



Net Zero Uncertainty and the Implications for Regulation

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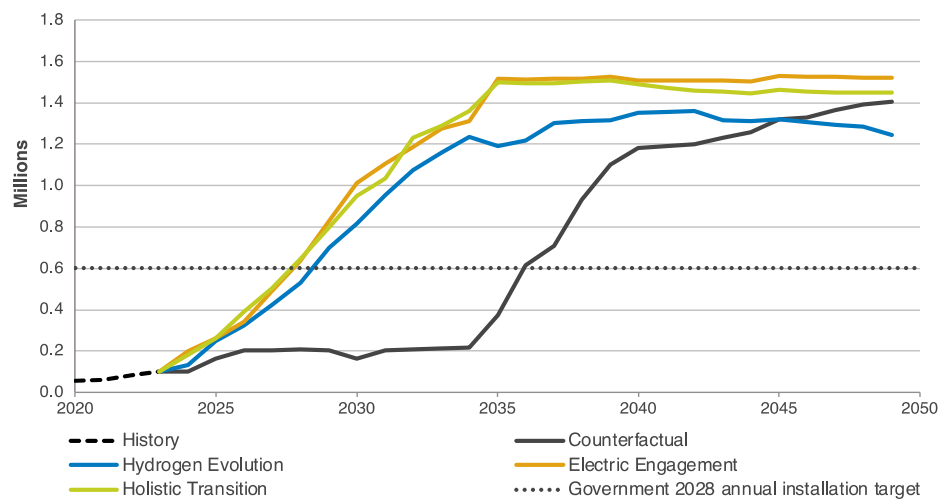
Outline

- With thanks to Andrei Covatariu and Daniel Duma and CERRE
- Uncertainty facing regulators
- Regulation on the path to net zero
- Governance and institutions
- Beyond RIIIO?
- Some ideas from other sectors

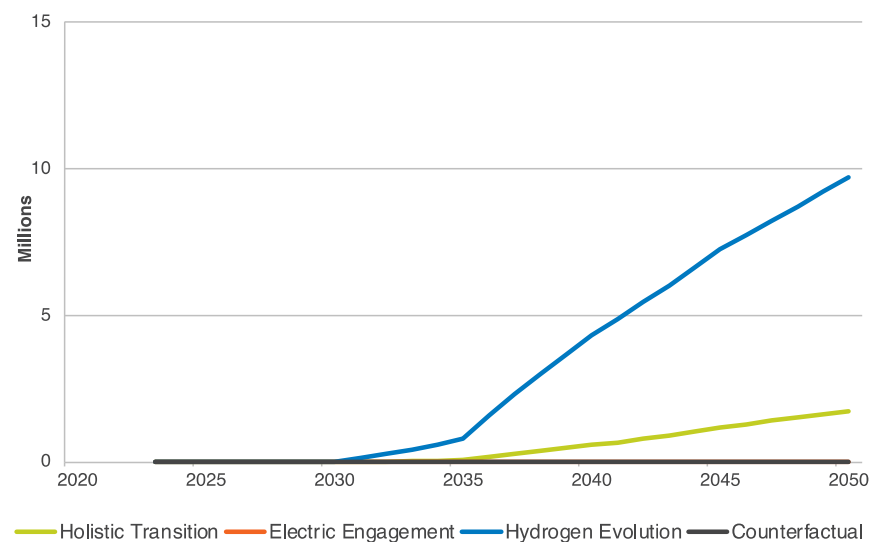
UNCERTAINTIES WHICH REGULATORS NEED TO LIVE WITH

Uncertainty 1: Technological wishful thinking

EC.18: Annual heat pump installations



EC.K: Total residential hydrogen boilers installed (including hybrids)



Source: NG ESO Future Energy Scenarios, 2024, Data Workbook.

Uncertainty 2: The impact of War and net zero

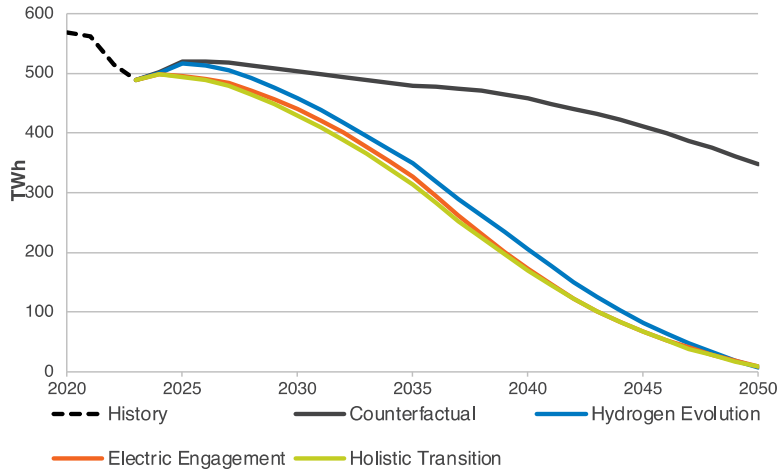


Birmingham Civic Centre Scheme
1939

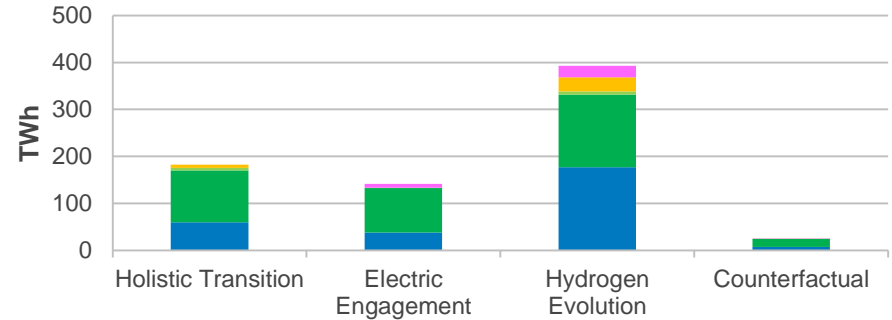
- Birmingham if there had been no WW2.
- Energy security back as a key issue
- Wind is unreliable and European single market necessary.
- How quickly will market be repaired.
- GDP and net zero?
- Higher price of gas probably bad for net zero.

Uncertainty 3: Gas vs Electricity Policy

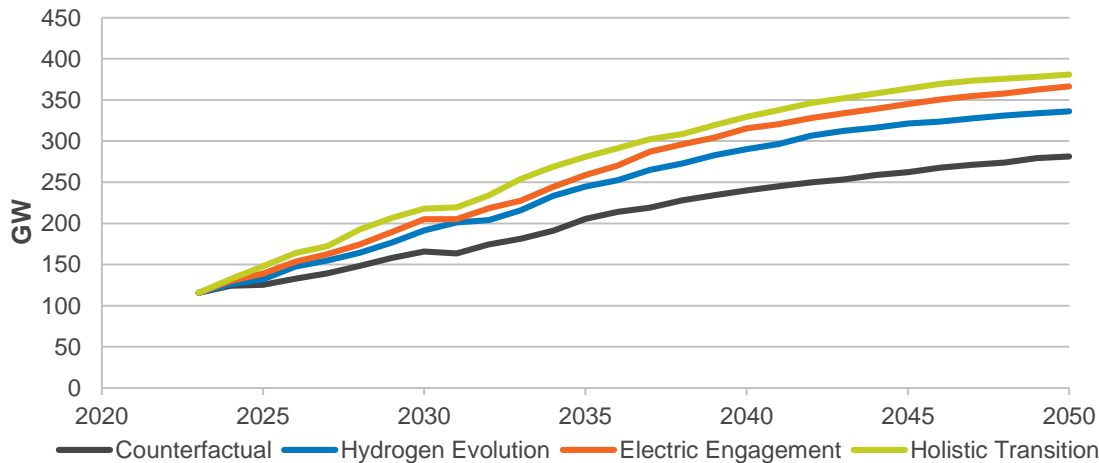
ES.29: Total annual consumer gas demand (excl. power and non-FES sectors)



ES.36: Hydrogen supply by technology in 2050



ES.06: Installed electricity supply capacity



■ Methane reformation with CCUS

Source:
 NG ESO Future Energy
 Scenarios 2024,
 Data Workbook

Uncertainty 4: Technological surprises

- *Good (so far):*
- Wind offshore and onshore, PV and Li batteries
- *Bad so far:*
- CCS, nuclear, hydrogen, synfuel
- *Unknown:*
- Fusion?

Figure 1: Volume-weighted average lithium-ion battery pack and cell price split, 2013-2023



Source: BloombergNEF. Historical prices have been updated to reflect real 2023 dollars. Weighted average survey value includes 301 data points from passenger cars, buses, commercial vehicles, and stationary storage.



Uncertainty 5: The size of the economy

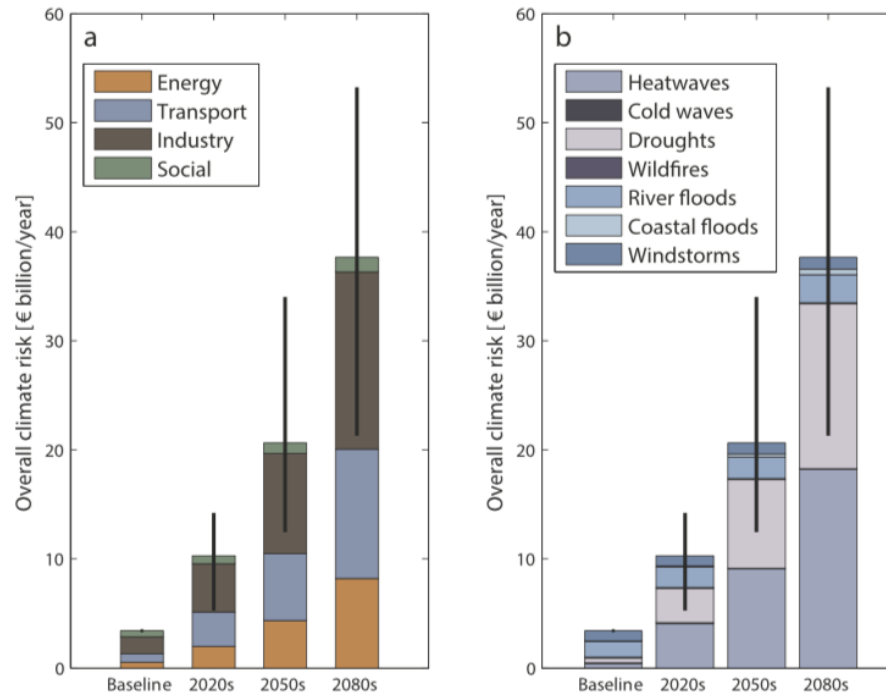
UK Figures

	2022 (est)	2042 (2012 est)	2042 (2020 est)	Relative differer 2020 vs 2012
Population	67.6m	74.7m	70.6m	5% lower
Average fertility	1.56	1.89	1.59	16% lower
Life expectancy male	79	84 (2036/7)	82.2 (2045)	2% lower
Life expectancy female	82.9	87.3 (2036/7)	85.3 (2045)	2% lower
Net migration	c.435k	200k p.a.	205k p.a.	3% higher
Productivity (per hour worked)	1	1.15 0.7% p.a. France est.	1.06 0.27% p.a. UK est.	9% lower

Sources: ONS National Population Projections 2020 - based interim;
 ONS National Population Projections 2012 – based Reference Volume Series PP2;
 ONS Long-term international migration provisional, year ending June 2022;
<https://www.niesr.ac.uk/blog/why-uk-productivity-low-and-how-can-it-improve>

Uncertainty 6: The impact of extreme weather and climate change...

An increase in the frequency of extreme-weather events will lead to more frequent damage to power supply infrastructure, **raising the value of Expected Annual Damage (EAD)** to asset operators and insurers.

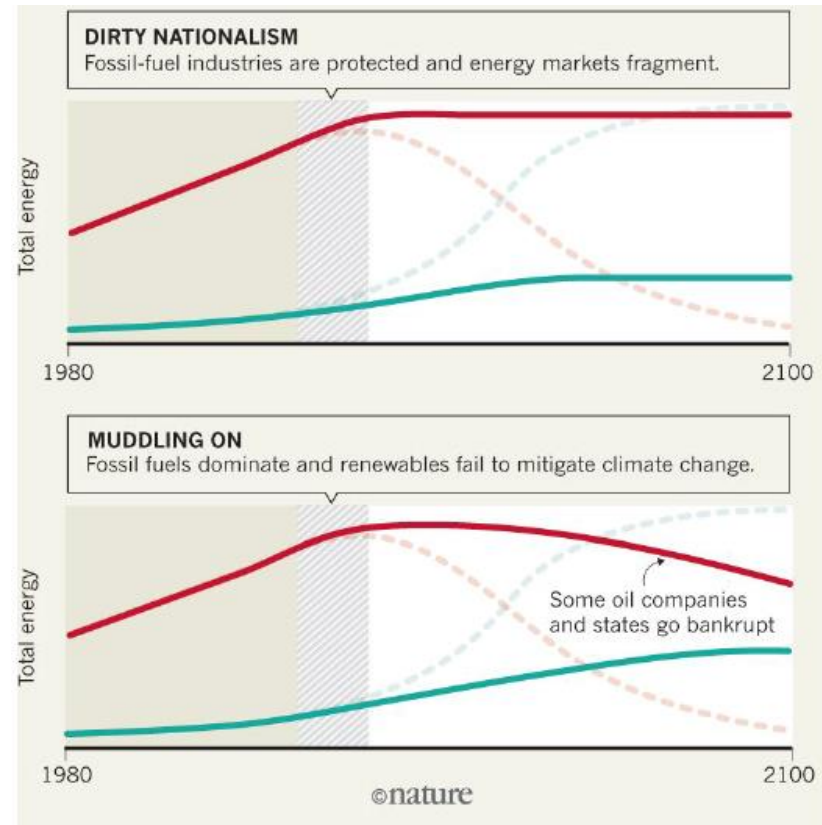
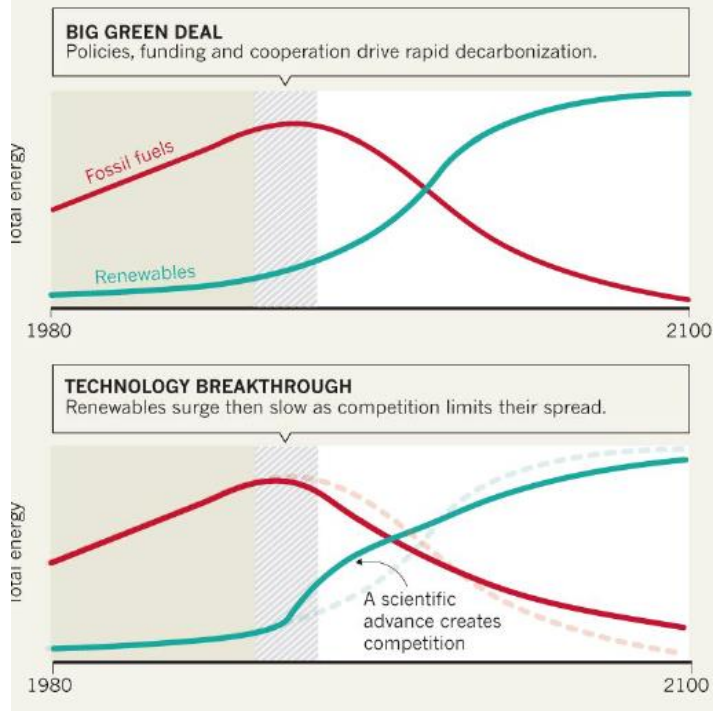


Source: Forzieri et al. (2018)

Uncertainty 7: Geo-politics and climate policy

FOUR FUTURES

Geopolitics in the next decade (hashed regions) will dictate whether or how fast energy from renewable sources will outpace that from fossil fuels, as these four scenarios depict.



Source: A. G. et al.

Source: Goldthau et al. (2019, p.30), <https://www.nature.com/articles/d41586-019-01312-5>

ECONOMIC REGULATION OF ENERGY UNDER NET ZERO

What does Net Zero Policy mean for a regulator?

- We were not on track to deliver 80%, so we are definitely not on track to deliver net zero.
- Net zero requires massive change and policy support, which cannot be delivered by regulators alone.
- Indeed regulators need to stand ready to change if necessary if societal preferences change.
- The energy regulator needs to focus on:
 - Security of supply under rising renewables and electrification
 - Control of average prices and price discrimination
 - 'Supporting' sensible decarbonization.

Do day job.

Economic regulation of energy

- Energy regulation has always focused on:
- Price – *average tariff and tariff structure*
- Security of Supply – *delivery of sufficient quality*
- Environmental impacts – *local, national (international)*

All of these will become more important under net zero.

Key elements of net zero

(see Chyong et al., 2021)

- Lower energy consumption compared to business as usual
- Final electricity demand will increase
- Electricity will additionally be required for hydrogen, synthetic fuel
- More variable renewable electricity (VRE)
- More investment in electricity grids
- Decarbonising heating via electrification, hydrogen, biomethane, synthetic fuel
- Decarbonising transport via electrification, hydrogen and synthetic fuel
- Higher carbon prices
- More international trade in electricity (not just in Europe and North America)
- Negative emissions required via bio-energy with carbon capture and storage

Key elements of net zero (see Banet et al., 2021)

- Higher unit energy and carbon prices underlie all sensible net zero policy
- More use of pricing and/or control in electricity to match supply and demand in real time
- Locational price signals for around energy networks can help manage local congestion issues
- Public acceptability of solutions will be challenging in heating (and transport)
- In transport, smart charging and pricing will be important, and distributional issues of who pays for private transport will need to be addressed
- National energy regulators do need to pay attention to local preferences in order to increase options and help with national policy goals.

Net zero makes 'good' economics more important not less...

- If targets were cheap, willingness to pay would cover up overpayment/negative distributional effects.
- Net zero will be expensive therefore only attention to economic cost and equity will deliver it.
- The pathway to net zero is more not less important, so scope for learning, behaviour change and long dated planned transitions important (e.g. switching off natural gas network).
- Co-benefits more important to justify costs, so wider assessments of benefits (and costs) important.
- Impartial advice will be at a premium, given the scope for 'group think'.

Some energy costs are energy policy costs in GB

Breakdown of household energy bill

October - December 2024 £		Electricity	Gas	Per MWh	Per Household
Total bill pre-VAT		994	876		
RO	Renewables Obligation	98.50		x	
CP	Carbon Pricing	29.00		x	
ECO	Energy Efficiency	26.90	35.88	x	
FIT	Feed in Tariff	22.70		x	
DCC	Data Communications Co.	14.53	10.92		x
WHD	Warm Homes Discount	10.91	10.91		x
CFD	Contract for Differences	10.84		x	
AAHEDC	Distribution network subsidy	1.42		x	
GGL	Green Gas Levy		0.38		x
Total policy		214.80	58.09		
% of bill		22%	7%		
Network costs		224.99	165.31		
% of bill		23%	19%		

- 1. Policies significant in electricity*
- 2. How they are charged for varies: variable vs fixed*
- 3. Mistakes material e.g. FIT (2%+), DCC (1%+)*
- 4. Regulated charges high e.g. overbuilding grid. Every £10bn of over-build adds c.1% to the household bill (at 8% annual capital cost)*

Source: Ofgem Price Cap Data, Standard Credit

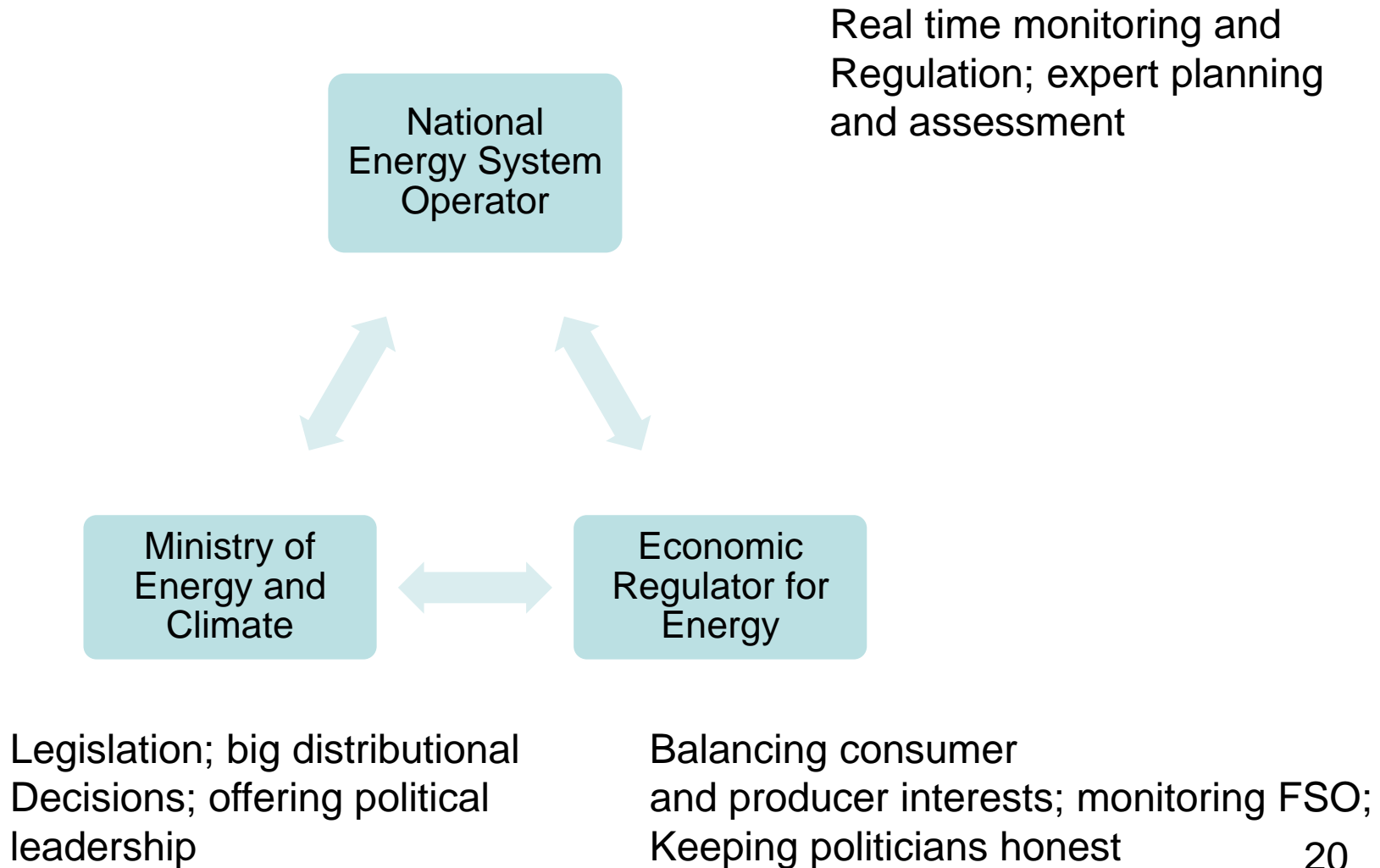
Back to the Day Job of being an economic regulator

Whatever happens with net zero and with technology, the energy regulator will still needed to oversee:

- Consumer protection from mis-selling.
- Data protection from cyber-attack and data loss.
- Price regulation of average price and the tariff methodology.
- Protection from bankruptcy costs due to service provider failure.
- Promotion of competition in data processing.

GOVERNANCE AND INSTITUTIONS: REGULATORS IN CONTEXT

The National Governance Triangle in Energy



Future Regulation of the NESO? Looking at Experience in US, South America and Australia (Anaya and Pollitt, 17)

- Good regulation involves not only assessing the efficient amount of revenue that the ISO requires but also about the efficiency of its procurement methods (market-based) and system optimisation (procurement levels).
- Stakeholders play a key role in the proposal and design of detailed implementation rules for new initiatives for the best ISOs.
- Complex voting rules are observed and are worthy of study for the lessons they might have for GB and Ireland.
- High level of internal and external oversight of ISO decision making is observed which is becoming more complex and subject to high levels of uncertainty.
- ISO State of Market Reports provide excellent examples of regular updates on key recommendations for future market design.

Observations on Governance

- The NESO is an idea whose time has come...
- Creation of NG ESO in NG has reduced set-up costs of creating NESO.
- G-ISO is not proven yet, but interesting to combine planning.
- NESO relationship to government more important than relationship to NRA.
- Will set up different dynamic and, for instance, it will significantly influence future NESO-DSO relationships.
- While it is an opportunity, would worry about NESO being overly conservative in its thinking.
- The idea is an enabling one, not a game changer by itself. So thinking about what it enables is important...

Ownership and regulation tradeoffs

- Europe, North America and Australia have pursued a separation and regulate model consistent with privately owned profit motivated network companies. This is not representative of global network companies (e.g. ESB).
- Public ownership of networks continues in many countries, with weak regulation.
- Consumer Trust and Common Ownership models can be experimented with e.g. Competitive Joint Venture model of Keisling.
- It would be odd if net zero did not require ownership reorganisations, given the scale of the challenge.
- The reorganization of ownership, especially of gas and electricity assets, to achieve net zero remains a viable alternative to regulatory solutions.

One idea for asset reorganization in GB

Bringing Energy Home

National Energy Agency

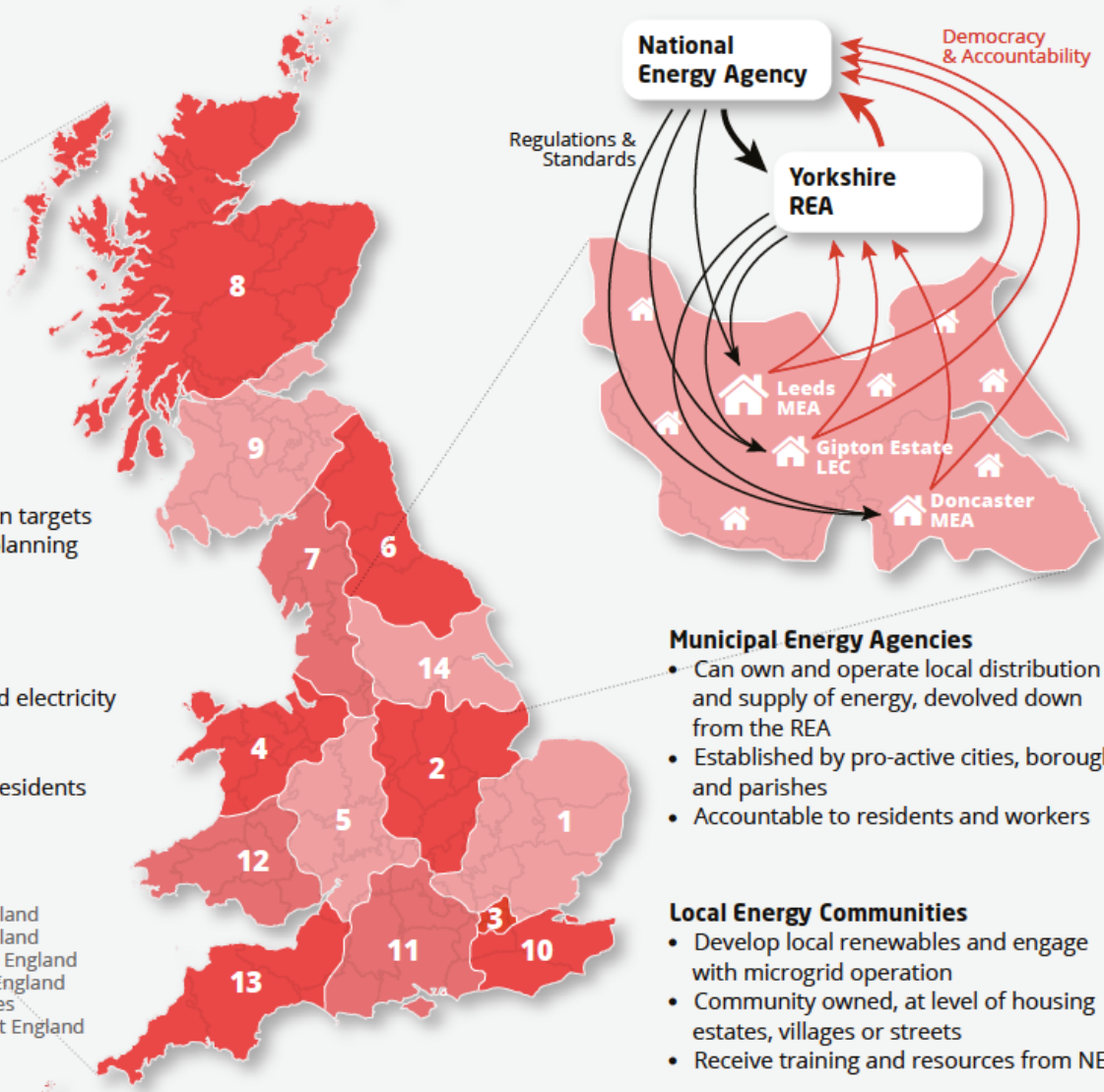
- Owns and runs high voltage transmission
- Regulates energy system
- Sets regional decarbonisation targets
- National skills & workforce planning

Regional Energy Agencies

- Own electricity and gas distribution
- Responsible for decarbonising heat and electricity
- Responsible for fuel poverty
- Drive regional industrial strategies
- Accountable to councils, workers and residents

Map Legend (REAs)

1	East England	8	North Scotland
2	East Midlands	9	South Scotland
3	London	10	South East England
4	N. Wales, Merseyside & Cheshire	11	Southern England
5	West Midlands	12	South Wales
6	North East England	13	South West England
7	North West England	14	Yorkshire



Municipal Energy Agencies

- Can own and operate local distribution and supply of energy, devolved down from the REA
- Established by pro-active cities, boroughs and parishes
- Accountable to residents and workers

Local Energy Communities

- Develop local renewables and engage with microgrid operation
- Community owned, at level of housing estates, villages or streets
- Receive training and resources from NEA

Source: Bringing Energy Home, 2019, p.9.

POST RIOO? (TO RIOO AND BEYOND)

Post RIIO?

Ofgem, the Great Britain energy regulator, issued an open letter on future of the price controls from 2026 (in September 2022) which explicitly asks this and related questions. The context is a discussion whether Great Britain's regulatory regime for networks based on RIIO – Revenue = Incentives + Innovation + Outputs – and itself a development of RPI-X incentive regulation remains fit for purpose.

Ofgem raised the following questions, inter alia:

1. Should there be a continued use of a periodic price control?
2. Is there an alternative to the current ex ante price control regime?
3. Is there scope for greater stakeholder participation in the regulation of networks?
4. Is it possible to have an ex post regulatory regime?

Dynamic Regulation?

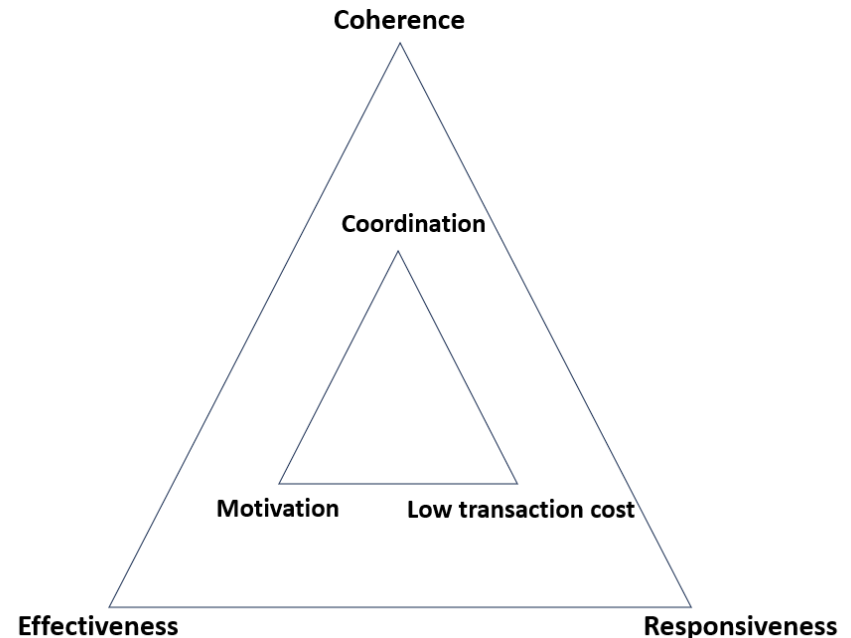
Regulatory Trilemmas to overcome (Pollitt et al., 2024)

First regulatory trilemma
(Parker and Braithwaite, 2005;
Teubner, 1986)

- Effectiveness
- Responsiveness
- Coherence

Second regulatory trilemma
(Eskesen, 2021)

- Motivation
- Coordination
- Low transaction costs



Uncertainty of Net Zero pathways may exacerbate trilemmas

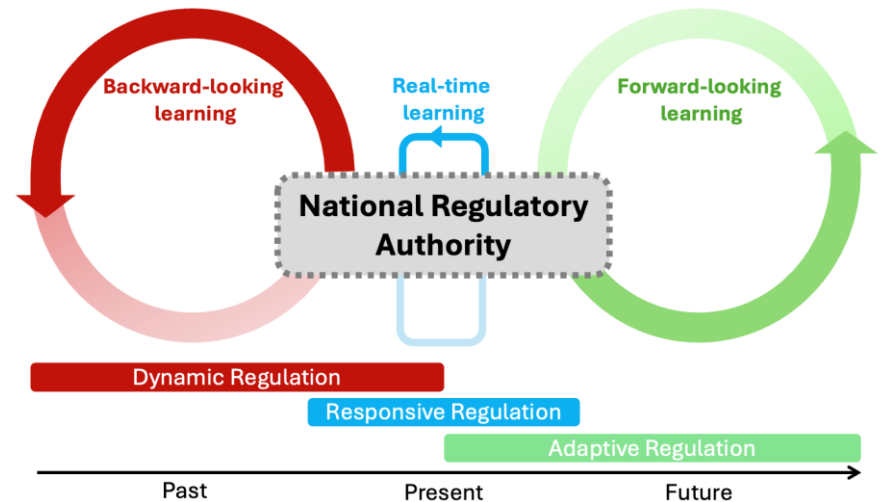
- The need for anticipatory investment becomes more significant but the exact amount required is not known (otherwise it would not be anticipatory). A greater level of uncertainty and potential of overinvestment will have to be tolerated.
- The credibility of ex-ante controls can be undermined by the frequent use of reopeners, needed to adapt to changing circumstances.
- The risks associated with ex-post rulings – which may affect remuneration of assets outside of plan – may translate into higher cost of capital demanded by investors.
- As decentralization continues, more numerous and diverse stakeholders may emerge but the cost of managing them rises, ensuring they are representative and informed enough to make choices on complex issues will be high.
- Innovation may become more consequential but also more difficult to manage. For instance, the temptation to reward only the one that is successful will discourage future attempts, while too much freedom may induce wasteful innovation spend.

Regulation may need to change

- Firstly, there may be need for changing the mandate of regulatory authorities. For example, under new Energy Act statutory responsibility for Ofgem to support the Government in achieving net zero by 2050.
- On planning [1], regulators currently ask networks companies for business plans for a specific period of time, which are subsequently negotiated and then settled.
- Relatedly, uncertainty mechanisms [2] will need improvement. At present, reopeners are seen as burdensome even in the most advanced regulatory regimes.
- Incentive [3] based regulation will also need to be adapted. This is potentially expensive under net zero!
- The large investment and higher uncertainty will impact financing [4] conditions.
- The emergence of DERs but also the high stakes of net zero will mean that networks companies will have to deal with a larger and more diverse set of stakeholders [5].
- Funding and adopting technological and business model innovation [6] is more important than ever.
- At the governance [7] level, there may be several directions of potential change. 29

The Learning Regulator

- **Dynamic regulation** (Agrell and Bogetoft, 2003)
 - **Responsive regulation** (Ayres and Braithwaite, 1995)
 - **Adaptive regulation** (Benbear and Wiener, 2019)
- All of these 'dynamic' approaches to regulation emphasise the need for regulatory learning.



The 'Learning' Regulator

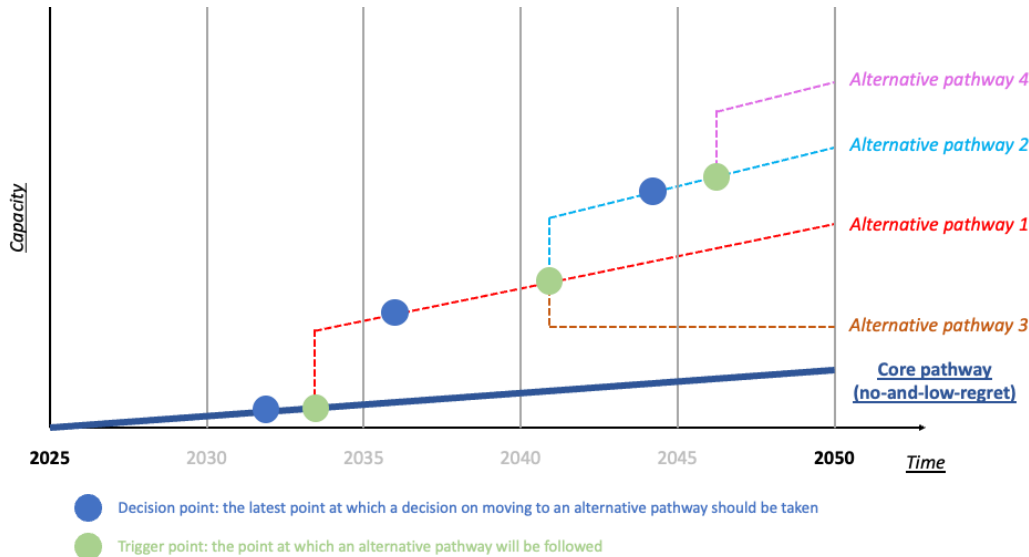
SOME IDEAS FROM OTHER SECTORS

Adaptive Regulation in practice

Role for longer-term planning

Ofwat, the water regulator in England and Wales, has chosen:

- **Adaptive pathways planning;**
- Companies adopt an adaptive pathways method to their business plans, **being prepared for changes to meet the challenges of the future;**
- **Business plans** are meant to cover **five years** but need to be presented within **25 years strategies + core pathway for 25 years;**
- Relevant **indicators** and **thresholds** for triggering alternative pathways that deviate from the core.



Example core and alternative adaptive pathways (Source: Ofwat (2022, p.7))



Differentiation and deregulation at London Airports

- Initially separate price controls at each airport, with joint ownership at privatization, administered by Civil Aviation Authority, CAA.
- Since 2012 high degree of differentiation in airport regulation and move away from traditional five year price controls. Substantial constructive engagement at each airport, between airport and airlines.
- Stansted is now substantially deregulated with airlines deemed to represent customer interests in negotiating settlement on price and service levels.
- Gatwick operates under a commitments framework which includes price and investment and quality targets, reviewed monthly, within a 5 year period.
- Heathrow retains large elements of a conventional 5 year price control, with challenging disagreements between airport and airlines and large uncertainty over passenger numbers.

Regulation for Innovation in Singapore

- In 2014, the Singapore Autonomous Vehicle Initiative (SAVI) was launched, which aimed to research the autonomous vehicle transportation sector and test-bedding. It created a cross-industry committee – which included both public and private representatives – in an attempt to better anticipate and integrate autonomous vehicles after the Land Transport Authority agreed to more flexible testing of these solutions.
- The initiative developed an open platform that allows authorities, research centers and think tanks, or industry companies to jointly run self-driving trials, to test various scenarios and solutions. As a result, it attracted the attention of [multiple foreign investors](#) into the sector.
- In 2016, an AV piloted by nuTonomy collided with a lorry, leading to an immediate investigation of the accident. Once the safety concerns were addressed, the pilot project was resumed.
- Long-term regulatory challenges remain, e.g. behavioral changes in AVs due to deep learning, cyber-attacks, and workforce disruptions (Tan and Taeihagh, 2021). To this end, the regulatory designs for medium and long term is similar to the electricity/gas frameworks, as they also embed high uncertainty that can deviate from baseline scenarios.

Concluding thoughts

- Uncertainty facing regulators – regulators face uncertainty on the path to net zero which they can partially manage.
- Regulation on the path to net zero – it is important to be clear what net zero implies for the scale of the challenge and the continuing role of good economic regulation. However the fundamentals of good regulation are not changed by net zero.
- Governance and institutions – regulators need complementary institutional structures with which to work. These wider institutional arrangements in government and industry will need to work with regulators to achieve net zero.
- Beyond RIIO? – Best practice regulation continues to evolve. Theories of 'dynamic' regulation suggest a key role for both learning and for tradeoffs in regulation. The best regulators develop the capacity to reduce the size of the tradeoffs and to achieve better outcomes at less cost.
- Some ideas from other sectors – We highlight some examples from water, airports and road transport where regulators are implementing some principles of adaptive regulation.

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