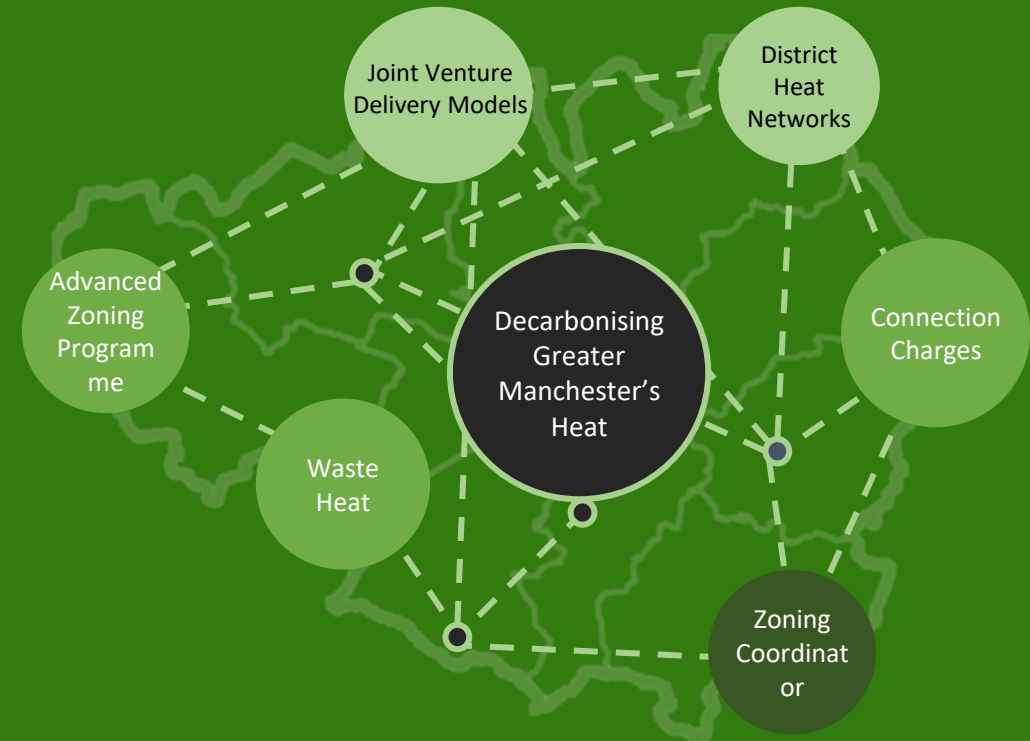


ITEM 07

Generation and Storage

Levelised Cost of Energy Study

Steven Hassall



Overview of WP5a Activity and Objectives

WS / AC	Asset Class 1: Building Assets (Solar on schools, LA estate, other public sector & private sector)		Asset Class 2: Land Assets (Larger generation on land grid connected/direct wire)		Asset Class 3: Storage / Gen+EVCi Asset (Other smart energy assets and bundles)	
WS 1 RESEARCH (Areas of Activity)	Design compelling generation & storage propositions for schools and public sector (POS)		Study & determine regional feasibility of larger generation (P-006a)		Complete GM specific storage market opportunity and public sector storage strategy study (P-010)	
	Design compelling generation & storage propositions for private sector (P-012)		Study & determine regional feasibility of larger generation Direct Wire (P-006b)		Complete Gen+EVCi colocation study (as an asset class) (P-011)	
	Local Energy Market (Exempt Supply Arrangement and P2P) LEM proposition/recommendation (P-008)		Local Energy Market (Exempt Supply Arrangement and P2P) LEM proposition/recommendation (P-008)			
WS 2 PIPELINE	Create integrated public sector building asset database for intervention and programme tracking (Internal)		Build land asset pipeline for viable asset classes (size, technology, connection type) (Internal)		Develop a new storage and gen+EVCi specific pipelines using research outputs (Internal)	
	Develop market and sector specific methodology for origination & pipeline development (Internal)		Build pipeline for public sector PPA consortia (P-008)			
WS 3 DELIVERY (Projects & Programmes)	Complete Powering Our Schools Programme Phase 1 (Internal)		Execute first GM Public Sector PPA consortia for offsite renewables (P-008)		Identify options for pilots in storage and gen+EVCi (TBC)	
	Support GB Energy programme delivery (Schools & Mayors Fund) and engage on collaboration (Internal)					
	Set up SPV delivey mechanism (Public Sector ESCO) for Powering Schools Phase 2 (Internal)		Invest in development of identified viable land asset sites (TBC)			
WS 4 PROCUREMENT & DELIVERY MODELS	Research and impliment new SPV delivey model for roof top solar		Delivery model options for land asset classes by type and ownership (public / private) (Internal)		Delivery model options for storage and EVCi based asset classes by type and ownership (public / private) (Internal)	
	Route to market gap analysis & recommendations for public sector procurement solutions					
	Public Sector - Community Sector partnership models and implimentation options					
Opportunity	GM Investment c £150m		GM Investment - uncertain/low Underwrite/Additionality c £450m		GM Investment c £TBC	

This workstream for generation and storage is arranged into:

3 asset classes

4 work streams

GM Large Generation – Feasibility Survey

Levelised Cost of Electricity (LCOE) Wind and Solar GRID CONNECTED

LCOE Study Objective

- Determine the realistic opportunity for large scale renewables
- Inform our resource allocation towards this asset class
- Inform what type of large renewables generation projects are more feasible (size, location etc)

	LAEP		NESO (2038)	LCOE Study	
	MW	£(m)	MW	MW	£(m)
Solar (Total)	10,300	14,881	53,000 (LAEP is 19%)	??	??
Solar (Ground Mount)	952	1,375		??	??
Solar (Domestic)	7,372	10,651		??	??
Solar (Non-dom)	1,976	2,855		??	??
Wind	NA	NA	NA	??	??

LAEP Forecasts Overestimate Solar

- The GM LAEPs and SOBC set expectations high for deployment of solar in general and large scale ground mount in particular
- Total solar LAEP estimate = 10 GW (£15bn) this is eq to 19% of NESO forecast for UK total solar need in 2038 nationally – just in Manchester. Manchester is in bottom 10% decile for irradiation. LAEP significantly overestimates this activity.
- No work in LAEP for wind opportunity due to wind ban at the time

Sources:

LAEP - [Microsoft Word - Appendix 1_LAEP GM Overview v0.4 - Clean.docx](#)

NESO - [Future Energy Scenarios 2025: Pathways to Net Zero / Future Energy Scenarios 2025 Data Workbook V004.xlsx](#)

What is LCOE - What Drives Costs

LCOE is the lifetime cost of generation from a given generation asset on a per MWh basis

It is the breakeven price for a project – the minimum price the project needs to sell at to be viable (at a given Cost of Capital)

Levelised Cost of Electricity (LCOE)

$$LCOE = \frac{\sum_{t=1}^n \frac{I_t + O_t + F_t}{(1+r)^t}}{\sum_{t=1}^n \frac{E_t}{(1+r)^t}}$$

I_t : Investment expenditure in year t

O_t : Operations & maintenance costs in year t

F_t : Fuel costs in year t (if applicable)

E_t : Electricity generated in year t (MWh)

r : Discount rate

n : Lifetime of the project (years)

The formula states: LCOE equals NPV of sum of lifetime costs divided by NPV of sum of lifetime generation i.e. what each MWh costs to produce.

- **Numerator** – capital and ongoing cost- higher costs mean higher LCOE
- **Denominator** – generation – higher output means lower LCOE
- **Discount Rate** – the assessment framework's cost of capital

What about IRR?

LCOE (a price) fixes the IRR, and IRR (a discount rate) fixes the price that defines the LCOE

The LCOE is basically the break-even price per MWh, and the IRR is the discount rate at which that LCOE makes the project's net present value equal zero.

How to interpret LCOE – Why it matters

Why it Matters

LCOE study will tell us how much it costs to make electricity in Greater Manchester (£/MWh)

This will be compared to to market prices for generation (what people are willing to pay) to determine investibility.

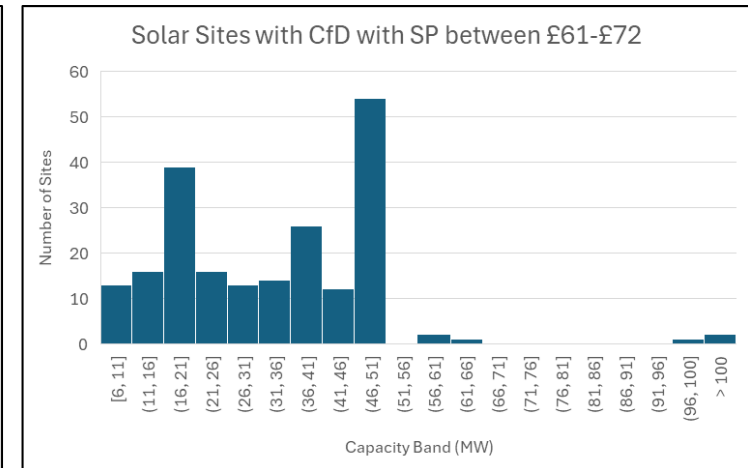
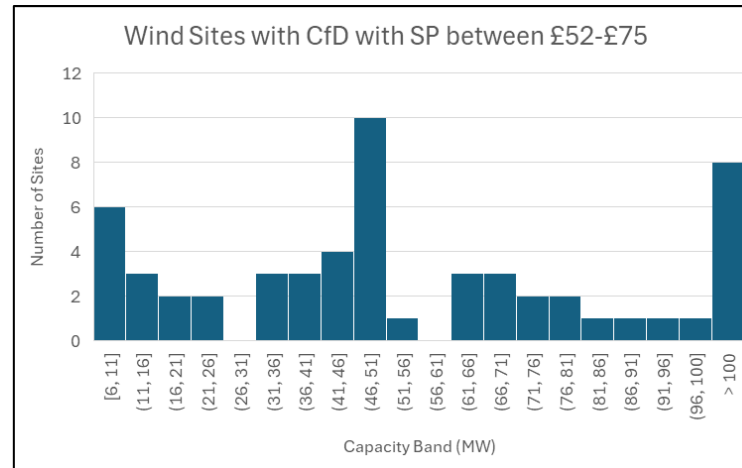
Market Prices

The CfD market is best proxy for where good value is at and source for price discovery and willingness to pay.

Solar Prices – Around 200 projects since 2016 (AR2-AR6) with site sizes well distributed from 5-50MW –strike prices (price discovery) are avg £68/MWh (£61-£72). Max bid upcoming AR7 is £78/MWh

Wind Prices - Around 56 projects since 2016(AR2-AR6) – strike prices are avg £70/MWh (£52-£75) are avg. Max bid upcoming AR7 is £95/MWh

CfD Results - AR2-6	Solar PV	Wind Onshore
Average Capacity (MW)	34.8	60.0
Min Capacity (MW)	6	6
Max Capacity (MW)	299	231
Average Strike Price (£/MWh)	68.5	70.8
Min Price (£/MWh)	61.16	52.25
Max Price (£/MWh)	72.27	75.47
Count	209	56
Total Capacity	7,276	3,359
CfD - AR7 Framework	Solar PV	Wind Onshore
Max Bids (ASP) (£)	77.8	95.4



LCOE – GM Data so far...Historic Projects and Studies

Before the study – we had some evidence from other work or projects that had been procured

Little Hulton Solar Farm (2MW Salford)

LCOE = c£150/MWh

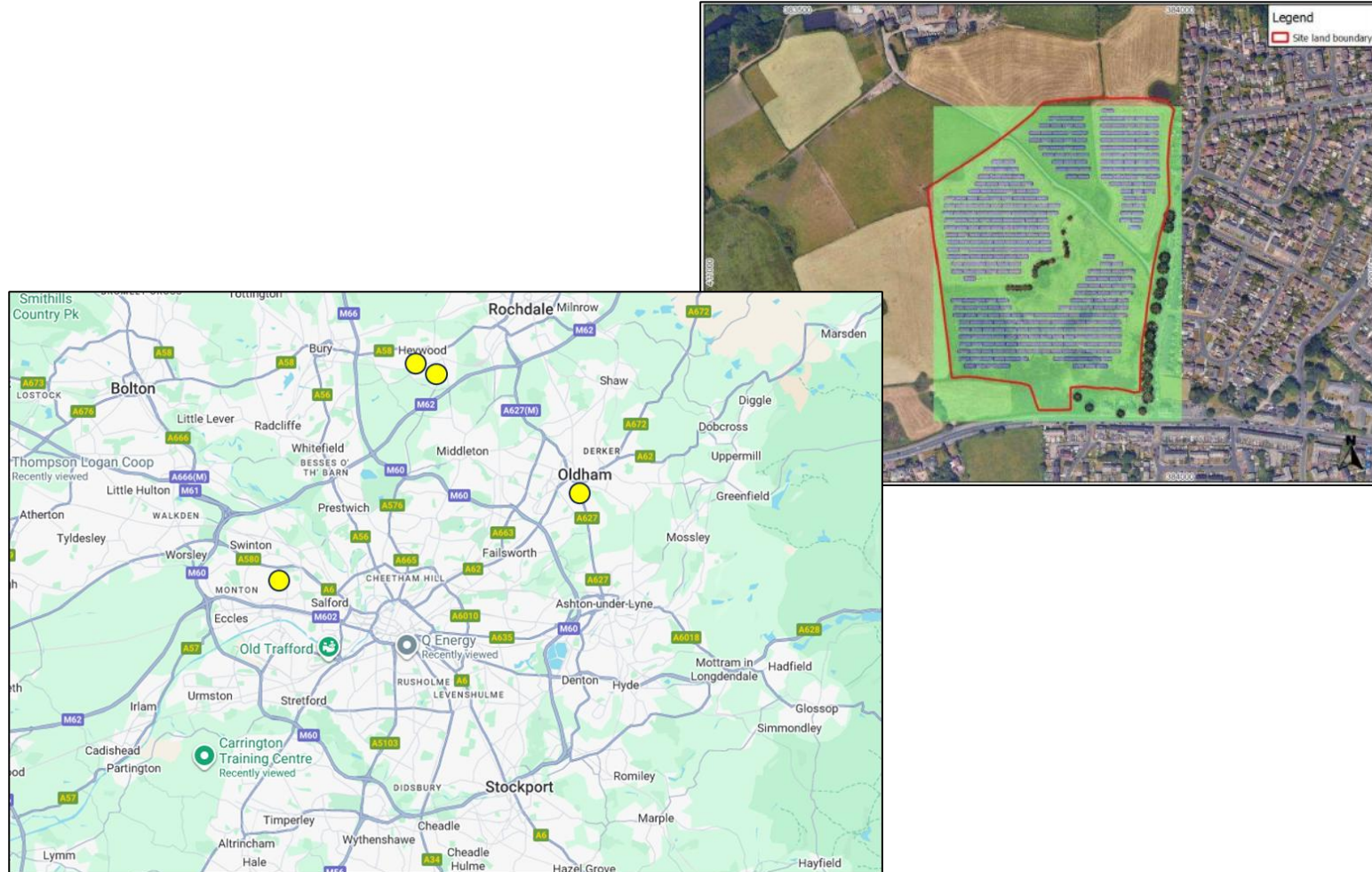
Chamber House Solar Farm (5MW Rochdale)

LCOE = c£150/MWh

Summit Street (feasibility study 2024)

LCOE = £100/MWh (£80-£130)

Buro Happold 2023 – several small solar farm sites studied in Oldham showed negative NPV

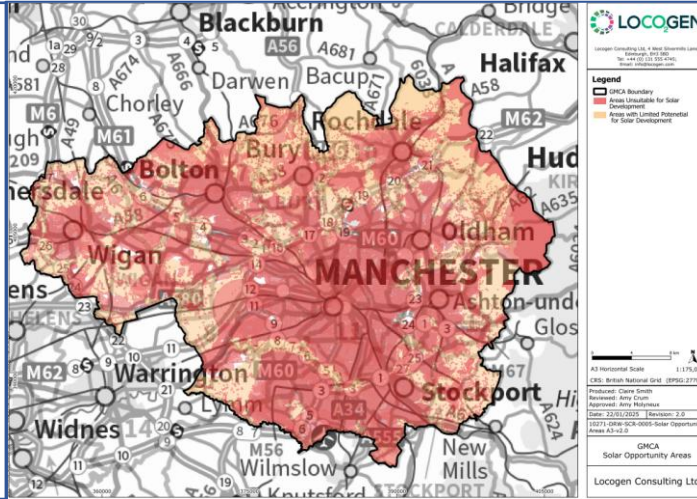


The GMCA LCOE Study – 5 Stages

Stages 1 & 2 – Screening & Sample Selection

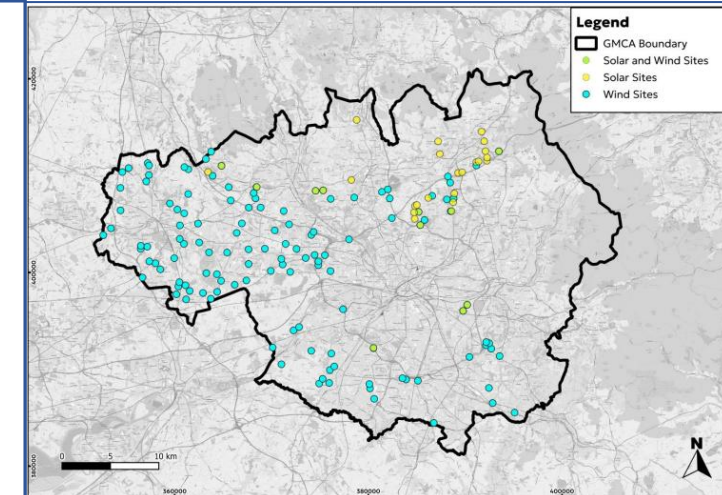
Step 1 Screening

Screen whole GM for constraints land, environment, radar, visual, green belt.
= where can we build or where could we build



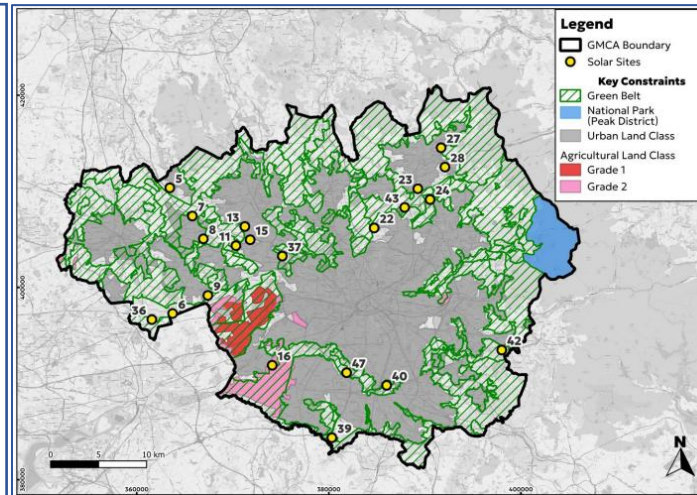
Step 2 Identify Possibles

Identify a long list of possible solar, wind solar+wind sites that could be sited in the constraints (public & private)



Step 3 Pick Sample for Feasibility

GMCA and Consultant picked a sample of 25 of these to progress to high level feasibility study and costing analysis – to derive LCOE



SOLAR SITES		Number of sites	Estimated capacity (MW)
Total across GMCA		21	267
Local Authority area breakdown	Bolton	5.5	53
	Bury	0	0
	Manchester	2	22
	Oldham	1	24
	Rochdale	5	47
	Salford	1.5	6
	Stockport	1	14
	Tameside	1	15
	Trafford	1	30
	Wigan	3	41
Ownership	Privately owned	7	190
	Public site	14	77
Capacity class	0-5MW	2	n/a
	5-10MW	8	
	10-20MW	7	
	20MW+	4	

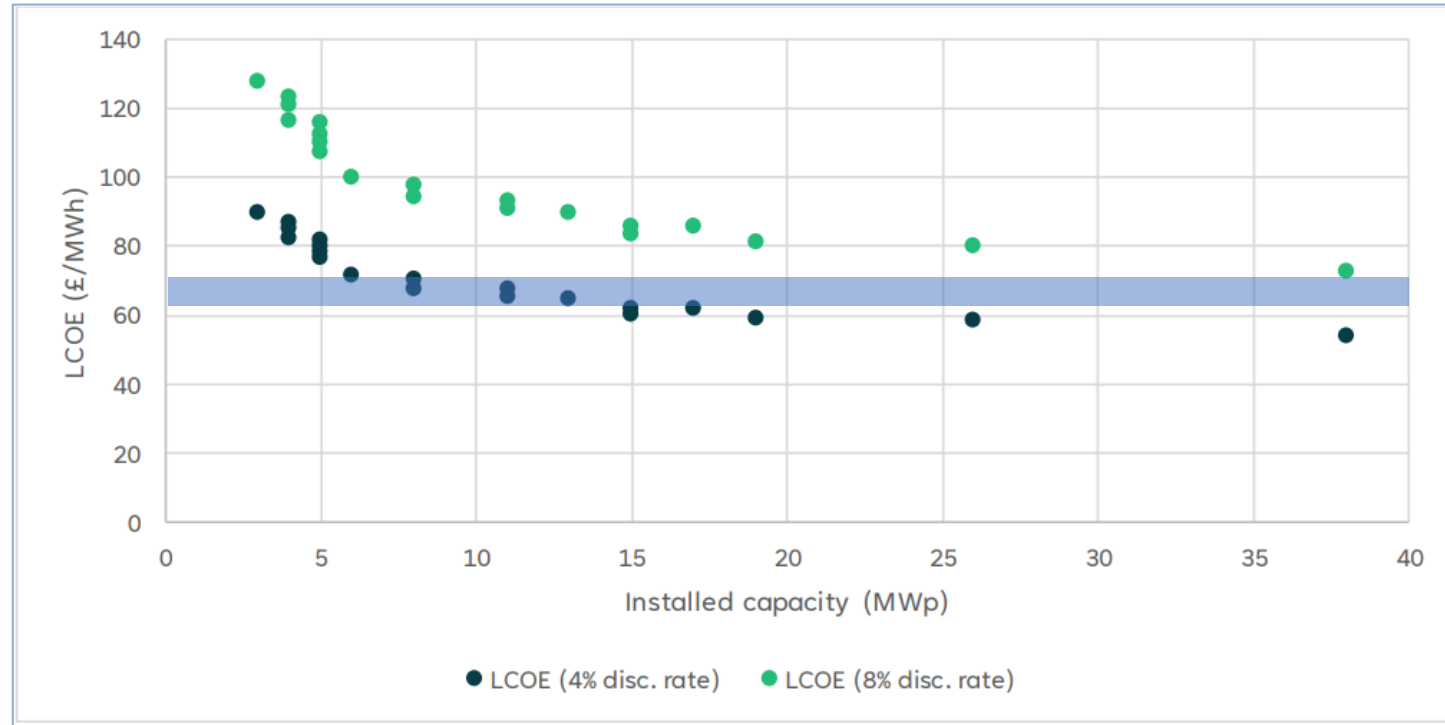
Sites were public and private land assets and a range of capacities.

The GMCA LCOE Study – 5 Stages

Stages 3 & 4 – Feasibilities Studies and LCOE - SOLAR

Solar Results – Graph shows LCOE for solar projects in our sample plotted against their capacity. Graph plots 2 discount rates, 4% (optimistic/public sector) and 8% (mainstream hurdle rate).

The blue line is the market price / willingness to pay range from CfD returns.
Results show log curve as expected as economies of scale apply. GM projects are expected to sit slightly higher than market due to irradiation resource (see Annex)



LCOE element	Average site LCOE percentage contribution (4% discount rate)	Average site LCOE percentage contribution (8% discount rate)
Operation & maintenance	15.1%	10.8%
Asset management	2.4%	1.7%
Business rates	3.9%	2.8%
Insurance	2.8%	2.0%
Electricity	3.1%	2.2%
Community benefit payments	0.7%	0.5%
Other OPEX	0.8%	0.6%
Rent	5.2%	3.7%
OPEX Contingency	1.7%	1.2%
Inverter replacement fund	2.5%	2.0%
DEVEX	1.0%	1.2%
DEVEX Contingency	0.4%	0.5%
CAPEX Grid	4.0%	4.6%
CAPEX (ex Grid)	50.8%	59.8%
CAPEX contingency	5.6%	6.6%

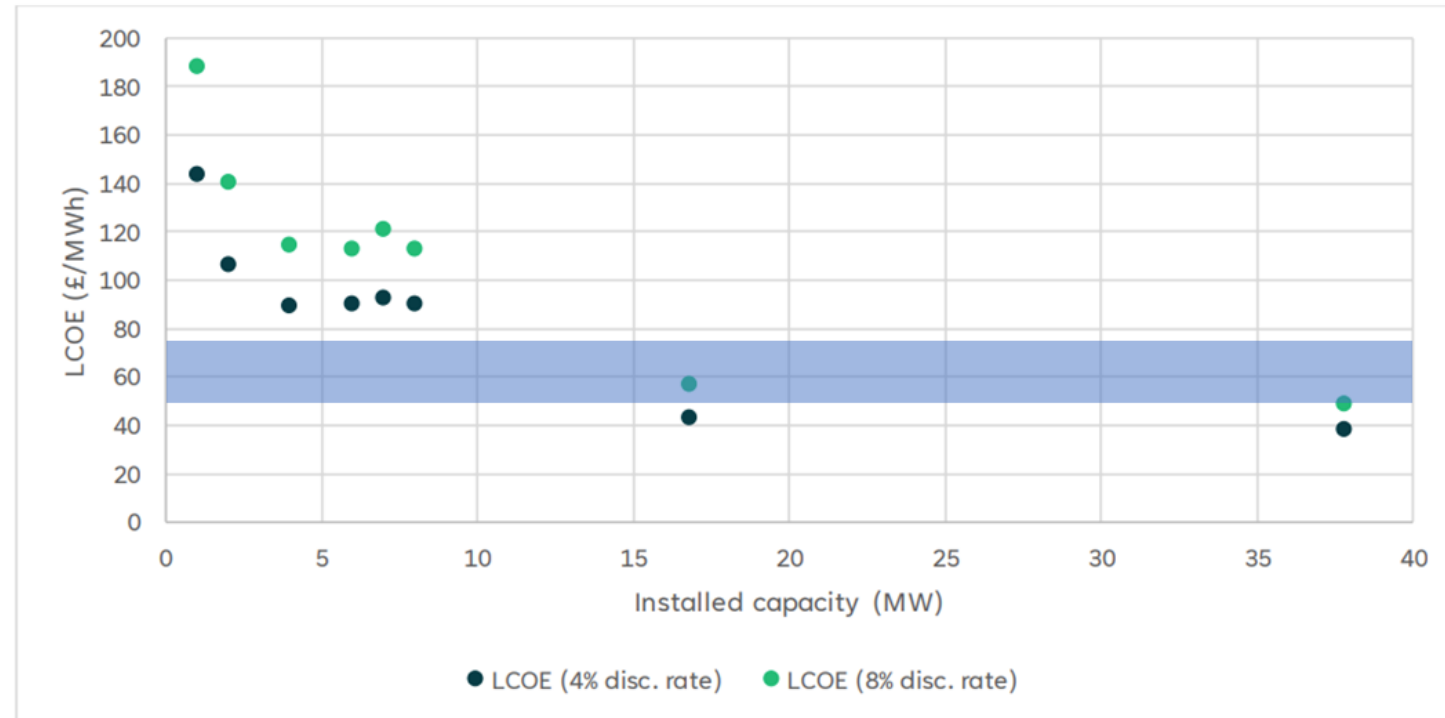
The GMCA LCOE Study – 5 Stages

Stages 3 & 4 – Feasibilities Studies and LCOE - WIND

Wind Results – Graph shows LCOE for solar projects in our sample plotted against their capacity. Graph plots 2 discount rates, 4% (optimistic/public sector) and 8% (mainstream hurdle rate).

The blue line is the market price / willingness to pay range from CfD returns.

Results show log curve as expected as economies of scale apply. GM projects are expected to sit slightly higher than market due to irradiation resource (see Annex)



LCOE element	Average site LCOE percentage contribution (4% discount rate)	Average site LCOE percentage contribution (8% discount rate)
Asset management	2.2%	1.7%
24/7 control centre	0.1%	0.0%
Finance & audit	0.4%	0.3%
Civil maintenance	0.3%	0.2%
Electrical maintenance	0.4%	0.3%
Turbine maintenance	14.2%	10.4%
Rent	9.1%	7.0%
GDUoS Charges	0.6%	0.4%
Metering and import charges	0.7%	0.6%
Insurance	3.9%	3.0%
Business rates	7.5%	5.8%
Community benefit payments	3.0%	2.3%
Decom fund accrual	2.3%	1.8%
Compliance monitoring	0.8%	0.6%
OPEX Contingency	0.8%	0.6%
DEVEX	1.2%	1.5%
DEVEX Contingency	0.1%	0.1%
CAPEX Grid	2.5%	3.0%
CAPEX (ex Grid)	45.1%	54.4%
CAPEX Contingency	4.8%	5.8%

BUT! - CP2030/SSEP Process

Regional Allocations for Grid Connection

GM might have opportunities BUT the CP2030 Clean Action Plan - introduces strategic planning into renewables infrastructure development WRT the grid connection process – what is needed where to 2035. SSEP will extend this beyond 2035.

This creates **regional allocations** (maximums) at years 2030 and 2035 for wind, solar and battery. Therefore some projects might not be needed in the strategic plan despite being close to economic viability....

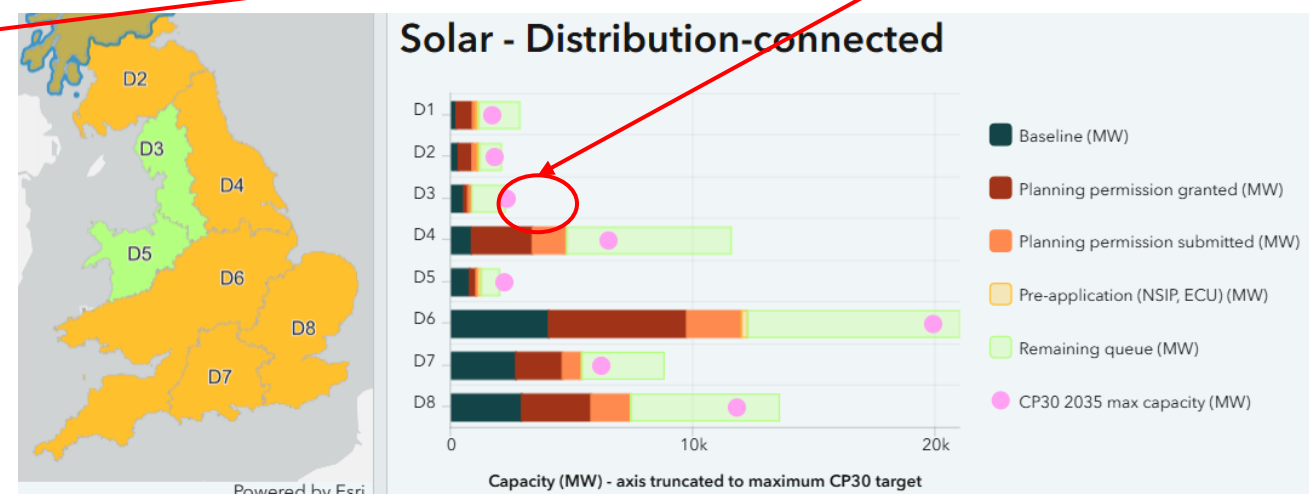
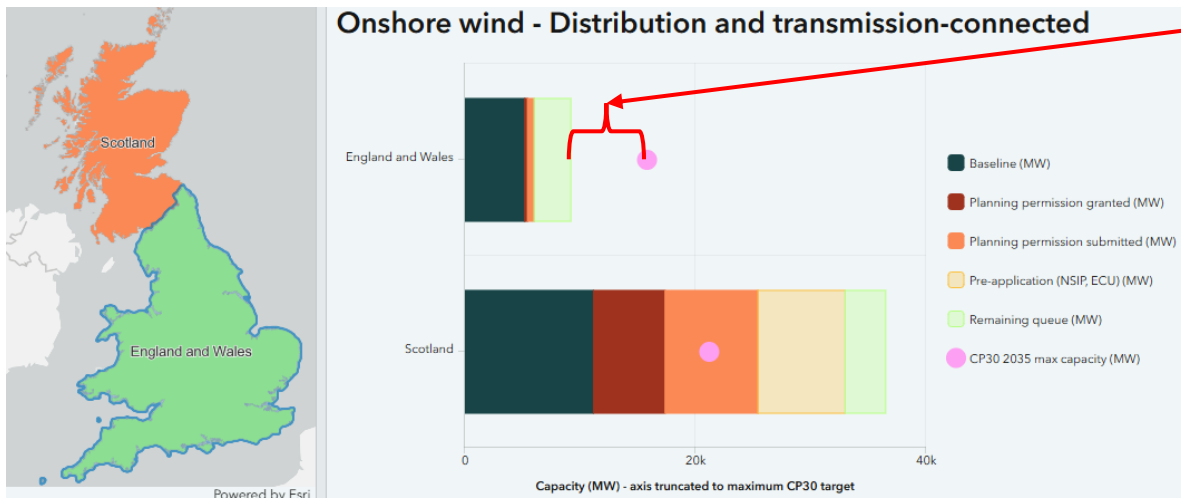
Allocations - Wind

The allocation for **wind** is national and currently not constraining with 2035 allocation for Eng&Wal exceeding current pipeline there we are just competing on price

Allocations - Solar

The allocation for **solar** is sub-national (GM is zone D3). The 2035 allocation for D3 is met already if considering all stages of development in the national pipeline. Therefore we might have viable projects, but our zone does not need them in the CP2030/35 Plan.

Saving grace....sub-5MW is unconstrained



So what is possible.....

Given these allocation constraints and our regional LCOE, where might there be opportunity in future

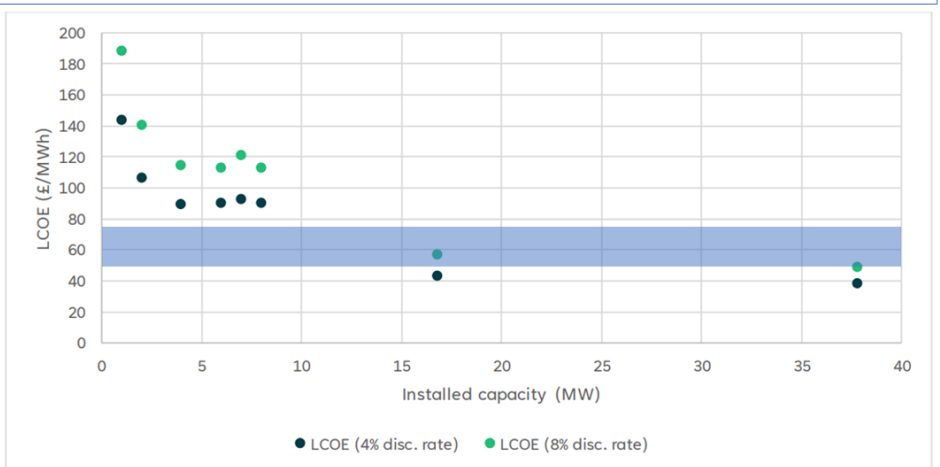
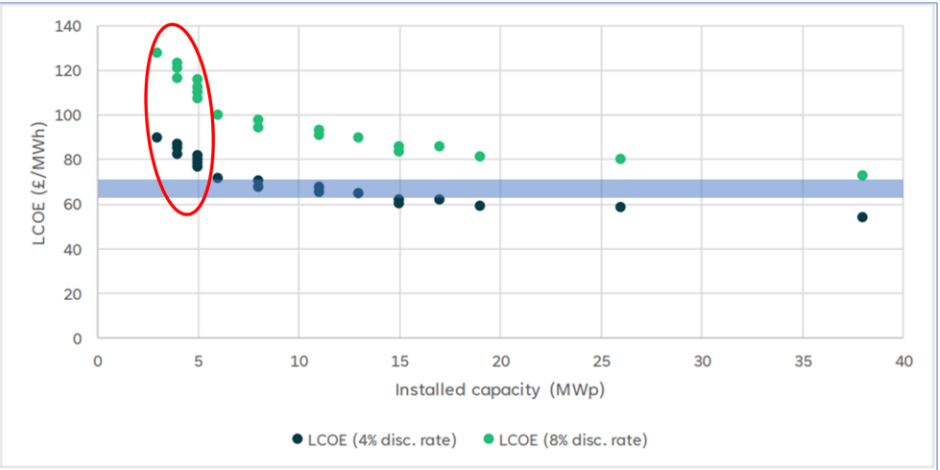
Solar

- We can only reliably plan to connect sub 5MW solar before 2035 – queue full larger projects not needed
- Therefore - a niche opportunity for solar sub 5MW
- But LCOE is high here for small projects (20-100% premium depending on CoC) – who will buy this power!
- Options – address a niche market (underserved small PPA market, buyers with local preference or public sector) OR exploit innovative transaction options like exempt supply. Understanding this will define the pipeline and opportunity.
- Conclusion – we have to work hard to make these projects happen – there is a very low likelihood of deployment. This is not a failure it is just where the market is now and GM is not a particularly suitable location for renewable resource.

Wind

- There is no strategic allocation constraint and so where projects are viable they can happen.
- But LCOE is high in GM and locations for wind are limited.
- Large sites over 10MW are a possibility

Co-Location – some of the wind and solar sites are co-located and there are certainly benefits to this that will be explored.



Stage 5 – We are also studying Direct Wire – What is it?



Warrington IKEA
wind turbine



Jaguar Landrover
Solar



UU treatment plant
Solar



Birmingham New
Cross Hospital Solar

What is it – this is generation assets (Solar / Wind Farms) connected behind the meter to larger consumers. Typically 2-4 but up to 7MW seen (see data next page).

Business Model – Sell 50-80% of power direct to consumer (at sub-retail) and the rest to grid wholesale. The weighted average must exceed the generator LCOE

Risks – industrial prices shifting, non-commodity charges reallocation ongoing (could destroy business model) and government intervention.

Challenges –this is largely a delivery model/proposition and engagement challenge



Gridserve EV
Hub+Solar
Hartlepool

Sources:

Hospital- [Bing Maps - Directions, trip planning, traffic cameras & more](#)

WTP Birmingham - [Bing Maps - Directions, trip planning, traffic cameras & more](#)

EV Station - [GRIDSERVE | Hartlepool](#)

Stage 5 – Direct Wire – UK Examples

Offtaker / Site	Tech	Size (MW)	Location	Connection Type	Commissioned	Support / Subsidy	Map Link (Bing)	Info Source
New Cross Hospital	Solar PV	6.9	Wolverhampton	Private wire (~0.5 mi)	~Apr 2024	PSDS via Salix	Bing	Vital Energi, Arcadis (solarpowerportal.co.uk)
Grafham WTW (Anglian Water)	Solar PV	11.65	Grafham, Cambs	Private wire	2020	PPA (GIG-backed)	Bing	UPOWA, Solar Power Portal (upowa.co.uk)
Royal Glamorgan Hospital (Coed-Ely)	Solar PV	1.0	Llantrisant	Private wire	2025	Council capex / PPA	Bing	CTMUHB release (ctmuhb.nhs.wales)
Diageo Leven bottling plant	Solar PV	4.2	Leven, Fife	On-site direct supply	Apr 2023	Corporate capex	Bing	Emtec/E.ON news (scottishconstructionnow.com)
Bentley Motors (Crewe)	Solar PV	5.0	Crewe	On-site (roof)	2013	(Not stated)	Bing	Gov case study (gov.uk)
JLR Engine Centre (i54)	Solar PV	~6.0	South Staffs	On-site (roof)	2014	(Not stated)	Bing	JLR release (jaguarlandrover.com)
Perth WwTW (Scottish Water)	Solar PV + Battery	1.0	Perth	Behind-the-meter	2021	SW Horizons capex	Bing	HIE guide (scottishwaterhorizons.co.uk)
Howden WwTW (Scottish Water)	Solar PV + BESS	1.1	Selkirk	Behind-the-meter	~2024	SW Horizons capex	Bing	Case study (scottishwaterhorizons.co.uk)
Broken Scar WTW (Northumbrian Water)	Solar PV	~5.7	Darlington	Private wire	2022	Equity-backed by Downing	Bing	Downing portfolio (downing.co.uk)

Link - https://chatgpt.com/s/t_68bbe19f0514819189a5ff49b0d3bace

Stage 5 – Direct Wire – Our Approach and the GM Opportunity

Direct Wire work package within LCOE Study

Looks to answer the question – given the cost of generation from small solar and wind:

- what is the opportunity for direct wire offtake to underwrite projects
- Where are these projects and who are the offtakers

Approach (Within Scope)

- Understand direct wire economics
- Develop a tool to map locations (see right panel)
- Sample sites for detailed feasibility (starting now)

Further Work (out of scope)

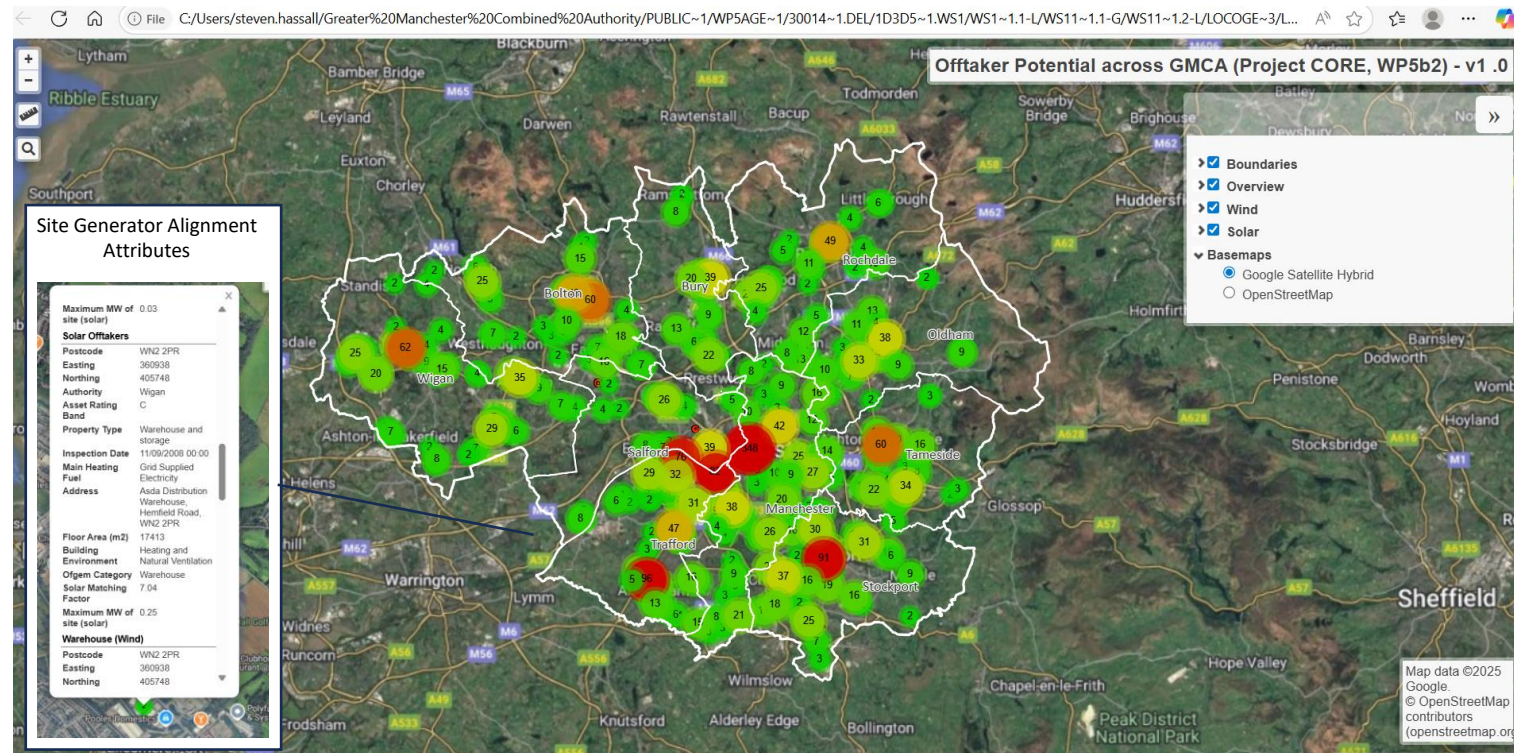
- Develop a delivery model or proposition to realise these projects (eg GMCA SPV PPA through to simple promotion and matchmaking)
- Engagement with offtakers, test appetite and test propositions

The realistic opportunity - for GM in larger generation direct wire is likely to be:

- | | |
|------------------------------------|--------|
| - 2-3 water treatment sites | £4-6m |
| - A couple of hospital sites | £5-10m |
| - Large heavy industry – eg Heinz | <£20m |
| - Several solar + EV charging hubs | £10m |

Renewable offtaker Mapping – A map is been generated of larger non-domestic consumers with attributes that describe the associated generation that could be supported by this offtaker

WARNING – Map currently shows very small sites in this filter – there aren't that many!



LCOE – Conclusion & Next Steps

Conclusion

Need time to digest the results but....

Solar LCOE vs Market - GMCA regional LCOE (breakeven price) for solar c£70-£100/MWh with the market for renewables (CfDs/PPAs) sources that underwrite investment is around £62-72/MWh

Wind LCOE vs Market - GMCA regional LCOE (breakeven price) for wind projects ranges from £90-£150/MWh with the market for wind at around £52-75/MWh

However – Solar deployment constrained above 5MW meaning more expensive projects and wind site in low LCOE categories are few in number

Direct Wire – is an opportunity although niche and will require a different approach and proposition with an exercise of engagement required

Next Steps

Determine where to focus – conclude report and determine which sub-sets of the large generation asset class we continue to focus on.

Further Work Grid Connected - Explore delivery model options for small sub-5MW solar with 20-30% price premium attached – who will buy.

Commission Direct Wire Engagement Study – Commission an engagement based survey of a handful of direct wire sites to better understand opportunity.

Engage with offtakers like industry, hospital, United Utilities etc to understand motivation and complete electrical investigation.

RECOMMENDATIONS

It is recommended that the Partnership:

- Note the presentation
- Comment on the proposed next steps

Link to analysis - <https://chatgpt.com/canvas/shared/68bbe6a6f2988191bc08d2c78c7983cb>