

Systems Engineering for Net Zero

The Foundation for Science and Technology

June 2021







Potential journeys to Net Zero



30 years





Net Zero Expensive

Net Zero

Cost Effective (>3% GDP)

Damaged UK industrial/manufacturing competitiveness

Exclusively importing innovations



Net Zero Nirvana

Net Zero

Cost Effective (<1% GDP)

UK innovations created new jobs across country

Example to rest of the world (and exports)





Net Zero Political Disaster

Net Zero

Costs as expected (<2% GDP)

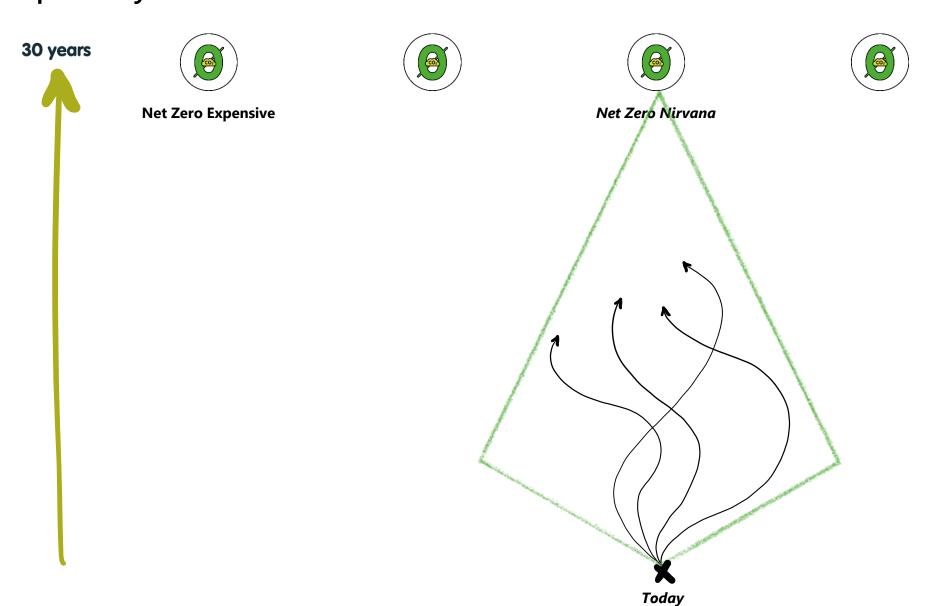
Measures have been unpopular

No UK economic benefit



Systems engineering approach helps you to converge on a desirable pathway







Net Zero Political Disaster

What is systems engineering?



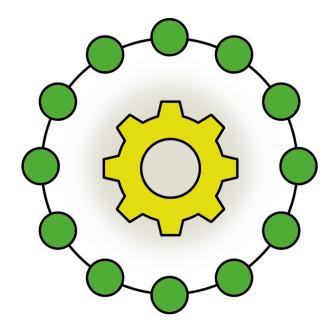
Systems engineering is a structured, multidisciplinary approach to problem-solving that transforms a set of needs into a balanced system solution. It is about **solving the right problem in the right way**.

Used to address **complex** and often **technologically challenging problems**.

It takes a 'whole system' approach where physical factors (infrastructure, novel technologies) are considered at the same time as economic, behavioural and social issues.

It is a discovery process that allows participants to consider the **interactions, trade-offs and synergies** between different parts of the system, using quantitative and qualitative tools, methods and skills. If implemented well, it can **lower costs** and **speed up implementation**.

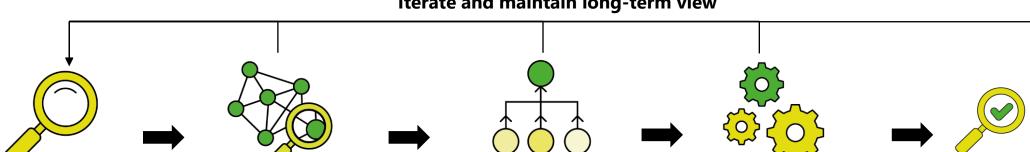
It provides a structured process for engaging **stakeholders**, allowing the capture of their expertise.



Simplified Systems Engineering Approach for Net Zero



Iterate and maintain long-term view



Exploration

• Define objectives/needs, and questions

- Engage with multidisciplinary, multi-sector stakeholders
- Identify key interactions
- Identify solution options
- Construct system of systems map

Analysis

- Simulate, model and test possible solution options
- Measure/acquire and analyse data
- Helps to answer "How do I achieve X?" or "What happens if I do Y?"

Decision

- Identify decision gates and key data
- Conduct decision making process
- Obtain consensus

Implementation and

- Sequenced implementation plans
- Integrate into wider system
- Check interoperability

Integration Planning

- Update System of Systems map, test interactions
 - Check solution meets requirements and stakeholder needs

Verification & Validation





Core question for Net Zero: what degree of central coordination does it require?

Highly Distributed Highly Centralised Authority Relationships ACKNOWLEDGED COLLABORATIVE DIRECTED

The systems are **centrally managed** to ensure goals are met; normal operations are subordinate to the central goals.

Example: metropolitan transportation systems

Although independently-owned, constituent services may collaborate to deliver metro services, they must also accept considerable operational direction in order to participate.

Objectives are recognised by the constituent systems, a designated manager, and dedicated System of **Systems resources.** Constituent systems retain independent ownership, objectives, funding, development and sustainment approaches. Ideally changes are consensus driven and escalation if that fails.

Example: air traffic control

Air traffic control is an example. Systems delivering managed and safe airspaces globally all recognise their shared goals, collaborate on best practice and adhere to regulations and protocols.

Systems **voluntarily** choose to participate to fulfil some central purposes, which can evolve based on collaboration between constituents and the System of Systems.

Example: current UK electrical grid

Autonomous constituent systems produce, transmit and distribute electricity to consumers. Unlike an acknowledged System of Systems, there is no overall directing authority. Constituent systems adhere to standards and regulations but can negotiate individually to evolve roles and working practices.

VIRTUAL

No central authority, nor an explicit, recognized purpose accepted by all. A virtual System of Systems can exhibit large-scale emergent behaviour, but relies on standardised formats or protocols.

Example: the internet

The Internet Engineering Task Force (IETF) publishes agreed standards and protocols. Independent service providers can leverage these for new services or products. No management or governance is either provided or accepted regarding usage, and there is no central purpose for all parties.

What tools would we build if we were serious about a systems approach to Net Zero?





System of Systems Map -- creates a 'live' repository for **institutional memory and knowledge**. Enables an adaptive approach and easy sharing of information.



Agile governance and regulation -- a 'systems architect' using a framework to test and learn about viable options, identify gaps and update knowledge, including a structured approach for managing stakeholder input.



Whole system **market simulation tools** to design future market arrangements. To support techno-economic models.



Real-world trial environments to co-create future energy market.
Living Labs provide a place to iterate market arrangements, consumer offers, consumer protection, digital standards and Pathfinders to test at scale



Allows the building of a **credible**, **viable and adaptive** 'living roadmap', with clear timelines/ sequencing and dependencies