Where to Start? The Sustainability of Water Systems in the Global Village

by

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Reader, Queen's University Belfast

Editor in Chief, Renewable & Sustainable Energy Reviews, Elsevier

Biography

- Reader, Queen's University Belfast
- Editor in Chief - Renewable & Sustainable Energy Reviews
- Editorial Boards - Renewable Energy & Inst. Civil Engineers Proc. Transport
- Board of Directors - Sustainable Northern Ireland
- 12 years industry - energy, transport & waste infrastructure
- BE(Hons) (1996) & PhD (2011) from University College Cork
- MScEng (1999) from Trinity College Dublin
- £2.3 million in research income
- h-index of 22 (Scopus), 19 (Web of Science) and 23 (Google Scholar)
- c. 70 peer international reviewed articles in top 10% journals
- Chartered Engineer, Fellow Engineers Ireland & Fellow UK Higher Education Authority

Abstract

- Water = complex part of natural, social & built environment
- Water = 2/3rd cover of our planet
- Affects & influences **every** aspect of our planet = **anthropogenic activities, climate, weather, geomorphology and flora & fauna on land, in our seas, rivers and oceans and in the air**
- Used annual = 4,600 cubic km of water
- **70% in agriculture**, 20% in industry and 10% in households
- Water demand grows = typically at 1% per annum
- World's population 10.2 billion by 2050
- up by about 8 billion from today,
- **2/3 in urban areas, which will put this already endangered valuable natural resource under increased strain**

Abstract

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- Water quality in water cycle continues to deteriorate in Africa, Asia, Europe, North America and Latin America
- Due to runoff of fertilisers, hydrocarbons, discarded plastics and the discharge of untreated or inadequately treated industrial & municipal wastewater….ALL RELATED TO ANTHROPOGENIC ACTIVITIES
- Climate change **models** predict that wet regions will be wetter and dry regions drier
- **Exacerbate existing pressures and create additional ones on the natural, social and built environment in terms of water shortages, further health issues and migration and economic and political strife**
- Plenary talk = 1) aspects of these challenges, 2) examine sustainability of water systems & 3) discusses the role we can play as researchers and academics in our various fields **to support and inform society to fight climate change and balance all our natural resources including water considering the Food Energy Water nexus**

Background

- Paris Agreement on Climate Change
- Prioritises finance, technology and capacity-building to deploy ‘green’ technologies across all sectors and industries to reduce GHG & minimises fossil fuel dependency
- Some aspects of the sustainable energy transition considering corporate social responsibility, people, the planet and profits in manufacturing

Push & Pull

- Ever increasing demand for basic necessities of life
- Fresh air, food, sanitation, energy and water
- Drive for ‘modern’ technology & lifestyles
- Examples: Wi-Fi, fast cars, beauty products, paper cups, botox, fake tans etc.) by young and old alike in developed and developing countries……
- Leading to a fast spiral of ‘disposable’ living
- **More and more emissions and waste and effluent entering our natural systems**

Food Energy Water Nexus

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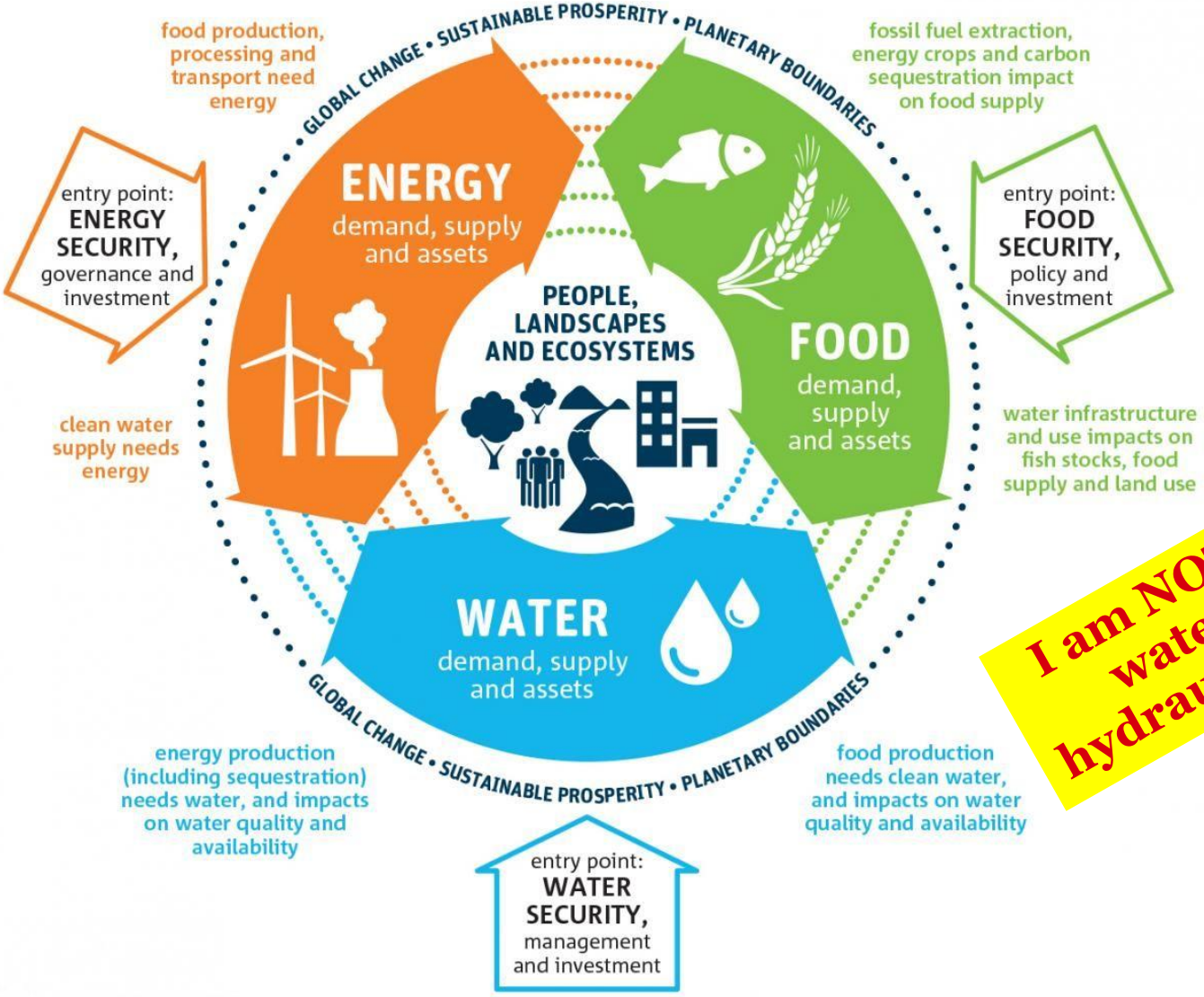
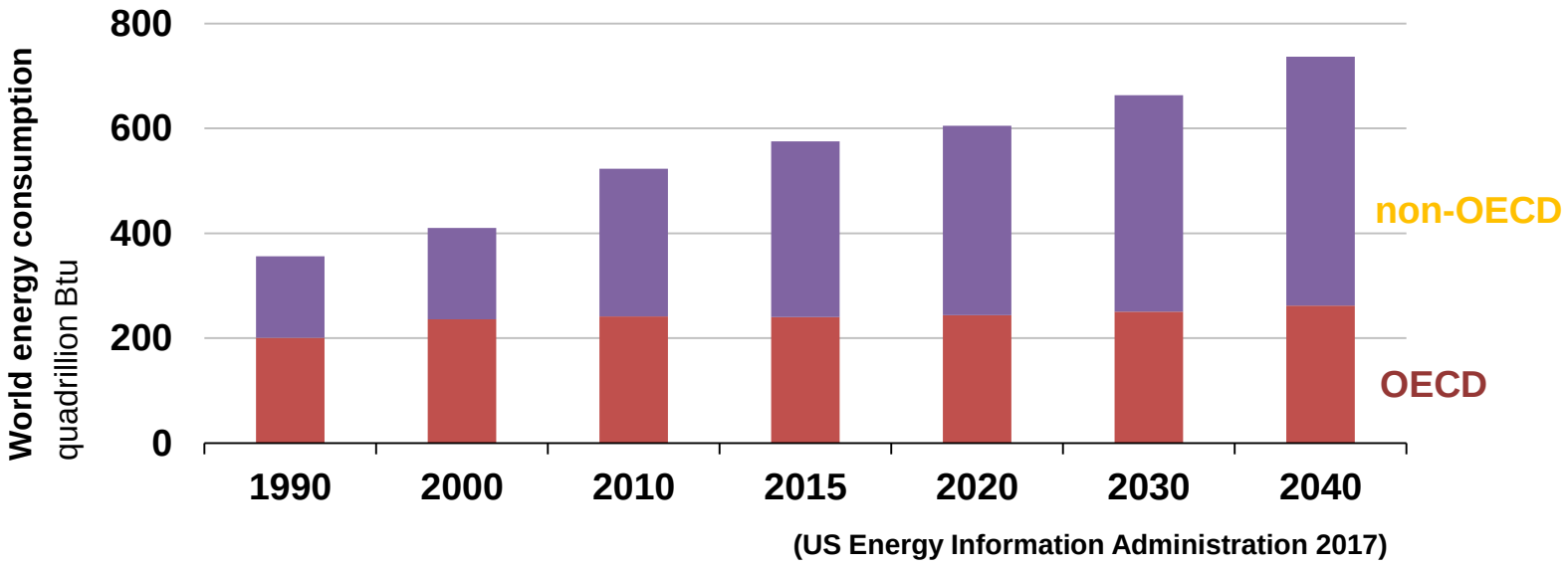


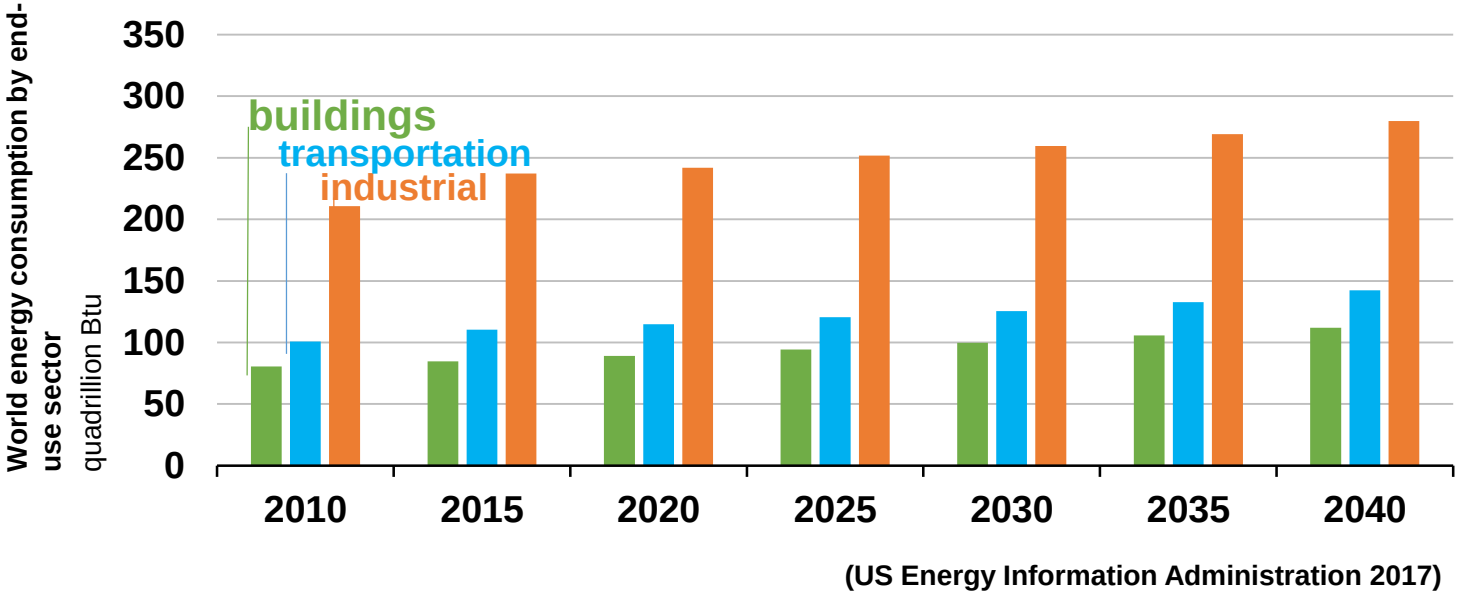
I am NOT an expert in water chemistry, hydraulics or hydrology

Global policy drivers



World energy consumption expected to rise 28% between 2015 and 2040

Global policy drivers



(US Energy Information Administration 2017)

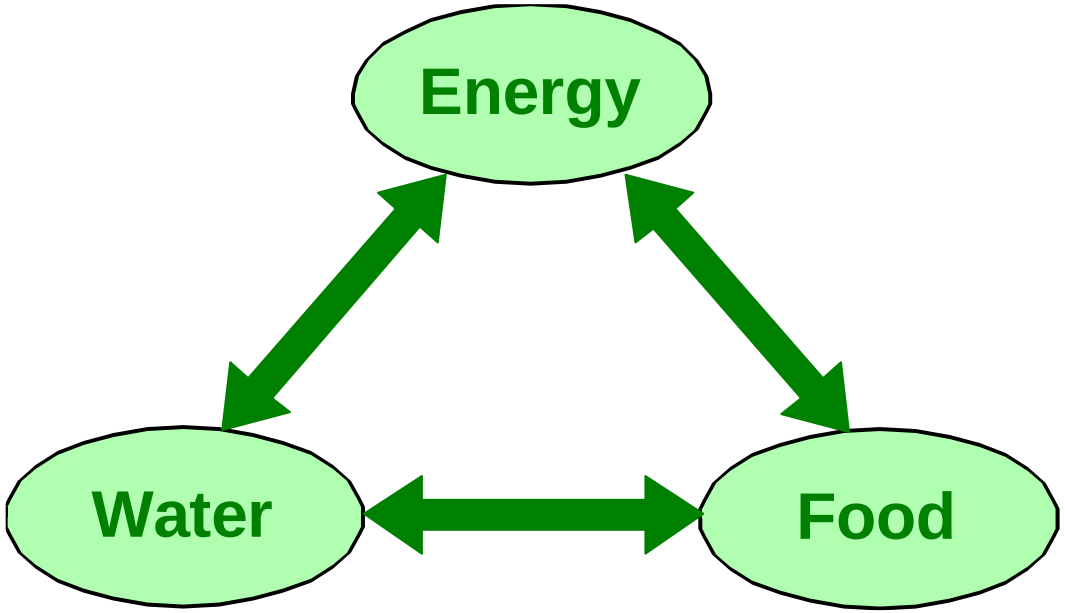
Industrial sector accounts for largest share energy consumption to 2040

Energy-Water-Food Nexus

- Electricity generation consumes some 15% of global freshwater water withdrawals
- 18% of global energy is consumed for water extraction, treatment and distribution
- Food production accounts for 70% of water withdrawals and 30% of energy consumption globally
- These interrelationships among the energy, food and water (EFW) systems are known as the EFW nexus

1. International Energy Agency (2001). Water for Energy. www.worldenergyoutlook.org/resources/water-energynexus.
2. FAO (2011a) The state of the world's land and water resources for food and agriculture – Managing systems at risk. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London.
3. FAO (2011b) Energy-smart for people and climate - Issue paper. Food and Agriculture Organization of the United Nations, Rome.

Energy-Water-Food Nexus



The security of the Energy-Water-Food nexus is a central challenge to the goal of sustainable development

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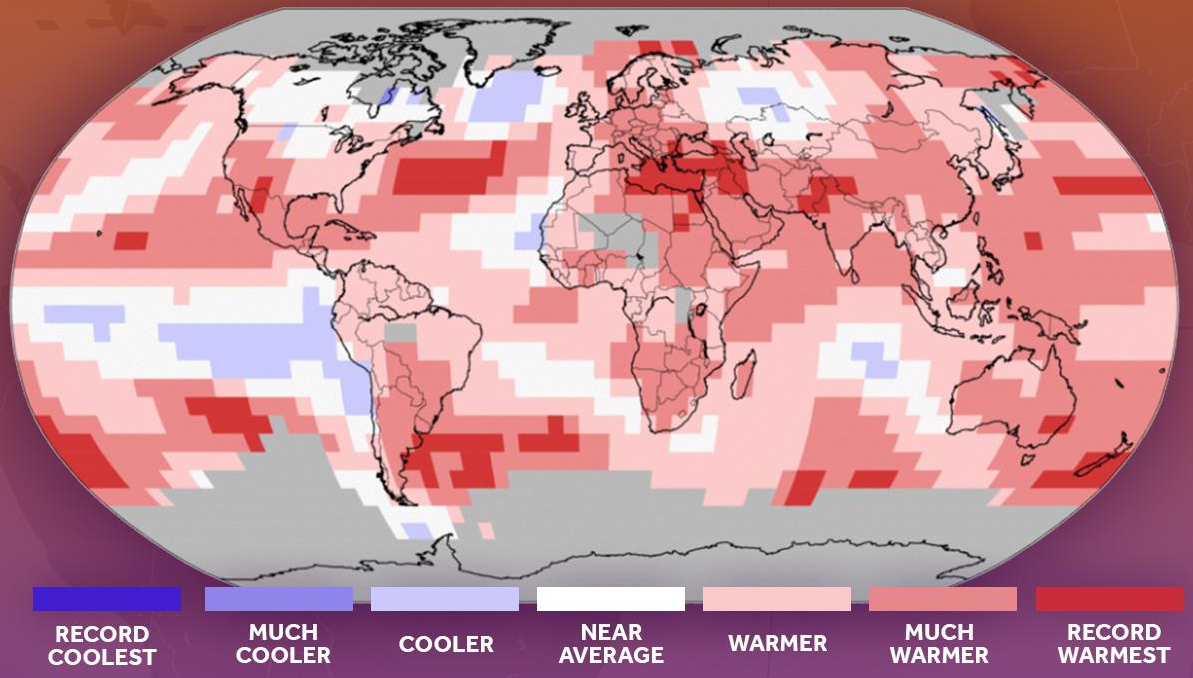
2018 GLOBAL TEMPS

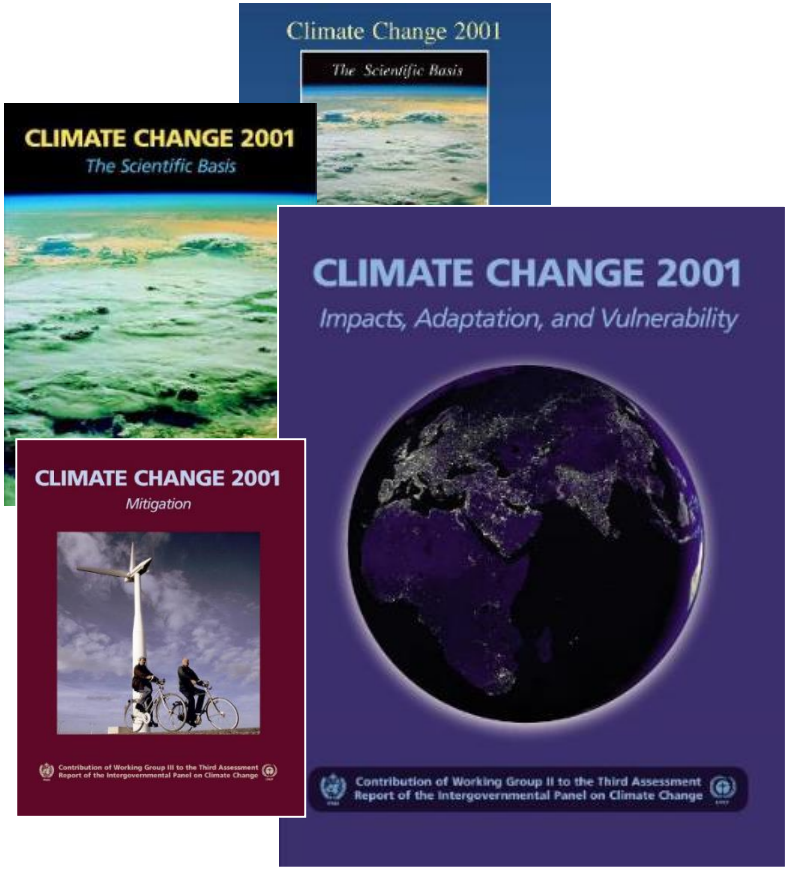
Jan-Jun Land & Ocean Temperature



Data as of 7/18/2018
Source: NOAA/NCEI Climate at a Glance

CLIMATE CENTRAL

What have done?



- **Internationally:**
  - Created an international scientific assessment
  - Negotiated an international treaty
  - Committed most of the industrialized world to mandatory reductions in GHG emissions
- **USA:**
  - Refused to submit international treaty for ratification
  - Proposed voluntary programs to reduce GHG intensity, lowering rate of growth of emissions
- **Non-government:**
  - Corporate, regional, local, faith-based initiatives

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE UNEP

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Important dudes with the bright colourful pin on their jacket lapel!

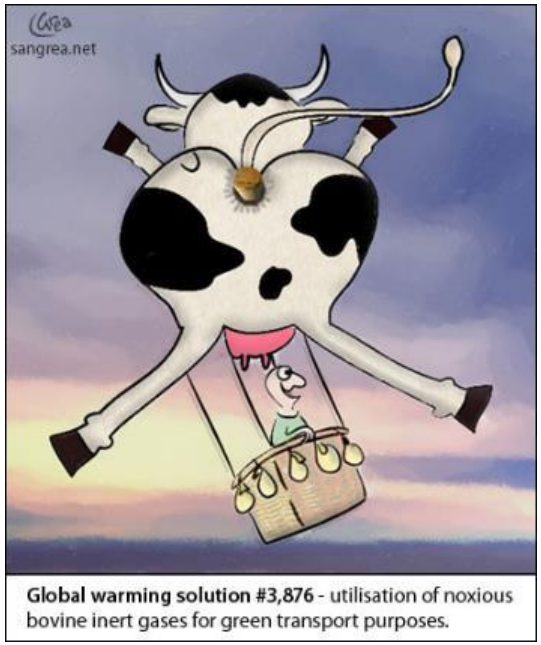
2030 Agenda for Sustainable Development

- adopted by **all 191 United Nations Member States in 2015**
- provides a shared blueprint for peace and prosperity for people and the planet
- 17 Sustainable Development Goals (SDGs)

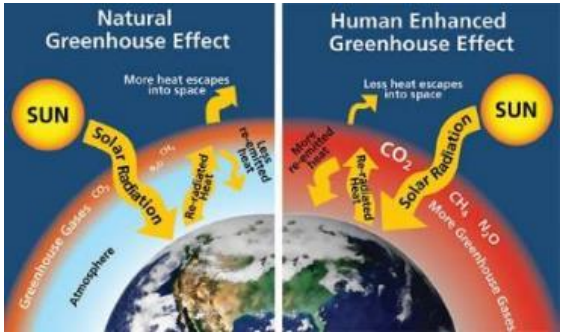
Humour in Scepticism

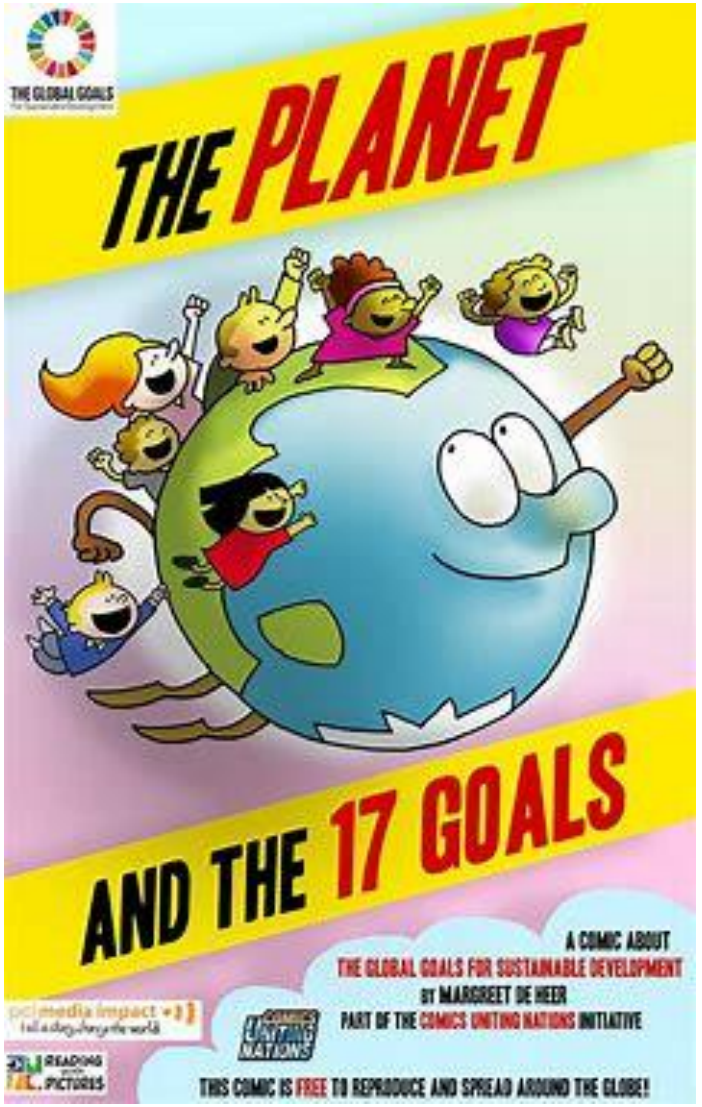
There are three primary goals of sustainable development:

1. minimize the depletion of natural resourc es,
2. create development without causing furt her harm to the environment,
3. provide methods for retrofitting existing developments .

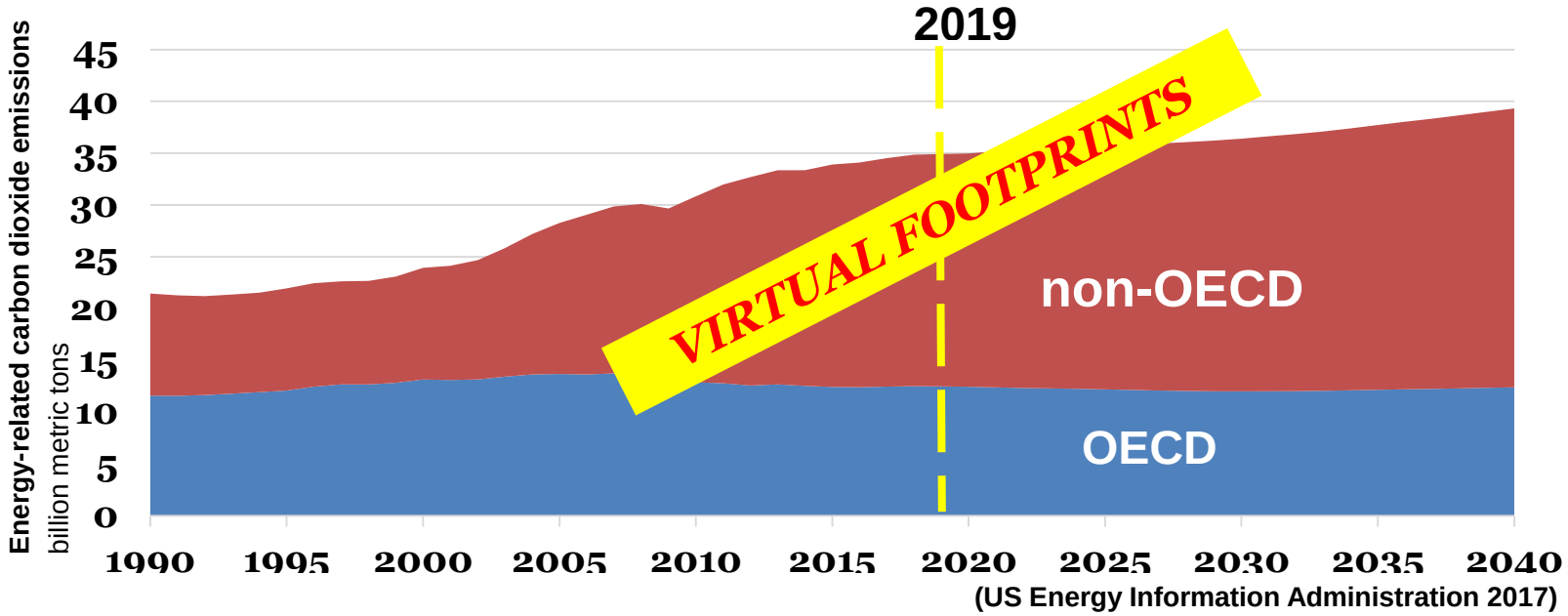


Global warming solution #3,876 - utilisation of noxious bovine inert gases for green transport purposes.





Global policy drivers

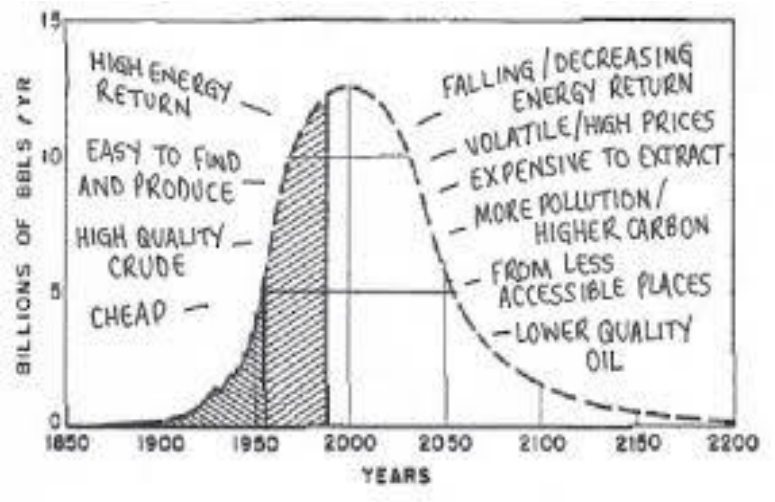


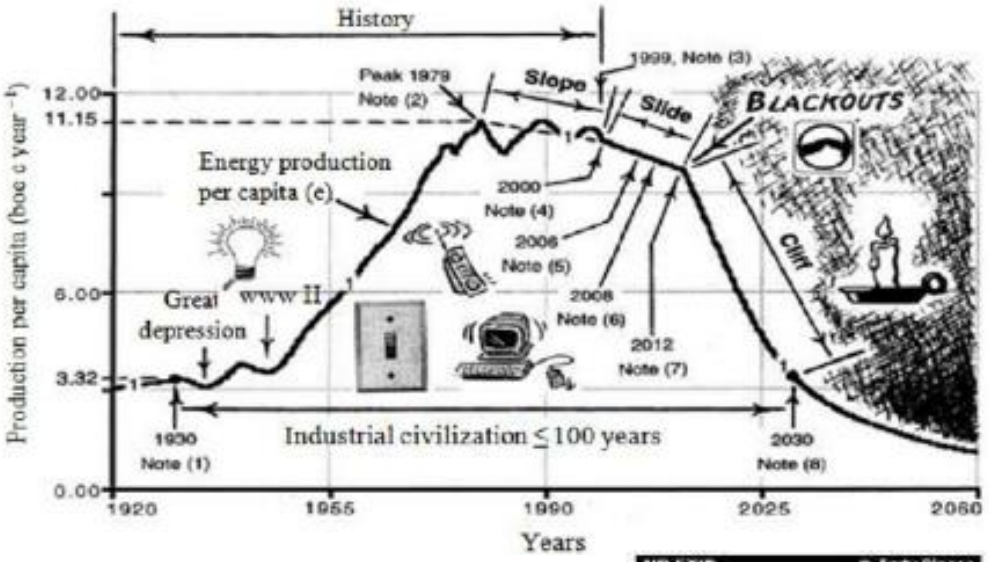
CO_2 emissions increasing globally as non-OECD countries 'develop'

Policies….everyone has one!

- Development policy
- Technology policy
- Information policy
- Energy policy
- Economic policy
- Foreign policy

Peaks.....!





'Peak oil' = Marion King Hubbert's peak curve theory. It illustrates that at some point in time oil production will peak such that demand will exceed supply.

Olduvai Theory (per capita energy production) = life expectancy for the Industrial Civilization is less than or equal to 100 years, between the years 1930 to 2030 (Duncan, 2001).

Models & models

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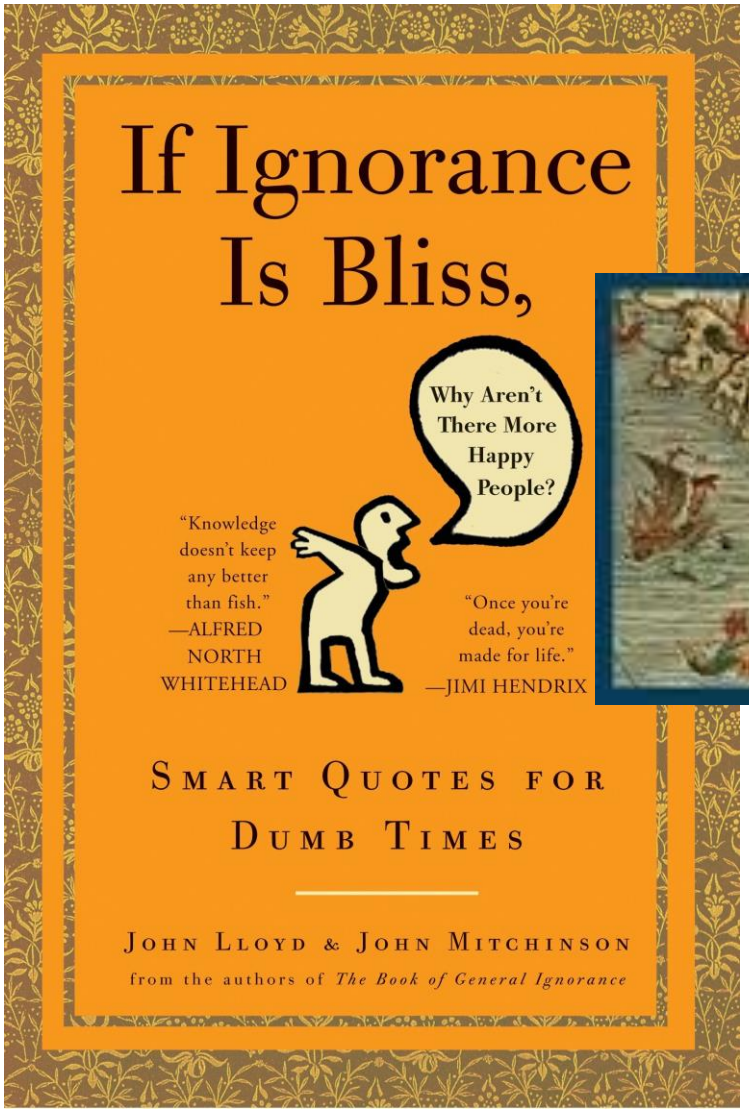
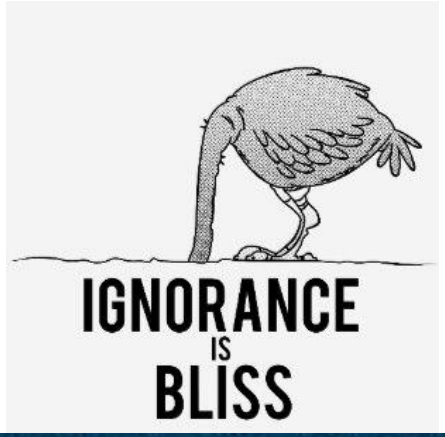


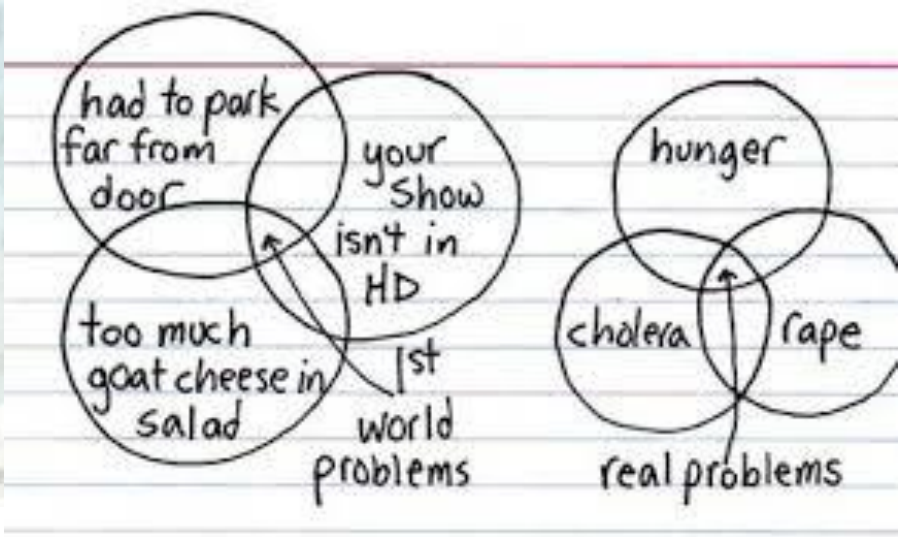


Be OPEN
Be critical
No model is infallible = imform

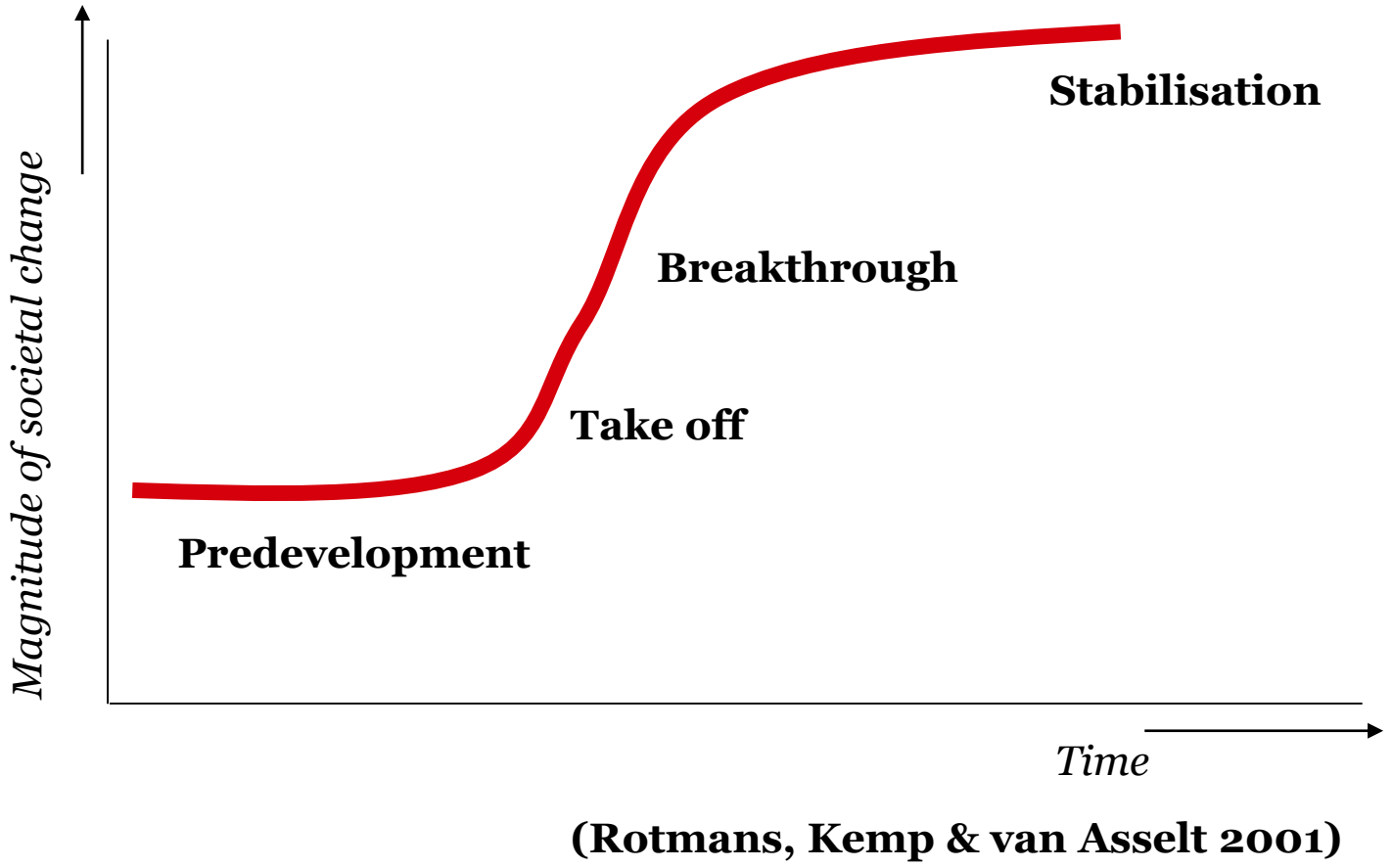
NO WITCH HUNT

Energy technology plan..ssssh...1001%RE?

Balance *v.* instant gratification

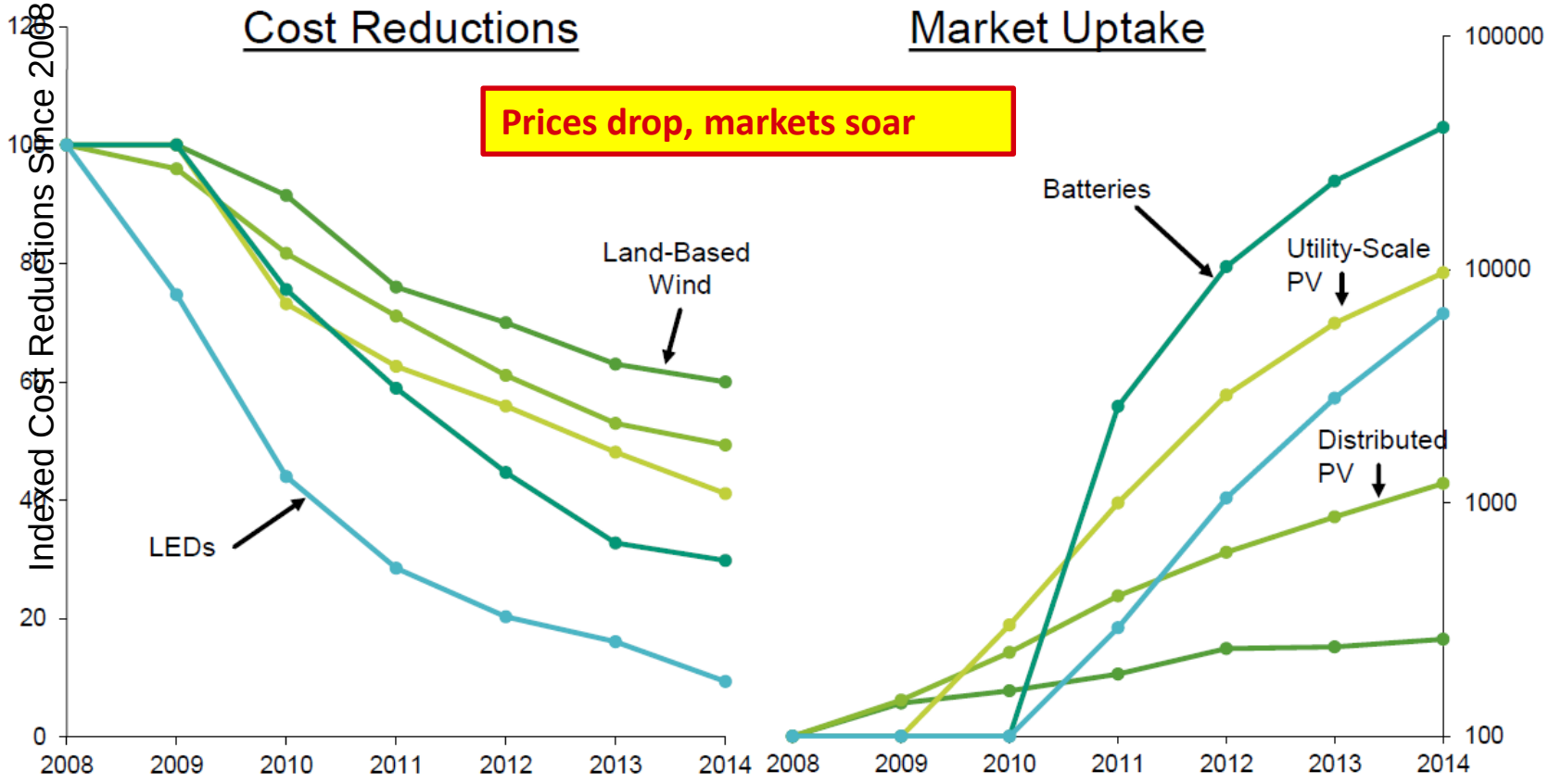


Transition phases



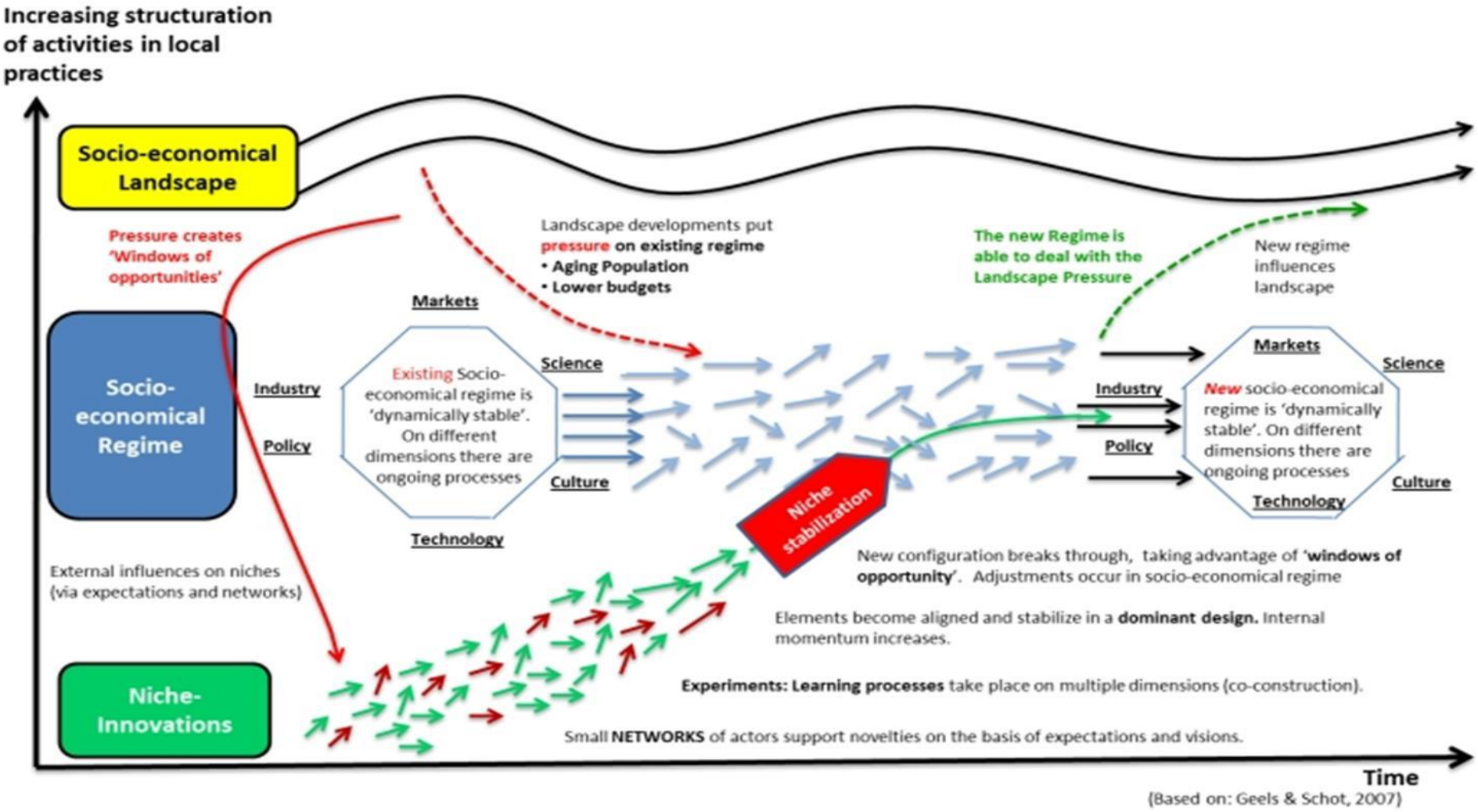
(Rotmans, Kemp & van Asselt 2001)

Technology, markets & uptake



Source: Adapted from DOE, "Revolution...Now: The Future Arrives for Five Clean Energy Technologies – 2015 Update," http://www.energy.gov/eere/downloads/revolution-now-future-arrives-five-clean-energy-technologies-2015-update

Transition phases



http://www.aurecongroup.com/en/thinking/archive/the-transition-towards-a-sustainable-public-private-partnership-regime.aspX

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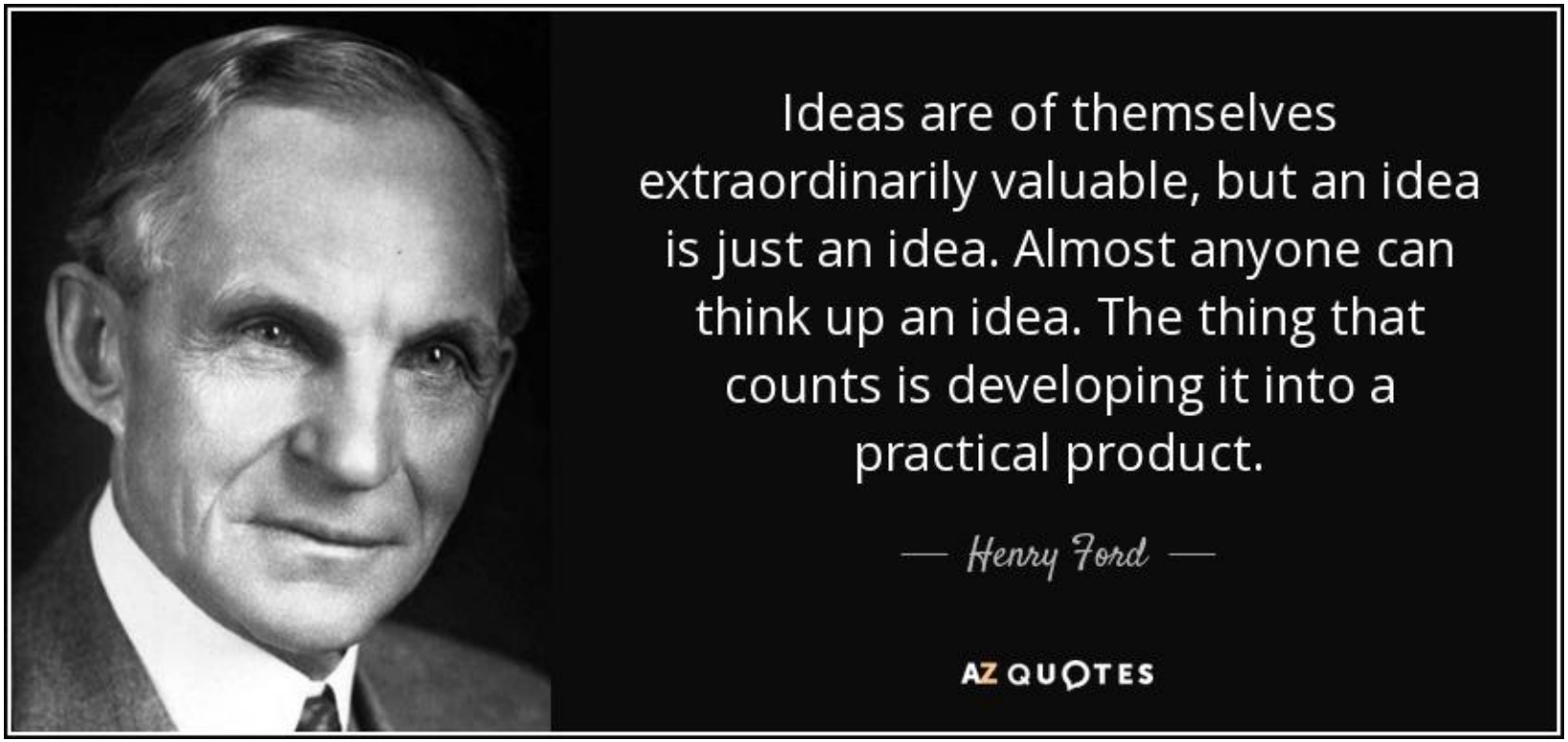
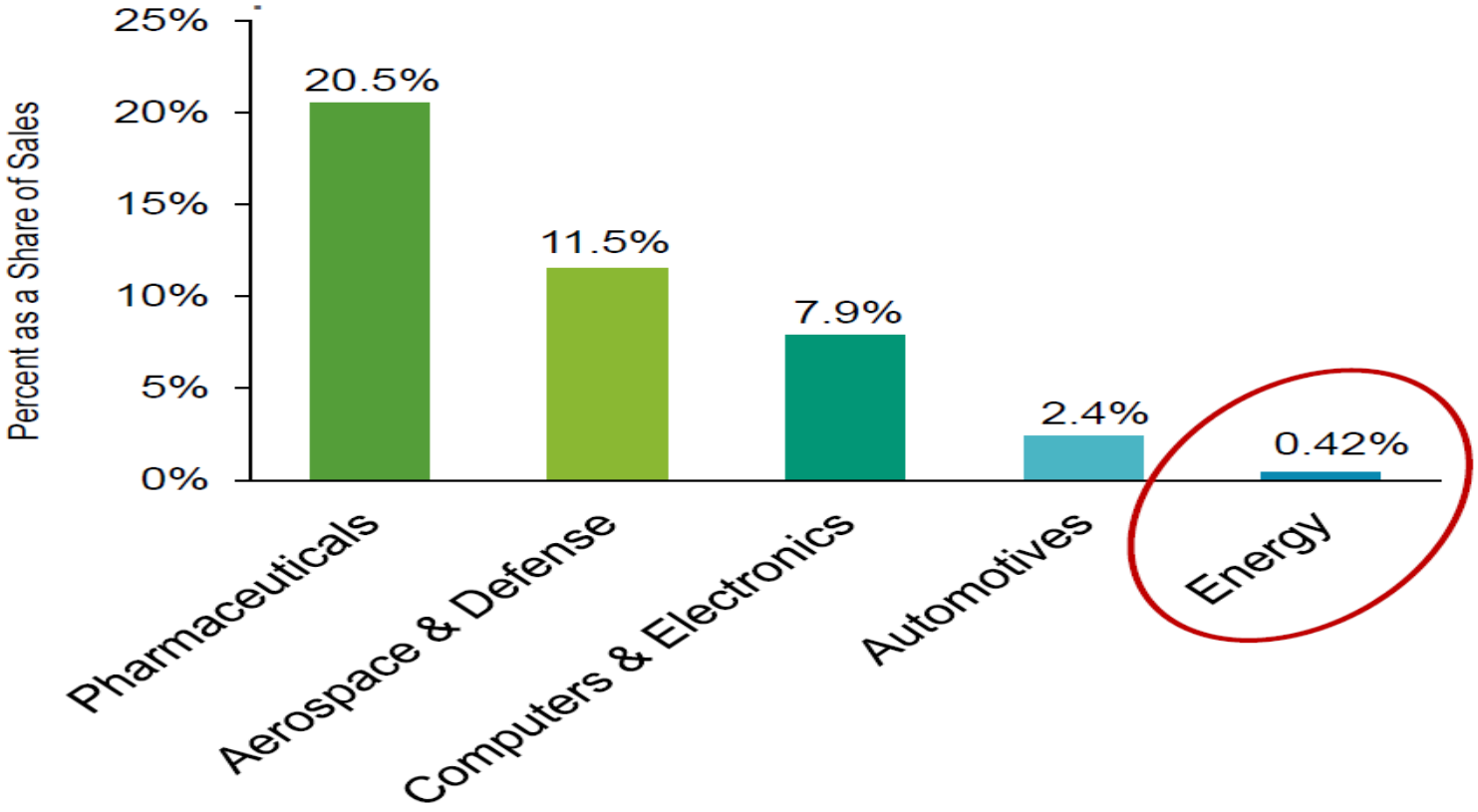


Total Private Sector R&D Spending % as a Share of Sales



Source: Bill Gates, "Energy Innovation: Why We Need It and How to Get It," https://www.gatesnotes.com/Energy/Energy-Innovation

Source: American Energy Innovation Council

Sectoral energy system transition - *Innovation & abandonment*

Governance of the abandonment of socio-technical systems: fading out, termination, deconstruction

Governance of socio-technical systems: a matter of progress & innovation

Choices

Be OPEN
Be critical
No model is infallible = inform

<u>NO WITCH HUNT</u>

Forecasting

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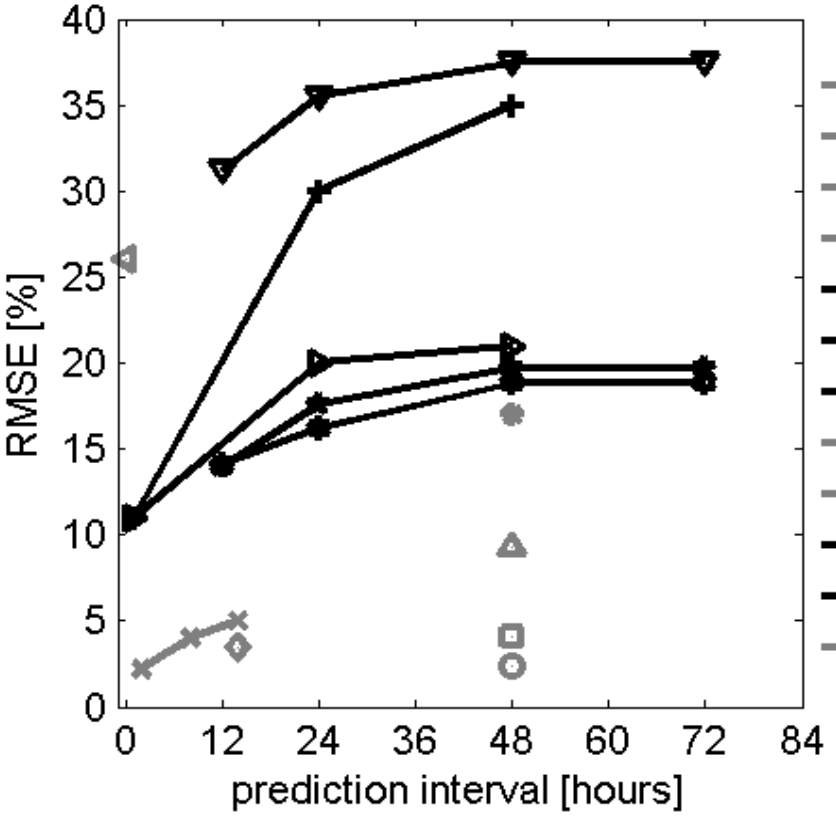
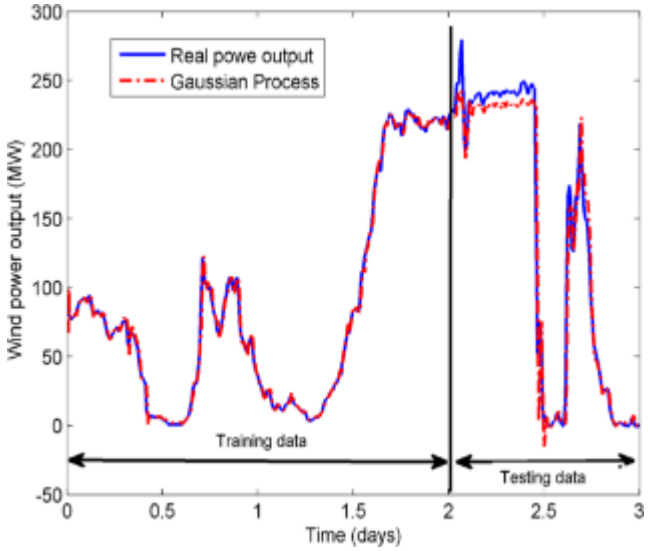
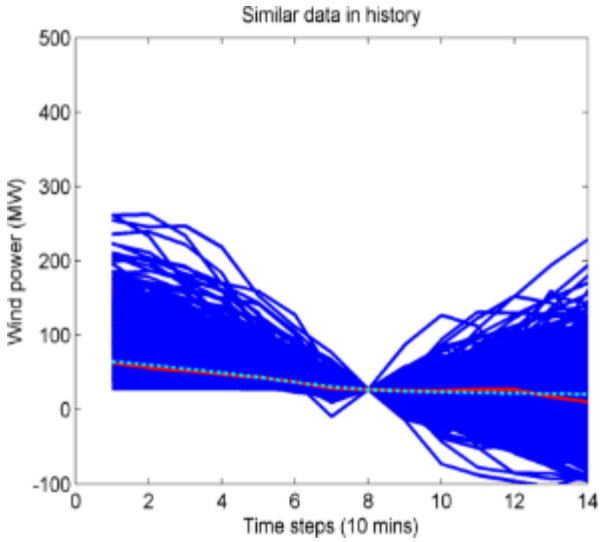


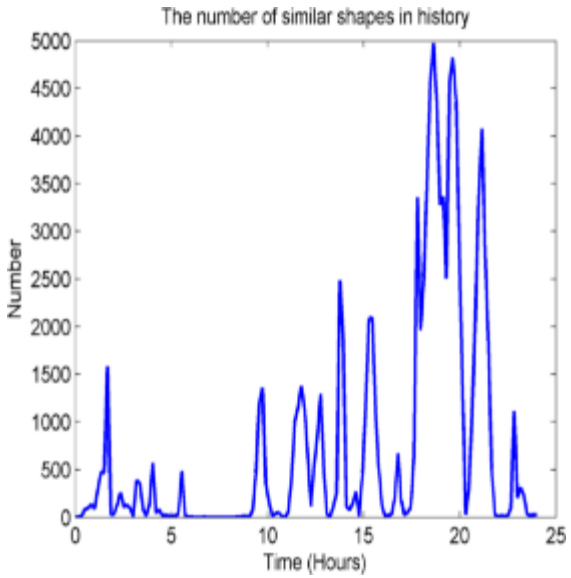
- RAMS-0.5km (Louka et al, 2008)
- RAMS-12km+Kalman (Louka et al, 2008)
- MS-EPS (mean) (Lang et al, 2009)
- MS-EPS (aggregated) (Lang et al, 2009)
- Persistence (Ramirez-Rosado et al, 2009)
- FORECAS (Ramirez-Rosado et al, 2009)
- SGP (Ramirez-Rosado et al, 2009)
- Persistence (Kusiak et al, 2009)
- MM5 (Kusiak et al, 2009)
- Persistence (Fan et al, 2009)
- SVR/BCD (Fan et al, 2009)
- NOGAPS (offshore) (McQueen and Watson, 2009)

Hybrid Gaussian approach

- Hybrid Gaussian Process (GP) combining both similar historical data patterns and recent wind generation data to improve the accuracy of very short-term forecasting results, much faster than normal GP
- GP and hybrid GP models applied to predict the wind power generation of a wind farm of Ireland on November 8th 2006 when ramping event, spikes, and uncommon trend all occurred

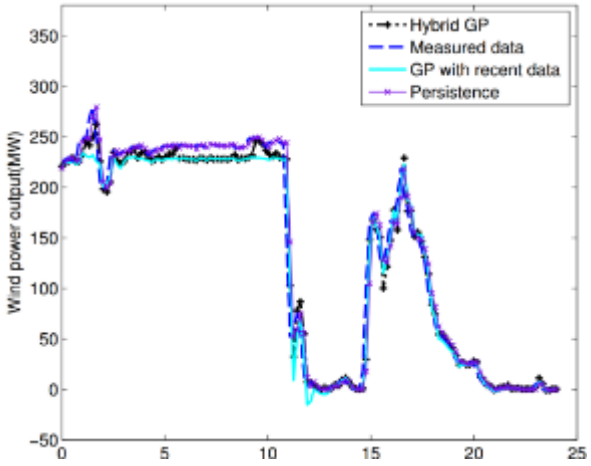


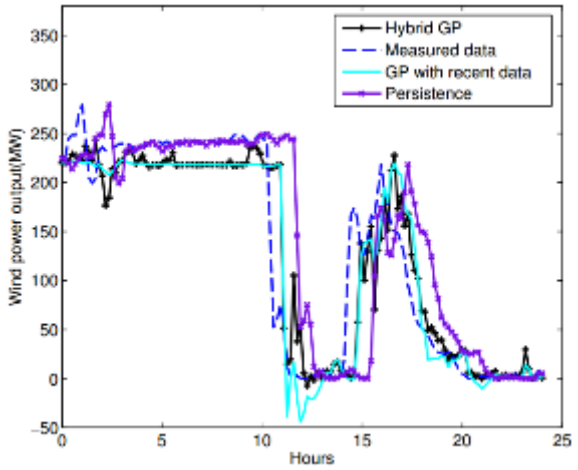


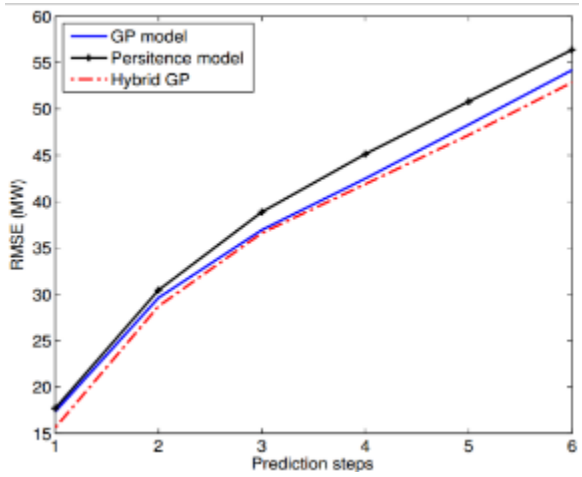


- Current state vector and its trend (red line) fit well with the mean value of similar vectors and their mean trend (the green dashed line), showing that the similar data could reflect the current trend of wind power, which is a proof of the rationality of the statistical similar pattern theory

Hybrid Gaussian approach







Methods	1	2	3	4	5	6
Standard GP	17.3	29.6	36.9	42.5	48.3	54.2
Hybrid GP	**15.6**	**28.7**	**36.6**	**41.9**	**47.2**	**52.9**
Persistence	17.7	30.5	38.9	45.1	50.8	56.4
Skill Score	11.7%	5.7%	5.8%	7.2%	7.1%	6.2%

Congestion v Curtailment

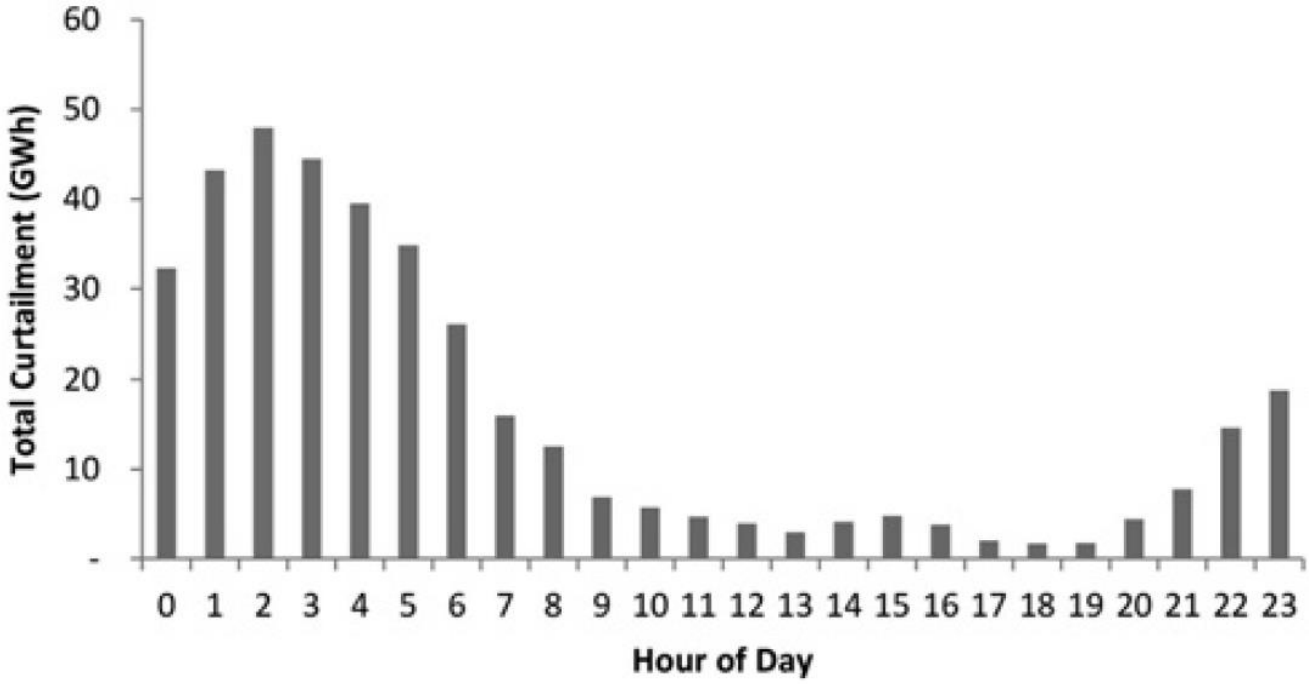
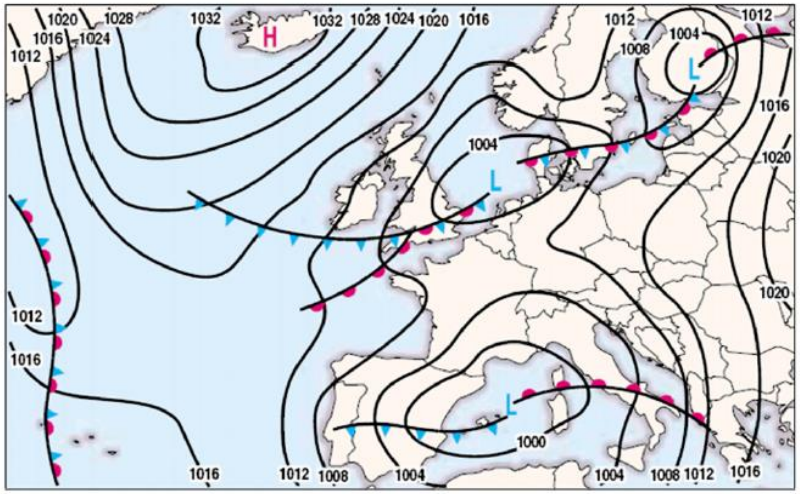


Fig. 2 *Total curtailment by hour 2020*

“Integrator technologies”



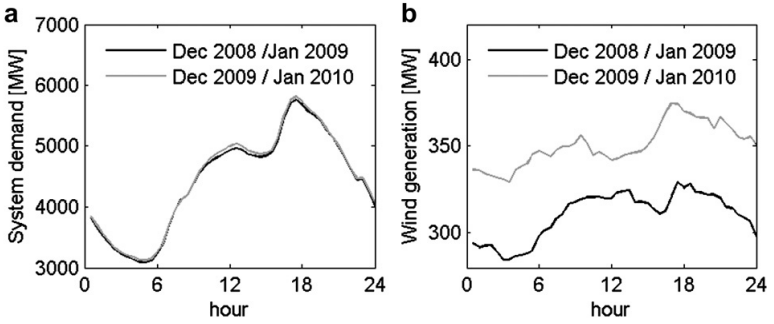


Fig. 6. Daily average profiles of (a) system demand and (b) wind generation from the study period in and 2010.

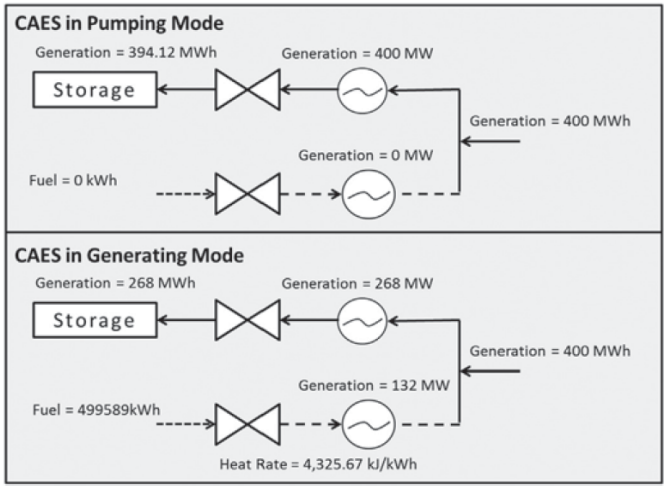


Fig. 2. CAES unit in SEM_2020 model.

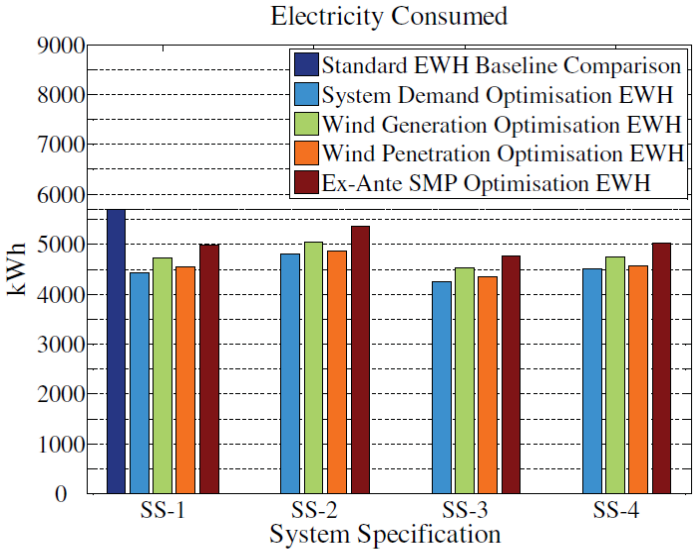
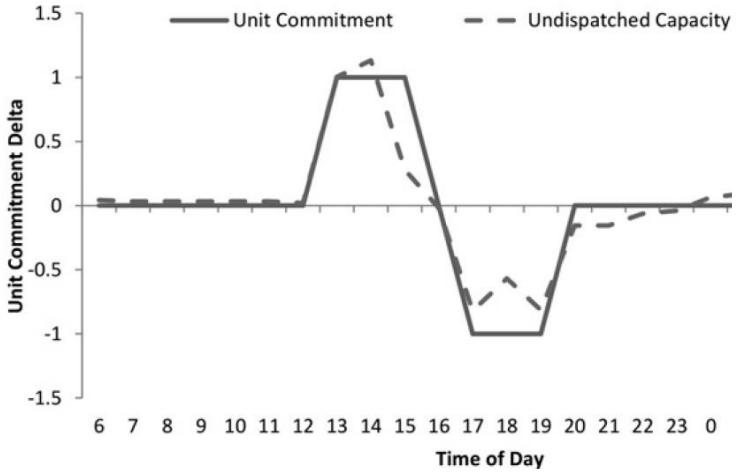
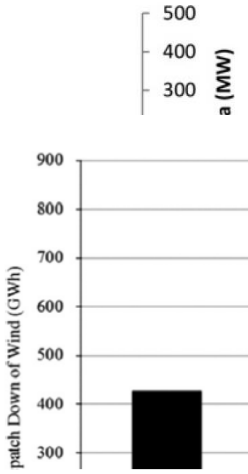
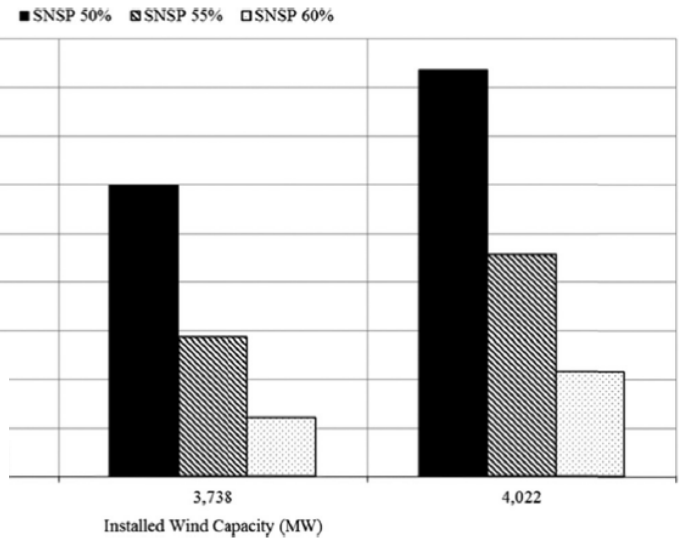


Fig. 8. Electricity consumed over a 12 month period.

“Integrator technologies”







ch-down of wind due to SNSP limit (Scenarios 1–9).

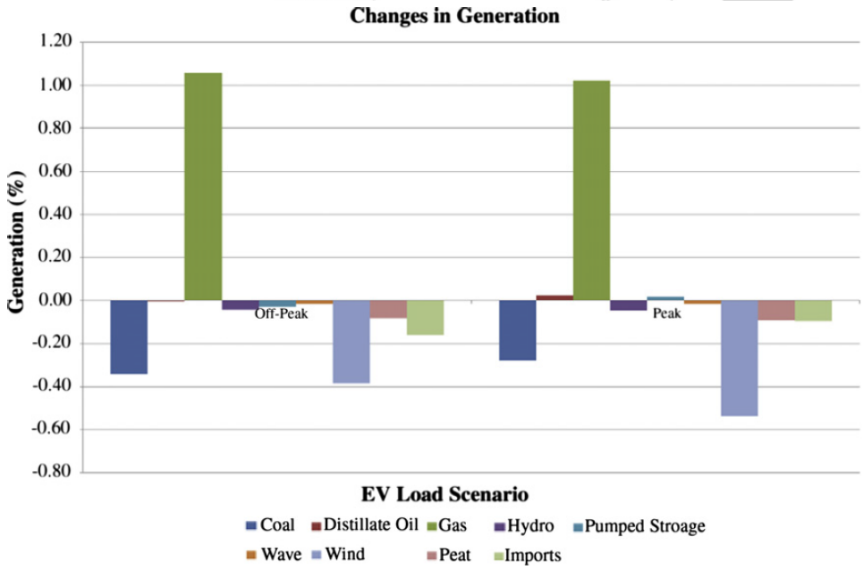


Fig. 7. Comparison of peak and off-peak EV charging scenarios.

Review of Non-intrusive Load Monitoring Methods in Distribution Networks to optimise renewable energy integration

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EPIC Research Cluster

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andres-moreno-0329

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energy, power & intelligent control

A state of the art techno-economic review of distributed and embedded energy storage

- Researcher: Neil McIlwaine, School of Electronics, Electrical Engineering and Computer Science
- Supervisors: Dr. A. Foley
  Prof. D.J. Morrow
- Background: Power generation 35 years

A review of the dynamic impacts of renewable generation, distributed generation and emerging smart loads on the power system

Dlzar Al kez, EEECS

Supervisors
Dr Aoife Foley
Prof John Morrow

THE BRYDEN CENTRE
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Interreg
Northern Ireland - Ireland - Scotland
European Regional Development Fund

Barry Johnston
Aoife Foley
Joanne Mitchell
John Doran
Timothy Littler

Levelised Cost of Energy, a Challenge for Offshore Wind

THE BRYDEN CENTRE
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European Regional Development Fund

Joanne Mitchell
Aoife Foley
Barry Johnston
John Doran
John Morrow

Current Diagnostic and Prognostic Methods used in Offshore Wind Operations and Maintenance

Summary
Metrics
Publications

Most cited publications

TIMES CITED

Current methods and advances in forecasting of wind power generation WEB OF SCIENCE

Authors: Aoife Foley, Paul G Leahy, Antonino Marvuglia, Eamon J. McKeogh
Published: Jan 2012 in RENEWABLE ENERGY
DOI: 10.1016/J.RENENE.2011.05.033

480

A strategic review of electricity systems models WEB OF SCIENCE

Authors: Aoife Foley, B.P. Ó Gallachóir, J. Hur, ... E.J. McKeogh, see more
Published: Dec 2010 in ENERGY
DOI: 10.1016/J.ENERGY.2010.03.057

138

Impacts of Electric Vehicle charging under electricity market operations WEB OF SCIENCE

Authors: Aoife Foley, Barry Tyther, Patrick Calnan, Brian Ó Gallachóir
Published: Jan 2013 in APPLIED ENERGY
DOI: 10.1016/J.APENERGY.2012.06.052

131

Climate change response in Europe: what's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries WEB OF SCIENCE

Authors: Reckien, D., Flacke, J., Dawson, R. J., ... Pietrapertosa, F., see more
Published: 2014 in CLIMATIC CHANGE
DOI: 10.1007/S10584-013-0989-8

114

The evolution of offshore wind power in the United Kingdom WEB OF SCIENCE

Authors: Paraic Higgins, Aoife Foley
Published: Sep 2014 in RENEWABLE AND SUSTAINABLE ENERGY REVIEWS
DOI: 10.1016/J.RSER.2014.05.058

59

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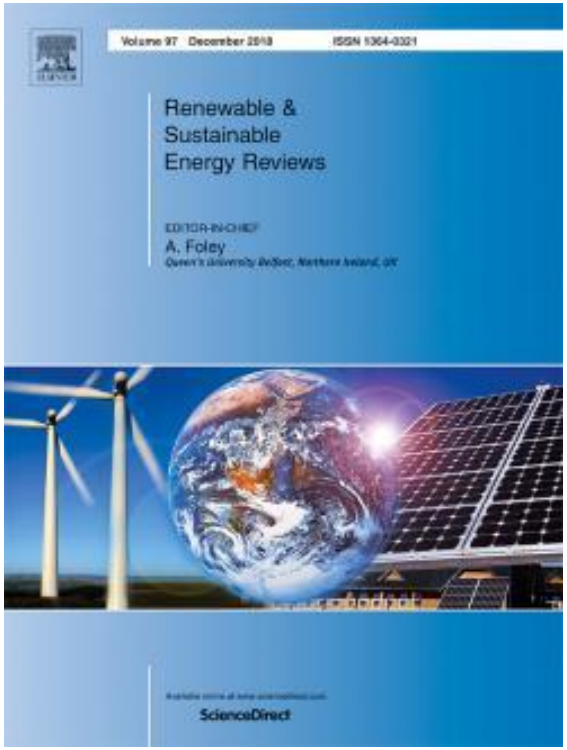

Renewable & Sustainable Energy Reviews

What role do (renewable energy) academic journals play?

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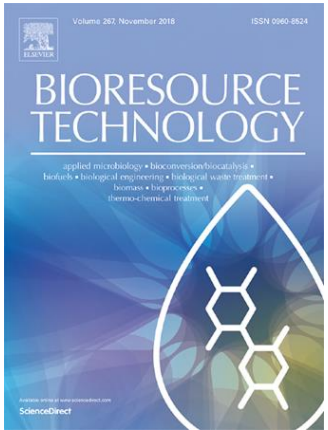
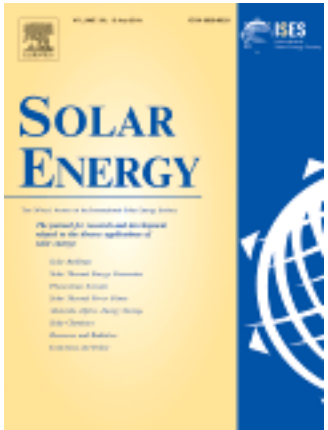
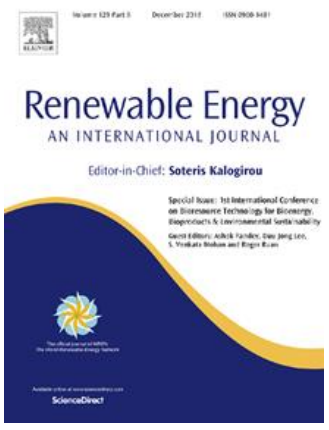
- Renewable and sustainable energy is a growing area of research, moving fast, and expanding.
- Renewable and sustainable energy is no longer a niche sector of novel technologies.
- It is now a major part of global research, as we seek to avert damaging climate change by sharing problems, solutions, novel ideas and technologies to support the transition to a low carbon future, and achieve our global emissions targets as established by the United Nations Framework Convention on Climate Change.
- **<u>We are an interconnected world, and need interconnected solutions.</u>**







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Mission

- The mission of *Renewable and Sustainable Energy* Reviews is to communicate the most **interesting and relevant critical thinking** in renewable and sustainable energy in order to bring together **the research community, the private sector and policy and decision makers**.
- The aim of the journal is to share problems, solutions, novel ideas and technologies to support the transition to a low carbon future and achieve our global emissions targets as established by the United Nations Framework Convention on Climate Change.

Article types

- Reviews
- Original research
- Case studies
- Expert Insights (invitation only)
- Cutting Edge (Invitation only)
- Editorials

Themes

- Applications - buildings, industry & transport
- Energy resources
- Environment
- Education
- Systems
- Sustainability
- Techno-socio-economic aspects
- Utilization

***provided* the link to renewable and sustainable energy is clear & thoroughly examined**

Who is the audience & audience?

Audience?

The core of the audience is:

- Academics and researchers
- Engineers
- Economists and the Finance community
- Technology manufacturers and companies developing renewable energy solutions

Also, those with a keen interest in the scale up of renewable energy:

- NGOs & Associations
- Governments
- Academic Societies

Even if you don't stay in research, you can still be a core part of the audience!

Authors?

The majority of our authors are:

- Academics and researchers
- Engineers
- Economists and the Finance community
- Technology manufacturers and companies developing renewable energy solutions

Some are those with a keen interest in the scale up of renewable energy:

- NGOs & Associations
- Governments
- Academic Societies

Even if you don't stay in academia, you can still contribute to research!

‘Visiting researcher’ opportunities!

- Group : 6 PhD students (3 as 1st, 3 as Co, plus 2 positions to fill), 6 masters & 1 Postdoctoral researcher (50%)
- Alumni: 6 PhD, 30 masters & 3 Postdoctoral researchers
- Visiting researcher: Strathclyde University, Tsinghua University, Energy Systems Institute of Russian Academy of Sciences

Collaborators

- Tsinghua University, Energy Systems Institute, MIT, UMass Amherst, Strathclyde, Cardiff University, Warwick University, Harbin Institute of Technology, Chongqing University, Oxford University, University College Cork, University College Dublin & colleagues across EU via Smart cities cost action e.g. Richard Dawson, Monica Salvia, Oliver Heinrich, Diana Riecken etc.

Affiliations

- EPIC @ EECS, Bryden Centre, Marei @UCC and the Energy Institute @ UCD & National Centre for Energy Systems Integration @ Newcastle University

Research Support

EUROPE & SCOTLAND
European Regional Development Fund
Investing in a Smart, Sustainable and Inclusive Future

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Thank you for listening