DIGITAL TWINS

MODEL, SHADOW, TWIN. THE CASE FOR POLICY USE.

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1. SUMMARY

As digital tools develop, policy makers should be leveraging all available tools and techniques to demonstrate and evidence the implications of their policy interventions. Digital twins, shadows or models; i.e, digital twin technologies, offer an opportunity to build evidence and highlight the impacts of possible future policy decisions, as well as retrospectively measure the impact of those already in train. The benefits of digital twin technologies are better understood for use case pertaining to the operation of the energy system. The benefits and use cases for policy makers are often not examined.

At a high level, below are use cases for digital twin technologies in policy work that can be enabled in the future, such as:

- Simulating the energy system for edge case events / national security scenarios
- Modelling forward long-term impacts and trajectory of the current system arrangements
- Scenario building for different high-level goals, such as net zero by earlier dates or certain levels of offshore wind with limited curtailment.
- Utilise full digital twin technologies and enabling system operator(s) to make limited policy changes via the digital tools in real time
- Testing options for optimising for different outcomes in a net zero system, such lowest overall system cost, or highest offshore wind penetration via North Sea build out.
- Generating better/more digestible insights for consumers

Government and regulators utilising these technologies for public good will be a key use case for the energy system as digital twin technologies are utilised more often for system operation purposes. This paper sets out what digital twin technologies are, the benefits of them for policy makers and some near-term use cases that government and Ofgem could leverage to improve the policy process in the energy sector.

2. WHY DIGITAL TWINS?

2.1. INTRODUCTION

For the purposes of this report, we will be using the following working definitions for Digital Twin Technologies.

Digital Model – A digital representation of a physical system or object e.g. a network infrastructure map which utilises data from a fixed point in time

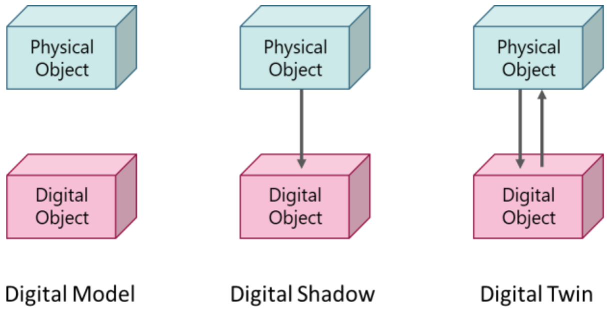

Figure 1: Breakdown of Digital Model, Shadow and Twin

Digital Shadow - A digital model which integrates automated one-way data flow from the physical system or object e.g. A network infrastructure map which pulls data from the system to dynamically update inventory, asset state and constraints

Digital Twin - A digital model which integrates two-way data flow between the model and physical object or system. Where making a change to one can change the other for example a control centre network map which displays real time system status and enables engineers to control assets to mitigate issues.

The energy networks obligation to follow the "presumed open" principle for data[1] has started the emergence of extremely valuable data to a wider set of data users. From this surfacing of data on themes such as network topology & networks conditions, the possibility to build digital twin of the energy system and its power flows has become more realisable. For example, National Grid ESO are expanding on their current transmission network control centre and exploring developing their own Virtual Energy System[2] similarly, BEIS are developing a digital twin demonstrator[3] in collaboration with Energy Systems Catapult (ESC).

There are several inputs required for a digital twin technology to operate successfully, but fundamentally a digital twin technology requires high quality, granular data representing the system modelled, and a clear understanding of the relationships between different the parts of the system. As networks develop the tools and capability to create, maintain and assess more granular data about the energy system, so should other participants think about what data they need to create, maintain, and utilise to measure the impacts of interventions, edge case events & conduct whole system planning in a data driven way.

A common goal of a digital twin technology implementation is to be able to make changes on the digital system that pushes changes to the real world, providing system operators a new tool in understanding and managing their networks. That said, the value of digital twin technologies is not simply in the better operation the physical system. It will be in combining real time, dynamic, and static/slowly changing data with any number of disparate sources – and changing the conditions of that digital twin technology to simulate, test and gain a fundamental understanding of the relationships. Those relationships could be between the physical system and connected devices,

[1] https://www.ofgem.gov.uk/publications/decision-data-best-practice-guidance-and-digitalisation-strategy-and-action-plan-guidance
[2] https://www.nationalgrideso.com/electricity-transmission/news/introducing-virtual-energy-system
[3] https://es.catapult.org.uk/project/energy-system-digital-twin-demonstrator-project/

the people using products and services on that system, or how the governance of the system and decisions made in one area impact another. A common understanding and shared data ecosystem underpins this, and to enable effective digital twin technologies to develop, further work on data sharing, licensing, interoperability and use cases is required.

2.2. THE CASE FOR BETTER REGULATION AND POLICY

As the UK continues to realign its policies, regulations, and legislation around meeting Net Zero targets, the need for impactful data to measure the success of that endeavour will be paramount. Without data of clear providence, that is able to measure the impact of interventions at a micro and macro level, the changes to policy, regulation and legislation will remain poorly understood. Recently ESC published a paper on Digitalisation Licensing in Energy[4], which looked at the clear need for the measurability of the regulations in place for the energy system and suggested an approach to be taken. Similarly, the Better Regulation Executive at BEIS has launched a tender to develop a platform for digitalising legislation, a product to help organisations across the value chain to better understand how legislation impacts activities. These types of activities and changes to the regulatory/policy landscape will create data points, certainty on how things should be measured and provide a baseline for analysis to be undertaken with advanced analytical techniques.

Approaches and activities like this mark a transition in how policy can be developed, shaped, and understood. With the increasing capabilities of technology, such as finding relationships and patterns via advanced data science techniques, the question of "how do we improve regulation and policy" needs to be discussed. Digital twins, with their key characteristic of being a real time interaction with the physical system, aren't likely a key priority of policymaking given the core methodology for policy change taking several months at minimum to push governance changes through the system. Digital shadows on the other hand, given their status as a representative model can be a very impactful tool in the box of policymakers to enable the below:

- Show system wide impacts of an intervention
- Test and validate predictions
- Measure impacts of interventions
- Simulate the future system

A policy and regulatory regime within the energy system that can create and test its interventions in the ways listed above will enable the governance of the energy system to be structured with greater transparency and certainty. Potential outcomes will be better understood up front in a common way. For example, interactions between different components of the regulatory regime, the physics of the system, different energy markets, and consumers interactions can be comprehensively built up over time using increasingly high-quality open data, supplemented with shared and closed data that the policymaker has access to. Digital shadows can be utilised as a key tool for evidence-led policy development which can ensure governance of the energy system can better manage the complexity of the decarbonisation task.

[4] https://es.catapult.org.uk/report/digitalising-licensing-in-energy/

3. THE JOURNEY TO DIGITAL TWINS

3.1. THE SYSTEM BENEFITS

As industry data standards align, data availability becomes commonplace and the capabilities of the digital twin technologies improve, the potential benefits of these solution types increases. There are several high-level benefits to the ecosystem of policymakers, system operators and incumbent organisations that digital twin technologies can help facilitate. These include:

- Benefits to the whole system planning, including assessing alternative paths for decarbonisation at the confluence of energy and other sectors such as mobility, heating, or buildings.
- Monitoring for system operators, enabling those organisations to be able to view sections, or the whole energy system they are responsible for in a more digestible, human readable format and make effective decisions.
- Planning for networks, where digital models or shadows could be run forward in time to help assess the impacts of network reinforcement (or lack thereof), creating digitally enabled Future energy Scenarios[5]

Over time as a firm baseline model or shadow of the energy system is developed, pulling data from other industrial sectors will become of paramount importance. The confluence between mobility, heating, telecommunications, health, manufacturing, banking, and others all creates complex interactions of which we currently only have *some* understanding of. Use case driven approaches to joining datasets for the purposes of more effective decision making will be very important in developing data driven policy over the coming years. Ultimately, the better we simulate the real world digitally, the more effective people can be in making evidence-based improvements to it and focus on creating an evidence-led, outcome driven policy environment.

3.2. THE POLICY BENEFITS

To ensure digital twin technologies can be utilised by policymakers several building blocks need to be in place. Fundamentally, granular data that can provide insight into different aspects of the energy system is required, and steps should be taken to identify and acquire that data for the policy teams. Identifying key data assets that will provide insight into how behaviour of the system changes should be driven by the use case and prioritised whenever a new regulation or policy is being considered. Developing a strong in-house knowledge of data across the energy system's value chain can develop policymakers' capabilities in data and digital and strengthen the policies themselves.

Over time, those data sources and the relationships between the data assets held will become better understood, enabling teams to feed that data into a digital model, shadow, or twin.

The table below sets out hypothetical, policy specific, data requirements for a digital shadow that seeks to test hypotheses on different locational pricing approaches.

[5] https://www.nationalgrideso.com/future-energy/future-energy-scenarios

Table 1: Hypothetical requirements for testing nodal pricing approaches

Data Required	Data Provider	Benefit to Policy Maker	Benefit to Data Provider
Household income	ONS	Demographic data can be utilised to see how income changes over time.	Learning from joining data across sectors can inform ONS's own work.
Points of Interest[6]	Ordnance Survey	Understanding where businesses/education and leisure services are located will help map impact on those organisations.	Demonstrating whole systems use cases by government leveraging this data strengthens commercial case of data utility.
Fuel Poverty Statistics	Gov.uk	Incorporating data on fuel poverty could enable policy makers to learn how policy intervention impacts vulnerable group(s)	High profile policy making using these statistics demonstrate the benefits of collecting, validating, and maintaining the data asset.
Social deprivation and economic activity indices	ONS	Insight into how big an impact price differential can have on specific geographic regions will be important to demonstrate impact on consumers.	High profile policy making using these statistics demonstrate the benefits of collecting, validating, and maintaining the data.
ChargePoint pricing and utilisation data	EV ChargePoint operator	Monitoring how price differences impacts use of services in a highly complex system will provide insight into how nodal pricing might impact these systems.	Sight of how future policy impacts their business models provides a useful market analysis function, in addition to evidence of impact on their business.

While ostensibly the benefits of any such digital shadow would sit with the organisation utilising the tool, the whole system benefits should also be made explicit. Utilising a tool for policy and regulation changes has several whole system benefits, such as:

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[6] https://www.ordnancesurvey.co.uk/business-government/products/points-of-interest

- Enabling policymakers to test hypotheses on how changes might impact different organisations, specific geographic locations, as well as the energy system itself.
- Enabling the quantitative outputs of the model, as well as the assumptions used in the model to be made available for others to test.
- Learning the specific relationships between different component parts of the energy system and how they are impacted by changes
- Creating common understandings of the energy system, it's relationships and impacts cascade across its components.
- Tracking specific targets made by government on themes such as overall emissions or levels of investment in particular locations on the system.
- Specifically measuring changes to the system based on an intervention.

Open data, data sharing, metadata, data licensing, API protocols as well as commercial sensitivities all come into play when pulling data from disparate sources and systems into any project. The coherence of approach across the energy ecosystem when it comes to these topics therefore becomes significant in ensuring any actor in the energy space can utilise data effectively. With the industry coalescing around the presumed open principle, which by Ofgem's definition includes software scripts, it would follow that any digital twin technology developed by government and the regulator to be, so far as possible with sensitivities, made openly available.

4. PRACTICAL USES

Within the capabilities of the data landscape in energy, there are several low hanging fruit use cases that a digital twin technology can enable by being embedded into the ways Ofgem and BEIS operate when developing justification for specific policy and regulation changes. Below a few are set out that may be feasible to develop now or soon.

4.1. MEASURING IMPACTS OF ENVIRONMENTAL SCHEMES

Over the last decade or so, Ofgem has been working administering environmental and social schemes on behalf of the government[7]. These are set out by BEIS and include the Warm Home Discount (WHD), Energy Company Obligation (ECO), Feed in Tariff (FIT), the Renewable Obligation (RO), the Renewable Heat Incentive (RHI) and the Boiler Upgrade Scheme (BUS). Each of these schemes has targeted a different section of the UK energy market to stimulate development of a particular aspect, such as the deployment of renewable energy on the grid (RO/FIT) or ensuring vulnerable customers have extra help (WHD).

The lifecycle of many of these schemes, and in particular the administrative burden of running each is likely to have generated a significant amount of data. For example, the RO and FIT schemes each have a register relating to the assets and their respective applications to join the schemes. The RO register[8] has significant public data relating to accredited stations, as well as the number of Renewable Obligation Certificates (ROC's) issued. The development of these policies, and the insight gained from their administration should be leveraged to help design the policy interventions of the future, as well as build an evidence base showcasing the benefits and drawbacks of the interventions to date.

Utilising a digital model or shadow to pick out and highlight the development of any of these policies through time and development of the energy system is possible. Including viewing their impacts on real world assets by leveraging the data that is held on their respective registers. This would provide an excellent evidence base for future policy interventions and provide robust interpretable insight that can be utilised to develop stronger policy in the future.

4.2. BENCHMARKING NETWORK PRICE CONTROL PLANS

Ofgem's recent publication of the final determinations for the RIIO ED2 price control[9] highlighted that they are expecting to undertake an innovation project named "Modernisation of the regulatory reporting process". The reporting process contains granular information relating to the whole stack of expenditure of the networks during that price control period. When modernising this data stack, consideration should be given to how it could be deployed into a digital twin model of the UK energy system, encompassing the likely future states envisioned by the detail of the plans set out by the networks.

There are several possible direct benefits that such an approach could enable:

- Comparing detailed, costed plans between networks to demonstrate and assess value to consumers
- Using that data to build future models of the energy system based on the plans provided by networks

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[7] https://www.ofgem.gov.uk/environmental-and-social-schemes
[8] https://renewablesandchp.ofgem.gov.uk/
[9] https://www.ofgem.gov.uk/publications/riio-ed2-final-determinations

- Better understanding of the whole system impacts of any planned investment or intervention by the networks

One of the core purposes of Ofgem is to protect consumers, and on their behalf negotiate with the energy networks to ensure that the investments in the grid and it's operation are in the public interest. Utilising new tools and techniques to do this will drive greater transparency and insight into those plans and can better drive the networks to consider the whole system impacts of their proposed solutions. It is possible that the regulatory data that is currently gathered may be fit for purpose for a use case described in this section; however, it is more than likely that further development of the data, particularly ensuring that geospatial data can be interpreted correctly within the plans to a reasonable degree of accuracy, will be critical to enabling Ofgem to better assess the price control plans, and their progress through the price control periods of the future.

4.3. SCENARIO PLANNING FOR SYSTEM SHOCKS

Recent developments in the energy market, largely stemming from the wholesale price of gas has put increased strain on the energy sector, particularly on energy retailers. Continued operation of critical national infrastructure during stress events is a core component of the remit of government and therefore utilising a digital shadow to scenario plan for differing outcomes would be a highly valuable tool. Government agencies can use these tools to understand the likely impacts of a particular event, as well as test possible mitigations and interventions they could make on the way the energy system operates to reduce the impact of the tested shock.

For example, testing scenarios of increased commodity prices and other externalities that impact primary fuel costs would be a valuable exercise. Modelling impact of how these increased commodity costs impact on network costs, and ultimately passes through to consumers via increased bills over time would provide some credible evidence on what the scale of any intervention by government should be.

5. CONCLUSION & RECOMMENDATIONS

The use of digital twin technologies has well understood practical applications when coming from a whole system modelling and operational perspective. Their ability to represent complex systems and articulate that in an understandable way can help asset managers across value chains in optimising for any measure in that system that is represented. Whereas in policy circles, the deployment of such tools and technologies has been extremely limited to non-existent, due to a lack of technical understanding in developing these tools, as well as due to a lack of a well-articulated value proposition to policymakers.

To make effective policy interventions as the system increases in complexity, a new approach to exploration and evidence gathering will be required. The physics of our energy system is changing, along with the modes of operation. Where consultation has, and should remain, a core element of the government and regulator's process - testing interventions on real world models or shadows of the energy system can enable better understanding of *what* is changing, and *how* it changes due to policy intervention. Indeed, as digital capabilities increase, leveraging insight from other sectors to help understand impacts on telecoms, water or transport should also be a longer-term goal.

This paper has set out a clearer articulation of benefits that can be achieved by using digital twin technologies in policy making. The changes in policies needed to continue to manage a complex system will be difficult – and it is in the interests of the whole system that any policy interventions can be evidenced effectively, with repeatably, via digital twin technologies or similar digital tools.

Government should continue to explore the use of digital twin technologies for policy development, and trial their use at the earliest opportunity. Further, a digital model/shadow capability should be developed openly that can be utilised by anyone to further democratise policymaking.

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