2016

Carpenter's Estate Infrastructure Regeneration

WATER AND ENERGY INFRASTRUCTURE REGENERATION STRATEGIES

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1. Introduction

The Carpenter's Estate (CE) located within Stratford, is a mixed social, leasehold and freehold housing development comprising 710 homes split between low-rise houses and three high-rise tower blocks, industrial buildings and community centres. Figure 1 illustrates the approximate area and location of the CE within the Greater Carpenter's area.

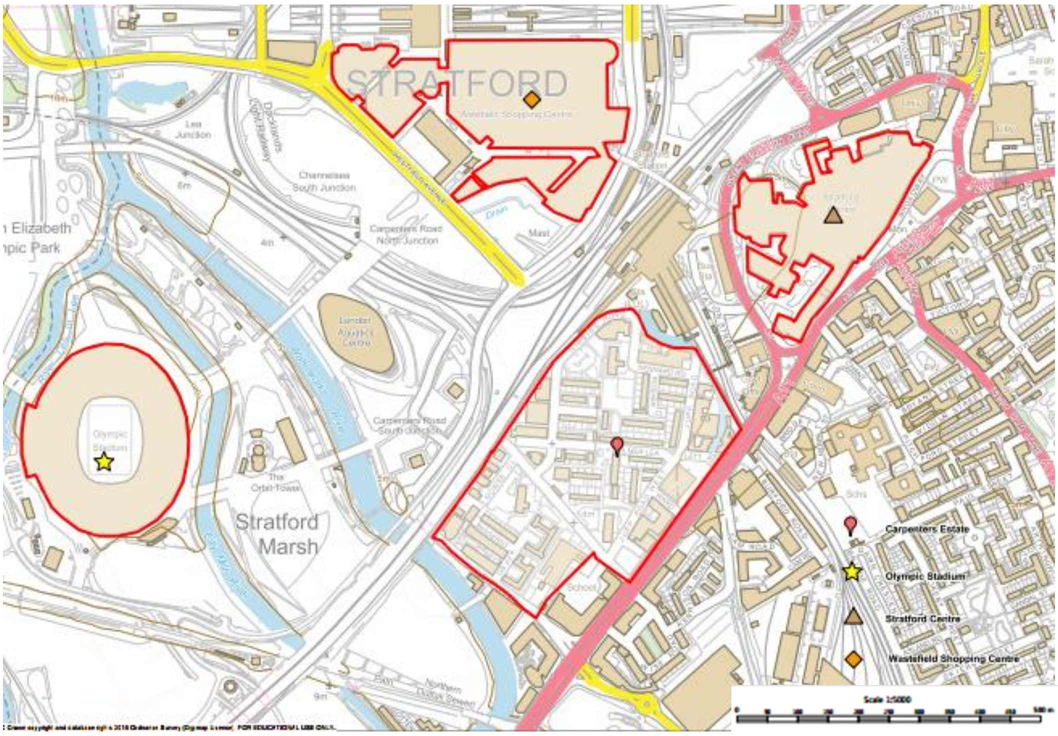

Figure 1. Site map of the CE

Extensive redevelopment under both the Stratford Metropolitan Masterplan (Newham Council, 2011) and the Local Plan (London Legacy Development Corporation, 2015) has been outlined for the CE, involving widespread demolition. As a result, Newham Council have been actively decanting residents since 2005 (Newham Council, 2015), which has led to a period of deterioration and poor maintenance for infrastructure within the CE (Dunn, Glaessl, & Magnusson, 2009). This is further supported by correspondence undertaken with current residents regarding the mismanagement of their utility systems (Khan, 2016); (Saravanamuthu, 2015).

The CE community have taken a proactive approach to the period of consultation with the London Legacy Development Corporation (LLDC) and Newham Council, creating a Neighbourhood Plan that provides an alternative solution to CE regeneration. This focuses on redevelopment of existing infrastructure rather than widespread demolition. This project supplements the Neighbourhood Plan by compiling detailed solutions for both water and energy infrastructure taking into account community objectives, sustainability and long-term capacity of the CE. Thereby, addressing the requirements of the Greater Carpenter's Neighbourhood Forum (GCNF) as the main client. This is also in line with the aims set by Just Space as the project's main sponsor (see Appendix A for more details).

2. Scope

This project presents energy and water infrastructure strategies for CE redevelopment as opposed to demolition. The options presented are evaluated with respect to technical feasibility, cost, sustainability, and community acceptability. They are also bounded by LLDC policy and government targets for infrastructure redevelopment, which are 105L of water/person/day and 40% energy reduction.

2.1 Fulfilment Criteria

Water and energy infrastructure strategies presented in the following section consider short, medium and long term redevelopment of the CE defined as 0-5, 5-15, and 15+ years respectively. The options presented take into account feedback from community engagement conducted throughout the duration of this project, as well as drawing on community objectives highlighted in the Community Plan (2013). To maintain feasibility of the options presented, water and energy policies denoted by the Local Plan (2015) regarding energy and water infrastructure and supply are also adhered to. This includes Policy S.2 for energy supply and demand, Policy S.3 for energy infrastructure and heat networks as well as Policy S.5 regarding the reduction of potable water demand usage to 105 litres per person per day.

The estate has a current water demand of 162L/person/day (Crawford, Demolition or Refurbishment of Social Housing, 2014). Potable and non-potable retrofit strategies below address the target 105L/person/day level of acceptability highlighted by the Local Plan (2015). Additionally, the Community Plan (2013) addresses the need for green spaces, implying a need for irrigation.

2.2 Aims and objectives

As a result, the objectives of this project are to:

- Undertake extensive community consultation so that solutions provided considers the existing needs of CE residents.
- Incorporate aspects of the Community Plan (2013) within final infrastructure solutions for both water and energy.
- Consider water and energy infrastructure solutions in short, medium long-term context of implementation.
- Evaluate water and energy infrastructure options, considering existing facilities and alternative solutions with respect to feasibility, cost, sustainability and community acceptability.
- Present water and energy infrastructure solutions for the CE that balance criteria and expectations.

3. Short Term Strategies

The strategies suggested below have integrated favoured water and energy infrastructure options to propose a holistic solution. These strategies are to be undertaken within a period of 5 years.

3.1 Energy

3.1.1 Reducing Energy Demand

In the Low Carbon Transition Plan, the Government sets out their ambition to reduce emissions from households by 29% by 2020 consistent with carbon budgets set under the Climate Change Act (HM Government, 2012). Due to the 20% increase in energy use on Carpenter's Estate this adjusted reduction would be approximately 41%. Reducing energy use to the following target or exceeding it would allow the site to function sustainably with the possibility of looking into alternative supplies of energy.

A mixture of energy saving solutions, both high and low tech, would need to be used to achieve a reduction of 41% as per required government reduction. A study from the London Borough of Camden (2013) found that by retrofitting houses with many of the technologies suggested a 40% reduction could be achieved. The Department for Communities and Local Government (2015) suggests that to upgrade council housing to the required standard would take around £1,000 per home.

3.1.2 Single Flat Insulation for High Rise Homes

As the high rise flats are relatively efficient compared to the terraced housing due to their low external area, it would not be cost effective to install insulation in individual home. Furthermore, it is more strategic to wait until an agreement can be reached to insulate and replace the entire façade of the high rise buildings.

3.1.3 Storage Heaters

For the energy supply, since the occupation rates are low, a first and simple step is to replace the electricity storage heaters with new, more efficient models. The maximum cost one can expect to pay is £700 for each heater replaced (Energy Saving Trust, 2014). The minimum annual savings are £100 but combining the new units with insulation and correct management and use of the meters, the savings can be expected to be as much as £200/year (StorageHeaters, 2009). Further savings can be expected if used with a PV system which could potentially be installed in the future. In terms of carbon savings, these can be directly calculated from the amount of electricity not used which would differ from house to house. Further significant carbon savings can be achieved with the transition to a different fuel source such as solar.

3.1.4 Cavity Wall Insulation for Low Rise Homes

Insulating cavity walls would require a specialist contractor to inject the 20mm gap with expanding foam. This could be done by individual residents but would again be most cost effective if a scheme could be introduced between contractors for the whole estate therefore benefiting economies of scale. The typical cost of cavity wall insulation is around £370 for terraced housing and £330 for low rise flats, both with a payback period of 3-4 years, which could be reduced with a contractor partnership (The Co-Operative Energy, 2013).

3.1.5 Boiler Replacement

For the energy supply, it is advised that when boiler needs to be changed (10-15 years), it is replaced with either or a heat pump (preferably ground source) or a micro CHP unit. There is also the option of installing an A rated gas boiler which could be eligible for the boiler cashback scheme of the Mayor of London. This scheme offers £400 for replacing a G rated boiler with either an A rated gas boiler or a heat pump (amongst other options), but has a cap of £2.6 million (Greater London Authority, 2016). Therefore, there is no guarantee that the scheme would still be running by the application date. The scheme was launched on the 2nd of February 2016 and after the voucher is received one has 12 months to install the new unit. Micro combined heat and power (CHP) is eligible for the Feed-In Tariff (FIT) but the new rates have not yet been announced. Heat pumps are eligible for Renewable Heat Incentive (RHI) Tariff for 7.42p/kWh for air source heat pumps and it is 19.10p/kWh for ground source pumps (Ofgem, 2016). If funds are available, ground source heat pumps are recommended and would benefit more from a future PV installation since they run on electricity. However, if the house is not or will not be insulated soon, one of the other two systems is a better fit. The systems also have different environmental benefits. Ground source heat pumps have the greatest carbon savings of 2,000kg CO_2 /year, while replacing the least efficient gas boiler with the most efficient saves 1,500kg CO_2/year. The carbon savings of micro CHP are based on the electricity produced, on top of the savings from the increased efficiency depending on the model replaced.

3.1.6 Usage of Energy-efficient Lightings and Fittings

Installation of energy efficient lighting and appliances would have a significant effect on energy demand drawn by households, with 3% and 14% total household energy use respectively. It is recommended that residents switch to compact fluorescent lamps (CFL) energy saving light bulbs with immediate effect from traditional incandescent, as they will start to see a cost saving in less than a year irrespective of allowing the old bulb to finish their lifecycle. Additionally, appliances can be replaced as and when they are needed to more efficient models, preferably A+++ rated appliances, which can save as much as 180kWh per year. These appliances however may be costly. For example: A+++ refrigerators prices start from £300 per unit while washing machines prices start from £225 per unit.

3.1.7 Energy Meters and Behavioural Change

Smart meters allow for occupants to monitor real-time energy use with an overall reduction of 2-3% (Department of Energy and Climate Change, 2014). These are recommended as they provide an important step towards behavioural change for the CE. However, this means that installation of the meters need to be accompanied with educational workshops for proper use, since it has been seen during community engagement that residents who already have some sort of meter do not know how to operate them. Table 1 summarises the characteristics of each short term energy option based on the chosen assessment criteria.

Table 1: Short term energy options

Option	Cost	Bill saving	Carbon emission savings
Storage heaters	£700/unit	£200/year	
Cavity wall insulation for low rise homes	Terraced houses: £370/house; low rise houses: £330/house		750kg CO_2/unit/year
Boiler replacement with efficient technologies	£2.6 million/scheme for boiler replacement		1,500kg CO_2/unit/year
Energy efficient appliances, lighting and fittings	£300+/unit for refrigerators, £225+/unit for washing machines	£34.02/year	15kg CO_2/per light bulb/year 90kg CO_2/per washing machine/year
Energy meters and behavioural change		2-3% reduction in energy	

3.2 Water

3.2.1 Simple Rainwater Harvesting (RWH) System

More rain could be captured within the low-rise houses area, i.e. 399.86m^3 per year. RWH for low rises can also be as simple as having water butts or small tanks at the end of gutter outlets, especially if used specifically for irrigation purposes. Therefore this option does not apply for residents in high rise homes. This would cost between £100-300/unit (Freerain, n.d.). Residents may choose to do this as a lower cost option. Usually, the water from this method of harvesting is for gardening/outdoor uses, meaning a possible annual water bill saving of £25.2, with estimated payback time between 12-16 years. RWH systems could save up to 1,433kg CO_2/year (AECOM, 2010) in low to mid rise buildings with high occupancy. However, this may differ as this depends on the carbon intensity from the mains connection and the exact units used in the system. Currently, this is unknown as more sophisticated RWH systems would need to be fitted to assigned buildings. Conversely, simple RWH systems may support aspirations of green spaces, as in the Community Plan (2013), within the estate considering the yield potential from available surface area within the estate, i.e. 52.1Mm^3.

3.2.2 Usage of water-efficient devices and fittings

Flushing consumes 30% of the water supplied from the mains. This is a substantial amount, therefore there are a number of ways to reduce water for this particular non-potable use. Firstly, using water displacement devices, e.g. HIPPO, save-a-flush, brick, in toilet cisterns can prove to be a cheap and easy method. Each unit costs around £2-3.50. Water HIPPOs may save between 2-3L/flush (HIPPO the Watersaver, 2013), while save-a-flush may save around 1L/flush (South West Water, n.d.). HIPPOs may save up to 600L/year, whilst save-a-flush may save up to 100L/year. This means these devices can save up to £30 within 5 years. The type of water displacement devices need to be assessed to fit the cistern as not all devices work best with any cisterns. Cisterns installed later than 2000s usually do not need them. Environmental implications for this solution are predicted to be negligible, as it does not need any energy input to operate.

Secondly, replacing old toilets with low or dual-flow toilets can be considered. They can cost up to £300/unit. Dual-flow toilets have 2 types of flushing flowrate, typically 4L/flush and 2.5L/flush (BRE Global Ltd, 2009), while low-flush toilets have flow rates lower than 10L/flush (ibid.). This means they can save up to 50% of the household water used for flushing, consequently saving up to £270 within 5 years. However, replacing old toilets with newer ones may be problematic for high rise homes as some wall restructuring may be required. This is caused by the presence of asbestos within the walls of Dennison Point building (Bellamy Surveying and Consultancy Services Ltd, 2007). It is unknown for other high rise homes. Conversely, this may be more beneficial for low rise homes. Associated carbon savings for this option is unknown at this stage as it depends on the carbon intensity emitted from the main system.

Thirdly, using low-flow showerheads (under 9L/minute (WaterWise, 2009)) may further reduce annual bills. For example: the annual water and heating bill saving by using the Gabi H_2O Slimline Showerhead is approximately £187 (The Greenage, n.d.) whilst investing in only around £30/unit. Table 2 shows the potential annual water bill saving if water efficient technologies are used.

Table 2: Potential annual water bill savings

Occupancy \ Option	Water-efficient showerhead	Save-a-flush
Single	£11	£5
Double	£23	£9
A family of four	£45	£18

(Thames Water, 2015)

3.2.3 Water Metering and Wastewater Management

Water metering received consistently negative feedback by the CE community and therefore is not considered further. Despite wastewater recycling reducing non-potable demand for the CE, general acceptability of these measures is low. Therefore, it is also not taken further in this project. However, detail for how they could be provided if behavioural change was to shift in the long-term in provided in Appendix H: Water Options.

3.2.4 SuDS (Sustainable Drainage System)

The basis of the surface water management strategy within the CE is the preservation, enhancement, and increase of natural systems as well as re-landscaping available green space areas. It is provided in order to raise infiltration and detention of surface water, alleviating strain on existing sewers and drains, and reducing risk of localised flooding during sustained periods of heavy rainfall. Within a period of 5 years, it is expected that a detention basin, infiltration trenches and swales can be formed (Appendix L), and extended through to medium-term, as well as retrofitting some permeable pavements during the initial 5 years. This time frame is feasible when considering comparative case studies such as the Queen Caroline Estate (Groundworks, 2016). During excavation and redevelopment, soils can be recycled within the areas to provide for requested micro-gardens and community allotments during informal discussions with residents. This provides a supplementary benefit of social pride and integration exhibited on the CE through these schemes as it encourages community integration and preservation (Jamieson, 2012) of the SuDS and natural systems. These benefits provided in the short term can carry through into a long-term time frame and therefore presents sustainable solutions for surface water management.

Table 3 summarises the characteristics of each short term water option based on the chosen assessment criteria.

Table 3: Short term water options

Option	Cost	Bill saving	Carbon emission savings
Simple rainwater harvesting system	£100-300/unit	£25.2/year	1,433kg CO_2/year
Water displacement devices	£2-3.50/unit	£6/year	Depends on carbon intensity of the mains
Water efficient toilets (e.g. dual flush)	£300/unit	£54/year	
Low flow showerheads	£30/unit	£187/year	

4. Medium Term Strategies

These strategies take up to 15 years to complete.

4.1 Energy

4.1.1 Insulation for High Rise Homes

Insulating the high-rise flats will be most economical if completed per tower. In comparison, the high-rise blocks loose less heat that a terraced house would due to the limited external face. For this reason, the only the façade will require significant thermal improvement which would be external insulation due to the limited space inside the buildings.

Planning permission may be needed for installing external insulation. Due to the scale of the project, it would require specialist contractors to fit (Insulated Render and Cladding Association, 2015). As external insulation will require changing the façade of the building, upgrade to the athletics of the building can be done simultaneously if requested by the residents as part of the modernisation of the tower blocks.

4.1.2 Solar Photovoltaics (PV)

The community could benefit from solar energy by producing electricity through PV panels. All the rooftops of both low and high-rise buildings in the Estate can have PV modules installed, unless they would be heavily shaded throughout the day which greatly affects the efficiency of the array, or they are not facing in the right direction. By estimating the area of roofs facing east to west through south [using Edina data (Edina, 2015)], the possible available area for PV installation is found to be around 8,000m^2 (Appendix J: Energy Strategy Schematic). A PV system installed in CE is expected to have a maximum output of more than 1MWp and an annual generation of close to 1MWh (Solar Century, 2013). Therefore, solar PV could cover around 10% of the Estate's electricity needs. By interpolating data from the Banister House solar project, it can be calculated that a 1MWp installation of solar panels could cost £1.4 million (Repowering London, 2015). The estimated cost for the project is to be significantly lower after the recent drop in solar PV prices. Solar PV is also eligible for the feed-in tariff (FIT), but recently the feed-in tariff has seen major cuts. This tariff is 4.65p/kWh but is subject to a cap in installations after which the tariff decreases. Therefore, it is uncertain what its value would be at the time of approval (Otero, 2016). A 1MWh/year installation could save up to 455 tonnes of CO_2 per year (Solar Century, 2013) and contribute significantly towards the Mayor's reduction targets. The initial costs are high, but similarly, smaller scale projects have managed to obtain funding from independent investors (Repowering London, 2015). Repowering London, who work on community PV systems, also offer workshops on legal and economic issues, as well as technical internships for young people in the area (Otero, 2016).

4.1.3 Heating Option 1: Combined Heat and Power (CHP) Plant

There is also another alternative option which is district heating. District heating energy systems provide heat and hot water to multiple buildings or dwellings from an energy centre. The network of insulated pipes can transfer heated water and energy to every single house or building. There is a heating exchange unit that includes a heat meter to monitor heat usage. The existing CHP plant and the community is located near one of the CHP connection point which is point C (Figure 2) (Greater London Authority, 2011), the main source of energy is woodchip which is more sustainable and can help to reduce carbon emissions. According to the Queen Elizabeth Olympic Park district energy scheme, the energy centre can reduce the CO_2 emissions by 60% compared to conventional gas boilers and provides a similar price to conventional high carbon systems (Woods, 2015). Meanwhile, the cost of district heating is roughly similar or might be lower compared to conventional gas and electric heating: district heating is around 5.51-14.94p/kWh, gas heating is 9.55-11.60p/kWh, and electric heating is 21-22.99p/kWh (Aylott, 2015). The implementation of district heating could reduce the costs, to up to 30%. The investment of pipe network construction may discomfit the community but the source of funding can be discussed and negotiated with NGIE (formerly COFELY). The estimated energy demand for London is about 16.4 MWh/household per year, of which energy for heat accounts for 60% (Henretty, 2013). The total pipe network construction is estimated to cost around £3,262,850, assuming the number of CE households remains constant which is 710, the payback time is estimated around 5-14 years. Those all indicates that the COFELY could be considered as source of funding.

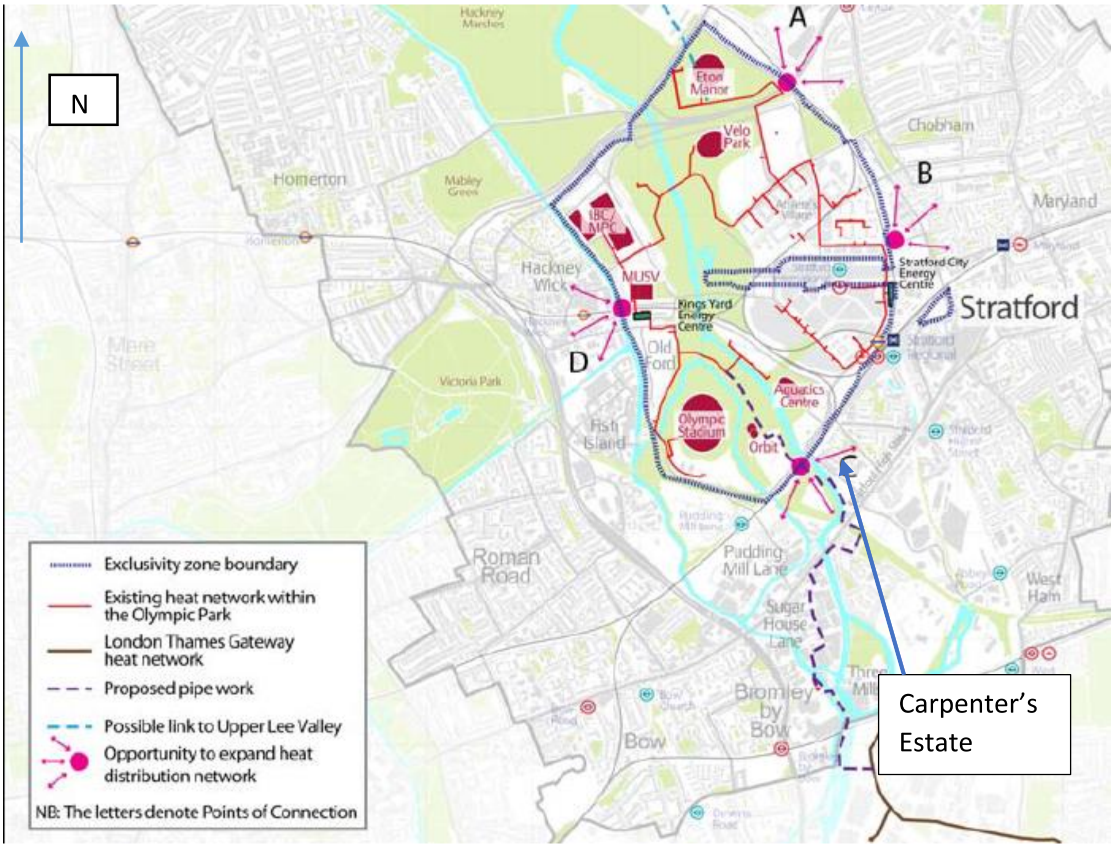

Figure 2: Energy network connection (Greater London Authority, 2011)

4.1.4 Heating Option 2: Heat Pumps

There are air source heat pump integrated systems for high-rise building that can be used in the Estate (Mitsubishi Electric, 2015). Air source heat pumps come at a cost of about £6,000 (Crawford, Johnson, Davies, Joo, & Bell, 2014) to up to £10,000 (The Green Age, 2014) per installation. For a large installation (high-rise), the cost per residence is expected to be closer to the lower limit. Since heat pumps operate with electricity, the cost of operation depends on the price of electricity. As their efficiency is 3:1, for every unit of electricity they produce three units of heat and therefore the price per kWh is a third of that of electricity (i.e. 7-7.5p/kWh). The Renewable Heat Incentive tariff for air source pumps is 7.42p/kWh, which means that the annual tariff for an average household is around £70. The annual CO_2 savings for air source heat pumps are up to 11,400kg CO_2 (replacing electric storage heaters) (Energy Saving Trust, 2014). This type of technology has been used in the past by NGOs and in social housing complexes and proofed reliable and cost saving (Mitsubishi Electric, 2015).

Ground source heat pumps are recommended for the low-rise dwellings where possible. For the ground source heat pump, a garden with access is needed for the borehole that is up to 150mm (CIBSE, 2013). Most of the low-rise buildings do have adequate garden area with good access for a ground source pump installation. For ground source heat pumps, the installation costs around £13,000 and the annual operation £650 (Centre for Sustainable Energy, 2013). Again, for a heat pump that will service many flats, the capital cost per residence is lower. Heat pumps are also eligible for the RHI and for ground source pumps it is 19.10p/kWh (Ofgem, 2016). For the average household usage, that equated to a tariff of around £180 per year. The annual CO_2 savings for ground source heat pumps are from 2,000kg CO_2 (replacing gas boilers) (Energy Saving Trust, 2015). Decision between the heating options above has not been made. Furthermore, in a recent consultation with the LLDC, the team was reassured that no one option is preferred over the other as far as they are all in line with the strategic policies on energy found in the Local Plan (London Legacy Development Corporation, 2015). Decision variables for heat pumps versus a CHP connection are expressly defined in Table 4 and Figure 3.

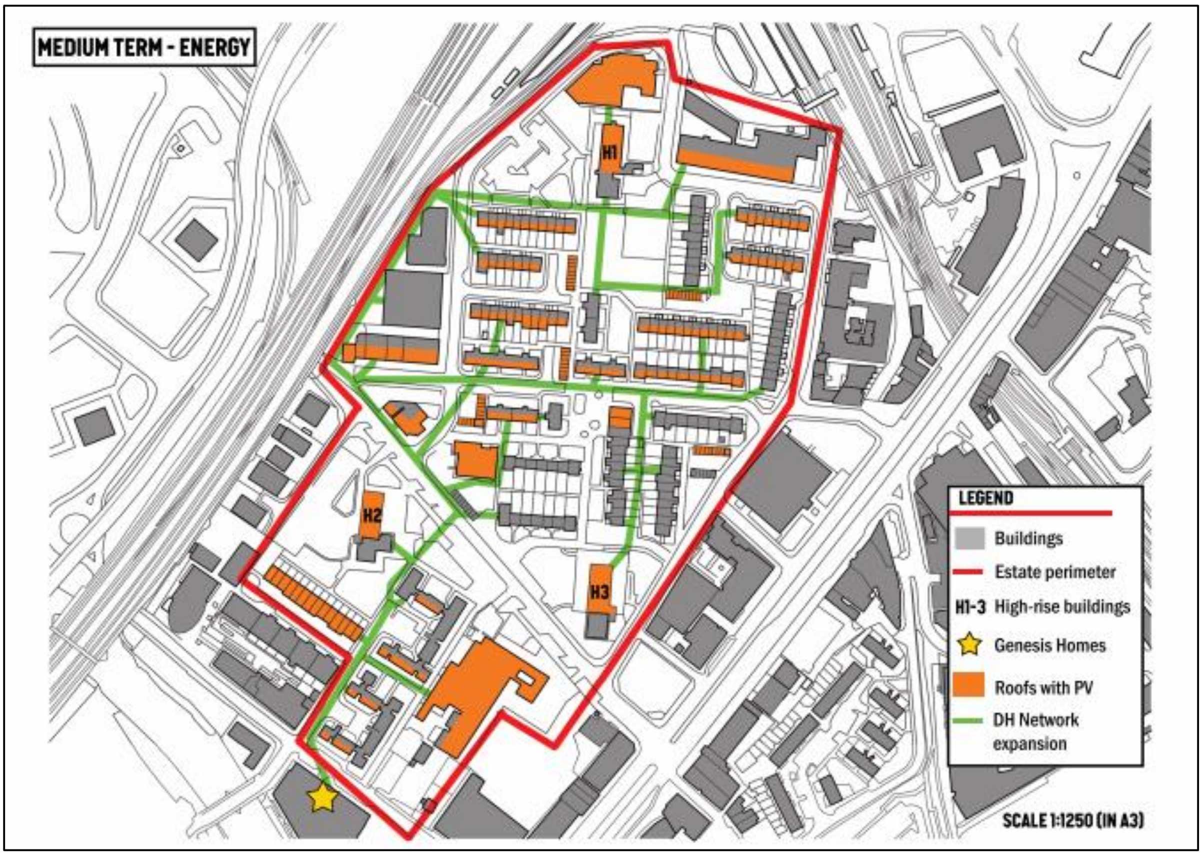

Figure 3: Integration of energy strategies within the CE for medium-term.

Table 4.Decision variables for medium term energy strategy

CHP Connection	Air-source Heat Pump
Pros	
In line with the LLDC Strategic Policies	In line with the LLDC Strategic Policies
Positive feedback from the community	Positive feedback from the community
ENGIE (the company who owns the CHP plant) benefits from the expansion of the network so could potentially invest in the Estate's connection	Eligible for the Renewable Heat Incentive Tariff
Easier connection expected in the future since new developments are being built	Higher bill savings
Lower prices compared to current are expected in the future as the network expands	Higher carbon savings
	Energy independence
Cons	
Would still need refurbishment of high-rise for wet heating system installation	Would still need refurbishment of high-rise for wet heating system installation
Legal help for contract would be needed as Carpenters is outside the concession area, although LLDC has some protocols.	No available funding
Some opposition expected by existing residents since they would be bound to one provider	Higher capital costs
Research cost for connection could reach up to hundreds of thousand pounds, money ENGIE might not be willing to invest	

Table 5 summarises the characteristics of each medium term energy option based on the chosen assessment criteria.

Table 5: Medium term energy options

Option	Cost	Bill saving	Carbon emission saving
Solar photovoltaics	£1.4 million/scheme		455 tones /year
Insulation for high rise homes			
Combined heat and power plant	£3.2 million/scheme		Reduce the CO_2 emissions by 60% compared to conventional gas boilers
Heat pumps	Air source: £6,000-10,000/unit; ground source: £13,000/installation	Air source: up to £1,295/unit Ground source: up to £595/unit	Air source: 11,400kg CO_2/year (replacing electric storage heaters); ground source: 2,000kg CO_2/year

4.2 Water

4.2.1 Intermediate RWH system

A more advanced RWH system equipped with a first flush unit, a purification unit, and a pumping unit in addition to the storage tank should be considered. This can be modified allowing several low-rise houses to share a system. Cottsway Housing Association estates in Gloucestershire proved this as the system implementation achieved Level 4 of the Code for Sustainable Homes (Rainharvesting Systems Ltd, 2013). Ranging between £2,000-3,000/unit (Rainharvesting Systems Ltd, 2015); (Freerain, n.d.), annual water bill savings can achieve approximately £108 if used only for flushing. More can be saved if also used for clothes washing (£46.8) and washing up (£28.8), totalling up to £208.8 per annum for an average household in addition to gardening uses. On the other hand, high-rise homes need to have intermediate level RWH systems. Although possible, they also prove to have less capturing potential for this system, i.e. 39.44m^3. Additionally, they may have some challenges for the pumping unit if the tank is located below ground or at low ground levels, and for the RWH pipe outlet to be connected to the high rise homes' water supply system.

4.2.2 SuDS

At this stage the SuDS, permeable pavements and infiltration basins can be fully implemented across the CE (Appendix K). Combining all these strategies and RWH, the expected management of surface water runoff volume is 5,616 m^3 (HR Wallingford, 2016), accounted for by the design capacities of both permeable pavements and SuDS (Appendix H). The total cost of these measures is approximately £295,000 (DEFRA, 2011a); (Defra, 2011b), with a cost breakdown presented in Appendix H. Holistically, these surface water management strategies are implemented in parallel with RWH systems, with an increase in RWH reducing the amount of surface water runoff. Addition and maintenance for green space for use as SuDS is beneficial to social wellbeing and adheres to multiple objectives specified in the Community Plan (2013) and is therefore maximised across the CE and illustrated in Appendix K and Figure 4.

Table 6 summarises the characteristics of each medium term water option based on the chosen assessment criteria.

Table 6: Medium term water options

Option	Cost	Bill saving	Carbon emission saving
Intermediate rainwater harvesting system	£2,000-3,000/unit	At least £108/year	1,433kg CO_2/year
SuDS and Permeable Pavements	£295,000		Alleviates strain on existing drainage infrastructure, minimising flood risk whilst maximising green space and enhancing biodiversity.

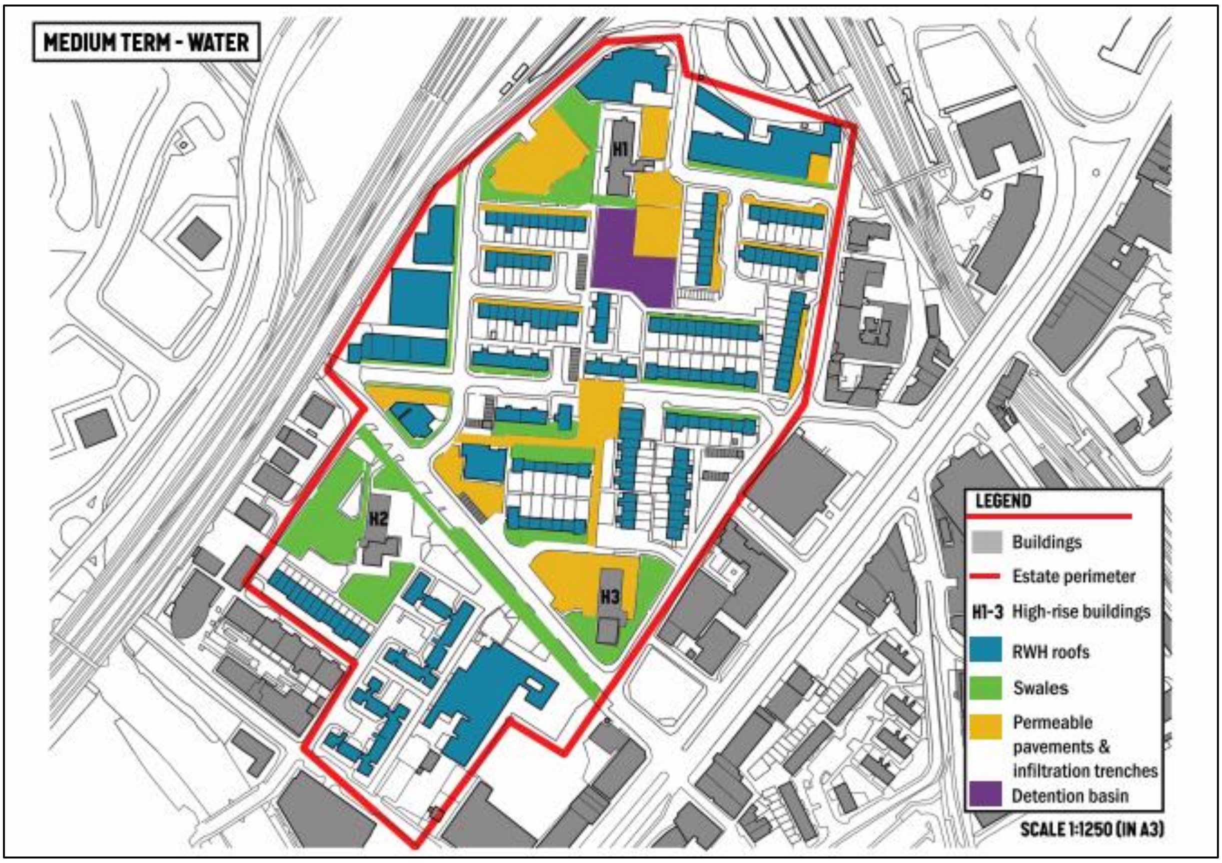

Figure 4. Integration water strategies within the CE for medium term

5. Long Term Strategies

This is subject to what the final designation for the CE will be, which is difficult to denote at this stage. Pertinently for the CE residents, they are more concerned with immediate measures for redevelopment. Therefore, short and medium strategies are presented in detail. There is a potential for sensitive infill of new homes on the Estate in the future, in accordance to the Local Plan (2015) and future Neighborhood Plan guidelines of when infill is desirable. This is subject to additional work and further analysis; the detail of which is outside the scope of this report. Consequently, the strategies presented supplement long term water and energy solutions.

6. Community Engagement

Community engagement activities undertaken throughout this project ensured that water and energy strategies presented have fulfilled resident and local business requirements. These activities included meeting with the GCNF, selected house visits, on-the-phone questionnaires, and drop-in Q&A session (Appendix B-D). Attendance at a GCNF meeting at interim stage raised understanding of these needs, as well as understanding the relevancy of this project in order to develop a Neighbourhood Plan with facets of technical feasibility. The house visits provided information for the team of the residents' most recent living conditions and building measurements for energy modelling purposes. The questionnaires also helped fulfil any information gaps of their living conditions and provide feedback of the proposed energy and water options. The drop-in session aimed to present the options to the residents and interact with them in an informal setting. Further details can be found in Appendix A.

6.1 Community Acceptability

In order to appraise the options identified, 30% of the occupied households were contacted between January-February 2016. From drop-in session, the results are shown in Table 5.

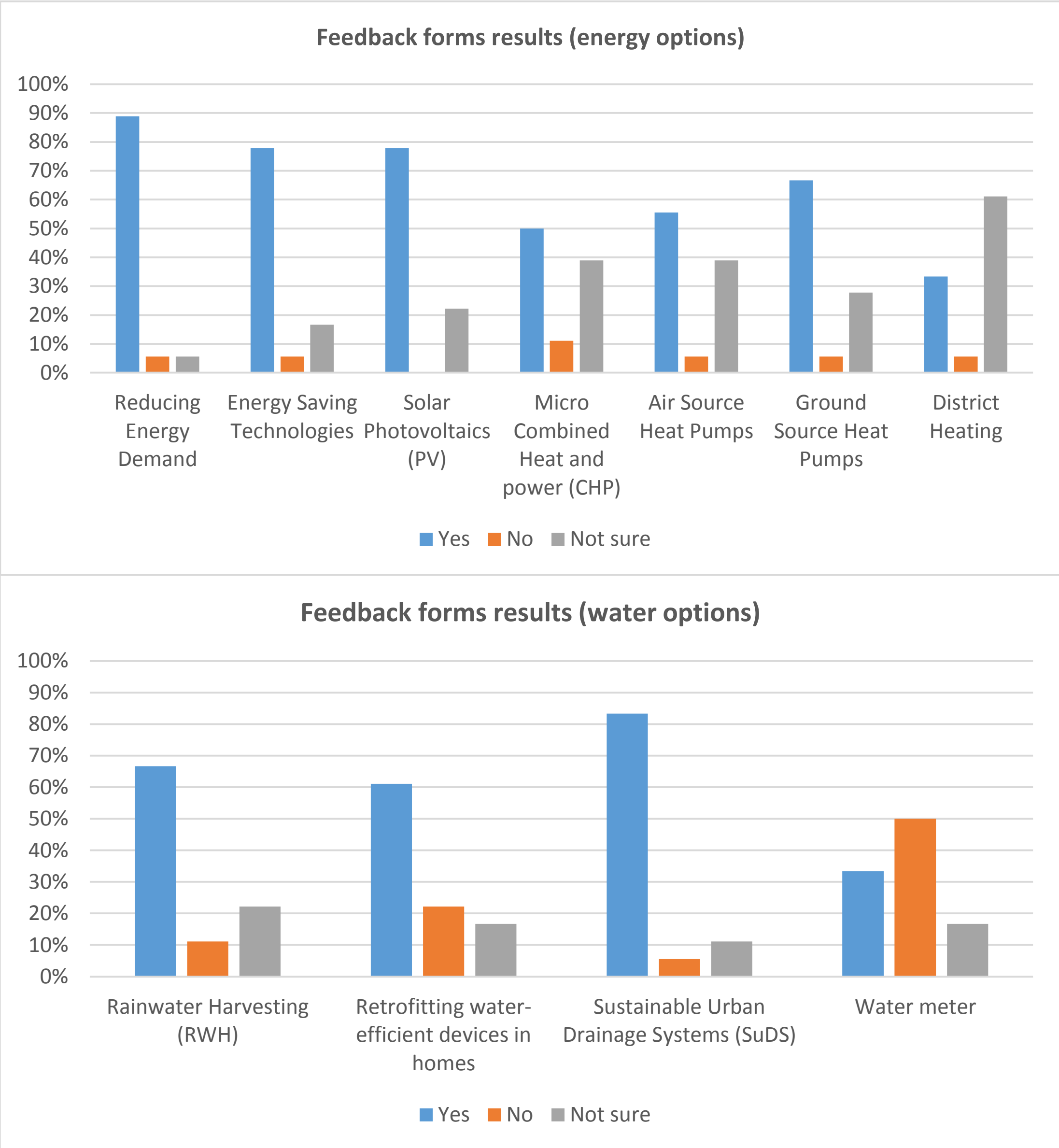

Figure 5. Results from community feedback regarding energy (top) and water (bottom) options

For energy measures, this translated to insulation and energy saving technologies being provided, and for water options SuDS were well received which also include community benefits such as retaining green space and enhancing biodiversity, proliferating a sense of community spirit through localised micro-gardening sites. The surveys indicated positive feedback for all energy measures, however the residents were more critical regarding water meters. Survey data trends strongly indicate that wherever options clearly related to projected cost saving, the residents were unanimous in support, as well as for preservation of natural capital.

Public participation has been maximised throughout this project with the levels of community involvement in decision-making reaching degrees of citizen influence considered to be the highest levels of public participation (Arnstein, 1969). Therefore, the infrastructure solutions provided present the objectives of the sample of community members that engaged in this project. The spirit of community involvement has been optimised at each stage within the relatively limited time, resources available, and the very real difficulties of engaging residents who continue to have the threat of demolition of their homes. However, this is considered to be attributed to the misgivings that CE residents have towards organisations attempting to present strategies for redevelopment and also due to the rate of residents' relocation of 88% (Newham Council, 2015).

6.2 Engagement Risk Evaluations

Overall participation throughout the engagement initiatives with both the community and clients, Just Space and GCNF, altered. Initial attendance at the GCNF meeting were dominated by only a few members and it was considered that they were unrepresentative of the overall CE community. Therefore, it was decided that informal visits and surveys directly distributed to residents could more accurately gain a more general consensus of feeling regarding the proposed water and energy infrastructure options. The London Tenants Federation assisted with distribution and receipt of the surveys and correspondence which counteracted the loss of contact with the GCNF and the disbanding of the Tenants Management Organisation. Contacting different stakeholders meant that risk of a lack of information received was minimised, whilst maximising the number of residents reached.

7. Sustainability

The premise of all the options suggested for both water and energy incorporate sustainability criteria such as a life-cycle reduction in CO_2 emissions and reducing both non-renewable sources and potable supply for energy and water respectively.

The onus of this project on retrofitting rather than demolition and replacement with new build homes for the CE is considered both more sustainable and cost effective when comparing with existing similar scale projects. Radian (2011) stated regenerated a 'hard to treat social housing development to an advanced energy performance standard.' Their results indicate a total lifetime emissions (embodied and operational) for retrofit homes to be 139kg CO_{2eq}, 30% less than new build homes. Average refurbishment cost per home for retrofit measures of £91900, 60% less than the cost of a same sized new build property. Furthermore, the number of properties to be retrofitted for the CE is greater, cost savings increase due to economies of scale.

Energy and water options provision of appliance retrofitting, energy supply and heating are produced in parallel to the Code for Sustainable Homes Cost Review (2008) so that cost, technical feasibility, and sustainability benefits can be compared directly. CHP/heat pumps, solar PV, and insulation provided from medium term for both low rise and high rise homes is considered the most sustainable solution for the CE. Combinations of holistic energy strategy are shown in (Appendix J: Sustainability), illustrating the changes in associated cost for providing multiple solutions.

As stated in section 3.1, the Government set out the Low Carbon Transition Plan, in which they aim to reduce emissions from households by 29% (HM Government, 2012). Due to the age and current condition of the houses within the estate, this was adjusted to 41% reduction to meet the same targets. The research conducted as part of this report, and the modelling undertaken by ESD, shows a reduction of 40% in CO_2. Therefore, energy bills can be achieved through replacement of electric storage heaters, improved glazing and the addition of external glazing in the high rise blocks alone.

It is an achievable prospect for the CE to become a sustainable estate in term of energy use by implementing minimal measures. Furthermore, it can become a frontrunner in individual and community energy use by implementing further options which can realise extensive energy and monetary saving, as shown in Table 7.

Table 7: High-rise energy reduction figures

Scenario	Carbon Emissions (kg CO2)	Carbon Savings	Cost (based on Tariffs)/Household (£)	Bill Savings
Current conditions: Electric Storage Heaters, Double Glazing, No wall insulation	538,940	0%	1,911.13	0%
Electric Storage Heaters, Double Glazing, External Wall Insulation	321,269	40%	1,139.25	40%
Air-source Heat Pumps, Double Glazing, External Wall Insulation	205,924	62%	730.23	62%
CHP District Heating, Double Glazing, External Wall Insulation	198,120	63%	643.84	63%

Targets specified by the Local Plan (2015) for a minimum of 105 liters/person/day are shown to be achieved by the water options provided when compared to the Code for Sustainable Homes Cost Review (2008). RWH, low-flush toilets, shower heads, and taps can reduce potable water consumption to a potential of 90 liters/person/day (Appendix I: Sustainability), receiving 4/5 of the credits available for water demand retrofitting, thereby meeting pre-requisite standards of new build homes through the redevelopment strategies presented in this project.

In addition, intrinsic parts of sustainable development are social factors which are both preserved and enhanced by the options provided in this project. The solar PV co-op and SuDS offer community ownership. Through re-landscaping and preservation of green space, residents are given greater opportunities to utilize these areas, maximizing social interaction and improving quality of life. Insulation and fabric refurbishment raise comfort and wellbeing for CE residents. Alongside SuDS, these measures enhance the image of the CE, in turn increasing the residents' pride in their neighborhood.

8. Conclusions

In summary, the following key conclusions can be drawn:

- Short-term solutions provided significantly improve both quality and efficiency of energy and water supply, with a short return on investment and cost savings for residents. Consequently, highly beneficial and much needed solutions for the CE that can be provided to have an immediate effect.
- Over the course of discussions with the LLDC it was suggested that despite detailed technical solutions developed, information passed on for the Neighborhood Plan is to be restricted to limited detail so that there is more flexibility and room for changes at the inspection phase.
- For future work presenting a feasible district heating networking, it is considered essential that further research is undertaken regarding mapping of existing utility lines relative to potential connection routes connecting CHP to the CE. This is because the company responsible, ENGIE, is not expected to invest in this research.
- Retrofitting water saving appliances was shown to be more beneficial for low-rise homes, with simple measures reducing water consumption to Local Plan (2015) requirements.
- SuDS provide social and community benefits ensuring that green spaces are maintained, enhanced and are more accessible as well as providing effective surface water management.
- During community engagement it was observed that residents were more concerned with energy infrastructure relative to water infrastructure measures. This is likely due to the direct economic impact being more easily understood.

Consequently it can be shown that overall, community needs unearthed from literature and direct community exchange was accounted for in conjunction with technical feasibility, expected policy (Local Plan, 2015) cost, and sustainability to comprise the final options provided for both water and energy infrastructure. Sections 3 and 4 have been evaluated and integrated into an overall holistic design. Design margins have also been incorporated considering any long term changes to the built environment within the CE. The next step would be to further appraise these solutions in the post-concept design stage for direct inclusion within the Neighborhood Plan.

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10. Appendices

Appendix A: PMP (Project Management Plan)

Aims and Objectives

Refer to section 2.1.

Benefits

- Contribute to the wellbeing of the community
- Revitalise the local economy
- Help meet the standards of sustainable development

Client requirements

- Cheap and clean energy
- Water management strategies meeting the Neighbourhood Plan standards
- Facilities for community activities (religious activities, sports, health care, workshops)
- Improved green spaces (including food growing, outdoor sports)
- Amenities to support local businesses
- Improve existing housing

System requirements and objectives

- Assess alternative energy sources for the community (including London Legacy infrastructure and opportunities for renewables)
- Identify possible spaces for community activities make them accessible to the residents
- Seek alternative options for irrigation of the green spaces
- Improve building envelope to prevent heat losses and water ingress

SWOT analysis

The table below is a matrix describing the strengths, weaknesses, opportunities, and threats possessed by the project.

Strengths	Weaknesses
Strong community involvement in the project	Newham Council's inaction
The engineers team possesses expertise in infrastructure	Limited communication links between the engineers and the community
The team is highly motivated to take part and to progress in the project	Team members have different time schedules, difficult to arrange frequent meetings
The team has contacts to key stakeholders in the project	Time constraints of the project
	Stakeholder documents from which information is extracted do not complement each other
Opportunities	**Threats**
The project to become a part of London Legacy infrastructure	Private developers to influence Neighbourhood Plan to fit their needs
Contribute to Neighbourhood Plan (Localism Act) to meet the needs of the community	Conflict of interest between community and Newham Council
Help revitalise the area's economy	The team might not be able to provide adequate information for the plan
Improve the community's satisfaction of the neighbourhood	Unforeseen change in community's needs for the infrastructure

Project Deliverables

Refer to section 2. To be accepted and have legal power, the infrastructure plan produced has to meet the requirements stated in Localism Act 2011 for a Neighbourhood Plan (UK Parliament, 2011) Critical timeslots and milestones will be described in the project schedule.

Responsibilities and Activities

There are several roles divided within the team to ensure project progress (Table).

Role	Person appointed
Manager	Anastasia Dharma
Communications & minutes taker	David Gance
Chair at meetings	Anastasia Dharma
Planner	Ette Armstrong Lach
Mediator	Myrto Skouroupathi
Team worker	Sheng Mao
Editor	Samuel Yick

The manager's task include distributing and managing the tasks allocated within the team, as well as keeping in contact with relevant stakeholders. The minutes' taker takes minutes of any meeting that will be held between the team and relevant stakeholders. The communications person is to communicate information correctly to the team from stakeholders and vice versa, including asking and answering questions on behalf of the team when engaging with stakeholders. Chair at meetings controls the meetings between the team and stakeholders, having all necessary remarks addressed through the chair. The planner arranges all activities that need to be done in the project through the project timeline (Gantt chart), making sure that each activity is finished on time. The mediator creates a comfortable environment for the discussion, an arbitrator in a meeting or discussion, as well as helping members of the meeting to reach an agreement. The team worker does task-based jobs that contributes to the completion of the project report, whilst the editor checks and edits all written documents that will be submitted as part of the report.

On a later stage on the design of the infrastructure plan, the team will be divided into two teams to further investigate water and energy options. The teams are as follows:
Energy team: Ette Armstrong Lach, Myrto Skouroupathi, Sheng Mao
Water team: Anastasia Dharma, David Gance, Samuel Yick

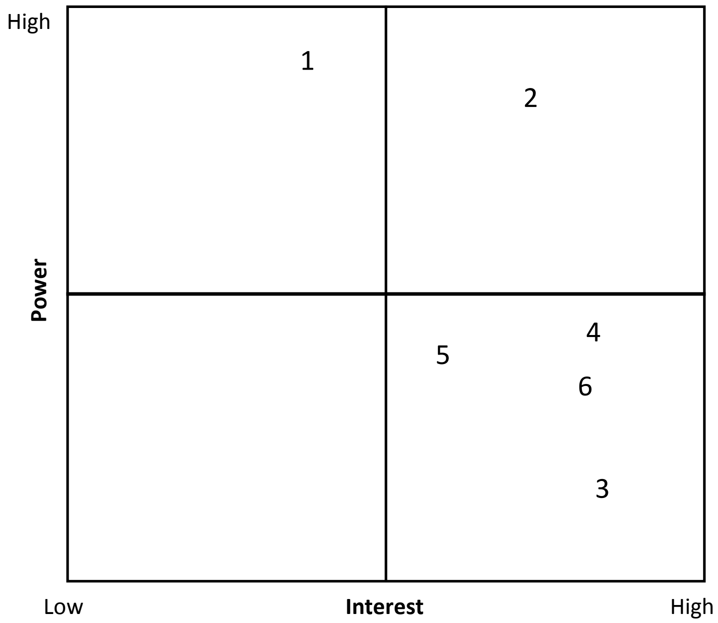
The topics assigned for each person are as follows.

Assigned member	Detailed option assessment task
Anastasia Dharma	Potable water infrastructure (for domestic use): greywater recycling, rainwater harvesting, behavioural change, retrofitting water efficient devices
David Gance	Surface water infrastructure: SUDS, groundwater runoff management
Samuel Yick	Wastewater infrastructure: blackwater recycling, greywater reuse, new water treatment plant
Ette Armstrong Lach	Demand management, retrofitting energy efficient technologies
Myrto Skouroupathi	Local energy infrastructure: solar PV, micro CHP, air source heat pumps, ground source heat pumps, anaerobic digestion
Sheng Mao	Site-wide energy infrastructure: new CHP plant, connecting to the existing CHP facility

Communications Plan

Stakeholder analysis

The stakeholders identified in this project are Greater Carpenters Neighbourhood Forum (GCNF), Carpenter's Estate (CE), Just Space, London Tenants Federation (LTF), LLDC, Newham Council, and ESD (Environmental Services Design). The figure below shows their power and interest in the project.



Key:
1: LLDC   2: Newham Council   3: GCNF & CE   4: Just Space   5: ESD   6: LTF & Trust for London

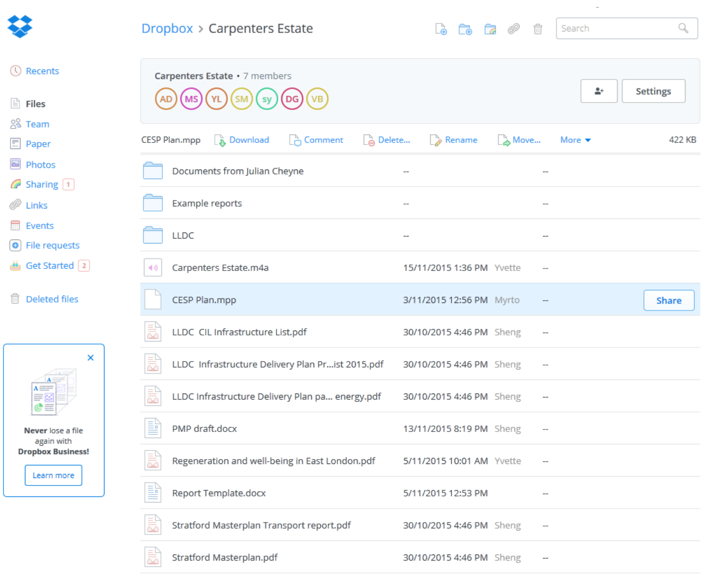
The team's clients are the GCNF and Just Space. The requirements extend to the CE community, receives the impact first hand of the regeneration project, although the community has no legal powers. For that, the Greater Carpenters forum was created, which does have more power since it is allowed to produce a Neighbourhood Plan through the Localism Act. The interest of the Greater Carpenter's is not as high as that of the Carpenter's community since it includes residents from the surrounding new developments. Just Space provide planning policy advice and act as a connector between communities and local authorities. Newham Council is a governmental institution imposing regulations onto the Greater Carpenters area, in which Carpenters Estate is located. LTF provides tenants with tools for their aspirations about their homes to be heard by local authorities. Here LLDC (London Legacy Development Corporation) is capable of bringing infrastructure change although seemingly shows little interest on the regeneration project. ESD are a building and environmental design consultancy firm that specialises in low and zero carbon advices, and energy performance and BREEAM assessments. ESD will provide technical assistance to the clients in cooperation with the UCL engineering team.

Communication plan matrix

All types, recipients, delivery methods, schedule, deliverable information, relevant stakeholders of the communication is delineated below.

Stakeholder	Deliverable info	Recipient(s)	Delivery method(s)	Schedule	Who's responsible
CE Community	Background information	Engineers team	Meeting	7 December 2015	Just Space (Richard Lee)
	Updates	Engineers team	E-mails	As needed	Community representative
	Requirements confirmation	Engineers team	Drop-in Q&A session	16 February 2016	Community representative
	Progress	Community	E-mails	As needed	Engineers team
	Plan appraisal	Community	Community forum	To be confirmed	Engineers team
LLDC	Exchange of information of the area's infrastructure plan	Engineers team, LLDC	Meeting, e-mails	24 February 2016	LLDC representative, engineers team
LTF	Information extraction	Engineers team	Meeting, calls, e-mails, and surveys	January-February 2016	LTF representative, Anastasia Dharma
Vera Bukachi	Updates	Engineers team	E-mails, meetings	Weekly	Vera Bukachi, Anastasia Dharma
Engineers team	Updates	Community, Vera Bukachi	E-mails, meetings	As needed	Anastasia Dharma
	Plan appraisal	Community	Meeting	29 February 2016	Community representative, Anastasia Dharma
	Further requirements confirmation	Engineers team	Surveys, questionnaires, or interviews	25 February 2016	Engineers team
Just Space	Background information	Engineers team	Meeting	Session completed	Anastasia Dharma, Just Space
Newham Council	Information extraction	Engineers team	Meeting	To be confirmed	Engineers team

Within the team, communication and information exchange is done through social media (e.g. Facebook), data cloud (i.e. Dropbox), instant messaging platform (i.e. Whatsapp), e-mails, and calls (see below). All communication within the engineers team is done as needed.



The list of meetings, formal and informal, carried out in the project is as follows.

Meeting with	When	What was discussed
GCNF	7 December 2015	GCNF consultation with the LLDC, team introduction and project communication to the forum (i.e. what would the project imply to the Neighbourhood Plan and what steps will be taken within the project timeline to support the Plan), stakeholder identification
Some of the Estate tenants and ESD	6 January 2016	Technical aid from ESD, hearing what the residents would like in terms of refurbishment and energy infrastructure. ESD became an additional stakeholder in the project.
LTF	5 February 2016	Update on UCL Engineering team's work so far
Repowering London (Agamemnon)	10 February 2016	Energy infrastructure options technical consultation
Just Space	15 February 2016	Update on UCL Engineering team's work so far
LLDC	24 February 2016	Energy infrastructure options planning consultation

Risk Management

All the risks identified for this project are not of physical nature as the scope ends before any actual building works, as below. The key to the table can be find below the risk management table.

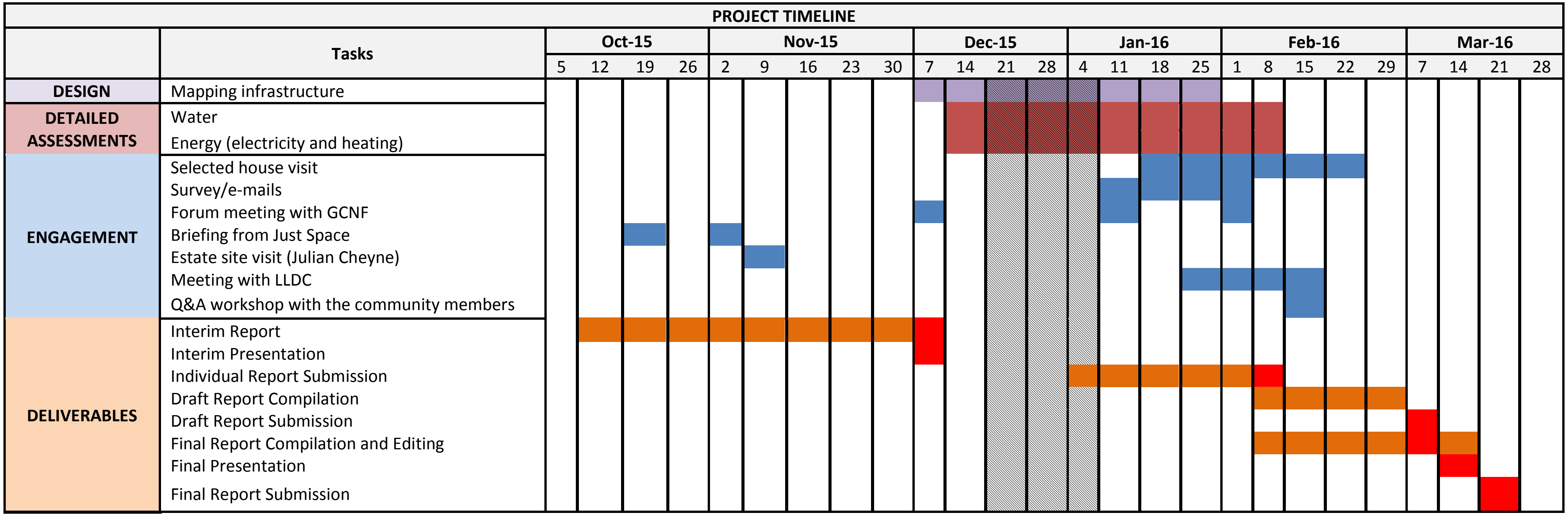
Activity	Hazard	Risk			Measures	Residual Risk		
		S	L	T		S	L	T
Communication with community	Misunderstandings with community.	3	3	9	Communicate through Richard and make scope clear from the beginning.	3	1	3
Communication with community	Imprecise about community's needs due to late meeting with them.	4	3	12	Communicate through Richard and Julian about current concerns.	4	2	8
Communication with community	Imprecise about community's needs due to lack of representatives from different teams within the community.	4	3	12	Conduct interviews, questionnaires or/and surveys (during and outside forum times).	4	2	8
Presentation of produced plan	Dissatisfaction of members of community.	3	3	9	Consult with community about different options.	3	2	6
Internal communication	Miscommunication within the team.	4	3	12	Share all information with all team members through communication platforms.	4	1	4
Internal communication	Conflicts within the team.	4	2	8	Discuss disagreements openly. If not possible, discuss with mediator.	4	1	4
Understanding of context	Biased information due to close contact with community.	3	3	9	Meet other stakeholders such as LLDC and Newham Council.	3	2	3
Unexpected change of scope	Configuration of the project focus, requiring changes in aspects of the project.	5	3	15	Consult with supervisor and main clients.	3	3	9
Additional stakeholder involvement throughout the timeline	Adjustment or change of the project deliverables.	3	3	9	Better communication between the stakeholders.	1	3	3

Severity (S) \ Likelihood (L)	0	1	2	3	4	5
5	0	5	10	15	20	26
4	0	4	8	12	16	20
3	0	3	6	9	12	15
2	0	2	4	6	8	10
1	0	1	2	3	4	5
0	0	0	0	0	0	0

Severity	Likelihood
0 = No effect	0 = Very low
1 = Minimal conflict	1 = Very unlikely
2 = Minor conflict/delay	2 = Unlikely
3 = Moderate conflict/delay	3 = Likely
4 = Major conflict/delay	4 = Very likely
5 = Failure to meet requirements/ deadline	5 = Almost certain

Project Schedule

PROJECT DETAILS	
Project Title	Carpenters Estate Regeneration Project
Project Team	Anastasia Dharma, Myrto Skouroupathi, Ette Armstrong Lach, David Gance, Sheng Mao, Samuel Yick
Start / End Date	19 October 2015/24 March 2016



Key: **Deadline**
Christmas Break

Initially, a meeting with Newham Council was planned. However the situation within the project timeline did not support this politically, as it was foreseen that it would make the relationship between the project client and the council even more volatile apart from restricted timescale. Concept design of the project was not achieved, although planned, as the project team realised that there would not be a single option only, i.e. there needs to be several options that are holistically integrated within the strategies.

Appendix B: Sample answered survey

only 4 living   6 in flat

The Engineering Exchange   UCL ENGINEERING Change the world

Dear residents,

This survey is conducted as part of a project undertaken by UCL Masters students in order to present the Carpenters Estate Community, hence the Greater Carpenters Neighbourhood Forum, with regeneration options for both water and energy infrastructure, with regeneration options for both water and energy infrastructure. The project undertaken involves Just Space and UCL Engineering Exchange.

The feedback from this survey will help to create water and energy infrastructure solutions that can best benefit the Carpenters Community and current residents. Providing an opportunity to raise any concerns about the current state of the low-rise / high-rise flats. Any suggestions are useful and will be taken into consideration within the final design.

Leaseholder

1. How many people live in your household? 2
2. What type of housing is your residence (e.g. flat, detached house)? Flat
3. How many bedrooms does your home have? 3
4. How long have you been living in your current residence? 33 Years 9 Months
5. How old are the occupants and what is the gender of each occupant? 74 yrs V 55 yrs
6. How many are in school and how many are in work? For those who are in work, what are the work times? None

Heating and electricity

7. How do you heat your water?
   - ☐ Gas
   - ☑ Electricity
8. If by gas, do you know what year was the boiler installed?
9. How do you heat your house?
   - ☐ Gas
   - ☑ Electricity
10. If by gas, do you know what year was the boiler installed?
11. If by electricity, what device do you use (e.g. radiator, air conditioner, heated floors)? Germany ... Electric heaters
12. Do you have a heating control (e.g. thermostat, smart meter)? No
13. How warm do you keep your home in the winter?
    - ☐ About 22°C
    - ☐ About 21°C
    - ☐ About 19°C
    - ☑ 17°C or less

CESP/Carp/H

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14. How long do you have your heating on for per day? If your heating is based on a certain tariff, what is it?
.......Timer is on from 1[illegible]:30pm to 6:30am. We do not have control.

15. What is your wall type (e.g. brick wall, insulated brick wall, solid stone wall, insulated stone wall)?
.......Brick.......

16. How many times in the last year have you experienced a power cut? Do you know the reason why? If yes, what was the reason?
.......No.......
....

17. When was the last time you 'switched' your electricity / heating supplier?
.......Done by Newham last year - not sure.......

18. How much is your heating and electricity bill? Is the bill per month or per quarter year?
.......This is included in Maintenance charge & we have two meters - one for our use of electricity & other for heating & hot water.

Water

19. How many people use the shower in your household? How long do they use it for on average per week?
.......2 people every day.......

20. How many people use the bath in your household? How long do they use it for on average per week?
.......—.......

21. How many times a day do you wash your dishes? If you wash by hand, how long do you take to wash them?
.......Hand wash every day.......

22. How many times a week do you do your laundry?
.......Once or twice a week depending on needs

23. At what temperature do you set your washing machine?
- [x] 30°C
- [ ] 40°C
- [ ] 60°C
- [ ] 90°C

24. What is the energy rating of your washing machine?
- [ ] A+
- [ ] A
- [ ] B or below
- [x] I don't know

25. Do you fully load your washing machine every time?
.......Almost.......

26. Is your toilet dual flush? (A dual flush toilet is a variation of the flush toilet that uses two buttons or handles to flush different levels of water).
.......No.......

27. What kind of shower do you have?
- [ ] Power
- [ ] Standard mixer
- [ ] Electric
- [x] None

28. If you don't have electric shower, do you have a low flow or eco shower head?
.......No.......

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29. Do you use a toilet displacement device (e.g. water hippo)

No

30. If you have a garden, do you use a hose to water it?

—

31. If you have a water tank, how do you fill it up?

—

32. Do you use it for watering your garden?

—

33. Have you ever experienced bad water quality or intermittent service? How frequent is it in a year?

Yes, colour was almost orange [illegible] has now looked at

34. Does your home have a water meter? Do you think it helps reduce your water consumption?

No

35. How much is your water bill? Is the bill per month or per quarter year?

£30/year

Your comments

36. Is there any other detail that you think might be helpful to this assessment?

To have the timescale of development and more information. Our lives are at standstill at the moment not knowing what's happening.

37. Would you like to be more involved in the completion of the Neighbourhood Plan or this particular project in general?

Yes, I'm already involved.

38. There will be a Q&A session about the progression of infrastructure regeneration options in February. If you would like to be contacted about this, please leave your contact details below.

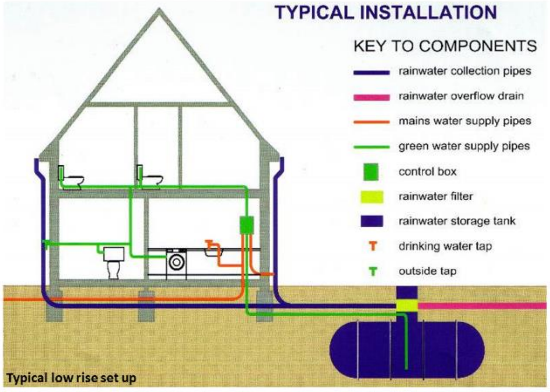
[illegible]@hotmail.com

Thank you for the time taken to complete this survey. Please do not hesitate to send us further questions or comments to Anastasia Dharma (anastasia.dharma.11@ucl.ac.uk) or to Janiz Murray (greatercarpentersforum@gmail.com).

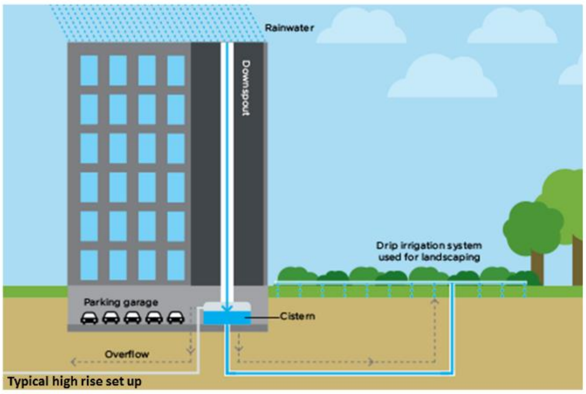
CESP/Carp/H

Appendix C: Drop-in Q&A session posters

Rainwater harvesting



Typical low rise set up



Typical high rise set up

What is it?

Collecting rainwater from roofs, which will be treated and stored for use later on.

What does this mean to you?

- Annual water bill saving of around £208.8 per household, return on investment after 12-16 years.
- Possible for domestic non-potable use, i.e. flushing.
- Possible for irrigation use for the Carpenter's Estate green spaces, play grounds, community gardening, etc.
- Low risk for the environment in its operation.

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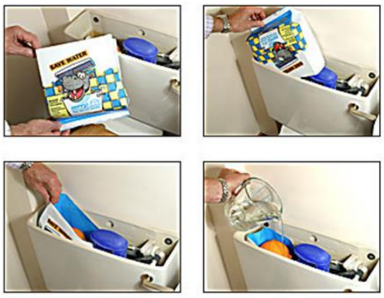
Retrofitting water-efficient devices in your homes



Installing water hippo

Dual flush toilet

Low-flow shower heads

Save-a-flush

What is it?

They are devices/add-ons that can help reduce your water use. Currently, almost all homes in the Estate do not have these.

What does this mean to you?

You can save money from your water bill by investing very little amount to these devices. This is **approximately** how much bill you can save annually.

Occupancy \ Option	Water-efficient showerheads	Save-a-flush
Single	£11	£5
Couple	£23	£9
A family of four	£45	£18

Source: Thames Water

Most homes in the Estate do not use water-efficient toilets. You can also save up to 40% of annual bill if using these toilets.

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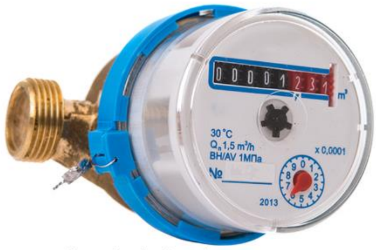
Water meters

FlexNet type smart water meter

Homerider type smart water meter



Conventional water meter

Shower timer

What are they?

They are devices that logs your water use. Smart meters log automatically in certain time intervals with the help of wireless telecommunication network. Currently, none of the homes in the Estate use them. It is **more suitable for low-rise homes**.

What does this mean to you?

These meters are available from Thames Water free of charge. This aims to make you aware of your water usage and improve your consumption pattern. This is **approximately** how much you can save annually.

Option / Occupancy	Reducing shower time by 1 minute/day	Reducing hot tap water use by 2 minutes/day
Single	£6	£9
Couple	£12	£18
A family of four	£24	£36

Source: Thames Water

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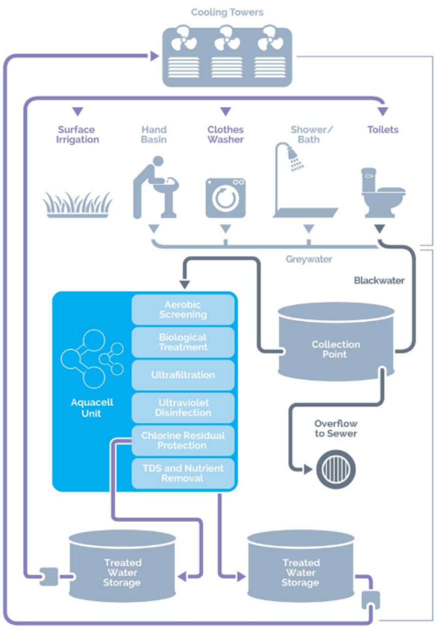
Wastewater Recycling (Black and Greywater)



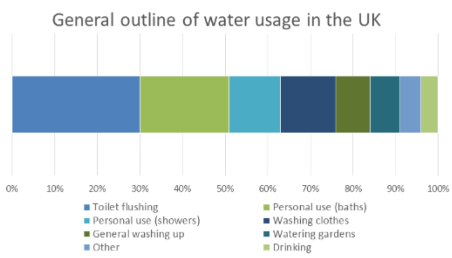
What is it?

When the toilet is flushed, sinks are being emptied, water from the bath, all this used water is known as wastewater. And these waste water can separated into two groups.

- *Blackwater – from toilet or urinal, and sinks containing food particles*
- *Greywater – from showers, washing machines, dish washers*

Why recycle these so called 'dirty water'?

- Water shortage and droughts
- No clean water needed to flush the toilets
- Only a small amount of water is actually used for drinking
- Reduce the Estate's dependence on supply from mains, saving money from annual bills



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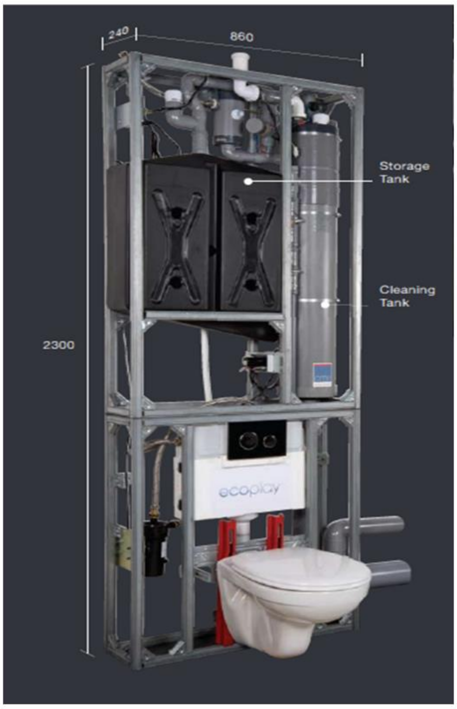
Greywater Recycling through Ecoplay



What is it?

Ecoplay is a simple water recycling system which takes water from baths and shower, and uses that water to flush the toilet. It works just like a normal toilet.

What does this mean to you?

- You can reduce the water used for flushing from the main connection. Therefore residents of the Estate can save money.
- Environmentally friendly, better reputation for the Estate as a whole.
- One off initial cost and very little maintenance is required.

Problems

- Might require additional piping if were to be retrofitted.
- Additional pumps for when bath and toilet is on the same level.

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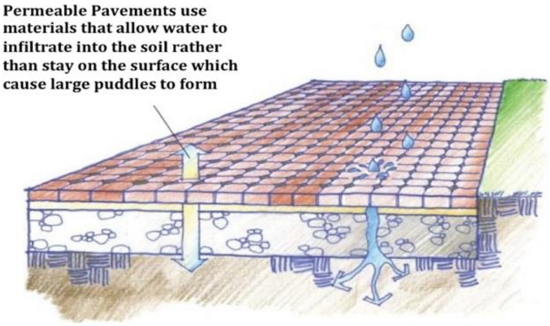
Sustainable Urban Drainage Systems (SUDS)

This is an example of a 'detention basin,' that can be used in a similar way on the Carpenter's Estate. Landscaped so that in times of heavy rainfall, water is collected in this area. Most of the time it is an inviting public space for Carpenter's Estate residents.

Permeable Pavements use materials that allow water to infiltrate into the soil rather than stay on the surface which cause large puddles to form



What are they?

SUDS are natural solutions to manage water runoff from rainfall, preventing flooding on the streets of the Carpenter's Estate whilst recycling water back into the environment.

These measures ensure that the green space within the estate remains and re-landscaped in a way that prevents drains from overflowing during periods of sustained bad weather.

What are the reasons?

- To stop drains and sewers from overflowing at any time.
- To reduce the local puddles formed on concreted surfaces such as roads pavements and walkways.
- To use natural vegetation to create a route for rainfall to travel to drainage points.

What does this mean to you?

More green areas and trees, mostly next to road surfaces.

Replacing pavements, front terraces and car-parks with material that allows water to infiltrate.

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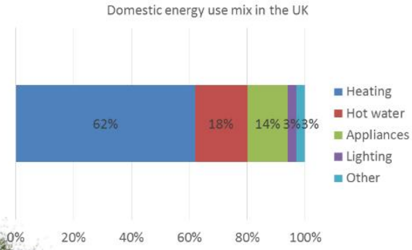
Reducing Energy Demand

Typical low energy loss in uninsulated home



What is it?

Reducing the amount of energy used on the Carpenter's Estate helps reduce energy bill and leads to more efficient and sustainable homes. It would also allow for realistic exploration into alternative energy supply.

What does this mean to you?

- Various options – High tech and low tech – from energy saving light bulbs to insulation
- Short and long term solutions
- Significant cost saving achievable – 40% reduction in CO_2 emissions and energy bills

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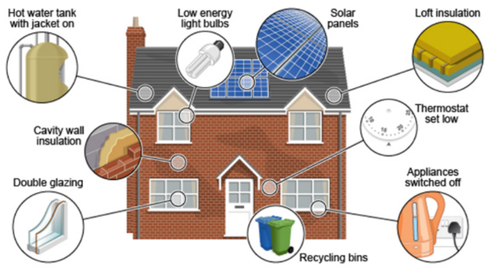
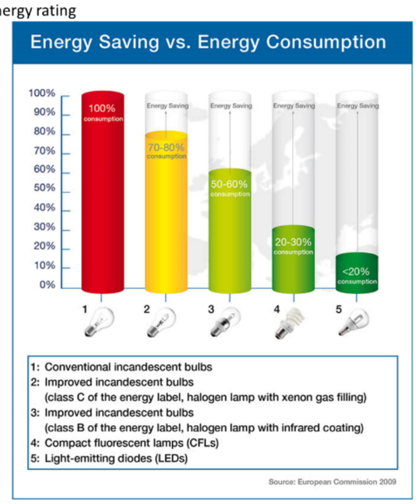
Energy Saving Technologies



Key expected benefits:

- Able to install individually or estate-wide
- Potential energy saving of £453 per year through reducing heat loss (low-rise and terraced)
- 1600 Kg of CO_2 saved up every year per household on insulation alone
- Electricity bill savings and potential eligibility for the Feed-in Tariff
- Around £170 saving per light bulb over 25,000 hours (including bulb cost) by switching
- When next switching an appliance such as a fridge a saving of around £90 could be achieved with a better energy rating



What is it?

A range of cost effective technologies can be easily installed around the home to reduce energy use.

What does this mean to you?

Any of these equipment can be used in any other the building types on Carpenter's Estate.

Some can be installed by individual tenants at little cost or expertise required.

Some methods such as insulation may need specialists but can be organised estate-wide to reduce cost.

Options…

- Energy efficient appliances
- Energy saving light bulbs
- Smart meters
- Thermal measures
- Fittings
- Behavioral changes

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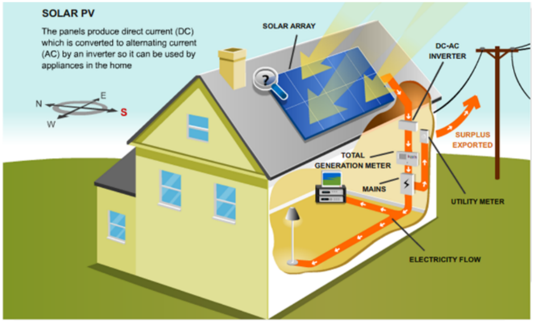
Solar photovoltaics (PV)



What is it?

Solar panels are devices that convert sunlight to electricity.

What does this mean to you?

You can produce electricity to use and sell the excess to the grid.

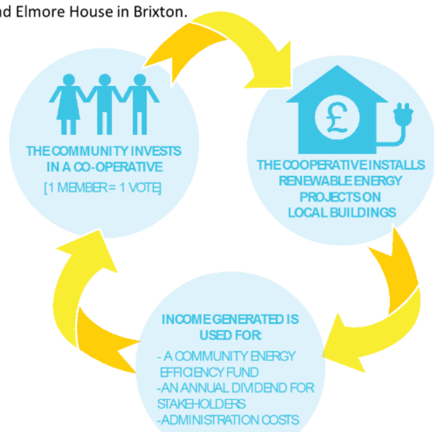
The model used establishes a co-op where all energy produced goes through the same utility meter and the electricity and benefits are shared amongst all members of the co-op.

The panels can be installed on flat roofs or roofs with tilt facing east to west through south (see image above), but all members of the co-op will benefit from the system (through community ownership).

Key expected benefits:

- 1MWp installation
- 455 tonnes of CO2 saved up every year
- Electricity bill savings and potential eligibility for the Feed-in Tariff
- Internship programme for youth to boost employability*
- Workshops and training sessions on energy efficiency and solar* technology*
- Co-op directors are members of the community

*These benefits are based on the services offered by the NGO Repowering London. Communities already benefited by the service include Banister House in Hackney, and Roupell Park and Elmore House in Brixton.



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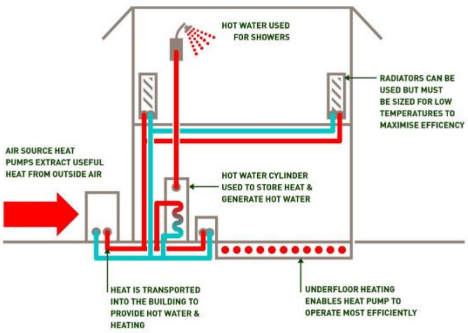
Air source heat pumps



What is it?

Air source heat pumps are systems that transfer heat from the outside air to inside the house. They can heat up the space and water for the taps and showers.

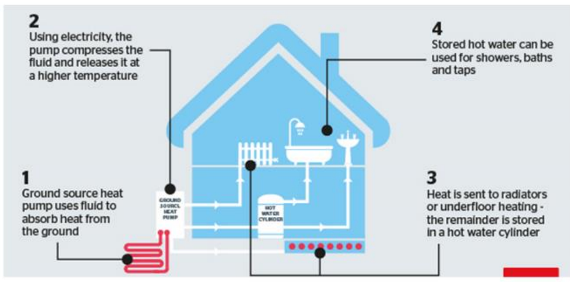
What does this mean to you?

You can produce warm water for direct use or heating for your house at a very efficient rate. Heat pumps produce 3 units of heat for every unit of electricity burned. The unit can be installed on the roof, thus it is ideal for high-rise buildings. Similar projects are Hinkler Place social housing community regeneration and Hunters Gate affordable housing in Cheshire.

Key expected benefits:

- £250(replacing gas)- £1250(replacing electricity)/year savings
- 7.42p RHI Tariff per KWh
- Annual CO_2 are from 1,600kg CO_2 (replacing gas) to 11,400kg CO_2 (replacing electricity

Ground source heat pumps (low-rise)



What is it?

Ground source heat pumps are systems that transfer heat from under ground to inside the house. They can heat up the space and water for the taps and showers.

What does this mean to you?

You can produce warm water for direct use or heating for your house at a very efficient rate. Heat pumps produce 3 units of heat for every unit of electricity burned. To install, access to your yard is required for the machinery. The actual borehole is only 150mm in diameter.

Key expected benefits:

- £400- £595/year savings (replacing gas)
- 19.10p RHI Tariff per KWh
- 2,000kg-3000kg CO_2 (replacing gas)

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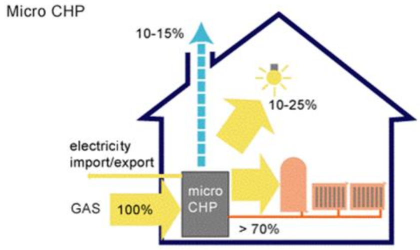
Micro CHP(low-rise)



What is it?

A micro combined heat and power (CHP) unit works in the same way as a gas boiler but produces both heat and electricity and thus is more efficient.

What does this mean to you?

You can produce both heat and electricity using gas. Electricity is a by-product, thus it is only produced when the heating is on. The system is the same size as a conventional boiler, therefore no more room is needed.

Key expected benefits:

• Electricity bill savings
• Eligible for Feed-in Tariff (rates not yet announced)
• 5% carbon savings

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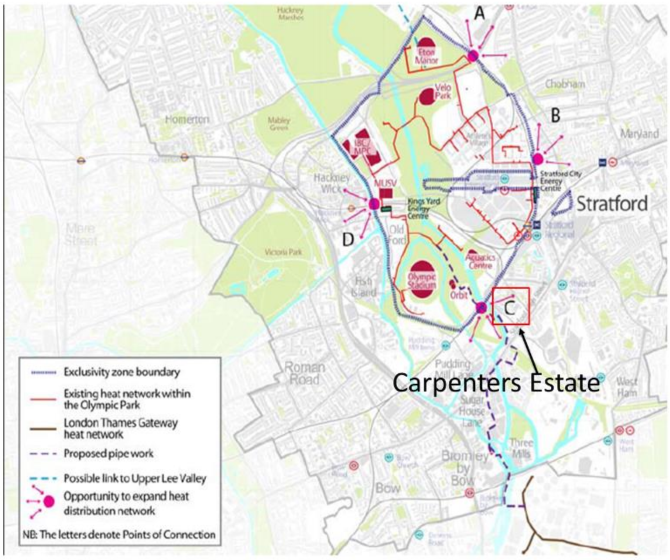
District Heating

CHP connection



What is it?

Using the existing CHP near the Carpenter's Estate which is owned by company COFDLY to provide heat to the Carpenters Estate (lower capital cost compared with building a new CHP). The existing connection point C has already been built, and Point C is only around 2 km away from the community.

Key expected benefits:

1. The main source of the energy center is from biomass which is from woodchip boiler plant, which means more sustainability (reduce 30% carbon emission compared to conventional generation process.)
2. Lower heating cost compared with conventional gas boiler (saving around 20% of their energy costs).
3. Existing power plant means no need for building a new plant.

Community interview feedback

Energy with low cost and carbon emissions could be acceptable.

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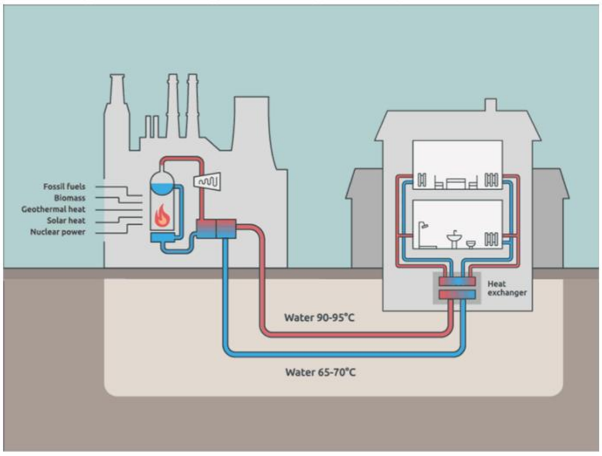
District Heating

Building a new combined heat and power plant (CHP)



What is it?

District heating is a system for distributing heat generated in a centralized location for residential and commercial heating requirements.

What does this mean to you?

1. A new CHP will be built near the Carpenters Estate
2. Lower heating cost compared with conventional gas boiler.
3. Heating and warm water can be supplied in 24 hours.

Key expected benefits:

1. It is simple to operate the heating in house
2. The District Heating system can provides warm water for whole day, there will be plant of warm water for washing and showering, moreover, warm water can arrive quickly at the tap point at all times.
3. Few energy leakage during transmission.
4. Energy Cost is low, district heating can contribute to reducing fuel poverty carbon emissions.

	District Heating	Gas Heating	Electric Heating
Price (p/kwh)	5.51-14.94	9.55-11.60	21.-22.99

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Appendix D: Sample answered options feedback forms

76 Gibbins Rd.

Questionnaire for tenants and residents of the Carpenters Estate on heating, energy savings and benefits and water – as part of getting your views on options for refurbishment and evidence for the Greater Carpenters Neighbourhood Plan

Energy infrastructure options

Option	What is it?	Key benefits	Please indicate which of these you think would be best for you and the estate. Tick the bullet points you support and/ or make comments in boxes below.
Reducing Energy Demand	A number of things could be done to reducing energy demand in households on the Carpenters Estate. The main thing here is better home insulation.	• 40% CO_2 reduction. • Saving on energy bills. where there is need ✓	How is it including from gov scheme. Think that homes have many
Energy Saving Technologies	A range of cost effective technologies like smart meters, energy saving lamps and energy efficient appliances could be installed.	• Electricity bill savings of up to of £453 per year. • This is a short term solution.	+ cavity wall filled. ← Not sure about the benefits
Solar Photovoltaics (PV)	Solar panels could be installed on the roofs which produce electricity from sunlight. A community based co-operative could be set up and everyone could benefit.	• Electricity bill savings and potential eligibility for Feed-in Tariff. • Internship programme for local young people could help them to gain employment. • Training and workshops. • Co-op run by the community. • Monetary returns on investment.	Needs further investigation → but possibly.
Micro Combined Heat and power (CHP)	This works in the same way as a gas boiler but produces both heat and electricity at the same time, reducing the losses	• Electricity bill savings. • Eligibility for Feed-in Tariff. • 5% carbon savings. ?	– is there a capital outlay in terms of wiring etc. Could this be done with existing wiring / pipe work
Air Source Heat Pumps	This is a system which transfers heat from the outside air to inside the house. This can heat up the space and water for taps and showers.	• Savings of ***approximately*** £250 (replacing gas) and £1250 (replacing electricity)/year savings. ? • 7.42p Tariff per KWh. ✓	This could be massive → in terms of works required & costings.

More detail! ✓ Numbers sound very good. →

(in terms of — [illegible] Formal [illegible] required

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	It works for outside temperatures of as low as -5 degrees. Uses electricity very efficiently.	• Annual CO_2 savings are from 1,600kg CO_2 (replacing gas) to 11,400kg CO_2 (replacing electricity)	
Ground Source Heat Pumps (for low-rise)	These are systems that transfer heat from underground to inside the house and can heat up the space and water for taps and showers. This works for very low temperatures and is very efficient.	• *Approximately* £400- £595/year savings (replacing gas) • 19.10p Tariff per KWh • 2,000kg-3000kg CO_2 (replacing gas)	✓ Sounds good in principle but same questions as above.
District Heating	Distribution of heat generated in a centralised location owned by COFELY for resident and businesses heating requirements.	• Simple to operate in households • Works 24/7 • 20% savings compared to gas	? Is this water based. What is the capital costs - for homeowners. ? could this cause problems [illegible] leaks

Water Infrastructure options

Option	What is it?	Key benefits	Please indicate which of these you think would be best for you and the estate. Tick the bullet points you support and/ or make comments in boxes below.
Rainwater Harvesting	Collecting rainwater from roofs, which will be treated and stored to be reused. The system contains a storage, pumping, and purification unit. Soak aways?	• Harvested rainwater can be reused for irrigation for green space in the Estate or flushing toilets. • For low rises, this can be done as simply as catching water runoff from gutters into a bucket. • Annual water bill savings could be **approximately** £208.8 per household if used entirely for flushing. • Helps reduce demands from mains. • Low impact to the environment. • This is a short term solution.	Is this self contained or collective → redirection of water - new pipes etc? Capital costs again? Maintenance?

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	It works for outside temperatures of as low as -5 degrees. Uses electricity very efficiently.	• Annual CO_2 savings are from 1,600kg CO_2 (replacing gas) to 11,400kg CO_2 (replacing electricity)	
Ground Source Heat Pumps (for low-rise)	These are systems that transfer heat from underground to inside the house and can heat up the space and water for taps and showers. This works for very low temperatures and is very efficient.	• ***Approximately*** £400- £595/year savings (replacing gas) • 19.10p Tariff per KWh • 2,000kg-3000kg CO_2 (replacing gas)	✓ Sounds good in principle but same questions as above.
District Heating	Distribution of heat generated in a centralised location owned by COFELY for resident and businesses heating requirements.	• Simple to operate in households • Works 24/7 • 20% savings compared to gas	? is this water based? What is the capital costs - for homeowners? ? could this cause problems ... leaks

Water Infrastructure options

Option	What is it?	Key benefits	**Please indicate which of these you think would be best for you and the estate. Tick the bullet points you support and/ or make comments in boxes below.**
Rainwater Harvesting	Collecting rainwater from roofs, which will be treated and stored to be reused. The system contains a storage, pumping, and purification unit. Soak aways?	• Harvested rainwater can be reused for irrigation for green space in the Estate or flushing toilets. • For low rises, this can be done as simply as catching water runoff from gutters into a bucket. • Annual water bill savings could be ***approximately*** £208.8 per household if used entirely for flushing. • Helps reduce demands from mains. • Low impact to the environment. • This is a short term solution.	Is this self contained or collective? → redirection of water - new pipes etc? Capital costs again? Maintenance?

Appendix E: Client summary

Introduction

Since 2005, the number of residents in the Carpenter's Estate (CE) have decreased significantly due to relocation by Newham Council. This has led to the deterioration of the neighbourhood both in terms of community kinship and infrastructure, with residents expressing widespread dissatisfaction as stated in the Community Plan (2013). For this reason, the UCL Engineering team have carried out assessments for water and energy options alongside open forums, discussions and surveys with CE residents. This has meant that community aspirations and aims for the future state of their homes and neighbourhood can be included in this project and in the Neighbourhood Plan.

Stakeholders

The main client is Greater Carpenters Neighbourhood Forum (GCNF) that extends their requirements for infrastructure improvement of the CE to the UCL Engineering team. The main sponsor of the project is Just Space. GCNF and Just Space intend for refurbishment to occur for the CE. Other stakeholders include London Tenants Federation (LTF), London Legacy Corporation (LLDC), Environmental Services Design Ltd (ESD) and Newham Council. LTF provides tenants with tools for their aspirations about their homes to be heard by local authorities. Here LLDC (London Legacy Development Corporation) is capable of bringing infrastructure change although seemingly shows little interest on the regeneration project. ESD will work together with the UCL Engineering team to provide technical expertise in the regeneration option assessments.

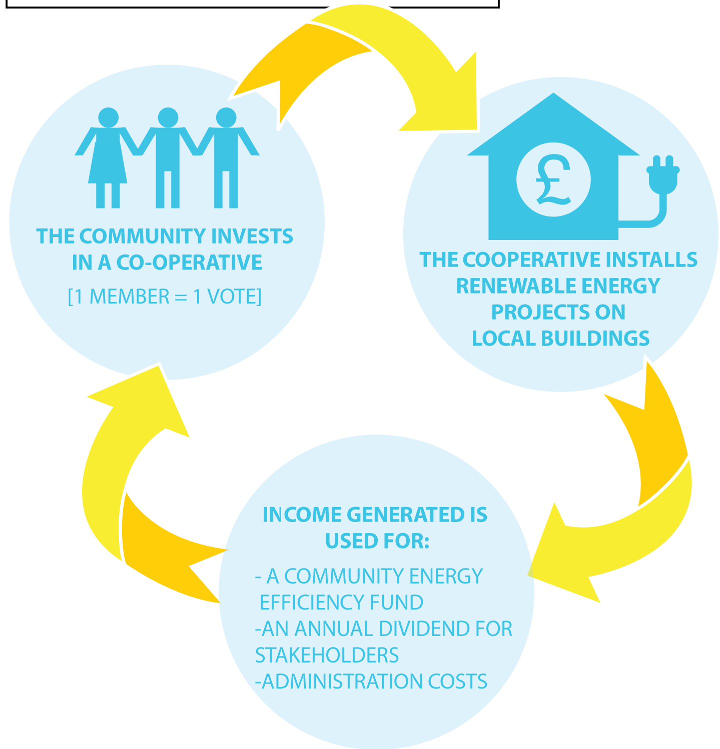
Infrastructure regeneration options

In this project, only water and energy infrastructure options are considered in the tables below (1 & 2). These options are presented in the form of short, medium, and long term strategies. All the options have been assessed in terms of technical feasibility, cost, sustainability, and community acceptability.

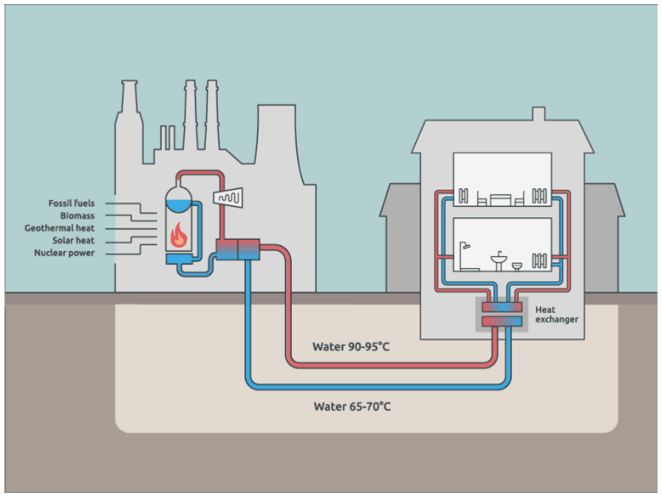
Table 1. Energy options

Option	What is it?
Reducing Energy Demand	Various strategies in Reduction of energy demand in the Carpenters Estate to be implemented. Main one is insulation.
Energy Saving Technologies	A range of cost effective technologies like smart meters, energy saving lamps and energy efficient appliances
Solar Photovoltaics (PV)	Solar panels to be installed on roofs which produce electricity from sunlight. A co-operative is set up by the community and everyone can benefit.
Micro Combined Heat and power (CHP)	Works in the same way as a gas boiler but produces both heat and electricity at the same time, reducing the losses
Air Source Heat Pumps	This is a system which transfers heat from the outside air to inside the house. This can heat up the space and water for taps and showers. It works for outside temperatures of as low as -5 degrees. Uses electricity very efficiently.
Ground Source Heat Pumps (for low-rise)	These are systems that transfer heat from underground to inside the house and can heat up the space and water for taps and showers. Works for very low temperatures and is very efficient.
District Heating	Distribution of heat generated in a centralised location owned by COFELY for residential and commercial heating requirements.

Solar PV Co-op model



Combined Heat and Power



Air-source Heat Pump

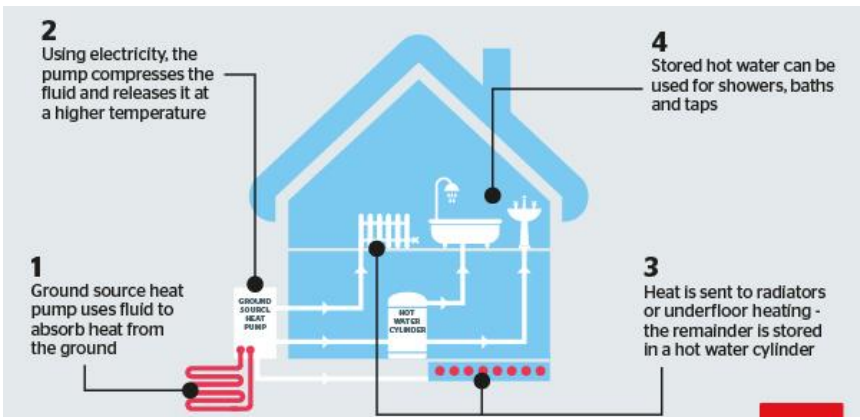
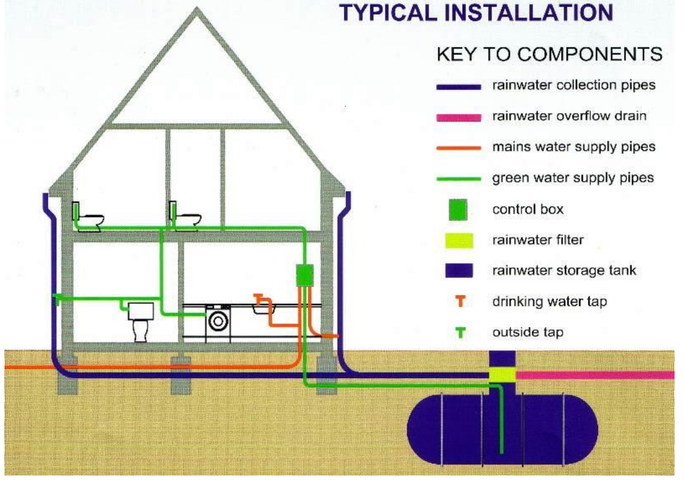


Table 2. Water options

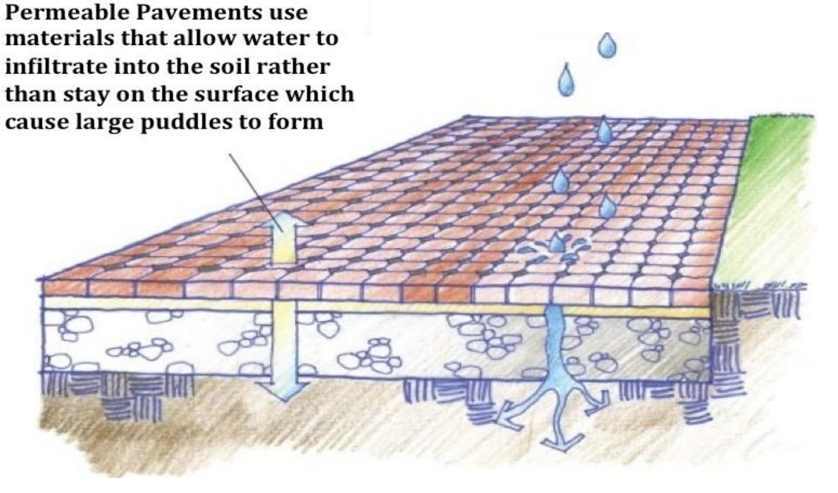
Option	What is it?
Rainwater Harvesting	Collecting rainwater from roofs, which will be treated and stored to be reused. The system contains a storage, pumping, and purification unit.
Retrofitting water-efficient devices in homes	Devices/add-ons which can be easily implemented. They are based on one-off installation. Currently, they are more suitable for low-rise homes.
Sustainable Urban Drainage Systems	Green space landscaped in such a way that prevents drains from overflowing during heavy rainfall. It also helps replenish ground water sources.
Water meter	Devices that logs your water use. Smart meters log automatically with the help of internet connection, whilst conventional meters must be read manually. Hence, smart meter readings are more accurate. It aims to help raise awareness of your consumption behaviour. They are ***free to install*** by Thames Water.

Water efficient device for toilets

Rainwater collection design



Replacing hard surfaces



Community participation

A number of forum meetings, surveys, and visits were carried out to involve the residents in the planning stages of the CE regeneration. There was a drop-in Q&A session for the residents to consult with the UCL Engineering team. This was further followed up by feedback from the residents to the UCL Engineering team to determine whether the options provided were accepted or rejected.

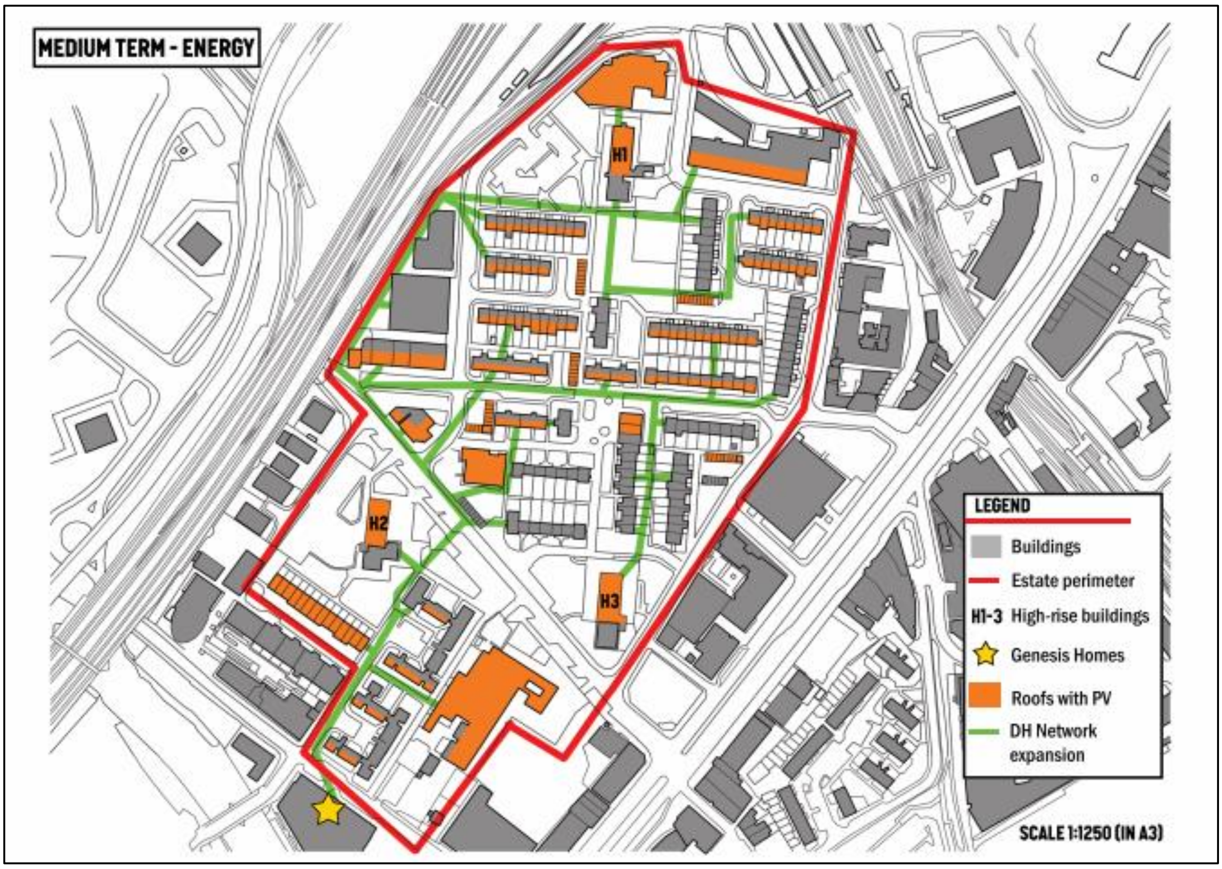
Table 3 lists all the best possible options for the estate subject to the residents' responses, with associated benefits.

Table 3. Water and energy options

Strategy	Infrastructure	Option	Cost	Bill saving	Carbon emission saving
Short term	Energy	Energy efficient appliances, lighting and fittings	£300+/unit for refrigerators, £225+/unit for washing machines	£34.02/year	
		Storage heaters	£700/unit	£200/year	
		Cavity wall insulation for low rise homes	Terraced houses: £370/house; low rise houses: £330/house		
		Boiler replacement with efficient technologies	£2.6 million/scheme		1,500kg CO_2/unit/year
		Energy meters and behavioural change		2-3% reduction in energy	
Medium term		Solar photovoltaics	£1.4 million/scheme		455 tones /year
		Insulation for high rise homes			
		Combined heat and power plant	£3.2 million/scheme		Reduce the CO_2 emissions by 60% compared to conventional gas boilers
		Heat pumps	Air source: £6,000-10,000/unit; ground source: £13,000/installation		Air source: 11,400kg CO_2/year (replacing electric storage heaters); ground source: 2,000kg CO_2/year

Short term	Water	Simple rainwater harvesting system	£100-300/unit	£25.2/year	1,433kg CO_2/year
		Water displacement devices	£2-3.50/unit	£6/year	Depends on carbon intensity of the mains
		Water efficient toilets (e.g. dual flush)	£300/unit	£54/year	
		Low flow showerheads	£30/unit	£187/year	
Medium term		Intermediate rainwater harvesting system	£2,000-3,000/unit	At least £108/year	1,433kg CO_2/year
		Sustainable urban Drainage Systems and Permeable Pavements	£295,000		Alleviates strain on existing drainage infrastructure, minimising flood risk whilst maximising green space and enhancing biodiversity across the CE.

The strategies are integrated to create a holistic solution. The short term strategies are mostly options that take place in domestic scale, therefore how they integrate cannot be shown. See Figure 1 for the integration of medium term strategies of water and energy infrastructures.



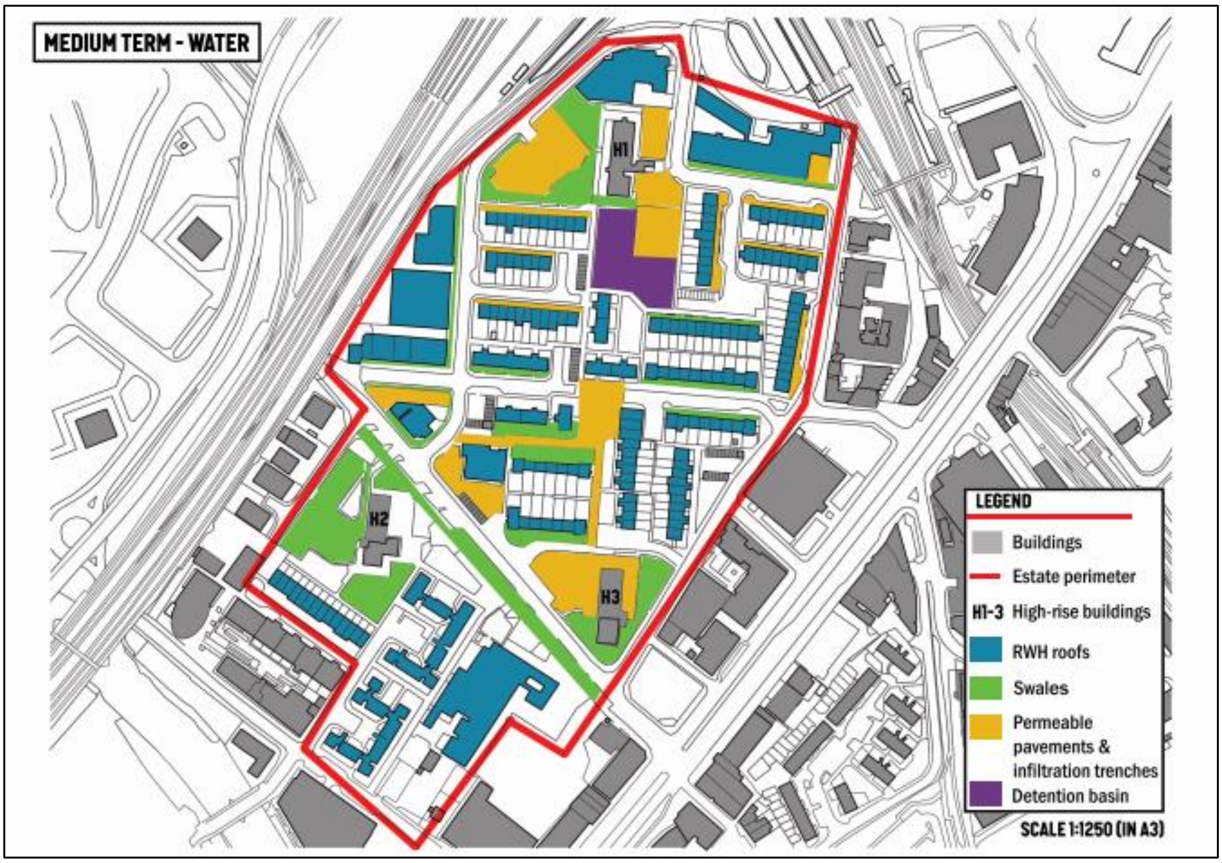


Figure 1. Energy and water medium term options integration

Benefits

Overall, it is important to note that for the water and energy options provided, cost and sustainability is more favourable for redevelopment of existing infrastructure rather than demolition of the CE. In addition, the benefits of the strategies provided this project can be divided into economic, environmental and social.

Economic benefits include:

- Less money is spent on average per home for retrofitting measures than for demolition and new build of same size homes.
- Cost savings on utilities can be received by residents both in the short and long term.
- Opportunity cost of demolition does not feature in this project.
- No loss felt by local businesses for the redevelopment options when compared with demolition.

Environmental benefits include:

- Retrofitting water and energy infrastructure options provided in this report have lower carbon emissions throughout their lifecycle when compared with demolition and new build.
- Green space is kept and increased across the CE, improving biodiversity, air quality and ambiance.
- Rainwater Harvesting and water saving devices reduces the amount of water consumed within the CE.
- The energy saving measures allow for the community to meet government standards and targets with respect to energy sustainability.

Social benefits include:

- Better insulated and more efficient homes improved the quality of life and health by creating a comfortable environment in the living space.
- Community use of alternative energy and water supply can create a greater participation in estate-wide activities such as maintenance works and potentially create job opportunities.
- Creating a community that can work together with a limited 'grid' connection could lead to a sense of community pride and fulfilment.

The annual water and energy bill savings support the fact that refurbishment options possess economic benefits for the residents. However, the residents will also receive societal benefits as the environment that they live in will have been improved, which means an improvement in quality of life. Once implemented, community ownership of the proposed strategies is to be expected to create a homely feel for the residents.

Conclusions and further work

The strategies proposed have undergone the UCL Engineering team assessment and community discussion to address the 2013 Community Plan. Steps to conceive the Neighbourhood Plan should be seen soon, and it will hopefully have been partly influenced by the assessments done by the UCL Engineering team.

Appendix F: Site analysis

Carpenters Estate – Existing Building Information

Block / Building No.	Street Name / Address	No Floors	Dwellings / Floor	Total No Dwellings	Services info	Fabric Info (ALL DOUBLE GLAZED)
1	1-27 Biggerstaff Rd	3	3-storey houses	27	Gas Boiler	one house had insulation installed
2	2-12, 26-38b, 14-24, 26-60 Biggerstaff Rd	3	23	35	Gas Boiler (some have fan heaters in bathroom)	Cavity wall
3	62-72, 74-90, 92-102, 104-138 Biggerstaff Rd	3	24/25	32	Gas Boiler	Cavity wall
4	Lund Point	21	8	168	Gas Boiler	Cavity wall
5	James Riley Point	21	06-Aug	132	Economy 7	30cm (brick wall)
6	1 Doran Walk, 14-24even Carpenters Road	2	2-storey houses	7	Gas Boiler	30cm (brick wall)
7	3-15odd Doran Walk	2	2-storey houses	7	Gas Boiler	Cavity wall
8	2,4,6,8 Doran Walk	2	2-storey houses	4	Gas Boiler	Cavity wall
9	1-19odd Jupp Road	2	2-storey houses	10	Gas Boiler	Cavity wall
10	1-7 Wilmer Lea Close, 21 Jupp Road	2	2-storey houses	8	Gas Boiler	Cavity wall
11	10-26even Doran Walk	2	2-storey houses	9	Gas Boiler	Cavity wall
12	80-86 Doran Walk	2	03-Apr	7	Gas Boiler	Cavity wall
13	100-106, 108-114 Doran Walk	2	7	14	Gas Boiler	Cavity wall
14	2-12, 14-24, 26-36 Gibbins Road	3	11	33	Gas Boiler	Cavity wall
15	28-38, 40-50 Doran Walk	3	06-Aug	22	Gas Boiler	Cavity wall

16	8-17 Wilmer Lea Close	2	2-storey houses	10	Gas Boiler	Cavity wall
17	23-43 Jupp Road	2	2-storey houses	21	Gas Boiler	Cavity wall
18	3-14 Rosher Close	2	2-storey houses	12	Gas Boiler	Cavity wall
19	52-62, 64-74 Doran Walk	3	07-Aug	22	Gas Boiler	Cavity wall
20	38-78 Gibbins Road	2	2-storey houses	20	Gas Boiler	Cavity wall
21	58-70 Gibbins Road	2	2-storey houses	13	Gas Boiler	Cavity wall
22	72-90even Gibbins Road, 76 Doran Walk	2	2-storey houses	11	Gas Boiler	Cavity wall
23	13 Kennard Road, 15-23 Rosher Close	2	2-storey houses	10	Gas Boiler	Cavity wall
24	2 Rosher Close, 45-57odd Jupp Road	2	2-storey houses	8	Gas Boiler	Cavity wall
25	1 Rosher Close, 1-11odd Kennard Road, 59 Jupp Road	2	2-storey houses	8	Gas Boiler	Cavity wall
26	Dennison Point	21	06-Aug	134	Economy 7	30cm (brick wall)
			Total No dwellings:	710		

Appendix G: Notes from the meeting with LLDC

Meeting at LLDC (minutes taken by Charlotte Johnson)

Attendees:

LLDC:

Alex Savine, Head of Planning Policy

Ngaire Thomson, Planning Policy

Jennifer Daothong, Environmental sustainability

UCL:

Myrto Skouroupathi

Sheng Mao

Charlotte Johnson

Discussion:

LLDC Q: what is the timescale for the neighbourhood plan?

What evidence do they need / expect to see?

The neighbourhood plan should demonstrate how it fits with the LLDC's local plan (Energy = 'Be lean, be green, be clean) and the London plan.

Look at LLDC planning documents Section 8, policy S2 & S3 – this provides the carbon targets.

Also look at the Olympic Legacy Planning Supplementary Guidance

In general:

- The LLDC check the NP fits with the LP, and external reviewer check whether the plans are practical and achievable.
- They do not need detailed technical evidence about specific options
- They are agnostic with regards to heat network connection vs. onsite RES generation.
- There is not much funding available for this type of retrofit.
- They did not make any suggestions about potential alliances or preferred outcomes from their perspective.

Factors to consider about heat network connections:

1) Feasibility of extension

Economics: depends on costs earnt through heat sales over time, minus cost of extending infrastructure, but potential new markets / routes opened up also influence this assessment.

Space: is there infrastructure in the way. Need to have a survey done to 'de-risk' the site. ENGIE is not likely to invest in this.

Legal: contracting party will need to have

2) Terms of contract:

Carpenters is outside of the concession area, therefore terms of service will need to be negotiated. LLDC is working with Genesis and others on non-concession area extensions so will have protocols.

3) Secondary network pipework:

This needs space within the estate and within the buildings, it is hard to fit in.

Developers need to know what to design and build – LLDC run sessions and will invite us.

4) Agreement:

With Retrofit, everyone will have to opt into a monopoly supplier, this is not the case in new builds – as opt to live there.

Appendix H: Water Options

Water meters are devices that log the amount of water used in a household over a period of time. They aim to increase awareness of water use behaviour among consumers, and ultimately improve their consumption behaviour. There are 2 types existing in the UK: smart and conventional. Smart meters run automatically with the help of a built-in wireless communication system connected to the Internet, whilst conventional meters do not. Therefore smart meters can collect data more accurately. Currently, Thames Water is taking the approach of implementing smart meters on top of conventional meters, supported by the evidence suggesting that conventional metering could reduce water use up to 34L/day (Jordan, et al., 2013) in an average household. This means up to £66 can be saved within 5 years. Thames Water provides water meter devices and installation for free to help establishment comply with the Building Regulations Part G (HM Government, 2015). Operational carbon emissions would most likely be negligible. However, this option received opposition from the residents in the most recent community engagement activity although they are motivated to reduce water consumption.

Table H1 presents a breakdown of costs for the different types of SuDS adopted for the CE as well as showing the respective capacity of surface water runoff to be managed by each solution.

Medium Term SuDS	Cost (£)	Capacity
Detention Basin	4,310	625m^3
Infiltration trenches, basins and swales	49,160	5,000m^2
Permeable Pavements (80mm)	210,000	10,000m^2
Geotextile membrane	14,000	10,000 m^2
Additional Base Layer	16,000	500 m^2

Table H1: Cost and Approximate dimensions for the SuDS SWMP for the CE, averaged from data (DEFRA, 2011a; DEFRA, 2011b)

Appendix I: Sustainability

Table I1 indicates the Code for Sustainable Homes (2008) credit criteria for water saving strategies implemented for either low or high rise homes. This table illustrates how the strategies adopted by the solutions presented for the CE reduce water consumption below the 105 litre/person/day criteria specified by the Local Plan (2015). Providing credence that retrofitting of infrastructure within the CE is both feasible and sustainable.

Measure	Water Consumption litre/person/day (CSH credits)				
	120 (1)	110 (2)	105 (3)	90 (4)	80 (5)
6/4 litre low flush WCs	✓				
4/2.5 litre low flush WCs		✓	✓	✓	✓
2 litre/min washbasin taps	✓	✓	✓	✓	✓
9 litre/min shower					
7.5 litre/min shower	✓	✓			
7 litre/min shower			✓	✓	✓
120 litre bath	✓	✓			
100 litre bath			✓	✓	✓
6 litre/min kitchen taps	✓	✓	✓	✓	✓
Rainwater harvesting				✓	
Greywater recycling					✓
Water efficient washing machine					✓

Table I1: Adapted from Code for Sustainable Homes (2008) indicating measures that reduce water consumption through retrofitting low and high-rise homes.

Figure I1 presented on the following page presents cost valuation of different sustainable strategy combinations, highlighting the benefits of a community CHP, insulation and heat pumps as opposed to mechanical ventilation with heat recovery and block heating. Figure I1 is a useful tool of comparison when decided on CE energy solutions going forward in the long-term as comparisons for cost between implementing energy solutions for flats and terrace homes (low-rise and high-rise) can be made.

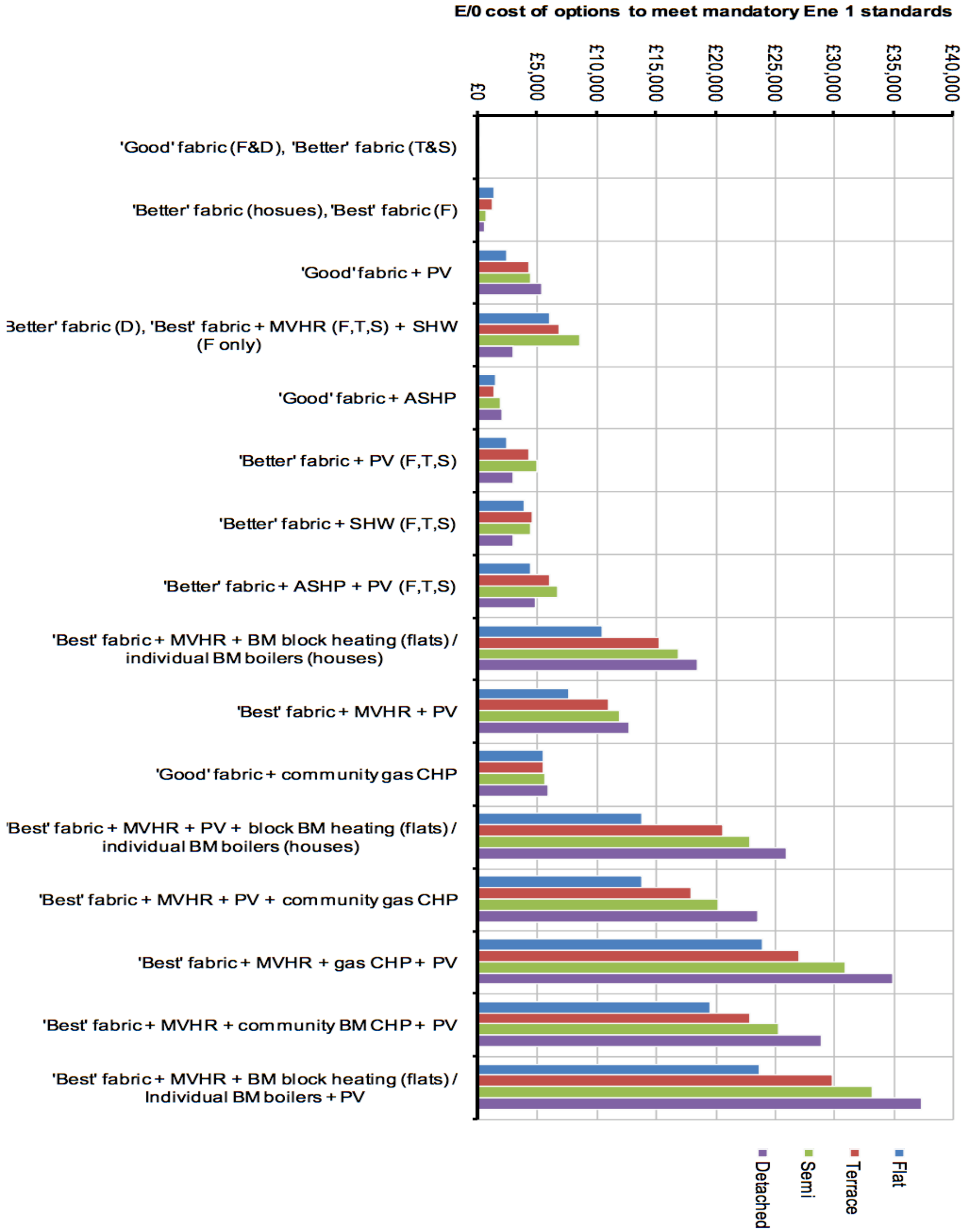


Figure I1: Adapted from Code for Sustainable Homes (2008) illustrating extra-over cost of different energy strategies for a large urban development. MVHR – Mechanical Ventilation with Heat Recovery. SHW – Solar Hot Water. ASHP – Air Source Heat Pump.

Appendix J: Energy Strategy Schematic

Appendix K: Water Strategy Schematic