Centre for the Evaluation of Complexity Across the Nexus

# A participatory systems map of the Energy Trilemma

A CECAN report for
the Department for Business, Energy and Industrial Strategy

by

Pete Barbrook-Johnson and Alex Penn

December 2018

The **Centre for the Evaluation of Complexity Across the Nexus** (CECAN) is a £3million national research centre hosted by the University of Surrey, bringing together a unique coalition of experts to address some of the greatest issues in policy making and evaluation.

# A participatory systems map of the energy trilemma

Department for Business, Energy & Industrial Strategy

cecan Centre for the Evaluation of Complexity Across the Nexus

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

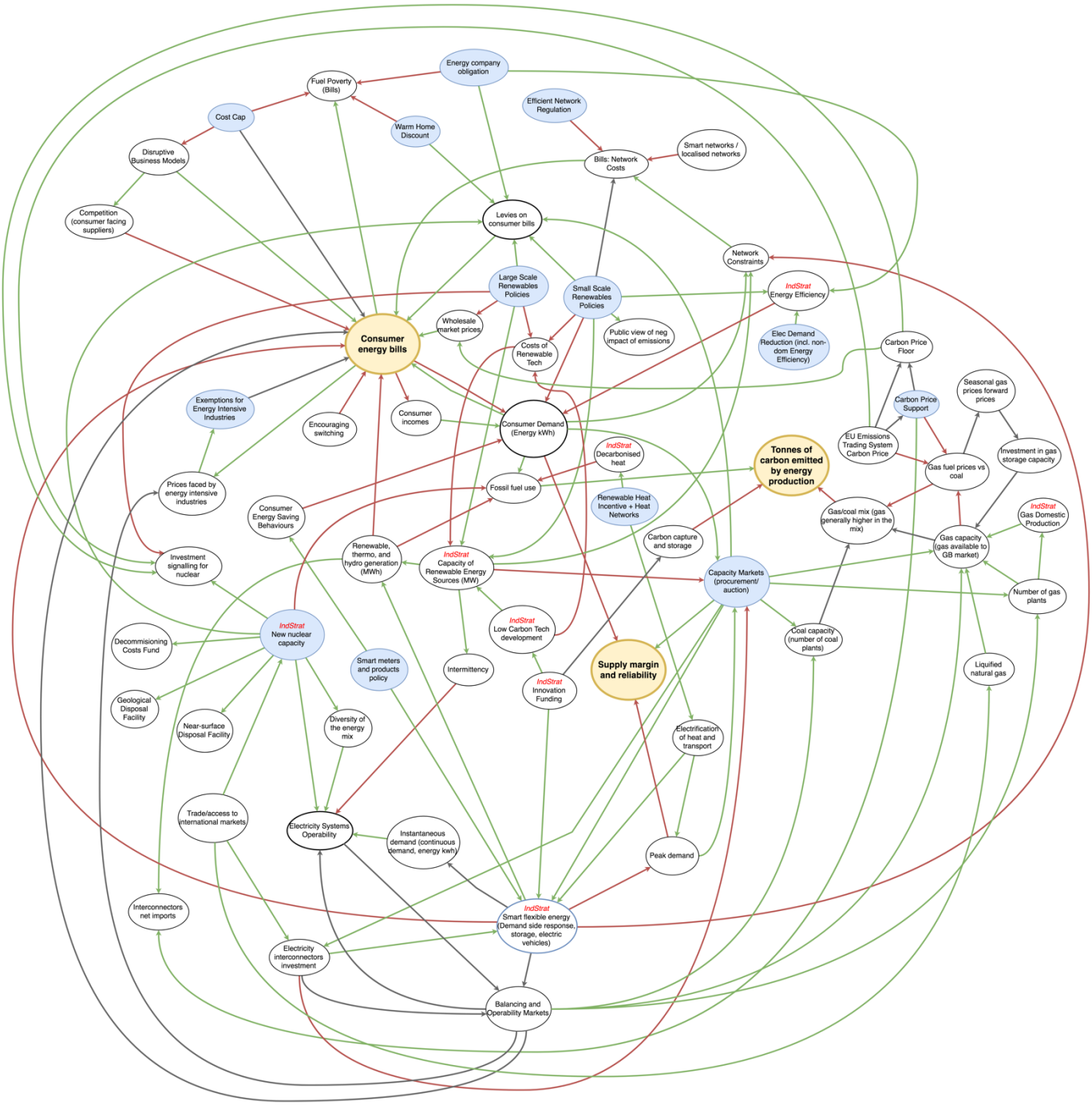
NERC SCIENCE OF THE ENVIRONMENT

This systems map was built by analysis and policy teams at BEIS, in collaboration with researchers at CECAN. It shows the causal relationships between a range of key energy trilemma outcomes, BEIS policies, and other factors. The map is an intersubjective object reflecting the views and knowledge of the BEIS staff who created it.

For more info contact Tajbee Ahmed (BEIS), Marianne Law (BEIS), or Pete Barbrook-Johnson (CECAN - p.barbrook-johnson@surrey.ac.uk)

**How to use this map:**

1. **Print it out** and **put it up** in your team area
2. Take a look at it **before and during your policy mapping** exercises
3. Get hold of the **editable online version**; **update, edit, and share** it




**LEGEND**

Key outcome for BEIS

BEIS policy

*IndStrat* = Of interest owing to the Industrial Strategy

Positive causal relationship: increase in A leads to increase in B, or decrease in A leads to decrease in B

Unclear or complex causal relationship (e.g. not sure, depends on other things, tipping points)

Negative causal relationship: increase in A leads to decrease in B, decrease in A leads to increase in B

**Edit and share the map:**
If you would like access to a 'live' version of the map which you can edit and share with colleagues, get in touch:
p.barbrook-johnson@surrey.ac.uk

**About this report**
This CECAN report presents a systems mapping project carried out by CECAN with BEIS between June 2017 and December 2018. The work is part of CECAN's programme of co-produced case studies with its co-funders. Read more about CECAN at www.cecan.ac.uk.

**Authors**
Dr Pete Barbrook-Johnson, University of Surrey
Dr Alexandra Penn, University of Surrey

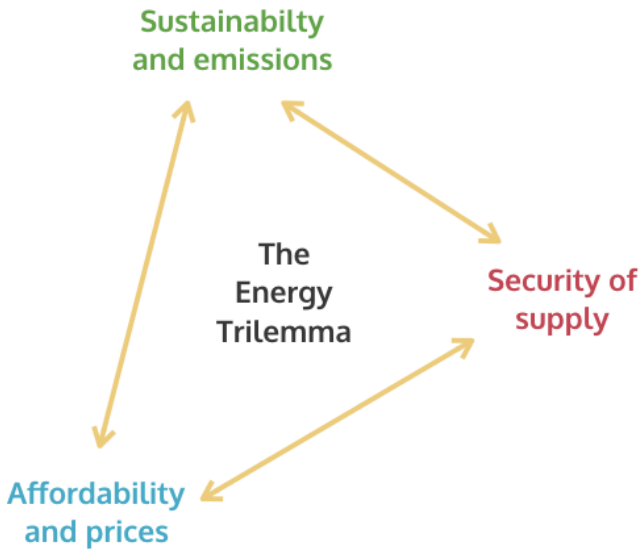
**Acknowledgements**
We wish to thank: Tajbee Ahmed at BEIS for supporting this work and her thoughtful guidance; the participants in mapping workshops for their time and enthusiasm; and Anna Kaxira for supporting the mapping workshops.

**Contact**
We welcome comment on this report, please email p.barbrook-johnson@surrey.ac.uk

**Please cite this document as:**
Barbrook-Johnson, P. & Penn, A. (2018) A participatory systems map of the Energy Trilemma: A CECAN report for BEIS. December 2018, Online at www.cecan.ac.uk



## Contents




## Introduction

There is a large range of central government policies and programmes that have effects on the energy trilemma (i.e. the interplay between sustainability and greenhouse gas emissions, consumer prices, and security of supply). Examples include: those specifically targeted at security such as the Capacity Market; polices designed to support renewable energy such as Contracts for Difference or Feed-in Tariffs; policies designed to protect consumers against high prices, such as the Warm Home Discount; and strategies for specific sources such as nuclear. The sheer number of programmes and policies with close interaction and overlap in this area has led to a crowded and complex policy landscape with a range of potentially complementary and conflicting aims.

Analysts and evaluators in the UK Department for Business, Energy and Industrial Strategy have expressed an interest to develop a richer understanding of the interaction of policies and other contextual factors on the energy trilemma. This understanding will specifically help to inform evaluation plans and priorities but is also envisaged to be valuable beyond this specific use, for example in developing policy maps and theories of change for individual policies and interventions.

Between June 2017 and December 2018, Tajbee Ahmed at BEIS, and Pete Barbrook-Johnson and Alex Penn at CECAN, have been addressing this interest by conducting a CECAN 'case study' (i.e. a co-produced project to explore the use of innovative methods in government policy evaluation), using CECAN's approach to participatory systems mapping. This report presents this work.

This report presents this Energy Trilemma systems mapping project, the map created, and associated analysis. **The report is intentionally short and concise**

## Aims

The aim of the case study was to explore, via participatory systems mapping, the energy trilemma policy landscape, and specifically:

- to map various relevant policies (i.e. those predominately led in the Energy and Security Group at BEIS, this includes Energy Security, Networks & Markets, Civil Nuclear & Resilience, Clean Electricity and Energy Development), their interaction and impact on the trilemma; and

- to highlight (i) their impacts on the three 'legs' of the trilemma (emissions, prices, and security), (ii) common and/or contradictory aims and mechanisms amongst policies, and (iii) uncertainty and evidence and gaps.

- to explore the complexity in this area as fully as possible, embracing uncertainty, feedbacks, and all possible causal connections.

The understanding developed during the mapping process, and presented in this report, is helping to support evaluation planning, to make the case within BEIS for, and to develop, proportionate evaluation(s). The systems map can also help feed into, or put in context, individual policy maps.

Complex systems are fundamentally **unpredictable.** Our work does not 'solve' this, but gives us the approaches and tools to explore the uncertainty with rigour

## What is complexity?

Complexity science is an approach to understanding the world which embraces the fact that it is made up of many diverse components, which interact in adaptive and nonlinear ways within 'complex systems'. Key characteristics of complex systems include: adaptation to changes, feedback loops, multiple scales, thresholds for change, areas of relative high and low stability, past states influencing possible future states, being highly dynamic, and being an open system, impossible to bound. These result in complex systems, both social and ecological, exhibiting tipping points, emergent new properties, and unpredictability.

**Complex systems are distinct from complicated systems.** A complicated system is one which may have many parts and interconnections but which is fundamentally predictable. For example, a car engine or an aeroplane, both have many parts, connections and interdependencies, but they behave in broadly predictable ways. A complex system is one in which we also have many connections and interdependencies, but these result in unpredictability. This unpredictability can arise for many reasons, but commonly does so because of the strong effect of feedbacks, nonlinear relationships, the important of context, tipping points, etc. as described above.

Strictly speaking, most if not all, government policy is either simple or complicated, but rarely truly complex. Complexity becomes an important issue for policy makers and evaluators because policies are acting in complex settings and systems; for example, the energy sector.

Building a systems map gives us **a richer understanding of our 'system', the context our policies act within**, and the feedbacks and uncertainties inherent in their action

## Approach

We ran one large half-day participatory systems mapping workshop in November 2017, and four smaller group mapping sessions in December 2017, with staff at BEIS from appropriate policy and analysis teams. The first workshop initially mapped the system, while the smaller group sessions were used to sense-check the map. Follow up sessions were held with key individuals throughout 2018 to further refine the map.

The mapping approach involves teams of up to twelve people collaboratively constructing a causal map of their system of interest. They do this around a table with post-its, 'white-board paper', and pens. The map is made up of 'factors' and their causal connections. Factors can represent anything as long as they are variables (i.e. they can go up and down). Connections represent causal relationships, in a mathematical sense either: positive (i.e. an increase in one factor causes an increase in the next, or a decrease in one factor causes a decrease in the next); negative (i.e. an increase in one factor causes a decrease in the next, or a decrease in one factor causes an increase in the next); unclear (i.e. we believe there is a causal relationship but we are unsure of its nature); or complex (i.e. the relationship depends on other third party factors, or is non-linear).

The map produced is an intersubjective object, it reflects the beliefs of the group of people that built it. It should not be assumed to be objective or comprehensive. A mapping process can give great value to those involved in its creation; the act of building a map can lead to important conversations developing shared understandings and consensus. The map can also be analysed and presented to a wider audience, as in this report. To read more about this systems mapping approach see http://steerplex.org.uk/tools/today-tools/fuzzy-cognitive-maps-fcm.

The process was designed around the trilemma. We started by agreeing a factor for each of the three legs of the trilemma, and built the map from there. Key aims were to include BEIS policies in the map, and consider other objectives and outcomes of interest to BEIS.

Read CECAN's manifesto on policy evaluation at **www.cecan.ac.uk/resources**

"I'm going to **print this map out and put it on the wall** by my desk!"

## How to use the maps

The main thing to do with these maps is look at them, carefully. A quick glance will give a rough sense of what is going on, but you won't get real value out until you dig into them.

1. Look at them – **question**, critique, and attack them!
2. **Follow** causal chains, **look** for factors you are knowledgeable about, **search** for gaps, omissions, or errors,
3. Most importantly, **do and discuss this with colleagues**, and
4. **Iterate** - do it several times with different people.

You may find it useful to do some of the following:

- **Print out the high-resolution version of the map** (available on the CECAN website), and put it up near your desk or team area

- **Edit and share the map.** If you would like access to a 'live' version of the map which you can edit and share with colleagues, get in touch: p.barbrook-johnson@surrey.ac.uk

- Go through the map with colleagues **before and during building a policy map or theory of change map** for a specific policy. Or **sense check a policy map** you have built, using this systems map

- Use the maps, and this report, to think outside-the-box about **what colleagues and other teams you might want to talk to**, that you don't always interact with, but the maps shows are in connection with your policy area.

## The maps

There are four versions of the map in this section: a full version, and then one version each focused on the factors and connections 'upstream' (i.e. that influence) of each of the three trilemma leg factors – Consumer Energy Bills, Tonnes of Carbon emitted by energy production, and Supply Margins and Reliability. **There is a version of the main map, suitable for large printing on the CECAN website.**

It is important to note, the map mainly focused on the electricity system and doesn't capture the role of oil in the energy system. We decided to include oil would add another layer of complexity which would be difficult and unhelpful to add given our aims.

"This map has **breadth**, not depth!"

## Whole map

Figure 1 shows the full map.

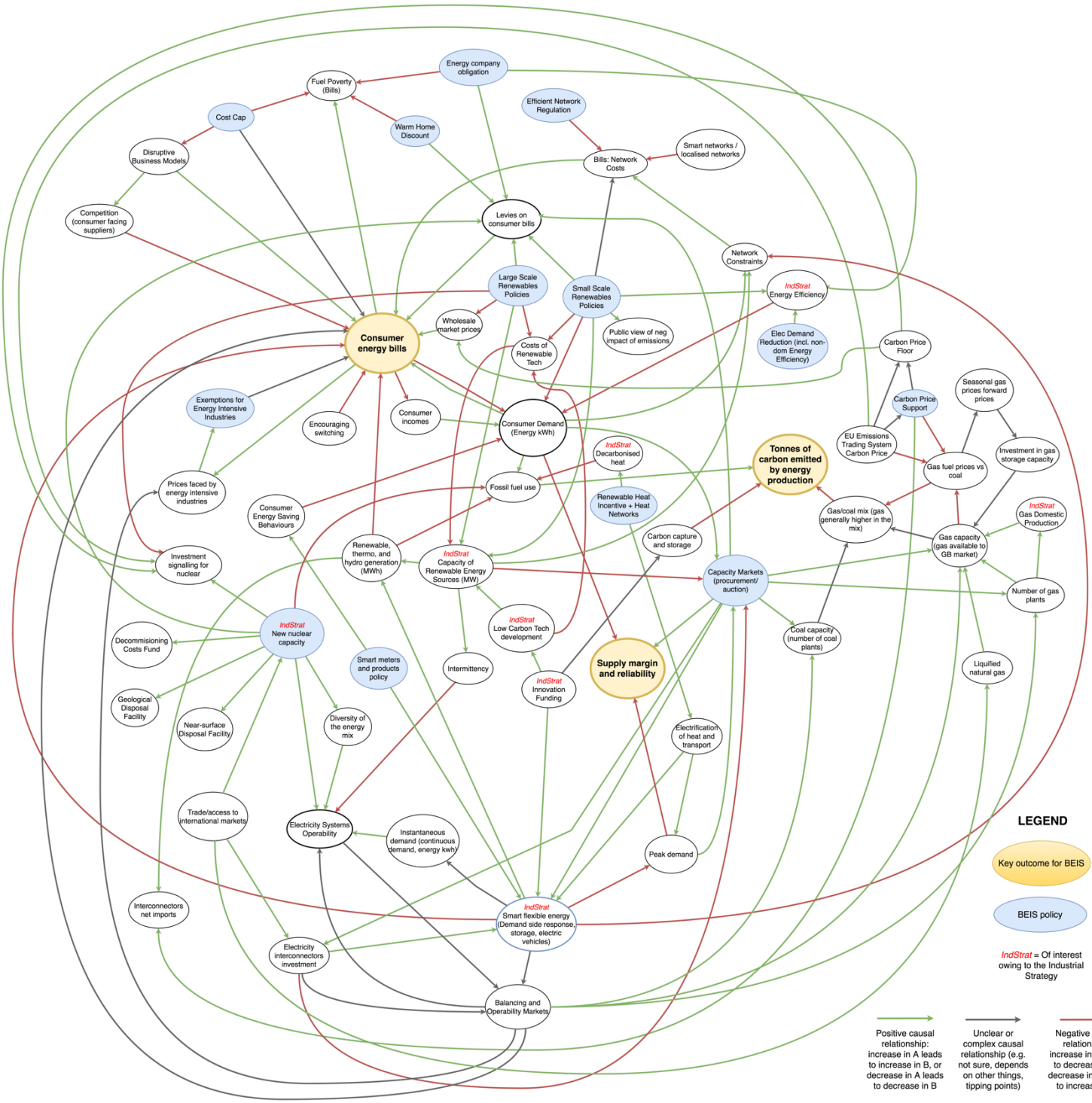



*Figure 1: The full Energy Trilemma Map*

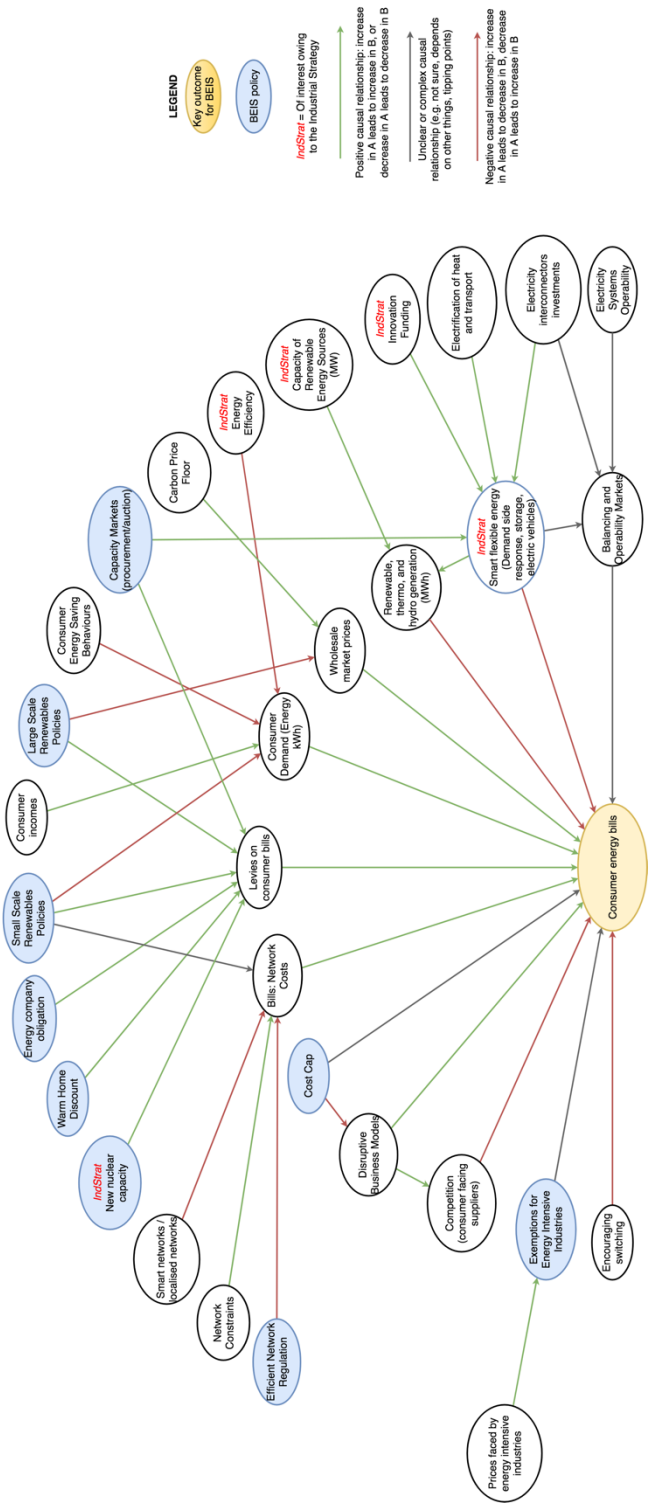



*Figure 2: The Consumer Bills sub-map*

## Consumer Bills sub-map

Figure 2 shows all of the connections and factors 'upstream' of the Consumer Energy Bills factor. It only includes factors and connections which are both within two causal connections of Consumer Energy Bills, and have a causal flow 'towards' Consumer Energy Bills. Factors 'further away' have been removed, and connections in the opposite direction have been removed.

### Things to notice

- Consumer bills are impacted by a large number of factors.
- Levies on bills mediate many of the impacts of BEIS policies.
- Network costs and consumer demand have many influencing factors.
- Smart Flexible Energy appears to represent a key opportunity to reduce bills.
- Smart Flexible Energy also has multiple paths into consumer bills, which may not always complement each other.

In these maps, **Consumer Bills are impacted by a large array of factors**, whereas the other two legs of the trilemma have fewer 'influencers'

## Tonnes of Carbon sub-map

Figure 3 shows all of the connections and factors 'upstream' of the Tonnes of Carbon Emitted by Energy Production factor. Again, it only includes factors and connection which are both within two causal connections of this and have a causal flow towards it. Factors 'further away' have been removed, and connections in the opposite direction have been removed.

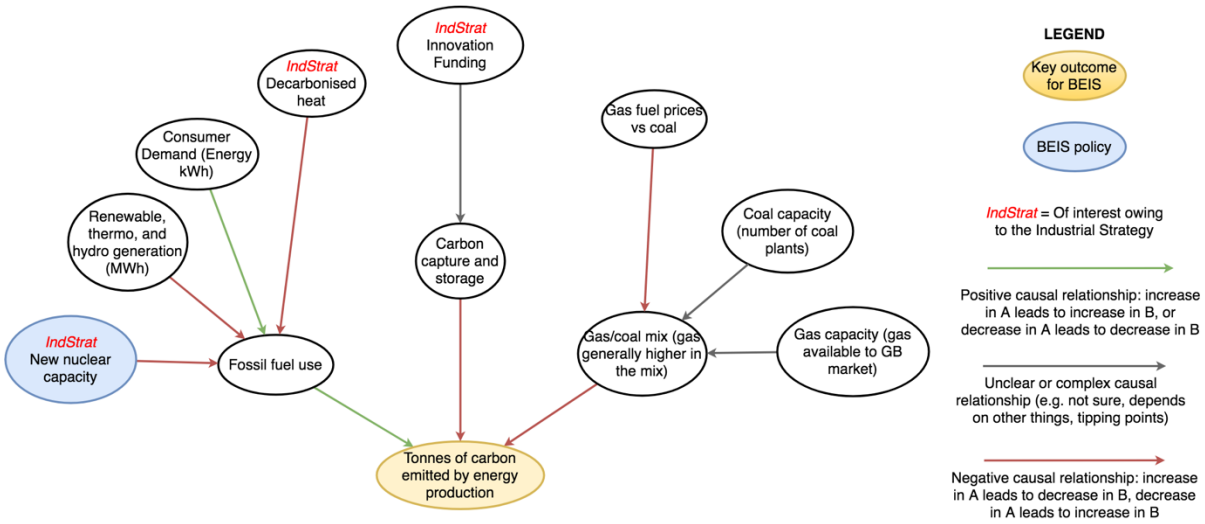



*Figure 3: The Tonnes of Carbon Sub-map*

### Things to notice

- Compared to Consumer energy bills, there appear relatively few direct influencers on this leg of the trilemma. This is because fossil fuel use acts as a bottle neck or mediator for many influences.

- Carbon capture and storage, and the Gas/coal energy mix are seen as the key drivers from a supply-side view.

Picking and prioritising indicators for security of supply was difficult. The term encapsulates a range of related but different concepts

## Supply Margin and Reliability sub-map

Figure 4 shows all of the connections and factors 'upstream' of the Supply Margin and Reliability factor. Again, it only includes factors and connection which are both within two causal connections of this and have a causal flow towards it. Factors 'further away' have been removed, and connections in the opposite direction have been removed.

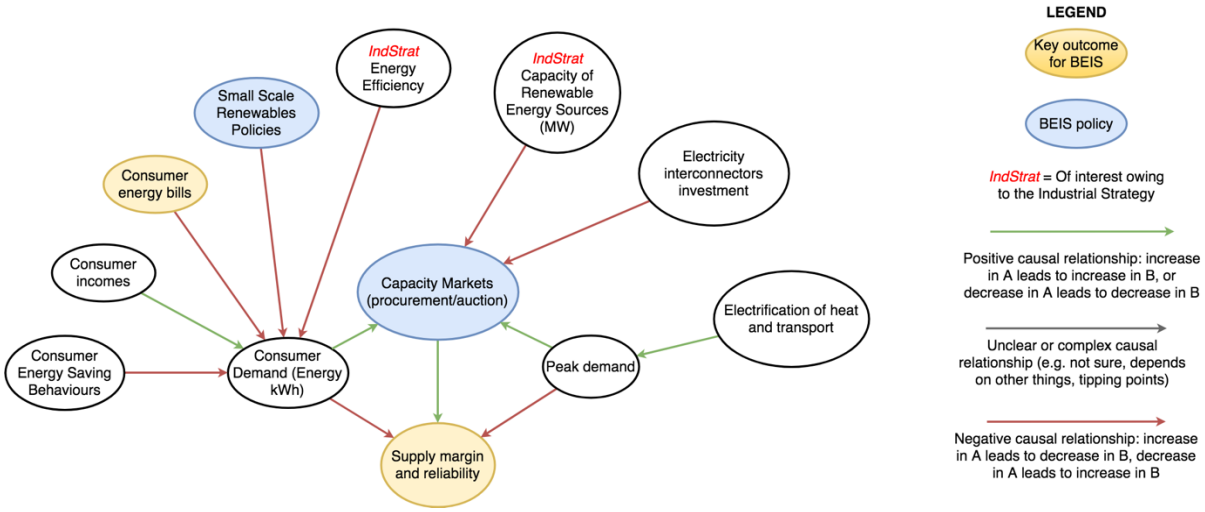



*Figure 4: The Supply Margin sub-map*

**Things to notice**

- Consumer demand was a key mediator of effects here.
- In the workshop, interconnectors were a key point of discussion, they mitigated several impacts and the team were keen to discuss uncertainty around their use, however this is not reflected in the final map.
- Deciding on a clearly defined factor for this leg of the trilemma was the most difficult. The concept of security of supply clearly encapsulated a range of related concepts and indicators to the team building the map.
- Consumer Demand and Peak Demand both go directly into the Supply Margin, but also affect it via the Capacity Market; there may be some counter-intuitive dynamics coming out of these multiple relationships.

# Analysis of the maps

## Impact of BEIS activities

Figure 5 shows a subset of the full map, which focusses just on those factors one causal connection 'downstream' from the BEIS policies included in the map. It is therefore a relatively narrow view of the map. However, it does allow us to consider where influences of the policies might complement or contradict one another and gives a sense of where policies are crowded or more connected, or where they are more disconnected from others.

**Common mechanisms**

The map suggests the following factors are impacted by a relatively large number of BEIS policies:

- Fuel poverty: bills: fuel poverty's status as a key focus for BEIS is reflected in its position in the map, being affected directly by three BEIS policies. It may be fruitful to consider more closely exactly how these policies interact with bills for those in fuel poverty. Is coordination between the policies optimal?

- Levies on consumer bills: many policies create an additional levy on consumer bills. The team building the map recognised this and discussed the tension between levies increasing bills whilst policies also impact other objectives and wholesale prices.

- Smart flexible energy: again, this was impacted by a range of policies which may not be directly related. Are policies which are not closely related coordinated when they have impacts on the same areas?

**Contradictory mechanisms**

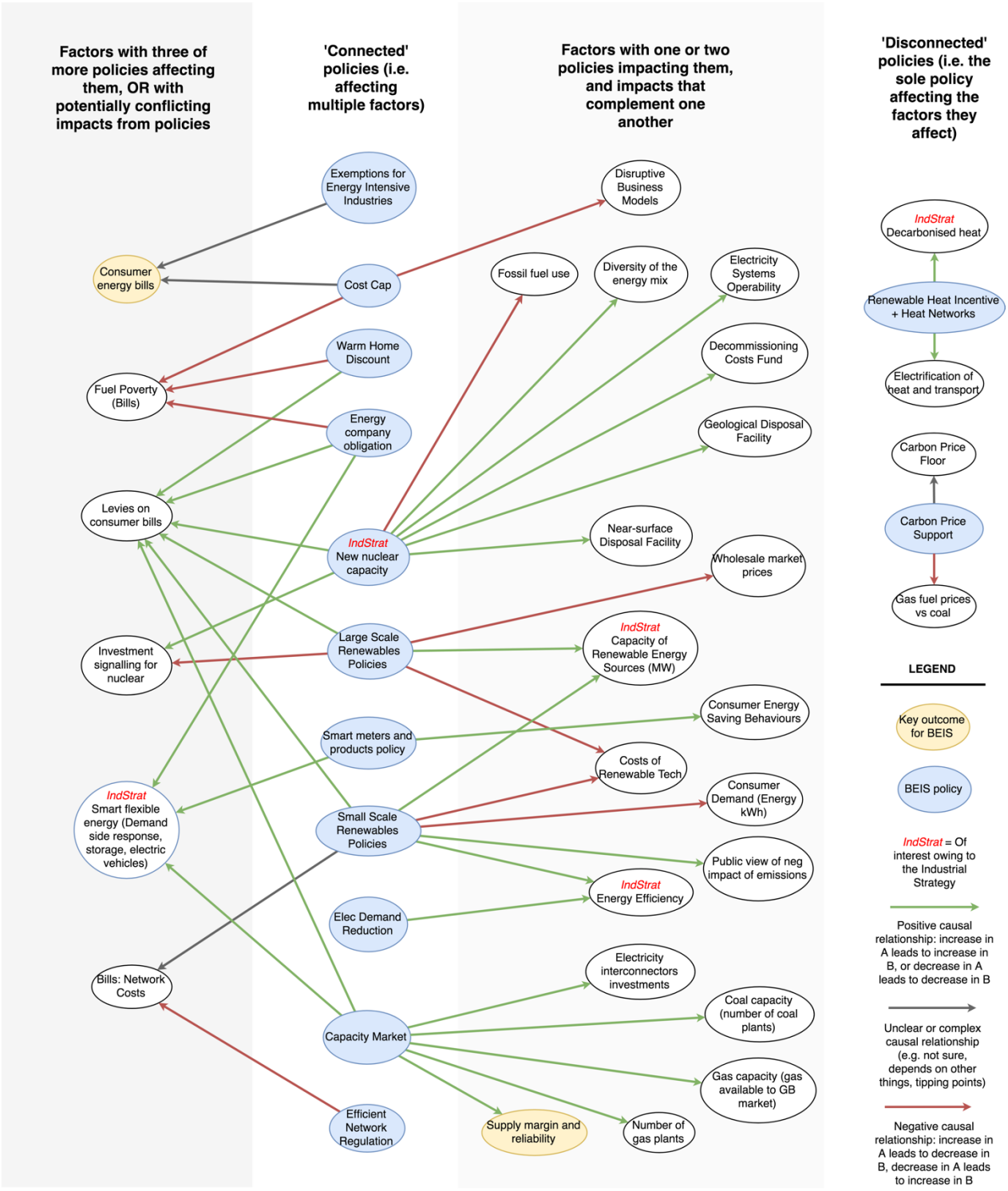
The map suggests the following factors are influenced in contradictory ways by BEIS policies:

- **Investment signalling for nuclear**: messages to the nuclear industry may be mixed owing to the signals large scale renewable policies send, alongside new nuclear capacity efforts. Are evaluation efforts considering or studying the tensions and impacts of these on industry sentiment (especially where the signals might not be formal policy)?

- **Bills: Network costs**: Efficient network regulation should reduce network costs on bills, but Small scale renewables have a more complex relationship; in some cases they can put pressure on network costs.

- **Consumer Energy Bills**: This key outcome is affected in complex ways by the exemptions for energy intensive industries and the cost cap BEIS factors.

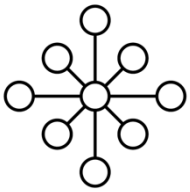
*Figure 5: Connections 'downstream' of BEIS policies*



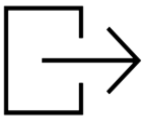
By analysing the **network structure** of the map, we can consider what this tells us about the trilemma system, and also what it says about the way the participants view it

## Network analysis of the map

The following factors are highly connected (i.e. 7 or more connections) in the map:



| | |
|---|---|
| Consumer Energy Bills | 16 connections |
| Smart Flexible Energy | 11 connections |
| Capacity Markets | 11 connections |
| Consumer Demand | 10 connections |
| Balancing and Operability Markets | 9 connections |
| New Nuclear Capacity | 9 connections |
| Gas capacity | 8 connections |
| Capacity of Renewable Energy Sources | 8 connections |
| Levies on consumer bills | 7 connections |
| Small scale renewables | 7 connections |



**Influencers:**
Amongst highly connected factors:

- Balancing and Operability Markets (9 connections, 3 in, 6 out) and
- New Nuclear Capacity (8 connections, 1 in, 7 out)

have a particularly strong effect on the rest of the system, whilst also having a relatively low number of factors affecting them.

**Influenced:**
Amongst highly connected factors:

- Consumer energy bills (16 connections, 12 in, 4 out),
- Levies on consumer bills (7 connections, 6 in, 1 out), and
- Gas capacity (8 connections, 6 in, 2 out)

are particularly affected by other factors, whilst influencing relatively few themselves.

**Things to notice**

- Consumer demand and bills were well-connected – what does this reflect about the system and participants' views?

- Capacity Markets, and Balancing and Operability Markets were highly connected and influential in the system – as Balancing and Operability Markets are operated by the National Grid, are they as connected to BEIS efforts and evaluations as we would hope?

- Smart flexible energy is a key hub which encapsulate a range of things both heavily influenced by and influencing the system.

## Factor characteristics

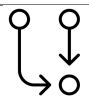
During the workshop, participants were asked what factors, apart from the trilemma and BEIS policies, might be strategically important. They noted the following factors as being of strategic importance to BEIS because of their relevance to the Industrial Strategy:

**Industrial Strategy**

- **Capacity of renewable energy sources**
- **Energy efficiency**
- **Decarbonised heat**
- **Smart flexible energy**
- **Gas domestic production**
- **Innovation funding**
- **Low carbon tech development**
- **New nuclear capacity**

## Uncertainty and evidence gaps

The team constructing the map identified the following relationships as particularly complex and/or having nonlinear dynamics, or being dependent on other factors:

|  **Complex and/or nonlinear** |  **Depends on other factors** |
|---|---|
| Cost cap --> Consumer energy bills | Balancing and Operability Markets --> prices faced by energy intensive industries |
| Small scale renewables --> Bills: networks | Balancing and Operability Markets --> Consumer energy bills |
| Seasonal gas prices --> Investment in gas storage capacity | Balancing and Operability Markets --> Elec systems operability |
| | Gas Capacity --> Gas/Coal Mix |
| | Coal capacity --> Gas/Coal Mix |
| | Elec Systems Operability --> Balancing and Operability Markets |
| | Innovation Funding --> Carbon capture and storage |
| | Gas fuel prices vs coal --> Seasonal gas prices |
| | Electricity interconnectors investments --> Balancing and Operability Markets |
| | Carbon Price Support --> Carbon Price Floor |
| | EU ETS Carbon Price --> Carbon Price Floor |
| | EU ETS Carbon Price --> Carbon Price Support |

These may be relationships which are ripe for further study or evaluation. There appear to be good sources of data on many of the factors identified in the map; key sources identified by the team include the range of data produced by commercial energy providers, and the Energy and Climate Change Public Attitudes Tracker conducted by BEIS.

## Alternative layouts of the map

Readers may find it useful to explore the map when it is visualised in different ways. In the following diagram (Figure 6) the map is the same, but it is laid out in a different way. The map is in a 'flow' layout; it is ordered roughly into a left to right flow; those factors on the left are those with more outgoing connections, in the middle there are both in and outgoing connections, and to the right are the factors with more incoming factors – the image is also more compacted, so connections are harder to see. Different layouts force us to look at the map afresh, and help us to interrogate it in new ways, in the process perhaps finding new or missing connections, and different causal paths and chains. What other layouts might you want to try?

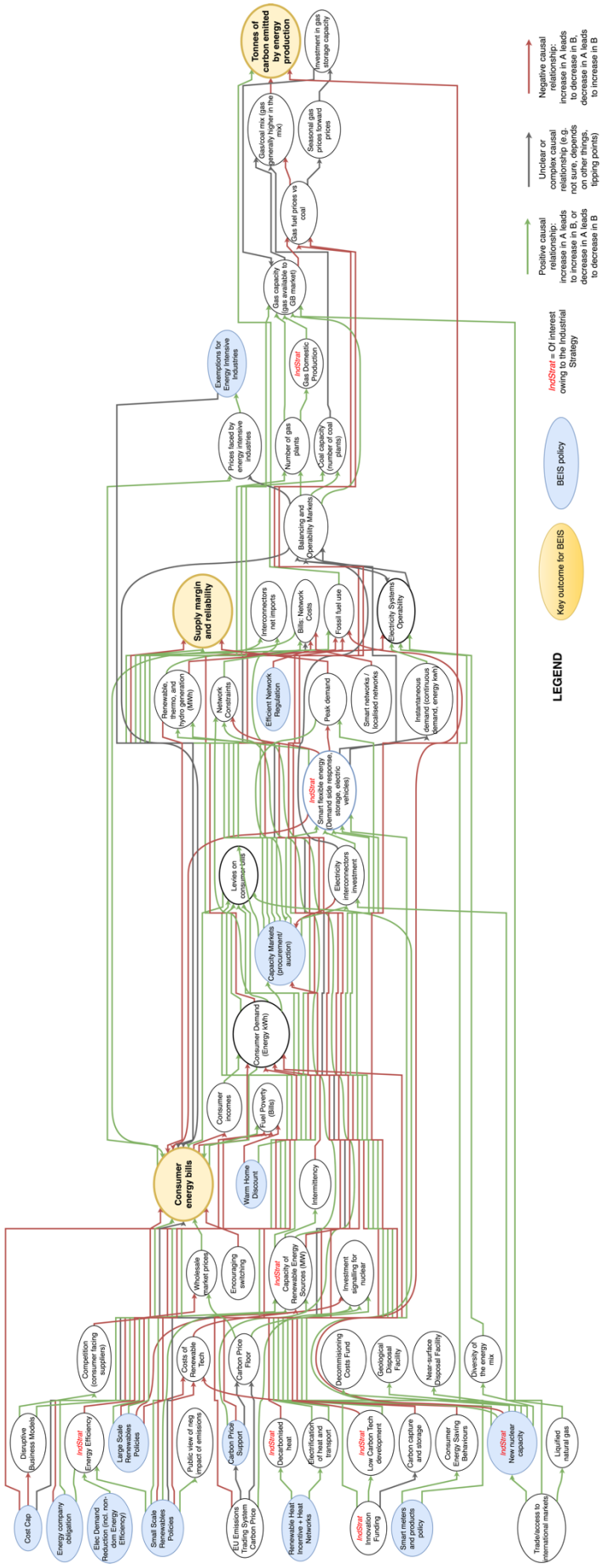



*Figure 6: The full Energy Trilemma Map – 'flow alternative version*

Our systems mapping approach doesn't offer certainty or definitive answers, but does allow us to **explore uncertainty and complexity with rigour and in a participatory manner**

## Conclusions and next steps

This participatory systems mapping project does not offer definitive recommendations about the energy trilemma, nor does it pretend to lay out an objective or comprehensive understanding of the system. However, the process of building the map and the analysis and provocations presented here do offer us a richer understanding of the trilemma and the impact of BEIS's policies on it. It allows us to consider wider connections and feedbacks, and explore and question our own beliefs and assumptions. Further work may include:

- **Maintaining and updating this map**: The map will go out-of-date in time, it may be helpful to revisit in a year or two's time to consider how things have changed.

- **Ownership of this map:** For this map to be used fully, individuals in BEIS will need to take ownership of it, explain it and its use to others, and encourage its use. Without some ownership and encouragement internally at BEIS it is unlikely to be put to its full use.

- **Extending the map:** The map could be extended further to include a wider selection of policies, or expand out to certain areas. For example, the map mainly focused on the electricity system and doesn't capture the role of oil in the energy system; this could be added. The map could also be combined with the map being developed by CECAN with the decarbonising heat team in BEIS.

- **Building more localised maps**: The same approach could be used in building maps of more localised systems, for example, of just the Consumer bills domain, or of the operation of one particular policy. CECAN is already in the process of doing this in relation to the Renewable Heat Incentive.

- **Building a systems mapping approach into existing policy mapping exercises**: Are there opportunities to refine existing policy mapping efforts to include some of the approaches used in systems mapping? We believe there may be value in using systems mapping flexibility to allow policy maps to include more feedbacks, wider contextual influences, and capture dependencies more explicitly.

- **Further validation of this map:** this map is not yet at a 'saturation point' of being refined. Further refining and validating this map could involve more workshops or rounds of small/one-to-one sessions. There is no obvious end point to such refining, however, there are likely to be diminishing return to each round of refinement.

## Our Funders


## Our Team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cecan.ac.uk | cecan@surrey.ac.uk | @cecanexus