Introduction
As we transition towards a lower CO2 society, with an increased proportion of renewables in the energy mix, ETP universities are working with policy-makers and industry, across the energy sector, to support Whole Energy Systems approaches and increase Energy Systems Integration (ESI).

Core Concepts

Energy System:
A set of interacting or interdependent resources, infrastructures and individuals organised specifically for the production, delivery or consumption of energy (NREL*).

Whole Energy Systems Approaches:
Consideration of energy systems within the context of the energy sector, as a whole, and how it interacts and inter-relates with any other systems and sectors.

Energy Systems Integration:
The process of optimising energy systems across multiple pathways and scales (NREL).

Design-for-the-Future/Future-proofing:
Design which considers future de-construction, re-use, re-purposing, decommissioning, flexibility and facilitates adaptations or modifications for other purposes.

Figure: Definition of Energy Systems Integration
Introduction to:
Whole Energy Systems & Energy Systems Integration

Scottish Government Draft Energy Strategy Challenges for Energy Systems
Broadly, the Scottish Government’s Scottish Energy Strategy highlights the following 3 groups of challenges for Energy Systems and their integration to deliver;

“A modern, integrated, clean, energy system, delivering reliable energy supplies at an affordable price in a market that treats all consumers fairly.”

1) Whole-system view
• Facilitate robust energy systems modelling to inform decision-making on future energy supply and demand.
• Facilitate the transition to an integrated approach to heat, power and transport.
• Facilitate incorporation of renewables to meet an all-energy target of 50% by 2030.
• Increase energy efficiency and reduce energy demand.

2) Stable energy transition
• Facilitate long-term energy systems planning and development to support the Climate Change Plan.
• Incorporate flexibility to allow for future changes in technology and energy use patterns.
• Facilitate a managed transition of energy supply, post-nuclear.

3) Community energy
• Develop and facilitate localised systems for energy supply and use.
• Facilitate and integrate locally owned and managed energy systems.
• Develop energy storage and smart energy management solutions.

Opportunities for Technological & Service Innovation
The many drivers and barriers for ESI can present both challenges and opportunities for technological and service innovation, such as; market incentives, government policy, and industrial infrastructure. Diverse and inter-related factors are also governing the pace of change, including: economic; environmental, socio-political; security; technological advances; behavioural; cultural; and data management capabilities. As a result, taking a holistic approach to technological innovation is key to support ESI.

ETP universities are working to facilitate incorporation of increased renewable and low CO2 energy sources. Alongside increased integration, improved operational efficiency in energy systems could enable us to:

• make them smart(er) and cleaner
• use whole-systems modelling techniques to support and inform decision-making
• reduce losses (e.g. through transmission, conversion and heat)
• increase and enhance energy supply in terms of; sustainability, security, quantity, quality, reliability, flexibility, efficiency, and diversity
• increase consumer engagement, empowerment, satisfaction, and efficiency in energy use and management
• enhance utilisation, interoperability, flexibility, adaptability, resilience and longevity of energy systems and assets
• enhance processes for data availability, integrity, processing, storage and retrieval

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