FROM LOCAL TO THE FUTURE: HOW ENERGY SYSTEMS ARE BEING TRANSFORMED

OR HOW WE CAN ENSURE OUR ENERGY SYSTEM IS NOT MESSED UP

Professor Malcolm McCullough
Associate Professor in Engineering Science and Group Leader of the Energy and Power Group at the University of Oxford

Did you know that by the end of this parliament, projections show that power capacity from all the connected electric vehicles in the country will be greater than all our nuclear power stations?

Our energy systems are changing fast. When a system evolves slowly, the challenges are well known and increasingly focused efforts are needed to eek out extra value. However, when a system changes rapidly, the challenges are not yet discovered and we need a broad, adaptive perspective to understand what the new societal value will be.

SO WHAT?

The question above shows three ways in which the system is changing rapidly:

Decentralisation

Firstly, the power system is transforming from being largely centralized to largely decentralized. The assets that create energy, and hence societal value, used to be large centralised power stations. In the new system *energy storage* will be a significant provider of value, as it will be distributed across the many local contexts where people live. Our challenge is how can we effectively meet national goals and take account of local opportunities and constraints.

Rate of change

Secondly, for the first time in over 50 years, the rate of change for the power sector is faster than political timescales. It takes at least 10 years to build a large fossil fuel power station – over which time the political regime can change several times, with changing priorities that create risk to the developer. Now technology is changing at a much faster rate – and bringing dramatic cost reductions for renewable technologies. For instance in 2008, the cost of solar modules started to fall dramatically, undermining the economic forecast models developed for the Feed in Tariff for solar PV. Looking forward, the emergence of long-life batteries from Tesla for example, will mean reduced battery degradation, and costs, enabling Vehicle to Grid (V2G) services.

It's not just about the power sector

Thirdly, there is a rapidly approaching potential collision between the transport and power sectors. The rapidly developing coupling between the two sectors has already started to have unexpected consequences. A large motor vehicle manufacturer recently obtained electricity generating licences in multiple jurisdictions. This new actor could well have market dominance in the power sector in a few years. The transport sector could also look to provide radically different service offerings to customers, where V2G services cross-subsidise mobility.

Space heating is also being electrified, implying a further potential collision between the building sector and power sector. The arbitrage of thermal comfort and power will lead to innovative business models, both for new housing developers but also for retrofit.

TIME TO CHANGE!

When a system evolves slowly, the challenges are well known and increasingly focused efforts are needed to eek out extra value. However, when the system changes rapidly, many of the challenges are unknown and we need a broad, adaptive perspective to uncover the challenges and to effectively unlock the new value.

Most of the existing relevant

institutions to regulate and operate the power system take a centralised, siloed, slow and methodical approach, which is no longer fit for purpose. As a nation we risk missing the once in a lifetime opportunity to maximise the rewards from this exciting transformation.

NEW TRIAL TO DISCOVER THE UNKNOWN UNKNOWNS

It is impossible to follow the usual evidence based policy route when the evidence is not fit for purpose. Therefore, we are trialling a new process – the **lean ecosystem approach** – that can efficiently manage a system which is rapidly evolving and will exhibit unexpected outcomes along the way. We are building on the core principles of the scientific method – *hypothesis, test and measure, evaluate, repeat until measurements yield data that is explained by the hypothesis* – with an approach to effectively manage change and the Rumsfeldian challenge of unknown unknowns. You may recognise that this iterative technique has familiar counterparts from complex IT projects – *agile* – to rapid product development – *lean startup* and *minimum viable product* (MVP). We add a systems flavour to make it more appropriate.

The lean systems approach was developed to enable rapid, effective, development of a Local Energy system in Oxfordshire, (Project LEO), one of the four demonstrator projects of the Innovate UK funded Industrial Strategy Challenge Fund *"Prospering from the Energy Revolution".*

The approach has five key steps, with built in feedback loops to ensure a clear outcome, see Figure 1.

A) Defining the Societal Goals

In our analogy to the scientific method the first step is to set up the hypothesis.

All systems exhibit a purpose, and this is the most important characteristic of a system. Step A explicitly brings together key stakeholders, including political and civic, to converge and prioritise the key goals that need to be achieved by the system. This process enables a clarity of purpose across all the stakeholders, and minimises the negative effects of any bounded rationality by different actors.

The goals could (should) go beyond the usual energy trilemma – ie *clean, affordable and secure* – to include aspects such as an equitable or, better still, a just, outcome for all, jobs creation, levelling up, and national leadership.

Whatever the goals and priorities, it is important that there is transparency to ensure that all participants are aware of, and agree on, the goals, and are all broadly working towards them. Prioritising the goals enables a clear process of decision making. And because this is an adaptive process, if the goals become no longer appropriate, there is a clear process as to how they can be changed.

B) Theory of Change (TOC)

In our analogy to the scientific method, this is the description of the proposed experimental approach.

This step could also be described as 'pathway' and 'back casting'. The key essence is to build a conceptual understanding of how we will journey from now to meet the goals. Like all models, it will be imperfect. The TOC is useful as it makes explicit the assumptions of how the proposed interventions will influence the system and achieve a desired outcome. It is also used to identify key performance indicators, both leading and lagging. →

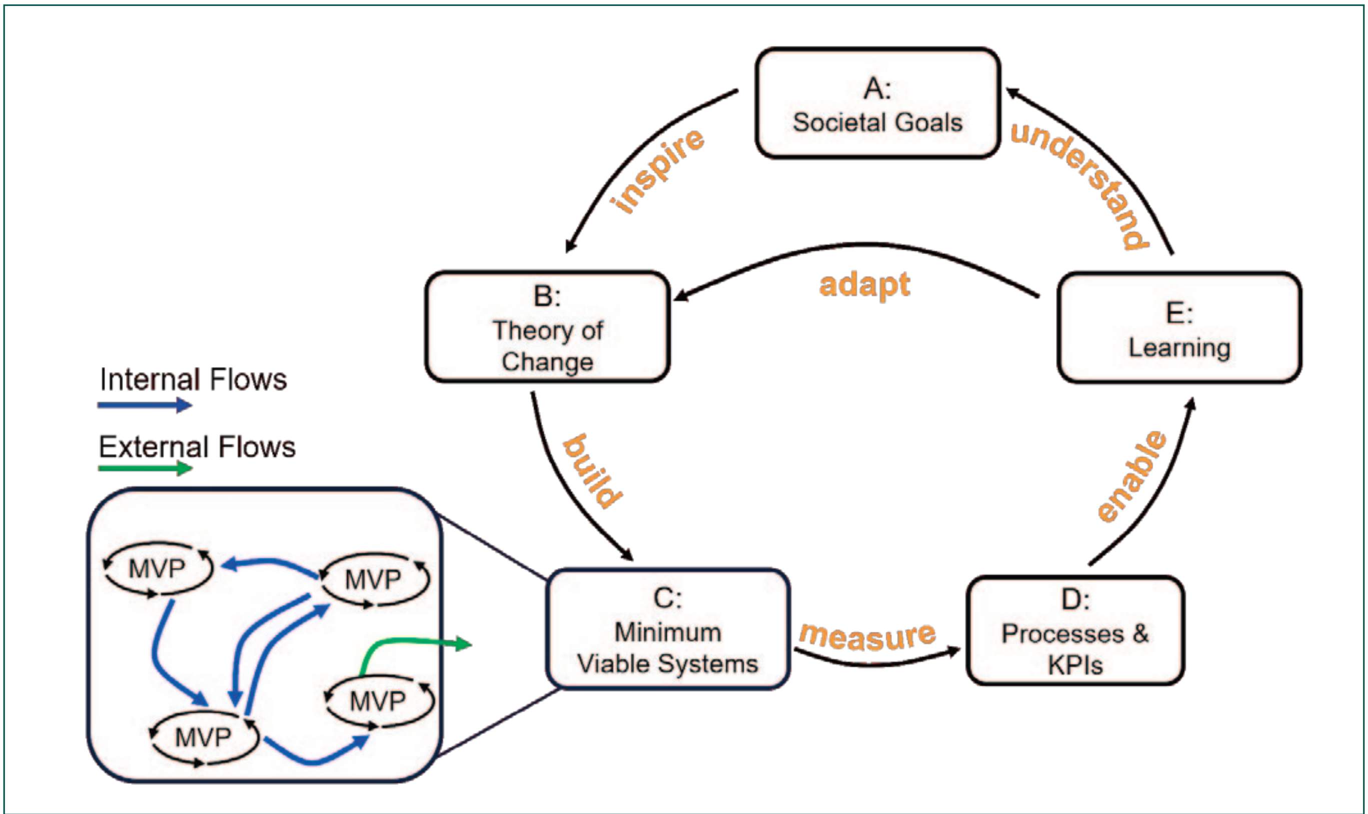

Figure 1 Overview of the Lean Ecosystem Approach

C) Minimum Viable System

In our analogy to the scientific method, this step is the experiment.

The next most important intervention in the TOC is identified, as is the minimum number of actors. A minimum viable system is created to test if the intervention does as expected.

An MVS consists of a group of two or more actors that interact to achieve a specific outcome. The process helps to identify the required actors, processes and interactions between the actors to achieve the desired outcome, and whether it is achieved as expected. The MVS ensures that mechanisms are in place to record the relevant Key Performance Indicators (KPIs, identified in the TOC and from the output required) and process maturity.

At the start, the processes can be done manually, or by using proxy methods. It is usual that each actor has a different level of maturity of their particular competence and interface with other actors. Part of the learning is for each actor to identify where effort should be deployed to maximise value. This leads to an effective and efficient co-development of the system across multiple actors.

D) Measure KPI and process maturity

In the analogy to the scientific method these are the measurements.

The actors run a trial and collect the relevant data from the KPIs and process maturity. The data should be formally recorded and shared with all partners. This approach allows for evidence to be gathered and used to adapt in-flight.

E) Learn and adapt

In the analogy to the scientific method, this is the assessment of the measurements against those predicted by the hypothesis.

The data is used both to determine if the processes are sufficient and to identify any unexpected behaviours. Having learned from the data, there are then three opportunities to adapt. First is to improve the particular MVS processes or to share learning across other MVS that are in operation. The second is to update the TOC to better reflect the actual impacts and outcomes of interventions, and to possibly improve the intervention based on the evidence gathered. The third is to reflect on the societal goals, which may need changing, not only from the evidence of the trials, but also from wider societal changes and incidents.

This process allows for a self correcting system that can effectively manage both the unknown unknowns, but also the different timescales of technology, market, and political change.

OUR TRIAL: THE LOCAL ENERGY OXFORDSHIRE (LEO) DEMONSTRATOR

LEO started in April 2019, and brings together key stakeholders from local government, three innovative SMEs, including a V2G provider, the local DNO, one of the Big Six energy companies, a community energy provider and two local Universities.

The challenge: develop a local energy system that can be readily replicated throughout the UK.

In a workshop with all the stakeholders – including those beyond the core partners – two Societal Goals were identified:

1. Maximise asset utilization by balancing local energy as best possible given wider constraints; and
2. Provide equitable energy for all.

We realised Goal 2 was dependent on Goal 1, so Goal 1 was prioritised first.

We developed a TOC which identified that a flexibility market was key to unlock value from the assets. Secondly, a strategic local energy plan would be used to understand and shape the land use of a decarbonised electricity system. A third success factor is multi-organisational collaboration.

Within six months of starting, project LEO ran its first MVS trial (it has now run more than 10). At the start many of the processes were manual, yet revealed that large batteries may have to be reconfigured for providing flexible services and that issues of non-delivery are more complex than anticipated. The trial highlighted valuable issues to resolve such as who validates, what measurements are needed, what about partial delivery, impact of reliability of assets, what nature of contract needs to be put in place and more.

So far, LEO has demonstrated flexibility delivered by storage (via a bus depot battery), generation (a run of river hydropower scheme) and reduced energy demand (via changed settings in a library HVAC system). Each has yielded much learning, which each partner is rapidly incorporating into their practices.

WHAT'S NEXT?

In the runup to COP 26, the world's eyes will be on us. Now is the opportunity for the UK to take on a global leadership role in the energy transition. Energy systems are operating at both the national and the local scale. Now we have the opportunity to align our energy transition to our societal goals to maximise the benefits for all.

Our first step as leaders is to articulate our national societal goals for a clean energy transition which could include job creation, a levelling-up agenda, equitable and just provision of energy for all.

The legacy we leave to the next generation will be judged not on whether it was expedient but rather that it was right and effective, for the long term.

Links to evidence that Nissan has entered the power sector

"Nissan Wins License to Trade in Japanese Power Market"
https://www.bloomberg.com/news/articles/2013-04-02/nissan-wins-license-to-trade-in-japan-electricity-market

"Nissan LEAF V2G Qualifies as a "Power Station" in Germany"
https://v2g.co.uk/2018/10/nissan-leaf-v2g-qualifies-as-a-power-station-in-germany/ ☐