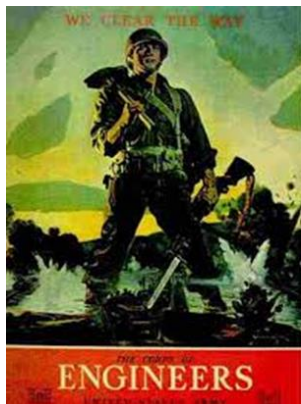
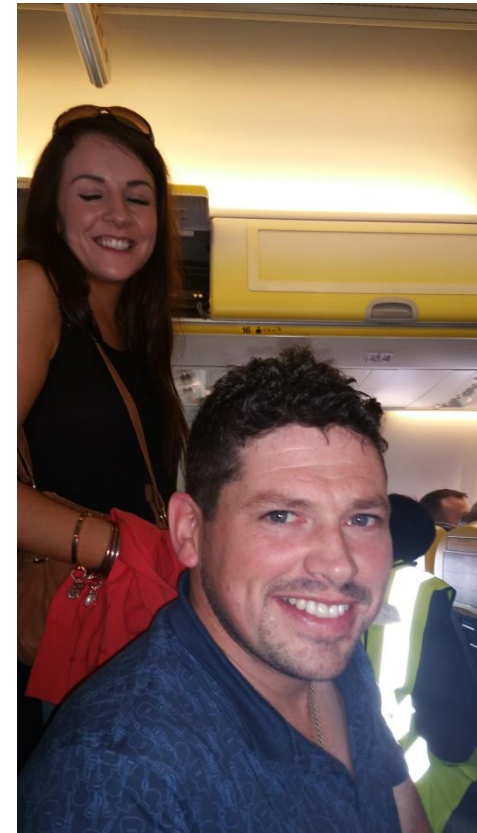


Future low carbon energy systems, technology revolution or behaviour revolution ?

Mark O'Malley



[mark.omalley@ucd.ie](mailto:mark.omalley@ucd.ie)



# Outline

- Low Carbon Energy Systems
  - Importance of Energy Systems Integration (ESI)
- Examples of why social science is so important
- Some observations
- Some initiatives
- Conclusions





## Energy Systems Integration

# ***What is Energy System Integration (ESI) ?***

Energy System Integration (ESI) is the process of coordinating the operation and planning of energy systems across multiple pathways and geographical scales in order to deliver reliable, cost effective energy services with less impact on the environment.



## **Energy Systems Integration: Defining and Describing the Value Proposition**

Mark O'Malley  
University College Dublin

Benjamin Kroposki and Bryan Hannegan  
National Renewable Energy Laboratory

Henrik Madsen and Mattias Andersson  
Technical University of Denmark

William Dhaeseleer  
KU Leuven

Mark F. McGranaghan  
Electric Power Research Institute

Chris Dent  
Durham University

Goran Strbac  
Imperial College London

Suresh Baskaran and Michael Rinker  
Pacific Northwest National Laboratory

Technical Report  
NREL/TP-5D00-66616  
June 2016

DOI link: <http://dx.doi.org/10.1172/1257674>

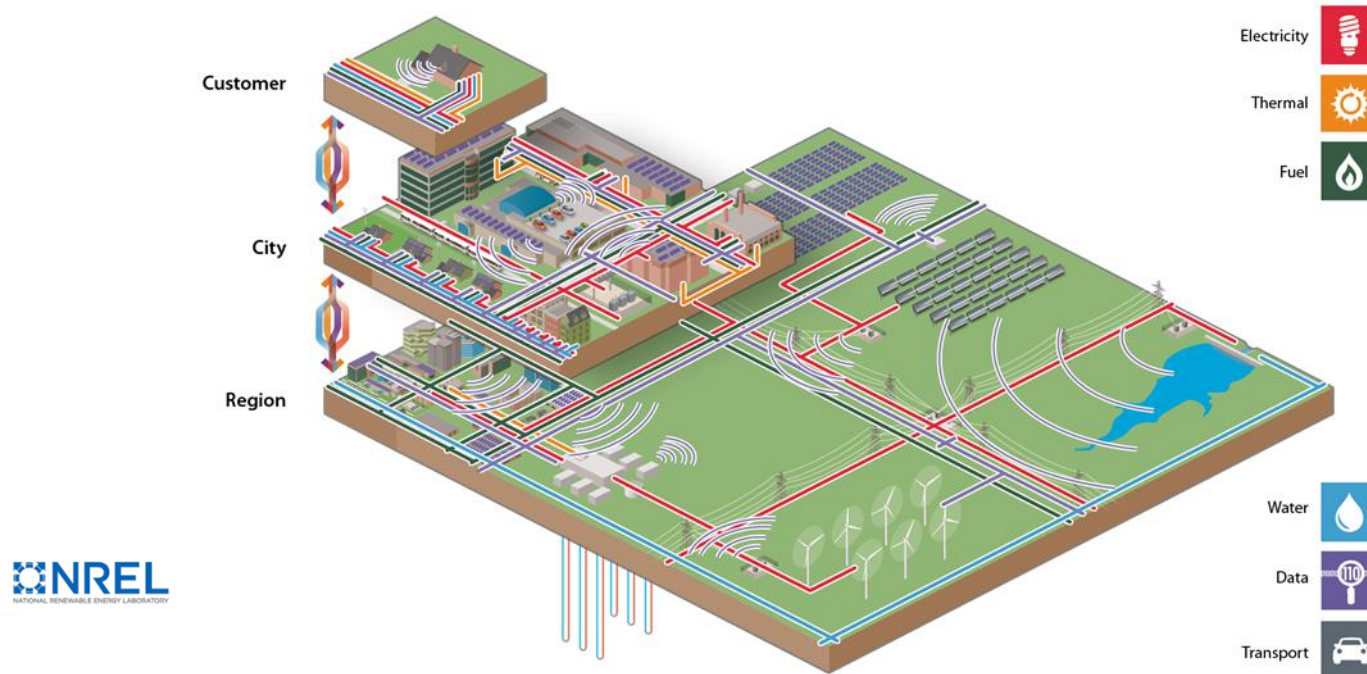
Contract No. DE-AC36-08GO28308

O'Malley, M.J., Kroposki, B., Hannegan, B., Madsen, H., Andersson, M., D'haeseleer, W., McGranaghan, M., Dent, C., Strbac, G., Baskaran, S. and Rinker, M., "Energy System Integration Defining and Describing the Value Proposition", NREL Technical Report NREL/TP-5D00-66616, June 2016.

[[10.2172/1257674](http://dx.doi.org/10.1172/1257674)]



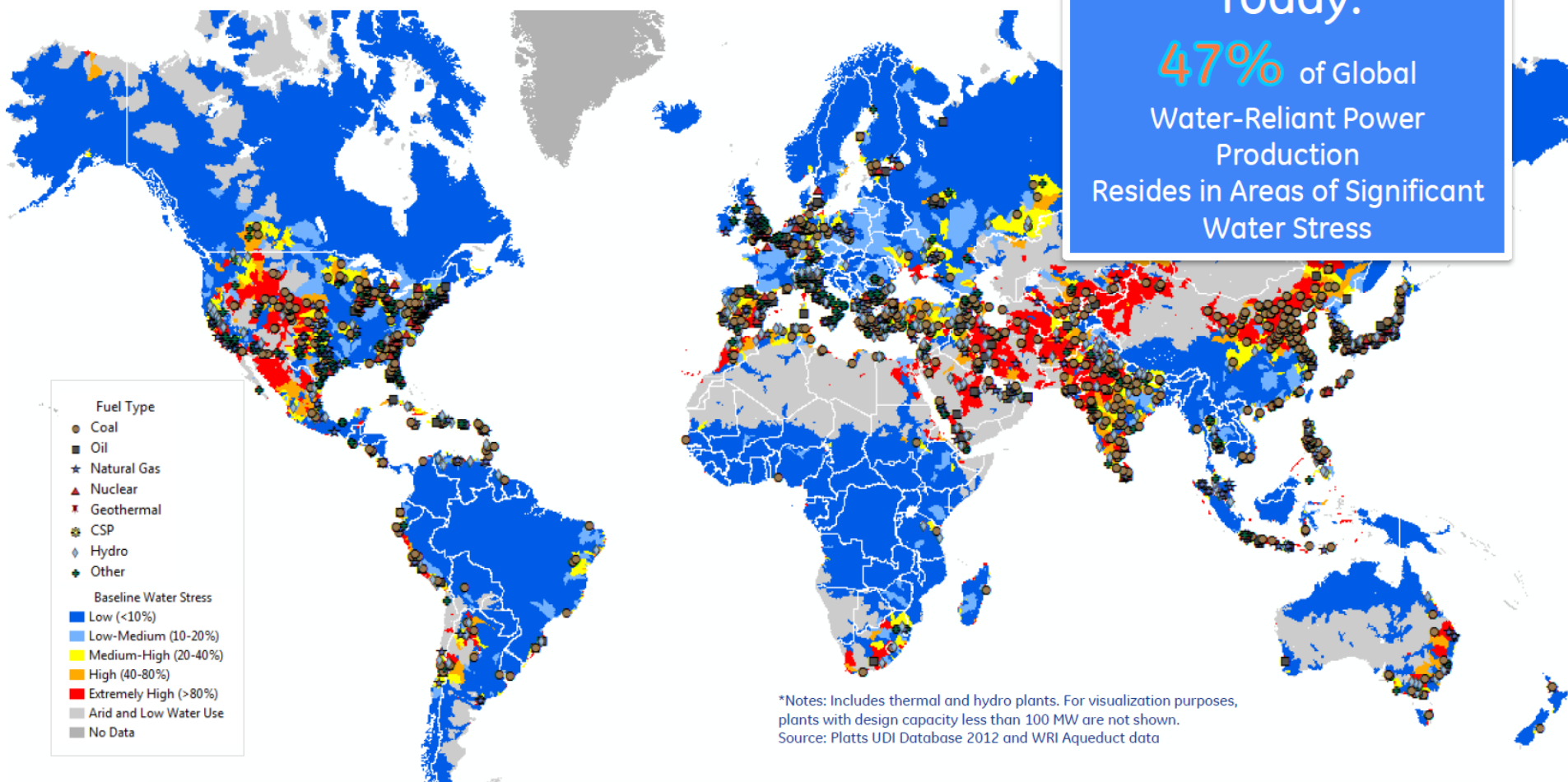
# Energy Systems Integration



- **optimization** of energy systems across multiple pathways and scales
- increase reliability and performance, and minimise **cost and environmental impacts**
- most valuable at **the interfaces where the coupling** and interactions are strong and represent a challenge and an opportunity
- control variables are **technical economic and regulatory**

# Global generation units with water stress\*

Medium to extremely-high stress



Over 26,000 units are in areas of medium to extremely-high water stress

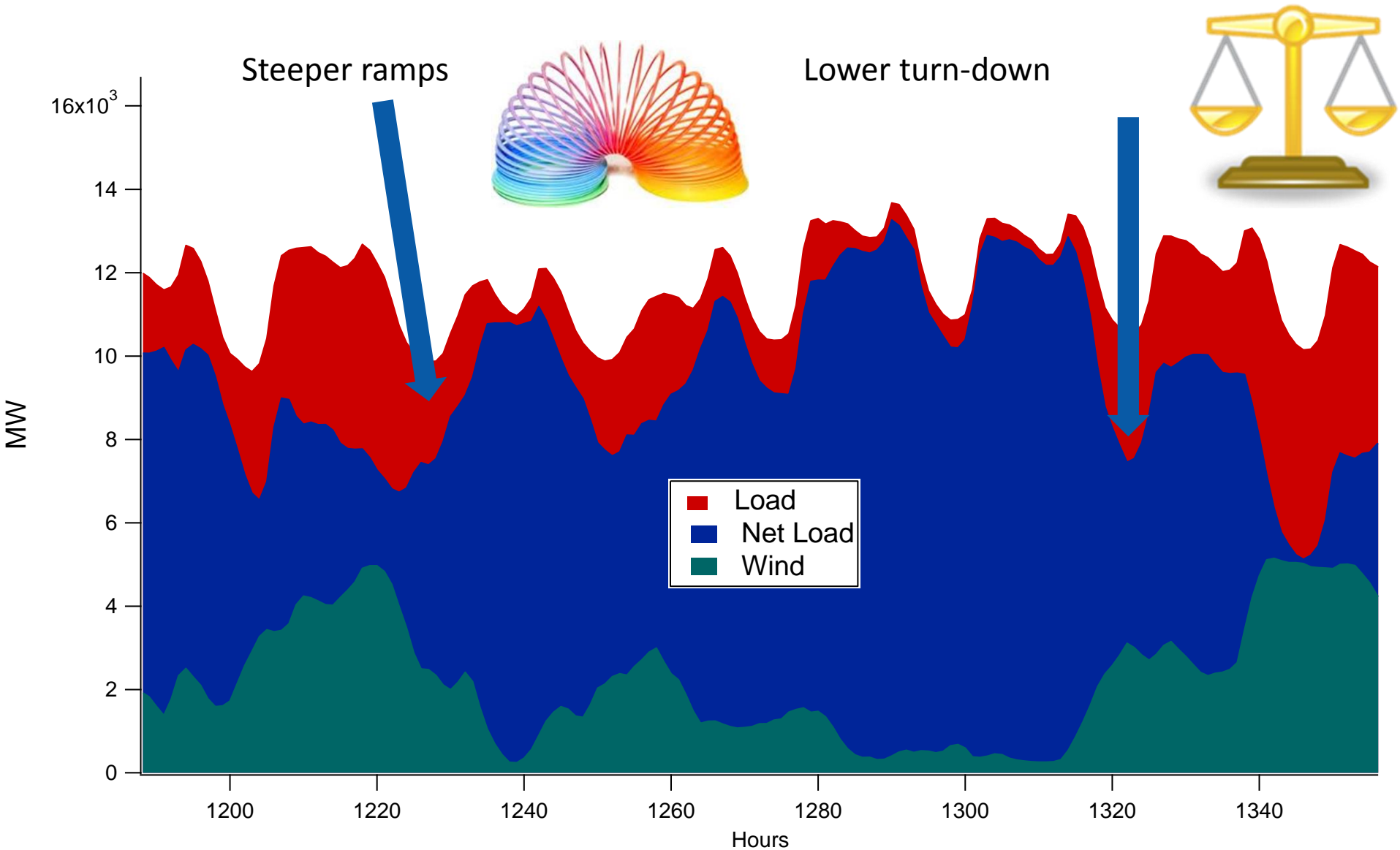




Examples of Grid Flexibility:  
A Social Science Perspective as seen  
by an Engineer



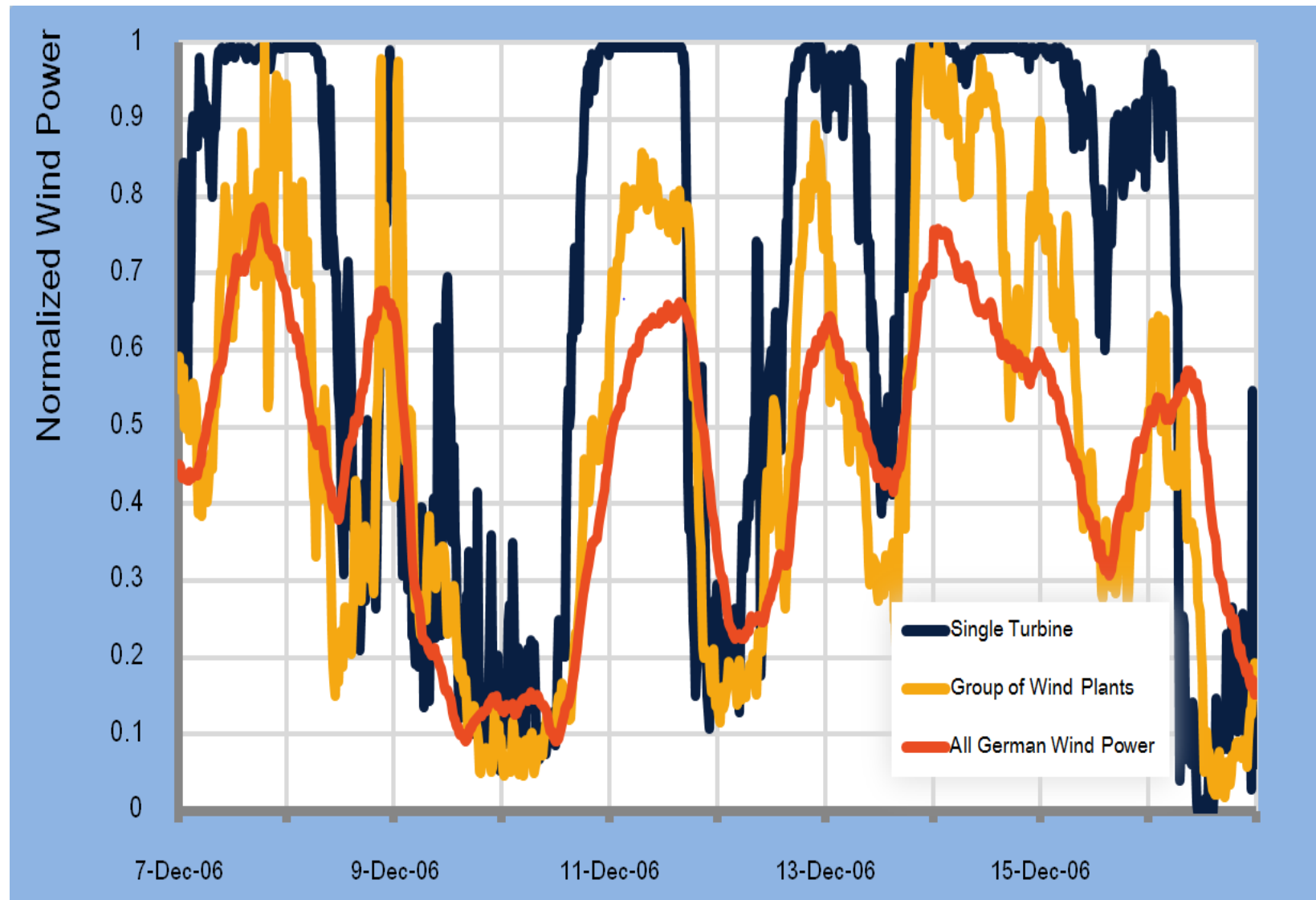
# With Variable Renewables More Flexibility is Needed



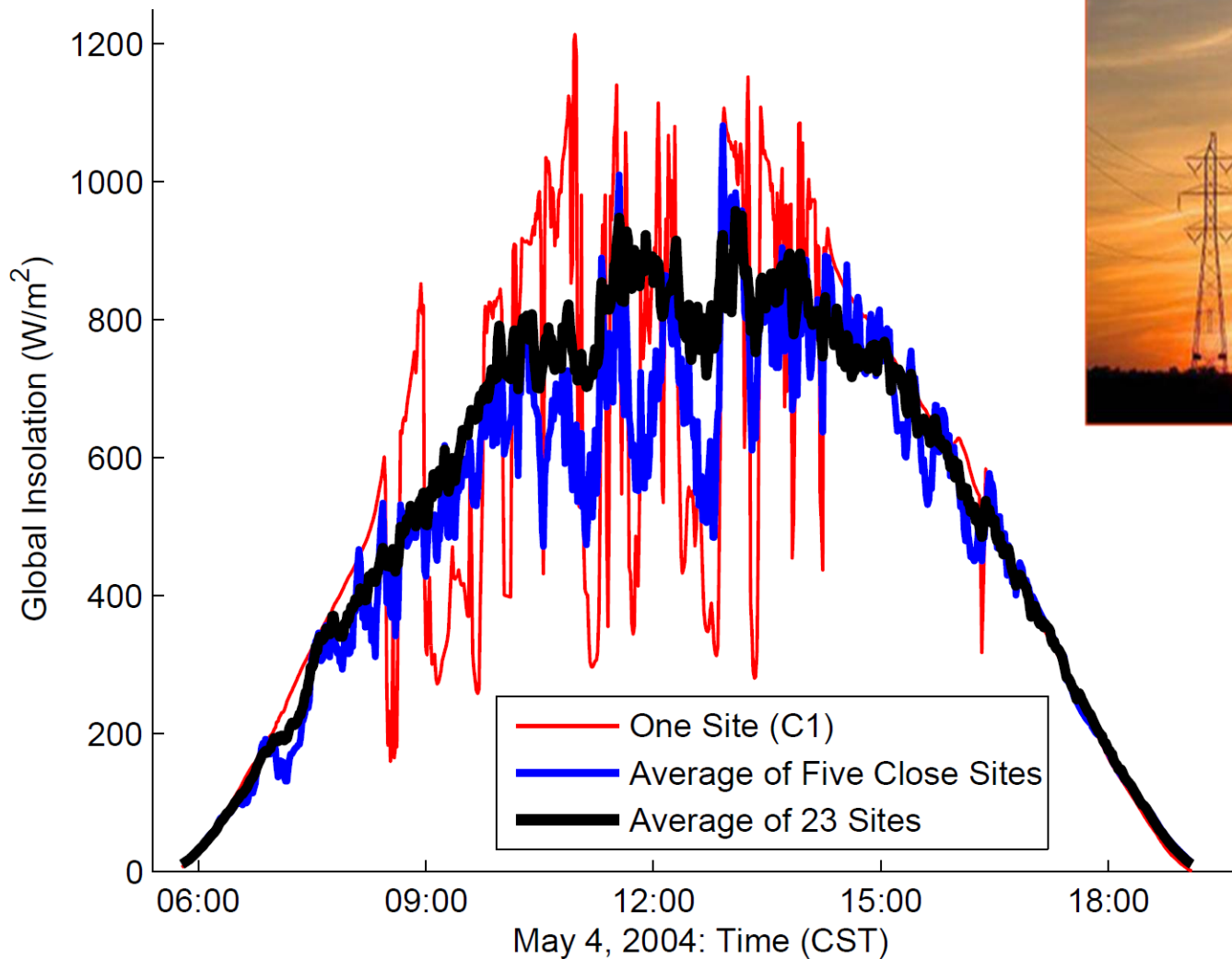




# Aggregation of wind with transmission



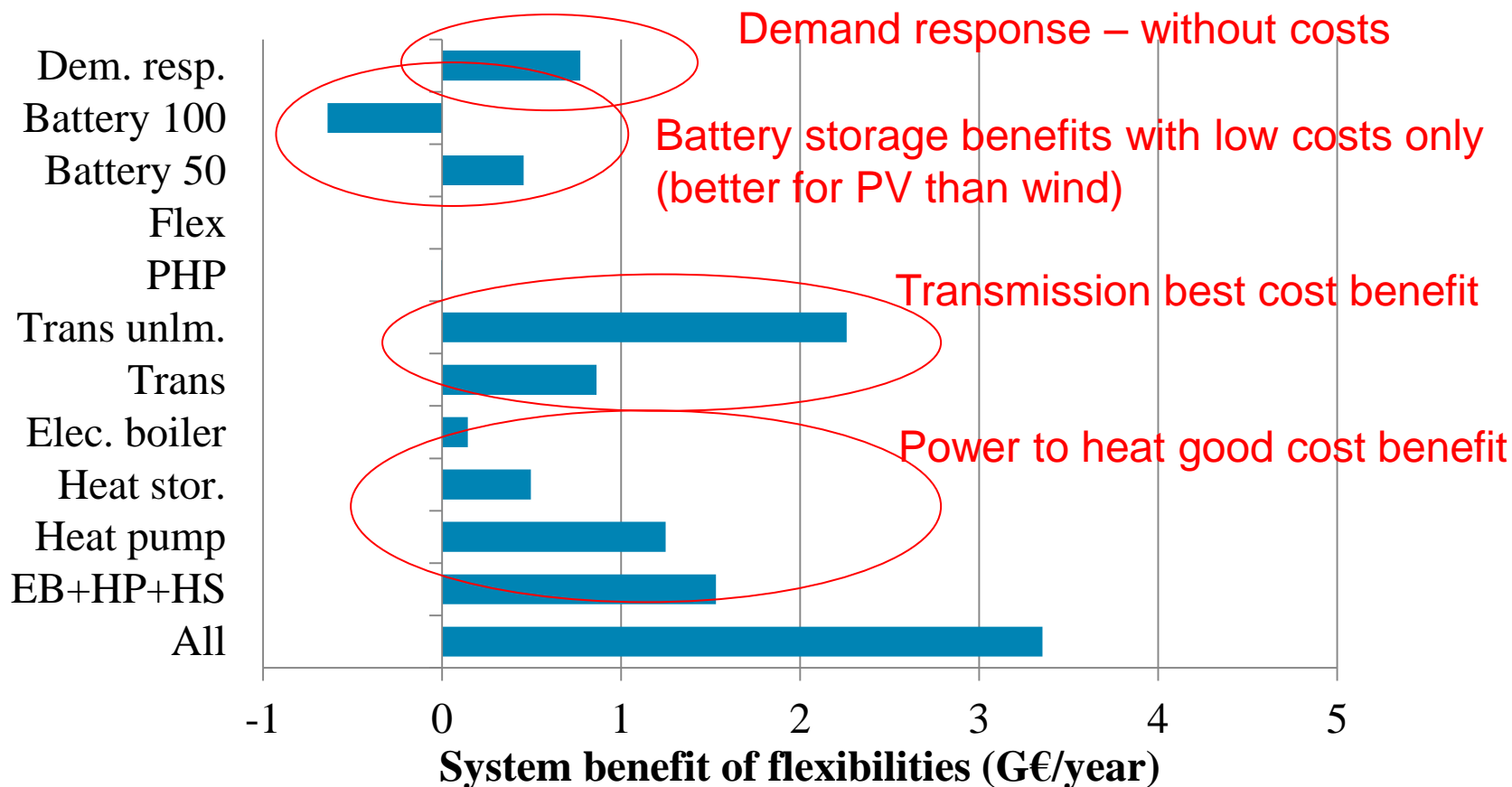
# Aggregation of solar



Mills, A. D, and R. H. Wiser. 2011. Implications of geographic diversity for short-term variability and predictability of solar power. In 2011 IEEE Power and Energy Society General Meeting, 1-9. IEEE, July 24. doi:10.1109/PES.2011.6039888.



# Comparing the flexibility options



- Relative value of new flexibility options for Northern Europe, scenarios with lot of wind power: 42-55% of energy
- For wind, transmission, heat sector flexibility and demand response most important

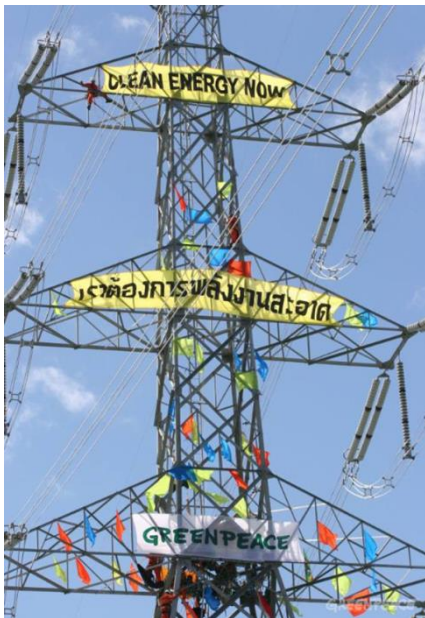


**If you love wind/solar you have to  
at least like Transmission**

# Enter the “consumer”



“Engineers (and economists) tend to be ignorant and arrogant about customers”, Janusz Bialek



‘Engineers and economists are ignoring people and miscasting decision making and action’, Sovacool, B.K. (2014) *Nature* 511, 529-530



Masai women from Kenya take a course on solar energy in India.

## Energy studies need social science

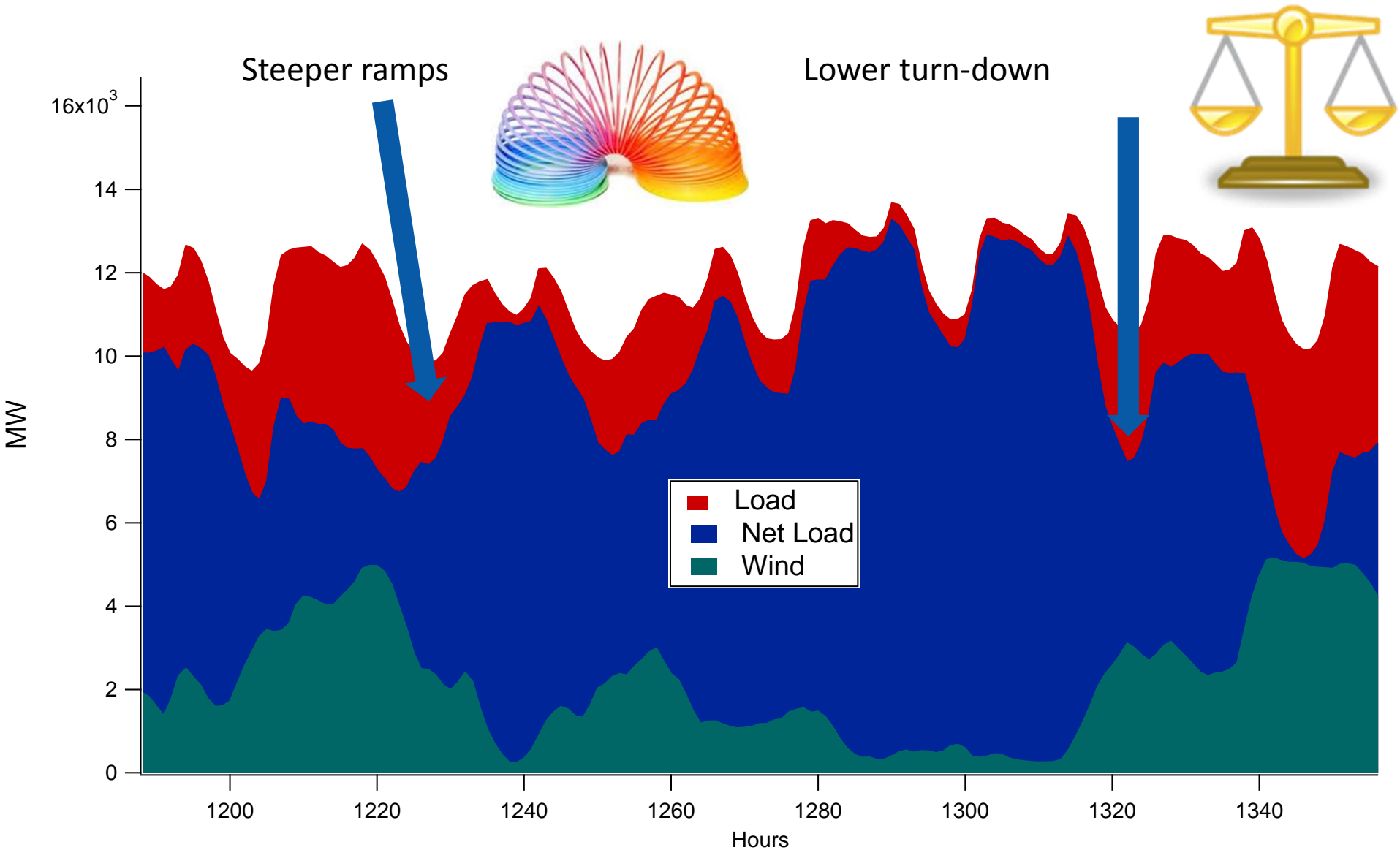


# Transmission: Take Away

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- Electrical transmission is almost always the most **cost effective technology** to enable the integration of variable renewable energy
  - But many in **society object** to its construction and the variable renewable energy infrastructure
- Social science research needed to **minimise public opposition**

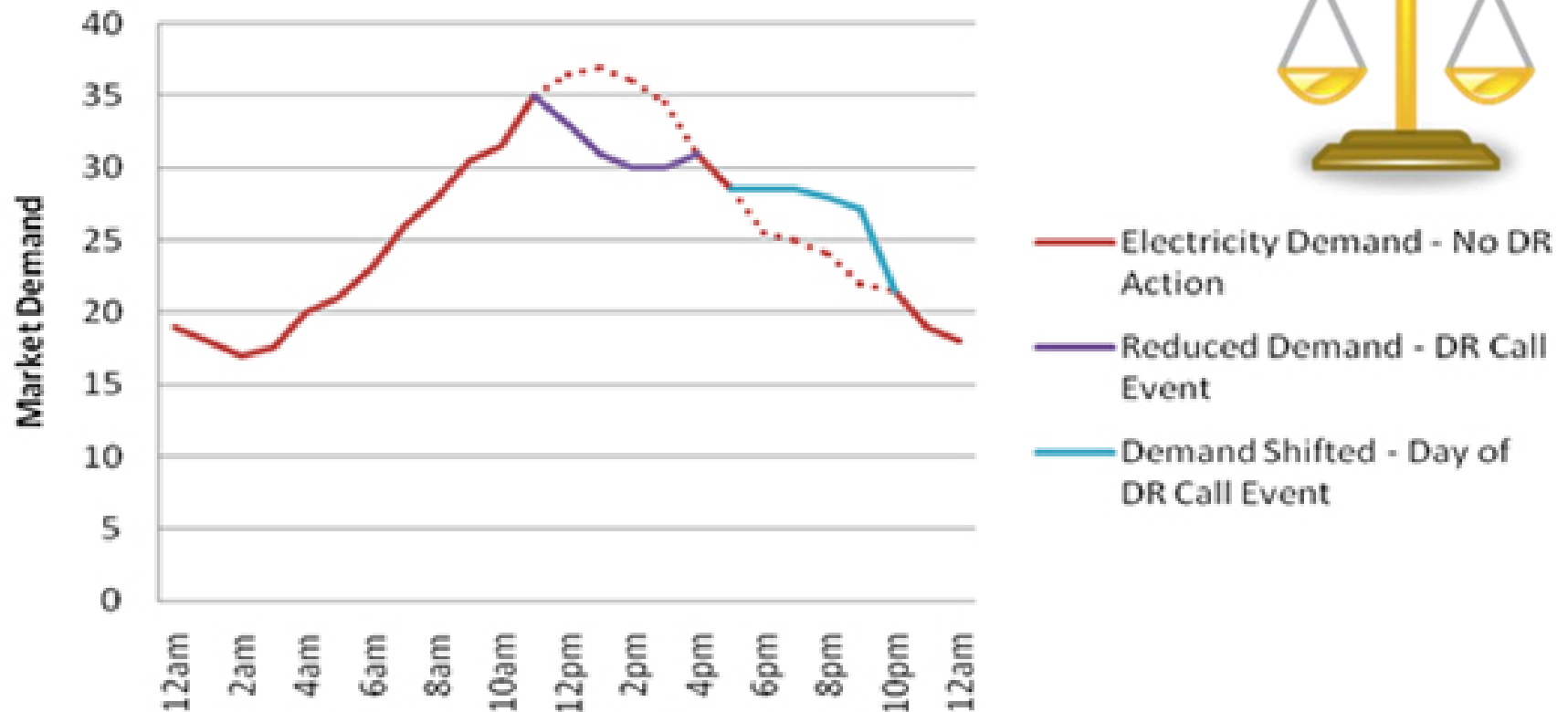
# With Variable Renewables More Flexibility is Needed



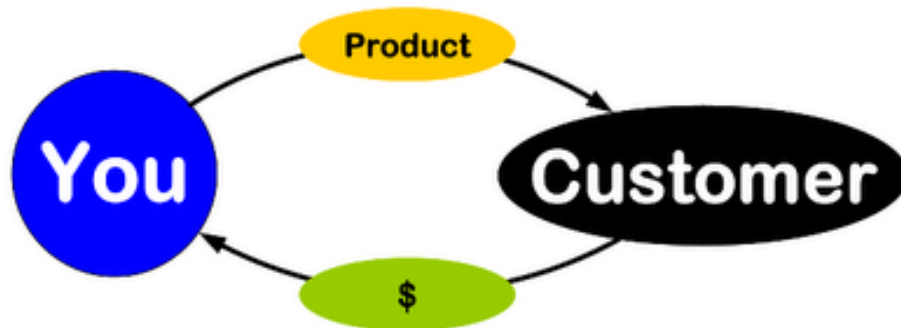
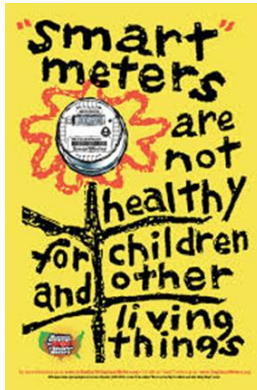


# Demand response

## Electric Grid Demand Curve

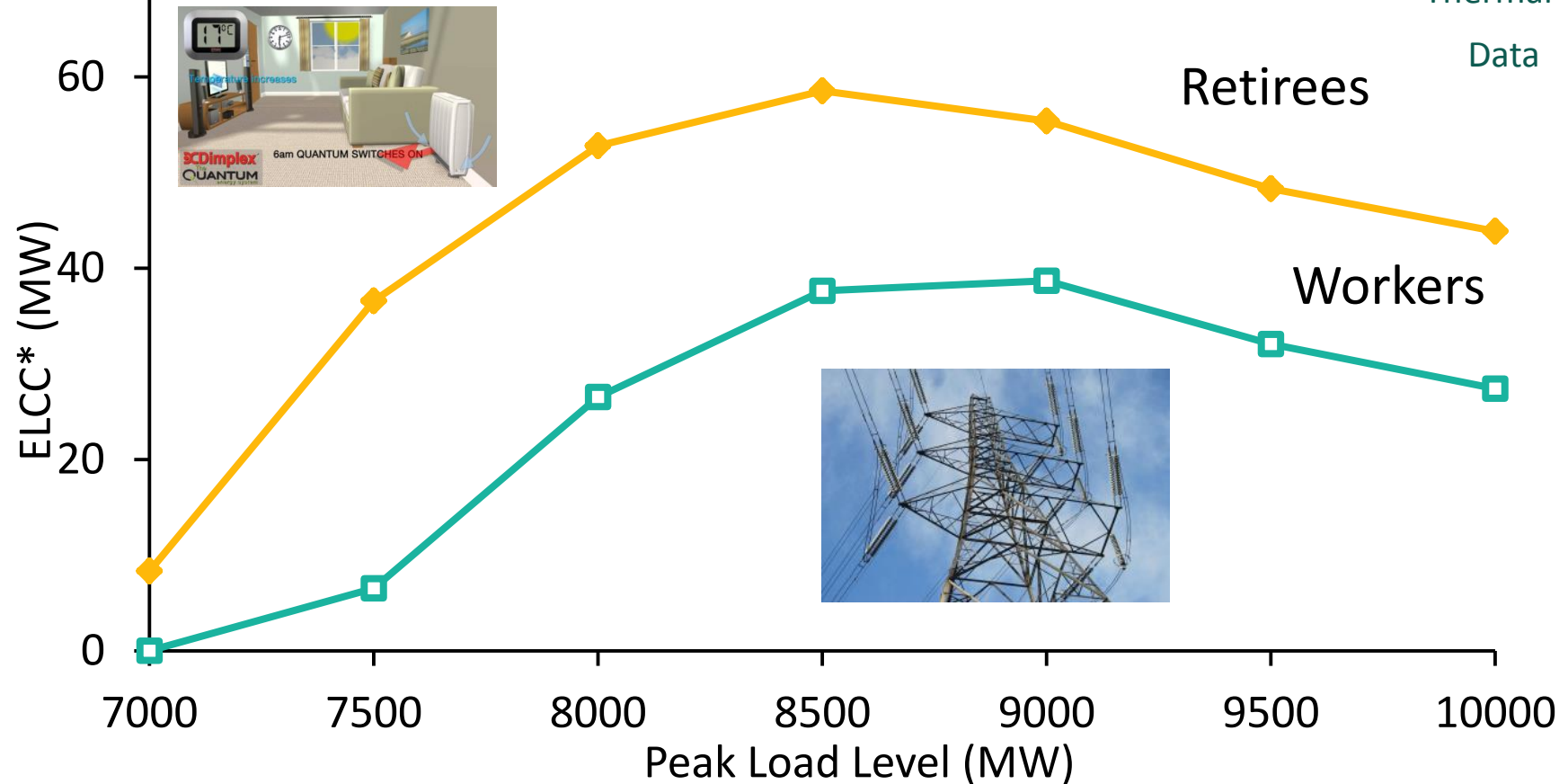


# Demand response - the “consumer” and the business model



# Consumer characteristics impact on demand response

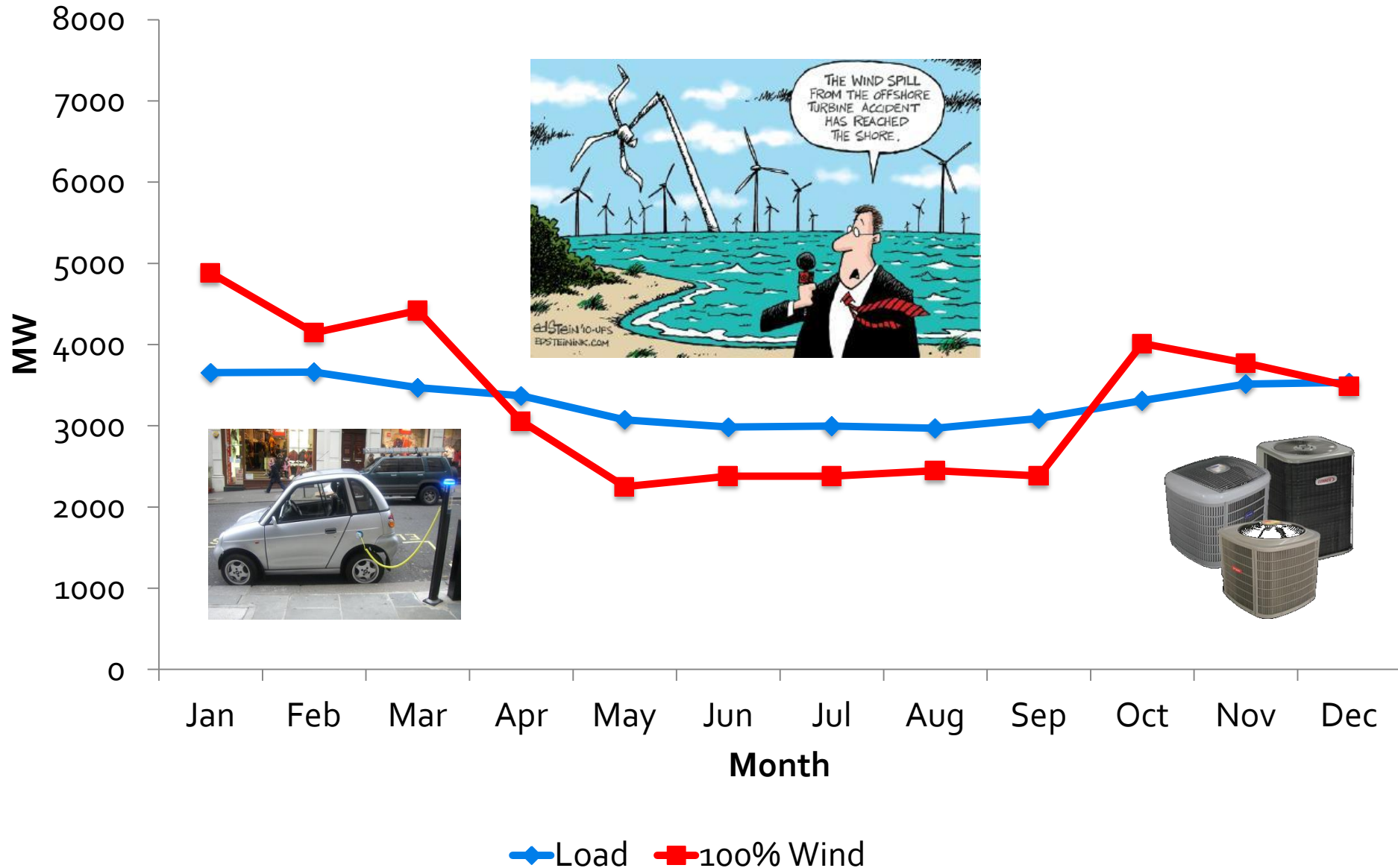
Effective Load Carrying Capability (ELCC) of 700MW of domestic electric heat storage under “optimal” operation



**Note: These are preliminary results and are part of on-going work**

# 100 % Wind we will have to change how we live

2010 Wind data scaled up to meet 100 % demand



# How they do it in China



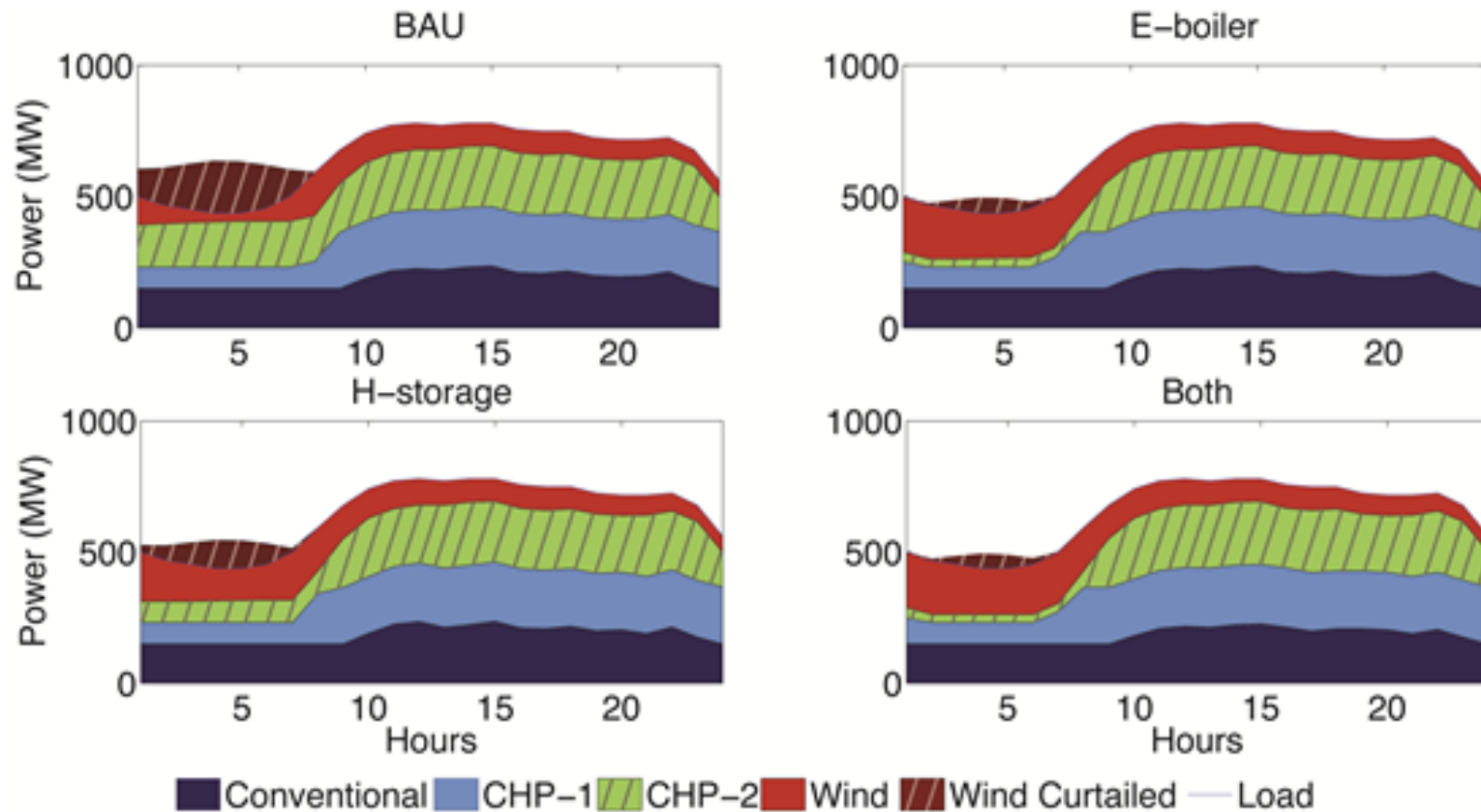
- Established in Inner Mongolia, 2014, with 20 electric boilers
- 500,000 m<sup>2</sup> heat supply
- 75 GWh wind power annually, equivalent to 19,000t coal
- Decrease CO<sub>2</sub> emission by 68,000t



Source: Chongqing Kang, Tsinghua University



# Flexible CHP can reduce wind curtailment



Chen, X., Kang, C., O'Malley, M.J., Xia, Q., Bai, J., Liu, C., Sun, R., Wang, W. and Hui, L., "Increasing the Flexibility of Combined Heat and Power for Wind Power Integration in China: Modeling and Implications", IEEE Transactions on Power Systems, Vol. 30, pp.1848-1857, 2015.

# Demand response: Take Away

---

- Flexibility on the demand side is a **cost effective technology** to enable the integration of variable renewable energy
  - But the **financial rewards to consumer** may not be enough to make an impact
- Social science research needed to **fully understand the motivations and rewards**
- To reach high penetrations of variable renewable society may **have to change** how it organises itself

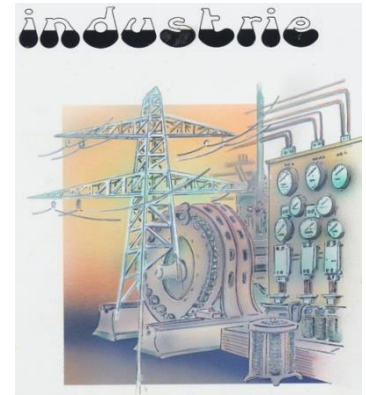
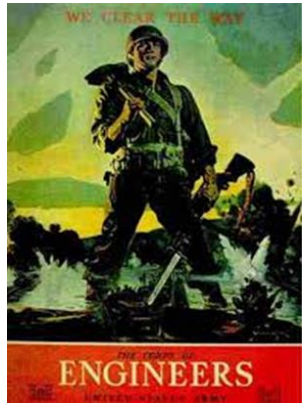


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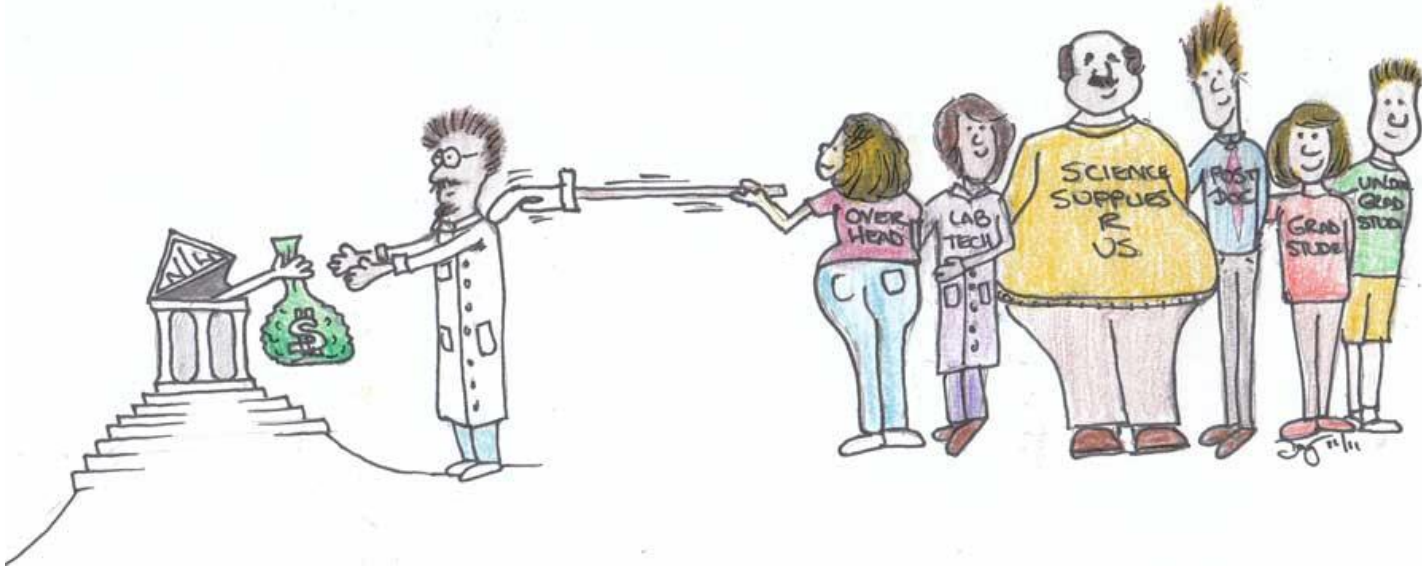
# Some observations

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# A “three” way bridge



# Research funding



**Does your laptop keep running out of power?  
No longer! Use the natural power of your  
own laptop to recharge itself!**



**Use the USB  
Laptop self-  
charger cable  
and never run out of power again!**





# Beware



# Observations

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- It is as much about education as research
- Research funding is needed
  - But not necessarily extra research money
- Beware of the hammer and nail brigade
- Difficult to encourage research between technology and social science – leadership required

# International Context

## Strategic Energy Technology (SET) Plan

Towards an Integrated Roadmap:  
Research & Innovation Challenges and Needs  
of the EU Energy System



[https://setis.ec.europa.eu/system/files/Towards%20an%20Integrated%20Roadmap\\_0.pdf](https://setis.ec.europa.eu/system/files/Towards%20an%20Integrated%20Roadmap_0.pdf)



<http://www.nrel.gov/esi/esif.html>



<https://es.catapult.org.uk/>

**Imperial College  
London**



Think. Share. Evolve.

iiESI is an international community of researchers collaborating to address global energy challenges.

**KU LEUVEN**

## iiESI Leadership



**Mark O'Malley**   
iiESI Director  
(University College  
Dublin)



**Bryan Hannegan**   
iiESI Executive  
Director  
(National Renewable  
Energy Laboratory)



Solving complex global energy challenges requires changing the way we THINK about energy systems, providing opportunities to SHARE knowledge, and helping nations EVOLVE by informing the discussions that are guiding energy investments and policy decisions.



## Summary of iiESI Workshop on ESI Research Challenges in London

March 30<sup>th</sup> and 31<sup>st</sup>

Imperial College London

The workshop brought together an experienced group of international research active people with a diverse range of expertise (see list of attendees below). The workshop was open and vibrant, (see agenda and briefing documents below) and while **the focus of the workshop was on identifying the research challenges in Energy Systems Integration (ESI)**, the discussion was much broader as the group grappled with the extremely complex environment within which the research questions have meaning and impact. There were some particularly salient ideas that defined the diversity and richness of the research challenges ahead of us. For example, “the difference between electricity and heat for an engineer is as profound as the difference between a consumer and a citizen for a social scientist”. This underscored one of the most significant outcomes of the workshop: **the need to combine economic, social, and political perspectives with the engineering knowledge** that better connects the behaviour of end use customers with how energy is produced and delivered. Such an approach is essential to produce ESI solutions that are both technically sound and desirable to users, thus enhancing the chances of real deployment and impact.

[http://iiesi.org/assets/pdfs/iiesi\\_london\\_summary.pdf](http://iiesi.org/assets/pdfs/iiesi_london_summary.pdf)



# EERA JP in ESI



**EERA**  
European Energy Research Alliance

Coordinating energy research for a low carbon Europe



## JOINT PROGRAMMES

About JPs

How does a Joint Programme operate

What is the outcome of a Joint Programme

Integrated Research Programmes

Collaborating with industry

International Cooperation

National Alignment

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List of JPS

- AMPEA
- Bioenergy
- Carbon Capture and Storage
- Concentrated Solar Power (CSP)
- Economic, environmental and social impacts (JP e3s)
- Energy Efficiency in Industrial Processes
- Energy Storage
- Energy Systems Integration**
- Fuel Cells and Hydrogen
- Geothermal
- Nuclear Materials
- Ocean Energy
- Photovoltaic Solar Energy
- Shale Gas
- Smart Cities
- Smart Grids
- Wind Energy

You are here » EERA Joint Programmes (JPs)

## Energy Systems Integration

### The EERA Joint Programme in Energy Systems Integration

This Joint Programme in Energy Systems Integration seeks to bring together research strengths across Europe to optimize our energy system, in particular by benefiting from the synergies between heating, cooling, electricity, renewable energy and fuel pathways at all scales. The energy elements of the water and transport system are also included as is the enabling data and control network that enables the optimization.

The Joint Programme in Energy Systems Integration is designed to develop the technical and economic framework that government and industries will need to build the future efficient and sustainable European energy system. It is fully aligned with the recently published SET Plan Integrated Roadmap and potential impact include increased reliability and performance, minimisation of cost and environmental impacts and, in particular, increased penetration of renewable energy sources.

The Joint Programme is organised in 5 Sub-Programmes (SP) that target different aspects of Energy Systems Integration. Given the nature of Energy Systems Integration, the SPs are strongly interlinked.

SP1: Modelling, coordinated by Dr. Juha Kiviluoma, VTT (FI)

SP2: Forecasting, aggregation & control, coordinated by Prof. Henrik Madsen, DTU (DK)

SP3: Technology, coordinated by Prof. William D'haeseleer, KU Leuven (BE)

SP4: Consumer, coordinated by Mr. Didier Van den Abeele, CEA (FR)

SP5: Finance & regulation, coordinated by Dr.ir. Laurens J. De Vries, TU Delft (NL)

The Description of Work (DoW) for the Joint Programme in Energy Systems Integration is available  [here](#).

 News of this program

 Useful documents

 EERA intranet

### Coordinator

Prof. Mark O'Malley  
 e-mail

Claire Cullen  
 e-mail

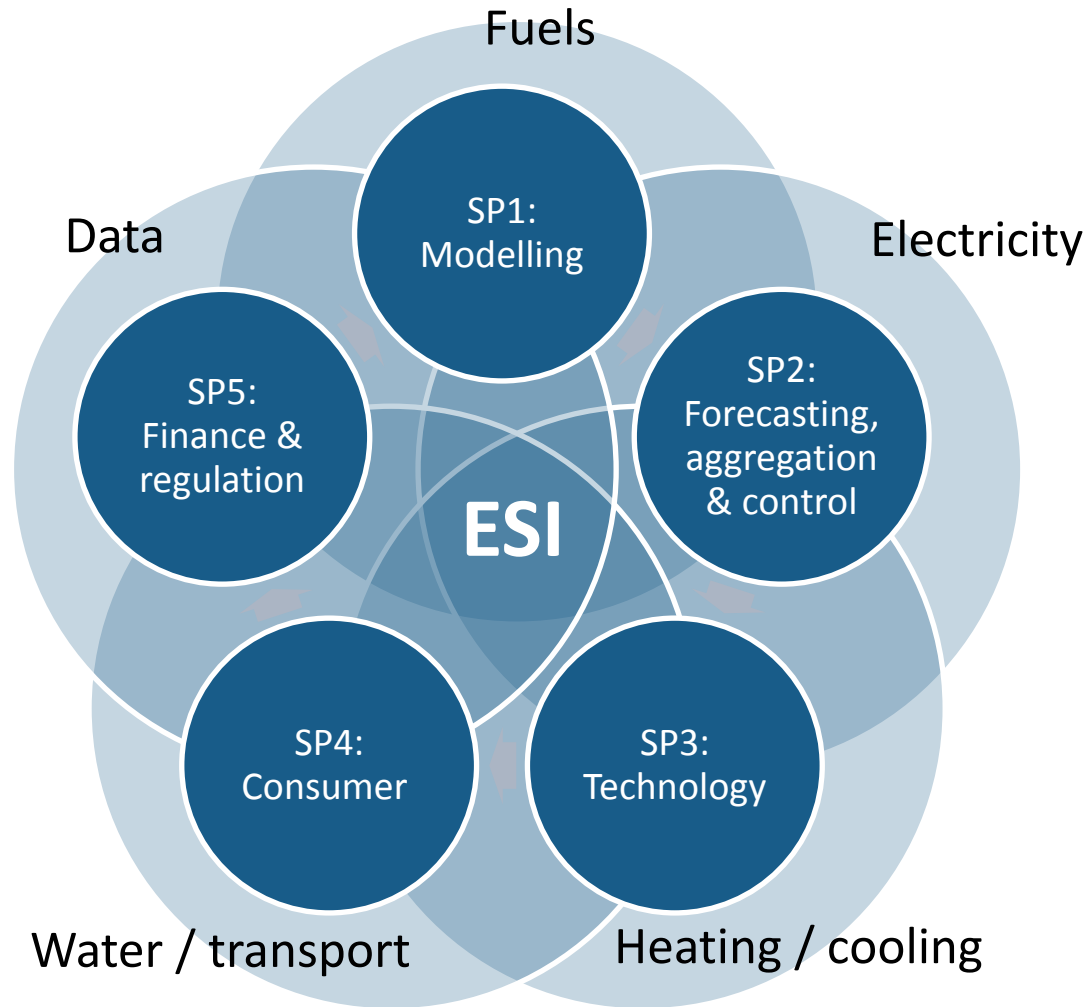


### Contact at EERA

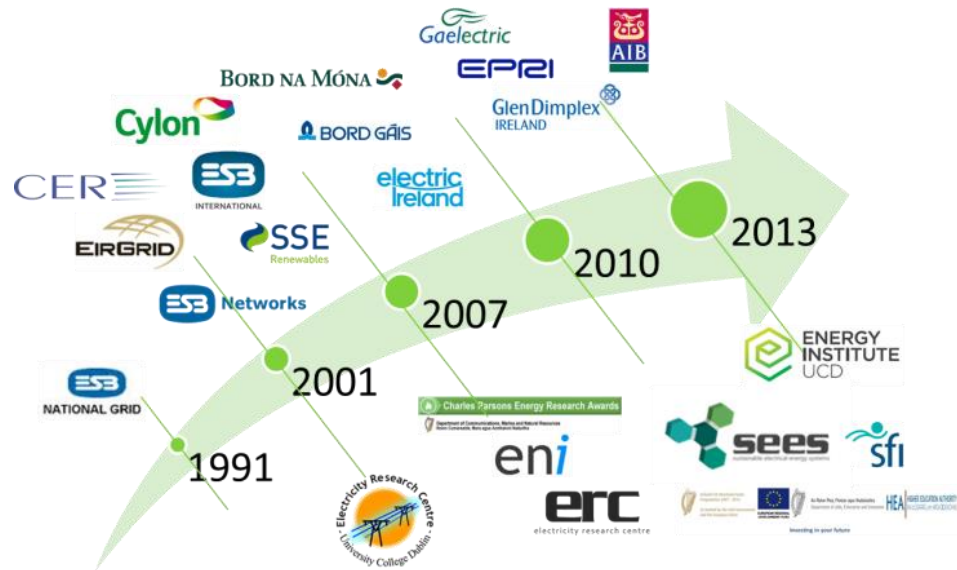
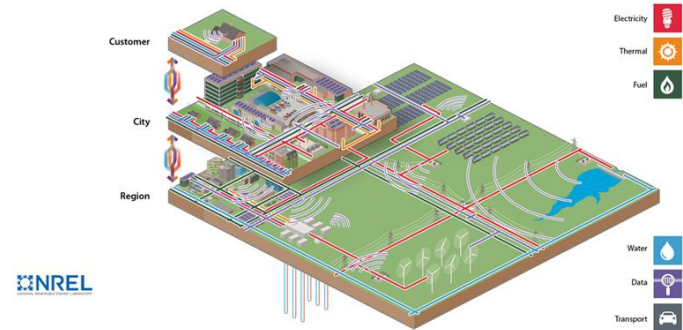
Maria Oksa  
 e-mail



# DESCRIPTION OF WORK



**ESIPP** Energy Systems  
Integration  
Partnership Programme



# Conclusions

- It is more about the whole **integrated energy system** than ever before including the “consumer”
- **Social science research is fundamental** to integration of variable renewable energy into electricity grids
- **Scope, funding, quality, leadership** all important
- Plenty of activity **evolving**
- How to **coordinate** to get best impact ?



# Trilemma plus the “consumer”





# Acknowledgements

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- Marta Lopez, A. Gomes Martins & BEHAVE 2016
- Linda Steg & PERSONS Platform
- My colleagues for many of the slides

