NORTHERN POWERHOUSE
HM Government

European Union
European Regional Development Fund

CATAPULT
Energy Systems

Unlocking Clean Energy in Greater Manchester Local Energy Markets & ANM Architecture

Contents

DISCLAIMER

1 Executive Summary

This report has been commissioned as part of the Unlocking Clean Energy in Greater Manchester (UCEGM) project [1] and is intended as a Thought Leadership exercise; whereby the contents discussed as well as the views expressed are aimed to act as a base of discussion around the future of Active Network Management (ANM) systems and Local Energy Markets (LEMs).

UCEGM is a pioneering project that aims to deliver a number of renewable schemes across the Greater Manchester area and is intended to create a blueprint which other cities and local authorities can replicate. The project has been funded by the European Regional Development Fund and has been incorporated in to the Manchester Combined Authority Five Year Environment Plan.

During the UCEGM project, questions began to arise concerning ANM systems; what their operation or function may look like at a more advanced level of development and mainly, how could ANM systems function alongside Local Energy Markets. The report has used Project BiTraDER (a Network Innovation Competition project [2]) as a starting point for the future of ANM operations in a scenario where integration between future Distribution System Operators (DSO) and the Electricity System Operator (ESO) would be required.

Project BiTraDER aims to provide generators the ability to trade their curtailments with each other based on ANM constraint forecasting, effectively creating a new market locally for generators that would have otherwise not have been able to produce energy. There is potential to build on this type of project with Local Energy Markets which the report aims to do. As part of the UCEGM project, the Energy Systems Catapult contracted Cornwall Insight, an independent energy research and consulting firm which developed a dynamic energy and market model that included the GB transmission model as well as a granular distribution model for the Greater Manchester area. This model reveals where constraints are likely in a future power system where demands are expected to increase drastically, and constraints were also modelled on the DNO networks around Active Network Management areas. Modelling outputs further reinforced the need for greater system flexibility and Active Network Management development to manage the growth in distributed connected generators.

The report has detailed in section 6 on how a staged rollout of a Local Energy Market could co-exist with an ANM, and how the ANM system would retain its core function as a protection mechanism whilst using the data captured by the monitoring devices (thermal data, generator outputs, line loads etc) to aid in the development of a Local Energy Market.

The proposed use of generator data, forecast generator positions and line loading data is the primary reason the report has used Electricity North West Limited' (ENWL) Project BiTraDER to showcase how an LEM could be developed alongside ANM innovations, as

[1] https://es.catapult.org.uk/project/ucegm/
[2] https://www.enwl.co.uk/go-net-zero/innovation/key-projects/bitrader/

ENWs innovation project essentially covers the first stage of the proposed development of an LEM and ANM integration as set out in the report.

1.1 ANMs Remain Protection Devices

- ANMs retain primary use as protection devices first and foremost with enhanced monitoring functions built in to them
- Generators can be turned off based on more precise MW requirements rather than a blunt use of ANMs i.e. the overload on a network may constitute 60MW but the ANM takes off a 100MW generator. A more advanced ANM system can remove a figure closer to the overloaded amount to maximise network efficiency
- If the market fails to deliver and constraints are not managed by a trading platform for whatever reason, the network is ultimately safe due to the last line of defence being the ANM and other protection systems

1.2 LEMs could add value to consumers

- OVO Energy trial has shown by participating in flex trials, customers saved £400-£800 depending on the level of service provided by V2G [3]
- An LEM could provide consumers a local platform to participate in flex services to unlock value and save money on energy bills. The LEM would also be a platform for generators, Local Authorities and storage providers
- More effective management of energy usage, constraints and how industry uses energy could result in fewer constraint scenarios and more efficient use of energy locally
- There have been studies done by the Greater Manchester - Local Energy Market project, that has shown the local value of an LEM and how it could provide community benefits, (local generation, job creation etc) [4]

1.3 Three Stage Rollout of an LEM

The report recommends a staggered roll-out of an LEM through the following stages:

1. **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).
2.
3. **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, however for industrial users they could also be integrated into the ANM as this is the central data source for the

[3] https://www.ovoenergy.com/ovo-newsroom/press-releases/2021/june/worlds-largest-domestic-vehicle-to-grid-trial-reveals-customers-could-recover-the-majority-of-their-household-energy-costs
[4] https://gmgreencity.com/gm-local-energy-market-what-the-people-think/

trading platform needs to function, or the data sources needed to integrate industrial users could come in the form of smart metering information provided to a port within the ANM.

4.

5. **Stage Three:** It is envisaged the final stage of an LEM rollout would be the most difficult as it would involve a large number of consumers being incorporated into an LEM. The final stage would require households to have smart metering data functionality and metering information submitted to either aggregators or suppliers, it may also require additional integration of Low Voltage Grid transformers into system monitoring activities 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. This control would be carried out by suppliers/aggregators on behalf of DER providers and not the DSO. DERs can still be disconnected under fault conditions by the DSO.

1.4 More ANM Connected DERs Could Provide Services to the ESO

Currently, the ESO establishes a relationship and procures generators connected to the DNO network with minimal issues or barriers, so long as they are not connected to an ANM zone. If they are connected to an ANM, then the ESO has strict criteria in the form of probabilistic constraint factors that may restrict a generator participating in ESO market services and the criteria is also service dependent.

The report has suggested a more advanced ANM system which begins to facilitate forecasting of generation and demand and will provide the DSO and ESO with accurate Probabilistic Curtailment Factors (PCFs) on Day-Ahead' or in Real-Time, which would give the ESO further confidence in procuring DERs in ANM zones. Further details on the what would be needed to facilitate PCFs are provided in section 3.2.

1.5 Technical Barriers and Other Caveats

- Communications need to be standardised to enable efficient integration with the DSO and ESO and to ensure a consistent experience for the user
- ESO-DSO communication is a sensitive area and needs careful thought. It may not immediately be possible to establish a communication link between the ESO and DSO; even if it was established the management of the data and how it is utilised is a problem which would require solving before rolling the protocol, out across all DSOs
- A physical data link may be required by each party within the LEM, the nature of use of which needs to be considered
- Integrating industry and consumers into an LEM would require all participants to have a smart meter, which have stagnated in their roll-out campaigns [5]
- Smart meters will need to submit 30 minute readings and possibly submit more granular datapoints for participation in operational timescales. Additional functionality of smart meters would also be needed in order for them to communicate with DERs such as EV chargers and Air Sourced Heat pumps
- Integrating DERs, like EVs, would be more socially acceptable but there may be issues when proposing the integration of resources like heat pumps into an LEM as consumers may not wish to have their source of heat taken away or could opt-out of the LEM. Participation of Air Sourced Heat pumps may not be viable until a heat storage solution is more affordable and widely available to consumers. Further research should be carried out to establish what minimum temperatures consumers are accepting of within the home
- Energy suppliers and aggregators would be best placed to involve consumers in the third and final stage of an LEM rollout. For example, in California between the California ISO and energy Suppliers [6] and the recent Octopus Energy trial which yielded positive results [7] where demand was flexed in line with the System Operator requirements.

[5] https://www.data.gov.uk/dataset/ed44b45d-6651-4767-9f73-92abd3f51e48/smart-meters
[6] https://www.flexalert.org/
[7] https://octopus.energy/press/octopus-energy-and-national-grid-eso-demonstrate-future-role-for-electric-vehicles-in-first-for-great-britain/

2 Background

As part of the Unlocking Clean Energy in Greater Manchester (UCEGM) project, the Energy Systems Catapult (ESC) is carrying out Phase II of the project which analyses Local Energy Markets (LEMs) and how these could co-exist alongside Active Network Management (ANM) systems. The report has also detailed and highlighted the barriers generators and Distributed Energy Resources (DERs) may face if they are behind an ANM zone whilst wishing to participate in ESO market services and has proposed a technical solution as to how this may be overcome.

LEMs have been proposed as one of the three future market scenarios under the UCEGM [8] project and this report summarises the ESC's view on how LEMs could be implemented in order to add value to generators connected to distribution networks, generators connected behind an ANM (so that they may provide services to the ESO), industrial users, residential users, the Distribution System Operator (DSO) and Electricity System Operator (ESO).

The work carried out by the ESC builds on the Electricity Networks Association (ENA) 'Open Networks' project [9] 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 [10] 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 ESC 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 an LEM.

Project BiTraDER which is an 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. 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 an LEM, the report builds on the functionality of BiTraDER as information processor as part of a wider Trading Platform and LEM.

[8] https://es.catapult.org.uk/project/ucegm/
[9] https://www.energynetworks.org/creating-tomorrows-networks/open-networks/
[10] https://www.energynetworks.org/creating-tomorrows-networks/open-networks/distribution-system-operation-transition

3 DER Behind ANM Zones - Limitations and Solutions

Today, DERs connected to an ANM zone have limited possibility of offering their services to the ESO due to a probability they may be constrained due to the ANM zone becoming active. This removes potential revenue streams available to the generator and services the ESO could access when managing the system. This section explores the mechanism by which this could change and DERs could offer services to the ESO with the confidence a curtailment probability is accurate.

3.1 Value of a Probabilistic Curtailment Factor (PCF)

With Costs of System operation costs set to rise to around £2 Billion by the end of the decade, up from around £1.3 Billion as of 2022 [11] [12], there would a significant benefit to the ESO were they able to access a large resource of DERs to balance and operate the system with. These DERs could offer many services to the ESO as well as enhance their services to the DSO, whilst providing additional value to the end consumer. Consumers could also benefit by being able to participate in energy markets and save on energy bills by providing services such as Demand Side Response.

3.2 Probabilistic Curtailment Factor (PCF) for the ESO

The ESO currently assesses DERs who wish to provide services to the Balancing Mechanism (BM) on a case-by-case basis and will determine the probability of the generator being constrained behind an ANM zone.[13]

For the ESO to procure services from DERs behind ANMs, there would need to be much greater confidence at both Day-Ahead and in Real Time that the ANM will not become active. The report has proposed to solve this by proposing a 'Probabilistic Curtailment Factor' that could be calculated by expanding the capabilities of the DSO and enhancing the cooperation between the DSO and ESO.

Figure 3.2a below provides an overview of the data sources and data processes that would be needed to provide a PCF to the ESO. The PCF as an output of an LEM architecture would be a part of the Look Ahead Zone, further details for which are discussed in Section 6.

[11] https://www.elexon.co.uk/article/bsc-insight-increasing-costs-for-balancing-the-gb-system/
[12] https://www.nationalgrideso.com/research-publications/network-options-assessment-noa/key-documents,
[13] https://www.nationalgrideso.com/document/177121/download

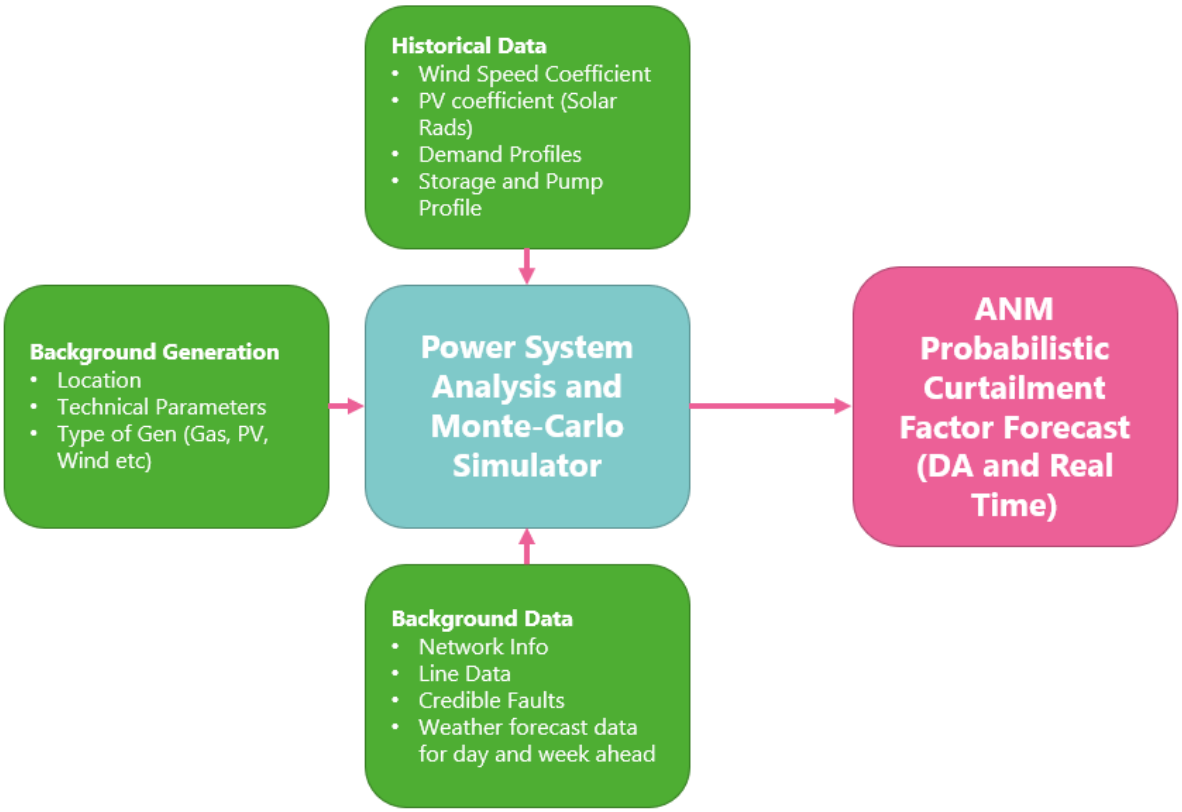


Figure 3.2a: Proposed architecture for a Probabilistic Curtailment Factor (PCF) that would be provided to the ESO at Day Ahead and in Real Time.

The DSO would need to expand current capabilities and have the facilities to forecast demand and generation at a more granular level and at day-ahead and real time timeframes. These enhanced capabilities would be very similar to the current capabilities of the ESO, where they are able to procure generation with a great degree of confidence whilst forecasting intermittent generation reliability.

This process would be very similar to a manual power systems study but could also be automated with credible fault cases constantly executed within a Power Network Analysis tool which would in turn produce the PCF used by the ESO. The analysis would be done on a dynamic basis and a constant loop with data feeds directly from the data historians and sources in the green boxes as per figure 3.2a.

3.2.1 Expanding the Monitoring Zone of the ANM

One of the ways in which these enhanced forecasting capabilities could be achieved is to increase metering rollouts either through standalone metering which is viewable via DSO control rooms or to expand the existing monitoring zone of the ANM to incorporate live demand data. This data would then be saved in a data historian and used to approximate future demand levels at day ahead and combined with other data such as weather forecasts, generator positions etc to provide a Probability of Curtailment Factor to the ESO.

Figure 3.2.1a illustrates at a high level, how demand data and other metered data is factored into the ANM monitoring zone. This data is then processed at the trading platform level which subsequently notifies the ESO of a PCF. The ANMs core role as a system protection mechanism would remain unaltered. The enhanced data recording capabilities that are being leveraged in this scenario, which would then inform the ANM how likely a curtailment is and how large a magnitude of power needs to be removed from the system to prevent any thermal loading issues.

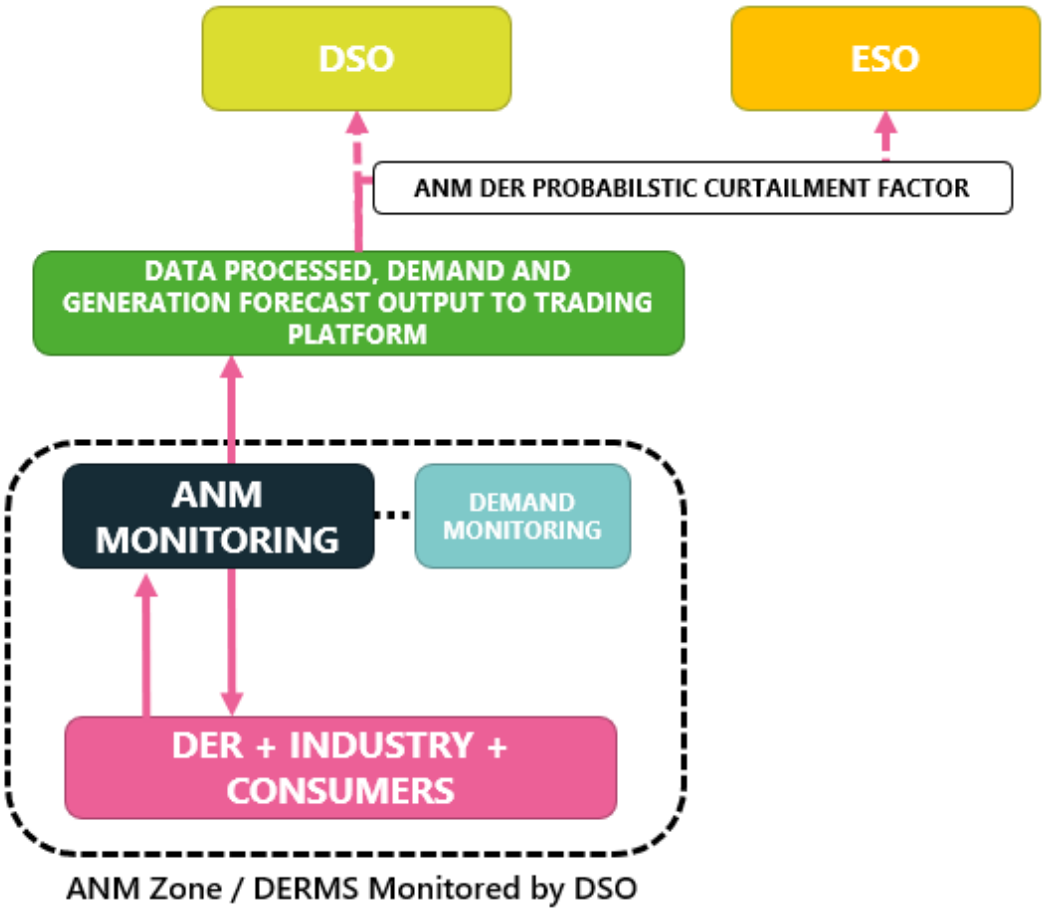


Figure 3.2.1a: Expansion of the ANM monitoring zone to incorporate demand data for processing

3.3 Probabilistic Curtailment Factor Signal at Day Ahead and Operational Timescales

The ESO can receive a PCF signal at day-ahead and operational timescales depending on how the data is processed. Day ahead signals are obtained using historical demand data, generator availability notifications and through the use of other data, as per section 3.2. For signals in operational timescales, real-time data alongside forecasting information, fault cases is needed. The manner in which they are processed remains the same i.e. automated power system analysis and a probabilistic monte-carlo statistical model.

As per figure 3.3a, the ANM is expanded to incorporate the monitoring of demand data, the processing of the data to achieve a PCF then takes places with signals sent via a trading platform. The signal can also be sent directly to the ESO, however for consistency the report has outlined how a Local Energy Market or Platform can facilitate this.

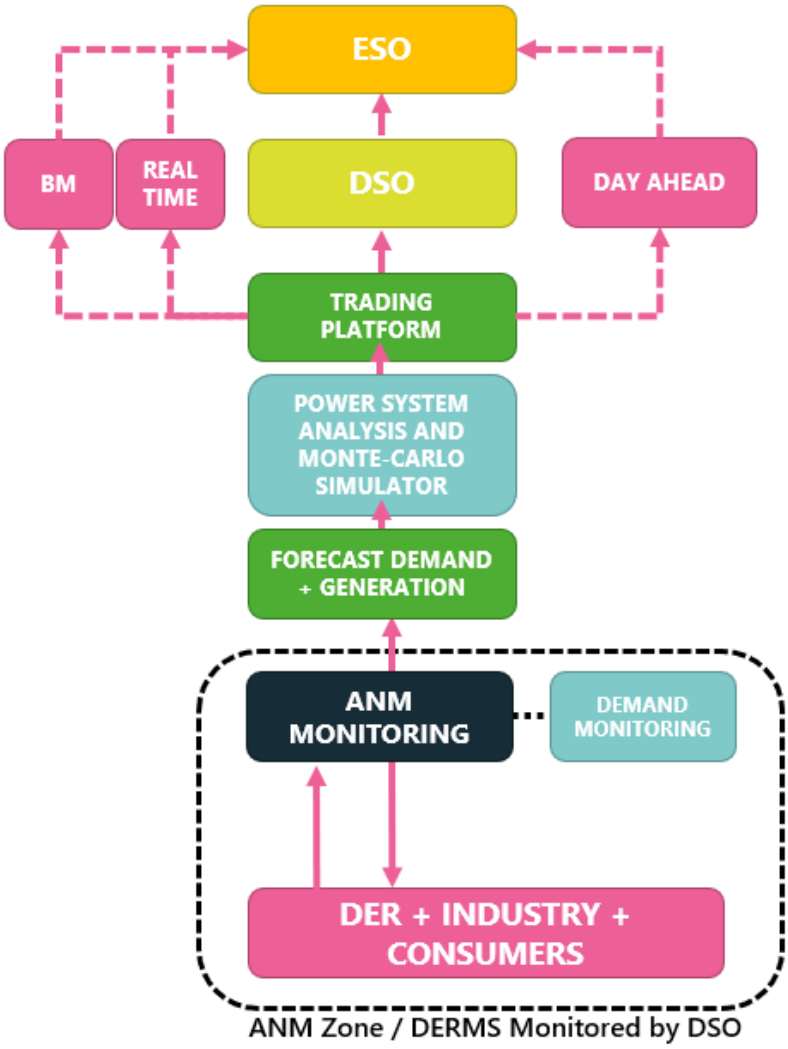


Figure 3.3a: High level overview of how a PCF signal can be sent to the ESO at both Day Ahead and Operational Timescales, the ESO has visibility of the curtailment factor via the trading platform for both day ahead and operational timeframes.

3.4 Hierarchy of Services

When DERs offer a service to the ESO, instances may occur where the DER may need conduct actions upon instruction of the DSO to maintain network stability and security locally. It is envisaged that any generator connected to the DNO network that will participate in ESO market services, whether they are within an ANM zone or a registered BMU, will be required in emergency, to adhere to any DSO instruction. [14]

The ENA Open Networks Project is currently assessing how a hierarchy of services should function through the WS1A-P5 'Primacy Rules for Service Conflicts' phase. [15] Following discussion with OFGEM and BEIS, simple interactions between the ESO and DNO procured services were given a set of prioritisation processes, however more complex interactions involving the ANM have been to deferred to the next rules development phase to allow further time for robust analysis.[16]

The aforementioned hierarchy of services is the current arrangement embedded generators are subject to with the rules they are subject to set to evolve. DERs who are offering their services to the ESO via a PCF signal would be tripped off automatically were an ANM to become active under adverse system conditions. It should be noted that this would be an event outside of the credible faults studied by the Power System Analysis tool i.e. a non-credible fault where the line loads exceed ratings under normal operating capacity.

Any non-deliverance of service would be dealt with by Elexon in the 14 month imbalance settlement period after the point of Final Physical Notification. [17]

---

[14] https://www.nationalgrid.com/sites/default/files/documents/Wider%20BM%20Access%20Roadmap_FINAL.pdf

[15] https://www.energynetworks.org/industry-hub/resource-library/on21-ws1a-p5-primacy-rules-for-service-conflicts-use-case-prioritisation-supporting-slide-(22-dec-2021).pdf

[16] https://www.energynetworks.org/industry-hub/resource-library/on22-ws1a-p5-primacy-draft-rules-increment-1-(28-apr-2022).pdf

[17] https://www.elexon.co.uk/settlement/

4 Local Energy Markets Explained

A Local Energy Market would function as an intelligent platform for energy producers, industry and flexible consumers (prosumers) where the trade of energy is facilitated. The core benefits of an LEM are to unlock value for local users and to maximise network efficiency with demand and generation growth in mind; networks will need large scale reinforcement in the future as National Demand is predicted to reach 98GW by 2050 according to NGESO under their 'Leading the Way Scenario' under the NGESO's Future Energy Scenarios. [18]

CT Consumer Transformation LW Leading the Way
ST System Transformation FS Falling Short

	2021	2030				2035				2050			
Emissions		CT	ST	LW	FS	CT	ST	LW	FS	CT	ST	LW	FS
Annual average carbon intensity of electricity (g CO_2/kWh)	156	40	47	15	106	-26	-26	-12	43	-53	-51	-19	-12
Electricity													
Annual demand (TWh)[1]	294	339	321	368	323	463	392	476	370	710	716	672	566
Peak demand (GW)[2]	59	69	64	63	67	87	73	82	78	113	100	98	114

Image Courtesy of National Grid ESO – FES

Within the North West, demands are predicted reach 49TWh according to ENWLs Distribution Future Energy Scenarios[19]. Another purpose for an LEM is to provide a platform for users to offer flexibility services to the DSO and to the ESO in managing a future energy system where flexibility will play an ever-important role.

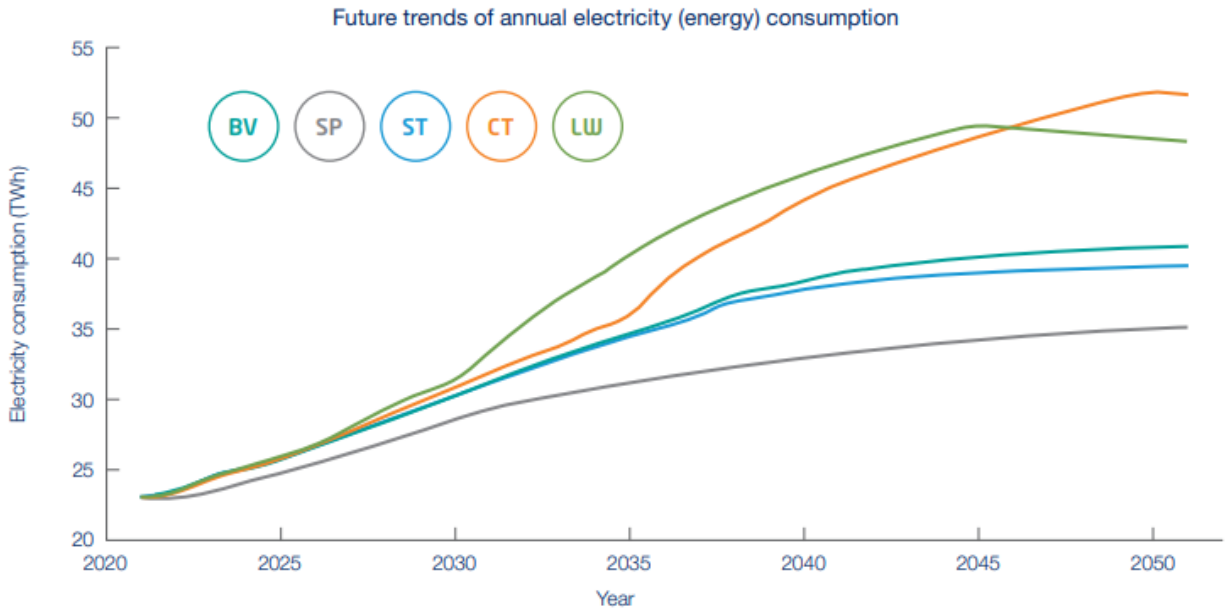


Figure 4a: Courtesy of ENWL – DFES 2021

[18] https://www.nationalgrideso.com/document/263861/download
[19] https://www.enwl.co.uk/get-connected/network-information/dfes/

The LEM platform will aim to optimise the use of local energy sources and importing from the HV Grid when necessary. The HV Grid in the case of the LEM will include higher DSO voltage levels and the National Grid GSP Import points. The other function of an LEM would be to optimise the way DERs connect and can participate in local and national markets.

The main components required for a Local Energy Market are detailed below.

Platform Participants

Participants within the LEM are the users and include generators, industrial clusters, consumers and can include others, such as suppliers, local authorities and aggregators etc.

LEM Exchange

An LEM Exchange is where finalised trades are conducted, services such as DSO and ESO market services are traded and where users can view platform activity. The exchange will allow the DSO control room to view LEM activity, including generator summaries, ANM activities and what industrial/consumer users are consuming/producing. The ESO would be able to view a summarised version of the LEM Exchange via an API integration link which would allow them to determine if generators within an LEM zone were available for services, or if other flexibility services were available in the area.

LEM Platform

The LEM Platform is where initial trading blocks are calculated based on data inputs into the platform such as generator constraint forecast data, ANM activities, industrial cluster outputs and consumer demand forecasts. The outputs from the Platform are sent to the exchange where trades are finalised.

DSO Control Room

The DSO control room have visibility of generators, industry and residential clusters at a granular level but the direct SCADA link between the DSO and LEM exchange allows them to see high level generator availability, generator positions, constraints, live ANM areas and forecast demands. This will all aid in a more efficient management of the DNO network.

ESO Control Room

The ESO will have the option to view the LEM Exchange via API integration, this will avoid the need for direct SCADA integration and the API protocol would allow the ESO to view similar information to the items the DSO could see. ESO could then utilise the LEM resources in system operation as they would be able to see forecast resource availability, ANM active zones etc. It should be noted, the API integration could also be used by energy suppliers when aggregating customers and would allow for external parties to participate within the LEM.

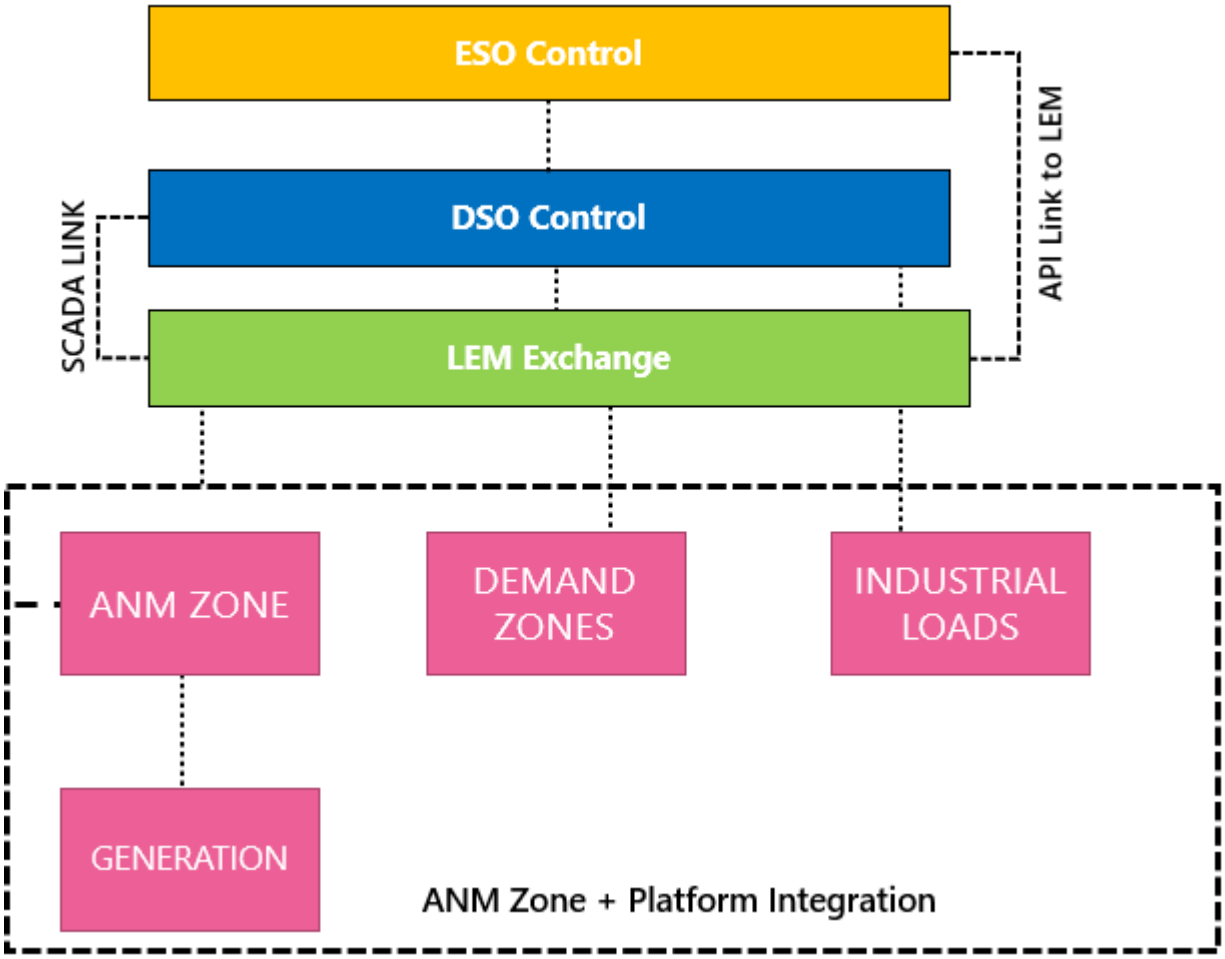


Figure 3a: Overview of an LEM

4.1 TraDER and Neutral Market Facilitation

Project TraDER was an innovation project on the Orkney islands that planned to develop, integrate and scale a flexibility exchange, seeking to optimise renewable energy integration into the UK's changing energy markets. [20] The project ran from second half of 2019 - to June 2021. The project Parties included: Electron, EDF, Community Energy Scotland, CGI, Kaluza and Energy Systems Catapult. Elexon and the distribution network operator (DNO), SSEN, provided essential support to the project as project partners and with the project Parties formed the core group, but they received no financial compensation through the project's grant, therefore facilitating the data transfers needed for a third party platform to act as a neutral market facilitator.

The ESC published a report on project TraDER in 2021 and concluded that there was great value in having an energy market at the DNO level where various services could be traded between parties but found some challenges when it came to the co-existence of Active Network Management (ANM) systems and Local Energy Markets. [21]

Some of the issues surrounding ANMs co-existing and integrating with the TraDER trading platform were:

- Older ANM systems did not have the functionality to implement most products on the trading platform, mainly the Curtailment Queue Management (CQM) and needed extensive re-design if they were to function in this manner.
- Currently the ESO cannot procure generation from the DNO network where resources are connected behind ANM zones due to probability of curtailment, despite the chance being small. This eliminates a large pool of resources the ESO could utilise. This is not an efficient way to operate the GB Power System where operating costs are increasing year on year (£2.5Bn by 2030)[22].
- ANM communications, their functionality, and the data they transmit may benefit from greater standardisation so the integration between ANMs and Trading platforms can be replicated across DNO networks.

[20] https://es.catapult.org.uk/report/project-trader/
[21] https://esc-production-2021.s3.eu-west-2.amazonaws.com/2021/10/Project-TraDER-Summary-Report.pdf
[22] https://www.nationalgrideso.com/research-publications/network-options-assessment-noa

4.2 Project BiTraDER

After gaining experience in the TraDER project, Electron, AFRY and Delta-EE are now commencing Project BiTraDER with Electricity North West Limited after being awarded £8.4M through OFGEMs Network Innovation Competition, with works beginning May 2022.[23]

The project aims to facilitate a neutral trading platform that will allow the live bilateral trading of generation and demand capacities on the network. The ANM will be used to forecast these capacities and constraints. The project is due to release a final report in July 2026.

Figure 4.2a below shows the proposed architecture for the Project BiTraDER platform which aims to facilitate a Constraint Queue Management (CQM) trade platform in a very accurate manner. The platform aims to unlock further network flexibility, allow bilateral trade of network capacity and would look to allow Distributed Energy Resources (DERs) the opportunity to offer services to both ESO and DSO. The diagram illustrates the function the ANM will play and how the data gathered by the zone will contribute to constraint forecasting.

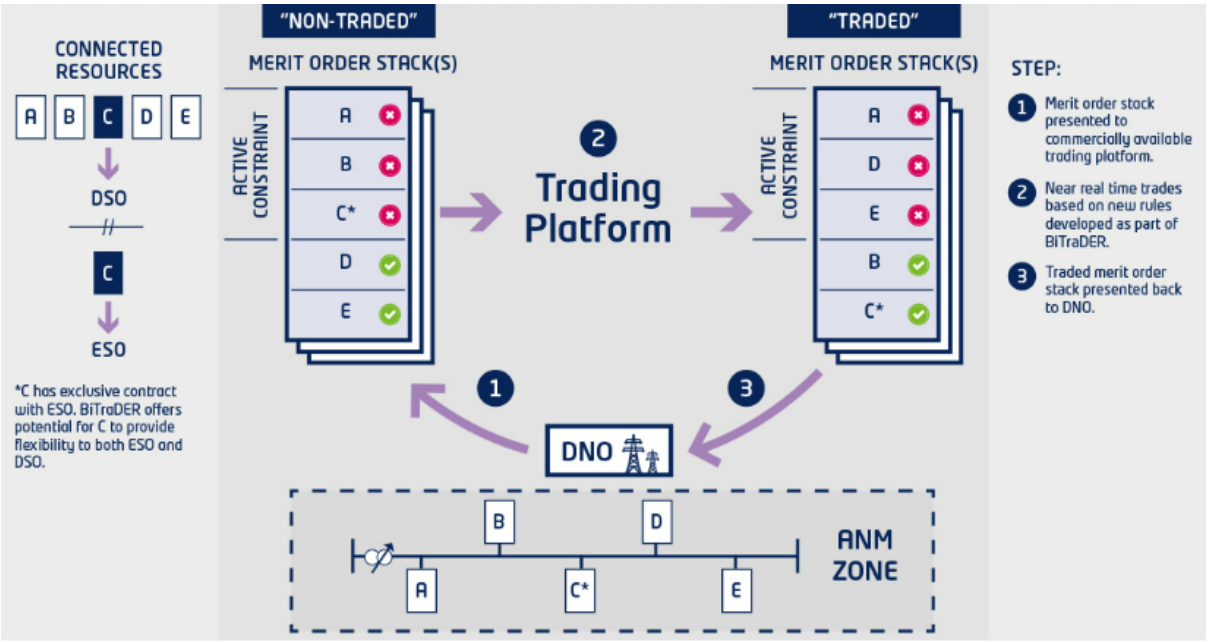


Figure 4.2a: BiTraDER overview, courtesy of ENWL via OFGEM NIC Submission

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

Figure 4.2b shares in greater detail, how the BiTraDER platform will function and how the ANM / DERMS (Distributed Energy Resource Management System) will feed into the algorithm which will calculate and forecast network capacity/constraints.

The ESC proposal is to build on the architecture in two more phases and allow for ESO visibility on a wider scale with the architecture below acting as a Stage One blueprint for other DNOs / ANM constrained networks.

From the 'Look Ahead' input data exchange, we can see the various forecast network capacities and flexibility services that could be needed, with real time trading taking place and resulting in some of the initial trades being executed. The services expected to be offered by BiTraDER will initially include capacity in both generation and user form, however the ESC proposal will envisage a large increase in trade and market services facilitated by the platform.

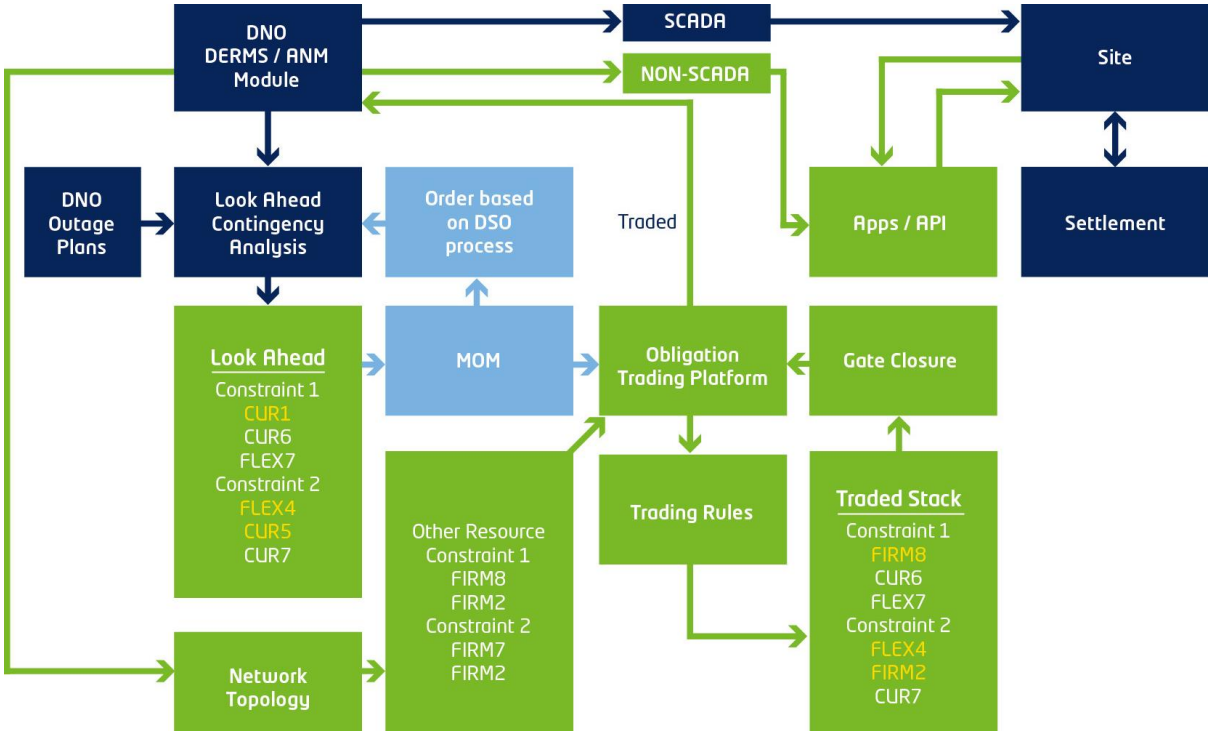


Figure 4.2b: BiTraDER architecture, courtesy of ENWL via OFGEM NIC Submission

4.3 Value Proposition

The proposed adoption and phased rollout of the LEM could present many benefits to multiple stakeholders. The ESC proposal is for a 3 Phase rollout of the LEM in a staged development, with testing of functions before final adoption of the market at each stage.

Figure 4.3a shows the value proposal of the ESCs ANM-LEM roadmap which includes Local Authorities and Consumers as well as 'Pro-sumers' who are able to benefit from being integrated into a neutral market trading platform.

The market is intended to function at day-ahead and in operational timescales where there is most value.

<table>
<tr><th></th><th>DNO</th><th>DSO</th><th>ESO</th><th>Generators</th><th>Consumers + Pro-sumers</th><th>Local Authorities</th></tr>
<tr><td>Network Reinforcement</td><td>Deferral of system builds in favour of flexibility</td><td></td><td>Greater coordination of network reinforcement and future demands to ensure SQSS compliance</td><td></td><td></td><td></td></tr>
<tr><td>Optimised System Operation</td><td>Network maintenance plans can be costed against constraints for best interest of end-consumer</td><td colspan="2" rowspan="3">Reduced cost of System Operation with increased competition, including participation of DSR

Lower constraint costs at a National and Regional level

Flexible contracts can be used for DSO or ESO services

Pricing of flex services competitive due to wider pool availability, National market still an option</td><td rowspan="3">Opportunity to provide wider market services</td><td>Time of Use and State of System tariffs can be scheduled based on local network state</td><td></td></tr>
<tr><td>Wider Resource Pool in Balancing System</td><td></td><td rowspan="2">Consumers are able to participate in DSR and Trader Alerted services

Reduction in energy bills possible

Offer aggregated DER services to DSO and ESO</td><td></td></tr>
<tr><td>Increase In Flexible Contract Use</td><td></td><td rowspan="2">Negates needs for grants due to wider market access and increased revenue streams</td></tr>
<tr><td>Reduces Energy Bills</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Figure 4.3a: Value proposal and beneficiary table

Active Network Management – Generator Service Procurement

In the current market, the ESO has stringent criteria when procuring generators connected to an ANM and in many cases procures very few market services from generation that is connected behind an ANM system due to probability of curtailment. There have been projects conducted by Western Power Distribution (now NGED) and NGESO to facilitate further procurement of ANM connected assets however the conclusion of these projects has meant further work is required in this area. [24] Having a platform which can monitor active constraints and forecast constraints could allow the ESO visibility on a more granular level, which would allow them to procure market services with a greater degree of confidence.

Lower System Operation Costs at a National Level

[24] https://www.westernpower.co.uk/innovation/projects/optimal-coordination-of-active-network-management-schemes-and-balancing-services-market

NGESO have predicted in their Network Options Assessment (NOA) 2022 publication that constraint costs may amount to £2bn per year until system reinforcements are built at the end of the decade (2030), mainly due to an increase in offshore wind and interconnector connections.[25] If a greater number of generators are connected at the distribution level and can offer their services to the ESO despite being connected behind an ANM, this could reduce system operation costs. The regional development programme has built on the works done by the ENA open access project and aims to address this issue, however LEMs would provide an additional vehicle for delivering this additional value to consumers. [26] A Local energy market would not just focus on Distributed Energy Resources, it would aim to forecast demand, generator constraints and include industrial clusters into the market, whereas the RDP has a heavy focus on unlocking value from additional DERs being brough into the National Markets.

Distribution System Operator – Network Optimisation

As Distribution Network Operators (DNO) are beginning the transition to a Distribution System Operator (DSO), the efficient management of generation and demand is becoming more of a focus. Rather than curtail generation, an LEM can provide further capacity due to the granularity of the monitoring available; traditional ANMs act, in some cases, as a blunt instrument and remove more generation than is necessary to manage constraints. It would also provide the DNO with further Network Flexibility options rather than Network Reinforcements which is a requirement under the current ED2 regulatory framework. [27]

Local Value and Participation

The phased rollout of an LEM from Generators to industrial users and finally to residential consumers would allow them to participate in flexible markets and aid in the management of local Grid management. Market participants could see lower energy bills as a result of their participation in an LEM as the overall lower cost of system operation at a DSO and ESO level is passed on to the end consumer.

LEM Ownership and Regulation

LEMs would be owned by third parties and not by the neutral market facilitator such as the DSO. This would be very similar in ownership structure to existing LEM projects such as project LEO [28] which is an LEM based in Oxfordshire that is aiming to bring ESO and DSO market services to the Oxfordshire area. An LEM would need to be regulated by OFGEM in a similar way to energy exchanges or market platforms such as the national wholesale market, with a proposed new regulatory framework required.

[25] https://www.nationalgrideso.com/research-publications/network-options-assessment-noa/key-documents
[26] https://www.nationalgrideso.com/document/189601/download
[27] https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/network-price-controls-2021-2028-riio-2/network-price-controls-2021-2028-riio-2-electricity-distribution-price-control-2023-2028-riio-ed2
[28] https://project-leo.co.uk/

DSOs would probably not be the owner of these platforms to avoid any potential conflict of interest as they would be the market data supplier enabling the function of the platform which would require some DSO functions ringfenced from the parent organisation.

Further work is needed in the area of LEM regulation. OFGEM recently announced a Call for Input on local energy institutions and governance, [29] which aimed to seek input from industry stakeholders on energy system function on the sub-national level, suitability of current governance arrangements and the risks/opportunities for alternative markets and arrangements.

There are no clear definitions around:

1. Who owns and operates the LEM and the licensing associated with this were LEMs to scale
2. How the market should be operated – Gate closures, imbalance settlements etc what structure is needed
3. Appropriate levels of market monitoring and enforcement procedures

These are areas the ESC are looking to conduct further research on in 2023.

[29] https://www.ofgem.gov.uk/publications/call-input-future-local-energy-institutions-and-governance

5 Role of Active Network Management in LEM

As ANM systems are noted to be varied in their capabilities across different DNOs across Great Britain, their possible use cases in facilitating trading platforms can be wide ranging.

This report assumes the ANM has a granular level of data recording for monitoring, forecasting and is able to discern network capacity issues to a reasonable magnitude e.g. limiting network capacity to the nearest hundredth kW rather than issuing large disconnection commands to DERs.

Figure 5a below shows the ANM monitoring a local area which includes a 132kV area down to 33kV level with two solar farms connected. The ANM feeds into a data-exchange centre which feeds into the trading platform. At the same time, industrial and residential users are able to see trade alerts in real time.

The ANM is producing monitoring data which and feeds this into the LEM platform, which in this case would incorporate a processing mechanisms such as BiTraDER. The ANMs core function as a protection device remains the same in case of market non-deliverance.

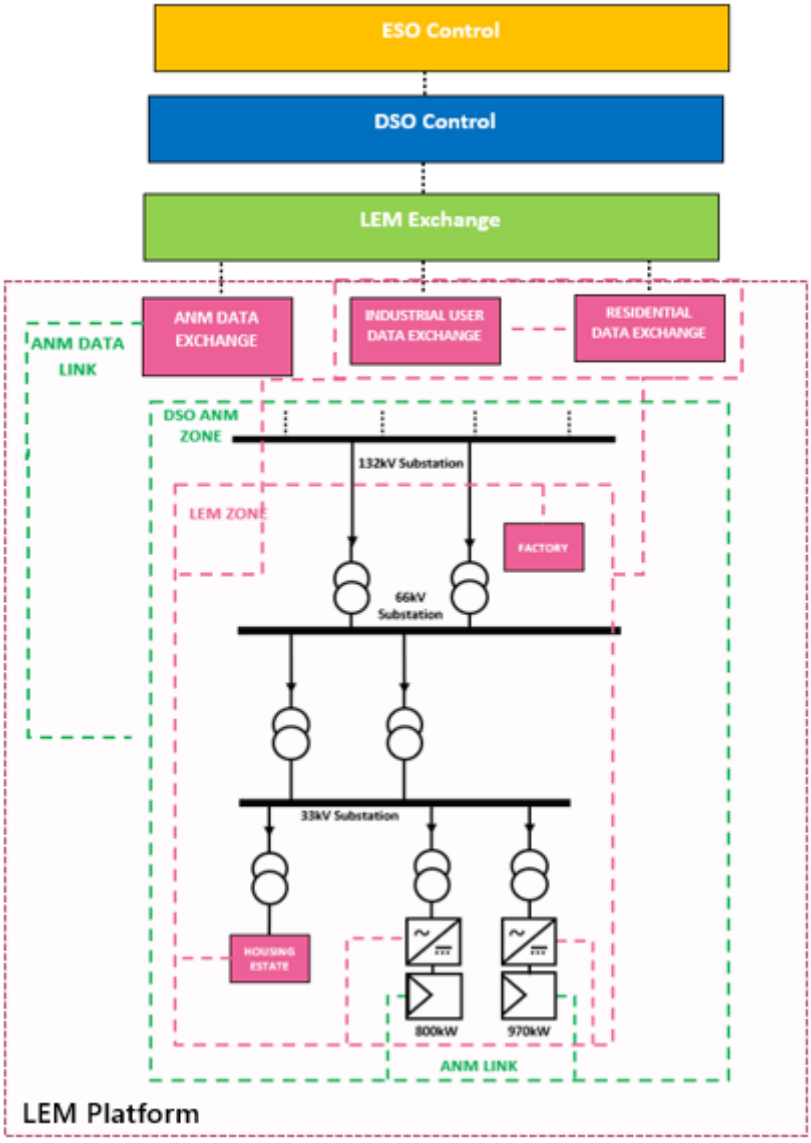


Figure 5a: High level overview on ANM monitoring and data links in an LEM as envisaged by ESC

6 Three Stage LEM Rollout

The initial goal of the LEM proposal as part of the UCEGM project was to develop a market architecture that would incorporate DERs, the ESO, DSO, DNO, Consumers and Local Authorities. It became apparent the technical and engineering complexities of proposing a market with all stakeholders at once was extremely difficult and potentially costly.

After taking the learnings and feedback from the Project TraDER report, the proposal by the ESC to construct an LEM in 3 stages is to allow for the initial data, communication, and platform creation issues to be identified at earliest opportunity and resolved by the BiTraDER project.

Stage One requirements for the project and adoption are detailed further below; BiTraDER allows for a modular approach to the full adoption of an where it would encompass Industrial Users and Consumers after generator constraint and capacity trading has been successfully rolled out.

Figure 6a: Three stage roll-out of the platform, with proposal to build on BiTraDER architecture

Stage One Rollout – Characteristics

- Project BiTraDER will allow generators to buy and sell constraint capacities based on ANM / DERMS forecasts
- Using this algorithm, the availability of generation can be seen by the DSO who in turn can allow the ESO to view this via ICCP (Inter Control Center Protocol) Links or alternatively, API Links into Non Scada channels (Wider Access saw the widespread use of API integration by the ESO)[30]. The benefit of an API approach would be the costs compared to setting up an ICCP link with numerous LEMs and the ESO
- ANM will maintain core function as protection device, the data will be captured to provide ESO with Generation views, such as availability, forecast constraints, forecast capacity and how much availability there is in ANM zones

Stage Two Rollout – Characteristics

[30] https://www.nationalgrideso.com/balancing-services/balancing-mechanism-wider-access

- The stage two industrial rollout will incorporate industrial users into the LEM that will allow them to provide market services to both the DSO and ESO. Demand side services, flexibility services and surplus power can all be traded on the platform
- Industrial users will all need to have < 30M metering or active monitoring. Many already have direct agreements with DNO so loads are seen relatively quickly. DSR metering is essentially what will be needed for rollout
- Smart metering for market signal response and gate closure participation
- Demand levels, forecasting all to be incorporated by BiTraDER / Platform for forecasting with capacity signal generated based on factory usage at gate closure
- Demand flex to manage system or provide capacity function incorporated

Stage Three Rollout – Strategy

- The third stage is expected to be the most complex and will incorporate consumers into the platform. This would allow consumers to participate in the LEM, provide their assets for use with the DNO network and provide an aggregated services to the ESO through means such as vehicle to grid (V2G). The LEM is intended to make the procurement of these services for the ESO as efficient as possible as it would allow entities such as energy suppliers, aggregators and energy retailers to procure and aggregate consumers at the LEM Exchange level
- BiTraDER / Exchange has access to 5M / Granular demand data, this level of granularity is expected from consumers as offering real time services to manage the network would require an increased level of smart meter granularity, compared to the existing 30M protocol submission. The 5 minute intervals of data submission would allow consumers to participate in live markets where opportunities could be more lucrative
- Suppliers and aggregators such as VLPs (Virtual Lead Parties) will handle the interface between ESO/DSO and the consumer, the supplier can facilitate this communication channel as an initial starting point for ease of access – Similar to Flex Alerts used by the California ISO [31]. However, it does not mean consumers will not have the capabilities in the future to offer flexibility services directly to organizations that offer these propositions. The interface in this case would mean the means in which consumers can communicate or view LEM Exchange activities or opt in for services through the use of smartphones, applications etc. The supplier or aggregator would manage this link between the consumer and the platform

[31] https://www.flexalert.org/

- Consumers could participate in markets without having live metering feeding into DSO monitoring systems, if necessary, by using 30-minute metering approximations. There are devices on the market that can wirelessly submit live consumer usage to DSOs[32] however would need to be cost effective for mass roll-out
- Smart solutions in low carbon technology like EVs and Heat pumps that can allow for aggregation of assets and consumers able to opt in to services like dynamic Vehicle to Grid services where the exchange will only take place if the vehicles battery is above a certain percentage
- Supplier sets up API integration for customers through BiTraDER Non-SCADA channels

Neutral Market Zone

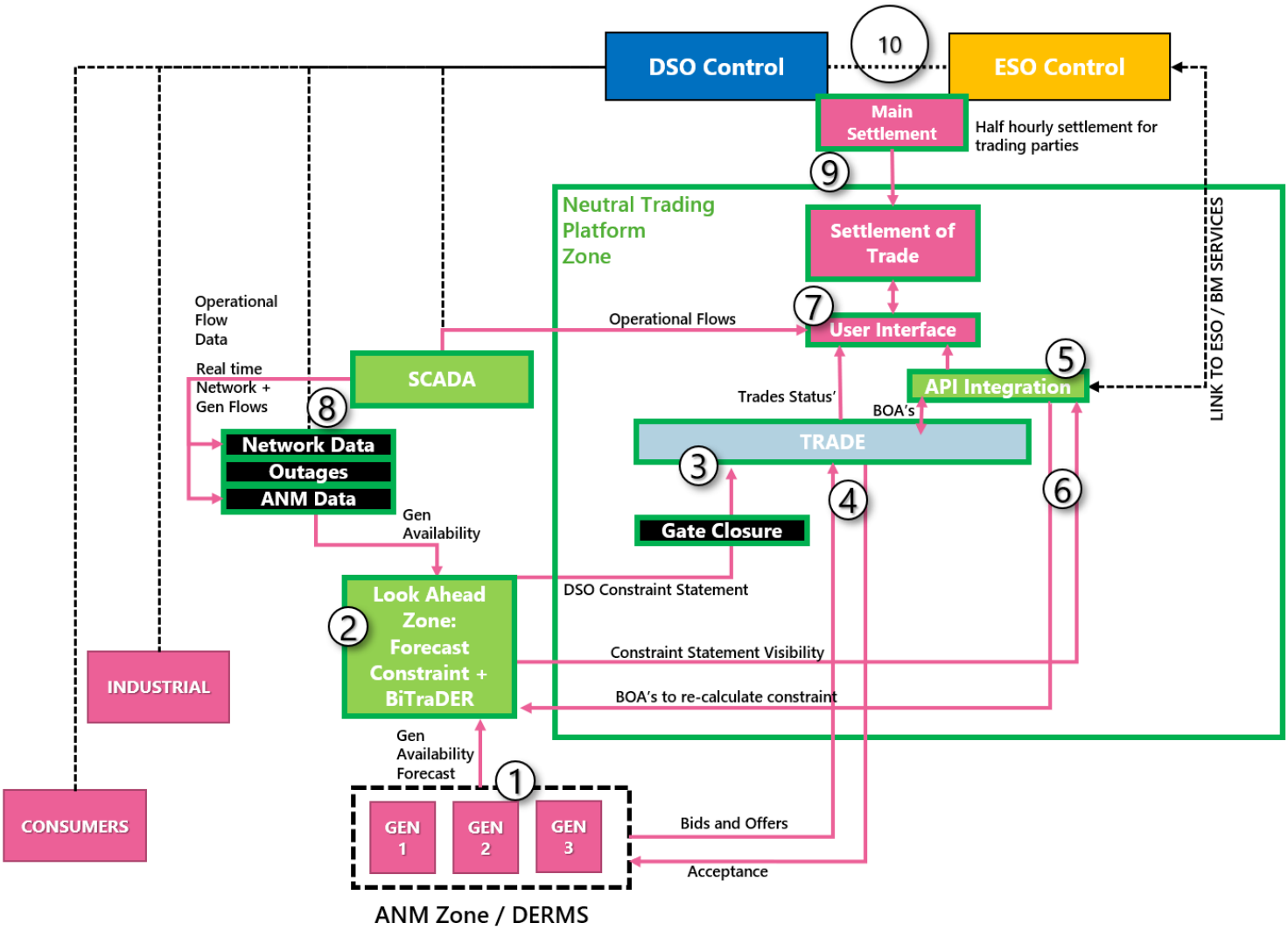
A neutral market zone that can be facilitated by the DSO or Local Authorities is one of the core functions required to facilitate a matured LEM. The information needed for the market function is provided by the DSO who would act as a neutral facilitator with no ownership of the market.

[32] https://www.informetis.com/en/product/device/

6.1.1 Stage One in Detail – Generator Integration into LEM

Stage one of the LEM roll-out would include the incorporation of generators into the LEM. Figure 6.1.1a below shows, at a high level, the current state of play and how the Neutral Trading platform would incorporate the ANMs well as the communication link between the ESO and DSO for greater system visibility and closer ESO-DSO cooperation.

Figure 6.1.1a illustrates a Stage One LEM proposal with key areas of the architecture explained by the corresponding number on the diagram.



Note: the numbers in 6.1.1a do not represent data flow order or merit order in exact order

Figure 6.1.1a: Stage One LEM Roll-Out Architecture Proposal

Look Ahead Zone Explained

Figure 6.1.1a illustrates the architecture of an LEM with generators included within the framework alongside a trading platform. In this case, the 'Look Ahead Zone' is the area where constraint forecasts are calculated using a combination of network data, historic data and metered data. This Look Ahead Zone is where a Probabilistic Constraint Factor (PCF) as highlighted in Section 3.2 could be calculated with the ESO having direct visibility.

Figure 6.1.1a Explained

1. Generator availability and forecast availability, current flows and Physical Notifications are fed into the look-ahead zone. The ANM Zone is constantly feeding forecast information into the look-ahead zone. This zone could also be combined with DERMS (Distributed Energy Resource Management System).

2. The look-ahead zone receives forecast ANM data, real time network data, outage information and real time ANM monitoring via SCADA to refine forecast constraint information. This occurs outside the zone of the Neutral Trading Platform, which in this case is one of the components of BiTraDER. The LAZ will also have the functionality to calculate probabilistic curtailment factors (PCF) and allow for the ESO to have visibility of these. This will then allow ESO to procure DERs connected behind an ANM zone with increased confidence.

3. The look-ahead zone (LAZ) provides the constraint blocks and capacity calculations into the trade platform. These are approximated constraints that have been calculated through the use of live data, forecasts, ANM data etc. The output generated by the LAZ is referred to as a Constraint Statement on the diagram. This occurs at day ahead to be accessible for market participation.

6.

4. Generators and market participants submit Bids and Offers which are seen by the Trade Platform and the status of the trades can directly be seen by the generator parties within the ANM Zone. When constraint blocks are produced for forecasts, the actual traded capacity Merit Order Stacks will determine which market participant has won the capacity bids, as per figure 5.1.1b

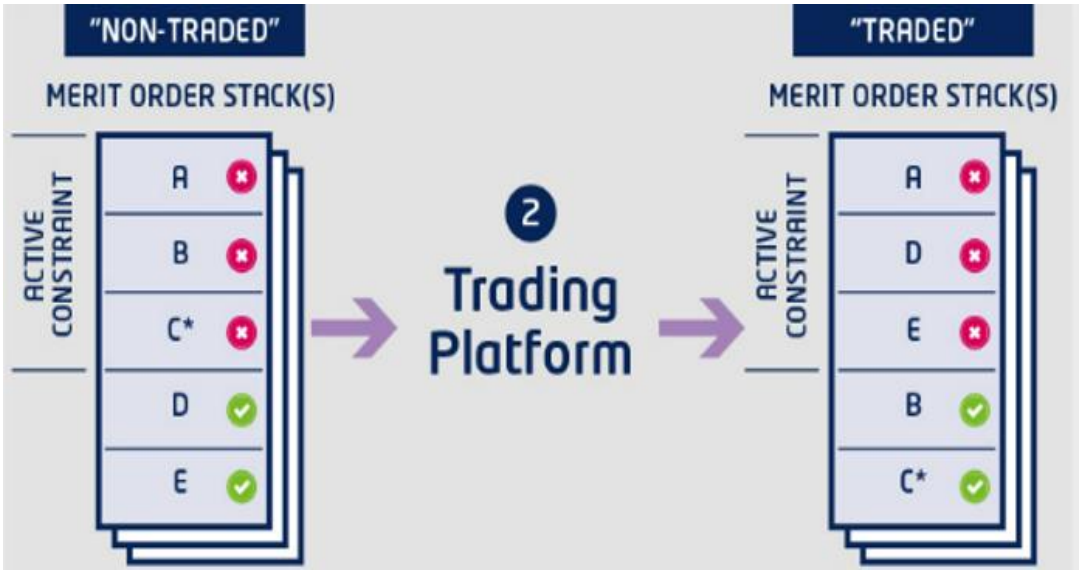


Figure 6.1.1b: Forecast capacities which are processed via the Trading platform,

courtesy of ENWL

5. Trade data, such as magnitude, market price and trade status are viewable via API integration. The API facility will allow users to view the status of the trading platform and plan operations, participate in the market and react to price signals accordingly. The API integration will also enable the ESO to view the actual generation available in the ANM zones, allowing them to procure generators connected to an ANM zone with greater confidence.

6. This area shows the communication between the LAZ and the API interface for external parties. The LAZ and API integration allows the user to view constraint forecast visibility. Trade information on executed trades is also fed back into the LAZ which allow it to refine constraint and capacity calculations.

7. The User Interface (UI) allows parties to view trades, live system information, active constraint zones and trade status.

7.

8. Network data such as voltage levels at substations, thermal performance, transformer winding temperatures etc will constantly be fed into the trading platform so corrective calculations can be carried. DNO outage data for Day-Ahead timescales can also be fed into the platform for forecast constraints at day-ahead. This data is coming directly from SCADA monitoring

9. Settlement of Trade occurs when trades have been executed in real time. These settlements are visible to the DSO in real time as well as the ESO. Main settlement functions also mean there is visibility for the DSO and ESO on half hourly settlements for trading parties.

10. ESO and DSO maintain communications and can both view LEM trades, ANM constraints and Settlements. Each operator can view select areas of the LEM if needed.

6.1.2 Stage Two in Detail – Industrial User Integration into LEM

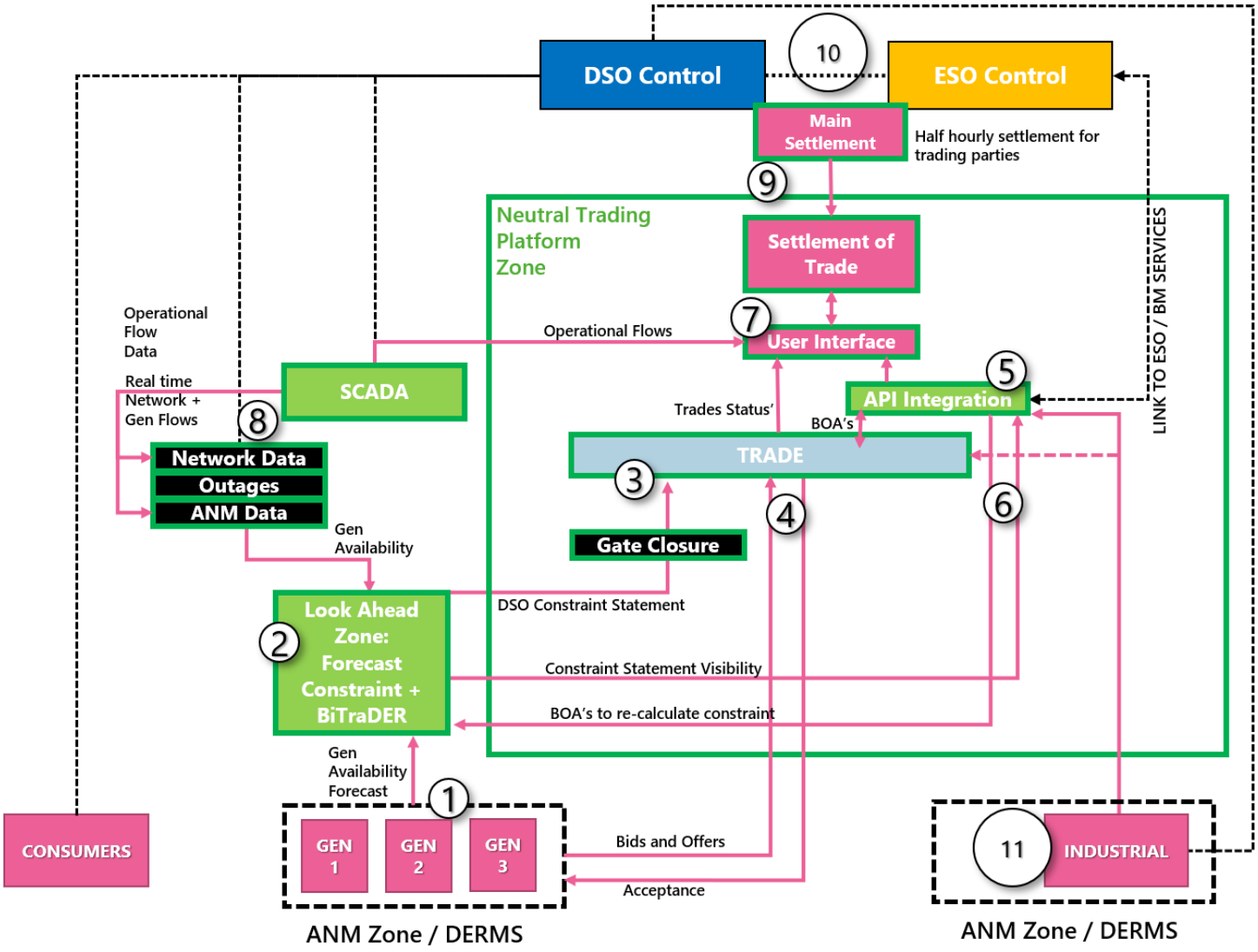
Stage Two of the LEM Roll-out would include industrial users and industrial demand nodes. The reason for including industrial users before residential is that the industrial participation in flexible markets such as DSR are already proven feasible with smart metering and technology in at reasonable scale.

Figure 6.1.2a shows the expansion of the ANM zone to include the data submissions by the industrial users in the area of monitoring. In reality the ANM would not need re-wiring or expanding as the detail diagram will show in section 6.1.2a. The industrial user data and live metering can be processed by the Trading Platform / Exchange which the ANM directly

feeds into and takes data from. Expanding to industrial users in this way unlocks further market participation and provides increased liquidity for the LEM.

The ANM will again, remain as a protection system and will not disconnect industrial loads based on its readings, disconnection will only occur due to fault occurrences and the ANM will only disconnect generator units in the event of system overloads.

Stage Two involves the close integration of industrial users within the LEM. Here, they can offer services such as Demand Side Response, Demand Turn Up and sell to the wider DSO and ESO markets if they are producing excess power.



Note: Diagram 6.1.2a Numbering and corresponding explanations remain the same as in section 5.1.1, the addition of Industrial Clusters into the LEM is explained in this section only.

Figure 5.2.1a: Illustration showing the inclusion of Industrial Users into the Local Energy Market

11. Industrial Users can participate in the LEM via the API integration mechanism and have direct access to the Trading Platform so they can receive market signals, provide market services, and generate additional revenue streams.

    Power produced on site by generators, such as rooftop PV, could be sold bilaterally despite being behind ANM due to new metering arrangements (increased granularity and resolution of 'behind the meter' DER concerns the DSO may have) and the constant calculation of new line loads by the ANM. The amount of power available to trade is limited by the capacity determined available by the trading platform, which DERs can then use to buy and sell this capacity allocation bilaterally. Further to this, self-consumption can be tailored based on market pricing data and signaling to incentivize LEM participation and add revenue for industrial participants.

6.2 Stage Three: Residential Users

Stage Three incorporates residential users into the LEM. This has been set as the final stage of the LEM roll-out due to the complexity and variables involved in opening a flexibility market up to consumers so that they become pro-sumers and take a more pro-active role in the way they use energy.

The ANM would already be taking metered data from street level Grid transformers in Stages One and Stages Two to approximate demand forecasts for the Trading Platform. Stage Three would allow entities such as energy retailers or aggregators to act on behalf of residential consumers in accessing market signals or buying or selling their own capacity. One the other potential revenue sources for residential users of an LEM would be to participate and respond to flexible events, DSR events and act as an aggregated DTU (Demand Turn Up) mechanism.

It should be noted, the ANM would act as a monitoring device in this situation and would not be controlling demand. Demand loss would occur in the same ways losses occur today, via faults etc. The proposal to expand the ANM to monitor demand is put forward due to integration assumptions; if street level transformers can be expanded into the ANM, this could allow the needed data sources when a platform like Project BiTraDER is computing generator constraint forecasts.

Stage Three assumes smart charging in EVs and other devices such as heat pumps are active and can be utilised via aggregation. The other major assumption made is suppliers/aggregators act as facilitators between the LEM Platform and consumers.

6.2.1 Stage Three in Detail – Incorporating Residential Consumers Into LEM

In early September of 2022, The California Independent System Operator (CAISO) issued several warnings to users advising of potential rolling blackouts on the Grid due to high loads and low reserve margins on the system. [33] The ISO issued several 'Flex Alerts' which send notifications to smartphone users who are signed up for the service, to turn down demand for monetary reward. The service worked as intended and the Grid was able to lower warning levels and avoid rolling blackouts. [34]

The Flex Alerts were facilitated by suppliers who would then reimburse consumers, not directly by the ISO. This is something the ESO and DSOs could utilise in a similar manner if consumers were to be included as part of an LEM. The ESO is already looking at procuring additional flexibility to combat winter peaks.[35] It would also remove the data handling issues away from Network Operators.

The NGESO launched the Demand Flexibility Service (DFS) on November 1st 2022, which allows the ESO to access flexibility when national demand is at its highest point. The service has been design to allow consumers as well as some industrial and commercial users through suppliers and aggregators, to reduce demand when called upon. [36] The DFS was built upon flexibility trials conducted by Octopus Energy which showcased demand flexibility services and how this could successfully lower demand by around 150MW over 2 hours. [37]

[33] https://www.flexalert.org/news
[34] https://www.theverge.com/2022/9/7/23340821/california-electricity-grid-power-outage-text-phone-alert
[35] https://www.nationalgrideso.com/industry-information/balancing-services/demand-flexibility
[36] https://www.nationalgrideso.com/industry-information/balancing-services/demand-flexibility
[37] https://www.nationalgrideso.com/news/national-grid-eso-and-octopus-energy-launch-trial-unleash-demand-flexibility-winter

Note: Diagram 6.2.1a Numbering and corresponding explanations remain the same as in section 6.1 with the exception of number 12 , the addition of residential consumers is explained in further detail in this section.

Consumers in an LEM – No Supplier Involvement

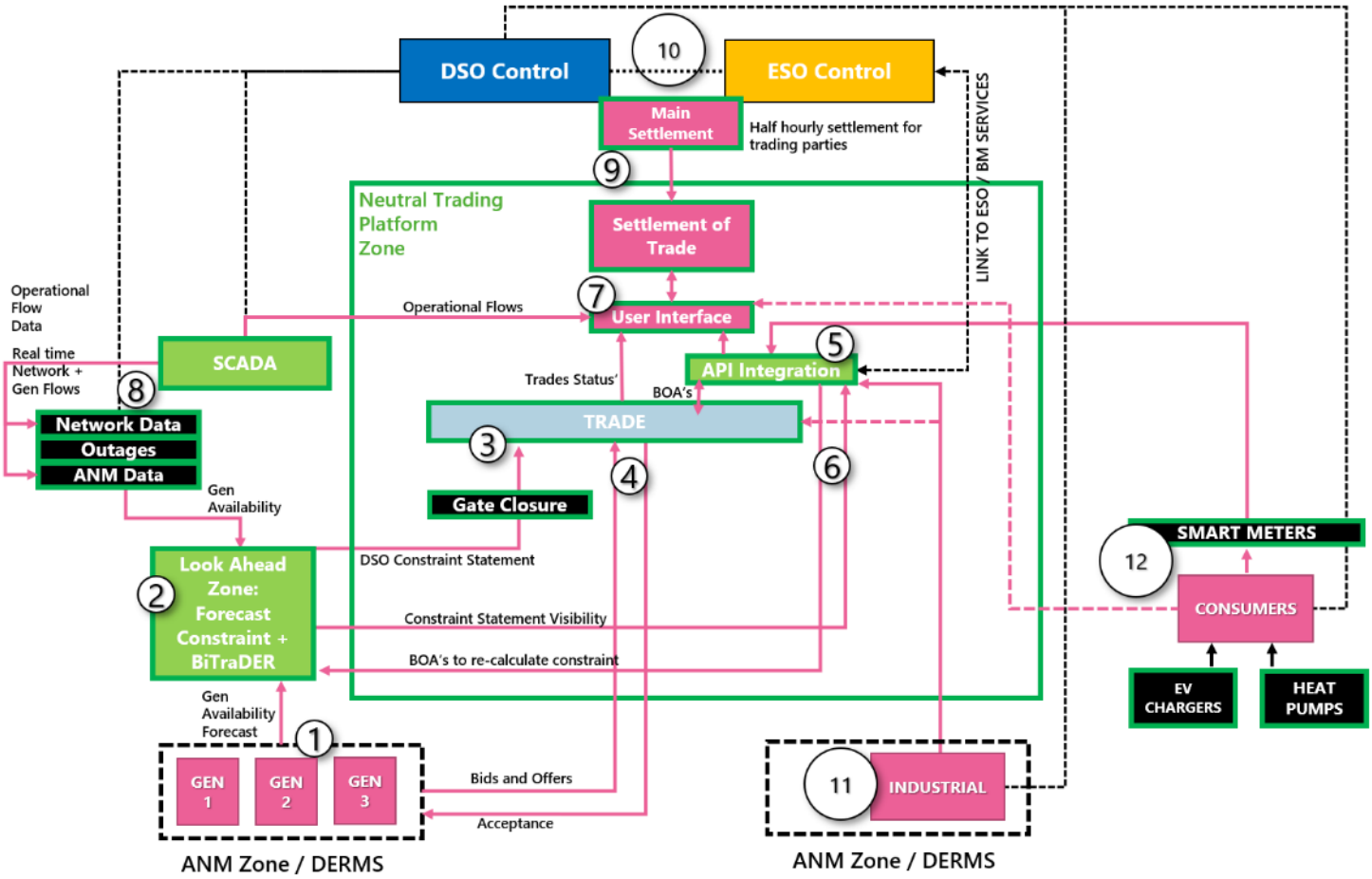


Figure 6.2.1a: Stage Three architecture Diagram showing residential users connected to the LEM

12. Consumers shown by the number 12 in figure 6.2.1a would be able partake in DSR events or take advantage of Time of Use tariffs. The scenario above would need to be facilitated by the DSO and ESO however, and this would present problems in the way of data management, communication and needing to communicate the consumers positions to the ESO.

Consumer and Supplier Architecture – Facilitation

To bring the large volume into a Local Energy Market, supplier facilitation of LEM access and Trading Platform notifications would be hugely beneficial as most retailer infrastructure is already set up to do this; smart phone notifications, smart meter readings etc. Figure 5.3.1b shows a potential supplier structure in Stage Three of the LEM Roll-out, with the dashed-line going towards the LEM architecture.

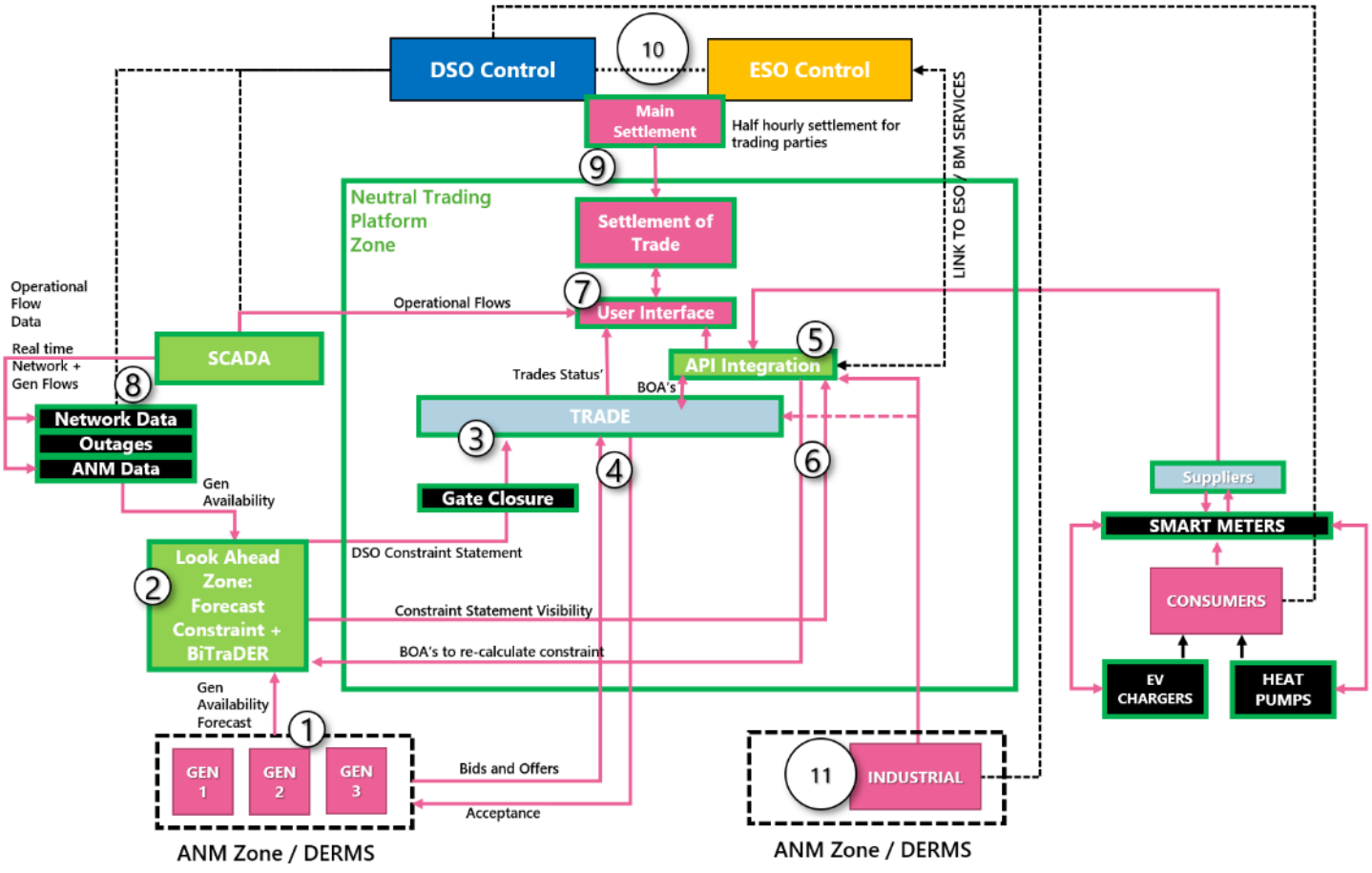
Smart meters can communicate wirelessly with EVs and Heat pumps and other loads, allowing the retailers to aggregate assets. The retailer would access the information needed to facilitate trades via API integration and phone applications.

Stage Three: Supplier, Consumer and LEM Architecture

The illustration in 6.2.1b shows a complete Stage Three roll-out and the communication links the retailer would have to establish in order to bring LEM access to consumers.

The DSO would still have visibility of Grid Transformer metering as normal but will also now have the ability to view live demand data grouped by supply points, as well as see the state of charge on EVs. This could then allow DSOs to use EVs for their Vehicle to Grid capabilities, if need be, for demand reduction or turn up. Devices like EVs and Heat pumps would have to communicate with the smart meter to allow this function. Whilst this function exists in some areas via aggregation, it would allow an increased number of consumers an additional market to participate in; services could be sold via VLP or if the functionality already exists the service can be sold locally to manage the DNO network or nationally for services like frequency response. The platform would be the medium which would allow the ESO to view how large the V2G resource availability is locally and aggregated nationally.

This degree of control would allow aggregated supplier positions and the use of consumer assets for constraint management, frequency response and to participate in ESO markets



in real time. Data recorded from these devices can also be used by the Trading Platform to forecast demand and constraint data more accurately.

Figure 6.2.1b: Final Stage Three illustration, with finalised consumer architecture in place

6.3 Metering Arrangement Requirements for an LEM

There are significant challenges associated with Stage Three of the LEM Roll-out. One of the biggest issues is having adequate metering and for the correct monitoring of the following areas:

- Smart Metering with <=30M intervals
- EV Smart Charging with Communication to Smart Meter
- Heat Pump Communications with Smart Meter
- Domestic PV and Battery Storage
- DSO visibility of EV state of charge average for an area, therefore protocol is required for the aggregation of EVs and DSO/ESO communications
- Supplier interface with Consumer and DSO/ESO

If residential users want to take part in operational markets where rewards are most likely to be higher, then metering would almost certainly have to be more granular than the 30-minute intervals currently used by suppliers. The issue with this is the amount of data that would need to be collected / stored and the processed if the smart meter recorded minute by minute.

Using ANM data, historical demand data and weather forecasts, the trading platform could estimate day ahead and live operational demands when issuing market signals in order to broaden the LEM participation to residential consumers without needing to fit huge numbers of fast smart meters or changing smart meters (or settings) on existing properties.

7 Next Steps

Although the core area of focus for this report was to propose a technical solution on how an ANM system could be integrated and function alongside an LEM, further research and work is needed in several key areas before fulfilling the goals of actually implementing these markets in their full forms, i.e. Stage Three of the LEM Road-Map.

There are many ongoing Local Energy Market projects and exchanges,[38] such as the Liverpool Energy Xchange[39] and Local Energy Oxfordshire[40] which are aiming to unlock the value of local markets. Past trials such as TraDER have been carried out in Orkney which demonstrated the use case for LEMs through the facilitation of a DSO.

Further research and development on the LEM Staged Concept Rollout is needed in the following areas:

Degree of standardisation in ANM development and Communication Standards
ANM capabilities currently vary across DNOs within Great Britain. The varying capabilities of these ANMs could cause compatibility issues when deploying LEMs of varying designs, or when further integrating these markets, DERs and resources with the ESO. Whilst it is important to acknowledge the regional differences between DNO areas has led to different development approaches for ANMs to suit the needs cases, greater thought should be paid by the regulator regarding the degree of necessary standardisation in ANM design and functionality.[41]

Communication standards between ESO, DSO and LEM platforms are also important and should face greater standardisation. In theory, there could be hundreds of LEMs in the future and having varying communication protocols for them all would make it impossible for the ESO to utilise the resources within the LEM Platforms. The viability of ICCP or adopting an API approach needs to be further explored from a technical feasibility and scalability standpoint.

Interaction with other energy planning and strategic decisions

There are numerous other energy related initiatives at the local level which Local Energy Markets will interact with, and care and attention will need to be paid to how those interactions will occur to ensure a cohesive approach between them, particularly regarding wider planning decisions.

[38] https://www.ukri.org/wp-content/uploads/2022/01/UKRI-250122-SmartLocalEnergySystemsEnergyRevolutionTakesShape.pdf
[39] https://liverpoolenergyexchange.co.uk/
[40] https://project-leo.co.uk/
[41] For further insights, see: https://es.catapult.org.uk/policy-brief/active-network-management-anm-opportunities-and-risks-for-smart-local-energy-systems/

Greater Manchester Council commissioned ESC to lead on a Greater Manchester Local Energy Market (GMLEM) [42] and the two major elements in deploying the LEM are creating a platform for trading energy and the wider energy systems planning.

Local Area Energy Planning (LAEP) conducted by local authorities, future build registers from the DNO, Ofgem's recent call for input on the 'Future of local energy institutions and governance'[43] and open letter on the next network price control review process[44], as well as the future remit of the Future System Operator (FSO), and the coordination future energy strategies between key stakeholders across different regional levels is an area that has been highlighted as needing greater attention, especially in light of LEMs.[45]

LEM Adoption after BiTraDER in 2026 for Phase II

An LEM framework could be explored as part of a Phase II of the BiTraDER project when it is due to complete in 2026. Greater Manchester council have announced a target of becoming carbon neutral by 2038[46], therefore there is a great opportunity to develop a framework for an LEM with a platform like project BiTraDER playing a key role.

Security of platform, Cyber etc

Metering at a large level, smart device aggregation for phase III and Phase II would take some work. Stage Three adoption could be the biggest challenge. Trial proposal for Phase II and Phase III: There needs to be a proposed post 2026 roadmap for LEMs

Value piece on cost benefit approximation for Full LEM phase III. Included in Value Piece is how LEMs negate the need for grants by Local Authorities in their clean energy and Local Area Energy Plans.

[42] https://www.greatermanchester-ca.gov.uk/what-we-do/environment/energy-supply/
[43] https://www.ofgem.gov.uk/publications/call-input-future-local-energy-institutions-and-governance
[44] https://www.ofgem.gov.uk/sites/default/files/2022-09/Open%20Letter%20FINAL_20220929.pdf
[45] https://es.catapult.org.uk/guide/guidance-on-creating-a-local-area-energy-plan/
[46] https://carbon.coop/portfolio/greater-manchester-local-energy-market-gmlem/

Acronyms

Acronym / Term	Expanded	Explanation
ANM	Active Network Management	DNO management system that curtails generation during periods of high export. Connecting behind an ANM area is often cheaper but may restrict what services a generator can offer to the ESO; the system operator will consider on a case-by-case basis depending on likelihood of curtailment.
CfD	Contracts for Difference	Contract agreed between the generator and the LCCC where the negative difference in market price is paid to the generator by the LCCC and vice versa.
DER	Distributed Energy Resource	Small scale electricity supply or demand resources on the DNO network.
Distribution Connection	Connection to the distribution network	Connection agreement is with the DNO. Connection voltage will be 132kV or lower in England and Wales and 66kV or lower in Scotland
DNO	Distribution Network Operator	Owner and operator of low voltage transmission network. Normally operate at voltage levels at 132kV or below.
DSO	Distribution System Operator	New function of a DNO, where operation of their local networks is now a priority. DSOs will actively look to work with the ESO to offer wider market services in operating the transmission network.
ESO	Electricity System Operator	Shorthand for NGESO – National Grid Electricity System Operator.
ESC	Energy Systems Catapult	
UCEGM	Unlocking Clean Energy in Greater Manchester	
NGESO	National Grid Electricity System Operator	The sole operator of the electricity transmission system in Great Britain.
LEM	Local Energy Markets	
STOR	Short Term Operating Reserve	Service employed by the ESO where generation is increased, or demand can be reduced by a market participant by a minimum of 3MW for 2 hours.
TO	Transmission Owner	Also referred to as NGET (National Grid Electricity Transmission) the owner of high voltage transmission infrastructure, normally operate at 275kV to 400kV.
Transmission connection	Connection to the transmission network	Connection agreement is with the TO. Connection voltage will be at 275kV or 400kV and in Scotland or 132kV
VLP	Virtual Lead Party	An aggregator of embedded generation. VLPs take a fee to aggregate smaller generators and offer their combined capabilities to the Balancing Mechanism and Replacement Reserve markets.

Licence/Disclaimer

Energy Systems Catapult (ESC) Limited Licence for Local Energy Market and ANM Architecture

ESC is making this report available under the following conditions. This is intended to make the Information contained in this report available on a similar basis as under the Open Government Licence, but it is not Crown Copyright: it is owned by ESC. Under such licence, ESC is able to make the Information available under the terms of this licence. You are encouraged to Use and re-Use the Information that is available under this ESC licence freely and flexibly, with only a few conditions.

Using information under this ESC licence

Use by You of the Information indicates your acceptance of the terms and conditions below. ESC grants You a licence to Use the Information subject to the conditions below.

You are free to:

- copy, publish, distribute and transmit the Information
- adapt the Information
- exploit the Information commercially and non-commercially, for example, by combining it with other information, or by including it in your own product or application.

You must, where You do any of the above:

- acknowledge the source of the Information by including the following acknowledgement:
- "Information taken from Local Energy Market and ANM Architecture, by Energy Systems Catapult"
- provide a copy of or a link to this licence
- state that the Information contains copyright information licensed under this ESC Licence.
- acquire and maintain all necessary licences from any third party needed to Use the Information.

These are important conditions of this licence and if You fail to comply with them the rights granted to You under this licence, or any similar licence granted by ESC, will end automatically.

Exemptions

This licence only covers the Information and does not cover:

- personal data in the Information
- trademarks of ESC; and
- any other intellectual property rights, including patents, trademarks, and design rights.

Non-endorsement
This licence does not grant You any right to Use the Information in a way that suggests any official status or that ESC endorses You or your Use of the Information.

Non-warranty and liability
The Information is made available for Use without charge. In downloading the Information, You accept the basis on which ESC makes it available. The Information is licensed 'as is' and ESC excludes all representations, warranties, obligations and liabilities in relation to the Information to the maximum extent permitted by law.

ESC is not liable for any errors or omissions in the Information and shall not be liable for any loss, injury or damage of any kind caused by its Use. This exclusion of liability includes, but is not limited to, any direct, indirect, special, incidental, consequential, punitive, or exemplary damages in each case such as loss of revenue, data, anticipated profits, and lost business. ESC does not guarantee the continued supply of the Information.

Governing law
This licence and any dispute or claim arising out of or in connection with it (including any noncontractual claims or disputes) shall be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the non-exclusive jurisdiction of the English courts.

Definitions
In this licence, the terms below have the following meanings: 'Information' means information protected by copyright or by database right (for example, literary and artistic works, content, data and source code) offered for Use under the terms of this licence. 'ESC' means Energy Systems Catapult Limited, a company incorporated and registered in England and Wales with company number 8705784 whose registered office is at Cannon House, 7th Floor, The Priory Queensway, Birmingham, B4 6BS. 'Use' means doing any act which is restricted by copyright or database right, whether in the original medium or in any other medium, and includes without limitation distributing, copying, adapting, modifying as may be technically necessary to use it in a different mode or format. 'You' means the natural or legal person, or body of persons corporate or incorporate, acquiring rights under this licence.

Energy Systems Catapult
7th Floor, Cannon House
18 Priory Queensway
Birmingham
B4 6BS

es.catapult.org.uk