EUA Energy Clustering Event

Insights from the “Action Agenda” report

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Introduction

Dr Douglas Halliday, Durham Energy Institute, Durham University

Introduction

The Energy Challenge

"…requires new cross-disciplinary approaches, integrating different energy technologies, energy systems, energy economies and markets, and importantly, embracing new regulatory frameworks, and understanding consumer behaviour and societal and cultural dimensions."

Effective solutions must address the whole energy system and its interface with society

Introduction

What does it mean for universities?

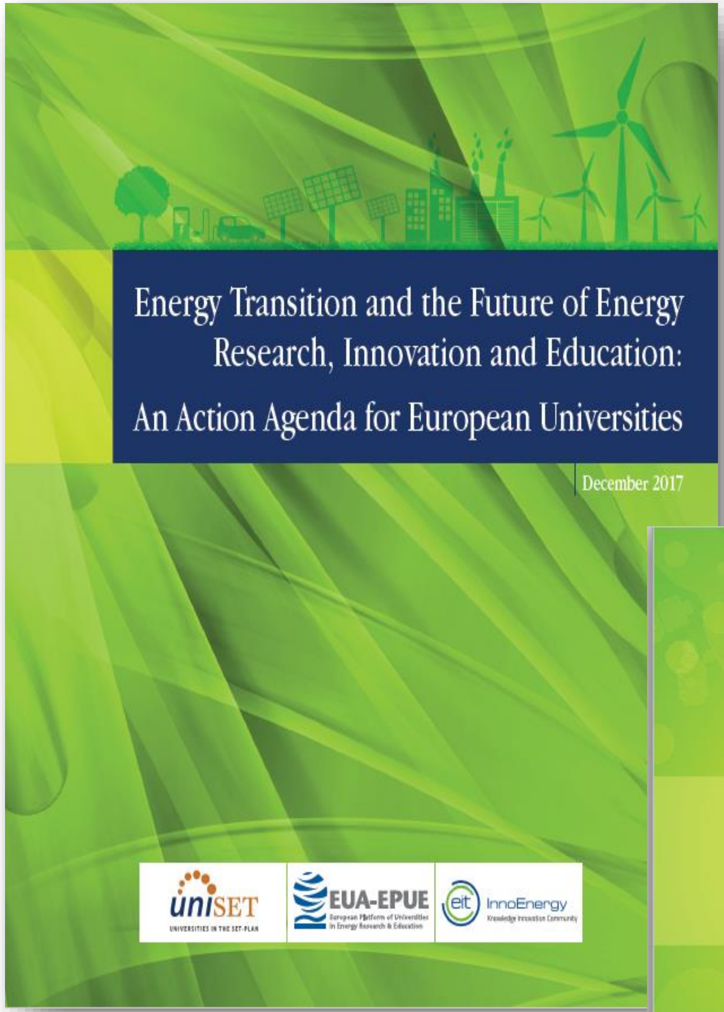
- Upgrade & innovate own programmes
- Collaborate with society and industry
- Update learning & teaching
- Break down disciplinary barriers
- More flexibility
- New interdisciplinary working – new insights

Introduction

An Action Agenda for European Universities

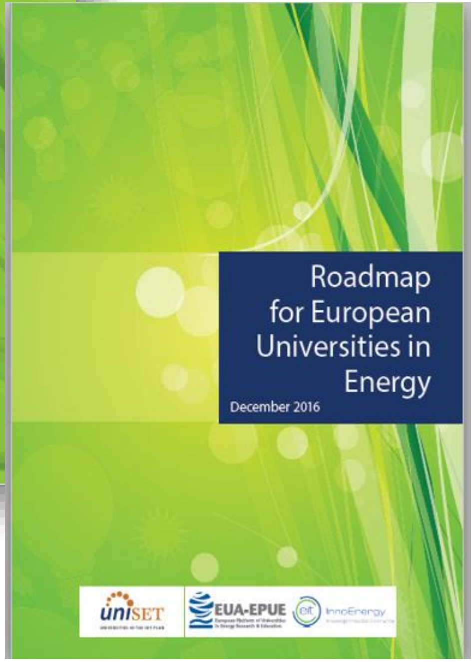
(input from 100 energy experts)

- Enable the **development of the actions set out in the Roadmap for European Universities in Energy**
- Adoption of **new innovative approaches to learning, teaching and research**: Novel framework and approach for structuring new energy-related programmes
- Bridging **skills gap** in higher education and business sector
- **Greater interaction** between universities and other energy stakeholders including European and national policy makers, industry and citizens
- **Specific examples** in key areas of energy technology: Energy Efficiency; Smart Grids and Systems, Integration of Renewables



Report available online:
http://bit.ly/action_agenda

Roadmap available online:
http://bit.ly/2FgZ1c8



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Introduction

An Action Agenda for European Universities

Four Working groups and chapters, including both technical/engineering and social science/humanities contents:

1) Horizontal content of cross-disciplinary education and research programmes

2) Energy efficiency

3) Smart grids & energy systems

4) Integration of renewables

Report available online: http://bit.ly/action_agenda

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Introduction

Main recommendations

- **Skills and knowledge** development need to go hand in hand
- Focus on **new learning and teaching approaches**
- **Rethink the role of the educator**
- **Institutional support** for interdisciplinary education and research
- **Combine breadth and depth** in T-shaped educational programmes
- Pay attention to **Lifelong Learning**
- Leverage **digital opportunities**

Introduction

Pathways to the solution

- New technologies & ways of working require **new skills**
- **Adapting curricula, learning & teaching, student-focussed approaches**
- Expansion of **research-based learning, entrepreneurship & innovation skills** – creating solutions
- **Learning and teaching in inter-/cross-/multidisciplinary challenges and teams** - communication
- More attention to **holistic & systemic perspectives**, especially for complex societal challenges such as energy – research methods and approaches
- Interface between **technical solutions and society needs** careful consideration
- However, need for specialised experts & scientists won't disappear – **universities play critical role in training**
- Developing **new knowledge and understanding**

Introduction

Practical solutions

Master-level education

- Expose students to the full breadth of the energy system
- Tailored ‘background components’ to the main field of study
- Consider all aspects – conventional & renewable energy technologies, storage, systems, transport, heating/cooling
- Public perception, energy practices, energy choices and prosumers, energy dialogues
- Economic and financial factors
- Energy policy

Doctoral education

- From “T-shaped” to “A/Q-shaped”
- Breadth and context provide foundation
- Develop interdisciplinary research training
- New research methodologies across traditional subject boundaries
- Maintain requirement for original knowledge and original research
- Structured doctoral education, benefits of a cohort approach

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Examples

16. Energy Communities - Society

Topics (for courses)	Understanding, Background Knowledge, Comprehension, General Appreciation of …	Design and Implementation / Deeper (Master level) Appreciation of …	Employment Skills
Technical	The technical challenges of building energy communities	Energy system solutions compatible with community needs	Examine/improve end-user practices
	The challenges and need for distributed generation	How to ensure that distributed generation does not affect supply reliability	
Social	Drivers for socio-cultural acceptability	The effects of distributed generation	Participate in the modern energy industry
	The changing roles of energy communities	Dissemination strategies for renewable energy technology	Communicate effectively with a variety of end users
	The need for building communities	Potential renewable energy technologies for future application and how users and producers respond	Work with different stakeholders
Economical	Differences in energy consciousness of both energy producers and consumers	Energy production and cost case studies to explain the historic and contemporary needs and uses of a specific energy technology	Awareness of significant historic developments for energy initiatives
	The history of energy production and costs	New economic models that support community responsibility for energy generation	Be an effective energy market operator
Political	Political framework requirements to support communities at global, national and regional levels	Improved governmental structures for larger community development/support	Support the 'return to the community'
	Supporting means for a cultural shift to community development	The need for a shift towards communities	

18. User Behaviour/ Engagement

Topics (for courses)	Understanding, Background Knowledge, Comprehension, General Appreciation of …	Design and Implementation / Deeper (Master level) Appreciation of …	Employment Skills
Technical	Techno-anthropological surveys and questionnaires	Statistical analysis of results, definition of uncertainty	Communicate with customers
	Technical implications of a move towards decentralised/prosumer based generation	Design control systems that operate locally, but can also interact with more centrally controlled operation	Understand why and how various groups of customers/citizens have various needs and different abilities to engage and benefit from various technologies
Social	How discourses, institutions and professions have historically shaped the conceptual landscape of robust and socially responsible technological innovation	The methods, tools and skills appropriate for studying consumer practices	Highlight different consumer practices
	Energy consumer practices and the willingness of consumers to change energy behaviour	Cases of robust and socially responsible energy technology innovation	Identify opportunities for the development of robust and socially responsible energy technology solutions
Economical	Inform consumers of good practices to supply their own energy demand	The potential benefits of incentives and whether this aligns with the best energy provision system for this consumer/prosumer	Economic benefit for users
	Cost benefit analysis for private prosumers		Communicate with customers
Political	Knowledge of incentives and legal framework for prosumers (e.g. interconnection to grid)	Legislation improvements that support prosumer behaviour	Good background for discussing user involvement
	The mechanisms of how political decisions (on regulation, energy or CO2 taxation, incentives) influence end-user energy consumption	The potential impact of legislation decisions on user behaviour and technology/economy/etc.	

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Energy Efficiency

Prof. Fabrice Lemoine, Energies for the future, Lorraine Université d'Excellence Programme

Energy Efficiency

State of the Art

- Increased energy efficiency is one of the cornerstones of both the 2020 and 2030 EU energy strategy.
- EU targets for energy efficiency, compared to 1990 levels:
    - 20 % by 2020
    - 25 % by 2030
- Constant challenge across all sectors, from energy production, distribution and consumption in industry, buildings and transportation as well as in agriculture and the service sector.
- Out of a total of over **7.600 research staff (FTE) at the surveyed universities**, almost **2.000 (over 25 %) are engaged in energy efficiency and smart city field**s. A similar share (1.350 out of roughly 5.000) of doctoral candidates also work within these fields.
- **Energy efficiency cuts across sectors and technologies** and requires interdisciplinary and systemic approaches. It is a "prerequisite" to the application of renewable energy.
- To be effective, measures for improving energy efficiency must always be seen in a **systemic interdisciplinary context** that includes a product/service life cycle within a local/regional energy system including end users.

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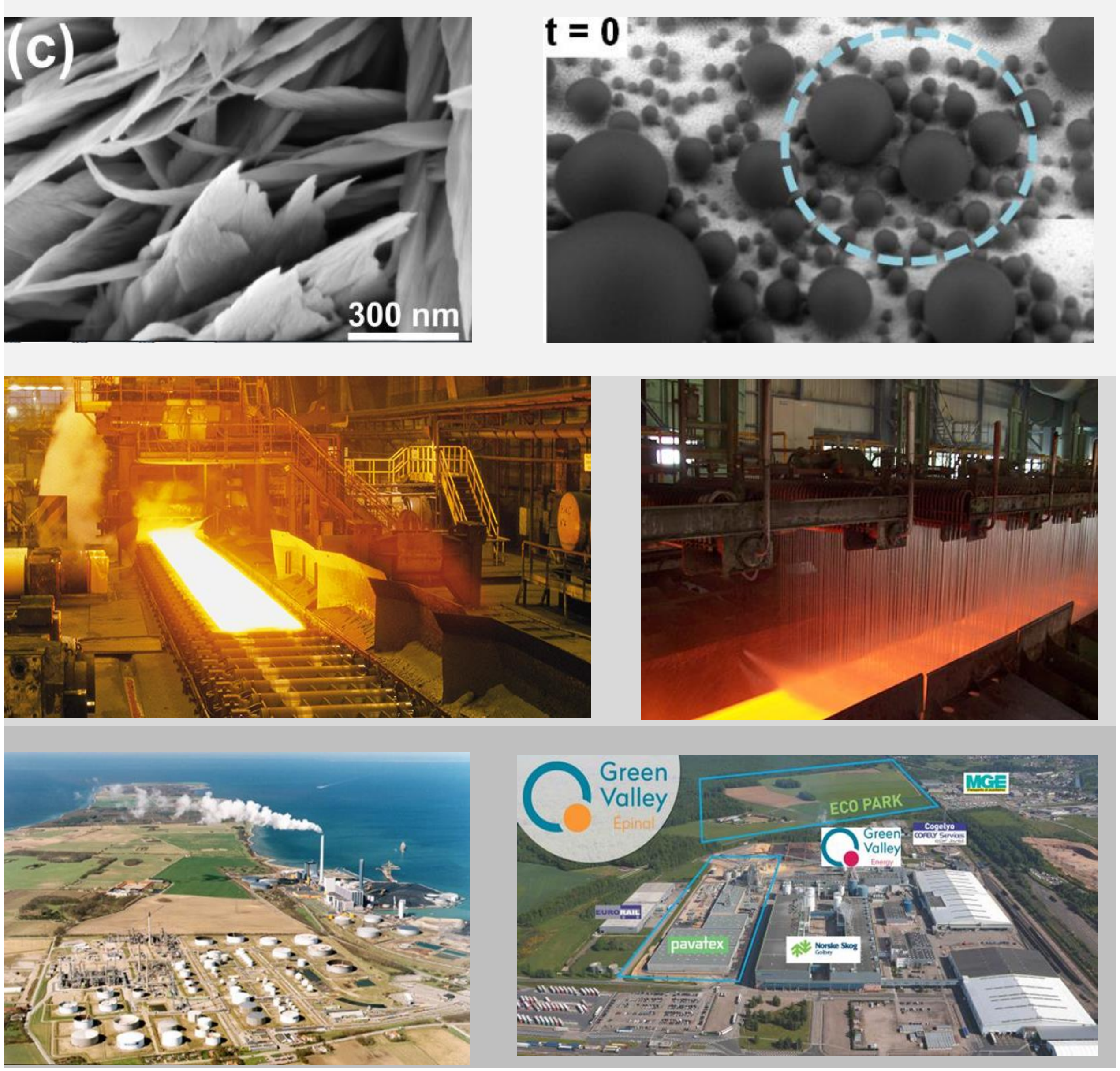
Energy Efficiency: all scales have to be considered



nm — Improvement of a condenser by a hydrophobic surface coating : gain +25%

m — Process : ex-steel making : energy is a major concern

km — Beyond the factory : optimization at the territorial scale

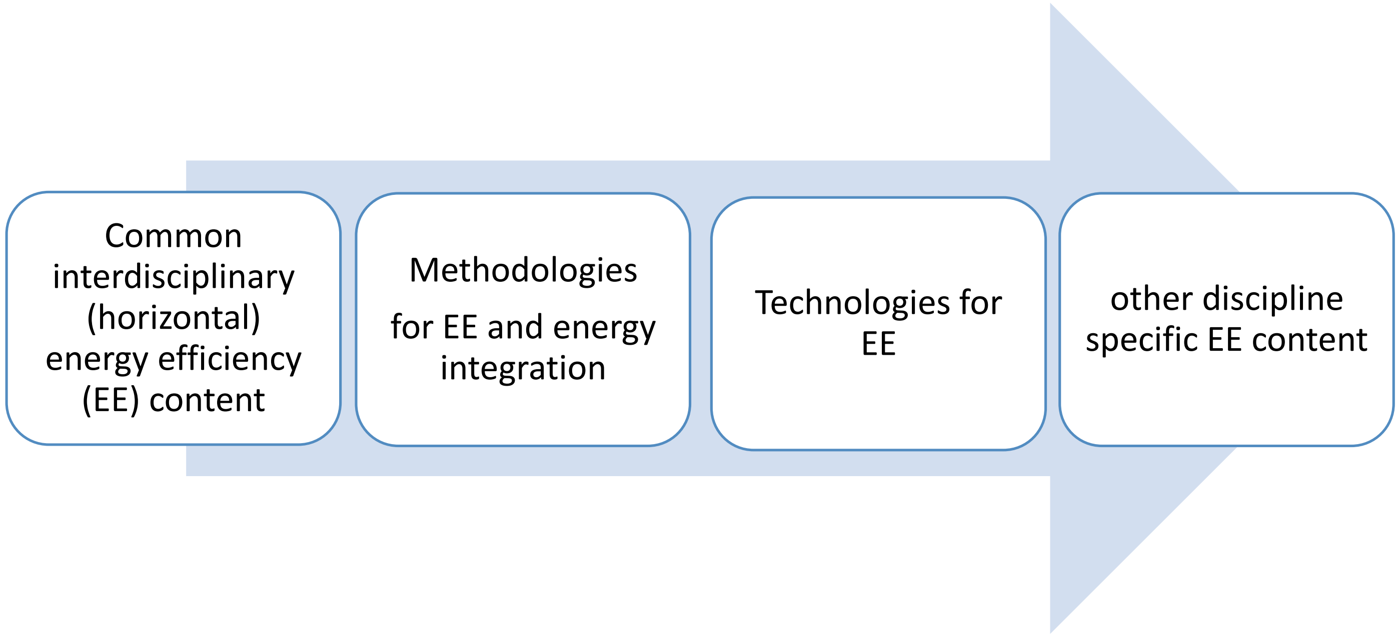
EE is by nature

- Multiscale
- Multi-physics
- Interdisciplinary

Energy Efficiency

Master level programmes general scheme

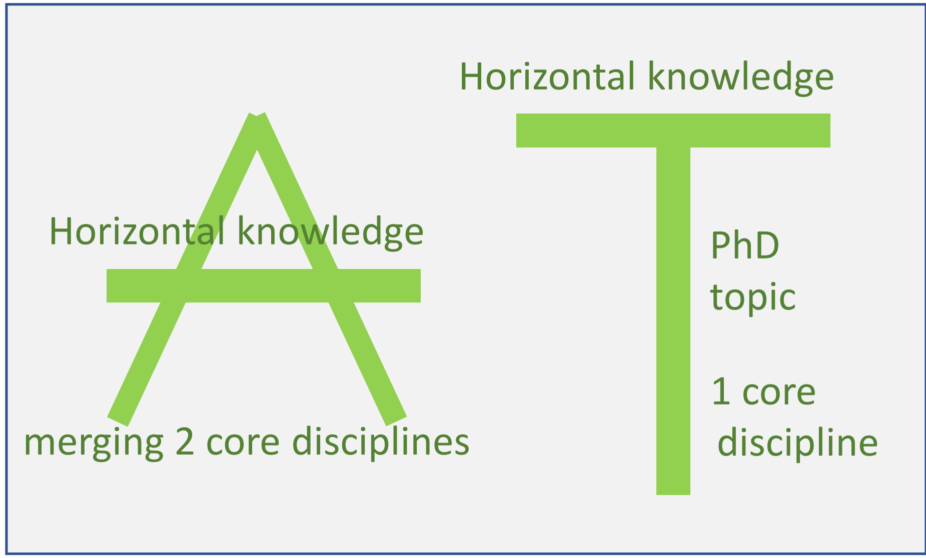
Should be part of energy, mechanical, electrical, chemical engineering masters, ...



Energy Efficiency

Doctorate and research programme recommendations

- Interdisciplinary as well as the transdisciplinary integration of different actors in order to achieve systemic energy efficiency will take precedence. Course elements will have to complement the knowledge acquired by students in their Master programmes.
- Doctoral candidates in all energy relevant disciplines must have a fundamental understanding of
  - *Energy efficiency technologies in industry, buildings and transport*
  - *Energy efficiency planning methods in industry, buildings, transport and spatial planning [Pinch analysis, Process network synthesis, Exergy Analysis]*
  - *Simulation tools for the definition of heating/cooling energy demand*
  - *Actor interaction to achieve systemic energy efficiency*
  - *Behavioural aspects of energy efficiency*
- Research subjects (EUA-EPUE scientific policy input to the SET-Plan)
  - *Energy efficiency planning methods repository (transitory methods, comparison, combination)*
  - *Total site energy integration*
  - *Model collaboration (continuous, discrete)*
  - *Socio-technical transitions*
  - *Rebound effect, i.e. Jevon's paradox*



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Examples and case studies

Competences, skills for employers

Subjects

7. Energy Efficiency

Topics (for courses)	Understanding, Background Knowledge, Comprehension, General Appreciation of …	Design and Implementation / Deeper (Master level) Appreciation of …	Employment Skills
Technical	The factors that influence systemic energy efficiency, incl. integrating energy along life cycles and within the spatial/ geographic context	The relationship between life cycle and energy efficiency	Propose energy efficiency measures at process level, potentially driven by data gathering
	Collected data analysis and appreciation of the power of such data, accepting its limitations	Simulation results and data gathered from measured consumption to improve energy efficiency	Propose energy cascades and efficiency improvements in whole life cycles
Social	The deployment barriers for efficiency improvements	Social barriers as part of a holistic analysis to improve implementation/integration	Consider social barriers
	The roles of actors in and impact on efficiency improvements	The impact of (new) technical processes in their spatial and social context	Interact with actors along the value chain/in the spatial context to improve systemic energy efficiency
Economical	Life cycle costs analysis of energy use with regards to generation efficiency	Calculate ROI for existing combined with new installations	Propose profitable and sustainable (costing) solutions
	The impact of pricing scheme trends (e.g. pricing based on kW instead of kWh) on management and new installations		Propose innovative business models for increased energy efficiency (uptake)
Political	Environmental regulations on efficiency and requirements	Adequate incentives for citizens and companies to move towards better energy efficiency	Operate in/create a legal framework
	Potential impact of economic incentives for energy efficiency improvements		

A comprehensive repository of case studies (challenge based teaching)

Appendix B - Case Studies

Energy Efficiency

Example 1 - Energy Efficient Regional Resource Use

Optimal use of existing, preferably local, resources is the ultimate improved efficiency goal. This requires students to generate holistic resource systems that make optimal use of restricted resources with state-of-the-art planning methods (e.g. Pinch, Exergy Analysis or Process Network Synthesis). When a group of (ideally engineering and urban/spatial planning) students is familiar with these technologies, they can be asked to optimise the resource use of a given region/urban settlement. Whenever possible, representatives from the region should be involved. The students will need to see data about the potential energy sources (bio, wind, hydro, solar) in the region, about demand (energy, subsistence, buildings), demographic development, existing businesses and existing infrastructure.

Each group of 4-5 students plans a method to overcome the existing problem. They propose an optimal resource-technology-demand system, integrating existing sites and infrastructure, and identify the most beneficial investments available. They present their results to the whole group, including tutors and regional representatives, followed by a discussion to analyse the strengths and weaknesses of the different approaches.

Example 2 - Multi Criteria System Optimization

A big chemistry plant produces a given number of tons of waste hydrogen and a given quantity of waste heat at 250°C per year. Students are given the annual electricity and primary energy resource consumption of the plant. CO2 emissions for chemical and own energy production are also provided. An onsite captive fleet is attached to the plant. Energy networks (electricity, gas and potentially heat) are part of the boundary conditions. The plant is located in a mid-rural territory that produces agricultural waste (wood, straw and manure are available). The region is rather windy, so a field of wind-turbines is currently being explored, while the yearly wind profile and installed power capacity are also provided.

Students are asked to:
1) Exploit waste as a resource
2) Create synergies within, and where possible across, plant boundaries
3) Increase the use of decarbonized resources.
Their main goal is to achieve multi-criteria system optimisation.

Groups of 4-5 students research the problem from a variety of perspectives, e.g: CO2 budget, deep decarbonization potential, economic impact/potential, energy efficiency, etc. An initial brainstorming is held to define potential technologies and synergies beyond the plant boundaries. Each group performs part of the modelling and simulation of the various potential technologies and synergies across plant boundaries. Results are discussed in a consensus meeting and presented to a broader panel of experts including people with non-technological backgrounds (geography, psychology, social, regulation, governance).

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Smart Grids and Energy Systems

Prof. Mihaela Albu, Politehnica University of Bucharest

Smart Grids and Energy Systems

State of the Art

- Concept of “smart grids” tends to include “**everything**”: dispersed generation, smart metering, microgrids, DC distribution networks, innovative control, solid-state transformers, IoT…
- Main aim is to find better ways to match **locally** generation with consumption, sometimes by controlling the end-use of electricity; however the end-users are customers of **competing stakeholders ,** using products and services sold on various markets
- Significant challenges with regards to: **interconnectivity, security, reliablility**, difference in speed of **technology change/adoption**

    For example, an energy system may be developed for a life span of 10, 20 or even 40 years, but in the lifetime of that product there would be many versions of OS that change → critical step in deciding on a **IoT approach** for substation supervision

Smart Grids and Energy Systems

Master level programmes general scheme

- Individuals must have very wide general knowledge, to e.g. appreciate impact, context, etc. while being able to also focus on the details of a very specific topic (e.g. communication requirements for smart meters).
- Programmes should **combine** (**50/50 to 80/20**), energy technologies (e.g. Energy Infrastructure – Smart Grids – Distribution Networks) with **holistic/generic system aspects**; through e.g. using **project/case studies** either within courses, or across the programme to bring different subjects more together.
- In designing a new "energy system" programme, one should consider:
  - integrating **more energy vectors**
  - Reliability, security and energy efficiency/saving
  - **Customer-centric vision**
  - Social responsibility issues
  - **Long time horizon**
  - Adoption **roadmap** of new technologies and policies (privacy / big data / **standards**)
  - …

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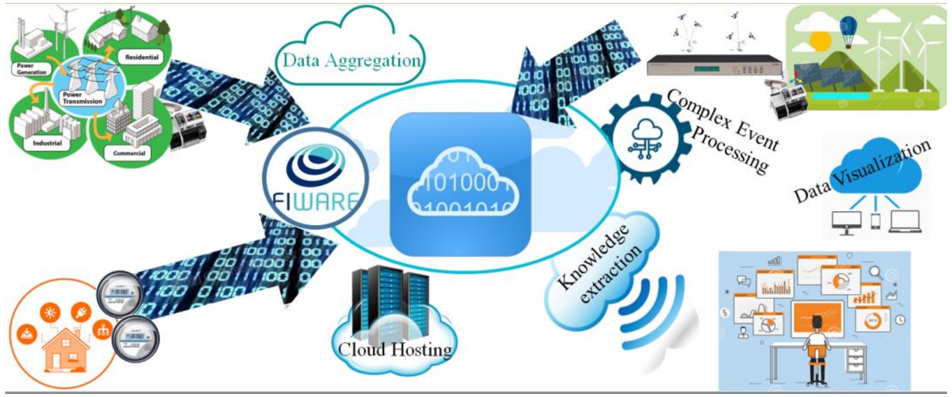
Smart Grids and Energy Systems

Doctorate

and research programmes

recommendations



- Aim is to ensure that part of a Doctorate study is to lead to this candidate being **a well-rounded individual**, that appreciates the different aspects of a piece of work, e.g. **social, economic, political, environmental**, etc.
- Both “applied” and “fundamental” research are necessary. Their **Impact** and **Context** are slightly different depending on the type of research (fundamental /applied research).
- In practice, each dissertation should incorporate **a section that focuses on the context and impact** of the performed research.
  - For applied research, this section could be larger and look more at the **impact** of the topic of research in business and in society.
  - For fundamental research, this section could be shorter and would aim to look more at the **long-term potential impact**.

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Examples and case studies

1. Energy Infrastructure - Smart Grids - Distribution Networks			
Topics (for courses)	Understanding, Background Knowledge, Comprehension, General Appreciation of …	Design and Implementation / Deeper (Master level) Appreciation of …	Employment Skills
Technical	The functionality of grid components and distribution of grid dynamics	The interplay of distributed generation/local use/network operation constraints to ensure grid stability and energy efficiency	Propose solutions to update network operation to emerging constraints, with the ability to work across borders between different systems
	Individual/multi energy grid components and (multi-energy) system theories/interactions	Holistic system analysis and modelling of electrical grids, thermal and gas distribution systems as multi source/carrier systems	Overall energy system analyses and implementations to improve energy flexibility by playing on the different energy vectors
		Control and communication structures for smart grid systems, including big data elements	Integrate correlated information and synchronized measurements
Social	The role of consumers in demand and generation	The value of critical energy infrastructure for different consumer types	Create/propose new types of utility/prosumer contracts and interaction with existing regulatory environments
	The social impact of the various energy markets	Solutions for overcoming potential barriers	Problem-solving from the start to the end of a project
	User engagement with their energy consumption	How user involvement affects the energy system	Professional, social/environmental contextual awareness
Economical	The costs related to grid operation	Design and propose innovative tariff schemes to positively influence the energy market in certain directions	Propose solutions compatible with the local energy market and required future shifts
	Energy markets	How energy market participation might affect control	Optimise market participation for different actors
	Business cases for different actors	Business cases from a consumer, utility and/or aggregator point of view	Propose business models for complex energy systems
	kW vs kWh tariffs, capacity/consumption prices of smart meters	Business models for technologies serving different grids	
Political	The role of regulators and grid codes	Country differences in regulatory environments - identify/propose future improvements	Apply grid codes
	Legislation issues and potential multi-scale governance of energy systems	Potential legislation barriers for multi-energy systems and how to overcome them	Appreciate the importance of legislation and standardization
	The political agendas of actors along the energy value chain		Interact with different actors along the energy value chains

Smart Grids and Energy Systems

Example 1 - Energy System Integration

Multi-energy systems integrate different energy vectors to achieve better energy use, reducing CO2 emissions, and achieving major economic savings. This requires a focus on the technical, social and human aspects of i.e. a smart grid or smart city case studies, preferably involving students from several different areas/backgrounds such as: techno-anthropology, economics, energy planning, electrical engineering, thermal engineering, control systems, communication and big data studies.

Groups are asked to select a real-life scenario in which electrical, thermal and/or transport issues need to be solved. They have to use knowledge from their various academic backgrounds to find a common solution, addressing the technical, economic and human sides to their chosen scenario.

All students work on the same context, but the focus of each project is different, according to the backgrounds of the students involved. Electrical power engineering students focus on the electrical grid and should be able to simulate and verify their project using the real data provided/obtained. They should also demonstrate awareness of how control, communication, thermal and/or transport systems interact with economics and human behavior, based on input from the other students. Economics students are to focus on energy market issues and describe the business cases, but should also have a general idea of technical system setup and control requirements.

Example 2 - Energy Storage

Energy storage is expected to be widely used in different ways in the future energy system. This could involve electrical battery storage, thermal storage or gases like hydrogen made from excess electrical power produced by wind turbines or PV systems.

Students therefore need to know about the different storage technology types and their applications in different contexts. For example, electrical battery systems can provide ancillary services and/or voltage control and can also be used to combine electrical and thermal systems using electric boilers or heat pumps to heat water for thermal storage. They will also need to appreciate demand management using e.g. electric vehicles in vehicle to grid or grid to vehicle conditions etc.

These topics could be taught as elective courses including workshops on the different technologies and storage applications for the respective energy vector markets (electric, thermal and/or gas) with their respective time scales. Workshops should also include the essential elements of energy storage business cases and legislation. Students must be able to scale, model, analyse and control the storage systems, and understand how they can be used for interactions between different energy vectors and seen in relation to a whole energy system and the relevant energy markets.

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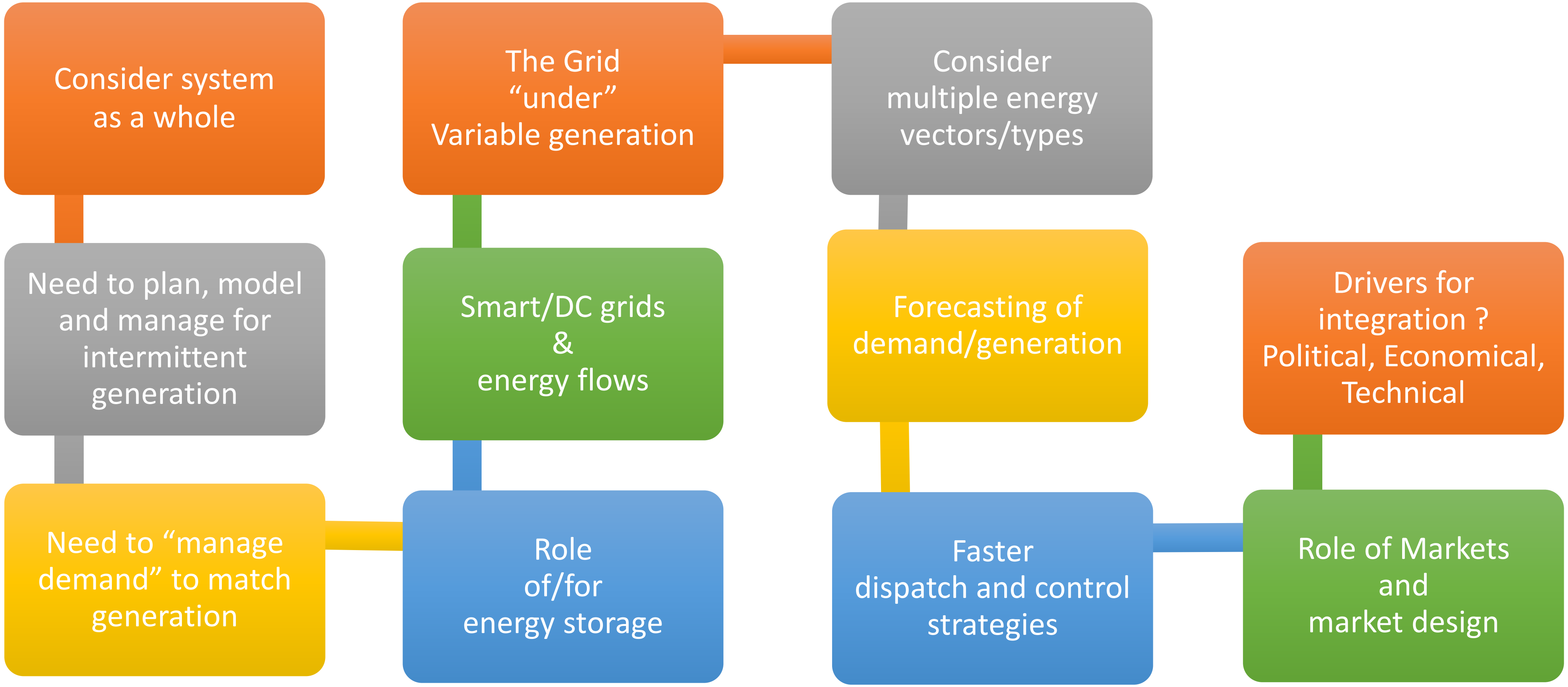
Renewables Integration

Dr Wim JC Melis, University of Greenwich

Renewables Integration

State-of-the-art /
Current issues



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Renewables Integration

- The **basis** of **master** curricula for **renewable energy sources** integration should enable every student to know:
  - How **renewable** energy sources **interacts with** the **energy system and** interacts with **society**.
  - Students need to understand **how their programme** ”fits” in the **energy system and society**.
- This includes:
  - Renewable energy **sources**, and **their respective pros and cons**
  - How renewable sources **interface with** the **grid** and/or **other energy systems**
  - To the user: **Energy** is a **Service !**
  - A notion of the **energy networks and vectors** and how a **“renewable system” interacts** with them
  - **System balancing** across time/geographic boundaries **through e.g. storage**
  - **Economic, Social and Political** factors **influencing energy**
- Giving **graduates** a more **holistic perspective**, will ensure they can **make a broader contribution to society !**

Renewables Integration

Doctorate level programmes:

- **Often** very **narrow** (e.g. thin film solar cells), but also **need a “broadened” part** putting the research into context. What is the **potential ”real-world” impact ?**
- The **ability to answer** more generic **questions**, such as:
  - **Where** does this **topic fit in** the **larger picture** ?
  - **Who are** the **stakeholders and** what is **the best business model to deploy** the results ?
  - Which **technologies** should/could this work be **combined with** to make it **more efficient at** a **system’s level.**

- **Europe is leading on** various **aspects of renewable energy** research, **but needs to** do more to **consider** the **integration of these technologies**.

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Examples and case studies

Other topics: Electrical/Thermal, Chemical, Energy Storage, etc.

6. (Renewable) Technologies - Energy Conversions			
Topics (for courses)	Understanding, Background Knowledge, Comprehension, General Appreciation of …	Design and Implementation / Deeper (Master level) Appreciation of …	Employment Skills
Technical	The fact that a system does not need to be balanced for one energy type, and that conversions can provide a great solution	Integrate energy conversion technologies in multivalent (e.g. electricity/heat/gas) demand systems	Establish integrated conversion systems
	Life cycle, efficiency of conversion technologies and energy cascades	Holistic electricity/heat/multi-type energy management evaluation	Establish control systems for multi energy systems with good hosting capacity
	The value of multivalent energy conversion technologies for specific situations (e.g. CHP)	How to design control systems that allow and support multi-type and valued systems with type conversions for optimised overall efficiency	Propose solutions to improve energy flexibility by playing on vectors
Social	The social challenges of integrating renewables and making them the preferred solution	Techno-anthropological studies, interaction with suppliers and customers on the integration of new installations	Know how to engage society, how people react to renewable integration and how to change this
	How to break the conceptual boundaries between energy types and know that one can be (more) easily converted into another	Environmental issues for the establishment/installation of renewables	Know about environmental issues and propose legislation changes to promote CO2 reduction targets
Economical	How renewables can influence energy markets, and how conversions can change that market	Detailed calculation of investment payback time including maintenance costs, etc. using future scenarios	Design detailed systems, including costs and incentives
	The challenges of investment and return on investment versus potential market influences/ uncertainties		Calculate cash flow and net present value of investments
Political	The legislative impact of a single energy market versus a split between the different energy types	Regional differences in regulatory environments and how and why those should change	Interact with relevant actors on each of the energy value chains
	The political agendas of actors in the energy value chain	Potential legislation barriers for multi-energy systems that rely he… conver…	Understand the importance of legislation and standardisation

Renewables Integration

Example 1 - Data Collection and Processing

A knowledge of actual energy consumption is a necessary, preliminary step for developing any action plan for energy integration. This concept applies equally to industrial, tertiary and residential end users.

The course covers a wide spectrum of skills as it addresses: the technical characteristics of instrumentation, sensors, data acquisition systems, BEMS, measurement methods, statistical processing of experimental data, definition and calculation of KPIs, the impact of occupant behaviour on energy demand, and more.

While some teaching provides the information necessary through traditional lectures, once basic knowledge has been acquired, students work in groups of 3-4 on case studies such as:

1) An industrial monitoring system to log the energy consumption data of (individual) production processes

2) A tertiary building equipped with a BEMS designed to collect environmental parameter data (outdoor/indoor climate, IAQ, etc.), as well as information about occupancy, lighting and HVAC,

3) A large residential complex connected to a central heating plant (e.g. district heating), in which individual household thermal energy consumption for heating and DHW production is measured.

KPIs are identified and compared against suitable benchmarks for each case. Energy saving measures are proposed to achieve the KPIs, and the potential for low-cost (or zero-cost) measures at system O&M level is highlighted.

Example 2 – Energy Integration, a Holistic Perspective

Energy integration can often be improved by looking beyond individual systems and across the boundaries of a system. It is therefore important to learn to examine system-of-systems. This assignment is based on students identifying suitable efficiency improvements in a real-life situation provided with enough technical information (equipment data sheets) and information about the legal framework and user expectations (e.g. a hospital). Students are then asked to work in small groups of 3-5 to identify suitable improvements and potential implementation barriers. They are given a restricted budget to implement their improvements. Each group competes to achieve the best overall improvement, and at the end of 6 weeks, they all have to explain how they went about the exercise, which solution they came up with and how effectively they think it would be integrated in real life. Assessment is performed by their peers using 5 agreed criteria. Each criterion has a set number of marks to be shared among their competitors. The presentations also open discussions about the different routes suitable, … il's advocates are brought in from a va… al, technical, economic) to improve the

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Thank you for your attention!

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