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CATAPULT Energy Systems

UNLOCKING CLEAN ENERGY IN GREATER MANCHESTER

Improving the business case for local renewable energy projects in the current market and under future market scenarios

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Stockport council

Wigan council

Oldham council

Rochdale council

Manchester city council

Salford council

Cornwall Insight

Procur3d

Local Partnerships

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EXECUTIVE SUMMARY

Greater Manchester Combined Authority declared a climate emergency in 2019 and launched its 5-year Environment Plan, which sets out a long-term environmental vision to be carbon neutral by 2038 and the urgent actions that need to be taken in the next 5 years to help achieve this. The Unlocking Clean Energy in Greater Manchester (UCEGM) Project was conceived as part of this vision. UCEGM is a European Regional Development Fund (ERDF) funded project comprised of two workstreams:

Work Stream 1 (WS1): Delivery of 10MW of local renewable generation owned by Local Authorities in Greater Manchester, in conjunction with the partner districts.

Work Stream 2 (WS2): Improving the business case for local renewable generation projects, for local authorities. With the aim of accelerating the development and delivery of projects and trying to negate the need for grant funding.

The selected WS1 local renewable generation projects included the following archetypes: roof mounted solar photovoltaic (PV), ground mounted solar PV and solar PV carports[1]. The projects were located within Greater Manchester and the installed capacity (size) of the projects tended to be less than 5MWp in rural locations, and typically less than 0.5MWp in urban. The project focused solely on developing new local electricity generation assets and did not include the acquisition by Local Authorities of existing assets, development of standalone battery or energy storage, or low carbon heating infrastructure, all of which are important to delivery of local Net Zero energy systems.

Smaller scale, local generation projects (as per the selected WS1 sites) have historically been seen as problematic from a financial viability perspective, due to lacking economies of scale and the removal of feed in tariffs. Hence, they have typically relied upon grant funding. Reliance on grant funding to develop and initiate renewable generation assets can cause additional complexity for local authorities, such as grant funding timescales not aligning with project planning and delivery timescales or grant funding obligations and requirements not reflecting local circumstances or decarbonisation priorities.

To truly unlock the value of local renewable generation there needs to be ways of developing smaller scale projects, other than grant funding (noting that their small size (less than 5MWp) typically precludes contracts for difference (CfD)). Investing in energy assets with a lifespan of over 20 years means that their viability is subject to changes in future energy prices, markets, and policies. This report considers the potential risks and opportunities for such projects and how to address them.

The first phase of WS2 demonstrated how innovative business models, good practice

[1] A micro-hydro scheme was initially included but due to cost and time limitations was taken out of the project scope to be pursued at a later stage.

procurement methods, and alternative routes to finance can improve the business case for these types of renewable generation projects, reducing the need for grant funding. The outputs, whilst using Greater Manchester local authorities as a pilot, are usable by all local authorities and include steps that will improve business cases.

In the second phase of WS2 the impact that different electricity market scenario designs could have on the costs and revenues of six sample projects was dynamically[2] modelled. Market scenarios focused on the main policy choices currently being explored under the Government's Review of Electricity Market Arrangements (REMA) – the status quo of uniform national pricing, introduction of locationally-specific pricing (locational marginal pricing, LMP), and separate pricing arrangements for renewable and non-renewable electricity (split markets). The results of the modelling were used to make a qualitative assessment of the impact on potential business models that local authorities may adopt.

The Catapult also considered qualitatively the potential for local electricity markets and advanced network management by Distribution Network Operators (DNOs) to provide additional sources of revenue for local energy projects.

It should be noted that the current energy crisis emerged during this project and the project has attempted to balance addressing the immediate priorities with solutions that will perform once the current market volatility has reduced.

[2] System behaviour in hourly intervals

2.1. Key learnings and recommendations

The project has delivered circa 10MW of local renewable energy generation across Greater Manchester and provided unique insight into the barriers and opportunities for unlocking clean energy in Greater Manchester and other local authority areas. The key insights and recommendations from the project are set out below:

2.1.1. Delivering planned local renewable energy projects

Developing integrated teams and shared vision:

Several instances were observed where the local authority project teams delivering renewable energy generation projects would have benefited from closer integration with other teams, such as Transport teams (fleet electrification), Finance teams (development and buy-in for business case) and energy managers (energy supply contracts and provision for PPAs). Decarbonisation projects have the potential to span across different directorates and different departments within a local authority.

Recommendation:

Developing a local area energy plan with associated targets and supporting policies that span across energy, transport and economic development can assist with strategic alignment, allocation of funds and resources across the authority. Collaboration across the teams is essential and must be recognised during project planning, through forming cross-departmental teams, which may include legal, estates, energy, transport, finance, regeneration, highways, and parking.

Understanding business models:

It can be challenging for local authorities to perform financial analyses due to misunderstanding complex business models (such as a Sleeved Power Purchase Agreement[3]). Developing a good understanding of business models takes time and is essential when validating feasibility with potential suppliers. The inconsistencies in the terminology used within the industry for things like Power Purchasing Agreements (PPAs) made this more challenging.

Recommendation:

Business models may appear simple but can have subtle complexities that the local authority teams must understand. This project has developed simple business model explanations, terminology, illustrations, and key findings to support understanding and engagement. The project outputs provide comprehensive guidance on five business models (see Section 6). This learning should be used to validate that the feasibility and suitability of possible business models. Several business models identified could provide local authorities with more predictable energy prices - these should be considered if price stability is a priority, particularly since the recent energy crisis. The standardisation and simplification of the terms used by different suppliers of products such as PPAs could also help to improve general understanding, effective decision making and business efficiency.

[3] See glossary and Section 6 for further details.

Local Authority roles within business models:

Business models vary in terms of complexity, expertise required and level of risk. Under UCEGM all the WS1 projects were developed and owned by the local authorities. For other jurisdictions with limited resources this approach can be challenging. The Catapult studied a range of business models and the different roles within each that a local authority may assume.

Recommendation:

Local Authorities developing renewable energy projects should actively consider possible business model options. They should consider the key criteria described in this report of desirability, feasibility, and viability. This will help to inform the choice of business model and the role and responsibility that they wish to adopt.

Leveraging generation and demand forecasts:

Understanding how well energy generation matches demand is important for the viability of local renewable generation projects. The project found this presented a number of challenges such as initial assumptions typically over-estimated site energy demand and likely self-consumption of renewable generation. Changes in energy supplier hindered getting access to historic energy consumption information. Other projects affecting demand and supply need to be accounted for too, such as building retrofit, LED lighting and other planned renewable generation projects.

Recommendations:

Local authorities should acquire the information necessary to understand the annual electricity demand for sites and expected yield from generation. This needs to be done in sufficient granularity (hourly or less[4]) to understand how much electricity can be consumed directly by authority-owned sites, the surplus and their remaining import needs. Local authorities should acquire the ability to use this information in commercial modelling to optimise the project design and financial value. This report describes a commercial modelling tool and method that could be adopted.

Both the scale of local renewable generation, and how well it matches energy demand, is important to energy supply contract negotiation. Local authority renewable energy generation project development should be actively coordinated with energy supply contract procurement.

[4] Half hourly data is typically available from suppliers for buildings with smart meters.

Procurement and supplier engagement:

It was observed that several renewable energy projects that were tendered for engineering works, did not initially attract sufficient interest from suppliers, causing delays, and required re-tendering. Access to specialist procurement knowledge and expertise was invaluable in delivering the WS1 projects and helping the Local Authorities.

Recommendation:

There is considerable regional, national (and international) demand for the delivery of renewable energy generation projects, a limited supplier base and some evidence of an increasingly strained supply chain in the UK. Regular market engagement is required to design procurements attractive to the market and raise awareness of upcoming opportunities. The success rate of procurements can be improved by establishing long term relationships with suppliers as well as collaborative delivery approaches. High quality tender information via detailed site investigations improves the chances of successful bids and mitigate risks at delivery stage. This learning and recommendation (the need for proactive procurement planning) is equally applicable to energy supply procurement with provision for PPAs.

2.1.2. Developing local renewable energy projects in uncertain future electricity markets

Understanding the local impact of projects:

Future electricity market arrangements are expected to be characterised by greater locational differentiation – through wholesale market prices (LMP), network tariffs and/or strategic planning. This means that the system impact and financial viability of renewable generation projects could vary by location, e.g. due to local electricity system characteristics. These characteristics will change over time, because of policy reforms and/or network investments.

Understanding viability, risks, and opportunities for different project locations, requires a sophisticated understanding of the energy system that most local authorities do not currently have in-house.

In this report we present the results from dynamic modelling that illustrates the impact on the electricity generation and prices for the 6 UCEGM sites in the snapshot years of 2025 and 2030.

Recommendation:

Local authorities that are committed to delivering renewable generation projects would need to access the relevant resource and expertise to conduct scenario- or sensitivity-based market modelling, of the kind summarised in this report. It can help local authorities understand the extent to which the value generated by projects is robust to policy and system changes.

Coordinated strategic planning:

This project has found that similar renewable generation projects can potentially deliver very different outcomes in different locations. This is because of the interactions between the local renewable energy generation, local energy demand, and local grid capacity. To account for this, coordinated place-based planning of investments in energy generation, related network infrastructure and future demands is essential. Coordinated planning creates the conditions for local authority projects to have the greatest positive impact on the energy system.

Recommendation:

Local Area Energy Planning (LAEP), which is a form of whole energy systems planning, can act as an effective enabler of coordination across energy generation, network infrastructure and demand planning within a local authority. LAEP can help local authorities to define local energy system designs consistent with Net Zero ambitions and identify barriers and opportunities to the delivery of local renewable energy projects.

Enabling policy environment:

The dynamic modelling summarised in this report shows that distributed generation can generate extra system value if it can alleviate transmission constraints by servicing local demand. But capturing that value depends on the design on electricity markets and of grid charges. We have found that under current market conditions the financial case for local generation is challenging because of the difficulty of capturing the value of distributed generation (e.g. due to different prices of importing vs exporting electricity).

Further, the market research has revealed that suppliers favour large scale projects. Such projects are able to benefit from access to support schemes such as Contracts for Difference, which are auctioned by the government. Eligibility criteria largely rule out smaller local projects accessing Contracts for Difference support. This makes it more difficult for such projects to compete.

Recommendation:

The energy transition is likely to require a more diverse portfolio of projects than can be delivered through centralised procurement. The Catapult advocates for replacing Contracts for Difference with a 'Clean Energy Standard' that would require suppliers to procure a growing share of their energy from clean sources. This outcomes-based approach could create more market opportunities for smaller projects.

Unlocking local value streams:

To make local authority-led renewable generation projects financially viable, local authorities need to consider how their resources (both financial and personnel) are used most efficiently to maximise value, focusing on the key revenue streams. In this report we highlight some of the longer-term business models that can facilitate such value, accounting for national and local energy trends.

Recommendations:

This report identifies a set of longer-term business models (e.g. Local Electricity Markets and Sleeving Pools[5]) and contains a preliminary analysis of how they may perform; we recommend further study of these. Findings from the review of potential policy reforms and the dynamic modelling suggest those business models that generate financial value through third party charge avoidance may become less profitable. Where transmission level constraints exist, but local demand is high there are opportunities for local generation and the business models that facilitate local trading. The report also sets out how the concept of Active Network Management, which is currently being deployed by some DNOs, could be extended to facilitate local electricity markets. DNOs, policymakers and Ofgem should explore the pathways to creating local electricity markets – either by building on Active Network Management or by scaling up the procurement of distributed flexibility.

Transmission – Distribution coordination:

As more small-scale renewable generation projects come onto the system, there will be a growing need to account for them in both national system planning and the operation of national electricity/balancing markets. Coordination between DNOs and the National Grid Electricity System Operator (ESO) is key to incorporating local projects into system planning and operations.

Recommendation:

The Energy System Operator is due to become the Future Systems Operator (FSO). The FSO should be responsible for coordinated strategic planning – considering distribution-connected assets as well as the transmission system. Ofgem has also proposed to introduce local subsidiaries of the FSO – known as Regional System Planners – who could have an important role in facilitating that kind of local-national coordination.

In this report we also describe a market architecture that would allow distribution connected assets to provide balancing and ancillary services at a national level to the ESO through a local electricity market.

[5] Described in Section 12.2.

3. REPORT STRUCTURE

Section 4 (Introduction): This section sets the context for the project by summarising the LA goals, the sites being developed, the physical system, the markets and regulatory landscape, and the challenges of using grant funding.

Section 5 (Project activities & summary): This section gives an overview of the activities undertaken and the rationale. It also summarises the outcomes.

Section 6 (Detailed design of short-term business models): The short-term business models are described in detail to enable districts to judge the viability (commercial), feasibility (how hard to enact) and desirability (value).

Section 7 (Commercial Modelling of Renewable Generation Projects): This section summarises the findings of commercial modelling undertaken in relation to the short-term business models and the factors affecting the commercial viability of local renewable generation projects (specifically sensitivity to changes in cost estimates and future electricity prices).

Section 8 (Local Authority Procurement): This section discusses effective procurement of supply chain partners in delivery of local renewable generation projects. It considers both procurement of physical assets and energy supply contracts.

Section 9 (Project Finance): This section identifies different means by which LAs may fund renewable generation projects and how well suited they are to different business models.

Section 10 (Future electricity markets and systems): This section describes the current landscape of reform in energy markets and then describes three potential market scenarios that may apply to future renewable generation projects.

Section 11 (Dynamic modelling): describes how the behaviour of the electricity system around GMCA has been modelled to understand system behaviour under different market scenarios to estimate the potential commercial impact on example local renewable generation projects, based on the WS1 sites.

Section 12 (Long-term business models): defines a set of business models that may become viable in the future and provides an assessment of these against the findings from the dynamic modelling.

Section 13 (Insights for future markets): uses the learning from sections 10, 11 and 12 to provide insights for different stakeholders (LAs developing renewable generation, DNO, ESO and policy makers).

Annex 18.1 (ANM and LEMS): describes a concept design with the potential for local electricity markets (LEM) and advanced network management (ANM) by Distribution Network Operators (DNOs) to provide additional sources of revenue for local energy projects.

Additional reports, tools and guidance are listed in Section 15. This material is referenced throughout this report and should be referred to for more detail as required.

4 INTRODUCTION

4. INTRODUCTION

Before describing the detailed activities and the results of WS2 (including the support provided to WS1 and the associated learning) it is important to set the context of the project; by summarising the LA goals, the sites being developed, the physical system, the markets and regulatory landscape, and the challenges of using grant funding.

4.1. The GMCA and districts' goals

Greater Manchester Combined Authority declared a climate emergency in 2019 and launched the 5-year environment plan, which sets out their long-term environmental vision to be carbon neutral by 2038 and the urgent actions that need to be taken in the next 5 years to help achieve this. The Unlocking Clean Energy in Greater Manchester (UCEGM) was conceived as part of this strategy. UCEGM is a European Regional Development Fund (ERDF) funded project comprised of two workstreams:

WS1: delivery of 10MW of local renewable generation owned by local authorities, in conjunction with the partner districts. (This aligns with the Greater Manchester 5-year plan target for 45MW[6])

WS2: improving the business case for local renewable generation projects, for local authorities.

The selected project sites included the following archetypes: roof mounted solar, ground mounted solar and solar carports. There were also certain criteria for projects due to characteristics and priorities of the local area:

- Focus on increasing local generation (and keeping emission reductions in the local area too)
- Because of being local and in built-up areas the capacity (size) of projects tended to be less than 5MWp (rural), but typically less than 0.5MWp (urban).

Alternative strategies for de-carbonisation (e.g. larger scale generation, acquiring developed assets, standalone battery storage, or low carbon heating) are not in scope for the UCEGM project.

Recent events (e.g. COVID and the current energy price crisis) have put considerable strain on local authorities, potentially leaving them with less capital and less borrowing capacity. This also puts more emphasis on the cost of projects and their financial viability.

[6] https://www.greatermanchester-ca.gov.uk/media/1975/5_year_plan_exec_summ_digital.pdf

4.2. GMCA and UCEGM partners

GMCA comprises of 10 districts as shown below. The following districts are part of the UCEGM project:

- ✳ Manchester
- ✳ Rochdale
- ✳ Salford
- ✳ Stockport
- ✳ Wigan

Figure 4-1: GMCA districts

The workstream 1 projects under UCEGM include the following sites (note the sizes are rounded up):

District	Project	Capacity (kWp)	Project Type
MCC	Velodrome (South car park)	196	Solar Carport
RBC	Chamber House Farm	5,500	Ground Solar
RBC	Belfield Community School	42.1	Roof mounted
SMBC	Stockport Sports Village	50	Roof mounted
SCC	Kenyon Way / Little Hulton	2,056.8	Ground solar
SCC	Turnpike	469.5	Solar Carport
SCC	Swinton Hall Road	176.3	Solar Carport
SMBC	Endeavour House	231.8	Roof mounted
SMBC	Grand Central	325.6	Roof mounted
SMBC	Stockport Exchange	80	Solar Carport
SMBC	Banks Lane Junior School	49.2	Roof mounted
SMBC	Westmorland Primary School	29.9	Roof mounted
SMBC	Ladybridge Primary	49.7	Roof mounted
SMBC	Bramhall High School	250.2	Roof mounted
Wigan	Robin Park Leisure Centre	280	Roof mounted
TOTAL		**9,787.1**	

4.3. The physical system

GMCA comprises of districts with high building densities (e.g. Manchester) and others with more rural land (e.g. Rochdale). The available space influences which types of renewable generation project may be viable and may favour smaller schemes.

The electricity demands of the buildings supplied by the energy supply contracts for each district vary considerably. For example in 2022 the Manchester total annual demand was around 7 to 8 times the demand of Rochdale. The districts' electricity demands for buildings are made up of many individual buildings including the following types:

- Leisure centres
- Schools
- Administrative buildings
- Residential homes
- Crematoriums
- Depots

It was uncommon for there to be a single council owned building with sufficiently high demand and/or available space nearby to merit a private wire (a dedicated non-network cable between the generator and the offtaker). There may be options to supply third party owned sites via private wire, but the grant funding rules prohibited this.

All the GMCA districts have a local area energy plan (LAEP)[7] that considers the current physical system and identifies options to de-carbonize the local area. It is important that the decisions to invest in local renewable generation are made cognisant of the other changes being made in the region (e.g. additional generation, network reinforcement, electrification of transport and heating).

4.4. The energy markets, policy, and regulation

The UCEGM project has coincided with a period of extreme market volatility, both in terms of energy prices and the costs of building the projects. Energy price volatility and changing CAPEX was factored into the commercial modelling (see Section 7.3.) The procurement challenges for projects under these conditions are discussed in Section 8.

Under current arrangements, small generators who do not at any time provide more electrical power from any one generating station than 10MW (or 50MW in the case of a generating station with a declared net capacity of less than 100 megawatts) can be classed as licence exempt[8]. The exemptions regime was initially introduced to give small scale electricity operators (generators, suppliers, distributors) the opportunity to avoid the costs and obligations associated with holding an electricity licence. It should be noted the exemptions regime is now under review[9], this is discussed in Section 10.

[7] https://gmgreencity.com/projects-and-campaigns/local-energy-market/
[8] The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001. https://www.legislation.gov.uk/uksi/2001/3270/schedule/2/paragraph/1/made
[9] https://www.gov.uk/government/consultations/exemptions-from-the-requirement-for-an-electricity-licence-call-for-evidence

4.5. Grant funding dependency

It is generally understood that smaller scale solar generation projects, particularly ground mounted, have struggled to be financially viable without some form of grant funding. This may in part be due to economies of scale since there are some costs that do not scale with project size.

Although grant funding is desirable from, a financial perspective, there are several reasons, why alternatives are desirable:

- Grant funding typically comes with additional rules for eligibility (e.g. not for profit) which can constrain the business models.
- Grant funding may need to be spent within timescales that allow procurement processes to be followed optimally.
- Grant funding availability will not typically coincide with when a local authority is ready to develop a scheme.
- Grant funding may encourage inherently risky enterprises (by lowering upfront costs, but not addressing skills gaps in managing long term assets).

5. PROJECT ACTIVITIES AND SUMMARY OUTCOMES

The previous section illustrated some of the motivations and challenges of delivering smaller scale, local renewable generation projects. To address these challenges and improve business cases the Catapult took a systems approach by considering the end-to-end aspects of developing the renewable generation assets and worked across the disciplines (e.g. finance, project delivery, procurement of energy and assets). Throughout the work the aim was to up-skill the districts and to share findings with other local authorities.

The project has provided tailored support to the UCEGM partner districts, from which lessons have been learnt and incorporated into this report.

Procur3d, Local Partnerships and Cornwall Insight have contributed to the delivery of this programme of work.

5.1.1. Addressing the current market challenges

The challenges: As previously explained it is desirable to negate the need for grant funding for smaller local renewable generation projects.

Developing energy assets is complex and creates risks that need to be understood and managed. This would benefit from additional capabilities that local authorities need to acquire or develop in-house. The markets these smaller generators could participate in as historically been restricted to either providing the investor with self-consumption, or to provide intermittent services to the local Distribution Network if enough excess generation is installed.

UCEGM activities & outcomes:

Innovative near-term business models have been developed (Section 6) that improve the value relative to those considered in initial feasibility studies; these are being enacted by the partner districts. They are described in detail to enable districts to judge the viability (commercial), feasibility (how hard to enact) and desirability (value). The commercial modelling (see Section 7) (of the business models) has assured potential viability of projects, with the current grant funding (circa 46%) and the sensitivity analyses show that some may be viable with some grant reductions (i.e. can achieve an acceptable IRR and payback within the life of the asset). This is complicated by current high electricity prices and rapid inflation of capital costs, which make it hard to provide a definitive answer. These conclusions are based on the current energy market paradigm; future potential changes to the energy markets and energy system could affect the viability; these are discussed below (Section 5.1.2).

Procurement practices (for assets and energy supply) were explored to reduce costs and improve feasibility (Section 8).

Procurement lessons have been learnt and proposed improvements have been developed for consideration on future projects. We would recommend further work in this area.

Alternative finance options were explored for financing projects (Section 9).

Alternative means of finance have been identified and evaluated. Generally the districts have sought finance through the Public Works Loan Board.

Provision of tailored support to the districts covering procurement of energy supply and PPAs, procurement of physical systems and commercial modelling.

The tailored support has been invaluable for learning lessons that have been incorporated into the project deliverables for the benefit of the partner districts and other local authorities.

5.1.2. Addressing the future market challenges

The challenges: investing in energy assets that have an expected economic life of at least 20 years, and will be dependent on future energy prices, markets and policy which create additional risks and opportunities that need to be understood and managed.

UCEGM activities & outcomes:

Future market scenarios applicable to GMCA were defined to understand the risks and opportunities (Section 10).

This work has informed the dynamic modelling described below. ESC has also identified a potential opportunity to integrate Active Network Management zones (ANMs) in a Local Energy Market (LEM).

Dynamic modelling of the GMCA area's electrical system under future market scenarios has been undertaken (Section 11).

This innovative approach has provided insights as to how dynamic electricity prices and constraints may develop under different plausible scenarios, which in turn reveals risks and opportunities for local authorities considering investing in renewable energy schemes. Under all the scenarios the modelling suggests that energy prices will fall reducing generation revenues, but also reducing energy costs for sites. Some locations may experience high demand (e.g. concentration of EV charging) or network physical constraints, which may provide specific risks and opportunities for generation and battery storage. Further work should be done in to develop actionable recommendations to mitigate risks and realise opportunities.

Long-term business models were examined to consider how value might be improved under future scenarios using the information from the dynamic modelling (Section 12).

Findings from the dynamic modelling suggest that local assets, in the modelled location (GMCA), especially battery storage, could help relieve network constraints (depending on their size and cause). This could be an enabler for the long-term business models, which are focused on maximising value from local renewable generation. Results from the dynamic modelling also exhibited low or negative electricity prices under certain market scenarios. This meant that revenue opportunities (from selling renewable electricity) were reduced but cost-savings opportunities (from lower cost grid imported electricity) were greater. The desirability of the long-term business models could therefore change depending on the role that the local authority assumes (generator, offtaker or generator and offtaker). Further work could use the dynamic modelling results to explore the commercial viability of the long-term business models (like the commercial modelling performed for some of the short-term business models – see Section 7).

6 DETAILED DESIGN OF SHORT-TERM BUSINESS MODELS

6.1. The Need

During Phase 1 of the UCEGM project, the Catapult explored a range of innovative business models for local authorities aiming to deploy renewable generation assets.

An evaluation was performed on each business model using the following criteria: Revenue and Cost Savings, Other (Non-Financial) Benefits, Scalability and Project Delivery (see Figure 6-1). The results from the evaluation exercise led to the development of a business model short list containing solutions that could either be delivered in the 'short' or 'long' term.

The 'short-term' category refers to business models that are already possible in current markets and where there is evidence of local authorities adopting these approaches. In comparison, the 'long-term' category encompasses emerging concepts that have the potential to generate more value (both financial and non-financial) but exhibit a greater amount of complexity and uncertainty (see Section 12).

The following short-term business models were identified:

1. **Sleeved Power Purchasing Agreement (PPA)**

Relevant Archetype: Ground Mounted Solar

In a sleeved PPA, electricity generated from a solar asset is 'sleeved' to other sites despite not being physically connected. The 'sleeving' is facilitated by an energy supplier for a fee (referred to as a 'sleeving fee').

2. **Private Wire**

Relevant Archetype: Ground Mounted Solar

In a private wire arrangement, electricity generated from a solar asset is connected directly to the source of off take (energy demand). Under current market conditions, electricity supplied through private wire connections can avoid certain policy and network costs.

3. **Storage and Site Optimisation**

Relevant Archetype: Roof Mounted Solar (with battery storage)

In this model, battery storage technology is integrated with solar to maximise the consumption of renewable energy. The battery may also be used to access additional revenue streams (discussed further in Section 6.3.1.3).

4. **Solar and Storage Licensing Agreement**

Relevant Archetype: Roof Mounted Solar (with battery storage)

In this model, solar and battery storage assets are installed under a 'licensing arrangement' in which the assets are owned, operated, and maintained by a third party. Renewable electricity consumed on-site is covered by a PPA. The PPA provides the offtaker (energy consumer) with a reduction in their energy bills for no upfront capital cost. This allows CAPEX costs to be recovered by the third party over the lifetime of the agreement (c.25-30+ years).

Revenue and Cost Savings
- Savings on energy bills
- Increased value of energy sold
- Revenue from flexibility services
- Other energy services

Scalability
- Geographical restrictions
- Economies of scale
- Regulation

Other Benefits
- Accelerating the delivery of Net-Zero
- Increased system resilience
- Green skills and jobs
- Equity and community
- Health and well-being

Project Delivery
- Contractual arrangements
- Model maturity
- Complexity of installation
- Resources required
- Policy and regulation

Figure 6-1. Criteria to evaluate business models in UCEGM Phase 1 work.

5. Solar Carport

Relevant Archetype: Solar Carport

Solar carports can be constructed above parking bays to provide energy to a nearby site. A more complex arrangement would involve integrating battery storage and EV charge points with the solar to provide additional EV charging services.

The research conducted in Phase 1 provided an overview of the key benefits (financial and non-financial), risks and considerations for each business model. However, there was a need to understand the following aspects of each business model in greater detail:

- What are the financial benefits?
- What factors influence commercial viability?
- How can the business model be delivered/ implemented?
- What are the key stages of project delivery?
- Who are the key stakeholders involved?
- What contractual/commercial arrangements may be required?
- What are the current market opportunities?
- How may the value of the business model change under different roles a local authority assumes?

6.2. Detailed Design of Short-Term Business Models

To address these questions, the Catapult performed a detailed analysis of each short-term business model. The analysis centred around three pillars of business model design: viability, feasibility, and desirability.

Figure 3-2 provides an overview of the activities undertaken to assess each pillar. Key findings to emerge from the activities are summarised throughout the remainder of this section.

VIABILITY

- Identifying revenue generation streams.
- Identifying cost saving opportunities.
- Investigating factors that may influence commercial viability.
- Illustrating commercial benefits of business models using example projects.

FEASIBILITY

- Identifying key activities and outputs for stages of project delivery.
- Exploring market opportunities through external validation with industry experts.
- Identifying lessons learned through engagement with local authorities.

DESIRABILITY

- Exploring the value of different roles that local authorities may assume in business models.

Figure 6-2. Activities undertaken to investigate three pillars of business model design.

6.3. Viability

Recognising that the viability of each business model will differ on a project per project basis, metrics such as payback time, internal rate of return (IRR) and net-present value (NPV) are not discussed throughout this subsection. Instead, this subsection provides an overview of key considerations for each business model that could influence commercial viability.

Please refer to the 'Detailed Design of Short-Term Renewable Generation Business Models' deliverable for a more detailed discussion on the viability of the short-term business models.

6.3.1. Business Model Viability

6.3.1.1. Sleeved PPA

The sale of renewable energy to an offtaker is the primary revenue stream for the generator (asset owner) in a sleeved PPA. If the amount of generation from the renewable asset is greater than the energy demand of the offtaker, additional revenue may be generated from exporting surplus power to the grid. This will require an additional commercial arrangement.

In sleeved PPAs, the power price is (typically) set to ensure that the offtaker pays less than the wholesale price of electricity. The offtaker is also responsible for paying sleeving fees, third-party charges, and other supplier fees for the sleeved electricity. Overall, the offtaker should see a reduction in their energy bills however the amount of cost-savings achievable will depend on the total cost of these charges.

6.3.1.2. Private Wire

The private wire business model differs to the sleeved PPA as the solar generation asset is directly connected to the source of demand (off take). Resultantly, certain policy and network costs are avoided (under current regulations). The benefits of these cost avoidances are shared between the generator and offtaker. The way in which these benefits are shared will need to be discussed by the generator and offtaker during contract negotiations.

Typically, the price paid for electricity in a private wire arrangement is set so that a) the generator receives higher value than the wholesale price of electricity (on a p/kWh basis) and b) the offtaker pays for electricity at a rate lower than the retail price (see Figure 6-3).

The commercial viability of the private wire business model depends on the avoidance of policy and network costs meaning that the business model is exposed to policy and regulatory risk. There are currently several initiatives/ consultations that could influence the amount of cost avoidance that is achievable (see 'Detailed Design of Short-Term Renewable Generation Business Models' deliverable.

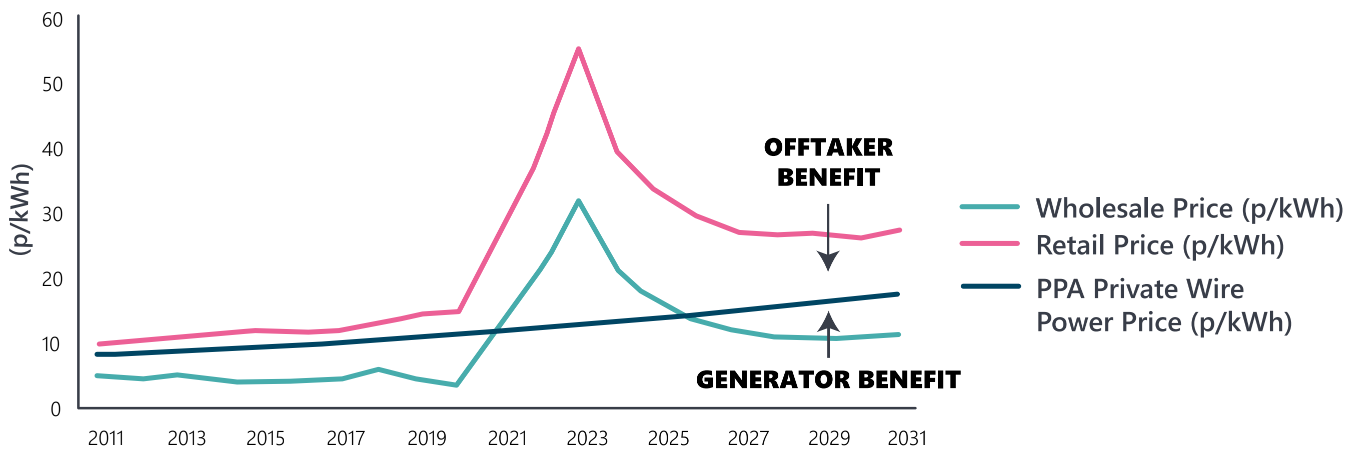

Figure 6-3. Illustration of generator and offtaker benefit in private wire business model

Although it is not yet known how these initiatives (and their possible outcomes) may influence the commercial viability of private wire projects, it is important for local authorities to stay up to date with policy changes and reflect these in any commercial assessments. Please refer to Section 10.1 for further discussion on potential areas of regulatory change.

6.3.1.3. Storage and Site Optimisation

There are likely to be times when the amount of solar energy generated from an asset is greater than site demand. With battery storage (some or all) of the surplus power can be stored and used to generate additional revenue and/or cost savings. Some of these opportunities are described below:

1. **Maximising Self Consumption:** Storing surplus energy in batteries and discharging to satisfy site demand when solar energy is not available.
2. **Arbitrage:** Using battery storage to exploit different prices for electricity during peak and off-peak periods (i.e., charging at low prices and discharging at high prices). To benefit from arbitrage, a time of use tariff or separate export arrangement may be required.
3. **Flexibility (Grid) Services:** Accessing flexibility markets available through the Electricity System Operator (ESO) or Distribution Network Operator (DNO).

If the battery is used to provide flexibility services, it is important for local authorities to understand what markets are accessible. Markets have different eligibility criteria relating to battery size, discharge rate and other factors.

Third parties such as aggregators and battery storage optimisers can offer services in this area and can also trade energy on a local authority's behalf. This may be required for smaller scale batteries as such organisations can pool flexibility from numerous assets and allow collective participation.

There are different pricing models that may be offered by third parties; each with their own benefits, level of risk, and influence on commercial viability. For example, a fixed price (p/kWh) contract may be offered. This would provide price certainty throughout the duration of the contract. However, to account for market risk, the third party may offer a more conservative export price.

6.3.1.4. Solar and Storage Licensing Agreement

This business model differs from Storage and Site Optimisation in two distinct ways. First, a third-party invests the necessary capital to deploy solar and storage technologies on behalf of the local authority. In turn, this changes how revenue is obtained by the generator.

To recover the initial capital investment, the third-party charges the offtaker (local authority) for any solar energy they consume through a PPA. Like the former model, additional revenue may be generated from flexibility services and exported energy. The price that the offtaker pays for power through the PPA is (typically) less than the retail price of electricity. Accordingly, the offtaker sees a reduction in their energy bills.

Second, solar and storage technologies are deployed at scale. This means that the benefits from numerous sites can be aggregated. Adopting a portfolio approach can provide an option to include less-desirable sites, in a wider portfolio, where the business case for storage may not stack up on its own.

During external validation, the Catapult spoke to an organisation that had expertise deploying solar and storage technologies at scale. Key considerations relating to viability to emerge from this discussion are summarised below in Table 6-1.

Implementation Cost
• As well as the capital costs of solar and storage technologies, there are additional costs associated with establishing virtual power plants and participating in flexibility markets.   • These costs are factored into the PPA price offered to offtakers.
Viability of Battery Storage
• For some sites, it is not possible to make a viable business case for battery storage. • For example, in some cases, the PPA price may end up costing more than retail the retail price of electricity. • This may mean that many (tens or hundreds) of assets are required to make an attractive proposition. • This can make the projects inherently more complex to deliver (discussed further in Section 6.4.2.4)

Table 6-1. Solar and Storage Licensing Agreement: Commercial Considerations from External Validation.

6.3.1.5. Solar Carport

Multi-functional solar carport arrangements (i.e., those with integrated solar, battery storage and EV charge points) present numerous opportunities for revenue generation and cost-saving opportunities depending on how energy is used in the system. These opportunities may change over time if and as demand for EV charging increases. Apart from revenue generation from EV charging services, alternative revenue and cost-saving opportunities for solar carports have already been discussed in relation to other short-term business models. For this reason, they are comprehensively listed below.

Potential Revenue Streams

- ✳ If solar energy is consumed by a nearby site (via private wire connection), revenue may be generated through a private wire agreement.
- ✳ Battery storage may be used to generate revenue from flexibility services or arbitrage.
- ✳ If EV charge points are available for public use, revenue may be generated from EV charging services – this may be facilitated by a charge point operator (CPO) (discussed further in Section 6.4.2.5).
- ✳ Additional revenue may be generated by exporting surplus solar energy to the grid – this will require an additional commercial arrangement.

Potential Cost Saving Opportunities

- ✳ If solar energy is consumed by a nearby site (via private wire connection), the building occupant should see a reduction in their energy bills through a private wire agreement with the generator.
- ✳ Cost-savings may be increased further by consuming additional solar energy stored in batteries.
- ✳ A reduction in operational spending for the local authority may be obtained if solar energy is used to charge local authority owned EV vehicles (fleets).

To assess the commercial viability of the solar carport model, sophisticated optimisation modelling will be required due to the number of integrated assets within the system, the different ways in which they may be utilised, and the numerous commercial opportunities available. Please refer to the 'Detailed Design of Short-Term Renewable Generation Business Models' for an overview of key factors that should be considered in technical and commercial assessments of solar carport projects.

6.3.2 Factors that Influence Viability

Matching Generation and Demand

One of the most important factors to consider in commercial assessments is how well solar generation and energy demand are matched. **Although often done in high-level calculations, it is not always correct to assume that 100% of power generated by**

a solar asset will be used to satisfy existing demand (see Section 7.3.3 for further detail).

At times, it is likely that generation will exceed demand meaning that surplus solar power may need to be exported to the grid (unless there are other assets that can consume this energy). The value of solar export is likely to be less than that of primary revenue streams or cost-saving opportunities. Therefore, the percentage of solar power that can satisfy demand vs. the percentage of surplus solar power should be included in commercial assessments as this can heavily influence viability.

System Optimisation and Prioritisation

For renewable generation projects that comprise several technologies, there are different ways that revenue generation and/ or cost-savings may be achieved (see Figure

It is therefore important to consider the most optimal way to use the energy available. The way in which a system is optimised may depend on the underlying objectives behind the project such as:

- Maximising revenue generation opportunities to invest in future projects.
- Maximising cost savings to reduce spending on energy bills.
- Minimising carbon intensity of site(s) to reduce local authority carbon emissions.

The underlying assumptions about how solar energy will be used throughout the lifetime of the project (and the associated revenue/ cost-saving opportunities) should be reflected in the commercial assessment of projects.

This will require energy demand profiles for sites/ wider portfolios, price forecast data and sophisticated optimisation modelling (which may be outsourced to third party providers). An example of this is discussed in Section 11 – Dynamic Modelling/ Simulation of Future State.

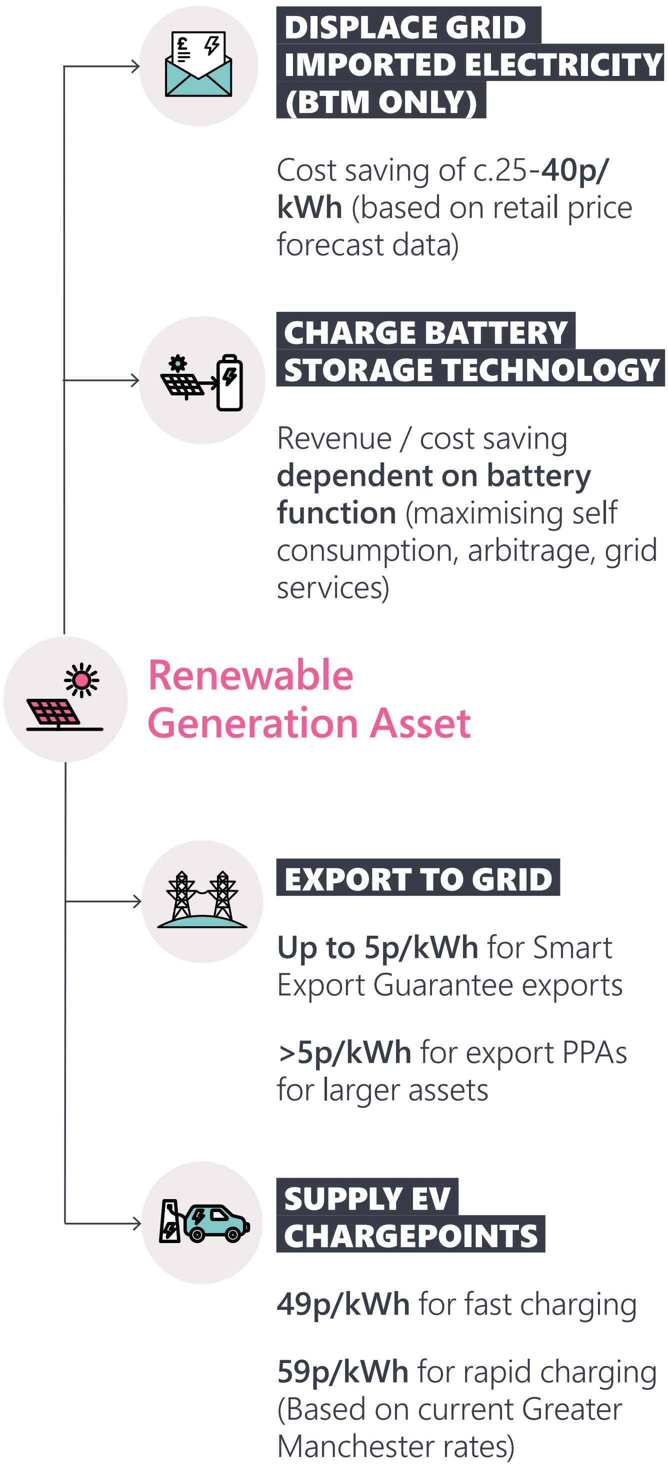

Figure 6-4. Overview of potential revenue / cost-savings for solar energy.

6. DETAILED DESIGN OF SHORT-TERM BUSINESS MODELS

Pricing Structures of Commercial Arrangements

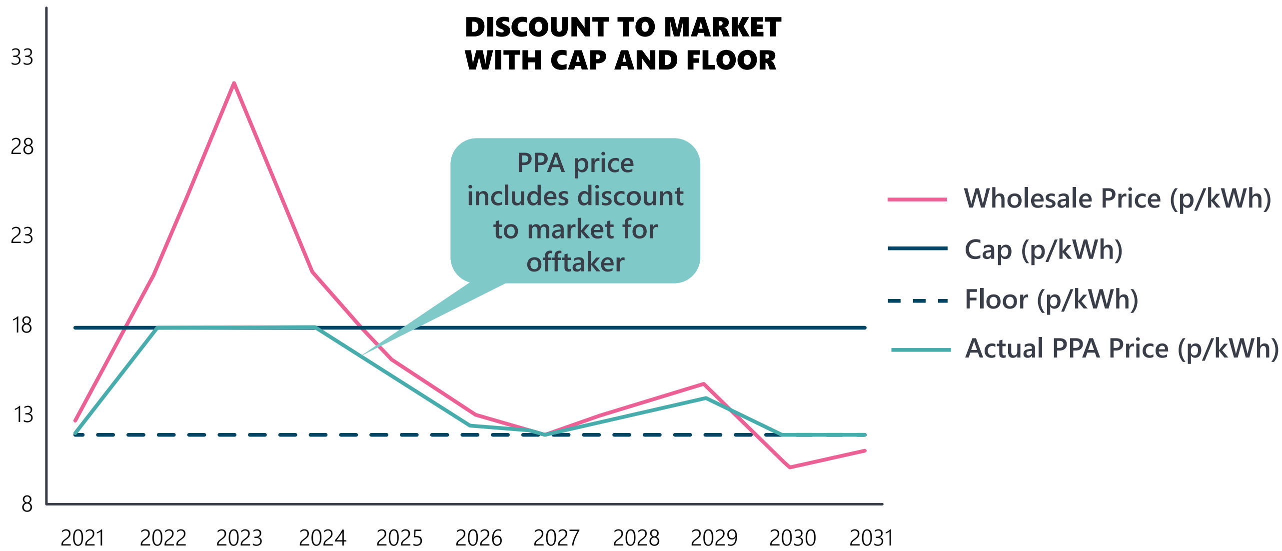

Figure 6-5. Example of fixed pricing structure with inflation.

Another factor that can influence viability is the type of pricing structure adopted. The most suitable pricing structure for a local authority will depend on the value they place on maximising revenue generation/ cost savings as well as their attitude towards risk (discussed further in Section 6.5: Desirability).

The 'fixed' pricing structure is one of the easiest to implement. In this arrangement, the generator and offtaker set a fixed price for power across the lifetime of the commercial agreement. There are variations to the fixed structure such as 'fixed price with escalation' and 'fixed price with inflation'. These may be preferred if the generator is looking for prices that accommodate potential changes to market conditions.

The fixed pricing structure provides revenue visibility for the generator and cost visibility for the offtaker. However, changes to wholesale market prices could make the PPA look less attractive overtime (to both Parties).

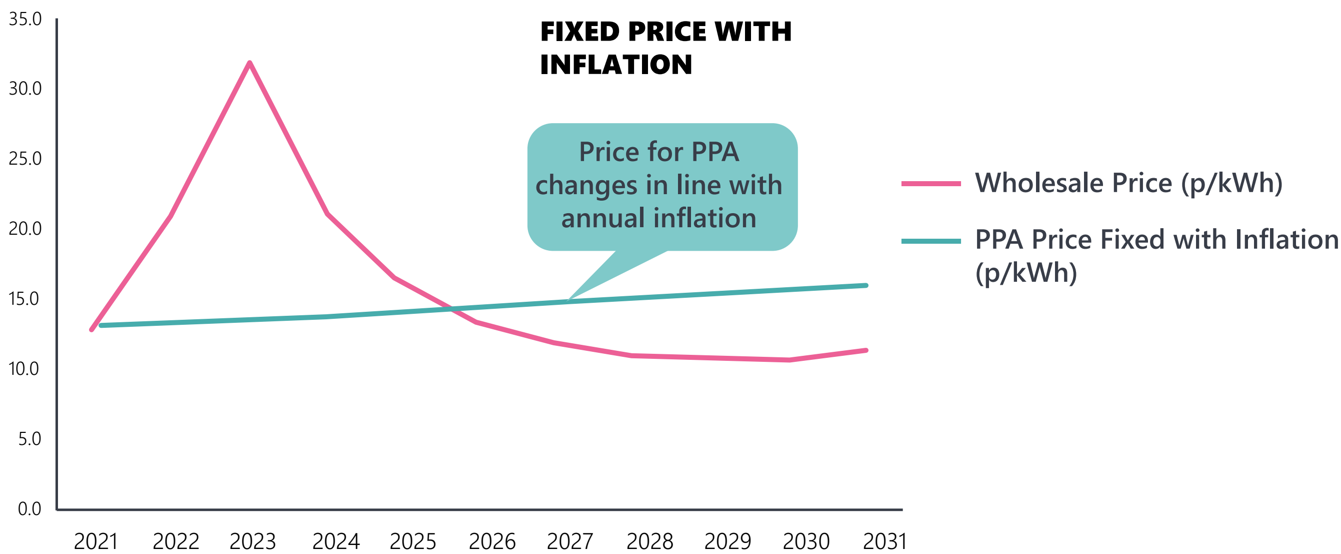

Figure 6-6. Example of cap and floor pricing structure with discount to market

Accordingly, local authorities may wish to explore alternative pricing structures that are more reflective of wholesale market prices such as the 'discount to market structure'; illustrated below in. For further detail on this pricing structure, please refer to the 'Detailed Design of Short-Term Renewable Generation Business Models' deliverable.

Depending on the length of commercial agreements, local authorities may have the opportunity to change pricing structures throughout the lifetime of renewable generation projects.

6.3.3. Key Points

Key points concerning viability are summarised below.

1. **Understanding Commercial Arrangements**

For each business model, contractual agreements will be required which detail commercial arrangements for the sale of energy (whether that be for offtake or export). There are numerous pricing structures and/or pricing models that are possible. Each of these can influence the viability of potential projects differently. Any assumptions around commercial arrangements should be reflected in commercial assessments.

2. **Understanding How Energy Will be Used.**

It is important to understand how (and when) energy will be used in renewable generation systems as this will dictate the revenue and cost-saving opportunities available.

This will require asset performance and/or generation data, energy demand data (both present and future), price forecast data and sophisticated modelling for more complex systems (i.e., those with integrated battery storage technologies and/ or EV charge points).

3. **Continuously Updating Commercial Models**

Commercial models should be continuously updated to reflect any changes to policy or regulation, market conditions and/or contractual arrangements as all these factors have the potential to impact the commercial viability of renewable generation projects.

6.4 Feasibility

Feasibility is a crucial component of business model design as it outlines what is required for the delivery/ implementation of business models (i.e., infrastructure, activity, resource, and partner requirements).

To assess feasibility, the Catapult first explored the stages of project delivery for renewable generation projects (agnostic to specific business models). The aim of this exercise was to understand what activities and outputs were intrinsic to each phase of project delivery.

The Catapult then undertook an external engagement exercise to identify feasibility considerations specific to each short-term business model. The findings from both exercises are summarised throughout the remainder of this section.

For a more detailed discussion on feasibility, please refer to Section 6 of the 'Detailed Design of Short-Term Renewable Generation Business Models' deliverable.

6.4.1. Stages of Project Delivery

Broadly, the delivery of solar based renewable generation projects can be summarised in six stages (see Figure 6-7). This subsection provides an overview of each stage as well as applicable lessons learned and findings from external validation.

Please refer to Section 8 of this document for further information relating to Stages 4 and 5 (Construction & Commissioning and Operations & Maintenance).

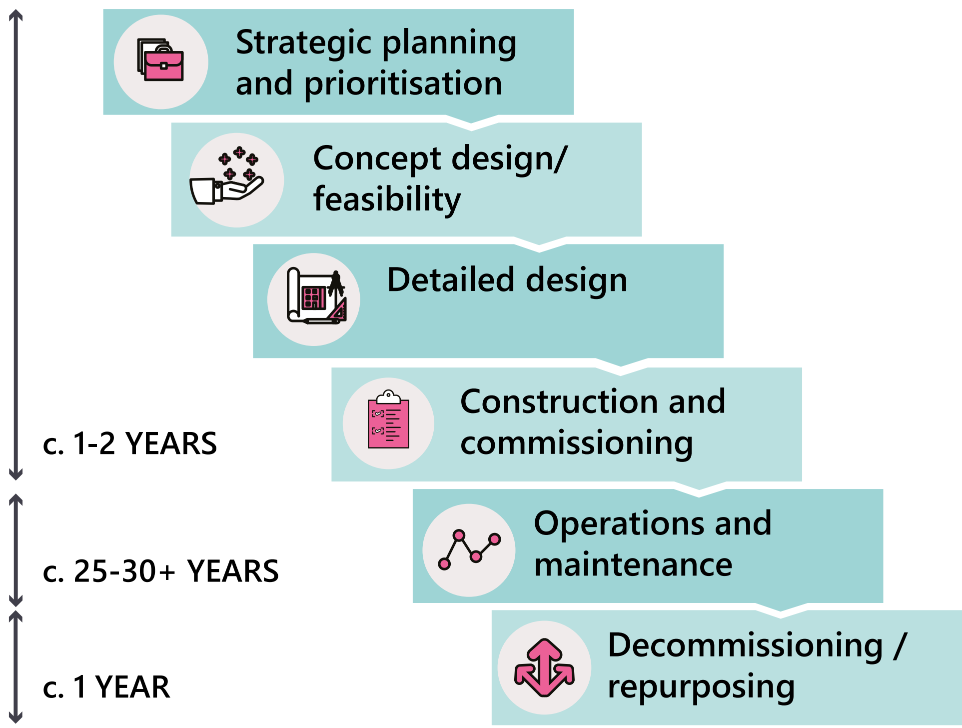

Figure 6-7. Stages of project delivery for renewable generation projects.

6. DETAILED DESIGN OF SHORT-TERM BUSINESS MODELS

1. Strategic Planning and Prioritisation

Strategic plans (policies) are designed by local authorities to address local priorities (i.e., climate change and decarbonisation). They provide direction for 'where things are going' and can assist in the allocation of funds and resources across the authority. Objectives outlined in strategic plans will inform the type of project/ low-carbon technology which a local authority chooses to prioritise during option appraisals.

In this stage, **it is also important that the correct project team is assembled.** Decarbonisation projects have the potential to span across different directorates and different departments within a local authority. Departments that were identified as being involved in the delivery of renewable generation projects during external engagement included the following: legal, estates, energy, transport, finance, regeneration, highways, and parking.

EXTERNAL ENGAGEMENT FINDING

During external validation, several industry experts explained that they had faced difficulties progressing low-carbon projects with local authorities. Often, this was because of challenges such as getting buy-in from key decision makers as well as conflicting objectives across different departments (i.e., financial gain vs. decarbonisation potential).

This stresses the importance of assembling a cross-departmental team, with aligned objectives, that works collaboratively to deliver decarbonisation projects.

LESSON LEARNED

During engagement with district partners, The Catapult learned that some local authorities were considering electrifying their fleets. In the absence of an electrification strategy, the number of and type of vehicles to be electrified was unknown. However, this information is key to determining an optimal solar carport system and subscequent commercial assessments.

2. Feasibility

The feasibility stage will likely influence which business model is most suitable for a renewable generation project. Activities intrinsic to this stage include the following[10]:

Site(s) Selection – This activity is often performed internally by local authorities but can be outsourced to external consultancies. There are numerous factors that influence the suitability of sites including shading, sloping, and proximity to infrastructure. Where applicable, specific site selection considerations are discussed in Section 6.4.2.

Asset Sizing – To size renewable generation assets, an understanding of the following is required: existing and future energy demand, percentage of self-consumption (if applicable), technological performance of chosen renewable technology(ies) and grid connection capacity.

Soft-Market Testing – It is recommended that local authorities engage with necessary stakeholders (i.e., energy suppliers, energy service providers and the DNO) as early as possible to understand what products, services and /or solutions are available.

[10] Please note that there is likely to be iteration between these activities.

Business Model Considerations – The outcomes from previous activities will likely inform which business model is most appropriate for a particular project.

For example, if looking to deploy ground mounted solar PV, both the Sleeved PPA and Private Wire business models could be potential options. However, if during site selection, a suitable site is identified which can consume a large percentage of the solar energy, the Private Wire model could be better suited.

Business model assumptions should be incorporated in subsequent commercial assessments.

Commercial Assessments/ Modelling – For a detailed overview of this activity please refer to Section 6.3 and Section 7 of this report.

Environmental and Regulatory Considerations – It is important to understand whether planning permission will be required for the renewable generation project. Some roof mounted PV installations may fall under permitted development. However, all ground mounted systems larger than 9m2 (approximately 4-5 large solar panels) will require planning permission (The Renewable Energy Hub UK, 2021a).

The primary output of this stage is a feasibility study which determines whether a project should be progressed.

LESSON LEARNED

The amount of self-consumption of solar energy calculated in WS1 feasibility studies was often greater than calculations that were performed after half-hourly meter data had been obtained (see Section 7 Technical and Commercial Modelling). This meant that commercial assessments had to be rerun for numerous sites to understand how much this impacted viability.

Feasibility studies should be as accurate as possible to avoid unnecessary costs (due to potential resizing requirements) and unnecessary delays during project delivery.

To improve accuracy, it is important for local authorities to provide half-hourly meter data where possible and to ensure that any future potential changes to energy demand are factored into initial designs.

3. Detailed Design

Once the feasibility stage is completed and a decision has been made to continue with the project, it progresses to the detailed design stage. This builds on the former as bespoke solutions are designed based on the site's specific physical and technical characteristics.

Other activities intrinsic to this phase include obtaining a grid connection agreement and planning permission (if required).

The outcomes from these activities will determine whether a final investment decision (FID) is reached. If so, a local authority may then go out to tender for construction, commissioning, and O&M works. Please note that the roles and responsibilities of a local authority at this stage will differ dependent on the delivery approach adopted (see Section 8.3 for further detail).

4. Construction and Commissioning

The construction and commissioning stage involves the physical execution of the project. Figure 6-8 outlines key activities associated with this stage (for solar assets only). For further guidance on the tendering and procurement process please refer to Section 8 of this report.

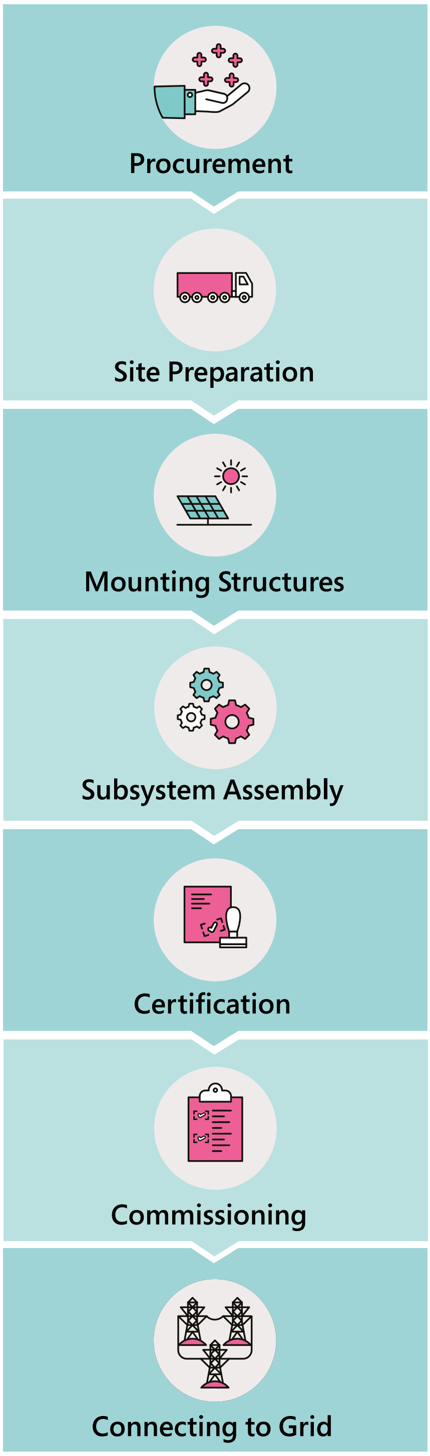

Figure 6-8. Overview of construction and commissioning process for solar assets

5. Operations and Maintenance (O&M)

The O&M stage ensures that assets are functioning properly throughout their usable lifetime. Operation related activities include energy monitoring, system performance testing, data analytics and commercial management. Some local authorities may consider taking on an asset management role once a project becomes operational.

Maintenance services can be categorised into the following: corrective, preventative and condition based.

EXTERNAL ENGAGEMENT FINDING

During external validation, ESC learned that local authorities may not receive final quotations from energy suppliers or other service providers (i.e., for PPA prices, export prices, etc.) until they have a commercial operations date (COD) for their asset(s) and have also obtained planning permission.

It is therefore recommended that sensitivity analyses on revenue streams (as well as costs) are factored into commercial assessments to determine whether a project is still viable if certain inputs were to change.

6. Decommissioning and Repurposing

The decommissioning stage takes roughly 6-12 months depending on the size of the renewable generation asset(s). Figure 6-9 provides an overview of the key stages of solar farm decommissioning.

Please note that this is applicable to ground mounted solar assets and that the decommissioning process will likely differ for other forms of solar PV (i.e., roof-mounted) as well as other renewable generation assets.

6.4.2. Business Model Considerations

The Catapult identified specific feasibility for each short-term business model through desk-based research and external engagement. These considerations could significantly influence the suitability of a business model to a local authority and should therefore be considered in parallel with viability.

Feasibility considerations across a range of themes are discussed for each business model throughout this subsection. For a more detailed discussion, please refer to the 'Detailed Design of Short-Term Renewable Generation Business Models' deliverable.

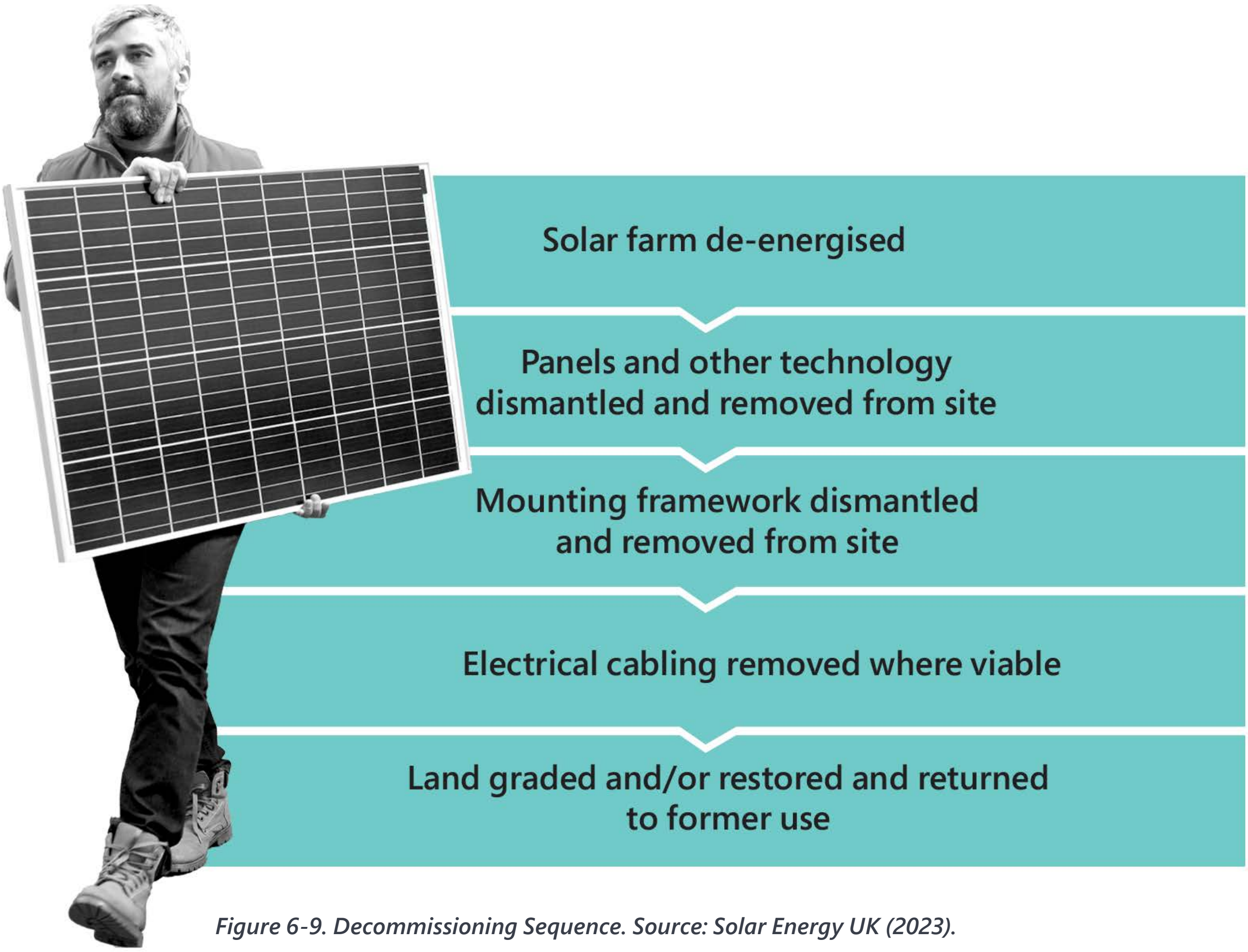

Figure 6-9. Decommissioning Sequence. Source: Solar Energy UK (2023).

6.4.2.1. Sleeved PPA

Title	Considerations for Feasibility
Site Selection	✳ In a sleeved PPA, the solar asset is not physically connected to the point of energy offtake (the site). This means that there is some flexibility when identifying an optimal generation site. ✳ If a local authority is constrained by land availability, they may wish to investigate the suitability of sites outside of the area to enact the sleeved PPA model.
Energy Supply	✳ **It can take between 6-18 months for a sleeved PPA agreement to reach fruition - this timeline should be considered alongside other project milestones.** ✳ Where possible, the PPA start date should align with the energisation date of the asset; especially if commercial modelling is based on this assumption. ✳ The implementation of PPAs may also need to align with the renewal of energy supply contracts. For example, some existing energy supply contracts may not permit sleeving meaning that the local authority may have to wait until their existing contract comes to an end before securing a PPA with an alternative supplier. ✳ If the length of an energy supply contract is shorter in duration than the PPA contract, provisions should be made to 'port' balancing and shaping responsibilities (typical supplier tasks associated with facilitating a sleeved PPA) to a new electricity supplier (Crown Commercial Service, 2020).
Soft-Market Testing	✳ During external engagement, the Catapult learned that PPA terminology used by energy suppliers differed considerably - both in terms of what was understood by the different types of PPA (sleeved, utility, etc.) and what was understood by certain fees (sleeving, shaping, etc.). This can make it difficult for local authorities to compare sleeving services on a like-for-like basis. ✳ **It is important to ensure that all stakeholders are aligned on terminology as assumptions around the PPA type, pricing structure and other fees will feed into subsequent commercial assessments (deliverables from this project may be used to inform conversations with energy suppliers).** ✳ To provide an estimation of sleeving fees, suppliers will likely require data including annual solar generation forecasts and half-hourly energy demand data from sites (that are to be included in the sleeving agreement). ✳ Having access to such data as early as possible can help avoid unnecessary project delays.

Title	Considerations for Feasibility

Partner Requirements	✳ To enact the Sleeved PPA model, the following contracts are likely to be required:
	  ✳ Sleeved PPA contract between the generator and offtaker that stipulates key terms (e.g., PPA price, volume and contract duration).
	  ✳ Contract between the generator and energy supplier that makes provisions for the transfer of energy and REGOs (if the generator is not retaining REGOs for themselves).
	  ✳ Contract between the energy supplier and offtaker, which makes provisions for the transfer of REGOs (if applicable) and outlines how the output of the generation facility will be credited against its electricity demand.
	✳ An additional commercial agreement between the generator and balancing responsible party (BRP) will be required for any surplus solar energy exported to grid. If the asset is under 5MWp, it may be eligible for Smart Export Guarantee.

Contractual Considerations	✳ The generator and offtaker are responsible for negotiating a suitable contract duration as well as other contractual terms.
	✳ The length of PPA contracts can range from 1-25+ years.
	✳ (With a fixed pricing structure) long-term agreements can provide revenue visibility for the generator and cost visibility for the offtaker which may inform forecasting and budgeting activities.
	✳ Long-term agreements may be preferred by local authorities who value revenue/cost certainty over maximising revenue/cost-saving potential (discussed further in Section 6.5.1.1).
	✳ Short-term agreements may be preferred where key changes to contractual terms are likely to be required.
	  ✳ For example, during periods of severe wholesale market volatility, short term PPAs could prevent Parties from being locked in at an unfavourable PPA price for extended periods.
	  ✳ There may also be changes to energy generation and/or energy demand that could require energy volume clauses to be renegotiated.

Table 6-2. Feasibility considerations specific to the Sleeved PPA Business Model

UCEGM PROJECT FINDING

During discussions with their energy supplier, one district partner was informed that a sleeved PPA agreement would only be possible if the asset's generation exceeded 50GWh per annum.

Instead, the energy supplier offered a utility PPA, linked to wholesale market electricity prices, with the option for the local authority to trade or retain REGOs.

This finding shows that sleeved PPAs are not necessarily readily offered by all energy suppliers.

UCEGM PROJECT FINDING

One project partner learned that, due to funding stipulations, only sites where the local authority was responsible for paying for electricity (i.e., not rebilling to tenants) could benefit from a sleeved PPA. This meant that some sites had to be excluded from the sleeving arrangement.

If required, it is recommended that local authorities check whether energy suppliers can offer tailored solutions like mentioned above. It is also important to determine whether there will be any additional fees associated with such a request.

This situation may not arise for solar projects that are delivered without grant funding. However, where a local authority wishes to include sites that are rebilled for energy (i.e., schools and leisure centres) in sleeving arrangements, they may instead wish to consider how the benefits (energy bill reductions) will be shared across tenants; especially where energy demands for sites may differ considerably.

6.4.2.2. Private Wire

Theme	Considerations for Feasibility
Site Selection	✳ **When identifying potential site locations for private wire schemes, the physical length of the private wire connection required is a crucial factor to consider as private wire connection costs contribute significantly to overall capital costs.** ✳ It is also important to know the energy demand sites being considered to understand how well energy generation and demand are matched (see Section 7).

Grid Connection	✳ Consideration needs to be given to where the scheme will connect to the grid (e.g., at the offtaker's site or at the generation site).
	✳ The most common arrangement is for the grid connection point to be located at the offtaker's site. This means that the offtaker can still have a separate energy supply arrangement with other suppliers (Welsh Government Energy Service, 2021).
	    ⁎ Where this is the case, the generator should consider what contingencies they need to have in place should access to the grid connection point be no longer available (e.g., the offtaker moves premises).
	✳ If the grid connection point is located at the generation station, the DNO may require this to become the offtaker's only point of electricity supply.
	    ⁎ This could result in supply risks for the offtaker (depending on how well-matched generation and demand profiles are).

Energy Supply	✳ To supply electricity to the offtaker, the generator would either need to be a licensed electricity supplier or fall under one of the exemptions in Schedule 4 of The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001. ⁎ Legal support will be required to determine whether compliance has been met. ✳ At the end of the private wire arrangement, the offtaker may not wish to renew the contract. ✳ In this case, the generator may choose to export all solar energy to grid by securing an export agreement with a balancing responsible party. ✳ This could be a complex process if the grid connection is under ownership of the offtaker. For example, the generator may be required to pay rent or usage fees to continue using the connection point.

<table>
<tr><th>Theme</th><th>Considerations for Feasibility</th></tr>
<tr><td>Partner Requirements</td><td>

To enact this model, a private wire agreement between the generator and offtaker that stipulates key terms (e.g., power price, volume and contract duration) is required.
An additional commercial agreement between the generator and a balancing responsible party (BRP) will be required for any surplus solar energy exported to grid.
If the asset is under 5MWp, it may be eligible for Smart Export Guarantee.

</td></tr>
<tr><td>Contractual Considerations</td><td>
Contract Length

Because the solar generation asset is directly connected to the source of demand, viability of the private wire business model is primarily dependent the price paid for energy by the offtaker across the lifetime of the asset.
This means that long-term contractual arrangements (15-25 years) are often required.

Energy Volume Considerations

The generator should make clear to the offtaker the anticipated volume of energy that will be supplied to the site (taking variability and asset degradation into account).
To reduce supply risk, the offtaker may wish to include a ‘minimum supply volume’ clause in the contract that outlines penalties for the generator if the asset does not perform as expected.
It is also possible that the offtaker’s energy demand profile may change over time (due to operational changes or the installation of energy efficiency technologies).
To minimise revenue risk, the generator may wish to include a ‘take or pay’ clause in the contract. This means that the offtaker would agree to a stipulated volume of energy and pay a penalty if it is not consumed at site.

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Table 6-3. Feasibility considerations specific to the Private Wire business model.

6.4.2.3. Storage and Site Optimisation

Please note that despite making efforts to reach out to numerous aggregators and battery storage optimisers, the Catapult was unsuccessful in obtaining any interviews. Therefore, the findings presented in relation to this business model are based solely on desk-based research.

Theme	Considerations for Feasibility

Partner Requirements (and Market Opportunities)	**Battery Storage Export**
	✳ 'Stacking' is often performed to maximise revenue generation from eligible markets.
	✳ A commercial agreement (optimisation contract) with an aggregator or battery storage optimiser is often required to trade energy on behalf of an asset owner as they understand the complexities of optimising energy storage assets and know which revenue streams to target to maximise returns.
	✳ Whilst there are examples of local authorities which have secured optimisation contracts, these are typically for large-scale storage assets that are either stand-alone or are co-located with solar farms.
	  ✳ For example, South Somerset District Council secured an optimisation contract with Limejump for 90MW of battery storage assets that they own across two sites (Limejump, 2022).
	  ✳ Warrington Borough Council also secured an optimisation agreement with Statkraft for their 23MWp solar and 10MW battery storage facility (Statkraft, 2022).
	✳ If unable to secure a commercial arrangement with an aggregator/ battery storage optimiser, a 'solar storage' tariff with a licensed SEG provider may be an alternative option.
	  ✳ Please note that some suppliers may only pay for electricity that is produced by on-site generation assets and do not have to pay for electricity that was originally imported from the grid and exported later (Energy Saving Trust, 2023).
	Renewable Energy Consumption On-Site
	✳ If the generator and offtaker are from different organisations, a private wire agreement will also be required for the consumption of renewable energy onsite (see Table 6-3).

<table>
<tr><th>Theme</th><th>Considerations for Feasibility</th></tr>
<tr><td>Contractual Considerations</td><td>Contract Length

✳ Longer contractual arrangements with aggregators and battery storage optimisers could help increase investor confidence and the likelihood of obtaining finance.

✳ However, findings from desk-based research suggest that optimisation contracts typically last 12-24 months.

✳ Although there are some cases of organisations securing longer-term optimisation contracts, the contracts awarded have been for large-scale battery storage assets.

    ✳ For example, Centrica Business Solutions have agreed to a 10-year contract for the optimisation of three battery storage plants (totalling 89MW) developed by Arlington Energy (Arlington Energy, 2022).

Asset Control (Prioritisation)

✳ As mentioned in Section 6.3.1.3, there are numerous ways that a battery storage asset can generate revenue and/or cost savings.

✳ Accordingly, it is important that both Parties agree on how the asset will be optimised throughout the duration of the contract.

    ✳ For example, some contracts may stipulate that the offtaker obtains the priority right to any stored energy from the battery (to satisfy their onsite energy demand).

    ✳ When the local authority does not require energy from the asset, provisions may be made to allow the aggregator/battery storage optimiser to generate revenue from export opportunities (PWC, 2021).

✳ Having visibility on asset availability allows third party organisations to optimise which revenue streams to target.

    ✳ This is particularly important for organisations that access markets where assets must be available for dispatch upon request.

Asset Performance

✳ During discussions with aggregators/ battery storage optimisers, offtakers should also discuss the effect that optimisation could have on asset degradation and how asset performance risks will be addressed.</td></tr>
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Table 6-4. Feasibility considerations specific to the Storage and Site Optimisation business model.

6.4.2.4. Solar and Storage Licensing Agreement

Theme	Considerations for Feasibility
Resource Requirements	✳ In this model, design, installation, operation, and maintenance activities are undertaken by a third-party provider. This significantly reduces resource requirements for the offtaker (local authority) for the following reasons: ✳ Third-party undertakes optimisation and design activities for all sites. ✳ Third-party is responsible for procuring and installing assets. ✳ Third-party trades surplus energy on behalf of the local authority which removes the need for additional contractual arrangements for export. ✳ This may be desirable to local authorities that have limited in-house expertise regarding integrated solar and battery storage project (discussed further in Section 6.5).
Energy Supply	✳ As mentioned in Section 6.3.1.3, battery storage assets can be used to maximise the self-consumption of renewable energy from solar. ✳ However, if solar and storage assets are deployed across numerous sites, this could interfere with a local authority's existing electricity supply contract. ✳ Electricity supply contracts may contain volume tolerance clauses and if the amount of grid imported electricity consumed by the local authority differs from the minimum volume stipulated in their contract, penalties may be incurred. ✳ It is recommended that local authorities contact their energy supplier to determine whether the installation of solar and storage assets (at scale) could result in a breach of their existing contract. ✳ If the proposed installation is likely to result in a breach of contract, the local authority may need to wait until their energy supply contract is up for renewal before assets are operationalised. ✳ This could lead to significant project delays.
Partner Requirements	✳ To enact this model, the local authority would need a contractual arrangement with the third-party provider that stipulates key terms of the solar and storage licensing agreement (see below). ✳ Additional contracts may be required with tenants for certain sites (see below).

Theme	Considerations for Feasibility
Contractual Considerations	**Contract Length** ✳ Capital and operational costs are recovered by the third-party provider through a long-term PPA contract (25+ years). ✳ Local authorities should consider whether a long-term contractual arrangement is a suitable option for them (e.g., are they aware of any anticipated changes to building stock in the mid-long term?) **Performance Guarantee** ✳ The amount of energy bill reductions available to the local authority is dependent on the volume of renewable energy consumed at the agreed upon PPA price. ✳ Local authorities may wish to explore whether the third-party provider is willing to include a performance guarantee in the PPA contract. **Buy-Out Clauses** ✳ Some third-party providers may offer 'buy-out' opportunities at periodic intervals throughout the duration of the contract (calculated based on the present value of the assets at the time of 'buy-out'). ✳ If the local authority decides to pursue this option, they will obtain ownership of the assets. ✳ This means they would be responsible for operating and maintaining the assets as well as decommissioning the assets at the end of their usable life. **Tenanted Buildings** ✳ Contractual arrangements can become inherently more complex for sites that are owned by local authorities but tenanted by other organisations (i.e., leisure centres, schools, etc.) ✳ Findings from external engagement suggest that one of the main reasons for this is debt risk (e.g., who takes on risk if the tenant is at risk of defaulting on their payments?) ✳ If the local authority (as building owner) is not able to act as a guarantor for the tenant, tri-Party agreements between the local authority, the-third party license provider and tenants may be required. ✳ Debt management should therefore be a key consideration during initial conversations with third-party installers to avoid unnecessary project delays. **Asset Ownership** ✳ Although the third-party provider retains ownership of the assets throughout the duration of the contract, ownership could be transferred to the local authority at the end of the agreement. ✳ This would allow the local authority to fully benefit from any renewable energy consumed at site (e.g., offset grid imported electricity). ✳ In turn, the local authority would be responsible for operating and maintaining the assets as well as decommissioning the assets at the end of their usable life. ✳ If the third-party provider retains ownership of the assets at the end of the contract, local authorities should check who is responsible for decommissioning the assets and repairing any potential damage as a result. ✳ Desk-based research suggests that the third party would take on this responsibility, but this must be confirmed during contract negotiations.

Table 6-5. Feasibility considerations specific to the Solar and Storage Licensing Agreement business model.

6.4.2.5. Solar Carport

Theme	Considerations for Feasibility

Site Selection and Sizing	* Before identifying suitable sites for solar carport projects, local authorities should be clear on the underlying objectives of the project.
	  * For example, local authorities should consider whether EV charge points are intended to be used primarily by the public (to improve access to EV charging facilities) or whether they will be used primarily by the local authority (to charge their own fleet).
	* If looking to deploy solar carports for the benefit of the public, characteristics of optimal sites include the following:
	  * High level of irradiance
	  * High number of EVs passing through the area (footfall)
	  * Sufficient/ large area to accommodate solar canopy structures.
	* If looking to charge electric fleet vehicles, the number of potential sites could be constrained by the number of council-owned depots and car parks available (where fleet vehicles can return to charge overnight).
	* Whilst there may be limited freedom in choosing a suitable site, in comparison to deploying carports for public use, this option provides an added degree of certainty relating to utilisation.
	  * For example, if the number of EV fleet vehicles, their charging requirements, and their charging patterns are known, this can help ensure that the assets are optimally sized.

Future Proofing Design	* The number of charging points required at sites will increase in line with EV uptake. * **Future proofing the system at the initial design stage can help minimise retrofit requirements as more EV charge points are installed.** * If and as the number of EV charging points increases, the energy demand of the site will also increase. * **When designing a solar carport project, consideration should be given to how the optimal use of renewable energy may change in line with future increases in energy demand as this could influence which revenue/ cost-saving opportunities are available.**
Resource Requirements (and Market Opportunities)	* Delivering a solar carport system can be complex due to optimisation modelling requirements and the (potential) need to secure numerous commercial arrangements with third-party organisations (battery storage optimisers, charge point operators, energy suppliers, etc.). * Local authorities may consider procuring a turn-key solution provider to deliver the project on their behalf to reduce resource requirements. * Desk-based research indicates that there are some organisations that can provide turn-key solar carport solutions for local authorities. * For example, Evo Energy undertook design, development, and construction activities for two solar carport projects on behalf of Leeds City Council and the City of York Council (Evo Energy, 2023a; Evo Energy, 2023b). * They are also currently responsible for operating and maintaining the systems.

Theme	Considerations for Feasibility
Partner Requirements	✳ The contracts required to enact this model depend on the revenue stream/cost-saving opportunities available (see Section 6.3.1.5). ✳ The following may be required: ⁎ Private wire arrangement between the generator and offtaker for energy that is supplied to satisfy nearby building demand. ⁎ Contractual arrangement between the generator and third-party organisation for exported energy (i.e., with an aggregator/battery storage optimiser or with a licensed SEG provider). ⁎ Contractual arrangement between the generator and charge point operator (CPO) if billing for EV charging services (discussed below). **Billing for EV Charging Services** ✳ There are a range of potential commercial arrangements with CPOs which have different implications for revenue generation, resource requirements and control over site selection: **CPO Funded** ⁎ Some CPOs offer equipment, installation, commissioning, and maintenance of charge-points at no upfront cost to local authorities. ⁎ In this arrangement, the CPO usually retains ownership of the assets and the grid connection. ⁎ In turn, the CPO pays the local authority for use of the site. This may be a rent fee (for using the land) or a percentage share of profit. ⁎ Local authorities are likely to have limited control over where charge points are installed in this arrangement. **Match Funded** ⁎ In this arrangement, capital and operational costs are shared between the local authority and the CPO. ⁎ Again, CPOs will undertake operation and maintenance activities throughout the duration of the contract. ⁎ During negotiations, both Parties will need to reach an agreement on equipment ownership and/or upgrades both throughout and at the end of the contract (Energy Saving Trust, 2019). ⁎ In this arrangement, the local authority will receive a revenue share based on their contribution to project costs. **Local Authority Funded** ⁎ In this arrangement, the local authority is responsible for paying all capital and operational costs associated with the project. ⁎ In turn, they would receive 100% of the revenue generated. ⁎ Operation and maintenance activities may be outsourced to CPOs for a fee. ⁎ This may be better suited to local authorities that wish to have greater control over site selection and EV charging tariff rates.

Table 6-6. Feasibility considerations specific to the Solar Carport business model.

6.4.3. Key Points

Key points relating to the feasibility of the short-term business models are summarised below.

1. **Soft-Market Testing**

Local authorities should engage with third party organisations as early as possible during project delivery to understand the full range of products and services that are available.

Asset ownership, capital investment requirements, project risk, revenue (or cost-saving) potential, and resource requirements can all vary considerably for the different solutions available. Local authorities should consider these factors in parallel with viability when considering which arrangement is best suited.

2. **Understanding Terminology**

Through external engagement, the Catapult learned that terminology used in the energy sector, especially relating to PPAs, is not always consistently applied.

It is important to ensure that all stakeholders are aligned on terminology to ensure that assumptions are accurately reflected in commercial assessments.

3. **Energy Supply Considerations**

It is important that local authorities review existing energy supply contracts to understand whether a chosen business model is feasible under their current agreement and/or whether it is likely to result in a breach of contract. This will likely require legal consultation.

In some cases, local authorities may have to wait until their energy supply contract is up for renewal before operationalising assets and entering commercial arrangements with third parties. This should be considered during project planning.

4. **Legal Requirements**

All short-term business models discussed throughout this section require at least one contractual arrangement with a third-party organisation. **It is therefore strongly recommended that local authorities seek legal advice to ensure that the clauses stipulated in contracts are fair to both Parties.**

Legal fees associated with project delivery should be factored into commercial assessments.

6.5. Desirability

There are different roles that a local authority could adopt within each of the short-term business models (e.g., generator, offtaker or generator and offtaker).

As generator, the local authority would be responsible for designing, developing, commissioning, and overseeing the operation and maintenance of a renewable generation project. Renewable energy generated would be sold to a third-party organisation. As an offtaker, the local authority would pay for any electricity that was consumed from a renewable generation asset (owned by a third party). As generator and offtaker, the local authority would be responsible for developing the project and would benefit from all revenue and/or cost-saving opportunities.

The role adopted within a business model will have different implications for viability (e.g., revenue generation, cost-savings, price certainty) and feasibility (e.g., resource requirements). It will also have its own level of risk. As a result, some roles may be more desirable (of more value) than others to a local authority. This section summarises key considerations that could inform which role is most desirable to a local authority for each short-term business model.

Please note that for some business models, some roles are not likely to be suitable (see Section 6.5.1.4 and Section 6.5.1.5 for further discussion).

6.5.1. Business Model Findings

6.5.1.1. Sleeved PPA

Local Authority as Generator

	Desirability Checklist	Considerations
Revenue Generation	Do you value revenue generation more than reducing costs?	⁕ As generator, the local authority will not benefit from cost savings as they are not purchasing and consuming renewable energy from the asset. Instead, they would have access to the following two revenue streams: ⁕ Primary Revenue Stream: Selling renewable energy to third party offtaker as per the Sleeved PPA agreement. ⁕ Additional Revenue Stream(s): Exporting (and selling) surplus renewable energy to the grid (if applicable).
	Do you value the opportunity to maximise revenue generation potential?	⁕ The value of the primary revenue stream is likely to be greater on a p/kWh basis. Therefore, revenue generation potential depends on how well renewable energy produced by the generator and energy demand of the offtaker are matched. ⁕ Revenue generation potential also depends on the pricing structure adopted. ⁕ Pricing structures that are linked to wholesale market prices (e.g., dynamic pricing) allow the local authority to benefit financially when wholesale electricity prices are high. ⁕ However, market volatility could affect revenue generation potential significantly throughout the duration of the PPA agreement.
Price Certainty	Do you value revenue and cost certainty?	⁕ Revenue certainty is influenced by the length of the PPA contract, and the pricing structure adopted. ⁕ Longer-term contracts in combination with certain pricing structures can provide greater revenue visibility for the local authority, which could increase investor confidence. ⁕ For example, the fixed pricing structure is most commonly adopted and offers the greatest level of revenue certainty. ⁕ If opting for a fixed pricing structure, the local authority would not benefit financially if wholesale electricity prices rose higher than the PPA power price. ⁕ The local authority may therefore experience trade-off between revenue generation potential and revenue certainty. ⁕ Typically, generators have more negotiation power when agreeing upon the desired power price, pricing structure and contract length as they have certain financial metrics that must be achieved. ⁕ As generator, the local authority would be responsible for paying imbalance costs to an energy supplier (or other BRP). ⁕ The total imbalance cost depends on how much actual generation (from the asset) differs from forecasted generation. ⁕ There is therefore a degree of uncertainty associated with this cost.

	Desirability Checklist	Considerations
Risks	Are you willing to take on some risk?	⁕ As generator, the local authority takes on some volume risk. ⁕ For example, if they are unable to supply the volume of energy as stipulated in the PPA contract, they may face financial penalties. ⁕ If opting for a pricing structure that is linked to wholesale electricity prices (e.g., dynamic pricing), the local authority would also be exposed to market (price) risks.

Resource Requirements and Expertise	Do you have experience delivering renewable generation projects?	⁕ As generator, the local authority would be responsible for designing, building, commissioning, operating, maintaining, and decommissioning the asset(s).
		  ⁕ If carried out internally, this will require significant resource as well as in-house expertise.
		  ⁕ Though, these activities may be subcontracted to third-party organisations for a cost.
		⁕ The local authority will also need to undertake commercial modelling to understand what PPA price is necessary to achieve desired financial metrics for project sign-off.

	Do you have access to legal support?	⁕ Legal support, either in-house or external, will be required for negotiating key contractual terms with the offtaker (e.g., price, contract length and volume).

Table 6-7. Considerations that could influence the desirability of the generator role within the Sleeved PPA business model.

Local Authority as Offtaker

	Desirability Checklist	Considerations
Cost Savings	Do you value cost savings more than generating revenue?	⁕ As an offtaker in a Sleeved PPA, the local authority would not generate revenue as they are not selling renewable energy to a third-party organisation. ⁕ Instead, they should achieve cost savings by purchasing electricity, via the PPA, at a lower cost than the retail price of electricity (on a p/kWh basis).
	Do you value the opportunity to maximise cost-savings?	⁕ Cost savings achieved in the Sleeved PPA will not be as significant as those from offsetting grid imported electricity. ⁕ For example, as offtaker, the local authority would still be responsible for paying sleeving fees (as well as other energy supplier fees and pass-through costs). ⁕ Sleeving fees can vary significantly amongst energy suppliers, and higher fees will reduce the amount of cost savings available to the local authority.
Price Certainty	Do you value cost certainty?	⁕ Cost certainty depends on the length of the PPA contract (which can last from 1-25+ years) and the pricing structure adopted. ⁕ Longer term contracts in combination with certain pricing structures can increase cost visibility for the local authority which can inform budgeting and forecasting activities. ⁕ For example, the fixed pricing structure is most commonly adopted and offers the greatest level of cost certainty.
Risks	Are you willing to take on some risk?	⁕ If opting for a fixed pricing structure, the local authority will be exposed to market risk. ⁕ If wholesale electricity prices fall, the local authority could end up paying more for electricity through the Sleeved PPA than they would through a typical electricity supply contract with an energy supplier. ⁕ This is an important consideration as wholesale market electricity prices have fallen recently since record breaking peaks were observed during the energy crisis.
Resource Requirements and Expertise	Do you have resource available to undergo soft-market testing?	⁕ The local authority will need to undertake soft market testing with energy suppliers (or other BRPs) to find the best value quotation for sleeving services. ⁕ The terminology used by suppliers may differ, which could make it difficult to compare quotes on a like-for-like basis and could make this activity time intensive.
	Do you have access to legal support?	⁕ Legal support will be required to implement the Sleeved PPA. ⁕ For example, the local authority's existing energy supply contract will need to be reviewed to understand whether sleeving is permitted. ⁕ If the local authority's current energy supply contract does not permit sleeving, they may need to wait until their contract is up for renewal before entering into a PPA. ⁕ There is a risk that this may not align with the anticipated delivery timelines of the third-party generator and could result in the agreement falling through.

Table 6-8. Considerations that could influence the desirability of the offtaker role within the Sleeved PPA business model.

Local Authority as Generator and Offtaker

Most points from Table 6-7 and Table 6-8 are still applicable if the local authority assumes the role of generator and offtaker. However, there are some distinct considerations associated with adopting both roles. These are discussed in Table 6-9 (below).

	Desirability Checklist	Considerations
Revenue and Cost-Savings	Do you value generating revenue and reducing costs?	* When assuming the roles of generator and offtaker, the local authority benefits from revenue generation and cost savings. This allows the local authority to set the PPA price to whatever best aligns with the underlying objectives of the project. * The price could be set so that cost savings are maximised (so long as the project pays back) or so that revenue generation is maximised for investment in future decarbonisation projects. * Energy supplier, sleeving, and pass through costs should still be considered when determining the optimal PPA price during commercial modelling exercises.
Price Certainty	Do you value price certainty?	* Price (revenue and cost) certainty is dependent on the length of the PPA contract, and the pricing structure adopted. * As generator and offtaker, the local authority can agree upon a contract length and pricing structure that is best suited towards their appetite for risk. * Longer term contracts with a fixed pricing structure can maximise price certainty for the local authority.
Risks	Are you willing to take on some risk?	* All risks previously identified could still be applicable to local authority assuming the role of generator and offtaker (see Table 6-7 and Table 6-8) though some depend on the pricing structure adopted.
Resource Requirements	Do you have experience delivering renewable generation projects?	* All activities previously identified in Table 6-7 and Table 6-8 are still applicable to local authority assuming the roles of generator and offtaker and resource requirements will still be high as a result. * However, the local authority will no longer be required to go out to tender for a suitable third-party PPA partner.

Table 6-9. Considerations that could influence the desirability of the role of generator and offtaker in the Sleeved PPA business model.

6.5.1.2. Private Wire

Local Authority as Generator

	Desirability Checklist	Considerations
Revenue Generation	Do you value revenue generation more than reducing costs?	⁕ As generator, the local authority will not benefit from cost savings as they are not purchasing and consuming renewable energy from the asset. Instead, they would have access to the following two revenue streams: ⁕ **Primary Revenue Stream:** Selling renewable energy to third party offtaker as per the Private Wire agreement. ⁕ **Additional Revenue Stream(s):** Exporting (and selling) surplus renewable energy to the grid (if applicable).
	Do you value the opportunity to maximise revenue generation potential?	⁕ The value of the primary revenue stream will be greater on a p/kWh basis. Therefore, revenue generation potential depends on how well renewable energy produced (by the generator) and energy demand (of the offtaker) are matched. ⁕ Revenue generation potential also depends on the pricing structure adopted. ⁕ Pricing structures that are linked to wholesale market prices (e.g., dynamic pricing) allow the local authority to benefit financially when wholesale electricity prices are high. However, market volatility could affect revenue generation potential significantly throughout the duration of the Private Wire agreement. ⁕ Under current regulations, certain policy and network costs can be avoided in Private Wire arrangements. ⁕ The amount of revenue generated therefore also depends on how the benefits of these cost avoidances are shared between both Parties when negotiating the private wire power price.
Price Certainty	Do you value revenue certainty?	⁕ Revenue certainty is influenced by the length of the private wire contract (typically 15+ years) and the pricing structure adopted. ⁕ Longer-term contracts in combination with certain pricing structures can provide greater revenue visibility for the local authority, which could increase investor confidence. ⁕ If opting for fixed pricing structure, the local authority would not benefit financially if wholesale electricity prices rose higher than the private wire power price. ⁕ The local authority may therefore experience trade-off between revenue generation potential and revenue certainty. ⁕ Typically, generators have more negotiation power when agreeing upon the desired power price, pricing structure and contract length as they have certain financial metrics that must be achieved.

	Desirability Checklist	Considerations

Risks	Are you comfortable with risk?	* The private wire business model is heavily exposed to policy and regulatory risk. Changes to existing regulation could influence what cost avoidances are achievable. In turn, this could affect the commercial viability of the model.
		* The local authority will also be exposed to counterparty risk. As a mitigation, counter party due diligence can be performed to determine whether the offtaker is at risk of defaulting on payments.
		  * This risk is especially important for private wire agreements where the primary revenue stream is dependent on the supply of energy to a particular site.
		* The local authority will also be exposed to some volume risk. For example, if the local authority is unable to supply the volume of energy as stipulated in the private wire contract, they may face financial penalties.
		* If the offtaker's energy demand profile changes over time, the local authority could also be exposed to revenue risk.
		  * For example, changes to energy demand could influence how well generation and demand are matched. This may be mitigated by implementing a 'take or pay' clause (see Section 6.4.2.2.).
		* If opting for a pricing structure that is linked to wholesale electricity prices (e.g., dynamic pricing), the local authority would also be exposed to market (price) risks.

Resource Requirement	Do you have experience delivering renewable generation projects?	* As generator, the local authority will be required to identify potentially suitable sites for the private wire installation. * This activity is crucial to understanding the commercial viability of the project as it will determine how well generation and demand are matched as well as the length of the private wire connection required. * Commercial modelling will also be required to understand what power price (and pricing structure and contract length) is necessary to achieve the financial metrics required for project sign off.
	Do you have access to legal support?	* Legal support will be required for negotiating key contractual terms with the third-party offtaker (i.e., contract length, power price, volume). * Negotiations should also include grid connection considerations (e.g., what provisions will be put in place for access to the connection point at the end of the agreement – if grid connection is at the offtaker's site). * Legal support will also be required to check whether the project complies with Supply Licence Exemption regulations (see Section 6.4.2.2.

Table 6-10. Considerations that could influence the desirability of the role of generator in the Private Wire business model.

6. DETAILED DESIGN OF SHORT-TERM BUSINESS MODELS

Local Authority as Offtaker

	Desirability Checklist	Considerations
Cost Savings	Do you value cost savings more than generating revenue?	* Not applicable as local authority does not own the renewable generation asset and is not selling the renewable electricity generated. * Instead, they should achieve cost savings by purchasing electricity, via the Private Wire agreement, at a lower cost than the retail price of electricity (on a p/kWh basis).

	Do you value the opportunity to maximise cost-savings?	* The amount of cost savings available to local authority as offtaker will depend on how the cost avoidance benefits are shared between both Parties.
		  * The generator typically has more negotiation power when setting the price for electricity meaning that cost savings may not be significant.
		* Unlike the Sleeved PPA business model, an energy supplier is not required to facilitate the transfer of energy in a Private Wire arrangement. As a result, the local authority is not responsible for paying supplier (sleeving) fees.
		  * Cost savings from Private Wire arrangement could therefore be greater than sleeved PPA.
		* Though, cost savings achieved in the private wire arrangement will not be as high as those from offsetting grid imported electricity (see Table 6-12 for further discussion).

Price Certainty	Do you value cost certainty?	* Cost certainty depends on the length of the PPA contract (typically 15+ years), and the pricing structure adopted. * Longer term contracts in combination with certain pricing structures can increase cost visibility for the local authority which can inform budgeting and forecasting activities.
Risks	Are you willing to take on some risk?	* If opting for a fixed pricing structure, the local authority as offtaker will take on market (price) risk (see Table 6-8 for further discussion). * The local authority will also take on some volume risk as offtaker (i.e., the actual volume of energy available may differ to that stipulated). * To mitigate this risk, the local authority could include penalty clauses in the Private Wire contract in case the asset does not perform as expected.
Resource Requirements	Do you have access to legal support?	* Legal support will be required for negotiating key contractual terms with third-party generator (i.e., price, volume, and contract length). * Depending on the size of the asset, the local authority may also need to consider whether this business model could result in breach to their existing energy supply contract (e.g., could it trigger the minimum supply volume clause?). This will also require legal support.

Table 6-11. Considerations that could influence the desirability of the role of offtaker in the Private Wire business model.

Local Authority as Generator and Offtaker

If the local authority assumes the role of generator and offtaker, the private wire business model would essentially become a self-consumption and export model where:

- Commercial viability is primarily dependent on the cost-savings achieved by offsetting grid imported electricity (see Section 7.3.3).
- Further revenue may be generated from surplus solar energy that is exported to grid (at a lower price on a p/kWh basis).

	Desirability Checklist	Considerations
Revenue Generation and Cost-Savings	Do you value both generating revenue and reducing costs?	✳ The generator and offtaker may be from different departments within the local authority and have different budgets. ✳ The departments may therefore need to agree and set a price for electricity internally (e.g., it may be necessary to demonstrate how certain financial metrics can be achieved to obtain project sign off). ✳ Where this is the case, the local authority could set the power price to whatever best aligns with the underlying objectives of the project (see Table 6-9 for further discussion).
Price Certainty	Do you value price certainty?	✳ As generator and offtaker, the local authority can agree upon a contract length and pricing structure that is best suited towards their appetite for risk.
Risks	Are you willing to take on some risk?	✳ The local authority in their capacity as offtaker will still be exposed to market (price) risk if opting for a fixed pricing structure. ✳ In the absence of a formal contractual agreement, volume and counter-party risks would be minimised.
Resource Requirements	Do you have experience delivering renewable generation projects?	✳ As generator and offtaker, resource requirements for the local authority would still be considerable as they are still responsible for delivering the project. ✳ However, in the absence of a formal contractual agreement, the amount of legal support may be reduced.

Table 6-12. Considerations that could influence the desirability of the role of generator and offtaker in the Private Wire business model.

6.5.1.3. Storage and Site Optimisation

Local Authority as Generator

	Desirability Checklist	Considerations

Revenue Generation	Do you value revenue generation more than reducing costs?	* As generator, the local authority will not benefit from cost savings as they are not consuming renewable energy from the asset. Instead, they would have access to the following two revenue streams:
		  * **Primary Revenue Stream:** Selling renewable energy to third party offtaker – likely through a Private Wire (BtM PPA) arrangement.
		  * **Additional Revenue Stream(s):** Selling surplus energy to aggregator/ battery storage optimiser (for arbitrage or flexibility services).
		* If unable to secure a commercial arrangement with an aggregator/ battery storage optimiser, a 'solar storage' tariff with a licensed SEG provider may be an alternative option.

	Do you value the opportunity to maximise revenue generation potential?	* One of the key factors that will influence revenue generation potential in this model is the way in which the battery is optimised to perform.
		* Findings from desk-based research indicate that, for behind the meter systems (BtM), batteries are most often optimised to maximise the consumption of solar generation (please note that this does not guarantee commercial viability).
		  * Please refer to Table 6-10 for further information on how revenue generation could be maximised under the Private Wire arrangement.
		* Revenue generation potential from arbitrage and flexibility services will be influenced by the following factors:
		  * The volume of energy that is exported (kWh)
		  * The markets that the aggregator/ optimisation provider accesses on behalf of the local authority (some markets are more volatile than others).
		  * The structure of the commercial arrangement with the aggregator/ optimisation provider.
		* If adopting a revenue share model with an aggregator/ battery storage optimiser, the local authority will be exposed to fluctuations in market prices meaning that revenue generation potential could vary significantly.

	Desirability Checklist	Considerations
Price Certainty	Do you value revenue certainty?	* In combination with a fixed pricing structure, long-term arrangements with the offtaker can help increase price certainty for the local authority (see Table 6-10 for further discussion). * Longer-term contracts could improve revenue certainty for commercial arrangements with aggregators/ battery storage providers. However, it may be difficult to secure a long-term agreement with such stakeholders (see Section 6.4.2.3). * As more battery storage assets come online, market saturation could occur for some DNO and ESO services (Cornwall Insight, 2023). This could change the way in which revenue streams are stacked by aggregators/ battery storage providers which, in turn, could also affect revenue certainty
Risks	Are you willing to take on some risk?	* If opting for a revenue share model with the aggregator/ battery storage provider, the local authority would be exposed to market (price) risk. * Although this could be partially mitigated with a fixed pricing structure, the local authority would still face some market risk due to potential market saturation in future. * Depending on the contractual arrangement with the aggregator/ battery storage provider, there may be stipulations relating to the availability of the battery storage asset and the volume of energy available. * Where this is the case, the local authority could also be exposed to some volume risk. * For risks relating to the Private Wire arrangement, please refer to Table 6-10.
Resource Requirements	Do you have experience deploying energy storage assets?	* The local authority will need to undertake sophisticated technical and commercial modelling to determine the optimal size of the renewable generation assets, the viability of the business model and how sensitive it is to changes in key parameters. * This could be subcontracted to third-party organisations at a cost.
	Do you have resource available to undergo soft-market testing?	* Optimisation contracts with aggregators/ battery storage optimisers typically last 12-24 months. * If unable to secure a longer-term agreement, the local authority would need to go out to tender numerous times for optimisation contracts throughout the lifetime of the project. * Each time, commercial models would need to be updated to reflect any changes to commercial arrangements and assumptions.
	Do you have access to legal support?	* Legal support will be required when negotiating both contractual arrangements (i.e., with the third-party offtaker and aggregator/battery storage optimiser).

Table 6-13. Considerations that could influence the desirability of the role of generator in the Storage and Site Optimisation business model.

Local Authority as Offtaker

	Desirability Checklist	Considerations
Cost Savings	Do you value cost savings more than generating revenue?	⁕ Not applicable as local authority does not own the renewable generation asset and is not selling the renewable electricity generated. ⁕ Instead, they should achieve cost savings by purchasing electricity, via the Private Wire (BtM PPA) agreement, at a lower cost than the retail price of electricity (on a p/kWh basis).
	Do you value the opportunity to maximise cost-savings?	⁕ The amount of cost savings available to local authority as offtaker will depend on how the cost avoidance benefits (from the Private Wire arrangement) are shared between both Parties. ⁕ In this model specifically, the amount of cost-savings achievable will also depend on the volume of renewable energy that is consumed at the private wire price (p/kWh). ⁕ If the battery storage asset is prioritised to maximise self-consumption, cost-savings could be increased. ⁕ However, please note that the generator may offer a higher price for electricity to account for the additional capital expense of battery storage assets.
Price Certainty	Do you value cost certainty?	⁕ Cost certainty depends on the length of the PPA contract (typically 15+ years), and the pricing structure adopted. ⁕ Longer term contracts in combination with certain pricing structures can increase cost visibility for the local authority which can inform budgeting and forecasting activities.
Risks	Are you willing to take on some risk?	⁕ If opting for a fixed pricing structure, the local authority as offtaker will take on market (price) risk (see Table 6-8 for further discussion). ⁕ The local authority will also take on some volume risk as offtaker (i.e., the actual volume of energy available may differ to that stipulated). ⁕ To mitigate this risk, the local authority could include penalty clauses in the Private Wire contract in case the asset does not perform as expected.
Resource Requirements	Do you have access to legal support?	⁕ Legal support will be required for negotiating key contractual terms with the third-party generator (i.e., price, volume, and contract length).

Table 6-14. Considerations that could influence the desirability of the role of offtaker in the Storage and Site Optimisation business model.

Local Authority as Generator and Offtaker

By assuming the role of generator and offtaker, this business model would become an extension of the self-consumption and export model (see Section 6.5.1.2. and Table 6-12). The integration of the battery storage asset results in additional considerations for each of the factors explored. These considerations are discussed throughout Table 6-15.

	Desirability Checklist	Considerations
Revenue Generation and Cost-Savings	Do you value both generating revenue and reducing costs?	⁎ The generator and offtaker may be from different departments within the local authority and have different budgets. ⁎ The departments may therefore need to agree and set a price for electricity internally (e.g., it may be necessary to demonstrate how certain financial metrics can be achieved to obtain project sign off). ⁎ Where this is the case, the local authority could set the power price to whatever best aligns with the underlying objectives of the project (see Table 6-9 for further discussion). ⁎ There may be times where the site does not require/ cannot consume energy from the battery storage asset. Where this is the case, additional revenue may be generated from a commercial arrangement with an aggregator/ battery storage optimiser (see Table 6-13). ⁎ If unable to secure a commercial arrangement with an aggregator/ battery storage optimiser, a 'solar storage' tariff with a licensed SEG provider could be an alternative option for generating additional revenue from export.
Price Certainty	Do you value price certainty?	⁎ As generator and offtaker, the local authority can agree upon a contract length and pricing structure that is best suited towards their appetite for risk (for energy that is produced and consumed onsite). ⁎ Price certainty is likely to be more limited for commercial agreements with the aggregator/ battery storage optimiser (see Table 6-13).
Risks	Are you willing to take on some risk?	⁎ In the absence of a formal contractual arrangement, risks associated with the production and consumption of renewable energy onsite are reduced (see Table 6-12). ⁎ However, the local authority will still be exposed to risks associated with the commercial agreement with an aggregator/ battery storage optimiser (see Table 6-13).
Resource Requirements	Do you have resource available to undergo soft-market testing?	⁎ As generator and offtaker, the local authority may still need to go out to tender numerous times for optimisation contracts throughout the lifetime of the project (see Table 6-13).
	Do you have experience deploying energy storage assets?	⁎ As generator and offtaker, the local authority will need to undertake sophisticated technical and commercial modelling to determine the optimal size of the renewable generation assets, the viability of the business model and how sensitive it is to changes in key parameters.
	Do you have access to legal support?	⁎ Legal support will be required when negotiating key contractual terms with the aggregator/ battery storage optimiser.

Table 6-15. Considerations that could influence the desirability of the role of generator and offtaker in the Storage and Site Optimisation business model.

6.5.1.4. Solar and Storage Licensing Agreement

As discussed in Section 6.3.1.4, this business model differs from Storage and Site Optimisation in two distinct ways. First, a third party provides the necessary capital to deploy solar and storage technologies on behalf of the local authority. Second, the technologies are deployed at scale (across numerous sites). This model was included as a potentially suitable option for local authorities that have limited access to capital but still wish to benefit from decarbonisation from renewable generation assets. For this reason, only the role of 'Local Authority as Offtaker' is considered.

Local Authority as Offtaker

	Desirability Checklist	Considerations
Cost Savings	Do you value cost savings more than generating revenue?	⁕ The local authority would not generate revenue throughout the duration of the contract with the third-party provider as they are not selling the renewable electricity generated. ⁕ Instead, they should achieve cost savings by purchasing electricity, via the PPA agreement with the third-party provider, at a lower cost than the retail price of electricity (on a p/kWh basis). ⁕ Please note that the local authority may be able to obtain ownership of the assets at the end of the contractual arrangement with the third-party provider. ⁕ In this case, the local authority could generate revenue from energy exported to the grid. This will require a commercial agreement with an aggregator/ optimisation provider or a licensed SEG provider (see Table 6-13 for further discussion).

	Do you value the opportunity to maximise cost-savings?	⁕ The amount of cost-savings achievable will depend on the PPA price (p/kWh) set by the third-party organisation.
		  ⁕ This price will factor in capital costs of the solar and storage technologies as well as costs associated with setting up virtual power plants and participating in flexibility markets.
		⁕ The amount of cost-savings achievable will also depend on the volume of renewable energy that is consumed across sites at the PPA price.
		  ⁕ If the battery storage asset is prioritised to maximise self-consumption, cost-savings could be maximised for the local authority as offtaker.
		⁕ If the local authority obtains ownership of the assets at the end of the contractual arrangement, any renewable energy consumed across sites will directly offset grid imported electricity; offering the maximum level of cost-savings.

Price Certainty	Do you value cost certainty?	⁕ Contractual arrangements for this business model are typically 25+ years long. ⁕ Long-term arrangements, in combination with certain pricing structures, can increase cost-visibility for the local authority which could inform budgeting and forecasting activities. ⁕ The fixed pricing structure offers the highest degree of cost certainty.

	Desirability Checklist	Considerations
Risks	Are you willing to take on some risk?	⁕ If opting for a fixed pricing structure, the local authority will take on market (price) risk (see Table 6-8). ⁕ As offtaker, the local authority will also be exposed to some volume risk. ⁕ To mitigate this risk, some third-party providers may offer a performance guarantee.

Resource Requirements	Do you have access to legal support?	⁕ Legal support will be required for negotiating key contractual terms with the third-party provider.
		  ⁕ As mentioned in Section 6.4.2.4, there are several key factors that should be discussed during contract negotiations including asset ownership, asset control, and performance guarantees.
		  ⁕ Contractual arrangements may also become inherently more complex if triparty agreements are required with tenants.
		⁕ Legal support will also be required to explore whether the Solar and Storage Licensing Arrangement puts the local authority at risk of breaching their existing energy supply contract.

	Do you have experience operating, maintaining, and decommissioning renewable generation projects?	⁕ One of the key benefits of this business model for local authorities is its potential to reduce resource requirements (see Section 6.4.2.4). ⁕ However, if the local authority does obtain ownership of the assets are the end of the contract, they would be responsible for operation, maintenance, and decommissioning activities (once the assets reach the end of their usable life).

Table 6-16. Considerations that could influence the desirability of the role of offtaker in the Solar and Storage Licensing Agreement business model.

6.5.1.5. Solar Carport

As mentioned in Section 6.4.2.5, solar carports may be deployed to decarbonise local authority owned fleets or to provide access to EV charging facilities for the wider public. For the former, the local authority is likely to assume the role of generator and offtaker. For the latter, the local authority will likely assume the role of generator (though may still use the charging facilities onsite). Considerations relating to each of these scenarios are explored further throughout Table 6-17 and Table 6-18.

To act solely as an offtaker in this business model, the local authority would require a commercial arrangement with a third-party organisation that was willing to fund the capital and operational costs associated with the solar carport system. Like the Solar and Storage Licensing Arrangement, the third party would recover these costs through a PPA with the local authority. As mentioned in Section 6.4.2.5, there are some CPOs that provide fully funded solutions for EV charging infrastructure. Likewise, there are some third-party organisations that provide fully funded solutions for solar and/or battery storage systems. However, during desk-based research and external engagement, there were no examples found of an integrated solar carport (solar, EV charging and battery storage) being delivered at no-upfront cost to local authorities. Whilst this may be an option that emerges in future, the role of 'Local Authority as Offtaker' is not considered in this subsection.

Local Authority as Generator

	Desirability Checklist	Considerations

Revenue Generation	Do you value revenue generation more than reducing costs?	* As generator, the local authority will not benefit from cost savings as they are not consuming renewable energy from the asset. Instead, they could have access to the following revenue streams (this will depend heavily on how energy is used within the solar carport system and how this may change over time):
		  * Selling renewable energy to third party offtaker onsite through a Private Wire agreement.
		  * Selling surplus energy to aggregator/ battery storage optimiser (for arbitrage or flexibility services).
		  * Selling energy to public for EV charging provisions (a CPO may be required to facilitate this – See Section 6.4.2.5).

	Do you value the opportunity to maximise revenue generation potential?	* As well as the frequency of utilisation, revenue generation potential from EV charging services will also depend on the tariff set (p/kWh).
		  * As mentioned in Section 6.4.2.5, the local authority has the freedom to set the tariff if they own the charging points.
		  * However, if opting for a match funded (revenue share) arrangement with a CPO, the CPO is likely to have more negotiation power in how the price is set to ensure financial metrics are obtained.
		* For considerations specific to the Private Wire business model, please refer to Table 6-10.
		* For considerations specific to the commercial arrangement with an aggregator/ battery storage optimiser, please refer to Table 6-13).

	Desirability Checklist	Considerations
Price Certainty	Do you value revenue certainty?	⁎ The optimal way in which energy is distributed and used in the solar carport system may change over time if an as the uptake of EV charging increases. ⁎ In turn, this could change which revenue streams are accessible to the local authority. ⁎ Revenue certainty, across the lifetime of the project, could therefore be limited. ⁎ For other short-term business models, it was mentioned that longer-term commercial arrangements, in combination with fixed pricing structures, with third-party organisations could increase revenue certainty. ⁎ However, given that the optimal use of energy may change over time for solar carports, local authorities should consider whether longer-term contracts are appropriate for this business model; especially if minimum supply clauses are included.
Risks	Are you willing to take on some risk?	⁎ As generator, the local authority will be exposed to revenue risk stemming from uncertainty relating to the utilisation of EV charging points. ⁎ For risks specific to the Private Wire business model, please refer to Table 6-10. ⁎ For risks specific to the commercial arrangement with an aggregator/ battery storage optimiser, please refer to Table 6-13).

Resource Requirements	Do you have experience delivering renewable generation projects with integrated assets?	⁎ If done in-house, the resource requirements and level of expertise required to deliver an integrated solar carport system would be considerably high.
		⁎ Sophisticated technical modelling would be required to determine the optimal sizing and configuration of the solar carport system.
		    ⁎ Outputs from the modelling would then need to be integrated with commercial models to understand the commercial viability of the scheme.
		    ⁎ Modelling would also need to consider how energy use in the system may change over time.
		⁎ In a similar vein, technical designs would need to consider how the system could adapt to/ accommodate changes in energy demand, and use, in future.
		⁎ Local authorities may choose to procure a turn-key solution provider to reduce resource requirements (see Section 6.4.2.5).

	Do you have access to legal support?	⁎ Legal support will be required for the negotiation of key contractual terms for any commercial arrangements with third-party organisations. ⁎ If and where there are numerous arrangements, asset control and prioritisation will be critical to discussions.

Table 6-17. Considerations that could influence the desirability of the role of generator in the Solar Carport business model.

Local Authority as Generator and Offtaker

If assuming the role of generator and offtaker, this model would become an extension of the self-consumption and export model[12]. The integration of the battery storage and EV charging assets results in additional considerations for each of the factors explored. These are discussed throughout Table 6-18.

	Desirability Checklist	Considerations

Revenue Generation and Cost-Savings	Do you value both generating revenue and reducing costs?	* The generator and offtaker, although both from the same local authority, may be from different departments with different budgets.
		  * Accordingly, a price for renewable energy consumed on-site (from the building and/or from EV charging points) may need to be set and agreed upon.
		  * Where this is the case, the local authority could set the power price to whatever best aligns with the underlying objectives of the project (see Table 6-9 for further discussion).
		* There may be times where the site does not require/ cannot consume energy from the battery storage asset.
		  * Where this is the case, revenue could be generated through a commercial arrangement with an aggregator/ battery storage optimiser (see Table 6-13).
		* If unable to secure a commercial arrangement with an aggregator/ battery storage optimiser, a 'solar storage' tariff with a licensed SEG provider could be an alternative option for generating additional revenue from export.

Price Certainty	Do you value price certainty?	* If applicable, as generator and offtaker, the local authority can agree upon a contract length and pricing structure that is best suited towards their appetite for risk. * If the number of local authority owned EVs (both current and those required in future), their charging requirements, and their charging patterns are known, current and future energy demands of the solar carport system can be better understood. * In turn, the local authority will have a clearer indication of the potential revenue and cost-saving opportunities throughout the lifetime of the project. * For considerations specific to the commercial arrangement with an aggregator/ battery storage optimiser, please refer to Table 6-13).
Risks	Are you willing to take on some risk?	* If it is necessary for the local authority to set a tariff for EV charging points, revenue risk, related stemming from uncertainty of utilisation, could be mitigated if the charging requirements of local authority owned EVs are known. * For risks specific to the commercial arrangement with an aggregator/ battery storage optimiser, please refer to Table 6-13).

[12] Renewable energy supplied to the EV charging points is still considered as self-consumption if the charging points are installed BtM.

	Desirability Checklist	Considerations
Resource Requirements	Do you have experience delivering renewable generation projects with integrated assets?	⁕ If done in-house, the resource requirements and level of expertise required to deliver an integrated solar carport system would be considerably high (see Table 6-17 for further discussion).
	Do you have access to legal support?	⁕ Legal support will be required for negotiating key contractual terms with the aggregator/ battery storage optimiser.

Table 6-18. Considerations that could influence the desirability of the role of generator and offtaker in the Solar Carport business model.

6.5.2. Key Points

Key points from this subsection are summarised below.

1. Understanding the Desirability of Different Roles

There are numerous roles that local authorities could adopt to enable the delivery of the short-term business models presented throughout this section. Each role has different implications in terms of revenue/ cost-saving potential, resource requirements and risks.

The tables presented throughout Section 6.5.1 can be used by local authorities to help inform what role may be most desirable to them for a given business model.

2. Potential Added Benefits of Adopting the Role of Generator and Offtaker

Only by assuming the role of generator and offtaker is it possible for local authorities to benefit from revenue generation and cost-saving opportunities.

Where required, this role allows local authorities to set the power price for electricity to whatever aligns best with the underlying (financial) objectives of the project (e.g., to maximise revenue generation potential to invest in future projects or to maximise cost-savings to mitigate against high energy bills).

This role also allows local authorities to set a pricing structure and contract length that is more aligned with their appetite for risk[13].

Please note that the resource requirements should also be considered when exploring the desirability of the 'generator and offtaker' role.

[13] Please note that this does not apply to commercial agreements with third-party organisations for export. It applies only to renewable energy that is generated and consumed by the local authority.

7 TECHNICAL & COMMERCIAL MODELLING

7.1. The need

7.2. The commercial model

7.3. Technical validation of the commercial model

7.4. Commercial model results

7.5. Further work - value of battery storage

7.1 The need

ESC observed that often the initial commercial analyses, from the Workstream 1 feasibility studies, did not accurately represent the business case for each of the renewable generation projects. The relative novelty and complexity of some revenue models (such as PPAs) makes them harder to model, especially given duration of contracts (short term – up to 5 years max) and expected asset economic life (up to 30 years) are not aligned.

Understanding the accuracy of the commercial analyses is important to provide local authorities with a good understanding of future cash flows and any risks and to ensure compliance with any internal investment or financing requirements.

In response to this, GMCA and the Catapult recognised the capability gap and ESC conducted commercial modelling to assess the viability of projects, as part of the tailored support to the local authorities. As a result of this work, additional lessons were learnt that are described below with references to other more detailed material and tools to help local authorities.

This work has also provided a useful insight into the variation of key metrics for each project for the UCEGM consortia members.

7.2 The commercial model

ESC built a commercial model, which is a spreadsheet-based tool that calculates key business case metrics such as the internal rate of return, the discounted payback time and the project cash flows each year.

The commercial model uses the following inputs:

- the project data (e.g., CAPEX (£), expected solar asset yield (kWh), level of self-consumption,
- the chosen revenue model,
- Electricity prices,
- The means of finance,
- The amount of grant funding.

The following revenue models are currently represented:

- Self-consumption (behind the meter) (see 'UCEGM Workstream 2 – Improving the business Case for Renewable Energy' deliverable)
- Sleeved PPA (see Section 6.3.1.1)
- Private wire (see Section 6.3.1.2)

It can be developed to represent further revenue models.

For a sleeved PPA (where the local authority is both the offtaker and the generator) [see Section 6.5] the commercial model includes terms for the PPA fees (charged by the energy supplier) and for any network charges.

ESC carried out the analyses for the projects and developed a set of automatic reports, from the tool, that contain the information required to facilitate project approval. The analyses include renewable generation projects in the following districts:

- Rochdale
- Oldham
- Wigan
- Manchester City
- Salford
- Stockport

ESC invested time discussing both the revenue models and the commercial model results with the local authority project teams. This engagement is essential, as it's a simple method of communication, to ensure that the results are understood by all stakeholders who need them to make business decisions. Otherwise, there is a risk that the value proposition is misunderstood resulting in a risk of reduced benefits to the local authority.

A specific example where the novel business models can cause confusion is the concept of the local authority setting the power price for the generator and offtaker as part of a Sleeved PPA [components that contribute toward the overall PPA power price are discussed in the 'Detailed Design of Short-Term Renewable Generation Business Models' report].

This tool has subsequently been developed for use by local authorities directly.

DO

- √ **Do involve the LA finance team early in commercial modelling.**
- √ **Do engage incumbent energy suppliers to check that they will offer a sleeved PPA.**
- √ **Do engage with PPA providers to validate the charges, fees, and revenue for excess generation.**
- √ **Do include sensitivity analyses to understand risk and avoid re-approval.**

DON'T

- X **Don't assume that 100% of energy will be consumed if using averaged data.**
- X **Don't consider development of a renewable generation asset in isolation, particularly if it may contribute to a large % of the total energy supply.**
- X **Don't assume that everyone has understood new business models, check!**
- X **Don't assume Smart Export Guarantee price for generation.**

Figure 7-1.: do and don't - commercial modelling

7.3. Technical validation of the commercial model

By doing the commercial modelling, on behalf of the local authorities, ESC had to consider the factors that affect the business case in detail. This helped ESC to identify business case risks and sensitivities, for which mitigations were developed. The key learning is presented below for use by local authorities undertaking similar projects.

7.3.1. Electricity price volatility

The UCEGM project has been undertaken during a period of considerable uncertainty; COVID and the war in the Ukraine. This has created a period of extreme price volatility. The retail price of electricity purchased from electricity suppliers affects the energy costs and potential savings that renewable energy projects can provide. This influences the project payback period and the dependency on grant funding. The commercial model allows the user to use different retail electricity price forecasts, such as a high, central, and low. ESC generated its own forecasts and procured a set of forecasts from an industry expert, to address the current uncertainty in the markets. In contrast the WS1 feasibility studies have used a single figure for retail energy prices (with or without inflation) that ranged from as low as 14p/kWh to 50p/kWh for the duration of the payback period. This has a big impact on the outcome of the commercial modelling and investment decisions. A simpler approach could be adopted when markets stabilise.

The different retail price forecast scenarios enable the commercial modelling to contain a sensitivity study showing how the internal rate of return, net present value, and discounted payback time will change under different scenarios. This provides further assurance for project approval.

Illustrations of the retail price forecasts, and the sensitivity analysis are shown below.

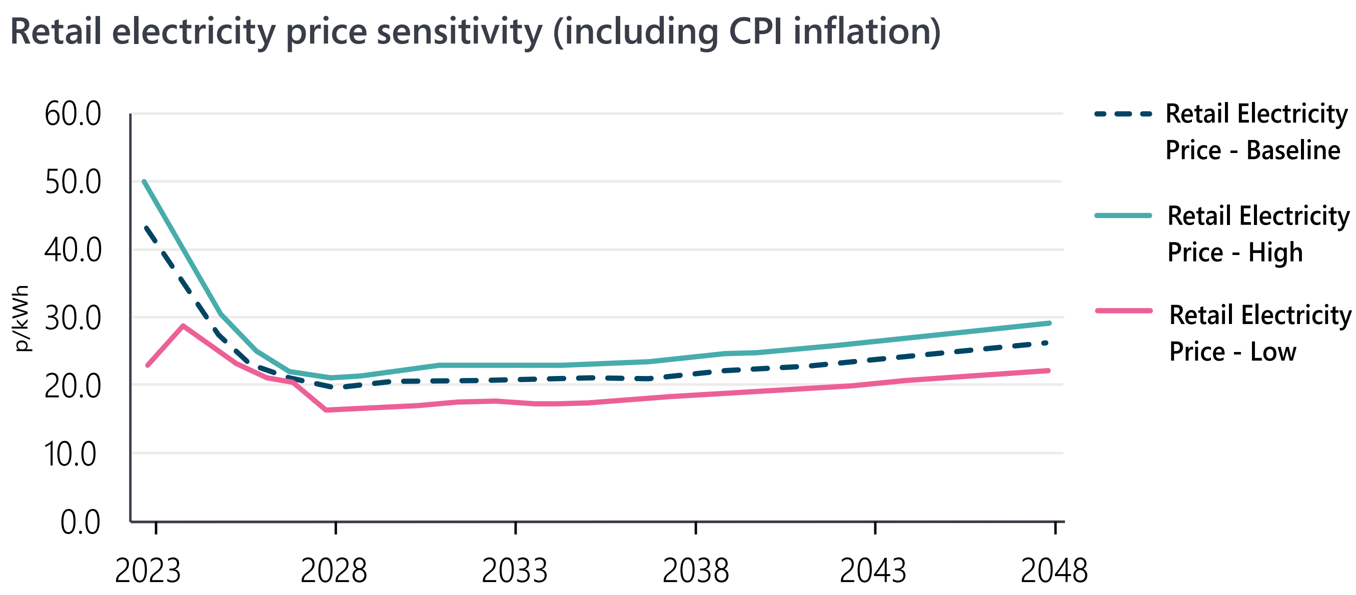


Figure 7-2: Retail electricity price forecasts

		Internal Rate of Return		
	Price scenario	Retail Electricity Price - Low	Retail Electricity Price - Baseline	Retail Electricity Price - High
CAPEX Variation	£/kWp			
-60%	490	33%	38%	43%
-45%	674	23%	27%	30%
-30%	858	17%	20%	23%
-15%	1041	13%	16%	18%
0%	1225	11%	13%	15%
15%	1409	9%	11%	13%
30%	1593	7%	9%	11%
45%	1776	6%	8%	9%

Figure 7-3: Capex & retail electricity price sensitivities

7.3.2. Capital Expenditure (CAPEX)

During the interval between the feasibility studies and the detailed design there was considerable variation in the CAPEX (cost estimates) for the projects (e.g. a 30% increase). The commercial model provides a sensitivity analysis to CAPEX variation to help address this uncertainty.

If a commercial model for a project is developed from the outset and maintained throughout, any changes in CAPEX or other inputs can be factored in to help understand their impacts on project viability. There is a risk that the analysis is performed once at the start and not revisited until final approval is being sought, when any unfavourable changes may be difficult to mitigate.

7.3.3. Self-consumption

Local renewable energy generation creates value by helping to reduce the amount of electricity purchased from the electricity grid. This is because retail electricity prices (local buying price) are higher than the price available for selling electricity to the grid via smart energy export guarantee (SEG) or a standard PPA (local selling prices).

To understand the viability of a it is important to establish how much of the electricity will be used by the local authority sites (self-consumption) and how much is exported (sold) back to the grid.

If one looks at monthly averages of solar generation and electricity demand it can mislead one into thinking that self-consumption is higher. **It was not uncommon for districts to state that they would consume 100% of the electricity generated, which may in part, be associated with charts such as the example below (Figure 7-4).**

In practice when one looks at the half-hourly demand across each day of the year versus the modelled solar output there can be a mismatch due to when the solar generates (daylight hours) and when the demand occurs. There can be a further mismatch if the local authority's sites include a lot of buildings with different levels of utilization during the week or seasons. Schools are a prime example with lower energy usage at weekends and during the school holidays (as illustrated by the dip in the demand curve in August in Figure 7-4 above.

ESC carried out a more detailed analysis of the self-consumption for several sites using a spreadsheet. This approach could be developed into a simple tool to help local authorities. It would require the local authorities to obtain the solar asset yield data and the half hour metered energy consumption data for their sites. **In the example above self-consumption was calculated at 88% (not 100%)** once low consumption periods have been taken into account. The size of the bars reflects the value to the local authority.

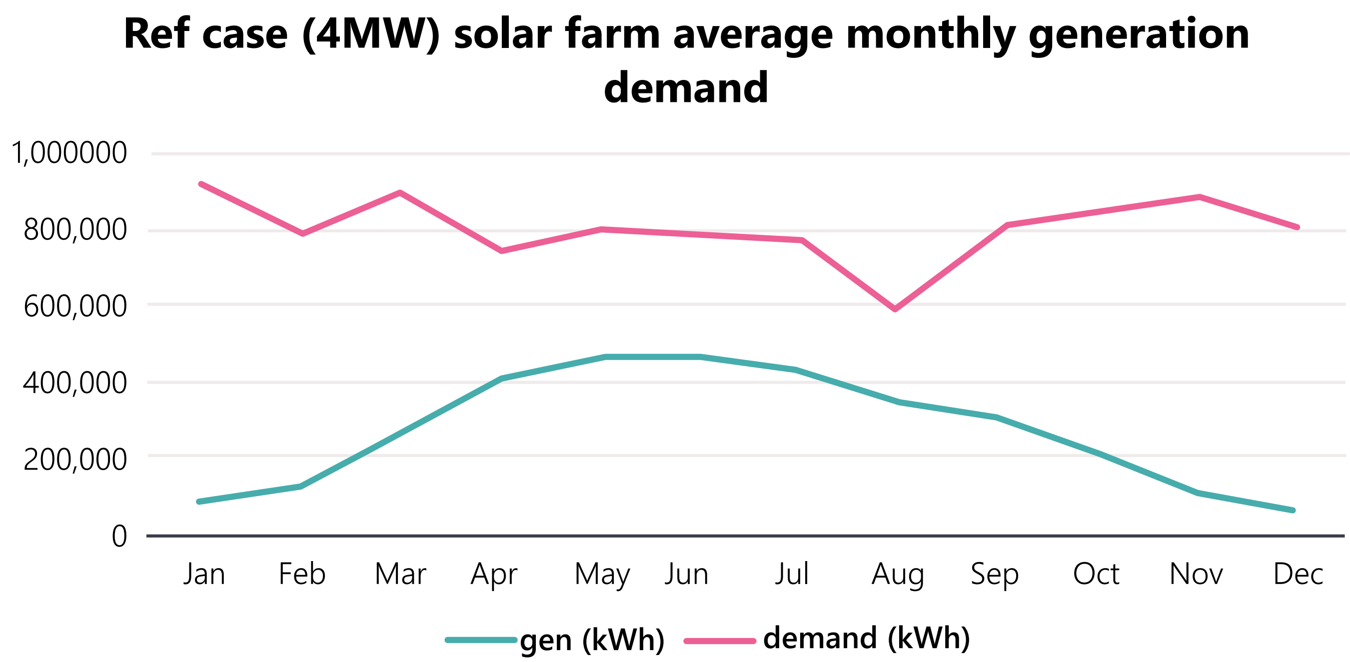


Figure 7-4: monthly average data

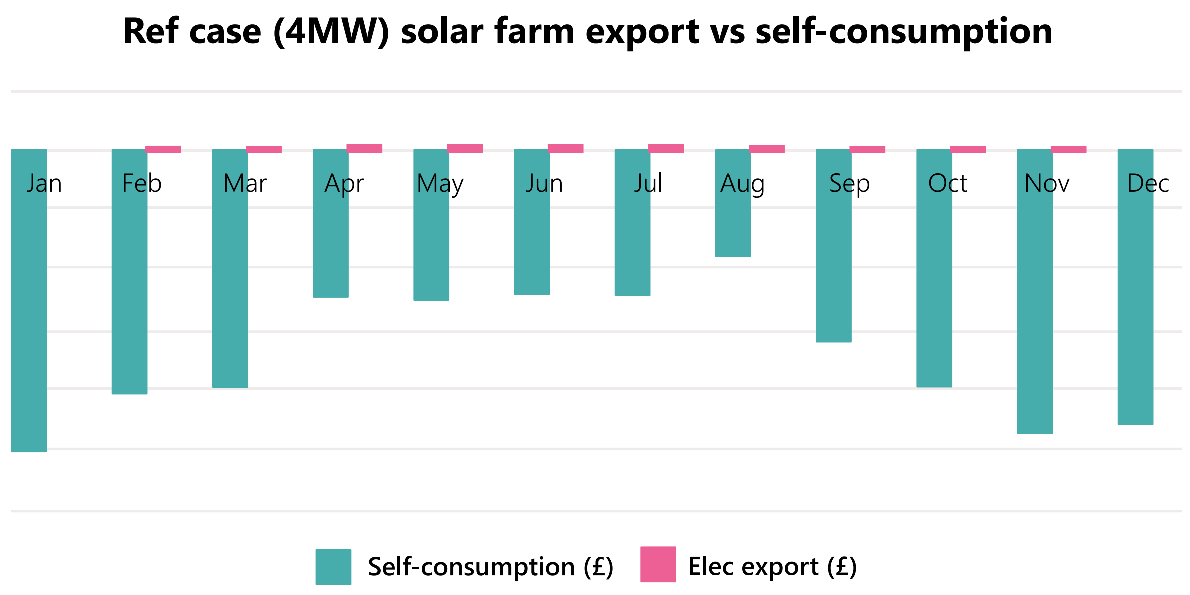


Figure 7-5: export vs self-consumption

There can also be a tendency to think that the optimum size of the solar generation is determined by the peak output (e.g. summer months) and the need to keep this below demand curve. This has been shown to not be the case. If one looks at the graph in Figure 7-6 one might increase the size of the generation system until the generation curve is higher than the demand curve in the summer months. This will increase the amount of energy exported to the grid, but the increased generation now displaces much more grid electricity in the winter, autumn and spring months, which may increase the value to the local authority.

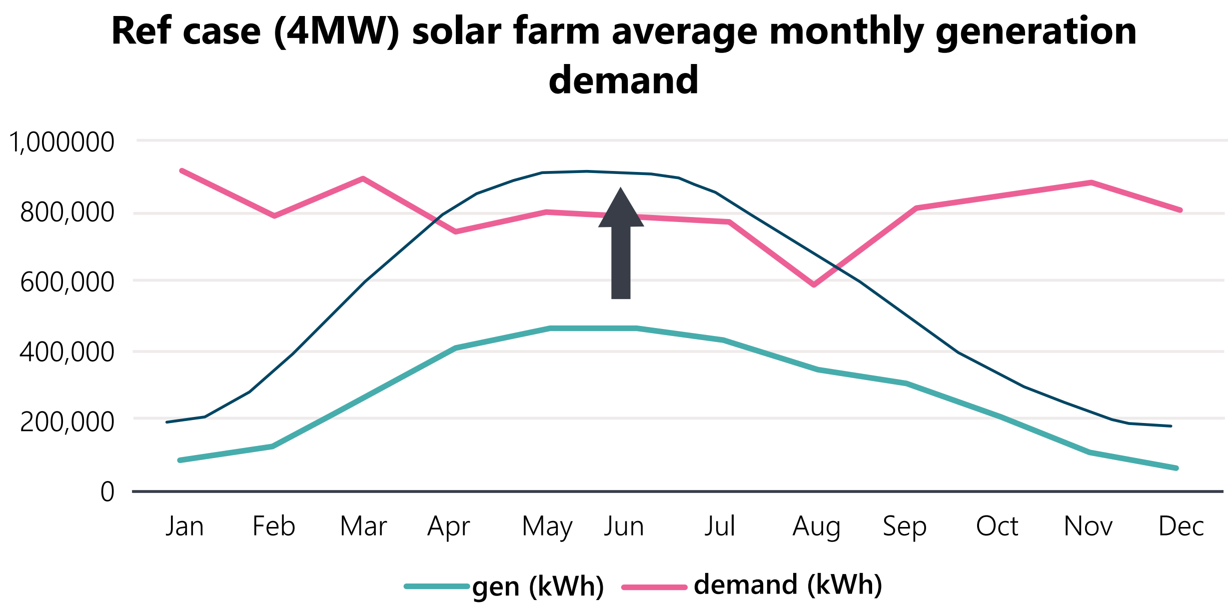


Figure 7-6: reduced grid imports

There are other factors that may make a larger generation site less attractive, such as the available space, the cost of grid connections, the risk of increased curtailment and affordability. The key message is that there is value in early exploration of different options via technical and commercial models. An optimal size from a commercial perspective, which takes into consideration the costs and potential future energy cost savings, may differ from just considering capex and peak output.

The last point to make about self-consumption is to be mindful of factors that may alter the available demand. There were instances of districts making other energy investments that changed the demand; it is important that a holistic view is taken to planning these investments. The Local Partnership's **forecasting tool** can help local authorities to do this. Another thing that may affect energy demand for a sleeved PPA are any instances where the local authority does not pay the energy bills for buildings despite them being both owned by the local authority and part of the same energy supply contract [see Section 6.4.2.1].

7.3.4. PPAs

The commercial model has provision for including PPA related charges, which are currently modelled as increasing with inflation. Further work has been undertaken to understand the different pricing structures that may be offered for PPAs [see Section 6.3.1.1].

It is crucial to highlight that not all energy suppliers may offer PPAs. It is important to start discussions early in the project and if possible, include provision in energy supply contracts. The PPA charges and the revenues from the sale of exported excess generation used in the commercial model should be validated. This is a complicated field and ESC procured the services of Local Partnerships to provide advice to the applicable districts, such as Oldham.

A further explanation of PPAs is provided in the 'Detailed Design of Short-Term Renewable Generation Business Models' deliverable.

7.4. Commercial model results

An example of the main output for a sleeved PPA is illustrated in Figure 7-7 . It shows the total PPA price which includes the price components paid to the generator, namely power price and REGO (blue), as well as, the fees charged by the supplier, consisting of sleeving costs (red), and the Policy and Network costs (green). Since the total PPA price is lower than the retail price curve (dashed) the project generate savings. By using the innovative revenue model (sleeved PPA) several of the renewable generation projects would be viable with less or no grant funding.

The Catapult provided commercial modelling for various WS1 sites which were all effectively one of two business model types: 'Site Optimisation' or 'Sleeved PPAs'. In both instances the LA is both the generator and the consumer; primarily getting value by displacing grid electricity imports for their sites and some additional revenue from exporting the surplus; the low prices available for selling electricity to the network (at the scale of these projects) favoured these arrangements. Some of the benefit of 'site optimisation' arises from avoiding network charges and levies that are applied to the volume of electricity consumed. Avoiding such charges has wider society implications and the opportunity to do so may change because of policy reform, described in Section 10.1. This does not apply to the sleeved PPAs as the charges still apply. Rather the LAs were able to set a price that pays back the asset and provides savings for their sites, particularly in periods of high energy prices. The reduced exposure to high and volatile retail prices has generated financial value for the LAs.

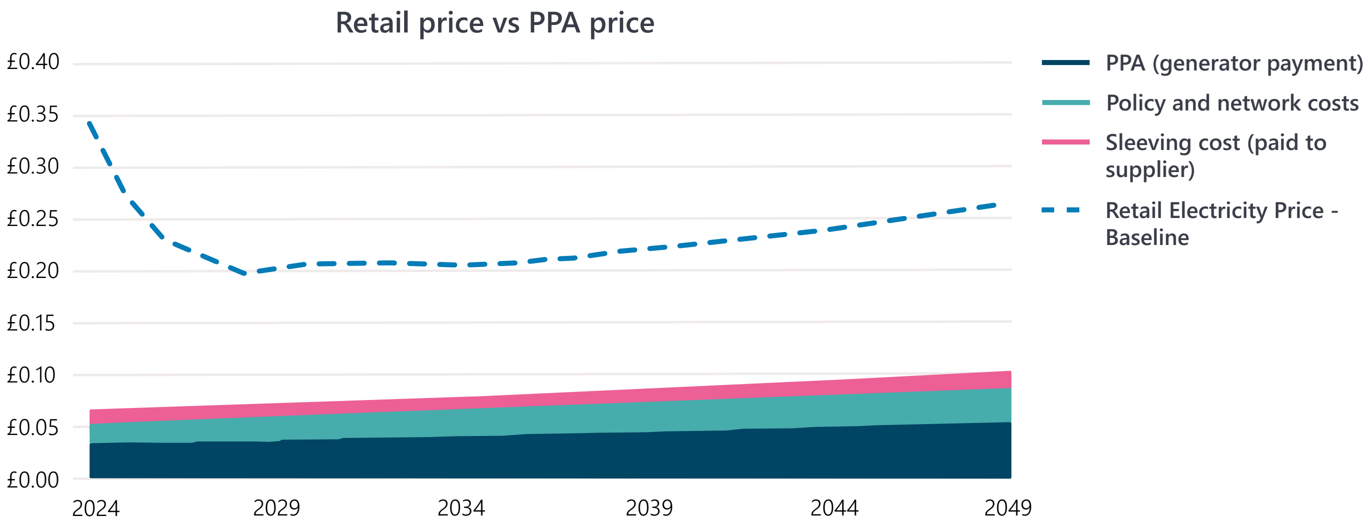


Figure 7-7: Commercial model results: forecasted PPA fees compared to forecasted retail electricity price.

The commercial model used the price data available at the time of the modelling for various inputs (e.g. electricity retail prices, PPA management fees, policy charges, loan interest rates). It is important that users of the commercial model or its outputs check and update the inputs based on the current market conditions, and the prices agreed in any contracts.

7.5. Further work - value of battery storage

There were several enquiries from districts about the value of battery storage along with the renewable generation.

Within the time and resource available it has not been possible to acquire the required information from potential suppliers and re-run the commercial models to understand the business case impact. The dynamic modelling undertaken by Cornwall Insight explored the potential value of batteries at different sites. This is described in Section 11.4. There is merit in further work to develop further guidance and insights for local authorities.

Further desk-based research has been undertaken to understand the different options (e.g. revenue sharing) for the merchant battery flexibility services (see Section 6.3.1.3).

There may be additional benefits such as reducing the imbalance (volume) risk which will offer an advantage when negotiating with a PPA supplier (see Section 6.5.1.1).

8 PROCUREMENT

8.1. The need

There are opportunities for local authorities to improve commercial viability for future renewable generation assets through robust procurement practices, by both obtaining competitive prices for equipment and services and by avoiding delays. However, this is reliant on there being the right resources to develop practices that will make a positive impact.

Within UCEGM ESC contracted Procur3d Consulting Ltd and Local Partnerships to support the WS1 partners with procurement. This support broadly fell into the following categories:

- Design (Procur3d Consulting Ltd) – support the procurement of multiple renewable energy capital works projects.
- Supply (Local Partnerships) – supporting key procurement activities through good practice including procurement of the energy supply contracts.

Working closely with the WS1 partners throughout the project highlighted key insights into the challenges, and potential opportunities local authorities have when procuring energy services.

8.2. The context

It is important to recognise that each of the local authorities operate as individual organisations despite their geographical proximity. Their approach to delivery varied significantly due to their needs but also the situation they operated within such as the length of their energy supply contract for example.

The individual nature of the required support caused Local Partnerships and Procur3d Consulting Ltd to tailor their offering to the need. However, there were commonalities in the context when it came to procurement.; this included:

- Availability of staff from key functions (e.g. finance and legal) needed for efficient procurement varied across the districts.
- Trade and import challenges, war in Ukraine, Covid exacerbated the global demand and logistical challenges.

8.3. Design

Whilst there are several approaches to delivering solar projects, three of the most commonly used have been detailed below:

- Design, build and manage – the client procures a supplier to engineer, procure, install and manage the asset.
- Design and build – client undertakes early stage design then upon completion procures a supplier to engineer, procure, and install.
- Build only – client undertakes the full design before procuring a supplier to install the scheme.

Robust planning and thorough analysis of delivery capabilities should be taken into account when choosing a delivery method.

8.3.1. Manufacturer direct engagement

Depending on the delivery model chosen, there is an opportunity for local authorities to procure solar PV equipment directly from manufacturers.

From interviewing several stakeholders in the space the following key lessons have been identified:

- Early equipment procurement – global demand and logistical challenges mean that securing equipment needed early should be of the utmost importance.
- When deciding on a delivery approach, public procurement regulations, minimum order values and the impact on scheme appetite by the EPC/Installer market should be taken in to consideration.

8.3.2. Installers

Demand

Demand for solar projects in UK is soaring putting significant pressure on installers. When combined with competing with the private sector that are not constrained by public sector procurement regulations securing installers is increasingly difficult.

Local authorities must make their projects more attractive to installers; with the following recommended:

- Undertake early engagement with the supply chain to optimise the project's delivery model and identify opportunities to share the risk.
- Aggregating demand and/or demonstrating repeat work through pro-active pipeline management.
- Innovation opportunities, increased cashflow, creation of strategic partnerships may all make the opportunity more attractive to suppliers.

Tendering

Some suppliers have concerns about tendering for public sector contracts, there were several common themes including inadequate tender periods and an influx of solar related public sector frameworks amongst others.

Local authorities must make steps to adapt commercial strategies to address suppliers' concerns; recommendations to assist include:

- Carefully analyse pre-existing routes to market rather than assume new frameworks are required.
- Market engagement prior to the tender event will ensure the market has the chance to organise so the tender timeline can be met.
- The evaluation model must be balanced and assess the tendering burden against the opportunity value.
- Sufficient project site information is included (should be informed by the early supplier engagement).

8.3.3. Key recommendations

There are opportunities for local authorities to improve the business case for their solar generation asset by seeking maximum value through procurement. To unlock this value the following key recommendations were considered:

- Project packaging strategies – local authorities have the opportunity to aggregate needs and seek economies of scale. While this could be done through multiple schemes within the same local authorities there is the opportunity to collaborate with neighbouring local authorities.
- Regular market engagement – ensuring key stakeholders are aware of upcoming opportunities and creating a continuous feedback loop will help to inform early stage design, scope and commercial strategy.
- Improving the quality of tender information – attracting interest on tenders is paramount to success. Improving the quality of information for example through early site investigation.

8.4. Supply

Local Partnerships were contracted by ESC to identify opportunities where the business case for renewable generation projects could be improved through robust procurement.

The support generally fell between two key areas:

- Tailored support – WS1 gave Local Partnerships the opportunity to work with the partners to understand some of the contract related challenges that local authorities face when delivering renewable generation assets.

- Energy Supply Guidance – The purpose of the guidance is to help councils consider how energy is procured and managed within a challenging economic environment.

8.4.1. Tailored support

Working with the WS1 partners, and other stakeholders within their network, Local Partnerships offered support in key considerations when renegotiating energy contracts. Whilst each LA had slightly different needs there were commonalities that should be considered.

It was clear that having a better understanding of energy consumption across the portfolio of council assets is essential to maximise the effectiveness of generation assets.

The WS1 partners had varying obligations to utilise preferred procurement frameworks. There are many benefits to utilising these frameworks including speed and having a track record of delivery. However, maintaining a regular dialogue with the suppliers or procuring organisations can unlock additional benefits including advice on when to go to market and how to package requirements (which is of interest if exploring PPAs etc.).

The remaining contract length between LA and energy supplier varied across the different WS1 partners. This greatly affected how local authorities approached choosing a business model to operate their asset, having these conversations with energy suppliers as early as possible is advised.

8.4.2. Energy supply guidance

From working with both WS1 partners, and their wider network, Local Partnerships identified two key areas where LAs should consider placing onus.

Forecasting

Reliable forecasting plays a critical role in how LAs manage their energy. An Energy Manager must understand both the current demand profile and forecast requirements to prevent from over committing energy spend or adversely, setting the requirement too low.

Whilst delivering WS1 it became apparent that energy efficiency projects were underway that would drastically alter the demand profile for the building and affect the business case. This is a risk that Energy Managers have to be aware of when developing demand and generation profiles for proposed generation assets – having any changes tested within the Commercial Model will show the impact of the change.

Local Partnerships developed a **Forecasting Tool** that has been designed to better forecast energy consumption and achieve better energy efficiency.

Energy Management Policy

Having an Energy Management Policy helps to support council decisions, and indeed Energy Managers or the person(s) undertaking that role. This should be clearly communicated to employees and be given the same level of importance other key policies such as environmental and equality & diversity.

It is important that an Energy Management Policy is kept up to date and should clearly link to other LA policies and strategies. Whilst not an exhaustive list the following should be considered:

- Climate Leadership
- Energy security and resilience
- Value for money
- Procurement/commissioning approach
- Asset management

8. PROCUREMENT

What to incorporate	Issues for consideration
Purpose	* Key drivers (i.e. budgetary certainty / hedging against future price rises / supplier robustness / resilience)
Executive ownership	* Internal senior sponsorship
Targets, baselining, benchmarking, monitoring and reporting	* Targets / KPIs in place * Regularity of reviews * Ability to demonstrate value for money
Energy sources / Contracts	* Pricing strategy * Services required * Diversity and flexibility of supply * Access to renewable energy tariffs * Review of existing assets and income * Opportunities to increase local generation * Understanding trading volumes to assess product offers
Efficiency	* Targets for energy efficiency / carbon reduction * Review of existing assets and opportunities assessment
Decarbonisation	* Priority for low carbon and renewable sources
Staffing and resources	* Internal vs external resource requirements * Brokerage vs in-house assessment * Governance arrangements for reviewing policies and procedures

Figure 8-1: Example structure - Energy Management Policy

It is often assumed that price is the main driver for how energy is managed, recent geopolitical events causing unprecedented increases in the wholesale market prices have done little to counter this argument. However, one positive is that the increasing cost has made business cases for energy related projects such as lighting upgrades and heating moving from gas to electricity a priority for some. With these projects impacting the LA's energy forecast it is essential that consideration is given to how these changes may also affect the business case for renewable assets.

Whilst energy price is still an important driver it is important to note that price is not the only driver particularly for local authorities. The geopolitical events causing increases in cost have also highlighted the necessity of local resilience and security of supply. Again, depending on the key items for consideration from the Energy Management Policy, this could have a bearing on the projects that are progressed from feasibility. Ensuring that key stakeholders are not only aware but actively support the Energy Management Policy is essential. This is also true for agreed net zero targets that the LA has.

9 FINANCE

9.1. The need

Grant funding provides local authorities a good route to raising capital to fund renewable generation assets but there are risks involved. Tight deadlines and additional requirements from the funding body responsible for the grant give local authorities less optionality for how they deliver, procure and energise their asset.

To reduce the dependency on grant funding it is necessary for local authorities to find alternative means of financing renewable generation assets.

The report highlights that there are good opportunities outside of grant funding for local authorities.

9.2. Routes to finance

Cornwall Insight were sub-contracted by ESC to identify routes to raising finance that were available to local authorities. Understanding the deliverability, risks and payback periods formed a key part of the shortlisting criteria.

Once shortlisted, Cornwall Insight held sessions with Workstream 1 partners and other stakeholders within their network to evaluate their effectiveness for local authorities. Whilst the evaluation covered how suitable the routes to finance were for local authorities, also considered were how the shortlisted routes to finance complemented the identified business models and the impact of potential policy changes. From this evaluation, four preferred methods were identified:

- Public Works Loan Board (PWLB)
- Crowdfunding
- UK Infrastructure Bank

9.2.1. Public Works Loan Board

From the evaluation of the routes to finance there was a clear favourable option, Public Works Loan Board (PWLB).

PWLB is a low cost, high flexibility and easy to access source of funding. It is Cornwall Insight's opinion that local authorities should strongly consider it as their default option for financing their renewable energy ambitions.

The process for securing funds through PWLB is a comparatively straightforward process with internal approvals causing the most challenge. Developing a robust finance section on a business case will be needed to gain consent from the relevant local authority's Section 151 Officer.

Whilst PWLB has many benefits, local authorities all have borrowing limits and with capital costs rising their ability to take on more debt to fund developments may be reduced. Figure 9-1 below illustrates borrowing limits vs total borrowed to date from the Treasury Management Strategy Statements.

Local Authority	Stated capital adequacy limit	Total borrowing
Greater Manchester Combined Authority	£2,800mn	£1,500mn
Manchester City Council	£2,000mn	£800mn
Rochdale Borough Council	£730mn	£540mn
Salford City Council	£1,200mn	£780mn
Stockport Metropolitan Borough Council	£920mn	£920mn

Figure 9-1: Capital Adequacy of UCEGM LAs for 2022-23

There are potential barriers to delivery though PWLB validated with local authorities both within UCEGM and beyond. In particular:

- Prohibition on investing for yield – although Cornwall Insight were confident that this wouldn't be a barrier for the WS1 projects.

- Capital adequacy / existing debt – special purpose vehicles may mitigate this risk as detailed in Section 6.4.
- Uncertainty on project returns and investment term.

9.2.2. Crowdfunding

It is important to note that whilst financial viability of the asset is of course a key factor in the approval process for the business case, there are other factors that are considered.

Validation sessions with stakeholders have shown that social or community benefits can provide impact that can't be financially evaluated. For these are opportunities there may be a potential to seek a Crowdfunding arrangement to raising finance.

9.2.3. UK Infrastructure Bank

UK Infrastructure Bank (UKIB) offers loans for capital projects owned by local authorities. The funding focusses on five strands clean energy, transport, digital, waste and water.

It is important to note that projects must be at least £5mn in size to qualify for the loan but can offer a slight discount to PWLB rates. Because of this, none of the WS1 projects would have been eligible for the funding.

However, during discussions with UKIB there was an enthusiasm to work with LAs or groups of LAs to deliver financing to portfolios of assets. There may be an opportunity for the LAs within WS1 and beyond to consider a joint submission.

9.3. Alignment with business models

ESC identified four business models that were shortlisted for local authorities:

- Sleeved PPA
- Private wire
- Site optimisation & storage
- Solar carports

These business models have the potential to significantly improve the business case for renewable generation assets. However, how this works together with the financial considerations of the route to capital is key to the success of the business case.

Cornwall Insight considered each of the routes to raising finance combined with the business models against the following categories:

- Revenue level
- Revenue stability
- Risks
- Payback period

Figure 9-2 illustrates how PWLB and Crowdfunding scored against the evaluation criteria:

	Sleeved PPA	Private Wire	Storage	Solar Carports
PWLB	High - where finance offers are comfortable with investment over asset lifetime rather than looking for swift payback	High - where finance offers are comfortable with investment over asset lifetime rather than looking for swift payback	Mid / High - higher risks but shorter paybacks	Mid / Low - revenues from EVs currently too uncertain, though other offtakers could stabilise the case
Crowdfunding	Mid - community unlikely to understand the business model, but will accept. Can deliver easier than financing routes with high due diligence	Mid / High - community more likely to understand the model. Higher revenues more likely to cover higher crowdfunding costs	Mid - higher risk, but higher returns benefit crowdfunders. Less likely to understand business model but more likely to accept due to higher returns available	High - adds an implicit community benefit and may allow rewards for local EV drivers or enable local EV take-up, which other models do not support

Figure 9-2: Summary of financial and business model considerations (excluding UKIB because of the need for projects to be £5mn in size)

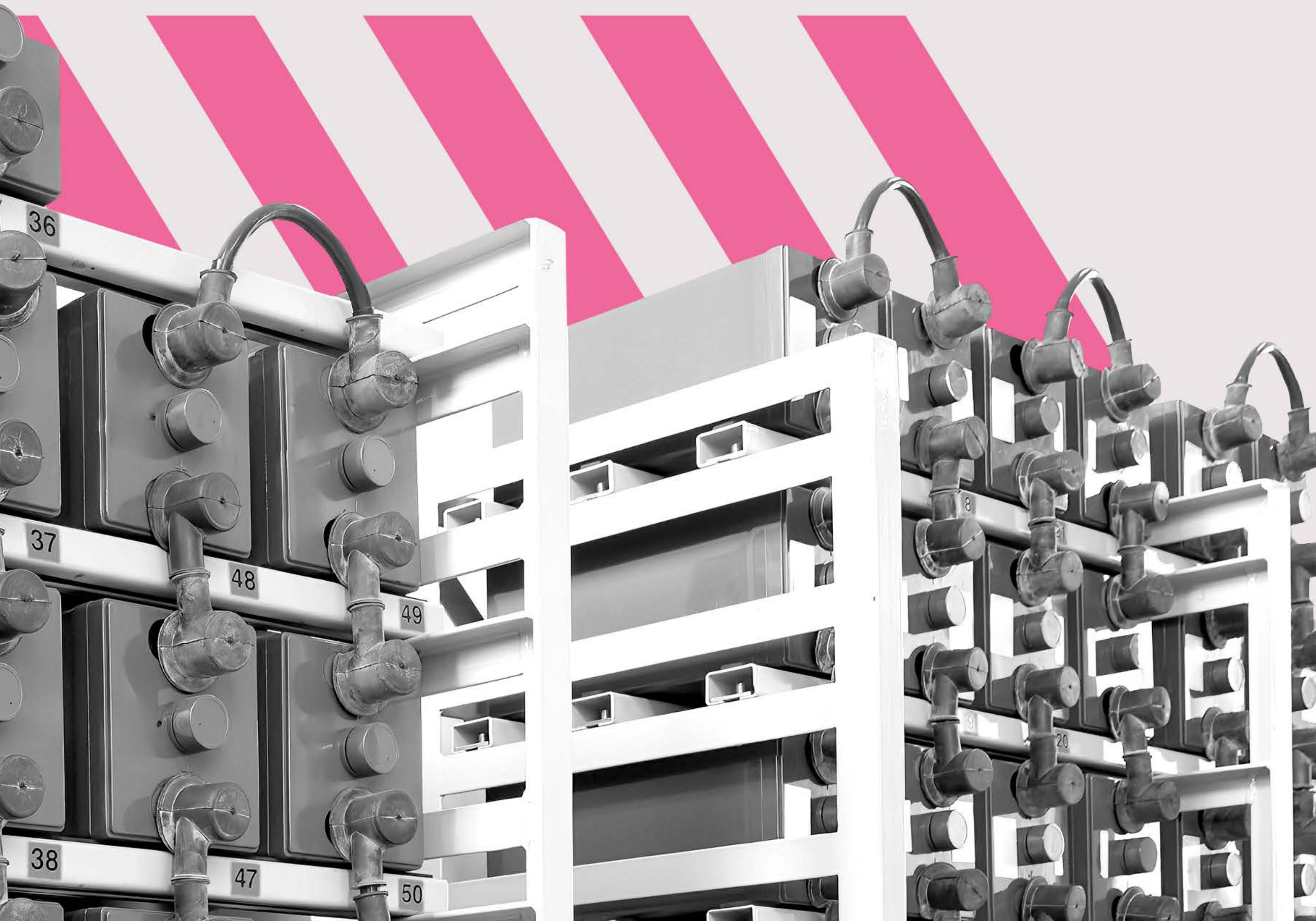
9.4. Project structuring and location

Local authorities have certain opportunities when developing their renewable generation portfolio.

In terms of raising finance, the holding structure of assets can have significant impacts on the costs of capital and the ways in which local authorities will look to access finance. Many local authorities have found that the private sector practice of establishing one or more asset-specific Special Purpose Vehicles (SPVs) a useful tool.

Geographical location of renewable generation assets can provide challenges for local authorities. Several local authorities noted that they intended to develop renewable generation assets only within their areas. Given the urbanised nature of much of the Greater Manchester region, this does restrict the opportunities for developing renewable generation on a large scale. This has significant impact when choosing a potential route to finance. For example UKIB would not likely invest in assets generating <5MW. Local authorities should use the 'drivers' for building the asset to inform which finance option is most suitable, if there are additional community benefits perhaps a Crowding approach would be best.

10 FUTURE ELECTRICITY MARKETS AND SYSTEMS



From this point forwards the focus is on future local energy systems (the physical systems, the markets, and regulations) and their implications for local renewable generation projects.

10.1. The current landscape of reform

There are a range of future market scenarios and accompanying policy and regulatory environments that may emerge in the coming years during the transition to net zero. The disparate initiatives discussed here are linked to the issue that location increasingly matters as we transition to a net zero carbon electricity system. So it is reasonable to expect that future electricity market arrangements will be characterised by greater locational differentiation, although exactly how that differentiation would be achieved is not yet known. It could be through any (combination) of these:

- The wholesale electricity market - e.g. introduction of LMP; or
- Reforms to transmission and/or distribution use-of-system charges; and/or
- Procurement of local flexibility by the DNO; and/or
- More central planning by the FSO and Regional System Planners

The implication for LA-led low carbon projects is that there can no longer be a presumption that a renewables project is necessarily desirable in any location. The kind of assets and projects that will be most viable will change by location, e.g. due to local electricity system characteristics.

There are already various policy and regulatory reform developments occurring, the outcomes of which could hold major ramifications for the commercial viability of future business models. In recent years, numerous policy and strategy documents[14] have repeatedly highlighted the inadequacies of the current system and associated market structures to meet the challenges of decarbonisation, whilst at the same time stressing the importance of unlocking innovations at the local level i.e. Local Authority and Distribution levels.

Perhaps the most notable of recent reforms has been the government's launch of the Review of Electricity Market Arrangements (REMA)[15] in 2022. REMA has set out the government's case for change in electricity market design and has highlighted numerous options on the table with regards to reforms of the wholesale market, increasing adoption of mass low carbon power, flexibility, capacity adequacy, and operability. These options are wide ranging in their implications for Local Authority business models seeking to increase renewable generation deployment.

Of note are the options which could increase the locational granularity of signals market actors are exposed to such as nodal/ locational marginal pricing (LMP).

At the same time, the government is working on a refresh of its energy retail strategy, considering a set of issues that are separate to those covered by REMA, including consumer protection, retail market sustainability and financial resilience, as well as new business models and services that could support net zero.

In addition to wholesale and retail market reforms, network charges design and allocation will also hold important implications for renewable generation development. Ofgem launched and concluded some major aspects of network charges regulation seeking to ensure fairer allocation of network costs. The Targeted Charging

[14] For example, see: Energy White Paper (2020); Ten Point Plan for a Green Industrial Revolution (2020); Smart Systems and Flexibility Plan (2021); British Energy Security Strategy (2022); Review of Electricity Market Arrangements (2022); Future of Distributed Flexibility call for input (2022).

[15] https://www.gov.uk/government/consultations/review-of-electricity-market-arrangements

Review (TCR)[16] and Access and Forward-looking Charges (AFLC)[17] Significant Code Reviews focused mostly on residual charges, reinforcement costs and access rights. Whilst this is expected to lead to generators facing reduced initial connection costs and greater certainty regarding curtailment limits from April 2023 onwards, other notable aspects of network charge allocation that could hold importance for local generation and flexibility propositions are continuing to be worked through via the TNUoS Taskforce[18] and DUoS Significant Code Review[19]. Of particular note includes potential alterations to how demand and generation are treated (including at different capacity sizing and voltage levels), and Ofgem's desire to better "level the playing field" could lead to certain sized generators exposed to charges they previously were not expected to contribute to.[20] However, the outcomes of these reviews are uncertain and will likely be heavily influenced by wider policy decisions.

There are also major reforms underway regarding the governance and operational nature of various aspects of the energy system at the national and local levels. Government is currently legislating for a new Independent System Operator and Planner (also known as the Future System Operator) to build on the work of the existing capabilities and functions of the Electricity System Operator whilst being required to act in a way that best achieves the three objectives of 'net-zero', 'security of supply' and 'efficiency and economy'.[21] At the same time, Ofgem has launched a review into the effectiveness of institutional and governance arrangements at a sub-national level to support delivery of net zero at least cost, and the case for alternative approaches.[22] Such a review is exploring the current and future energy system functions needed at the local level including: energy system planning; market facilitation of flexible resources; and real time operation of local energy networks. This has led to preliminary proposals to introduce new Regional System Planners; assign a market facilitation function to a single entity to deliver more accessible, transparent and coordinated flexibility markets; and keep real time operations within the DNOs.

At the same time, Ofgem has launched a review of The Future of Distributed Flexibility[23], exploring different archetypes for a common digital energy infrastructure that can overcome the noted market failures and blockers to unlocking distributed flexibility. This is expected to potentially accelerate and supersede the work of the Energy Networks Association (ENA) Open Networks programme which has been seeking to advance various aspects of market development, network operation, and planning/development of networks.[24]

The nature of how distributed generation is treated in relation to the charges it is exposed to, the types of markets it will be able to access, and the different signals for investment are all likely to evolve over the coming years. All of this highlights the rapid pace and scale of reforms that have emerged in recent years of which Local Authorities will need to take into consideration when designing and adapting their business models.

[16] https://www.ofgem.gov.uk/publications/targeted-charging-review-decision-and-impact-assessment

[17] https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-decision-and-direction

[18] https://www.ofgem.gov.uk/publications/tnuos-task-forces

[19] https://www.ofgem.gov.uk/publications/distribution-use-system-charges-significant-code-review-launch

[20] See Ofgem's minded-to positions on the Access and Forward-looking charges SCR

[21] https://www.gov.uk/government/publications/energy-security-bill-factsheets

[22] https://www.ofgem.gov.uk/publications/consultation-future-local-energy-institutions-and-governance

[23] https://www.ofgem.gov.uk/publications/call-input-future-distributed-flexibility

[24] https://www.energynetworks.org/creating-tomorrows-networks/open-networks/

10.2. Future market scenarios

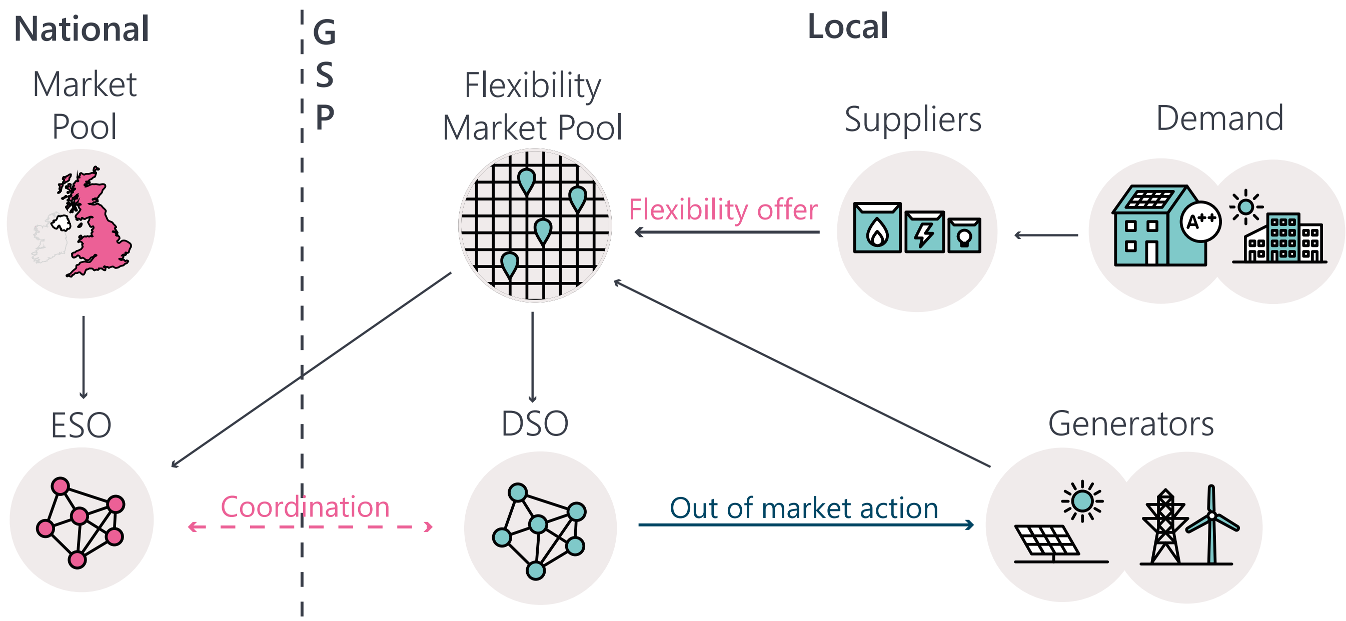


Figure 9.2a: High level overview of the current market and infrastructure layout, illustrating a national market.

Given the fact that there are a variety of pathways on the journey to net zero that the Local Authority assets within the Greater Manchester area could be exposed to, the UCEGM project sought to explore three main market scenarios: Enhanced National Market Design; Locational Marginal Pricing; and Local Energy Markets.

The ***Enhanced National Market Design*** was largely based on today's market arrangements with assumptions around how it will develop over the coming years with minor reforms.

A ***Locational Marginal Pricing*** scenario (also known as Nodal Pricing) takes into account market clearing prices in several local areas on the electricity transmission system, known as nodes. The price of electricity is calculated based on local energy value which would include production of the electricity and the cost to transport it. This would differ significantly from the current energy market where a singular national wholesale price is set by the market. This option has been promoted by ESC[25] and other institutions such as NGESO[26] as a favourable option for reform and is one of the options for consideration within REMA. LMP is determined by constraint boundaries and could save a significant amount of money on system operation as generation is only dispatched if the capacity on the constraint boundary exists. A high-level overview on LMP is provided in figures 9.2b and 9.2c below.

[25] https://es.catapult.org.uk/project/rethinking-electricity-markets/

[26] https://www.nationalgrideso.com/document/268781/download

"Nodal Pricing" scenario - Wholesale + transmission balancing

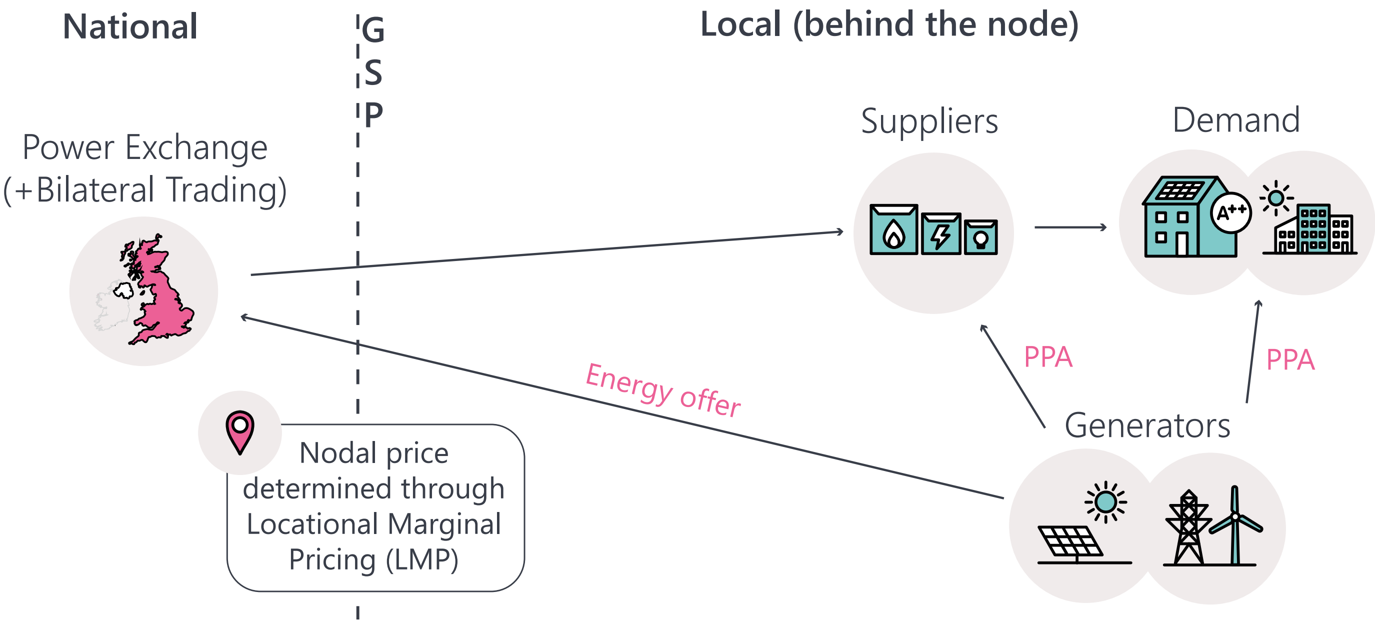


Figure 9.2b: Overview on LMP illustrating how the National Exchange is on the other side of a Grid Supply Point, which are normally clustered in areas of constraints.

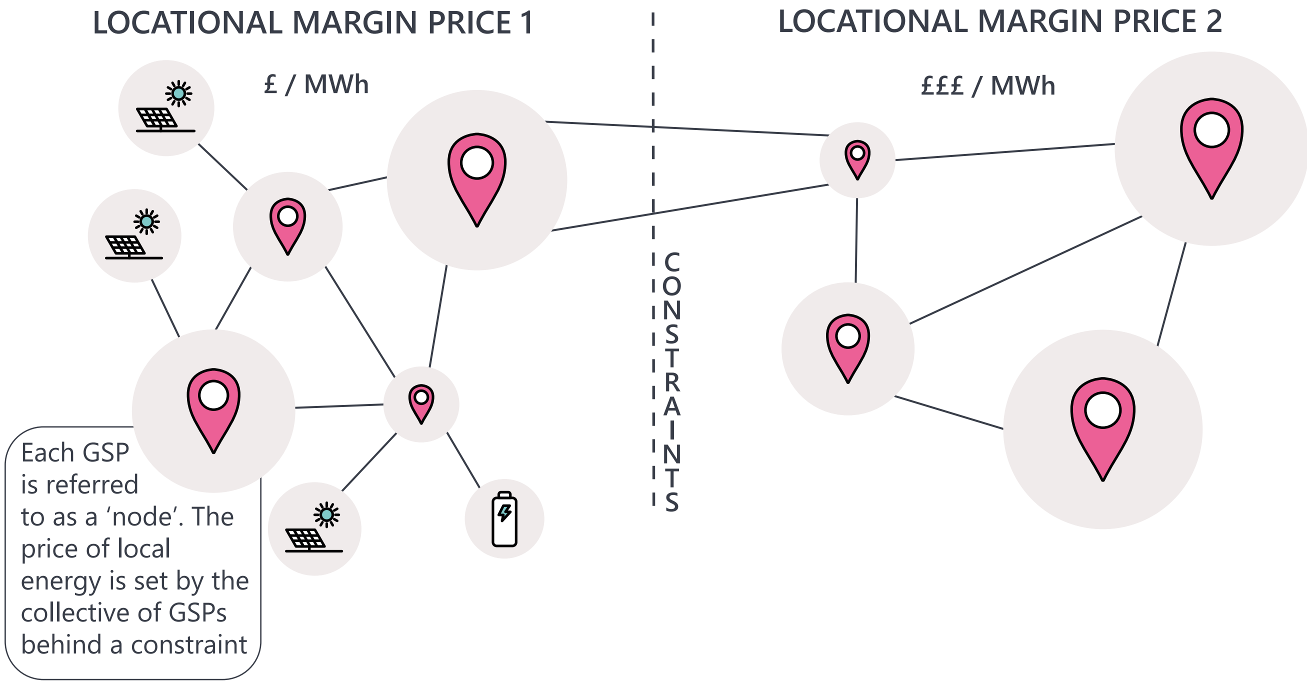


Figure 9.2c: The markers represent multiple grid supply points (GSPs) with a transmission constraint illustrated by the dotted line in the middle. Price of electricity is cheaper on the node with more generation capacity relative to demand, when the constraint applies

A ***Local Energy Market (LEM)*** is designed for local use and allowing further flexibility for producers and consumers of electricity to choose where they buy and sell energy, which could function under the Enhanced National Market Design or a Nodal pricing scenario. A Local Energy Market is intended to provide local communities with an additional market they could participate in as well as enhancing participation of consumers on the transition to Net Zero.

Below is a high-level overview of an LEM which illustrates the function of a trading platform and the use of exchanges for the transfer of information needed to facilitate the LEM. There are also potential benefits to the Distribution System Operator (DSO) where the local network may be managed more efficiently, minimising constraints, and unlocking capacity with the LEM allowing this to be facilitated.

Greater Manchester Combined Authority are focusing on the development of a Local Energy Market known as the GMLEM. More of which can be read about here.

When analysing alternative market structures and business models, it should be noted these alternative markets could change significantly in the future, therefore the analysis has been carried out with a mind to assess plausible market designs - focusing on the key differences between the three designs rather than the variants each design could carry.

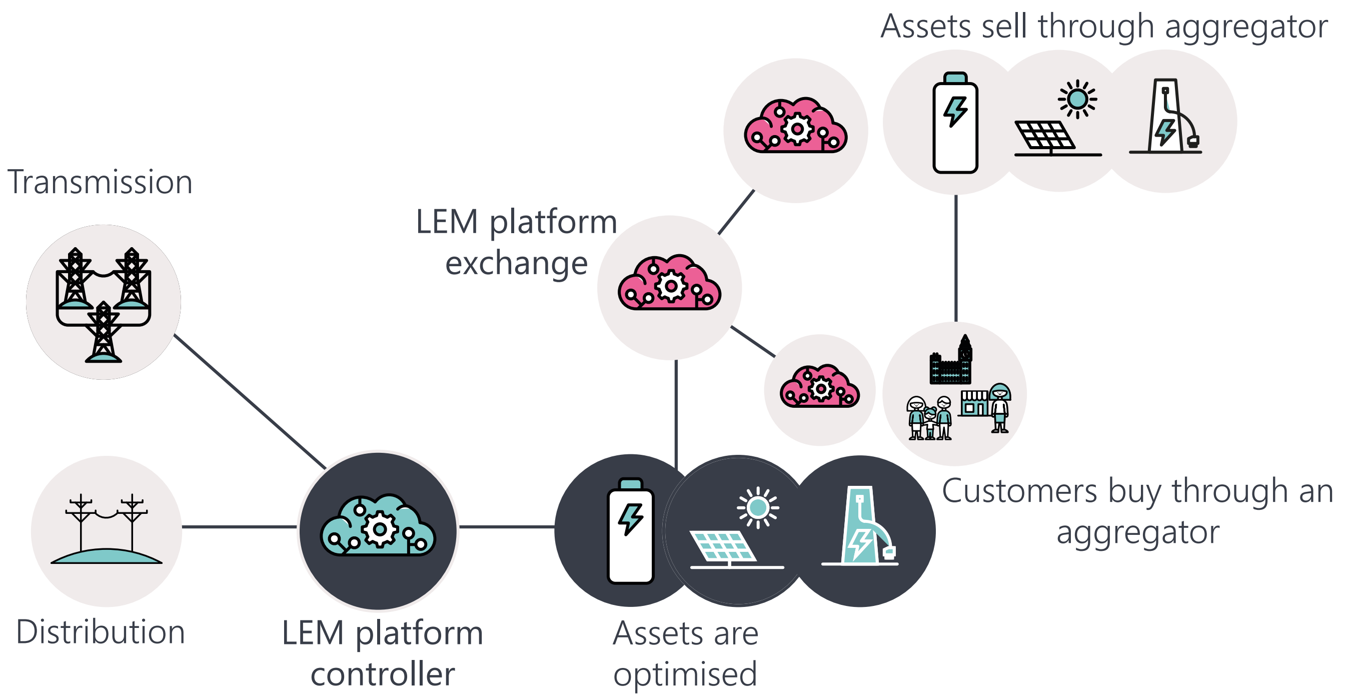


Figure 9.2d: Overview of a Local Energy Market showing how consumers, producers and aggregators could be structured.

11 DYNAMIC MODELLING / SIMULATION OF FUTURE STATE

11. DYNAMIC MODELLING/SIMULATION OF FUTURE STATE

11.1. The need

The energy system is likely to change over the course of the renewable asset lifetime. How these changes will affect the operation of the asset and the business models is unclear. Section 10.2 described three potential market scenarios (Enhanced National Market Design, Locational Marginal Pricing, and Local Energy Markets) that are being considered. **Means to perform an impact assessment of these potential future market changes on key business metrics, to better understand the risks and opportunities for their investments, is beneficial to local authorities and other stakeholders of the local energy system.**

11.2. The solution

ESC procured dynamic energy system modelling to understand the financial viability of the business models. Cornwall Insight were appointed through a competitive tender to conduct the work.

An additional scenario for a Split Wholesale Market was added by Cornwall Insight to the scope of work since this is being considered by government in the REMA process in response to the current energy crisis. This explores the consequences of a potential splitting of the wholesale electricity price for renewable generation from other generation.

A decision was taken with Cornwall Insight to not model a Local Energy Market as a unique scenario as the modelled dynamic system behaviour would be similar to that of a locational marginal pricing. Cornwall Insight also simulated the effects with a local power market option, which passed power through to other local users with savings on non-commodity costs.

11.2.1. The model architecture

The analysis uses a set of linked models:

- The existing Cornwall Insight **benchmark power curve (BPC)**, which generates wholesale electricity price forecasts.
- A national **Location marginal price (LMP) model** that determines the price of electricity at the GB grid supply points across the transmission system. In the LMP future scenario this is used to set the electricity prices at the boundary between the Electricity North West Limited (ENWL) distribution system and the national transmission system.
- A **local electricity distribution system model** (in PLEXOS™) that contains the grid supply points, sub-stations, line characteristics, generator characteristics and the electricity demand for the GMCA region.
- A **Power BI dashboard** to view the results via a python interface.

11.2.2. The inputs

The modelling uses a comprehensive set of inputs that include:

- National Grid line model information (e.g., impedances, ratings of the lines in MW)
- Grid transformer ratings for both DNO and National Grid levels
- DNO distribution system data (line and sub-station characteristics)
- DNO long term development statement
- UCEGM Details of the Work Stream 1 projects (location, generation, and demand)
- UCEGM Location and electricity usage data for the council owned sites.
- ESO National (infrastructure) development statement (10 year)
- ESO Future Energy Scenarios (FES) and DNO DFES to understand future electricity demand scenarios.
- Cornwall Insight Wholesale energy prices in the national market scenario

- Cornwall Insight Third party cost forecasts (network, policy, and supply). The GMCA region was treated as in the middle band for consumption and generation and charges were treated the same across scenarios. The TNUoS cost is expected to continue at a similar level in the region.
- Generation and demand data for the local area
- Details of vehicle fleet sizes at a sample of depots and estimates of electrification rates and charging loads
- Sample wind and solar factors
- Electric vehicle demand predictions

11.2.3. The method

The modelling method comprises several stages.

Initially modelling is done at a national level to generate wholesale price curves and to establish non-commodity costs (third party charges) for each of the future market scenarios. This provides the electricity prices at the grid supply points (GSPs) that supply the GMCA area.

At the local GMCA level, a set of demand and generation (load) curves are developed with a particular focus on the relevant estates of the UCEGM partner districts. The local network and constraints are geographically mapped in the model. The locations for generation and demand are then added to the model and associated with the sub-stations using their addresses.

The model then uses an optimiser to determine how the generation is dispatched to supply the demand considering:

- Local network constraints
- User (offtaker) costs
- Generation profits
- Storage revenues

National modelling

The national modelling calculates the most economic deployment of imports through interconnectors, the dispatch from generators and when to use storage, to ensure the supply matches the demand.

In the **Enhanced National Market Design** market scenario the model determines the most expensive generator that needs dispatching to meet the demand, each hour, which sets the hourly national wholesale price for electricity. The average annual wholesale prices are illustrated below in Figure 11-1.

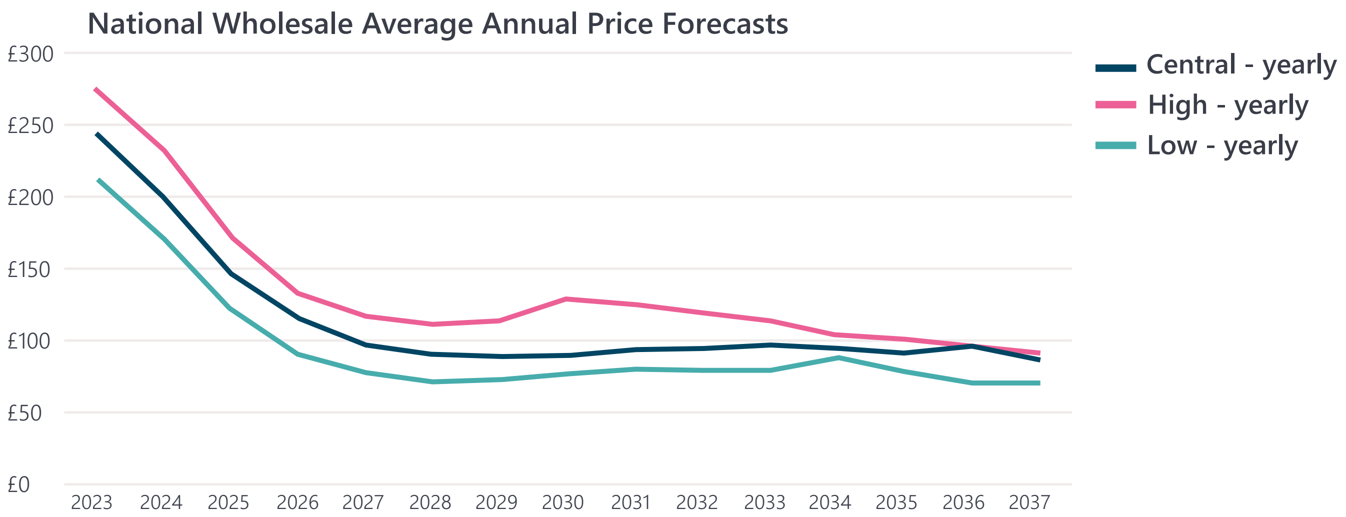


Figure 11-1: National average wholesale electricity prices

11. DYNAMIC MODELLING/SIMULATION OF FUTURE STATE

In the **LMP market scenario** the price of electricity is calculated based on local energy value which also includes the cost to transport it. Figure 11-2 is an illustration from Cornwall Insight of how wholesale electricity prices may vary across the GB under a LMP market scenario based on the average nodal price within the 27 TNUoS generation zones at a specific point in time. Blue shading indicates lower costs; amber / red indicates higher costs. For UCEGM the LMP model granularity is down to the grid supply points (GSP) to provide indicative price differentials that may occur around the GMCA region.

In the **split wholesale market scenario** the model determines the marginal levelised cost of energy (LCOE) for renewables and a national wholesale price for non-renewables (dispatchable generation). The consumer would pay a blend of split & national price, depending on how their consumption matches with renewable generation.

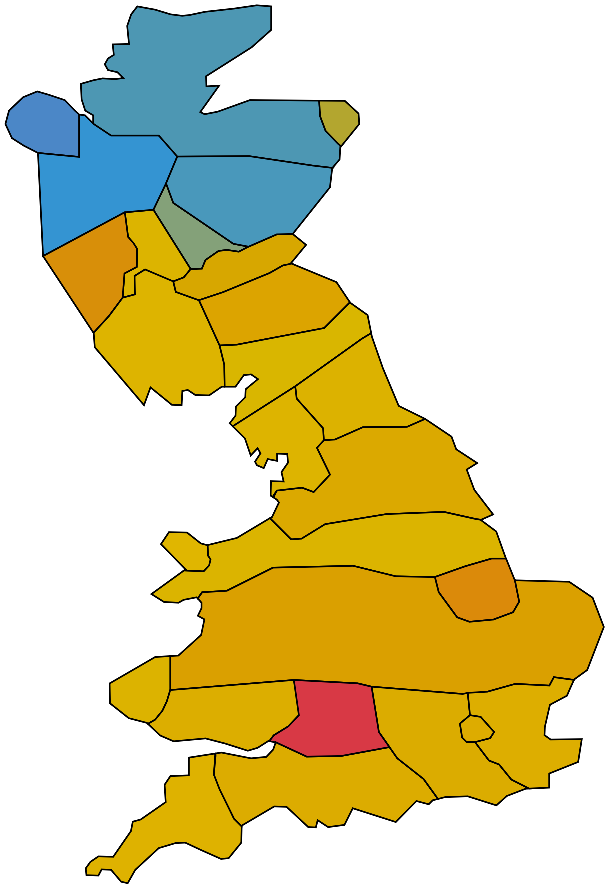


Figure 11-2: LMP illustration (Cornwall Insight UCEGM report)

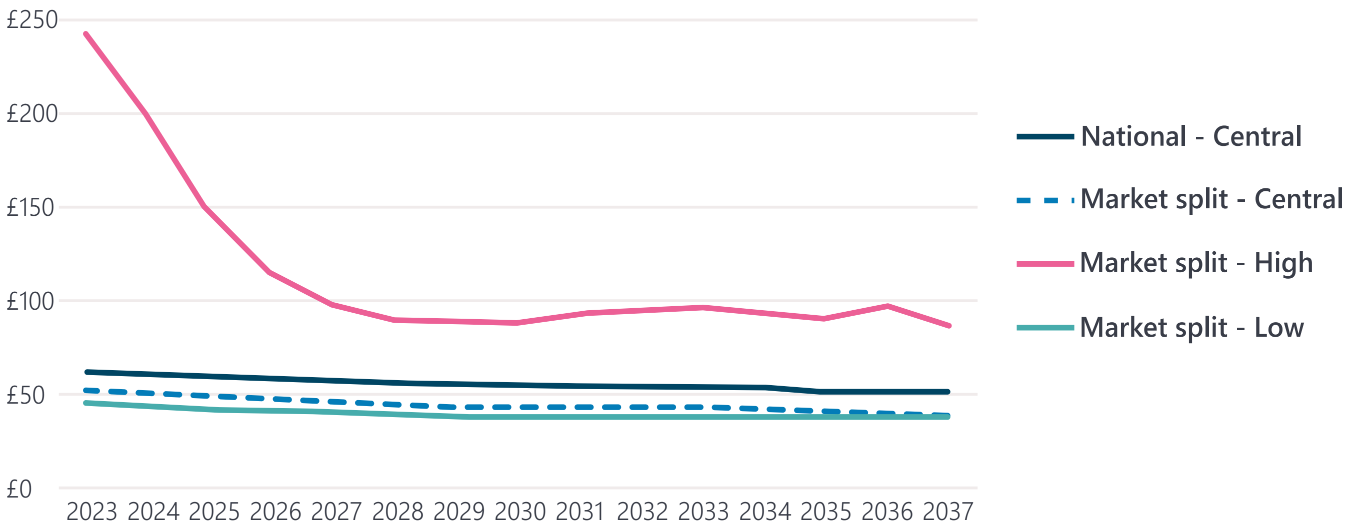


Figure 11-3: Annual average split wholesale price forecasts – source: Cornwall Insight modelling.

Figure 11-5 shows the variation of prices under a LMP market scenario at the different GSPs that supply the GMCA region. In the near term the current energy crisis is creating a spread of prices. One of the causes are the differences in the mix of generation types connected to each of the GSPs. **Towards the end of the period shown in the graph one starts to see two trends. Firstly the prices begin to rise again, this is due to ongoing electrification (increased demand) and the lack of information currently available about future energy asset development (e.g. transmission/distribution grid build) beyond the early 2030's. Secondly the spread in the prices starts to increase, this is due to an increasing mismatch between local demand and the generation that is available (subject to the network constraints). This is because of the limitations of the data available for the modelling in later years, not a feature of LMP market design. In both cases additional system changes will be required (e.g. investments in flexible demand, transmission infrastructure, or new generation and storage), which would reduce these affects.** Please note that this graph also indicates seasonal variation in prices, which is averaged out in the previous two graphs.

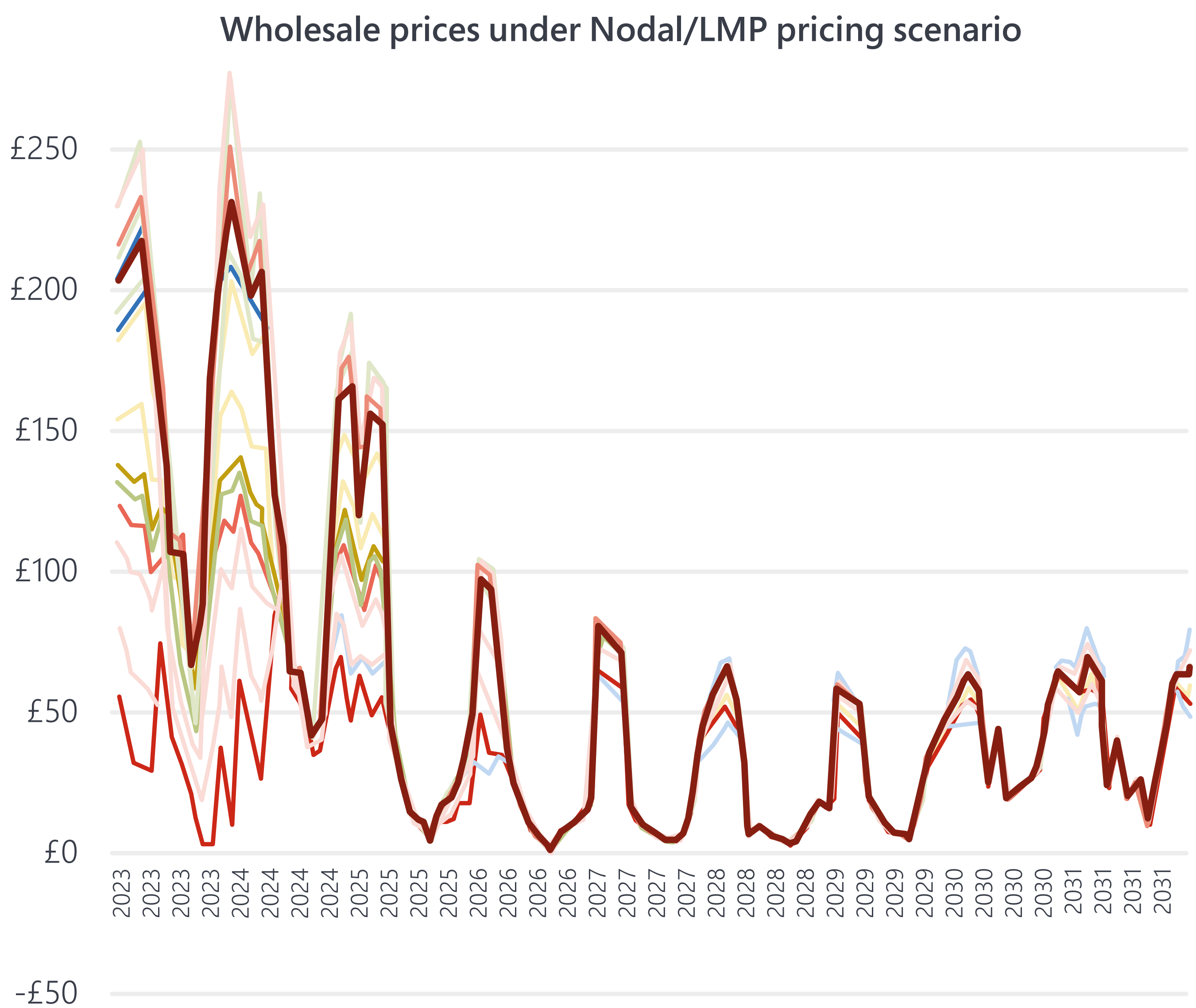


Figure 11-5: average nodal (GSP) prices under LMP

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Local modelling

The GMCA network was modelled based on the reporting by the local distribution network operator (DNO), Electricity North West Limited (ENWL). It includes information from ENWL's longer term development statement, and information regarding the expected locational growth of demand using sources such as the ENWL (DNO) DFES.

The transmission and distribution substations and the cables were mapped across the region. The hourly demand was mapped to each sub-station and the model finds the optimum means of meeting the demand using the available generation, within the system constraints.

The network is shown in Figure 11-6. The capacity of the lines is represented by the thickness. The loading is represented by the colour (blue lines representing lower and red lines representing higher levels of constraint). One can see that the transmission system is mostly ring-based, while the distribution system is radial.

In addition to the loading and capacity constraints, the model provides a range of metrics for the local energy system. As an example, the model shows the average spread between the daily low and high electricity power prices at each of the nodes, and variation in future years. **This indicates potential opportunities for battery storage due to network constraints.**

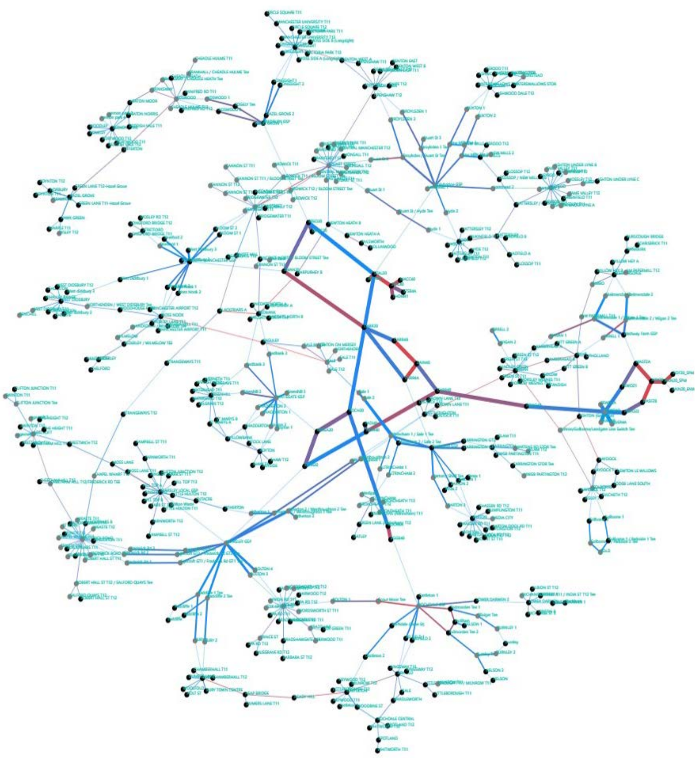

Figure 11-6: GMCA network model

It should be noted that these are average prices and hourly prices will have greater variation. This and other metrics are discussed in the context of different stakeholders in the results Section 11.4.

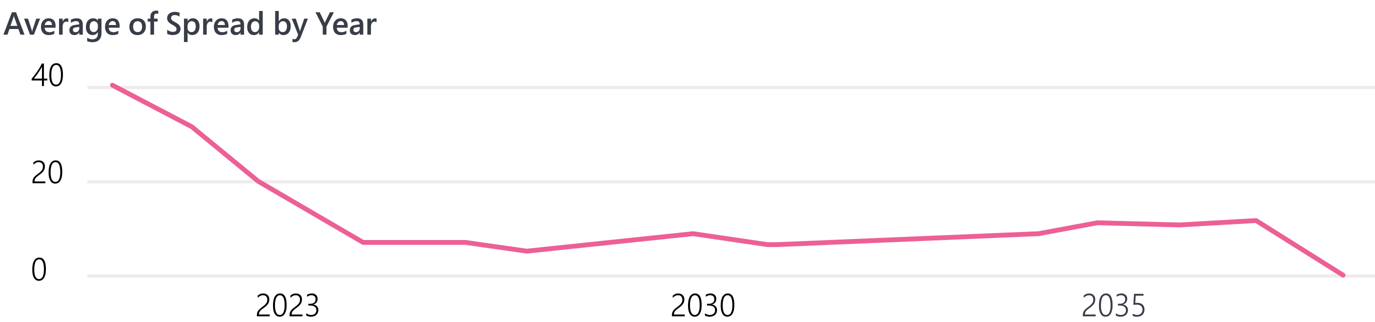

Figure 11-7: Example of electricity annual average price spread

11.3. The assumptions and limitations

Due to the uncertainties associated with modelling future states of the energy system, care should be taken to not rely overly on the absolute values from the model, but rather to look at the relative differences and trends. Some important examples of uncertainty and potential error are described below.

1. Long term national development statements go out to 10 years. Beyond that the electricity system becomes more constrained due to on-going electrification, but there are no further details of national infrastructure investment to alleviate those constraints. It is reasonable to expect some level of further investment, but that could not be captured in the modelling owing to a lack of suitable forecast.
2. The model includes details of local energy projects (generation and storge) that are currently planned, but as one goes out to further timescales, beyond 2030 no further new build is assumed in the model as one would have to make decisions as to where these would be built, which is out of scope.
3. The model assumes the location of generation and storage remains as per current plans/expectations, whereas less conservative assumptions would expect a certain level of locational siting optimisation in response to price signals.
4. The national electricity prices are based on the Cornwall Insight Power Benchmark Curve (PBC), which in turn uses a levelised cost of energy (LCOE) model. These contain several assumptions about the future such as capital cost assumptions, how much new generation is built, and at what rate.
5. Nuclear generation is only assumed at existing sites. If SMRs were deployed in industrial areas then they would change the prices, particularly under LMP, due to the certainty of the generation.
6. Half hourly metered data (electricity usage) was provided by some of the districts for their buildings. For some districts ESC had annual consumption data which CI applied standard half hour profiles too.
7. Electrical vehicle demand is based on where people live today (i.e. no new major housing developments).
8. No major hydrogen development in the region (which would increase electricity demand) due to electrolysis needs.
9. The summary data has been aggregated / averaged for each month for ease of use. However by losing hourly granularity it is harder to understand the underlying reasons for the results, which can necessitate using the original dynamic model.

In general this means that energy price predictions from the model become even more uncertain beyond 2033.

11.4. The results

It should be noted that these results are based on an initial analysis. The dynamic model has generated a large amount of data, which could be analysed further depending on stakeholder needs. The model is an economic model that optimises value for the renewable generation assets (sites) within the market and regulatory conditions.

11.4.1. Key observations

These are the main observations from the model results as contained in the Cornwall Insight Report summary:

1. "The results of Locational Marginal Pricing are particularly interesting, with short term pricing and long-term pricing dependent on GSP [Grid Supply Point] to a much greater extent than we would have expected. [It should be noted that the representation of LMP in the model may not reflect a future implementation].

- This is due in the short term largely to whether the GSP is more gas linked or renewables linked.
- In the long term, this is due to increasing constraints on the network as demand grows past the planned transmission reinforcements."

2. "The network map created shows several key points of constraint. These include at the boundaries of Greater Manchester, where imports may require upgrades to the transmission network, and some internal constraints including core areas of Rochdale, Wigan and Staylbridge."

3. "We [Cornwall Insight] also note that some of the example sites used to model generation and consumption may not be appropriately sited or sized: in particular, the Swinton Road depot site sees EV charging consumption much larger than can be sustained by the local network" [This is based on the depot fleet size and an assumed rate of electrification (conversion to EVs) – that may differ in practice, but does show how such a model can highlight potential concerns and the need for integrated planning between stakeholders].

In addition the modelling has shown:

4. Under LMP electricity prices were more volatile, but on average lower, which reduces generator revenues but reduces bills for consumers. The prices also reveal constrained regions of the network, which can inform decisions on where reinforcements are most valuable.

5. The installation of batteries appears to have the greatest benefit at the ground solar sites. This is because there are no on-site, behind the meter, loads that the solar could alternatively supply, which would create additional value for site owners by not incurring policy and network charges (Section 10.1 discusses the wider implications and applicable policy reform). Co-location of batteries may also reduce connection charges and land costs. Batteries added some value to most of the sites, but it was noticeable at one site, as modelled, that very high network constraints would prevent effective operation. Alternative solutions may need to be investigated.

11.4.2. Workstream 1 projects

The dynamic model contains a representation of various workstream 1 renewable generation assets. The modelling has examined how their performance is affected by the following variables:

- Changes in the energy market arrangements (i.e. current markets, LMP, split wholesale markets).

- Changes in the physical electricity system (demand, supply, constraints) over-time (between 2025 and 2030). For this summary 2025 has been chosen as a possible date by which markets may become less volatile and 2030 has been chosen as after this there is less certainty about infrastructure developments. The scope is illustrated in Figure 11-8 below. The full set of results are discussed in the **Cornwall Insight report**. For this summary the 2025 results (without batteries) have been used as a reference case and the other results are compared to this as percentage changes.

- Changes in battery size (all 2 hr batteries with the power varied between half, equal to and double the installed solar PV generation power).

- Different electricity wholesale price scenarios (high, central, and low). Although this summary only considers the central scenario for simplicity.

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Central Scenario

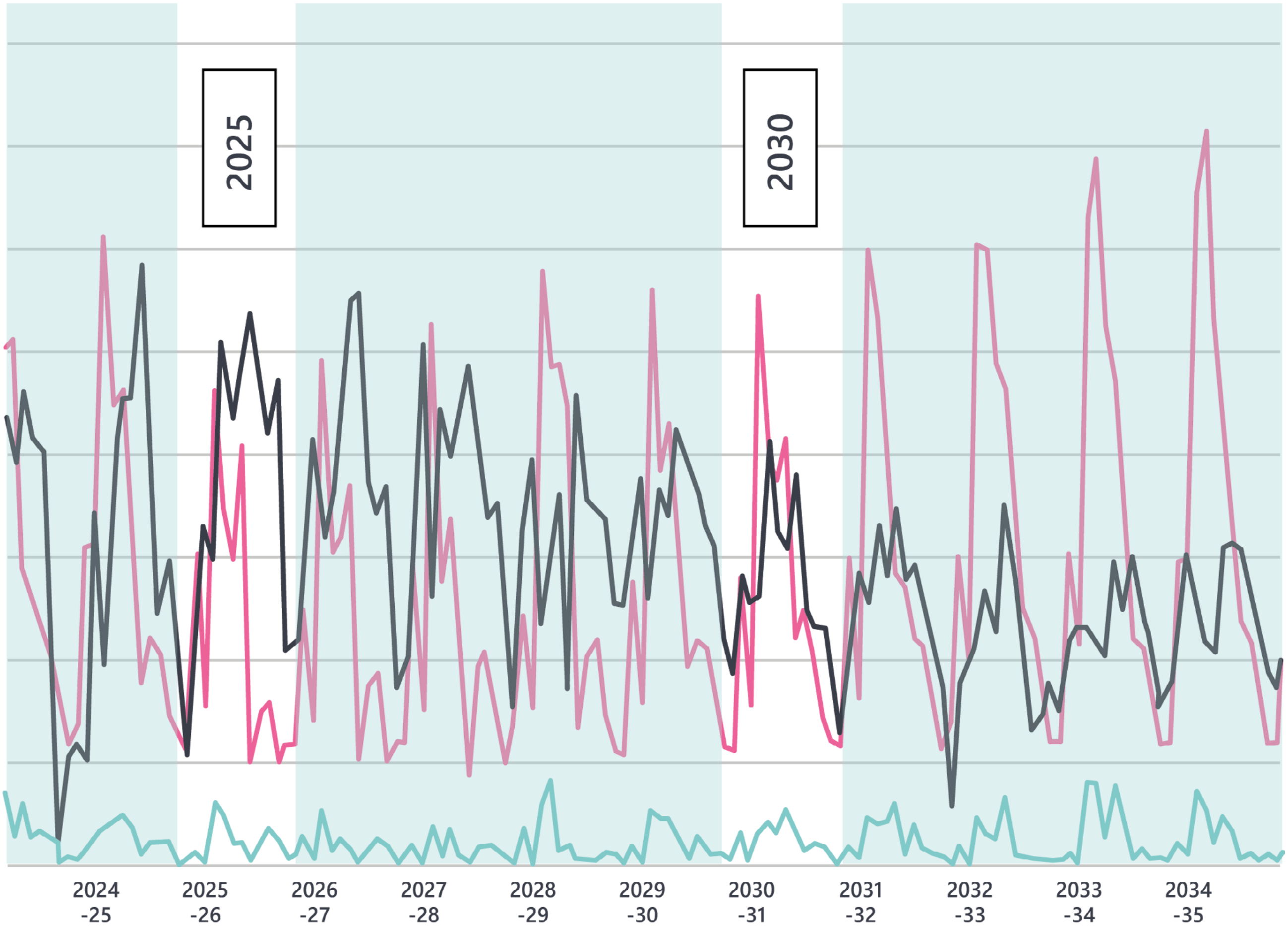

Figure 11-8: Scope of dynamic model results for summary analysis (illustrative only)

A further explanation of how the modelling works and how the results are generated is provided in **Dynamic Modelling report** completed by Cornwall Insights.

Implementation of batteries at WS1 sites

The installation of batteries of different sizes at these sites has been simulated to explore the how these might affect the system operation and revenues. Based on the electricity prices the model optimises the value from the battery through either price arbitrage (buying at low price and exporting at higher price) or to improve self-consumption (time-shifting the surplus supply to meet demand). The model shows how prices vary daily at each of the nodes.

In a split wholesale market the batteries tend to import at the split price and export at the dispatchable power price. The decisions (and hence the results) are not too dissimilar to the National market scenario. Hence these results are omitted for simplicity and only LMP and National market scenario results are shown.

It should be noted that the model does not include any revenues from ESO and DSO services and the Cornwall Insight report states "ESO service revenues (e.g., from Dynamic Containment) are in the process of falling rapidly. They are forecast to make up under 1% of the revenue stack over the lifetime of a battery. DSO service revenues are short-term, locational, and highly uncertain. The LMP scenario provides a proxy for these values." As discussed in the policy reform Section 10.1 OFGEM is looking to standardise and scale this up, so the value of DSO services may well rise in the future. The LMP scenario provides a proxy for ESO service revenues as prices are set at the

GSP level, but not for the DSO services which relate to lower voltage system constraints.

The presence of batteries in the model is not a reflection of the assets currently under development.

Metrics for WS1 sites

The modelling provides metrics regarding:

- the amount of electricity generated,
- the amount of self-consumption (to satisfy site loads);
- the amount of electricity exported to the grid.
- the amount of electricity imported from the gird; and
- the associated value (price) for each of these and hence the revenues and costs.
- $C0_2$ reduction

For this report 6 sites have been chosen that provide 2 examples for each of the following renewable generation asset archetypes that are associated with different business models:

Renewable generation type	Associated business model(s)
Ground Solar	PPA
Chamber House Farm	
Kenyon Way	
Roof top solar	Self-Consumption and Export (Behind the meter)
Robin Park	
Grand Central	
Solar Carport with EV charging	Solar carport
Swinton Road	
Turnpike Lane	

Table 11-1: Sites for dynamic modelling

Without EV charging, the Solar Carports are (for the purposes of the model) the same as a rooftop solar, supplying the site loads. Therefore to gain additional learning a decision was taken to include EV charging and assume a progressive electrification of the known vehicle fleets at the depots.

Within this report the high-level findings are presented, for more detail see the **Cornwall Insight report.**

Due to the uncertainties associated with modelling future states of the energy system care should be taken to not rely overly on the absolute values from the model, but rather to look at the relative differences and trends. Therefore the results below are shown as percentage changes relative to a baseline case (2025, Enhanced National Market Design – National Pricing, No Battery).

11.4.3. Ground solar sites

Chamber House

This ground solar generation site is in Rochdale and is expected to have a power of approximately 5.5MWp. No on-site demand (behind the meter) is included rather the electricity is exported to the grid and could potentially be sleeved into the energy supply contract for the district's sites. The export revenues column only reflects the value that the electricity system puts on the exports. Without an on-site load there are no additional cost-avoidance opportunities from grid imported electricity (including third party costs).

Market scenario impact: The table below illustrates the relative impact of the different market scenarios if they were implemented in 2025 (no batteries).

Market	Volume Exported	Export Revenues
2025 reference case – no battery		
National (CDT)	100%	100%
Potential market scenarios in 2025		
LMP	63% (-37%)	25% (-75%)
Split wholesale	100% (0%)	37% (-63%)

Table 11-2: Chamber House - Market scenario impact

11. DYNAMIC MODELLING/SIMULATION OF FUTURE STATE

The model indicates that this region is un-constrained (network capacity) and that the demand is relatively low compared to the supply; power can flow freely to local demand users. Hence under a LMP scenario prices are low and there is no consumption to increase demand and prices from generation at this site, which is effectively economically constrained.

Under the Split wholesale market scenario the price paid to renewable generators is set centrally and is lower than the current National market price as there is no-longer an up-lift from dispatchable generation. Since the prices are national there is no economic constraint and volumes remain constant as there are no local physical constraints that necessitate curtailment.

Physical system change impact: The table below illustrates the relative impact of system changes between 2025 and 2030.

Market	Volume Exported	Export Revenues
2025 reference case – no battery		
National (CDT)	100%	100%
2030 – no battery		
National (CDT)	100% (0%)	59% (-41%)
LMP	75% (-25%)	26% (-74%)
Split wholesale	100% (0%)	34% (-66%)

Table 11-3: Chamber House – physical system impact

Between 2025 and 2030 the model includes increases in demand in the region that reflects the DNO DFES (e.g. more electric vehicles, more heat pumps), but no increases at the specific district owned sites. The model also includes the energisation of any new generation assets (including batteries) in the region. Wholesale prices are forecast by Cornwall Insight to fall during this period; this is largely a partial normalisation from current very high levels. Under LMP the demand for electricity from this site appears to increase by 12% compared to the LMP scenario in 2025 (see previous table), but the reduction in prices means there is very little increase in revenues.

Battery impact: The impact of adding a 2-hour battery with a power rating equal to the solar PV is shown below (for Chamber house this equates to a 5.5MWp battery, with 2 hours capacity i.e. 11MWh). In this instance the Volume exported is equivalent to exports from the solar generation plus exports from the battery. The battery may choose to import from the grid if there is a price arbitrage opportunity (i.e. the price differential is sufficient to offset incurring network and policy costs).

Market	Volume Exported	Export Revenues
2025 reference case – no battery		
National (CDT)	100%	100%
2025 – equal sized battery		
National (CDT)	166% (+66%)	129% (+29%)
LMP	152% (+52%)	45% (-55%)
2030 – equal sized battery		
National (CDT)	147% (+47%)	77% (-23%)
LMP	139% (+39%)	35% (-65%)

Table 11-4: Chamber House - battery impact

Relative to the reference case without a battery one can see that the exports are greater as the battery is importing from the grid as there are price arbitrage opportunities. The net site revenue has improved because of the price differentials, but not as much as Little Hulton, this is in part because the network is unconstrained and power flows freely, reducing the value and price available to batteries.

The model also generates an approximate value for additional CO_2 (kg) reduction by including batteries at the site. The batteries are charged by solar and displace electricity that would generally be supplied by dispatchable generation (e.g. gas-powered generation).

The reduction is based on an hourly national electricity system carbon intensity, rather than a local calculation.

The CO_2 reduction is affected by how the battery is operated, which is in turn influenced by the physical system and market arrangements. The model indicated an additional CO_2 reduction for installing an equal sized battery (5.5MWp) in 2025 under the central LMP scenario of about 33,500kg/annum and reduced to about 14,600kg by 2030 due to the changing mix of planned generation supplying the region. This compares to reductions of 125,300kg (2025) and 38,000kg (2030) under the central national scenario.

These figures are based on how much of the solar generation at the site is used to charge the battery (without losses) and an average value for carbon intensity of grid electricity in each month of the year. Again it should be emphasised that the model is simplistic, and one should not focus on the absolute values. **The main points are that co-located batteries can provide additional C02 reductions, that decline over time and are sensitive to how the battery operates (e.g. in response to price signals).**

Little Hulton

This ground solar generation site is in Salford and is expected to have a power of approximately 2.5MWp. The model indicates that this region is in a more constrained area (relative to Chamber House). No on-site load (behind the meter) is included rather the electricity is exported to the grid and could potentially be sleeved into the energy supply contract for the district's sites. The export revenues column only reflects the value that the electricity system puts on the exports. Without an on-site load there are no additional revenues from avoiding imports, which include third party costs.

Market scenario impact: The table below illustrates the relative impact of the different market scenarios if those were implemented in 2025 (no batteries).

Market	Volume Exported	Export Revenues
2025 reference case – no battery		
National (CDT)	100%	100%
Potential market scenarios in 2025		
LMP	96% (-4%)	26% (-74%)
Split wholesale	100% (0%)	37% (-63%)

Table 11-5: Little Hulton - Market scenario impact

Compared to Chamber House the volumes exported under LMP remain high, potentially because constraints in this region initially give this distributed generation asset an advantage (i.e. can supply demand, avoiding some constraints).

Physical system change impact: The table below illustrates the relative impact of system changes between 2025 and 2030.

Market	Volume Exported	Export Revenues
2025 reference case – no battery		
National (CDT)	100%	100%
2030 – no battery		
National (CDT)	96% (-4%)	57% (-43%)
LMP	81% (-19%)	24% (-76%)
Split wholesale	97% (-3%)	32% (-68%)

Table 11-6: Little Hulton – physical system impact

At Little Hulton one can see that the volumes of electricity exported reduce across the market scenarios between 2025 and 2030. This location is more physically constrained (network capacity) than Chamber House in the model. As demand and generation increase the lack of network capacity may lead to greater curtailment. This becomes more pronounced if one looks at later years (e.g. 2035) but may not manifest depending on further network investment. The **Cornwall Insight dynamic modelling report** contains further detail, including graphs, that help illustrate this system behaviour. The revenues are also further impacted by the reducing wholesale prices.

Battery impact: The impact of adding a 2-hour battery with a power rating equal to the solar PV is shown below. In this instance the Volume exported is equivalent to exports from the solar generation plus exports from the battery. The battery may choose to import from the grid if there is a price arbitrage opportunity.

Market	Volume Exported	Export Revenues
2025 reference case – no battery		
National (CDT)	100%	100%
2025 – equal sized battery		
National (CDT)	166% (+66%)	129% (+29%)
LMP	186% (+86%)	46% (-54%)
2030 – equal sized battery		
National (CDT)	166% (+66%)	105% (+5%)
LMP	197% (+97%)	61% (-39%)

Table 11-7: Little Hulton – battery impact

The relative change in the volumes exported have increased by more than Chamber house, under LMP, this is perhaps due to the region being more constrained and seeing a bigger spread in prices, which increases the value of price arbitrage. The battery helps address the constraints by storing more solar, which can be released later. However those constraints can, if they continue to worsen beyond 2030, have a negative effect as the battery may not be able to operate effectively (e.g. may not be able to buy and sell energy at the best price, since the network cannot accommodate the required energy flows). This is illustrated in the graphs within the Cornwall Insight report. The model indicated an additional CO_2 reduction for installing an equal sized battery (2.5MWp) in 2025 under the central LMP scenario of about 39,300kg/annum and reduced to about 14,800kg by 2030 due to the changing mix of planned generation supplying the region. This compares to reductions of 57,400kg (2025) and 16,500kg (2030) under the central national scenario.

OBSERVATIONS

The constraints at the second site arise due to behaviour in the wider electricity system rather than the site itself. This indicates that the site is less likely to have liability for reinforcement charges (under the current rules).

Some level of constraint in the network appears to be beneficial for these local generation assets as the generation assets may provide additional system value by relieving the constraints. However excessive constraint will impact efficient operation. Understanding how constraints may develop is complex; more strategic engagement with DNOs should bring net system benefits.

Revenues from generation alone (no storage) reduce over time, particularly under the LMP scenario. **It should be noted that lower prices will generally be beneficial to districts and help reduce the cost of electrifying heat or transport.**

There are factors that may improve the value of such sites to the districts:

- If the network is constrained and experiences a wide price spread, then batteries can improve the revenues. The benefit needs assessing against the additional costs.
- Co-locating batteries and generation has advantages in terms of land and connection costs.
- If the local node (sub-station) is not constrained, then supplying a local demand may be less constrained.
- Depending on the retail price for the electricity supply to the district's buildings sleeving the power may improve the value by reducing import costs. The presence of a battery may provide additional benefits for a sleeving arrangement such as reducing the imbalance risk, which will be advantageous when negotiating with a PPA supplier.

11.4.4. Rooftop solar

The main objective of these sites is to supply on-site electrical loads, displacing imports from the networks. This offers a higher marginal value (to the site owners) for power than exporting power to the networks. Any excess generation will be sold to the networks. **The model assumes that excess is exported at the current wholesale price (this reflects the value to the network). In practice the price obtained will reflect the business model and the contractual arrangements.**

Robin Park

This site is a leisure centre in Wigan with an on-site electricity load (demand) of around 666MWh annually and a roof-top solar installation of around 280kWp as modelled. Despite the monthly average demand being relatively high compared to the monthly average yield the self-consumption is not as high as one may first expect. The leisure centre has a relatively flat demand throughout the day that starts early in the morning and ends late in the evening (a battery and/or demand side response may improve the alignment). At its peak, the solar PV output exceeds the on-site demand during the day during summer months.

Market scenario impact: As modelled this site still imports much of its electricity from the grid as the solar PV yield is not a large percentage of the total demand. There is limited surplus to export from this site. In the LMP scenario we see import costs reduce significantly (by 29%), and the net site costs reduce by a smaller amount as the price received for exported electricity drops under this scenario too. The 19% drop in export volumes under LMP reflects a 10MWh difference, which may be more a reflection of the model accuracy at this scale of site.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case				
National (CDT)	100%	100%	100%	100%
Potential market scenarios in 2025				
LMP	81% (-19%)	25% (-75%)	82% (-18%)	71% (-29%)
Split wholesale	100%	100%	100%	100%

Table 11-8: Robin Park – Market Scenario impact

* This is a combination of revenues from exporting electricity to the network or avoiding costs from imports. **The import costs reflect the costs of procuring electricity from the network to meet onsite loads that cannot be satisfied by the solar generation.

Physical system change impact: The on-site electricity demands are not modelled as changing over this period. This location on the distribution network has little local constraint, which doesn't appear to change significantly between 2025 and 2030, so the system is able to work efficiently. The wider changes to the electricity system and the reducing costs of electricity over this period are reflected in the changes to the revenues and import costs.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2030 – no battery				
National (CDT)	100%	100%	72% (-28%)	70% (-40%)
LMP	95% (-5%)	101% (+1%)	65% (-35%)	58% (-42%)
Split wholesale	100%	100%	72% (-28%)	70% (-30%)

Table 11-9: Robin Park – physical system impact

Batteries impact: The impact of adding a 2-hour battery with a power rating equal to the solar PV is shown below. The exports directly from the solar PV to the grid reduce across all scenarios as most of the surplus solar PV generation is used to charge the batteries. The batteries are further charged during periods when import prices are lower. The battery is effectively being used to optimise self-consumption and take advantage of system price differentials. Under the LMP scenario exports are lower than under the national scenario, because prices are lower and the site is choosing to self-consume more. The net site costs are reduced significantly through the presence of the battery across the scenarios.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2025 – equal sized battery				
National (CDT)	57% (-43%)	105% (+5%)	58% (-42%)	107% (+7%)
LMP	36% (-64%)	98% (-2%)	50% (-50%)	70% (-30%)
2030 – equal sized battery				
National (CDT)	38%	101%	46%	72%
LMP	15%	95%	42%	57%

Table 11-10: Robin Park – battery impact

Grand Central

Grand Central is a leisure centre in Stockport with an on-site electricity load (demand) of around 146MWh annually and a roof-top solar installation of around 210kWp as modelled. The size of the solar PV installation relative to the load is bigger than the previous example site (Robin Park). The demand profile is similar in shape to Robin Park; this and the relatively large solar installation means that a higher % of the generated electricity is exported to the network (63% without batteries). Grand Central is in a more constrained region of the network relative to Robin Park, this leads to a greater spread in LMP energy prices (during a day and across seasons), which can increase export income for batteries.

Market scenario impact: Since this site exports a high percentage of the solar PV power the site, as modelled, generates a net profit under the baseline national scenario in 2025. **To realise this value for this roof-top solar site would require a contract to sell the exported electricity to the grid at the market price. The volumes are likely to be less attractive than a larger site, which may be reflected in the price obtained.** Under the LMP scenario the price paid for exports and imports both drop. As stated above, the solar generation is large relative to the demand. By volume the site exports more than it imports and under the national price scenario (higher prices) the site sees a small net revenue (in the model). Under LMP the grid electricity prices are lower, particularly when the solar is generating. The site now experiences a net cost for electricity rather than a revenue, hence the negative figure. In absolute terms the changes are not large. It should be noted that the site, as modelled, cannot do much to physically change its export and import volumes.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case				
National (CDT)	100%	100%	100%	100%
Potential market scenarios in 2025				
LMP	95% (-5%)	101% (+1%)	-24% (-124%)	66% (-34%)
Split wholesale	100%	100%	100%	100%

Table 11-11: Grand Central – Market Scenario impact

* This is a combination of revenues from exporting electricity to the network or avoiding costs from imports. **The import costs reflect the costs of procuring electricity from the

network to meet onsite loads that cannot be satisfied by the solar generation.

Physical system change impact: At this site the modelling does not show any significant change in the export and import volumes between 2025 and 2030. The revenues / savings and the import costs do reduce over this period based on the electricity cost forecasts.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2030 – no battery				
National (CDT)	100%	100%	49% (-51%)	70% (-30%)
LMP	100%	100%	-6% (-106%)	55% (-45%)
Split wholesale	100%	100%	49% (-51%)	70% (-30%)

Table 11-12: Grand Central – physical system impact

Batteries impact: Across the scenarios and over time (2025 to 2030) the model shows a battery at this site being used to increase self-consumption of the solar PV power from around 37% to around 60%. The battery is also importing from the grid at lower prices to supply the onsite loads and to export to the grid when prices are higher. The constraints at this location enable the battery to increase the revenues considerably.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2025 – equal sized battery				
National (CDT)	85% (-15%)	117% (+17%)	231% (+131%)	152% (+52%)
LMP	67% (-33%)	78% (-22%)	113% (+13%)	59% (-41%)
2030 – equal sized battery				
National (CDT)	65%	81%	155%	83%
LMP	63%	71%	92%	49%

Table 11-13: Grand Central – battery impact

OBSERVATIONS

The model shows the batteries able to be used to both improve self-consumption and generate revenue through exports.

Optimising self-consumption generally offers the highest economic value for a site as it avoids imports which include third party charges.

Where there are some network constraints the batteries can provide some alleviation, and this is reflected in the prices for both imports and exports.

Under the LMP market scenario the price of electricity is lower, which reduces the revenues / savings for these sites, making it harder to justify investments.

Optimising self-consumption is still favourable under LMP, as it avoids third party charges, but should be noted that future reforms could change how these costs are levied.

These sites may generate a considerable surplus in summer months, particularly without batteries installed. The model calculates the value of selling this surplus, but in practice it may be hard for smaller sites to secure these prices under the current market conditions. Section 6 discusses the potential use of aggregators or other means to secure better prices.

11.4.5. Solar Carports

The next two sites are local authority vehicle depots. They are having solar PV installed as part of UCEGM. For the dynamic modelling in workstream 2 we have taken the available details about the fleet and have assumed that the vehicles are gradually electrified and charged on site. The charging regime is simplistic in the model and has not been optimised.

Turnpike Lane

In the model Turnpike Lane has a relatively large solar PV installation, 469kWp and an onsite load in 2025 of around 155MWh annually rising to around 515MWh by 2030, based on the assumed rate of electrification. Turnpike is not in an overly constrained part of the network and hence the network can supply the additional power required for EVs that the solar PV can't support (this assumes the site grid connection has the required capacity).

Market scenario impact: Initially in 2025 the site and EV charging loads are low enough that the site exports much of the electricity that is generated. Since this site exports a high percentage of the solar PV power the site, as modelled, may generate a net profit under the baseline national scenario in 2025. To realise the value for this roof-top solar site would require a contract to sell the exported electricity to the grid at the market price.

Under the LMP scenario the price paid for exports and imports both drop. The drop in revenue for the exports means that this site sees a large drop in the revenues. The volume of imports under LMP has gone up significantly, which despite the price drop shows as an increase in import costs.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case				
National (CDT)	100%	100%	100%	100%
Potential market scenarios in 2025				
LMP	115% (+15%)	167% (+67%)	16% (-84%)	109% (-34%)
Split wholesale	116% (+16%)	165% (+65%)	94% (-6%)	165% (+65%)

Table 11-14: Turnpike Lane – Market Scenario impact

* This is a combination of revenues from exporting electricity to the network or avoiding costs from imports. **The import costs reflect the costs of procuring electricity from the network to meet onsite loads that cannot be satisfied by the solar generation.

The increase in imports, particularly under LMP is initially counterintuitive; Cornwall Insight examined the hourly model data to better understand what was happening. During the summer months at midday there is a high level of generation in the region relative to demand. The generation is being curtailed to manage the network flows as the model has determined this is more economical for managing the constraint rather than taking other routes. The low or even negative electricity prices means that the site chooses to import more, as this is commercially better. This is illustrated below (Figure 11-9).

Figure 11-9: Illustration of negative prices and imports

For this site once can see a difference under the split market scenario. Solar export earns the renewable price, imports are at the split price. The site is choosing to export more of the solar during the day because the price is higher under the split scenario. It is then choosing to satisfy the demand from imports later in the evening this is due to the flexibility of EV demand and when it can be satisfied.

Physical system change impact: In the model there is progressive electrification of the vehicles at this site and the charging is assumed to be on-site. This leads to a significant increase in the site loads, by 2030, which can be seen in the large increase in site Import volumes and costs. It is interesting to note that there is still considerable export of power from the site, which indicates that there is potential to optimise the charging regime (the impact of adding batteries is shown in the next section).

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2030 – no battery				
National (CDT)	61%	587%	-22%	420%
LMP	71%	655%	-43%	365%
Split wholesale	73%	652%	-29%	464%

Table 11-15: Turnpike Lane – physical impact

Batteries impact: It is particularly interesting to see how the inclusion of a battery affects the system performance in 2030, when the model assumes considerable EV charging loads. One can see that in 2030 under LMP the amount of electricity exported is 22% (of the reference case) relative to 71% shown in the previous table (2030, no batteries). The battery is being used to maximise self-consumption to support the high site loads. The model also suggests that with batteries installed the site still generates a small net revenue, noting that this disappears in later years assuming continued electrification of the fleet.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2025 – equal sized battery				
National (CDT)	106%	243%	136%	398%
LMP	94%	140%	63%	119%
2030 – equal sized battery				
National (CDT)	31%	533%	55%	482%
LMP	22%	443%	34%	313%

Table 11-16: Turnpike Lane – battery impact

Swinton Road

In the model Swinton Road has a 148KWp solar array (and battery) and a load that varies from 155MWh in 2025 to 477MWh by 2030, assuming fleet electrification. The power generation is relatively small compared to that installed at Turnpike Lane. Also this site is in a constrained part of the network. The constraints could in some instances drive the modelled electricity prices towards the value of loss load (VoLL) and were capped in the model at £400/MWh, to be relevant for investments. The effects of this constraint are reflected in the results below, particularly in the later period, 2030.

Market scenario impact: The different market scenarios effect Swinton Road in a manner like Turnpike Lane, but the changes are potentially larger due to the more constrained nature of the location.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case				
National (CDT)	100%	100%	100%	100%
Potential market scenarios in 2025				
LMP	159% (+59%)	139% (+39%)	73% (-27%)	118% (+18%)
Split wholesale	158% (+58%)	137% (+37%)	42% (-58%)	135% (+35%)

Table 11-17: Swinton Road – Market scenario impact

* This is a combination of revenues from exporting electricity to the network or avoiding costs from imports. **The import costs reflect the costs of procuring electricity from the network to meet onsite loads that cannot be satisfied by the solar generation.

Physical system change impact: Since the solar generation is much smaller than that at Turnpike Lane a much higher percentage of the generated electricity is consumed on site. It should be noted that in the reference case the site generates a small net profit from net exports, but in 2030 the site is a significant importer and has high costs. When one compares these high costs to the reference case they appear as a large negative increase (>1000%).

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2030 – no battery				
National (CDT)	17%	500%	-1148%	358%
LMP	40%	526%	-1052%	326%
Split wholesale	40%	523%	-1202%	370%

Table 11-18: Swinton Road – Physical system impact

Batteries impact: In 2025, before significant fleet electrification the battery is used to increase the net revenues (note that although the % change is large the absolute values are small as there was only a small net revenue in the national scenario). Under the LMP scenario the network constraints and volatile prices drive a lot of imports and exports between the battery and the network. By 2030 the extremely high on-site demand takes precedent over other market signals. The network constraints mean that the battery cannot work effectively (e.g. charge and discharge at optimum times) and the site energy costs worsen (increase), noting that the more extreme prices were capped as they approached the VoLL price.

Market	Export (MWh)	Import (MWh)	Net site cost*	Import costs**
2025 reference case – no battery				
National (CDT)	100%	100%	100%	100%
2025 – equal sized battery				
National (CDT)	92%	118%	349%	166%
LMP	234%	231%	337%	147%
2030 – equal sized battery				
National (CDT)	14%	594%	-1252%	437%
LMP	16%	592%	-1024%	370%

Table 11-19: Swinton Road – Battery impact

OBSERVATIONS FOR SOLAR CARPORTS

Initially these sites may generate a considerable surplus in summer months, particularly without batteries installed. The model calculates the value of selling this surplus, but in practice it may be hard for smaller sites to secure these prices under the current market conditions. Sections 6.4.2.3 and 6.5.1.3 discuss the potential use of aggregators or other means to secure better prices. If EV charging is installed and vehicle fleets are electrified then the large increase in demand will consume much, if not all, of the surplus.

The following observation is not specific to solar carports, it could apply to the rooftop solar sites too, rather it simply occurred at the location of one of the modelled solar carports. Under LMP electricity prices during the summer at midday were very low or even negative, meaning that the export of surplus solar was curtailed and the site chose to import due to the low price. This may indicate that a site is not well suited for solar generation due to the local electricity system characteristics. However this may be a temporary situation if the system changes, for example increased EV charging loads or the inclusion of battery storage.

Typically the batteries charge from the grid during low-priced overnight periods. This leaves the solar to export or satisfy on-site loads during the day, due to higher demand and prices during the day. This is typical of co-located solar and storage.

If high constraints are expected in a region, then the network operator will be unwilling to grant a connection. The modelling has highlighted the need to understand the constraints and where the costs may fall under different market / regulatory regimes. It may be that a site is not suitable for substantial EV loads and either the loads need to be managed (smart EV charging) or perhaps charging must be done at another location.

12 LONG-TERM BUSINESS MODELS

12. LONG TERM BUSINESS MODELS

12.1. The Need

During Phase 1 of the UCEGM project, the Catapult developed a business model short-list containing solutions that could be delivered in the 'short' or 'long' term (see Section 6.1 for further detail).

Long term business models refer to emerging concepts that have the potential to generate higher value (both financial and non-financial) but have a greater amount of complexity and uncertainty.

As discussed in Sections 10 and 11, there are a range of future market scenarios and accompanying policy and regulatory environments that may emerge during the transition to net-zero. If realised, they each have the potential to influence the viability, feasibility, and desirability of renewable generation business models.

Drawing on findings from Section 11, this section explores key considerations for the design of the long-term business models under different market scenarios and states of the physical system (in 2025 and 2030).

Please note that some of the considerations outlined in this section may also be applicable to the short-term business models discussed in Section 6. Where this is the case, it is referenced in Table 12-1.

12.2. Overview of Long-Term Business Models

During Phase 1, the following long-term business models were identified:

1. Sleeving Pool/ Local Energy Market

The sleeving pool and local energy market (LEM) business models link multiple generators with multiple offtakers to increase the value of local generation.

In the sleeving pool model, generators and offtakers establish direct, sleeved PPAs with each other (see Section 6 for further information on the Sleeved PPA business model). Generators can also leave some supply open to be traded in the pool. A 'Pool Manager' is required to co-ordinate contracts for stakeholders participating in the pool.

In the LEM model, the generation, storage, supply, and consumption of energy from decentralised energy assets can be coordinated within a confined area. This is facilitated by a digital platform (Local Energy Exchange).

The energy usage in the area is matched to the local area assets (e.g., PV & storage) and local users can buy directly from a local generator. Generators can also provide services to the local area such as flexibility, balancing or capacity.

In both models, a central organisation is responsible for local balancing and intraday trades (i.e., the Pool Manager or Local Energy Exchange).

2. Local Energy Tariff

A local energy tariff is a specific tariff or service for locally generated energy. There are a few variations of local energy tariffs that have been demonstrated to date:

Local Generation Tariff

Customers are incentivised to match their electricity consumption to periods when local, renewable assets are generating. In turn, they receive a discounted rate on electricity (p/kWh). This is referred to as a 'Match Tariff'.

Any remaining electricity consumption that is not matched to local generation is charged at different prices during different times of the day. This is referred to as a 'Time of Use Tariff' (Energy Local, 2023).

Local Investor Tariff

Customers part invest in a renewable generation asset and, collectively, own the asset. An energy supplier buys electricity from the asset at the price it cost to produce (i.e., the operating cost) rather than the wholesale price. The difference between the production cost and wholesale cost of electricity is referred to as the 'savings rate'.

The amount of savings that are applied to the customer's electricity bill are calculated based on their percentage ownership of the asset. Customers will see a reduction in the electricity component of their bill, but other third-party charges are still applicable (Ripple Energy, 2023). The individual components that make up a retail electricity bill are discussed in the 'Detailed Design of Short-Term Renewable Generation Business Models' deliverable.

3. EV Charging Hub

The EV charging hub model delivers a combination of solar, storage and EV charging assets within a local area to increase the quality and availability of EV charging. There are three key distinctions between the EV Charging Hub and Solar Carport models:

1. **Scale** – The assets deployed in an EV charging hub system are of greater scale (both in terms of the capacity of renewable generation/storage assets as well as the number of EV charging points).
2. **Operation** – An energy service provider takes on responsibility for project development and operations once the hub is live.
3. **Connection** – Due to the scale of the assets deployed, EV charging hubs typically have a 'front-of-the-meter' connection meaning they are directly connected to the grid.

A commercial arrangement can be set up with the local authority to exclusively power electrified fleets.

12.3. Insights from Dynamic Modelling

The long-term business models are all focused on maximising local value. The viability, feasibility and desirability of these models may therefore change under different future market scenarios. Accordingly, Table 12-1 provides a summary of key findings from the dynamic modelling exercise and explores their potential implications on business model design for the long-term models (and short-term models where applicable).

Although this section focuses on findings from the dynamic modelling exercise, it is also important to note that other policy and regulatory developments (outside of market reform) could also influence the design of long-term business models (i.e., network charge design and allocation). Please refer to Section 10.1 for further discussion.

12. LONG TERM BUSINESS MODELS

Dynamic Modelling Insight	Applicable Market Scenario(s)	Implication(s) for Business Model Design
Physical System Insight		

The dynamic modelling network map showed several key points of constraints. Accordingly, some example sites may not be appropriately located and/or sized.	All	* **It is important for local authorities to understand where constraints could occur in future.**
		  * This could assist in determining the suitability of sites that are identified during site selection activities.
		  * For example, constrained sites could result in significant connection fees which can affect the commercial viability of the project (assuming that the local authority assumes the role of generator).
		* As some areas within the region are likely to be more constrained than others, local authorities may wish to explore whether there are any opportunities for cross-district collaboration (i.e., district partner in a constrained area partners with a district partner in a less constrained area to deliver a renewable generation project in partnership).
		
		  * In some instances, a local area may experience higher prices due to constraints higher up in the electricity network as opposed to congestion in the local network.
		  * Where this is the case, new generation assets may not incur high connection charges and may offer further system value by operating below the constraint.
		  * This could be an enabler for the Sleeving Pool/LEM business models.
		
		* It is also important for local authorities to understand what is causing the constraint.
		  * For example, is the constraint related to infrastructure/ network capacity or a mismatch between supply and demand?
		  * If the latter, this could be an enabler for the long-term business models as local assets could contribute towards relieving the constraints – particularly if battery storage technologies are deployed.

Some level of constraint in the network appears to be beneficial for local generation assets as the generation assets may provide additional system value by relieving the constraints.
 	
However excessive constraint will impact efficient operation.
	All	* **It is important for local authorities to understand the magnitude/size of the constraint.**
		  * As described above, local assets, that could be deployed as part of the long-term business models, could contribute towards relieving constraints.
		  * Up to a certain level of constraint, this would provide revenue generation opportunities to the local authority (as generator).
		  * However, beyond a certain point, constraints could increase the amount of energy that is curtailed from generation assets. In turn, this would limit revenue generation opportunities for the local authority.
		  * Both examples could impact the commercial viability of the business model.
		  * This stresses the importance of building sensitivity analyses into commercial models where certain parameters (inputs) can be manipulated to understand how sensitive the business model is to change.

Dynamic Modelling Insight	Applicable Market Scenario(s)	Implication(s) for Business Model Design
Market Scenario (and Electricity Price) Insight		

Under LMP, electricity prices were more volatile but lower on average; meaning that revenue generation opportunities are reduced but cost-savings are greater for offtakers.	LMP	* This finding **could** make some of the long-term business models appear more desirable than others.
		  * For example, in the EV Charging Hub model the local authority is assumed to be an offtaker of energy to charge their EV fleet.
		  * Accordingly, lower electricity prices could be considered as advantageous.
		  * In contrast, for the Local Investor Tariff, there **could** be a risk that the cost to produce electricity, at certain times, is greater the wholesale market price. Where this is the case, energy bill reductions **may not** be feasible.
		  * This **may** mean that lower electricity prices have the potential to be considered as disadvantageous.
		  * In the Sleeving Pool/LEM models, the local authority could participate as a generator, offtaker or generator **and** offtaker.
		  * Accordingly, depending on the role that the local authority assumes, lower electricity prices could be perceived as either advantageous or disadvantageous.
		* **It is therefore important that local authorities understand the value (desirability) and risks of the different roles that they could assume, within a certain business model, to determine which is most suited to their individual needs.**

Under LMP, at specific sites, electricity prices during the summer at midday were very low or negative meaning that surplus solar export was curtailed. Some sites may therefore not be suited for solar generation. This may be a temporary situation if the system changes (i.e., increased EV charging loads or inclusion of battery storage).	LMP	* The risk of curtailment at certain sites may be a motivating factor for local authorities (as generators) to install additional assets as well as solar PV (i.e., battery storage assets and EV charging points) that can consume energy that would otherwise be curtailed. * For example, for sites where it is known that energy demand is likely to increase in future, some business models **could** become more desirable (i.e., Solar Carport and Storage and Storage and Site Optimisation). * However, commercial modelling would be required to determine whether the value of consuming surplus energy, as demand from battery storage and EV charging grows in future, outweighs the low prices observed for export in the short-term (in relation to the 30+ year life span of the renewable generation project) and the cost of additional technologies.

Dynamic Modelling Insight	Applicable Market Scenario(s)	Implication(s) for Business Model Design
Market Scenario (and Electricity Price) Insight		
The results from the dynamic modelling show that, at certain times, surplus solar export provides value to the system. This value is reflected in the wholesale market price observed. The model assumes that surplus solar energy is exported at the wholesale price.	All	* In practice, the price received for solar energy (either that exported to the grid or sold to an offtaker) will differ from the wholesale price (its market value). * In some commercial arrangements, the local authority (as generator) could receive a higher price for electricity than wholesale (e.g., where a private wire arrangement is in place). * However, in other commercial arrangements, the local authority **may** receive a lower price than wholesale (e.g., through SEG). * **When determining the optimal business model for a renewable generation project, local authorities should consider whether they are able to obtain the market price for electricity (or exceed it) and if not, the mechanisms that could be explored to maximise the price obtained (i.e., aggregating exported energy from numerous sites).**
Battery Storage Insight		

The co-location of batteries with renewable generation assets can/may provide the following benefits:
* Reduction of connection charges.
* Additional carbon reduction benefit.
	All	* The potential benefits of co-locating battery storage, in addition to those identified in Section 6.3.1.4, could make some of the long-term and short-term business models more desirable to local authorities as generators (e.g., Storage and Site Optimisation, Solar Carport, and LEM/Sleeving Pool[27]).
		  * However, from a viability perspective, commercial modelling will be required to determine whether the **potential** reduction in connection fees as well as the revenue/cost-saving opportunities outweigh the additional CAPEX requirements associated with battery storage technologies.
		  * Alongside this, the local authority should also consider how feasible it is to access the potential revenue streams (e.g., what commercial arrangements are required with third-party organisations and how likely is it that these will be obtained?). This is discussed further in Section 6.4.2.4.
		* Despite showing an additional carbon reduction benefit, the co-location of battery storage assets may not generate financial metrics that are typically required for project sign-off at some sites.
		  * This stresses the importance of having decarbonisation strategies in place that underpin the underlying objectives for renewable generation projects (e.g., to maximise revenue generation potential, to maximise carbon reduction potential or to maximise cost-savings).

13 INSIGHTS FOR FUTURE MARKETS

To meet growing demands, electricity networks are shifting towards smarter systems and relying more on Distributed Energy Resources and consumer flexibility for reinforcement. During the project, valuable insights were gained about existing markets, potential future markets and the changing policy landscape. These insights are summarised below.

As previously noted, modelling is limited by the assumptions and inputs that underpin it, and so caution should be taken when drawing conclusions.

13.1. Insights for local renewable energy projects

Co-ordinated place-based planning is essential. The modelling analysis shows how similar renewable energy projects can deliver different results in different locations. To ensure the best use of LA resources a process such as Local Area Energy Plans should be undertaken to identify projects with the greatest potential. The modelling methodology could be used to further enhance the information used to make decisions by providing an understanding of how the system may dynamically operate as the physical system changes and under different market scenarios in response to potential policy reforms; examples are provided below.

Identifying potential locations for renewable energy projects: modelling such as that described in Section 11 could be used to analyse the local energy system and facilitate identification of areas where renewable energy projects, such as solar or wind farms, could potentially be developed to meet the energy needs of the region (subject to planning permission and other factors). The modelling on this project has focused on generation and co-located storage assets, but the approach could be extended to understand the impact of new demand side assets (e.g. electrolysers, heat pumps and EV charging). The approach could be replicated for any region in Great Britain.

Assessing financial viability under market scenarios: Future electricity market arrangements are expected to be characterised by greater locational differentiation; various policy options are under review. Modelling various scenarios could provide inputs for commercial (financial) models to test the viability of projects and business models under different assumptions and reveal their sensitivity to changes. This information may help project developers to make decisions.

13.2. Insights for DSOs / ESOs

13.2.1. DSO/DNO Insights

The methodology used on this project may provide value to a DNO/DSO in several of which the following are particularly relevant to local renewable generation projects.

Constraint Management: In future scenarios, the DSO could identify areas of congestion and network constraints in the local electricity network, allowing them to prioritise network reinforcement and development investments in the areas where they are most needed. This could be done with some degree of confidence in line with published network infrastructure development projects out until 2033 (NOA, HND, RIIO-ED2 and Future Build Publications by the DSO). By identifying areas where smart solutions and flexibility are most effective, the DSO could optimise their investments in network development and operate an increasingly congested local electricity network more efficiently.

Enhanced DSO-ESO Coordination: The need to enhance cooperation between the DSO and ESO is becoming increasingly more important as distributed energy resources are connected and impact the operation of the system (e.g. flexibility to help manage peak loads and provide market services).

The results of the modelling illustrate the interaction at the distribution and transmission system interfaces (e.g. GSPs). Such information may assist with co-ordination.

Local Energy Markets: The work undertaken on this project has highlighted potential opportunities for local renewable generation projects at the distribution system level. This approach could help the DSO to identify and develop local energy markets and gauge their effectiveness, where local energy producers can trade electricity locally, to optimise the use of local resources and reduce the need for grid reinforcement.

Active Network Management and their Evolution: The project has proposed an enhancement to Local Energy Markets, their existence alongside Active Network Management (ANM) and how this could benefit consumers, DSOs as well as the ESO with a more cohesive operation of the local electricity network and to provide the ESO with a platform to access Probabilistic Curtailment Factor (PCF) notifications sent by local generators who otherwise would not have been likely to participate in ESO markets. See Annex (18.1).

13.2.2. ETO/ESO Insights

Transmission-Distribution interactions: If smaller renewable generation projects are to become more prevalent, then the ESO will need to adapt its system planning approach accordingly, as well as the access rules for its balancing and ancillary services markets.

Dynamic modelling such as that undertaken on this project, highlighted areas of increased constraint out to 2030 and the potential impact on smaller renewable generation projects. Beyond that the results become volatile due to the lack of firm data. Since these projects may have a life span of greater than 20 years, the provision of longer-term infrastructure development plans can improve investor confidence.

13.3. Insights for government and regulators

Co-ordinated place-based planning: The modelling has highlighted the need to understand the system impact of different projects, which will vary by location, and to adopt project designs that makes the most positive system impact. Whatever national market design is adopted under REMA, there will be a need to understand and, in some cases, account for differential impacts on different stakeholders and different project types.

Whilst there will inevitably be winners and losers in any reforms, the more granular information provided under an LMP future market scenario should provide stronger signals and incentives for Local Authorities to invest in appropriate low carbon assets that reflect the physical system of their locality.

When combined with planning processes such as Local Area Energy Planning, this can lead to more efficient build of generation and network assets that reflect the needs and situations of local areas.

Outcome rather than technology-based policies: Smaller renewable generation projects such as the LA-led projects explored in this report face different economics than larger projects. Subsidy schemes like CfDs create boundaries that favour certain technologies and/or project scales over others. But net zero requires a diverse portfolio of projects that would be very difficult to deliver purely through central contracting - that's why the Catapult advocates for a shift to an outcomes-based approach that places the onus on suppliers to procure a growing share of their energy from clean sources.

14. GLOSSARY

Term	Description
ANM	Active Network Management. A system utilised by the Distribution Network Operator that monitors the thermal performance on circuits where there is a build-up of connected generation. ANMs allow for cheap connections but generators are at risk of curtailment in the event of the ANM becoming active due to a fault, or other adverse system condition.
CAPEX	Capital Expenditure
CfD	Contracts for difference: in the context of this report it refers to a private law contract between a low carbon electricity generator and the Low Carbon Contracts Company (LCCC), a government-owned company.
Curtailment	The act of limiting the export of electricity from generation or storage due to network capacity (physical constraints). DNO connection offers typically quote curtailment indices as a % of exports that may be curtailed annually,
DER	Distributed Energy Resource: An energy resource (such as generation, storage, heat pumps) connected to the distribution network
District(s)	Within the context of UCEGM this refers to the districts that are part of Greater Manchester
DNO	Distribution Network Operator (DNO) is responsible for operating, maintaining, and developing the distribution network within a specific geographic area. DNOs manage the local distribution networks, connect customers to the grid, and ensure the reliable delivery of electricity to end consumers.
DSO	Distribution System Operator (DSO) is an entity responsible for operating, controlling, and optimising the distribution system.
ENWL	Electricity North West Limited: The DNO for the GMCA region
ERDF	European Regional Development Fund
ESC	Energy Systems Catapult
ESO	Electricity System Operator. The GB Electricity System operator is National Grid Electricity System Operator (NGESO). They are responsible for operating the power system in a safe, efficient and cost effective manner.
Flexibility	Energy systems need to continuously match supply to demand, this is referred to as energy balancing. Energy system flexibility is the ability to adjust supply and demand to achieve that energy balance.
GMCA	Greater Manchester Combined Authority
GSP	Grid Supply Point: Connection Point at which the Transmission System is connected to a Distribution System
Imbalance charge	One of the sleeving costs. A charge that reflects how well the generation and demand profiles match each other, and the level of certainty. These affect the electricity that a supplier must purchase to balance the energy that they buy and sell. (See business model detail design deliverable)
kWh or MWh	Kilowatt hour or Megawatt hour, which are both measurements of the amount of Real Power used within an hour. A Kilowatt contains 1000 Watts, and a Megawatt contains 1,000,000 Watts.
kWp or MWp	Kilowatt peak or Megawatt peak rating
LA	Local Authority
LEM	Local Energy Market

14. GLOSSARY

Term	Description
LMP	Locational Marginal Pricing (sometimes referred to as Nodal Pricing) refers to a pricing mechanism used to reflect the varying costs and constraints associated with delivering electricity to different regions or areas within the country. It considers the differences in network infrastructure, transmission losses, and generation availability across different locations.
Offtaker	A site with an energy demand satisfied in part by taking energy from the grid (typically the distribution network for UCEGM).
Policy and Network charges	The price paid for electricity supplied via the electricity network includes additional charges to pay for using the network and levies. (See business model detail design deliverable)
PPA	Power Purchase Agreement (see business model detail design deliverable)
Price arbitrage	The value and price of electricity varies throughout the day (and year) because of supply, demand, and constraint variation. Price arbitrage is the practice of trying to buy at low prices and selling at higher prices. Flexible tariffs provide price signals and reflect the system need for flexibility.
Private wire	A privately built wire between a generation asset and an offtaker. (See business model detail design deliverable)
PWLB	Public Works Loan Board
Reinforcement	Investing in the electricity network to reduce physical constraints
REMA	Review of Electricity Market Arrangements
SEG	Smart Export Guarantee
Self-consumption	Energy generated at a site (e.g. roof-top solar) that is used to supply the on-site electricity demands. (See business model detail design deliverable)
Sleeved PPA	A PPA where the power generated is provided to an offtaker via their energy supply contract, as a service provided by the energy supplier (see business model detail design deliverable)
Sleeving Costs	There are costs associated with a Sleeved PPA that are charged by an energy supplier. (See business model detail design deliverable)
Solar carport	Canopies with solar PV built over carparks that may supply an on-site energy demand and / or electric vehicle charging
UCEGM	Unlocking Clean Energy in Greater Manchester
UKIB	United Kingdom Infrastructure Bank
Value of loss load	The estimated amount that customers receiving electricity with firm contracts would be willing to pay to avoid a disruption in their electricity service.
Virtual PPA	A PPA where a generator and an offtaker agree a strike price and agree to pay the difference (see business model detail design deliverable)

15. SUPPLEMENTARY MATERIAL

Listed below are the other documents that have been produced by workstream 2 of the UCEGM project - all can be found here.

Item	Title	Author organisation
1.	Detailed Design of Short-Term Renewable Generation Business Models	ESC
2.	Financing Options Report	Cornwall Insight
3.	Solar Energy Generation: Market Intelligence Report	Procur3d
4.	Local Authority Electricity Forecast Tool	Local Partnerships
5.	Energy Supply Guidance	Local Partnerships
6.	UCEGM Energy Market Modelling	Cornwall Insight
7.	Local Energy Market and ANM Architecture	ESC
8.	Commercial Modelling Tool	ESC
9.	UCEGM Workstream 2 – Improving the Business Case for Renewable Energy	ESC

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17 ANNEX

17.1. Active network management (ANM) and local energy markets (LEMs)

17.1. Active network management (ANM) and local energy markets (LEMs)

Energy Systems Catapult carried out a second phase of thought leadership work as part of the project which analysed Local Energy Markets (LEMs) and how these could co-exist alongside Active Network Management (ANM) systems.

Active Network Management (ANM) is a protection function used by DNOs to actively manage and control the flow of power within the network, especially in constrained areas if the distribution network. ANM allows utilities to dynamically balance supply and demand, while maintaining network stability and optimizing the use of renewable energy sources. Generators can connect to ANM zones which are often cheaper than having to pay to reinforce the network, but they must accept they could be curtailed if network conditions become adverse. However, ANM connected generators are often prohibited from accessing other markets (e.g. certain NGESO ancillary services) due to the probability of them being curtailed which excludes a large market for them and narrows NGESOs potential resources for system operation.

The work carried out by Energy Systems Catapult builds on the Electricity Networks Association (ENA) 'Open Networks' programme [28] which focuses on the transition of the electricity network to a smarter and more flexible network. Workstream 3 of the ENA Open Networks project has focused on the DSO transition[29] and the DSO Implementation Plan which is advocating for smarter grid mechanisms which could provide the DSO with a greater degree of control over local supply and demand.

As part of this report, the Catapult has taken the learnings of our previous research into the future of ANMs and has maintained that the ANM will remain as a protection system in principle and aims to promote the discussion surrounding ANMs and how they may function alongside a LEM.

Project BiTraDER, which is a Networks Innovation Competition project, is being carried out by Electricity North West (ENWL) and intends to build and provide a platform for generators to trade their capacity amongst curtailed generators.[30] As this trading platform and project essentially covers the requirements for a proposed Stage One rollout of an LEM within this report, Project BiTraDER has been used an example within this project to illustrate how an advanced development of an ANM and a trading platform could be used alongside an LEM.

Note: It is important to note that whilst Project BiTraDER does not describe itself as a LEM, the report builds on the functionality of BiTraDER as an information processor and as part of a wider Trading Platform and LEM.

[28] https://www.energynetworks.org/creating-tomorrows-networks/open-networks/

[29] https://www.energynetworks.org/creating-tomorrows-networks/open-networks/distribution-system-operation-transition

[30] https://www.enwl.co.uk/go-net-zero/innovation/key-projects/bitrader/

The project found that combining the functionalities of an ANM with an LEM roadmap be a way to develop and grow a smart local electricity network in a modular way by adopting a three-stage roll-out taking the learnings from Project Bi-TraDER.

The three-stage approach is summarised below:

Stage One: Integrate generation into the LEM first, the use of an advanced iteration of the ANM like Project BiTraDER would cover the first stages of this, with ESO-DSO communications and coordination the remaining technical hurdles that would need to be resolved (metering, communication links, standardisation etc).

Stage Two: Integration of Industrial users into the LEM. The ANM will remain as protection for the system and data needed to construct a generator constraint trading market would be sourced by the ANM. The reason for including industrial users before residential is that the industrial participation in flexible markets such as Demand Side Response are already proven feasible with smart metering and technology in at reasonable scale.

Stage Three: The final stage would require the integration of domestic customers with smart meters, either through their supplier or an aggregator. Low Voltage Grid Transformers may also require integration into system monitoring of the DSO. Distributed Energy Resources (DERs) such as EVs and Heat pumps would be integrated into the LEM by 'opting in' to have energy usage controlled when immediate action is needed to alleviate system constraints. Consumers could flex demand in return for monetary reward. Connection arrangements and emergency measures to control DER output would remain the same.

Energy System Catapult proposed an architecture where the ANM could provide signals to the National Grid Electricity System Operator (NGESO) and may offer an increased pool of resources that the system operator can call upon. This increased number of generators available for system operation could reduce energy bills.

Figure 9.3a below illustrates how an ANM system could be expanded to allow industry and consumers into the monitoring function, which could in turn allow capacity signals to be sent to generators. Trade could also be facilitated in much more efficient manner, allowing for more granular capacity trading and for consumers to participate in network services that could benefit the DSO and ESO.

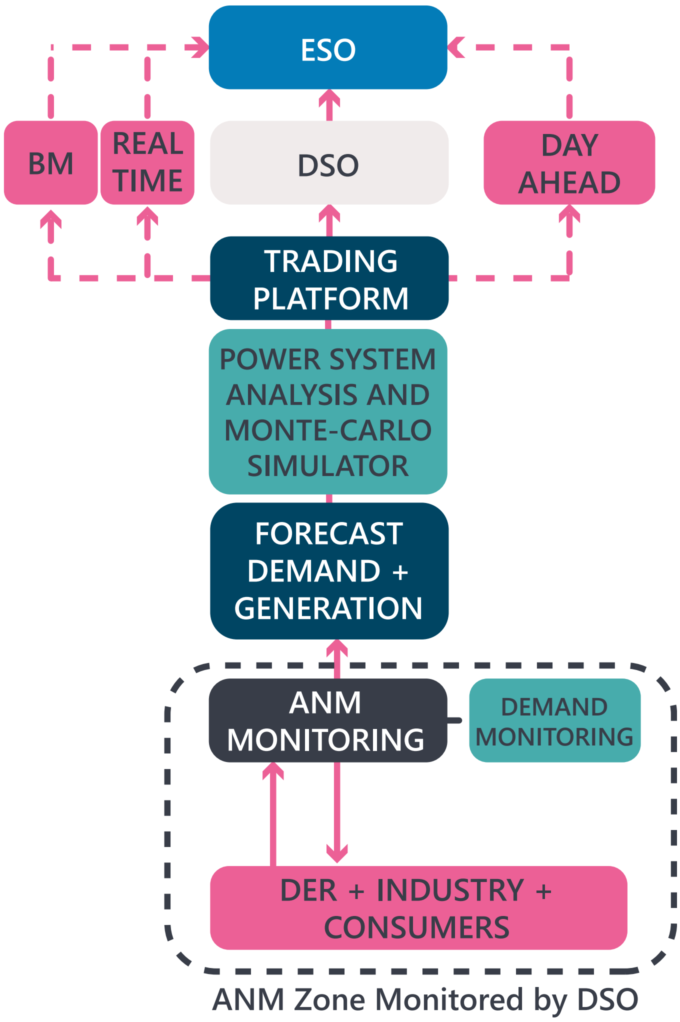

Figure 9.3a: High level architecture proposed as part of the UCEGM Phase II research into LEMs and their coexistence with ANMs.

This functionality would require an evolution of the DSOs capabilities especially in areas such as demand forecasting, which the DSOs are currently treating as an area of increased importance.

One of the key recommendations from the project around ANMs and LEMs co-existing, was the opportunity this presented to the ESO in terms of increased visibility of generation and capacity at the local level which in turn could be used for more efficient national forecasting. This would be done through the ANMs sending a Probabilistic Curtailment Factor (PCF) to the ESO. See Figure 9.3b below. This would give the ESO increased confidence in procuring generation connected to an ANM system as the PCF would be calculated using real-time and forecast data.

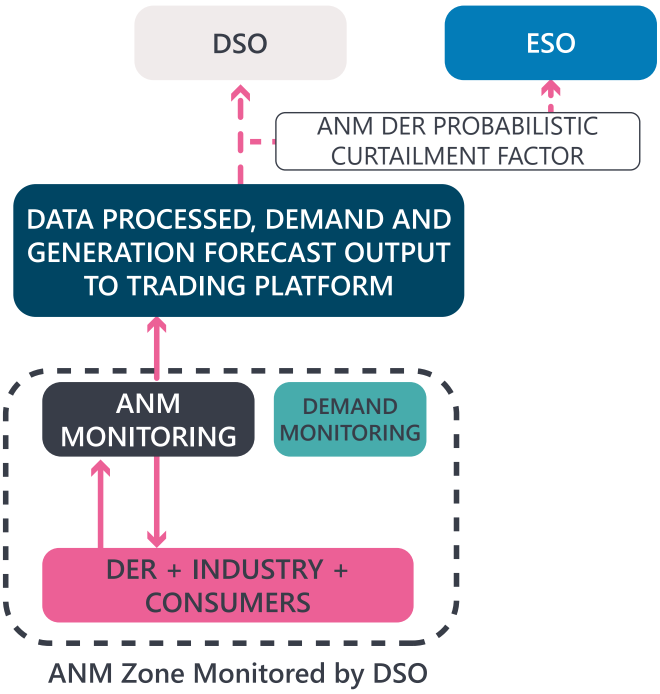

Figure 9.3b: Probabilistic Curtailment Factor being sent to the ESO via an LEM trading Platform.

Through the Dynamic Modelling (see Section 11), DSOs could identify potential future bottlenecks on the network where the deployment of an LEM/Evolution of the ANM could allow for a more efficient way of managing generation and demand on the network, deferring hard reinforcements that could save the end consumer money on energy bills through opportunities to offer services as well as cheaper connections for generators.

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