

Appendix E – Manchester Corridor Smart City Project

E1 Summary

This appendix identifies the project cost, energy savings and carbon benefits of the Manchester Corridor Smart City Project, and how the benefits might be scaled up to GB. It covers three types of low-carbon interventions and how they are managed by the distribution network:

- An Electric Vehicle Refuelling Network (section E2)
- Electrical Demand Reduction from community energy-efficiency schemes (section E3) and
- Demand Side Management (section E4), leading to a combination of electrical demand reduction and load-shifting from peak to off-peak

These elements are expected to deliver benefits in the form of carbon savings, which can be expressed in tonnes CO₂ and converted into financial terms by application of Financial Carbon Equivalent Values.

The appendix summarises the calculation of carbon and financial savings in each of these areas, and shows the calculation of projected benefits if these developments were rolled out across Great Britain.

Adapting the distribution network for new demand growth and more complicated power flows involves costs as detailed in the main bid. These costs are detailed in section E5. However, this network expenditure, combined with the demand reduction and load-shifting, can be expected to allow the deferment of the currently projected levels of network reinforcement, bringing further financial benefit. This would take the form of a direct benefit to Electricity North West if applicable to reinforcements identified for the current Price Control period (DPCR5); these are the figures that appear as Direct Benefits in the Full Submission spreadsheet. However, a significant proportion of the benefit, both to the local DNO and GB-wide, will accrue in future Price Control periods for which baseline allowances have not yet been set. Thus, there will be financial benefits that will pass straight to customers through lower allowances being set for DNOs.

Other costs excluded from further consideration in this appendix are listed in section E6.

The following table summarises the carbon reduction benefits of the replication of this project across GB

	Carbon Reduction (tCO₂e)	Carbon Equivalent Value (£NPV)
EV Refuelling Network	299,077	11,530,000
Demand Reduction Schemes	5,358,762	117,090,000
Demand side Management	56,441	2,050,000

E2 Electric Vehicle Refuelling Network

E2.1 EV Direct (DNO) Project Costs

The Project will deploy 20 refuelling points over the four years with 5 being installed in year 1/2 of the project, 10 in year 2/3 and 5 in year 3/4. Within the main project bid, the predicted costs associated with installing 20 EV recharging points are as follows in the four years of the project.

Within LCNF bid	2011	2012	2013	2014
20 EV recharging points (£)	4,800	43,757	167,084	9,015

E2.2 EV Carbon Savings for project

The following assumptions and calculations are made for each refuelling point:

Consumption per refuel cycle	15kWh
Charges per day	2
Number of charging days per year	250
Consumption per year (15x2x250)	7,500kWh
DECC GHG conversion factor (Annex3) ^{1,2}	0.61707kgCO ₂ e/kWh
GHG emissions per year (7500x0.61707)	4,628 kgCO ₂ e
Vehicle full charge	24kWh
Vehicle range on full charge	100 miles

¹ DECC GHG conversion factor (Annex 3)

<http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm>

² This GHG conversion factor reflects the 2008 grid rolling average; as the carbon emissions of the electricity mix reduce over time as suggested by the Low Carbon Transition Plan, this is likely to overestimate the GHG emissions associated with electricity demand.

Yearly mileage per recharging point
($7500 \times 100 / 24$)

31,250 miles

This is compared with the emissions that would arise if the same mileage were carried out by petrol cars:

Fuel consumption for equivalent petrol car (35mpg)	7.7 miles per litre
Equivalent fuel consumption for full year ($31250 / 7.7$)	4059 litres
DECC GHG conversion factor (Annex1) ³ of petrol	2.73290kgCO ₂ e/litre
GHG emissions per year (4058×2.73290)	11,093 kgCO ₂ e
Saving in GHG emissions ($11,093 - 4,628$)	6,465 kgCO ₂ e

Based on this method the carbon benefits for the project are scaled up by the number of charging points to

	2011	2012	2013	2014
Number of charging points	0	5	15	20
Consumption (kWh)	0	37,500	112,500	150,000
Miles	0	156,250	468,750	625,000
Total Saving (kgCO₂e)	0	32,324	96,973	129,297
£/tCO ₂ e	14.30	14.50	14.70	14.90
Carbon Value(£)	0	469	1,425	1,917

The financial carbon equivalent values in the above table are calculated based on the DECC traded carbon values⁴ in £/tCO₂e.

E2.3 Electric Vehicle GB Projection

The project focuses on the issues around deployment of EV refuelling points in a loaded inner city environment. Therefore, the knowledge generated and benefits will be applicable to other similar inner city environments. We have assumed a similar EV refuelling point rollout in the other 65 cities across the UK from 2016 onwards.

³ DECC GHG conversion factor (Annex 1)

<http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm>

⁴ Financial Carbon Equivalent Values

http://www.decc.gov.uk/assets/decc/what%20we%20do/a%20low%20carbon%20GB/carbon%20valuation/1_20100610131858_e @@_carbonvalues.pdf

These costs are scaled up to a GB-wide rollout by considering that such infrastructure is provided in all 66 cities in GB from 2016 onwards. Rounded to the nearest £100,000 and expressed in 2015/16 prices, this indicates the following *additional* costs for a GB rollout.

Replicate to 65 cities	2015	2016	2017	2018	2019
20 EV recharging points (£m)	0	0.4	3.3	12.6	0.7

The carbon and equivalent £ value benefit of such a deployment is shown in the table below:

EV GB Projection				
Year	EV Charging Points	Carbon Saving tCO2e	Carbon Value (2009) £/tCO2e	Carbon value of reductions (£)
2011	0	-	14.30	-
2012	5	32	14.50	469
2013	15	97	14.70	1,425
2014	20	129	14.90	1,927
2015	20	129	15.10	1,952
2016	1320	8,534	15.40	131,417
2017	1320	8,534	15.60	133,124
2018	1320	8,534	15.80	134,831
2019	1320	8,534	16.10	137,391
2020	1320	8,534	16.30	139,098
2021	1320	8,534	21.70	185,179
2022	1320	8,534	27.10	231,260
2023	1320	8,534	32.40	276,488
2024	1320	8,534	37.80	322,570
2025	1320	8,534	43.20	368,651
2026	1320	8,534	48.50	413,879
2027	1320	8,534	53.90	459,961
2028	1320	8,534	59.30	506,042
2029	1320	8,534	64.60	551,270
2030	1320	8,534	70.00	597,352
2031	1320	8,534	76.50	652,820
2032	1320	8,534	83.00	708,288
2033	1320	8,534	89.50	763,757
2034	1320	8,534	96.00	819,225
2035	1320	8,534	102.50	874,694
2036	1320	8,534	109.00	930,162
2037	1320	8,534	115.50	985,630
2038	1320	8,534	122.00	1,041,099
2039	1320	8,534	128.50	1,096,567
2040	1320	8,534	135.00	1,152,035
2041	1320	8,534	141.50	1,207,504
2042	1320	8,534	148.00	1,262,972
2043	1320	8,534	154.50	1,318,441

2044	1320	8,534	161.00	1,373,909
2045	1320	8,534	167.50	1,429,377
2046	1320	8,534	174.00	1,484,846
2047	1320	8,534	180.50	1,540,314
2048	1320	8,534	187.00	1,595,782
2049	1320	8,534	193.50	1,651,251
2050	1320	8,534	200.00	1,706,719
Total Lifetime Saving (tCO₂e)				299,077
Total Lifetime Saving Carbon Value (£)				28,189,678
Total Carbon Equivalent NPV (£) to nearest £10,000				11,530,000

E3 Community Energy Efficiency (CEE) Schemes

E3.1 CEE Direct (DNO) Project Costs

As part of the Manchester Corridor Smart City project, we will work with the local community and enterprises to develop a variety of energy reduction initiatives. This work is included within the bid within the labour costs of all the partners, not just Electricity North West as the DNO.

E3.2 CEE Carbon Savings

The following table summarises the projected energy savings over the course of the project.

Project kWh Savings	2011	2012	2013	2014
Manchester City Council	34,000	554,000	608,000	662,000
Central Manchester Hospital NHS Trust	125,000	500,000	500,000	500,000
Manchester Metropolitan University	9,000	1,184,768	1,837,978	2,219,579
Manchester Science Park	180,250	721,000	721,000	721,000
University of Manchester	32,216	193,297	386,595	579,892
Bruntwood	-	662,500	662,500	662,500
Total Demand Reduction (kWh)	380,466	3,815,565	4,716,073	5,344,971
Total Project Demand Reduction(GWh)				14.3

The demand reductions are converted into carbon savings using the DECC GHG conversion factor (Annex3)^{1,2} – kgCO₂e per kWh = 0.61707.

Carbon savings are converted into financial values using the DECC traded carbon values⁴ in £/tCO₂e.

Project Carbon Reductions	2011	2012	2013	2014
Total Demand Reduction (kWh)	380,466	3,815,565	4,716,073	5,344,971
KgCO₂e	234,774	2,354,471	2,910,147	3,292,221
£/tCO ₂ e	14.30	14.50	14.70	14.90
Carbon Value(£)	3,357	34,140	42,779	49,143

E3.3 CEE GB projection

The dissemination and project management costs within the LCNF bid would not need to be replicated in full to repeat this project across 65 cities in GB. Instead, a rough estimate of £300,000 per city has been made. This would include costs for interaction with local partners implementing energy-efficiency measures, but not the costs of installing those energy-efficiency measures.

Replicate to 65 cities	2015	2016	2017	2018	2019
Management cost (£m)	19.5	19.5	0	0	0

The carbon savings achievable from a GB roll out of similar projects are estimated by assuming that the same savings as a percentage of total industrial and commercial (I&C) electrical consumption are made across GB as are achieved in the Manchester project.

Manchester total yearly I&C electrical consumption⁵
1,868GWh.

GB total yearly I&C electrical consumption⁵
192,543GWh.

Calculated scaling factor 103.07

	2011	2012	2013	2014
Total Project I&C Consumption (GWh)	1,868	1,868	1,868	1,868
Demand Reduction (GWh)	0.38	3.82	4.72	5.34
% of total I&C consumption	0.02%	0.20%	0.25%	0.29%
Total GB I&C Consumption (GWh)	192,543	192,543	192,543	192,543
Demand Reduction (GWh)	39	393	486	551
Carbon Reduction (tCO ₂ e)	24,199	242,686	299,962	339,963
£/tCO ₂ e	14.30	14.50	14.70	14.90
Carbon Value (£)	346,049	3,518,948	4,409,444	5,056,445

⁵ GB regional electricity consumption figures from <http://www.berr.gov.uk/files/file45726.xls>

The table below outlines the full projected roll-out to 2050 assuming the schemes continue based on lifetime of equipment.

CCE GB Rollout			
Year	Carbon Saving (tCO ₂ e)	2009 £/tCO ₂ e carbon value	Value £ for carbon reductions
2011	24199	14.3	346046
2012	242686	14.5	3518947
2013	299962	14.7	4409441
2014	339963	14.9	5065449
2015	339963	15.1	5133441
2016	339963	15.4	5235430
2017	339963	15.6	5303423
2018	339963	15.8	5371415
2019	276157	16.1	4446128
2020	240742	16.3	3924095
2021	216470	21.7	4697399
2022	186417	27.1	5051901
2023	186417	32.4	6039911
2024	186417	37.8	7046563
2025	186417	43.2	8053214
2026	185449	48.5	8994277
2027	167915	53.9	9050619
2028	160938	59.3	9543623
2029	155131	64.6	10021463
2030	155131	70	10859170
2031	134141	76.5	10261787
2032	67866	83	5632878
2033	57943	89.5	5185899
2034	48021	96	4610016
2035	48021	102.5	4922153
2036	48021	109	5234289
2037	48021	115.5	5546426
2038	48021	122	5858562
2039	48021	128.5	6170699
2040	48021	135	6482835
2041	46431	141.5	6569987
2042	16219	148	2400412
2043	16219	154.5	2505836
2044	16219	161	2611259
2045	16219	167.5	2716683
2046	16219	174	2822106
2047	16219	180.5	2927530
2048	16219	187	3032953
2049	16219	193.5	3138377
2050	16219	200	3243800
Total Carbon Saving (tCO₂e)			5,358,762
Total Carbon Value (£)			213,986,435
Total Carbon Equivalent NPV (£) to nearest £10,000			117,090,000

E4 Demand Side Management

The following section is based upon no DSM potential being used in the initial stage of the project, 50% of DSM potential being used in the second year, and the full potential going forward.

E4.1 DSM Direct (DNO) Project Costs

A key element in the Corridor Smart City Project is the development of a commercial framework to support demand side management schemes. This framework will be developed with several parties including National Grid, Electralink, Enernoc and NPower. These costs are included in the main bid, and this work prepares for replication of the project across GB.

The other elements of costs associated with DSM are the payments to customers for their demand response. Within the main project bid, the predicted costs for the four years of the project are set out in the table below. These are based on the value of deferred investment in the Corridor, as section E5.1 will detail.

Within LCNF bid	2011	2012	2013	2014
Payments to users (£)	0	75,000	155,000	160,000
NPV (£)				361,469

E4.2 DSM Carbon Savings

We have assumed that the DSM scheme can call on customers to reduce demand at peak times. We have assumed 300 customers in the scheme and 8 demand reduction events per year where the demand is reduced by 5kW for 3 hours. This behaviour will not be 100% demand reduction - we assume that that 50% of DSM is demand reduction and the remaining 50% of DSM is load shifting during winter periods. DECC's GHG emission factors for company reporting do not provide a standard comparison of the difference in carbon emissions associated with peak and off-peak electricity demand. However, Table 5A of the 2010 Digest of UK Energy Statistics⁶ indicates the variations in carbon emissions based on fuel source – around 500 tCO2e/GWh on average for all generators. This changes to around 900 tCO2e/GWh for coal and 400 tCO2e/GWh on average for gas i.e. a difference of 500 tCO2e/GWh. This suggests that in terms of carbon saving, a fuel switch from (winter) peak coal to off-peak gas is equivalent to the carbon saving

⁶ <http://www.decc.gov.uk/assets/decc/Statistics/publications/dukes/311-dukes-2010-ch5.pdf>

from a reduction in demand.

Therefore, for this analysis we value both demand reductions and demand-shifting from peak to off-peak at DECC's GHG conversion factor (Annex3) of 0.61707kgCO₂e/kWh. The following assumptions and calculations are made for each year:

Number of customers	300
Demand reduction events	8
Duration of each reduction	3hours
Demand reduction per customer	5kW
Energy saving (300x8x3x5)	36000kWh
DECC GHG conversion factor (Annex3) ^{7,8}	0.61707kgCO ₂ e/kWh
GHG emissions per year (36000x0.61707)	22,215kgCO ₂ e

The financial carbon equivalent values are set out in the following table to the nearest kgCO₂e:

Year	2011	2012	2013	2014
Total Saving (kgCO ₂ e)	0	11,107	22,215	22,215
£/tCO ₂ e	14.30	14.50	14.70	14.90
Carbon Value (£)	0	161	327	331

E4.3 DSM GB projection

Since an important role of the project is to assess the commercial ability of DSM and to test opportunities, this element of the costs and carbon savings is difficult to estimate both for the initial project, and when it is replicated. Thus there is a high degree of uncertainty around the costs and carbon savings in this section. Rounded to the nearest £100,000 and expressed in 2015/16 prices, multiplying the initial payment values by 65 indicates the following *additional* costs for a GB rollout.

Replicate to 65 cities	2015	2016	2017	2018	2019
Payments to users (£)	-	5,700,000	11,700,000	12,100,000	12,100,000
NPV (£)					37,887,279

⁷ DECC GHG conversion factor (Annex 1)

<http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm>

⁸ This GHG conversion factor reflects the 2008 grid rolling average; as the carbon emissions of the electricity mix reduce over time as suggested by the Low Carbon Transition Plan, this is likely to overestimate the GHG emissions associated with electricity demand.

If we assume that similar schemes are deployed in all 66 cities in GB, the annual energy saving would be as shown below.

DSM Carbon savings GB	2016	2017	2018	2019
Number of customers	0	9900	19800	19800
Number of events	0	8	8	8
Demand reduction at meter (MW)	0	0.005	0.005	0.005
Energy Saving (MWh)	0	2,376	2,376	2,376
Total Saving (tCO ₂ e)	0	1,466	1,466	1,466
£/tCO ₂ e	14.30	14.50	14.70	14.90
Carbon Value (£)	0	10,629	21,550	21,843

Projected out to 2050, the saving is shown in the following table.

Year	Carbon Saving (tCO ₂ e)	2009 £/tCO ₂ e Carbon Value	Value £ for Carbon reductions
2011	0	14.3	-
2012	733	14.5	10,629
2013	1466	14.7	21,550
2014	1466	14.9	21,843
2015	1466	15.1	22,137
2016	1466	15.4	22,576
2017	1466	15.6	22,870
2018	1466	15.8	23,163
2019	1466	16.1	23,603
2020	1466	16.3	23,896
2021	1466	21.7	31,812
2022	1466	27.1	39,729
2023	1466	32.4	47,498
2024	1466	37.8	55,415
2025	1466	43.2	63,331
2026	1466	48.5	71,101
2027	1466	53.9	79,017
2028	1466	59.3	86,934
2029	1466	64.6	94,704
2030	1466	70.0	102,620
2031	1466	76.5	112,149
2032	1466	83.0	121,678
2033	1466	89.5	131,207
2034	1466	96.0	140,736
2035	1466	102.5	150,265
2036	1466	109.0	159,794
2037	1466	115.5	169,323
2038	1466	122.0	178,852
2039	1466	128.5	188,381
2040	1466	135.0	197,910

2041	1466	141.5	207,439
2042	1466	148.0	216,968
2043	1466	154.5	226,497
2044	1466	161.0	236,026
2045	1466	167.5	245,555
2046	1466	174.0	255,084
2047	1466	180.5	264,613
2048	1466	187.0	274,142
2049	1466	193.5	283,671
2050	1466	200.0	293,200
Total Carbon Saving (tCO₂e)			56,441
Total Carbon Value (£)			4,917,918
Total Carbon Equivalent NPV(£) to nearest £10,000			2,050,000

E5 Smart-grid project costs and deferring network reinforcement

E5.1 Remaining project costs

The total costs of in the funding request are a combination of

- a) 'technology costs' or the main expenditure on the network and communications project, as shown in the first line of the table below. This involves the technical work and development of the project, such as the introduction of monitoring, communications, automation and project management, but does not involve any network reinforcement.
- b) 'other costs' including development of the DSM project, DSM payments, new EV recharging points and the Corridor partners' costs.

Within LCNF bid	2011	2012	2013	2014
Technology costs (£)	342,249	5,135,862	5,010,998	1,283,359
Other costs, including DSM payments, EV infrastructure and corridor partners' costs (£)	79,751	284,138	377,002	167,641
Total Second Tier Funding Request (£)	422,000	5,420,000	5,388,000	1,451,000

Many of the circuits in the Manchester Smart City Project area are heavily loaded. Projections based on economic growth suggest that a further 26MW of demand from 17 identified developments will be introduced by the Corridor's build-programme to 2020^[1]. Additionally, electric vehicle refuelling points and distributed generation will further stress the network. The estimated costs for reinforcement to meet this demand are shown in the table below.

Item	Cost
2x32MVA Transformers and switchgear	£6.5M (Southern Gateway)
33kV supply circuits	
Typically 4 x 6.6kV circuits	£1.4M (@£350k each)

We consider that a DNO would only bear 15% of these costs, since they are connections-related reinforcements and customers would contribute a large proportion of these reinforcement costs. We have estimated the upper-limit on the value to the DNO of such delayed reinforcement (beyond 2012/13) by considering the income in the price control allowance from depreciation, return and O&M based on making such an investment. This logic has been used to estimate the payments to users for DSM at 50% of this upper value, with the

^[1] The Corridor Manchester - Utilities and Infrastructure Assessment (May 2009)

direct benefit to the DNO during DPCR5 forms the remaining 50%. The acceptable commercial values and risks associated with DSM will be tested within the project and may alter from these initial assumptions.

E5.2 Technology costs GB projection

Replication of the project across GB would be cheaper than the initial project, because of the learning undertaken in the initial stage. As a rough estimate, the costs of replication are estimated at 60% of their value in the initial project shown in the table above. Multiplied by 65 cities, rounded to the nearest £100,000 and expressed in 2015/16 prices, this indicates the following *additional* costs for a GB rollout.

Replicate to 65 cities	2015	2016	2017	2018	2019
Technology costs (£m)	0	20.7	310	302.4	77.5

However, the introduction of smart grid technologies will bring value by deferring planned reinforcement costs between now and 2020. The value of this deferment could also be replicated to 65 cities starting from 2016, potentially reducing future reinforcement costs (£7.9m x 65). This could be of the order of £600m, but this represents the maximum value if reinforcements are avoided rather than deferred. Whether the reinforcement costs can be indefinitely deferred will depend on the background load growth; in the case of the CMSCP, the background load growth means the reinforcement is only deferred. The balance of benefit between DNOs and customers would depend on the future regulatory settlement.

Replicate to 65 cities	2015	2016	2017	2018	2019
Avoided reinforcement costs (£m)	0	0	0	0	600

E5.3 Carbon savings associated with (deferred) network expenditure

An internal ENW report (previously shared with Ofgem) identified the following one-off embodied carbon benefits of *avoiding* asset installation.

33/11kV transformer	103 tonnes CO ₂ equiv
33kV cable	75 tonnes CO ₂ equiv per km
HV (6.6kV) cable	30 tonnes CO ₂ equiv per km

The network expansion for the Corridor project would involve two transformers plus cable upgrades. This suggests hundreds of tonnes of embodied carbon would be involved; the project envisages that

this would at least be deferred, and potentially avoided although that can not be claimed here. The default assumption is that the carbon would simply be deferred. This scale of deferring hundreds of tonnes of embodied carbon is relatively small compared to the thousands of tonnes of carbon savings that the network facilitates via the electric vehicles, energy efficiency and DSM projects.

E6 Costs excluded from this description

The CMSCP project bid does not include the following costs.

- the cost of investment in demand-reduction initiatives by the Corridor partners on their own sites (nearly £7m during the CMSCP project),
- the costs of owning and recharging electric vehicles,
- the creation of electric vehicle infrastructure outside the CMSCP area (as envisaged by the Association of Greater Manchester Authorities in its forthcoming bid for Plugged-in Places funding), and the associated management of the whole recharging network including the CMSCP area.

These important elements are being paid for and managed separately from this LCNF funding bid. For simplicity and comparability, these aspects have also been excluded from the costs scaled up to the whole of GB.