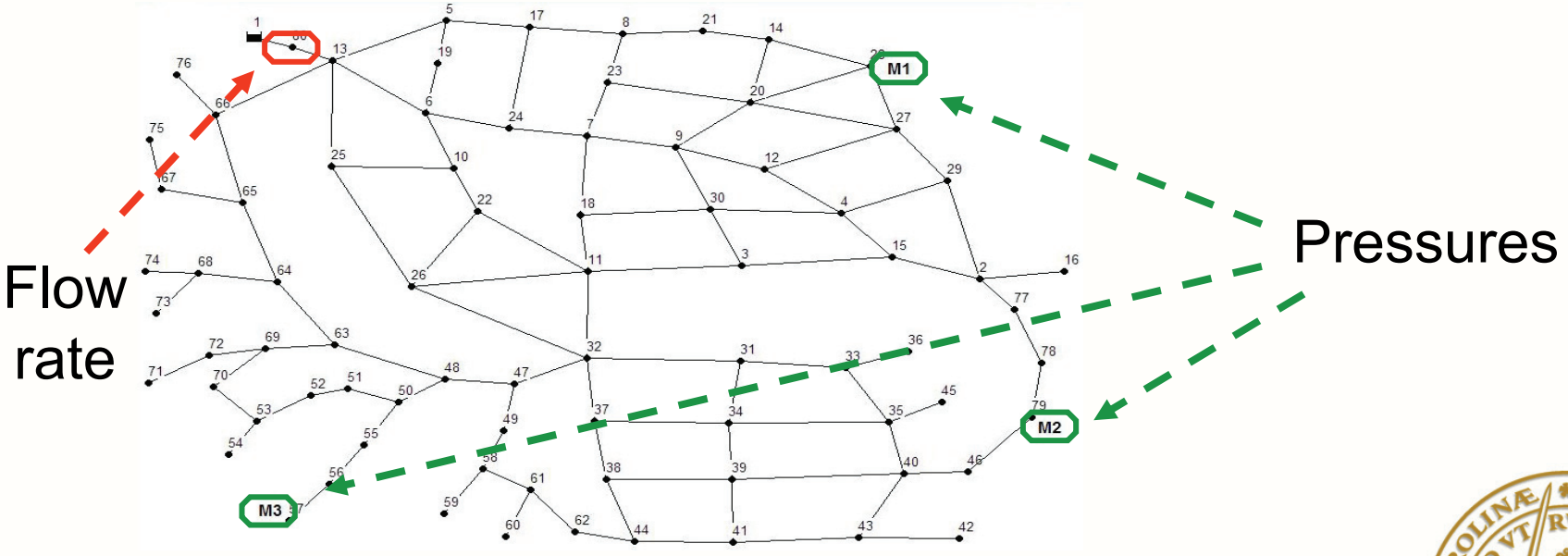
Water Supply - Pipe Failure

Automatic detection and localisation

Gustaf Olsson, Lund, Sweden

Water Supply
Failure Monitoring

- ***Continuous monitoring***
- ***Detection and location of bursts***



Content

- Water – there are no substitutes
- The water – energy linkage
- Energy in the water industry
- Monitoring
- Energy to produce clean water
- The systems approach

The World at Night

1.6 billion people lack access to electricity
More than 1 billion people lack access to clean drinking water
3 billion people live on less than $2 per day

Energy Security-What Does It Mean?

Broad themes associated with energy security:

- **Physical energy security**
- **Economic energy security**
- **Environmental externalities associated with energy use**

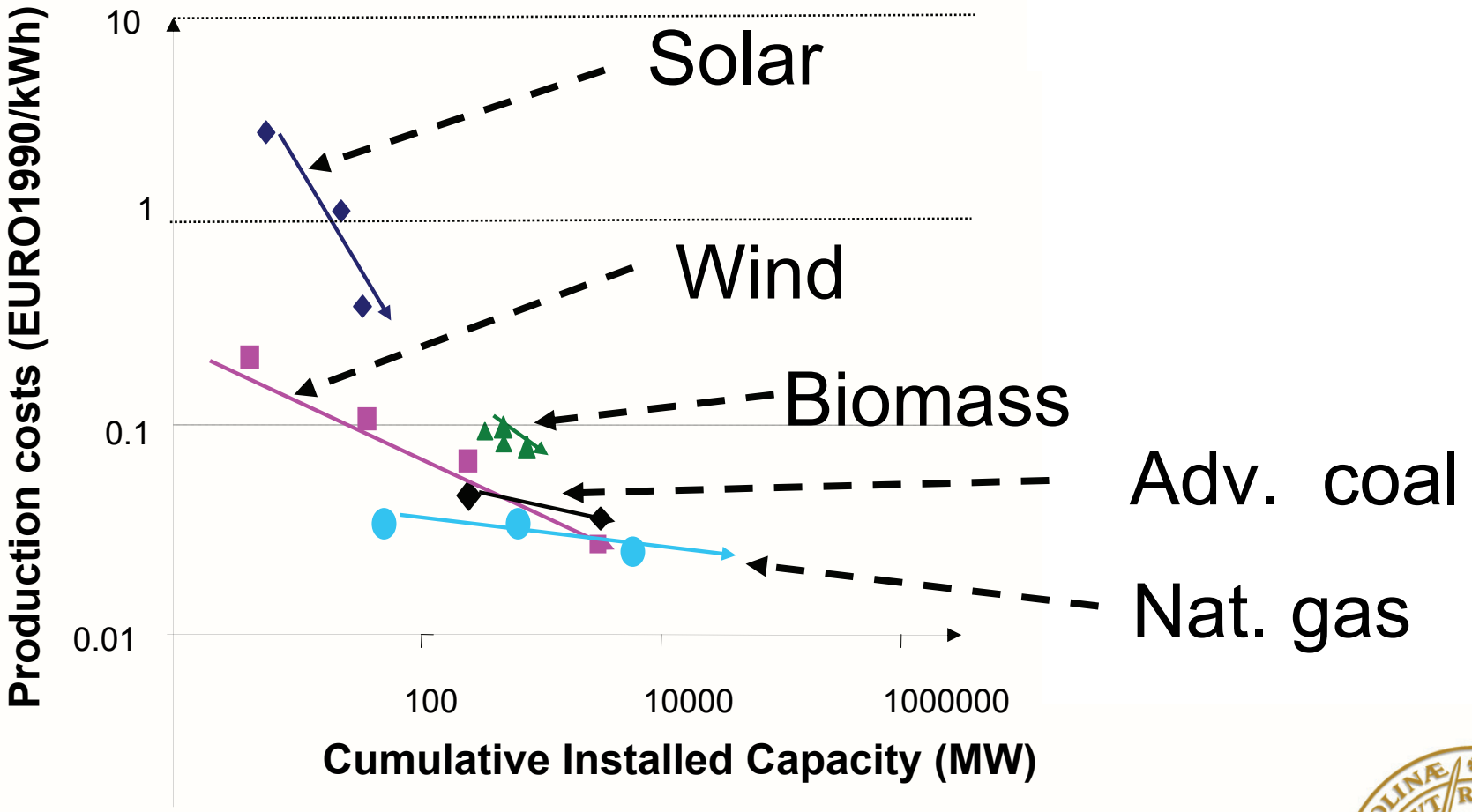
Dr. Allan R. Hoffman
U.S. Department of Energy

Energy and Water

To reach the MDG:

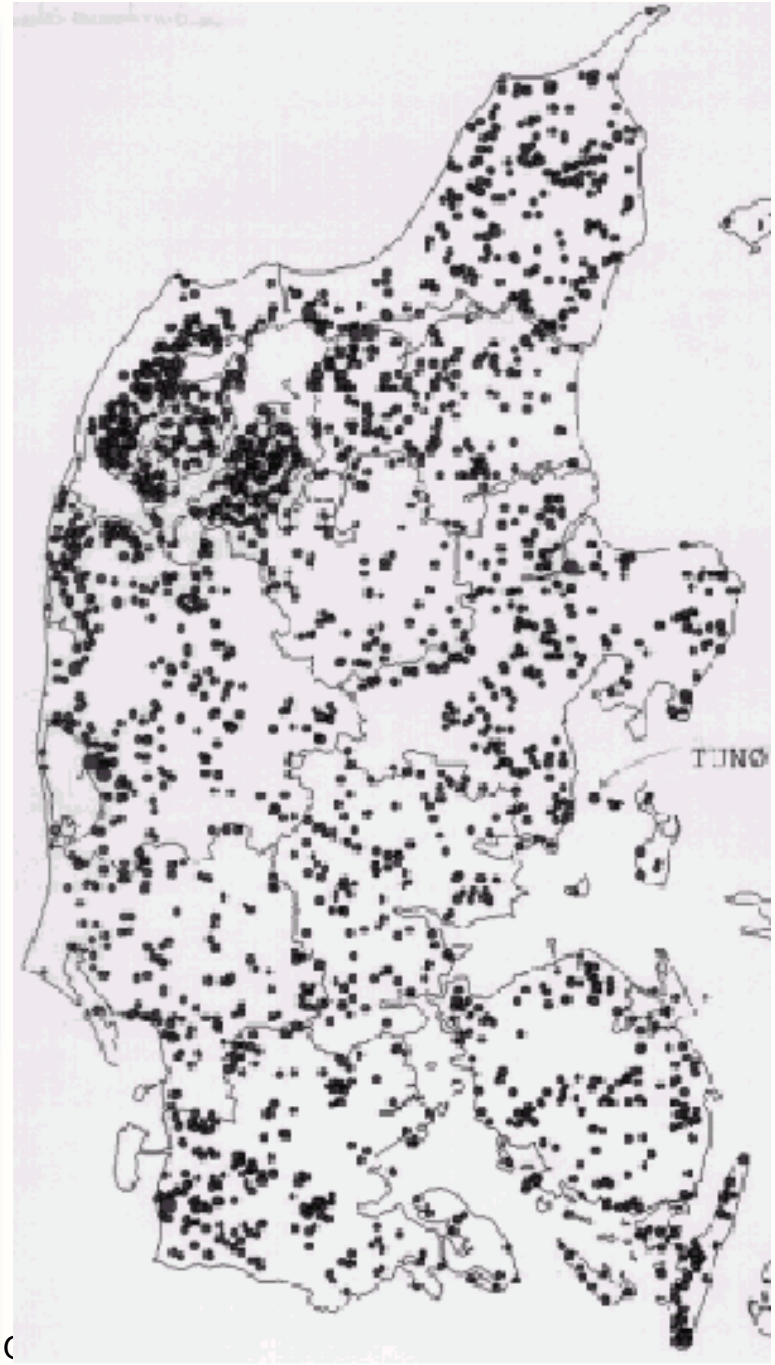
- **We have to find other solutions than those in industrialized countries**
- **Using sustainable sources of energy**
  - **Wind**
  - **Small scale hydro**
  - **Photo-voltaic (“solar”)**

Cost of Technologies



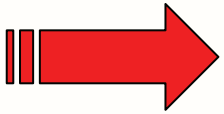
Source: IEA

Wind Power in Denmark



Content

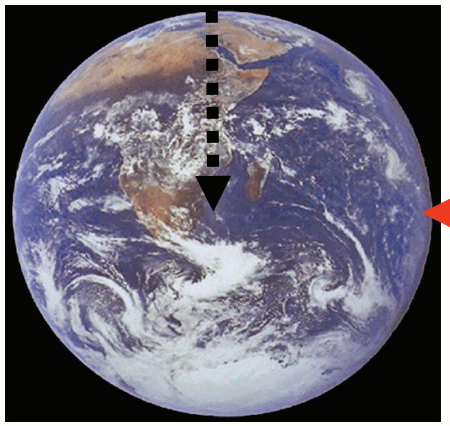
- Water – there are no substitutes
- The water – energy linkage
- Energy in the water industry
- Monitoring
- Energy to produce clean water
- The systems approach



Energy and Water Transformation and Delivery Process in 2035 - Three Key Characteristics -

Smart things everywhere

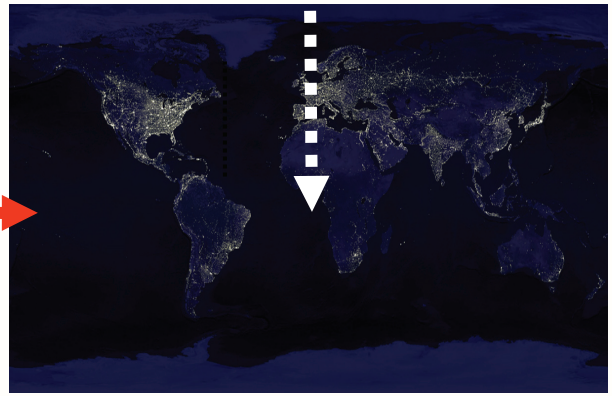
Information, sensors, actuators and ubiquitous computing



Resources

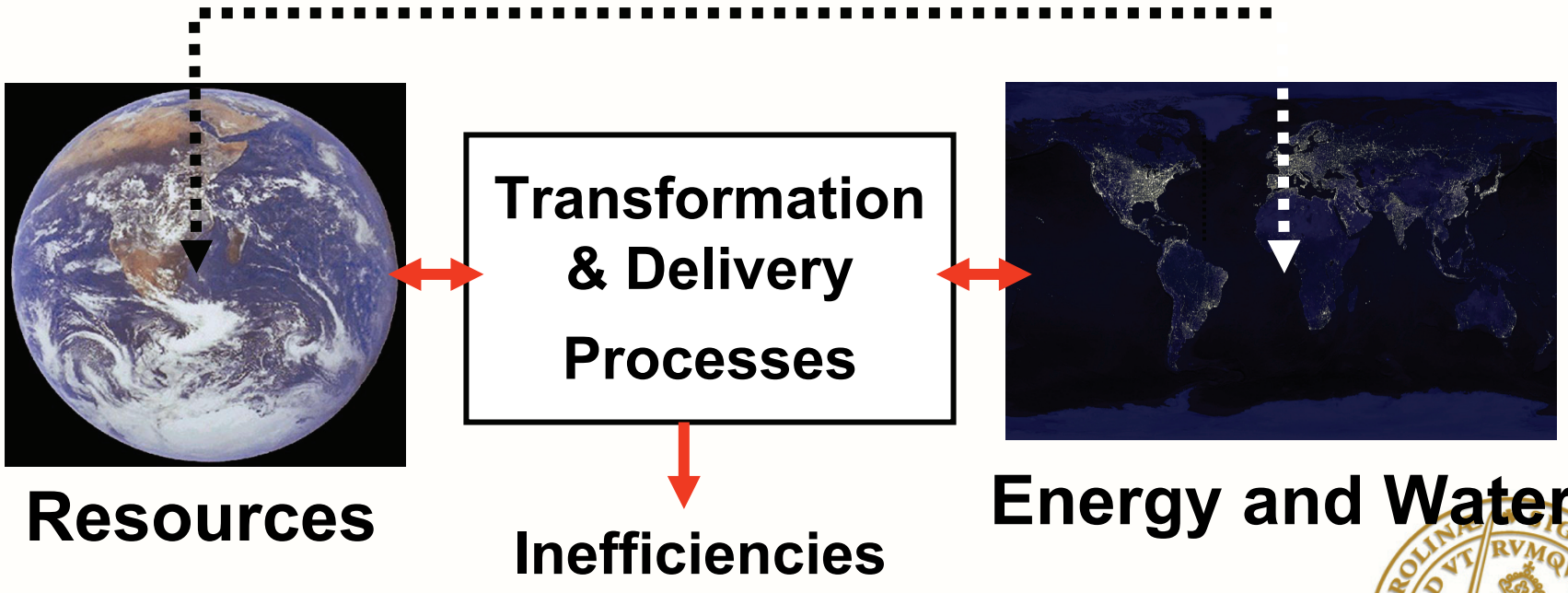
Transformation & Delivery Processes

Inefficiencies

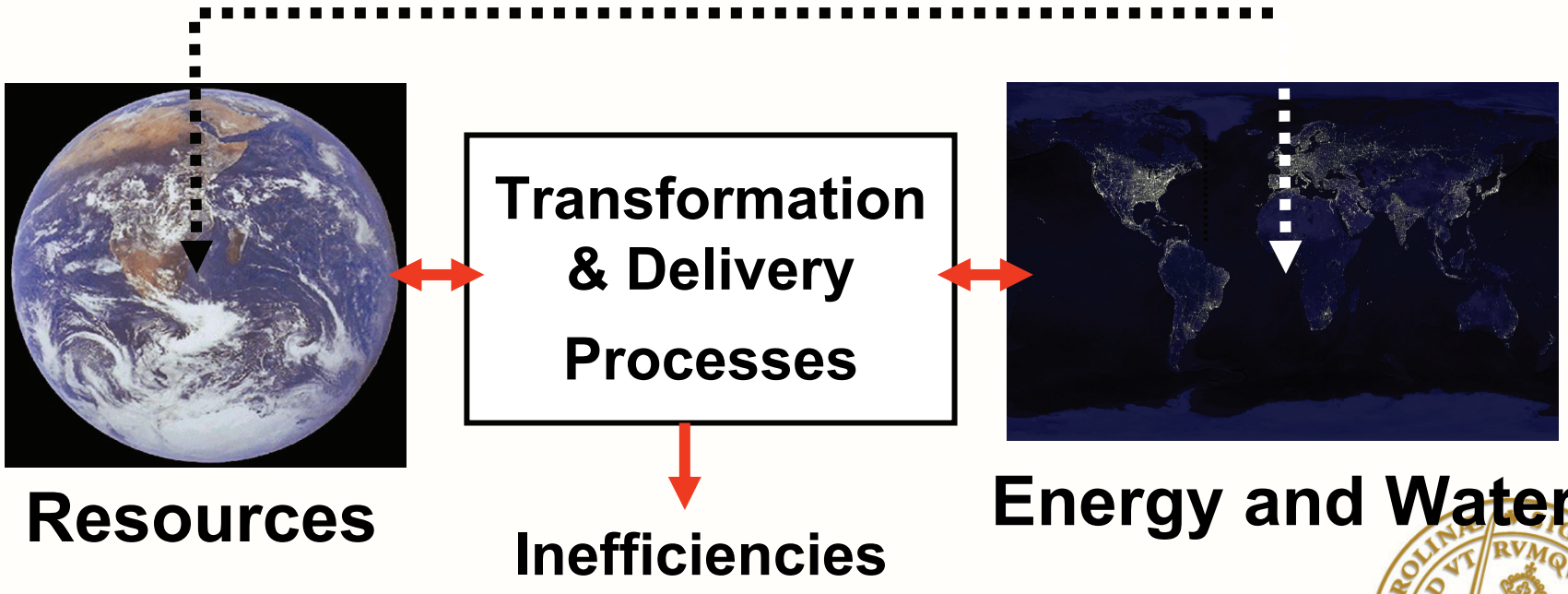


Energy and Water

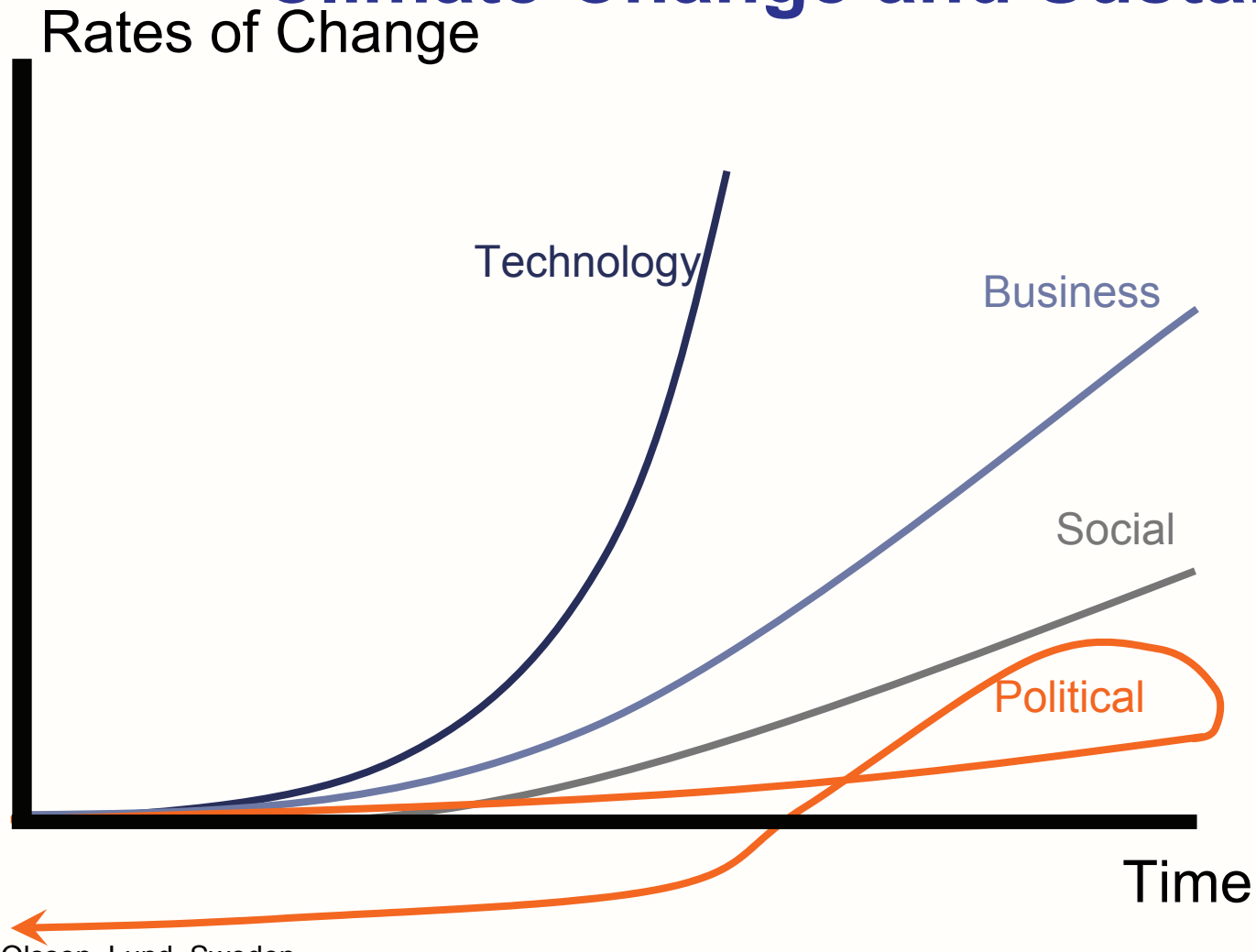
Small – Applications of Nanotechnology everywhere



Complex **– Interconnected and multilayered man-made artifacts with properties of natural systems and organisms**



Changes Required to deal with Water and Energy in light of Climate Change and Sustainability



Gustaf Olsson, Lund, Sweden

Conclusions (1)

- **Clean water is a human right**
- **We need**
  - **national strategies for water and sanitation**
  - **increase international aid**

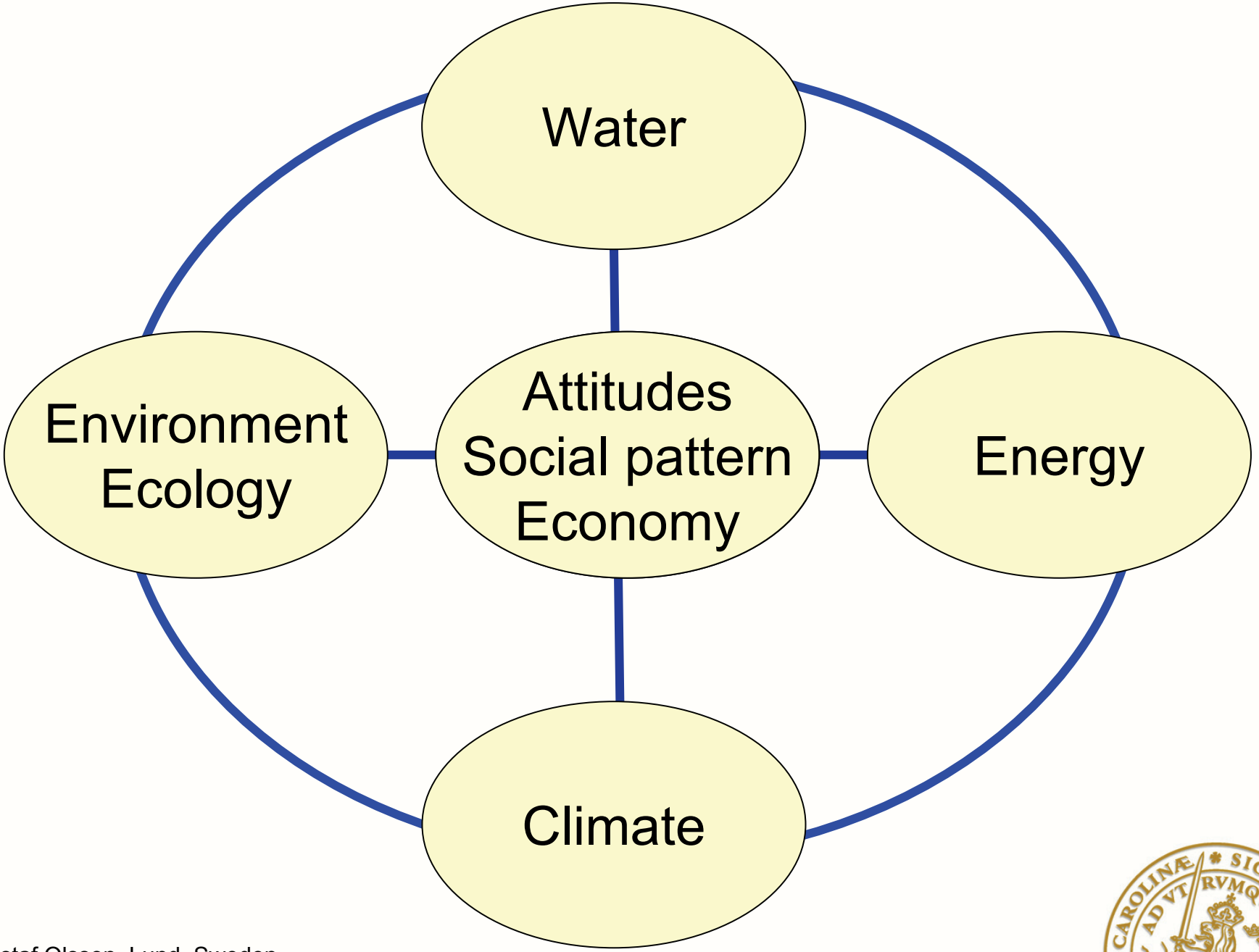
Conclusions (2)

- **Energy issues cannot be separated from water issues**
- **We can not take water resources for granted if energy security is not achieved**
- **If we are to achieve water and energy security, the linkage between the two must be explicitly recognized and acted upon**

Challenges...

- We have a lot of technology
- We need to develop even more
- **BUT:** we need more than science and technology
- Act in an integrated manner

  Water supply, sanitation and hygiene
- The water sector too often fragmented – private and public


Water
Environment
Ecology
Attitudes
Social pattern
Economy
Energy
Climate

If you don't want to do something, you can always find an excuse.

If you do want to do something, you can always find a way.

Old Polish Proverb


Thank you!

Please contact…

Gustaf Olsson

gustaf.olsson@iea.lth.se

Industrial Electrical Engineering and Automation