ZERO CARBON RUGELEY
WP3-D3: TECHNOECONOMIC VIABILITY OF VALUATION MECHANISMS

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Technoeconomic Viability of Valuation Mechanisms

Prepared for Engie

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1 Introduction

This document makes reference to the previous reports submitted by Opus One: D1 Defining Market Structures and D2 DER Valuation. From the information shared in these two reports, this report will investigate the feasibility of the DER valuation mechanisms. This will be done first by considering the technical, economic, and regulatory efficacy of each mechanism. Then each valuation mechanism will be evaluated based on the defined market structures.

The three valuation mechanisms are: Distribution Locational Marginal Price (DLMP), Locational Marginal Price with Distribution (LMP+D), and Flexibility Valuation. DLMP uses a reference locational marginal price (LMP), or a timeseries energy price. Additionally, it computes the cost of losses and congestion to determine a temporal and locational cost of energy. LMP+D also uses a reference LMP and computes capacity, maintenance, and losses components. The Flexibility Valuation references the business as usual traditional network solutions and the alternative costs of network reinforcement and network losses. It further considers remaining asset life, net avoided outage costs, loss of export capacity, and avoided energy.

The four market structures have unique objectives: carbon reduction, cost savings, low barrier to entry, and supply security. The market configuration parameters will be modified to enable each of these market structures.

Market Flow

In the above market structures and valuation mechanisms, the market process flow will be constructed from a distribution system operator perspective and the workshop will be run as follows:

- With each market scenario and simulation, a network model will be evaluated based on a load forecast. Properties of this load forecast will be shared with simulation participants (e.g. high loading during hours 8 and 9)
- Participants will have resources assigned to them and be given an opportunity to submit bids and offers into the market
- A cost minimising optimal power flow will be run by the market operator to select the dispatch quantities from market resources that ensure system security and minimise costs. The different valuation mechanisms advise the market operator on the relative value of a market resource's bid or offer
- These dispatch quantities will be presented to the participants to accept or reject

An alternative market flow could be considered in the future where:

- The market operator submits an open flexibility request to the market
- All participants can review and decide if they wish to submit a flexibility response
- The market operator would then review all responses and select their desired contracts. Valuation mechanisms could be used to advise on this selection process.

2 Distribution Locational Marginal Price (DLMP)

The DLMP valuation methodology is calculated as follows:

$$\text{DLMP} = \text{Energy} + \text{Loss} + \text{Congestion}$$

- Energy: cost to provide energy to this general geographical area, typically the LMP or the cost paid by the retailer for the energy
- Congestion: impact of a binding line or transformer constraint on the DLMP of a node
- Losses (residual): impact of network losses and voltage considerations on the DLMP of a node

2.1 Technoeconomic and Regulatory Analysis

Technical and Economic Analysis

The DLMP methodology uses the same technical and economic analyses performed by bulk system operators for determining the cost of a marginal generator. The concept is applied in the distribution network with a representative network model. The DLMP valuation is completed through a cost minimising optimal power flow analysis.

The congestion and energy components are created based on the need to balance system supply and demand. These components are then priced by the available market options and settled economically. The losses component is calculated by understanding the marginal losses at a particular location. The marginal loss factor, computed by the optimal power flow, is then converted into a price.

Regulatory Analysis

The DLMP methodology is typically not applied for DNOs in the Great Britain (GB) because the cost of energy is not a value they incur or pass onto customers on their network. As an energy retailer, DLMP could be a viable option for Engie if they are to operate and manage the market. DLMP could form a basis for Engie to evaluate bids and offers as they are submitted.

2.2 Market Structure Analysis

Carbon Saving Market

The DLMP methodology does not have a direct application for incentivising low carbon resources. There could be an artificial increase in offer price applied to carbon emitting resources to account for this in the procurement process, but this extension is beyond the methodology's intended purpose.

Cost Saving Market

The DLMP methodology supports a cost savings market by evaluating the lowest cost resources that can be dispatched to meet the system needs. This cost valuation is valid if the market operator accepts the

LMP base energy cost. The DLMP valuation employs a pay as bid payment mechanism, meaning all cleared resources are paid their bid price.

Supply Security Market

The DLMP methodology supports a supply security market because it evaluates the value of resources to solve constrained network scenarios. There is the possibility that there are not enough resources to resolve the constraints on the network. In that case, the DLMP valuation would not converge on a solution and alternative solutions, such as traditional network upgrades or the deployment of additional DERs, should be considered.

This market structure could help improve the supply security market by allowing smaller resources to participate in flexibility markets and making it more likely that a resource is placed in an optimal location for constraint relief.

Low Barrier to Entry

The DLMP methodology is indifferent to the size or number of resources in the market. It sequentially evaluates the next marginally priced generator. As cheaper resources are fully allocated, subsequent resources will be procured as necessary.

3 Locational Marginal Price + Distribution (LMP+D)

There are three value stacks considered in the LMP+D methodology: bulk system benefits, distribution system benefits, and external benefits. The general formulation is as follows:

$$LMP + D = B1 + B2 + D1 + D2 + D3 + E1$$

Where:

B1 = Avoided Generation Capacity Cost

B2 = Avoided Bulk System Purchases

D1 = Avoided Distribution Capacity Infrastructure

D2 = Avoided Distribution Operations and Maintenance

D3 = Avoided Distribution Losses

E1 = Avoided CO_2

The LMP+D methodology can be evaluated based on its individual components and components can be excluded in Zero Carbon Rugeley as necessary.

3.1 Technoeconomic and Regulatory Analysis

Technical and Economic Analysis

The B1 and D1 components require an understanding of expected generation and distribution capacity costs and predicted peak system demand over the next year. There are assumptions that the predicted number of peak events is accurate and the predicted capacity costs should be evenly distributed over these events. When modelling these costs in GB, we could implement standardised valuation methodologies for network reinforcements taken from the Common Distribution Charging Methodology (CDCM) or specific methods such as Long Run Incremental Cost (LRIC) or Forward Cost Pricing (FCP) used by DNOs at the Extra-High Voltage (EHV) level.

The B2 and D3 components are similar to the energy and loss components from the DLMP methodology, with the exception that the energy component is always referenced from the substation (or retail/wholesale electricity price), rather than the cheapest generator. This concept is prevalent in North America, where the bulk energy system can have varying prices at different interfaces between the bulk and distribution systems, represented by a substation. This could result in generators with cheaper offers being valued much higher by the methodology and generators with expensive offers being valued much lower. A subsequent decision would have to be made on whether to compensate the generator with the generator's offer or LMP+D valuation.

D2 refers to the cost that would be incurred for operations and maintenance of a network that is operated beyond its recommended physical limits (voltage, current, etc).

The E1 component assumes a price of carbon that is earned by qualifying resources (non carbon emitting).

Regulatory Analysis

Similar to the DLMP methodology, the LMP+D methodology is typically not applied for DNOs in B because the cost of energy isn't a value they incur or pass onto customers on their network.

The B2 and D3 components are applicable for Engie if they are to operate the market and wish to consider the cost of energy and impact of losses. As the identity and role of the market operator is not yet fixed in DSO markets, the assumption of Engie as an energy retailer fulfilling this role allows the Zero Carbon Rugeley project to test this market construct with a timeseries cost of energy.

The B1, D1 and D2 components are relevant to study in Rugeley, but these savings will only be applicable to the DNO (unless Engie assumes some responsibility in network infrastructure costs in the future). For the purposes of Zero Carbon Rugeley, they can be excluded.

The E1 component supports the key goal of Zero Caron Rugeley for carbon reduction. The value for this component could be informed by Ofgem.

3.2 Market Structure Analysis

Carbon Saving Market

The E1 component of the LMP+D methodology incentivises carbon neutral resources by slightly increasing their valuation. This can increase their market competitiveness and improve the return on investment for renewable resources and stimulate more interconnections.

Cost Savings Market

The LMP+D methodology supports a cost savings market similar to the DLMP methodology. The LMP+D methodology will evaluate the lowest cost resources relative to the locational marginal price to dispatch to support the system. Since the LMP+D valuation may differ from the uploaded offer price, there is a decision to be made by the market operator on settling procured services with the LMP+D price or offer price. The LMP+D price could yield a cost savings for the market operator, but likely will be more costly than paying the cleared offer price. The LMP+D price represents the upper limit on how the market should clear. If a market is consistently clearing above the LMP+D price, then alternatives market mechanisms should be considered.

Supply Security Market

The LMP+D methodology has two components to incentivise DER procurement for large loading scenarios. There is a bulk system and distribution feeder loading threshold configured, represented by the B1 and D1 pricing components. If the loading threshold is exceeded, the price valuation will be more lucrative to represent avoided capacity and infrastructure investment. This threshold benefits markets that rely on measurements at the substation level. For markets that have a good understanding of system limits (e.g. line thermal ratings), the LMP+D methodology is not as effective in system security.

Low Barrier to Entry

Similar to the DLMP methodology, the LMP+D methodology is indifferent to the size or number of resources on the network. Resources with cheaper offers will be procured to service the market.

4 MERLIN Flexibility Valuation

The flexibility methodology developed in Project MERLIN[1], an initiative by Southern and Scottish Energy Networks to identify, evaluate, and procure flexibility solutions, considers traditional reinforcement net present value, network losses, and flexible service administration and management costs. Additional fields to be considered in the future include remaining asset life value, asset life costs, net avoided outage costs, loss of export capacity, avoided energy, community generation credit, and net avoided greenhouse gasses.

These valuations are not performed within the market simulation software provided by GridOS. In the Merlin project, the flexibility valuation is performed prior to market simulations. Market simulations are run with a pay as bid or pay as clear valuation mechanism.

4.1 Technoeconomic and Regulatory Analysis

Technical and Economic Analysis

The Merlin flexibility valuation methodology considers several economic factors. The value of a flexible solution is defined as the alternative cost of implementing a traditional solution. For a DNO, this yields economic savings through time value of money. For asset life and avoided network costs from outages or losses, the analyses make some assumptions for how assets and the system is modelled (such as asset degradation and remaining asset life). These give a reasonable estimate of potential value from a technical perspective.

Regulatory Analysis

Community generation credits depend on regulatory implementation. A community resource can earn value for all consumers in the community. Much of this analysis depends on the regulatory interpretation for cost of energy. Avoided energy and avoided losses can be perceived as savings through an opportunity cost, and whether this applies to the market operator. For a DNO or DSO, these energy efficiencies could be given back to their organisation. For generators and retailers, this may not be as applicable as they may be incentivised to over produce to account for system losses.

One of the purposes of the Merlin project is to explore new flexibility valuation strategies. In the referenced material, there are other unconventional valuation criteria that are not yet further investigated. As a result, a regulator may not heavily consider these criteria, but these are still suitable to consider for the purposes of exploring new market structures in Rugeley.

4.2 Market Structure Analysis

The metrics introduced by the Merlin flexibility valuation methodology are not calculated by the market platform. They are performed as part of an independent planning study. Since the Merlin project makes

[1] https://project-merlin.co.uk/wp-content/uploads/2021/02/1.06-Flexible-Service-Valuation-Mechanism-Report.pdf

use of pay as bid and pay as clear payment functions, those can be used to evaluate the market structures.

Carbon Saving Market

Similar to the DLMP valuation mechanism, pay as bid and pay as clear functions do not clearly demonstrate a carbon saving market. An artificial increase to the offer price of carbon emitting resources could represent a market carbon tax to favour procurement of carbon neutral resources. This could be applied to both pay as bid or pay as clear markets.

Cost Savings Market

Assuming the bidding behaviour of DERs is the same in both markets, the cost saving market structure is achieved by the pay as bid function, which compensates every subsequent resource with the minimum amount necessary. In contrast, the pay as clear function renumerates all assets at the level of the most expensive procured resource.

Supply Security Market

The supply security market structure is not as clearly demonstrated by these two payment functions. A carefully constructed scenario, where an expensive resource is placed downstream of a network constraint, can demonstrate supply security, but it is not emphasised by the payment functions.

Low Barrier to Entry

The low barrier to entry market structure could emphasise the difference in cost savings between pay as bid and pay as clear functions, as a small and inexpensive resource could be paid much more in the latter function.

5 Conclusion and Next Steps

Based on the descriptions and nuances of the valuation mechanisms identified in Opus One's previous report, there are several considerations that highlight the benefits and limitations of each mechanism. These technoeconomic and regulatory considerations are summarised in Table 1 below.

Table 1: Technoeconomic and regulatory considerations of each valuation methodology

Valuation Methodology	Technoeconomic	Regulatory
DLMP	• Based on bulk system marginal pricing methodologies • Computed through an optimal power flow analysis • Constrained by physics of the network • Optimised by economic decisions	• Does not apply for a DNO, but could apply for a retailer
LMP+D	• Based on bulk system cost of energy timeseries • Computed through an optimal power flow analysis • Constrained by physics of the network • Settlement methodology options	• Does not apply for a DNO, but could apply for a retailer • Some components can be excluded • Some components can be adapted for GB (B1 and D1) • Environmental component is useful for Rugeley
Merlin Flexibility Valuation	• Implementing traditional DNO valuations • Introducing new technical and economic value streams	• Preliminary analysis strategy, exploring new options for their merit

Factoring in the different market structures from Opus One's first report, there are advantages to using a particular valuation mechanism to achieve a market objective. These are summarised in the Table 2 below. In the upcoming market workshop, the following market structures will be constructed with a fitting valuation methodology.

Table 2: Valuation Methodology Impact on a Market Structure Objective

Valuation Methodology	Carbon Saving	Cost Saving	Supply Security	Low Barrier to Entry
DLMP	No	Yes	Yes	No
LMP+D	Yes	Partially	Partially	No
Pay as Bid	No	Partially	No	Partially
Pay as Clear	No	Partially	No	Partially