Dún Laoghaire Rathdown Parks

Fernhill Park and Gardens Páirc Bhun na Coille
Sustainable Development Strategy






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Executive Summary

Fernhill Park and Gardens is a public park, having been recently acquired by Dún Laoghaire Rathdown (DLR) County Council. It is undergoing a measured but transformative programme of works managed by DLR Parks. The natural beauty and peaceful surroundings of the gardens, woodlands and meadows are very much to the forefront of a restorative programme of works. DLR Parks intends to open the facilities up to the wider community to promote education and awareness of health and well-being of mind and body to all age groups.

There will be a renewed focus on environmentally sustainable practice in all aspects of the design, construction and day to day operation of the park to include; garden management (fruit and vegetables); water supply; waste water management; energy efficiency and renewable energy supply; ‘green’ transport; smart communications and accessibility.

The energy and water management elements of this strategy will be the most challenging to adopt and implement. Analysis shows that while it is possible to generate sufficient energy to meet the demands of the site, energy storage and control systems will be needed to optimise the plant operation.

Central to achieving the goals set out herein will be the coordination of the electrical infrastructure and smart metering with ESB Networks. This will be subject to review by the ESB during the detailed design of the renewable energy systems and equipment. We recommend continued progression of the design and procurement of these elements (wind turbines, PV arrays, thermal energy storage vessels, battery storage, electric vehicle charging, battery management systems and Supervisory Control Automation and Data Acquisition (SCADA) systems).

Similarly, the water conservation and waste water treatment systems need to be further developed subject to agreement with DLR Parks.

Fernhill House and Gardens will be a major tourist attraction while serving important community services in so many aspects of our lives. It will go a long way to redressing the balance in our digitally connected world by taking the best of these technologies to enhance and reinforce our awareness of a biodiverse natural environment in beautiful, serene parklands within our capital city.

The following summary poster captures the key objectives for the restoration of Fernhill Park and Gardens.

This Sustainable Development Strategy Report is informed by DLR Parks Sustainability Strategy in Appendix 6 of the Part 8 Planning Report for the Proposed Development of Fernhill Park & Gardens, Stepaside, Co. Dublin with Works within the Curtilage of the Protected Structure (Fernhill House) PC/PKS/01/17.

DLR Parks is committed to innovation throughout the project, much of this has already been discussed above, but can be synopsised as follows:

- Use of SMART technologies
- Well considered design and construction
- The vision for Fernhill Park and Gardens
- Balancing high intensity of use with the ethos of the Park
- Interactive signage and mapping
- A playful landscaped area that is safe but challenging
- Real time information
- Energy monitoring
- Green outdoor gyms.
- Natural play areas
- Enhanced accessibility options/solutions

Photograph 1: Aerial photo of Fernhill House

FERNHILL PARK & GARDENS

a showcase for community engagement with the natural environment

dlr Comhairle Contae County Council

Fernhill Gardens, a gateway park to the Dublin/Wicklow Mountains, aims to be a demonstrator model of sustainability, providing a public park focussed on community engagement with our natural surroundings. Dun Laoghaire Rathdown County Council Parks is developing a programme of socially and environmentally focussed initiatives that include:

- Collaborative shared participation in the annual cycle of the community gardens (that originally provided fruit, vegetables, herbs and flowers for Fernhill House)
- Improved access to mature woodlands rich in biodiversity, using boardwalks and viewing platforms and a range of walking / running circuits with exercise stations
- Open play areas for family and club based sporting activities
- Provision of educational prgrammes focussing on the natural environment and healthy living (mind and body)
- Effective utilisation of energy with significant renewable energy contribution
- Discreet lighting scheme for carparks and selected pathways
- Waste recycling initiatives
- Water conservation practice
- Green transport infrastructure for electric vehicle charging and autonomous vehicles
- Sensitive use of smart technologies to support initiatives at Fernhill Park & Gardens including the promotion of biodiversity and the Irish Pollinator Plan

COMMUNITY GARDENS

WASTE MINIMISATION / RECYCLING

GREEN TRANSPORT INFRASTRUCTURE

WATER CONSERVATION

NEARLY ZERO ENERGY PARK

EDUCATIONAL PROGRAMMES

WALKING & RUNNING CIRCUITS

OPEN PLAY AREAS / ACTIVITY PARKS

DIGITAL/ SMART TECHNOLOGY

RENEWABLE ENERGY SITE

BIODIVERSITY POLLINATION SITE

1 Introduction

Fernhill Park and Gardens, a gateway park to the Dublin/Wicklow Mountains, aims to be a demonstrator model of sustainability, providing a public park focussed on community engagement with our natural surroundings. Dún Laoghaire Rathdown (DLR) Parks is developing a programme of socially and environmentally focussed initiatives that includes:

- Collaborative shared participation in the annual cycle of the community garden (that originally provided fruit, vegetables, herbs and flowers for Fernhill House),
- Improved access to mature woodlands rich in biodiversity, using boardwalks and viewing platforms and a range of walking / running circuits with exercise stations
- Open play areas for family and club based sporting activities
- Provision of educational programmes focussing on the natural environment and healthy living (mind and body)
- Effective utilisation of energy with significant renewable energy contribution
- A lighting scheme for carparks and pathways between the community gardens, café, shop and the main house
- Waste recycling initiatives
- Water conservation practice
- Green transport infrastructure for electric vehicle charging and autonomous vehicles within the park.
- Sensitive use of smart technologies to support Fernhill Park and Gardens and the wider network of public parks with communications and transport links between them.

Photograph 2: Aerial photo of Fernhill Park and Gardens

Arup were engaged by DLR Parks to further develop the Sustainability Development Strategy as set out in Appendix 6 of the Part 8 Planning Report for the Proposed Development of Fernhill Park & Gardens, Stepaside, Co. Dublin with Works within the Curtilage of the Protected Structure (Fernhill House) PC/PKS/01/17. Extracts from that document are included in this report *"in italics within quotation marks"*

The timing of this report coincides with early stage works being undertaken on site. These relate to the undergrounding of 2 overhead lines, the installation of a 400kVA pad mounted transformer and development of the carparks, the sports pavilion in the Road Field, the playful landscaped area in the 9 acre field and adjoining woodlands.

DLR Parks will adopt a light touch approach to enhancing the natural surroundings, taking due consideration of the following environmental and societal drivers in relation to the day to day management of Fernhill Park and Gardens:

- Collection and re-use of rainwater
- Minimisation of Waste
- Composting of biodegradable waste (including wormeries)
- Removal/Control of Invasive Species
- Protection of Habitats
- Use of renewable energy generated on site
- Avoidance of use of fossil fuels for heating
- Recycling of resources
- Community participation and education.

2 Health and Well-Being

"The value of Parks and Open Space to both physical and mental health are well recognised and documented by the World Health Organisation and others. Fernhill Park and Gardens will realise this through both passive and active recreation, both structured and unstructured, and will be designed to maximise accessibility to all regardless of age or physical capability. We will also cater for Children's Play and Teenage adventure in an innovative and challenging natural environment, incorporating existing woodland and streams."

2.1 Community Garden

"DLR has engaged in extensive consultation in advance of the production of the Masterplan for Fernhill. This will inform the range of Community Facilities to be provided in Fernhill, through Community Gardens, Outdoor Classrooms, Horticultural and Biodiversity initiatives that will facilitate a diverse range of Community Groups. The facilities will be provided through existing buildings, or new community led initiatives." "Herbicide use will be minimised with a view to its eventual abolition."
"A modern Park should provide opportunities for visitors and users through high quality food and liquid refreshment. In Fernhill this will be provided in association with and directly adjacent to the Community Garden, with the aim to provide food grown and produced on the site. The menu will therefore change according to the season, and patrons will be see the history and origin of the food from production to ingestion."

The original kitchen gardens will be redeveloped through active participation by the local community. This will be supported by leading gardening advisors and horticulturalists from similar community schemes.

The gardens will not be managed by allocation of allotments, rather they will be managed by a collective team effort with participation building social networks as well as growing the fruit and vegetables, herbs and flowers. A cafeteria located in the Coach House will use produce from the gardens for its patrons, and return waste food and scraps to the garden through a managed composting regime.

There will be a focus on education for young and old, demonstrations and rewards to provide incentives for the gardening community. Organic farming techniques will be encouraged. Biodiversity of plants, birds, animals and insects will be fostered through initiatives such as bees, pond-life, wild-flower meadows and active species management.

2.2 Walking and Running Circuits

Figure 1:Map of Fernhill Park and Gardens showing pathways throughout the park.

Walking circuits for young and old, fit and not-so-agile will be provided through the lower meadows and upper woodlands. The original 'Broadwalk' is a 4.2-meter-wide, 300-meter-long, straight avenue running to the southeast boundary of the park from Fernhill House. The 'Broadwalk' is designed in a way that provides visitors an opportunity to walk through some of the most impressive trees and specimen plants to be found in Ireland. Dogs will not be allowed in the garden area of the park, including the Broadwalk, with the exception of guide dogs. At the other end of the 'Broadwalk' from Fernhill House, walkers will be able to climb up through the woodlands on a boardwalk (a wooden pathway) to prime viewing platforms on the upper reaches of the estate, where views across Dublin Bay will reward the avid climbers. Outdoor classrooms in the natural environment will provide prime locations for teaching and learning about the flora and fauna of Fernhill Park and Gardens.

Exercise stations will be provided for the more energetic individuals who can complete a full body workout in the tranquillity and fresh air of the meadows and woodlands. A 400 meter running circuit will be provided in the Road Field. This will play a major role in the health and well-being driver for Fernhill Garden.

2.3 Open Play Areas

There are 3 large fields for families and clubs to use for sports activities and exercise. A sports pavilion will provide changing and public toilets to support children's team sports in the Road field. A playful landscaped area at the foot of the 9 Acre field will provide a space that encourages our younger citizens to explore and develop their coordination skills. And beyond the stream and pond at the base of the Wood field, a trapeze will find the more daring enthusiasts zip-lining across the field into the woods over Fernhill House.

2.4 Educational Programmes

"The character of Fernhill is diverse and unique. It crosses a multitude of habitats, topographies and micro-climates. DLR will stay faithful to the existing site characteristics in the construction of this new Park through the following guiding principles: Plant Collection: Fernhill's historic collection of mature trees and acid loving plants is internationally recognised and celebrated. DLR will seek to conserve the existing collection while renovating and improving wherever necessary, this is already happening through the engagement of horticultural and arboriculture expertise in the cataloguing and survey of the plant collection, and will continue into the future through the capable hands of DLR Parks. Woodland: The majestic shelterbelts, and rugged hillside trees will be continually assessed, any tree work will be kept to a minimum, and a management plan specifically for the woodland will ensure their protection into the future. Biodiversity: DLR will respect the existing biodiversity as it is within the different parts of Fernhill. Practices to conserve and improve the biodiverse nature of each part will be central to the management and educational opportunities of the Park into the future. This will happen in line with the National Pollinator Plan among other initiatives. The Biodiversity Officer will be part of this conversation. The educational opportunities that this provides cannot be understated."

A key driver for Fernhill Park and Gardens is to build life-long skills for active participants. Educational programmes will be delivered through a range of indoor and outdoor activities and facilities. These will focus on the natural environment, the food chain, challenges to our environment such as impact of climate change and reduction of biodiversity, and health and well-being.

Smart technologies and communication networks will be used at key locations in the park. While in other parts of the gardens, due respect to peace and solitude will be encouraged by adopting a technology free (mobile phone free) policy.

3 Nearly Zero Energy Park

"Fernhill Park & Gardens will be designed and managed as a model of sustainability in terms of energy generation and usage. The existing 83 acres provides many opportunities for the harnessing of the energy provided by a combination of Wind, Solar, Biomass and Hydro (Water flow). All of the energy requirements for the day to day running of the Park, whether it is for the house itself, staff depot, or courtyard area, will be provided by the Park. This will be done in an explicit and highly visible way. Other innovative interactive solutions for energy generation will also be investigated and included, one example is the installation of exercise equipment that uses human kinetic energy to charge a smartphone. Through good design the energy requirements for the Park will be minimised. This will ensure that the construction impacts associated with generation will have a very low impact on the Park."
"The construction of the various items that make up a modern Park will be using the lightest of touches. Wherever possible existing materials on the site will be reused in the construction process, whether this is in relation to the path network, play areas, buildings or access points."

The goal is to operate and maintain Fernhill Park and Gardens with a low a carbon footprint. This will require initiatives to be implemented on both the energy demand and energy supply side. Energy demand will need to be minimised. All buildings will be built or retrofitted to standards as set out in Part L of the Building Regulations (Conservation of Fuel and Energy) to achieve Nearly Zero Energy Building (NZEB) status. Gardening equipment and transport vehicles will be powered by low carbon energy sources. Energy supply will be met by a combination of renewable energy technologies, wind, solar, geothermal and air source heating systems, and biofuels.

Energy storage, by way of lithium ion batteries and thermal energy storage, will be used to store excess wind and solar energy for use at times of peak demand.

Operating a fossil fuel free park requires that all energy requirements of the park will use electricity - heating (via air or ground source heat-pumps), cooking, garden tools and electric vehicles. The energy strategy for Fernhill Park and Gardens aims to avoid the need for oil, natural gas or petrol / diesel.

These renewable energy technologies and energy storage systems will be integrated in the overall masterplan for Fernhill Park and Gardens and will act as an educational feature, raising awareness of low carbon technologies and how they can be integrated with our existing infrastructure.

3.1 Energy Demand

Fernhill Park and Gardens will be connected to the grid to meet any surplus demand to that provided by the renewable energy technologies. Electricity will be supplied from a new 400kVA pad mounted transformer located on the northwest side of gate to the Road Field next to the boundary with Rosemount School. Power will be connected to the load centres scheduled in Table 1.

Building	Capacity kVA
Fernhill House	67
Sports Pavilion	8
Coach House – restaurant	55
Proposed Tower Building/Shop/Community Building	22
Existing shed – proposed Shop/Community Building	5
Plant and Store	6
Gate Lodge	10
Dwelling 1	5.5
Dwelling 2	5.5
Electric Vehicle Charging	114
Total	298

Table 1:Capacity loads for the site. Actual energy use will be lower than the peak loads listed.

Note: The transformer also feeds two private residences on the Enniskerry Road.

3.1.1 Thermal (Space Heating and DHW)

To assess the heating demand, it is assumed that all buildings meet NZEB standards of energy efficiency in terms of insulation, glazing, draught proofing and ventilation. It is assumed all buildings would have natural ventilation and there would be no requirement for mechanical cooling. The assessment for heating is based on the thermal energy required per square meter area of each building. It is assumed minimal heating will be required during the summer and that heating of domestic hot water (DHW) will not occur at the same time as space heating.

Building	Area m^2	Heat loss W/m^2
Fernhill House	897.0	50
Sports Pavilion	109.3	25-50
Coach House – restaurant	214	25-50
Proposed Tower Building/Shop/Community Building	231	25-50
Existing shed – proposed Shop/Community Building	32	25-50
Plant and Store	32	0
Gate Lodge	75.0	25-50
Dwelling 1	23.0	25-50
Dwelling 2	86.0	25-50

Table 2: Building floor areas and thermal heating demand allowances

3.1.2 Power - plug loads and internal lighting

The buildings will aim to maintain low energy use in terms of plug loads and lighting. Efficient LEDs will be used for lighting and the electrical services of the building will be met by the highest energy efficiency technology available e.g. hand dryers, speakers or media equipment.

Catering Equipment for the café will require some high power use equipment. The power use estimate for the catering equipment will vary greatly depending on the services and technologies installed in the kitchen. The catering equipment will be electric with induction hobs and electric water heater. This will allow the energy use to be met by either renewable generated on site or by the grid. Natural gas will not be brought onsite. It was assumed the catering equipment would include a 2.5kW oven, 1.5kW fridge, 3kW water heater. The peak energy demand at the café would be during morning set up and lunch time.

Electrical gardening equipment will need to be charged and ideally this will be done overnight so that it can be fed from renewables power generated at night when the other demands are low. Gardening equipment will be charged in the workshop building next to the coach-house cafe.

3.1.3 Power Profiles

A power profile maps the power demand for each hour of the day which informs the energy consumption predictions. For Fernhill, the demand profile runs over 16 hours. 7am to 11pm. The public use buildings will assume a shorter demand time than the occupied dwellings. The demand profile of the public use buildings – the coach-house, tower building, shop and sports pavilion – will consume energy during daylight hours.

Fernhill House, due to its large floor area, has a considerably larger energy requirement than the other buildings. It will also be more challenging to bring this heritage building up to a high standard of energy efficiency. Expectations are that Fernhill House will be available for evening functions. For this report, it is assumed to be in use and heated from 7am to 9pm.

It is estimated that the max daily power demand and annual power demand for the buildings on the Fernhill estate will be as follows:

Building	Winter Daily Energy Use Estimate (kWh)	Annual Energy Use Estimate (kWh)
Fernhill House	222	55,000
Sports Pavilion	18.1	6,000
Coach house -restaurant	43.1	14,500
Proposed Tower Building/ Shop/Community Building	21.9	7,000
Existing shed- proposed Shop/Community building	5	1,500
Plant and Store	12.5	4,500
Gate Lodge	42.5	14,500
Dwelling 1	36.46	13,500
Dwelling 2	36.46	13,500
Total	438.8	131,000

Table 3: Energy use estimates for buildings in Fernhill Park and Gardens

Note: These load profiles are a best guess estimate to help inform the strategy of the site. Site monitoring and data analytics will provide true values of energy use to inform ongoing energy management.

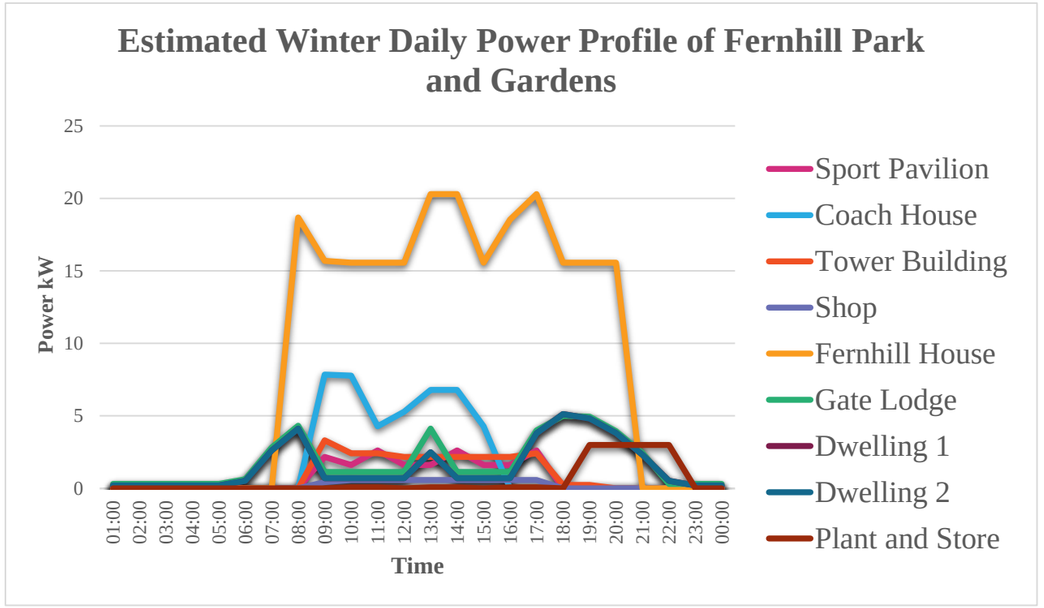


Figure 2: Estimated daily power profile for each building during the winter months

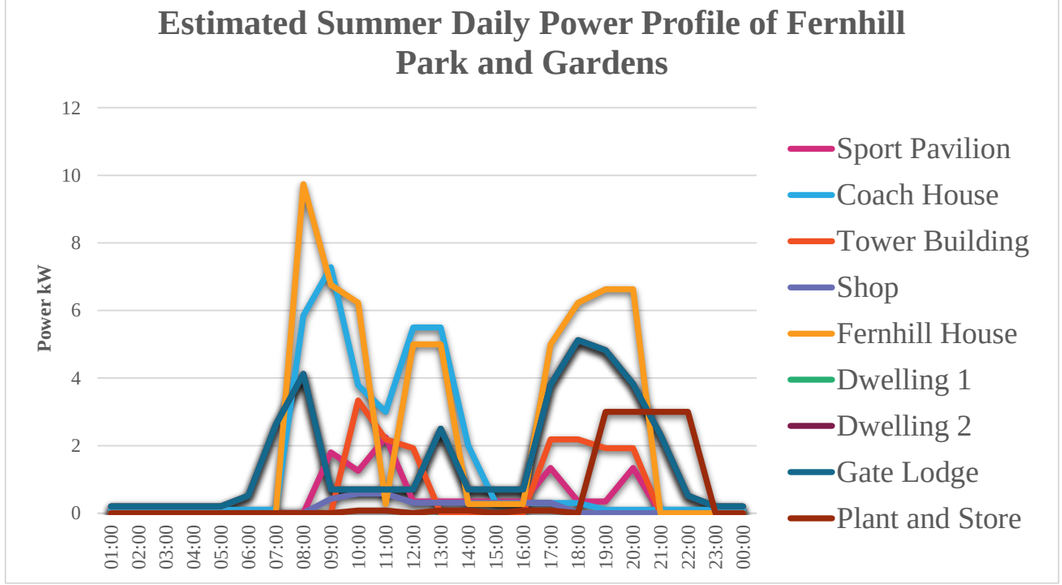


Figure 3: Estimated daily power profile for each building during the summer months

3.1.4 Lighting

External lighting will be required for the primary circulation routes. A lighting scheme has been designed to provide lighting along the new road from the entrance at Rosemount School to the north, east and west carparks, along the pathways and in the children's play area of the park. The lighting is designed to have low impact and blend into the natural surroundings, using wooden posts.

Photograph 3: Lighting installation proposed for Fernhill Park and Gardens

The energy demand of the lighting is estimated as 1,327kWh per year, operating only half of the year as minimal lighting will be required in the summer months. It is assumed for winter-time lighting will be required for 1 hour before sunrise and 1 hour post sunset. It is recommended that the external lighting is powered from the coach-house plantroom. This load centre has the best capacity to utilise wind energy and with battery storage could meet the energy demand of the external lighting.

Lights	No. of lights installed	Power (W) Capacity	Hours of use	Days of use	Total kWh
EX1 – Secondary pathway lighting	19	24	1	182.5	82.2
EX2 – Primary road lighting	10	36	1	182.5	65.7
EX3 -Carpark lighting	27	48	1	182.5	236.5
					384.4

Table 4: Energy Demand estimate for external lighting

3.1.5 Electric Vehicle Charging

The uptake of Electric Vehicles (EV) in Ireland is increasing and will continue to do so with financial grants available, lower road tax and lower running costs. Electric vehicles have reduced CO_2 emissions and improved air quality when compared with and petrol or diesel car. Even when emissions from Irish electricity generation are considered, the CO_2 emissions from EVs are less than those from the cleanest petrol engines.

	CO_2 g/km
Electric Vehicle	60
Petrol Engine	130

Table 5: Comparison of CO_2 Emissions from EVs and Petrol Cars - Source: SEAI

As the mission of Fernhill Park and Gardens is to be a zero-carbon park the use of EV as a mode of transport to and from the park should be supported. The prioritisation of the location of EV charging spaces will enforce the message that the park supports the move to cleaner transport. 10% of parking spaces reserved for EV charging would equate to 16 spaces. This would require a capacity of 112kW. It is not expected that the EV would be charged from the renewable energy generated onsite but supplied from the national grid. The EV charging will come through a separate electric meter on site and allow for the energy use for vehicle charging to be monitored separately to the other load centres.

Charging facilities for electrically powered bicycles will be provided in the carpark.

3.1.6 Annual Energy Demand Estimates

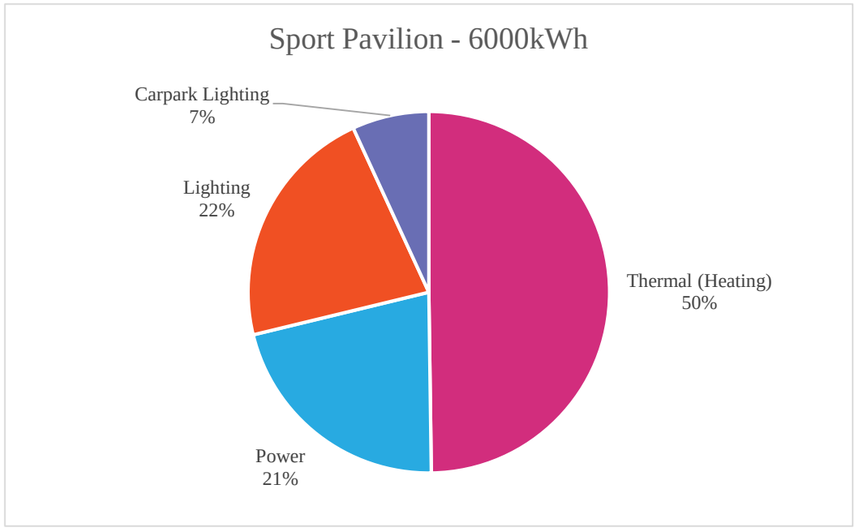


Figure 4: Pie chart of energy demand breakdown for Sports Pavilion

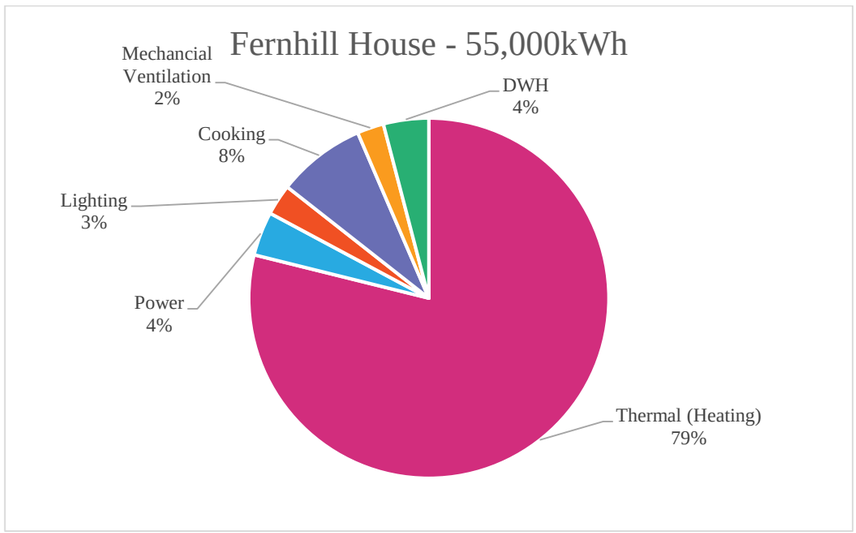


Figure 5: Pie chart of energy demand breakdown for Fernhill House

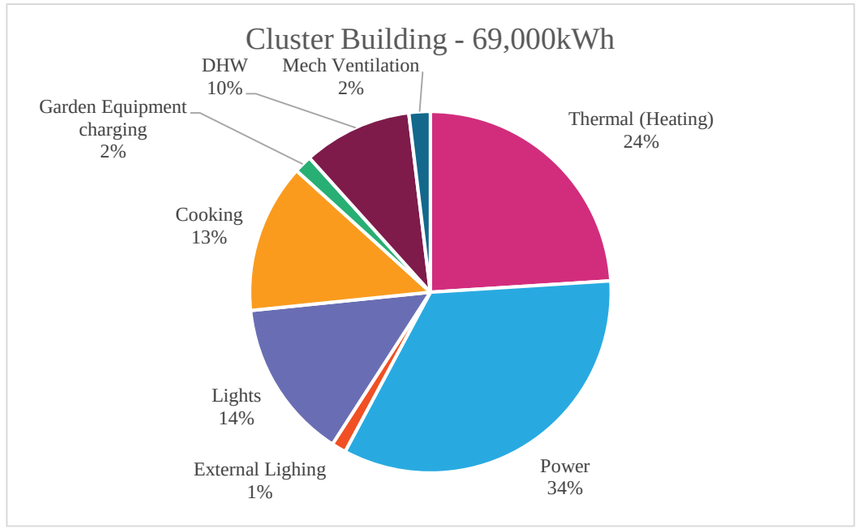


Figure 6: Pie chart of energy demand breakdown for Cluster Buildings[1]

[1] Note: The energy demand and supply are best-guess estimates to help inform the energy strategy for the site. Site monitoring and data analytics will provide true values of energy use to inform energy management of the site in the future

3.2 Energy Supply

The energy loads detailed in Part 1 will be met, in part, by a combination of renewable energy technologies. These will be integrated into the site, in a phased approach and aim to have a minimal impact to the environment and natural aesthetics of the park. The renewable energy technologies explored for Fernhill Park and Gardens are as follows:

3.2.1 Wind

It is proposed to install three 25kW wind turbines at a 15m hub height. It is estimated that two wind turbines will supply renewable energy to the cluster buildings and the third turbine will supply energy to the main house. The proposed locations for the wind turbines is within the playful landscaped area, at the north end of the 9 Acre field. The trees to the north of the site are taller than the total turbine height and will not affect the view of the park from the north, the Enniskerry Road or Belarmine housing estate. This site will need to be surveyed for wind resource, either by inspection or installation of an anemometer for realistic power estimates to be calculated.

There are a number of considerations with the installation of a wind turbine.

- Access roads at 4m wide will be required for the installation of the turbines. Grass-crete could be used on the roads and hardstand area to blend these areas into the parkland. (Subject to design by civil/structural engineer)
- The hub of the wind turbines may need yearly inspection as part of routine maintenance. Some small turbines have the ability to be raised and lowered at a hinge point at the base, some may require a cherry picker for access. Maintenance needs to be considered at procurement stage of the turbines.
- The proposed height (15m tower plus 6.1m blade) will be 21.1m.
- An assessment of the impact of the wind turbines will be required to ensure that no adverse effects are caused to the birds, bats, wildlife and natural environment.
- The noise impact of the turbines is estimated to be approximately 45dBA at a distance of 5m.
- The base of the turbine will need to be landscaped to deter any interference with the base of the turbine and to be sympathetic to the natural surroundings.

DLR County Council published a County Development Plan 2016 – 2022 detailing a Wind Energy Strategy. In this report, the council recognises the importance of wind energy in the fulfilment of its policy to support the National Climate Change Strategy. There is a need to balance their support for renewable energy with the council's requirements to preserve the natural resources throughout the County. DLR Parks aims to integrate three, commercially viable, wind turbines into the surroundings and demonstrate how renewables can be incorporated into the natural landscape.

Photograph 4: A wind turbine installed in Ireland

Photograph 5: Wind turbine installation. Access roads to site will need to be assessed for suitability for long vehicles.

3.2.2 Photo-Voltaic, PV

PV will be installed on the roof of the Sports Pavilion and on the south facing section of the Tower Building, Shop and sheltered walkway. Power generated from the roof PV will feed the power requirements of the respective buildings. The Sport Pavilion roof is designed with low gradient, south facing roof and will be able to hold approximately 8kW of PV to power the Sports Pavilion directly.

As discussed above, the public buildings are only active during the day with their peak demand matching the peak daylight hours (12-3pm). This makes PV an optimal energy solution for these buildings.

It is proposed to install a sheltered walkway over the stream that would couple as a platform for another PV installation. The power generated on this walkway would feed to the main house. It is estimated 50m2 of PV could be installed at this location, equating to 8kW of power.

Photograph 6: Rooftop PV on the Samsung Zero Energy House, South Korea

3.2.3 Hydropower

There are two small streams that transverse the site. Plans are in place to divert one stream into a pond with a weir that would stagger the flow of water over small waterfalls. Hydropower was investigated as a renewable energy solution for the site. For sufficient energy from a hydropower installation, one of two requirements need to be met, either a high flow rate (>1.9m3/s @2m head) or a large head (>100m @ 40litres/s). Unfortunately, neither a sufficient flow rate or large head would be achieved on site. A waterwheel could be installed on the weir to demonstrate the concept of hydropower to the public

but this would not generate any usable power output.

Photograph 7: A water wheel

There is opportunity for the use of a hydraulic ram-pumps for CO_2 free water pumping needs across the estate. A hydraulic ram takes in water at one "hydraulic head" (pressure) and flow rate, and outputs water at a higher hydraulic head and lower flow rate. The device uses the water hammer effect to develop pressure that allows a portion of the input that powers the pump to be lifted to a point higher than where the water originally started. The hydraulic ram can be used where there is a source of low-head hydropower to pump water to a destination higher in elevation than the source. The ram requires no outside source of power other than the kinetic energy of flowing water. This could be used as a demonstration device of CO_2 free water pumping. This option would require further investigation of the head and flow rate of the water from the attenuation pond to ensure feasibility of the device.

Photograph 8: A hydraulic ram that drives a fountain at the Centre for Alternative

3.2.4 Heat Pumps

A study to determine the recommended heating system solutions for Fernhill House and Gardens concluded that the primary heat source should be through the use of hybrid heat-pump technology, using both air and ground source heat-pumps. Considerations regarding the selection of the preferred heating system solution are recorded in Appendix A – the summary table from which is copied here:

	Biomass	Heatpumps	BioGas	Wood burning Fireplaces
Carbon Intensity	1	2	2	1
Labour Intensity	4	1	2	4
Operational Cost	3	2	4	1
Capital Cost	3	3	3	1
Reliability	3	2	2	1
Longevity	2	2	3	1
Space requirements	4	2	2	1

Air-source heat pumps require an inside unit, slightly larger than a fridge freezer, and an outdoor, fan -assisted heat rejection (or heat absorbing) unit. This technology takes thermal energy from the outside air and using a refrigerant and heat pump technology increases the temperature of the water/air circulating in the building. The heat pump can operate to heat either air or water. An air-to-air heat pump, will circulate warm air through the ventilation system of the building. An air-to-water heat pump, will circulate warm water and distribute heat through fan assisted radiator panels and underfloor heating. Heat pumps operate at lower temperatures than a standard gas boiler heating system and fan-assisted convection radiators are needed to boost the heat output of the radiator. A specification / data sheet for convection radiators can be found here.

Ground-source heat pumps extract thermal energy from the ground by running a water / anti-freeze solution through underground pipes laid to a depth of 1m. A closed loop system recirculates the brine solution continuously through the laid pipes and transfers the heat through a heat pump system to the building.

The proposed heating systems for the different buildings are as follows:

Building Cluster (Coach house, Tower Building, Shop, cottages): hybrid air/ground source heat pumps. One heat pump system will be used for these buildings from the Plant and Store building. The geothermal piping will be laid in the soft ground of the playful landscaped area, at a dept. of 1m. The return piping to the building cluster will pass through buried service ducts / pipes under the east carpark and tree belt. Approximately 2km of buried pipe will be needed to meet 50% of the heating requirements of the three buildings. Air-source heat pumps will meet the remaining 50%.

Fernhill House: Similarly, to the building cluster, the Fernhill House will use a hybrid heating system of air / ground source heat pumps. The heat pumps will be housed in an outhouse beside the main building. Pipes will feed heated water from the outhouse to the main house for distribution to the rooms of the main house. The proposed site for laying geothermal piping for the old house in under the attenuation pond. Approximately 2.25km of buried piping will be needed to provide for 50% of the heating capacity of the old house. Air-source heat pumps will meet the remaining 50%.

Sports Pavilion: This building has a low heat demand. An air-source heat pump will be the primary heat source.

3.3 Energy Storage

Renewable energies, such as wind and solar, are a variable power source. The energy generated will not always meet demand onsite nor will there always be demand for the energy generated. The energy generated will not only vary across the time of day but also seasonally. Whilst wind generally provides more power at night and in the winter months, solar will provide more power during the day and in the summer.

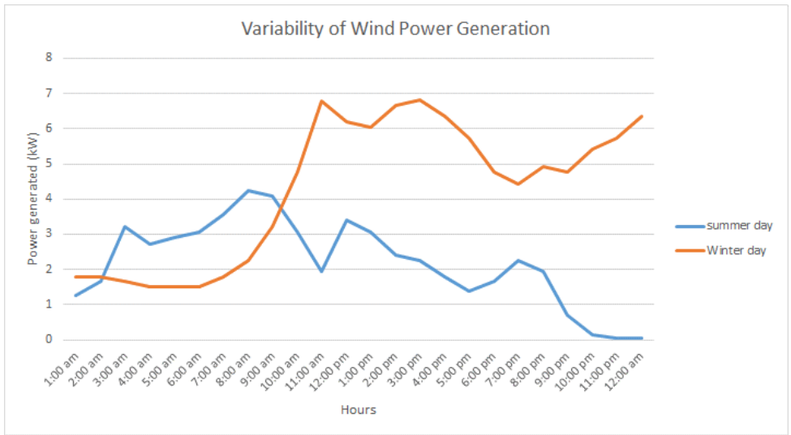


Figure 7:Variability of wind power generation at a Dublin site for two randomly selected days; one summer and winters day.

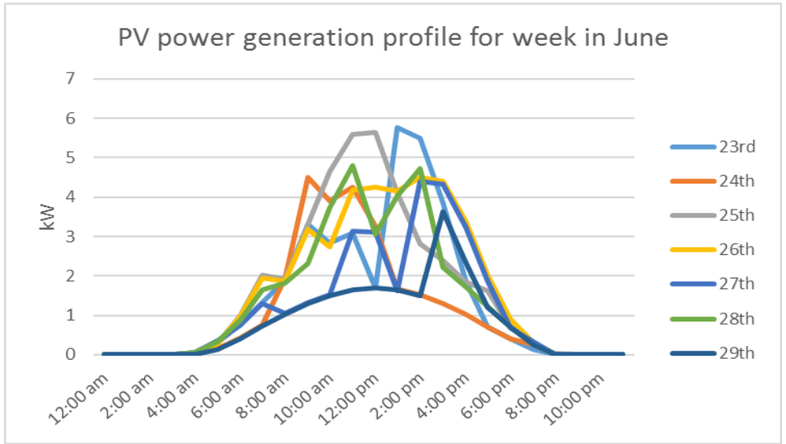


Figure 8: Profile of PV generation for sample 7 days

For Fernhill Park and Gardens a combination of three key storage strategies will be used:

- Battery storage using lithium ion batteries,
- Thermal energy storage using a hot water buffer vessel with heat pump technology to store the heated water for when it is needed. Preliminary calculations indicate a buffer vessel of 4m in height and 1.5m in diameter.
- Thermal energy storage using underfloor heating to store heat energy in the thermal mass of the floor. Polished concrete floors are recommended for maximising thermal benefit and for ease of cleaning in the coach-house café.

3.3.1 PV Battery Storage

Sizing a battery for a solar storage system is complex, depending on the nature of the site and the intended use. The choice of size lies somewhere along a continuum between two extremes:

- Battery too small. When the additional cost of the installation is more than the financial benefit from the stored power.
- Battery too big. When the battery cannot be fully charged except on a few very sunny days of the year.

In considering where on this spectrum the battery should be sized, the following factors need to be considered:

- Solar array output (PV system size). As battery size increases there comes a point where the daily solar input becomes insufficient to fully recharge the battery. Although solar output varies considerably during the year, the maximum daily output is relatively easy to determine and can be used to fix an upper battery threshold. In the case of Fernhill Park and Gardens, the max. output from a 50m2 south facing PV array would be 33kWh/day on the 23rd of June.[2]
- Load use. Sites with loads that run throughout the day will reduce the available solar power for battery recharging and mean that a smaller battery is generally required. The tower building and sports pavilion with PV installed will have daily load with small loads at night. This will reduce the requirement for PV battery storage as the power generated during the day can be used at that time. Although the load of these building will be variable with groups of visitors coming for periods of time throughout the day. Furthermore, the load will be very small for the Sport Pavilion and Tower Building, particularly in summer when no heating and less lighting is required.
- Back-up capacity. Where power is required during a power cut, some or all of the battery capacity can be set aside for these occasions. This will generally mean that a significantly larger battery is required than one specified solely for time-shifting mode. There is little back up capacity required as the site is connected to the grid. This will reduce the required battery size.
- Maximum charge-discharge rate. For some systems, the maximum charge or discharge rate the battery is able to handle will be relevant. For example, a battery selected for use in a system providing off-grid functionality needs to be able to deliver the worst-case (surge) currents that the inverter will require during off-grid operation. Large surges of current will not be required in on the site as peaks in demand will be fed from the national grid.

It is recommended that the batteries for the PV installations are installed at the location of the PV and the power used at that location. The PV installed on the sheltered walkway that should feed to a battery in the outhouse and provide power to the Main House.

Many PV installers in Ireland will provide an integrated solution of batteries and PV and it is recommended that both are procured together.

[2] Solar output estimated using the NREL PV Calculator for a location Dublin, PV efficiency: 16%.

3.3.2 Wind Power Storage

The energy storage for the wind turbines should be installed separately in the cluster buildings and Fernhill House. Wind turbine 1 and 3 should feed into an energy storage system in the Plant and Store building. Wind turbine 2 should feed into an energy storage system in the outhouse of the Fernhill House.

The maximum output of the wind turbine on a very windy day is estimated to be 263kWh. No energy storage should exceed this capacity.

Thermal energy storage will be considered as an energy storage method for excess wind power generation. For thermal storage the heat pumps are used to store the excess energy as hot water for space heating and DHW when required. For this system a large buffer vessel would be required to store the hot water for when it is needed. If the buffer vessel is installed in the Plant and Store would need to be installed below floor level to obtain a height of 4m to allow for thermal stratification in the tank. The table below shows the split between thermal demand and electrical demand. With a high proportion of energy generated required for heating, thermal storage is a suitable option in combination with battery storage.

The load of the cluster building and Fernhill House can be split between Thermal Electric Load[3] for space heating and DWH and Electrical Power Load. The excess wind generated could be split between thermal energy storage and battery storage.

	Thermal Electrical Load	Electrical Power Load
Fernhill House	83%	17%
Cluster Building	34%	66%

Table 6: Split of electrical demand between thermal and power requirements

Battery storage will be able to provide power for heat pumps and electrical load. The cost of this storage method will likely be higher than using thermal storage.

The following table gives insight into the size requirement for the storage to cover varying no. of hours of cover:

	kWh of storage	Footprint required (m2)	No. of battery units
Cluster Buildings			
Max. daily power required (12hour operation)	197	4.68	4 x 52 kWh units
4 hour of storage	65	1.74	2 x 52 kWh units
8 hour of storage	110	3.5	2 x 58 kWh units
Fernhill House			
Max. daily power required (12hour operation)	222.82	6.96	4 x 58kWh units
4 hour of storage	74.3	2.34	2 x 52kWh units
8 hour of storage	148.5	3.5	3 x 52kWh units

Table 7: Estimate of battery storage size based on hours of use. These estimates were made using the specs. of Saft's Intensium Smart 52kWh and 58kWh models

[3] In this case the thermal electric load accounts for the electrical load required for the heat pumps. A COP of 3 is assumed. This means for every 1 unit of electricity, 3 units of thermal energy is achieved for space heating and hot water.

Photograph 9: Saft's Intensium Smart 52M

Photograph 10: Saft's Intensium Smart 58M

Any battery provider will be able to assess the particulars in this case and recommend a suitable size for Fernhill Park and Gardens.

A number of constraints need to be considered when deciding on the final balance between the thermal energy storage and battery storage.

- Cost
- Space required
- Hours of cover desired
- Actual generation by the wind turbines on site
- Actual demand when the park is open.

3.3.3 EV Charging

A final consideration for energy storage is the battery of electric vehicles. Any on-site electric vehicles, be it used for gardens or maintenance, could have a charging point close to any of the load centres. This could be charged over night to make use of any night time on-site renewable generation. This would reduce the size of any standalone battery, and therefore reducing costs and lifecycle energy costs associated with the standalone battery option.

3.3.4 Battery Management System

A battery management system will be required to monitor and control the flow of energy within each energy centre. Synchronisation with the electrical power supply from the national grid (frequency and voltage) will be a key operational requirement.

Given the scale of the campus wide deployment of renewable energy generation and energy storage, it is expected that a Supervisory Control and Data Acquisition (SCADA) system will be needed to control and optimise the energy flow across thermal storage, battery storage and EV charging in future phases of the development programme.

3.3.5 Metering and Smart grid control

Currently there are three ESB Electrical Meters on site at the Gate Lodge, Main House and Bungalow. The existing metering will be restructured and replaced to provide a total of the six ‘smart’ meters as follows:

- ESB Meter No. 1: Cluster Buildings
- ESB Meter No. 2: Main House
- ESB Meter No. 3: Sports Pavilion
- ESB Meter No. 4: North Carpark Electric Car Charging Mini pillar
- ESB Meter No. 5: East Carpark Electric Car Charging Mini pillar
- ESB Meter No. 6: West Carpark Electric Car Charging Mini pillar.

Meter No. 1 for the Cluster building will serve the following buildings; Gate Lodge; Café; Tower Building; Shop; Plant and Store; Dwelling No. 1 and No. 2.

Two of the wind turbines installed onsite will feed in downstream of this meter, along with the PV installed on the tower building and shop/community building.

The third wind turbine will feed in downstream of the Meter No. 2 at the Main House, along with the PV installed on the sheltered walkway.

PV installed on the roof of the Sports Pavilion will feed in downstream of Meter No. 3.

This will allow for renewables generated on site to be treated as parallel connected generators. Energy generated would be used on the downstream side of the fiscal meters. The renewable energy generation capacity is greater than 11kW which will require approval from ESB Networks (NC 5 Application Form).

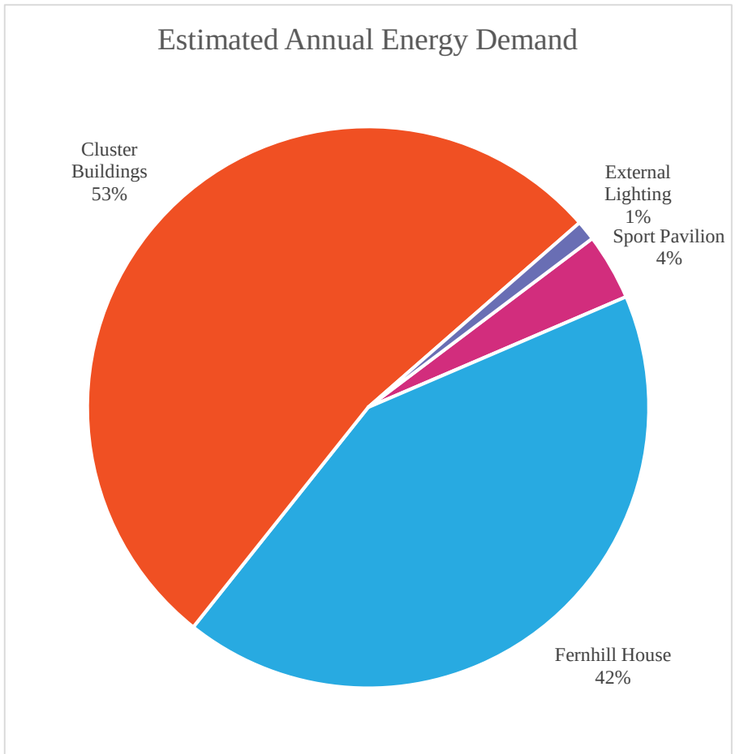
The ‘smart’ meters specifications will be agreed with ESB Network who are in the process of managing the smart metering programme for Ireland.

Graphic User Interface (GUI) terminals will be provided at information boards in the carpark, the Tower Building and at the entrance next to Rosemount School.

3.4 Energy Balance

The aim of a carbon free park will be to meet energy demand with supply from renewable energy generated on site. There are challenges in in matching the energy generation at times of demand due to the variability of renewable and the peaks and troughs of demand. Fernhill Park and Gardens will be better enabled to achieve a balance with the use of energy storage. There will be times when import from the grid will be required but with an adaptable system in place coupled with effective monitoring and management the extent of imported energy will be minimised – with the overall aim of Fernhill Parka and Gardens achieving carbon neutrality.

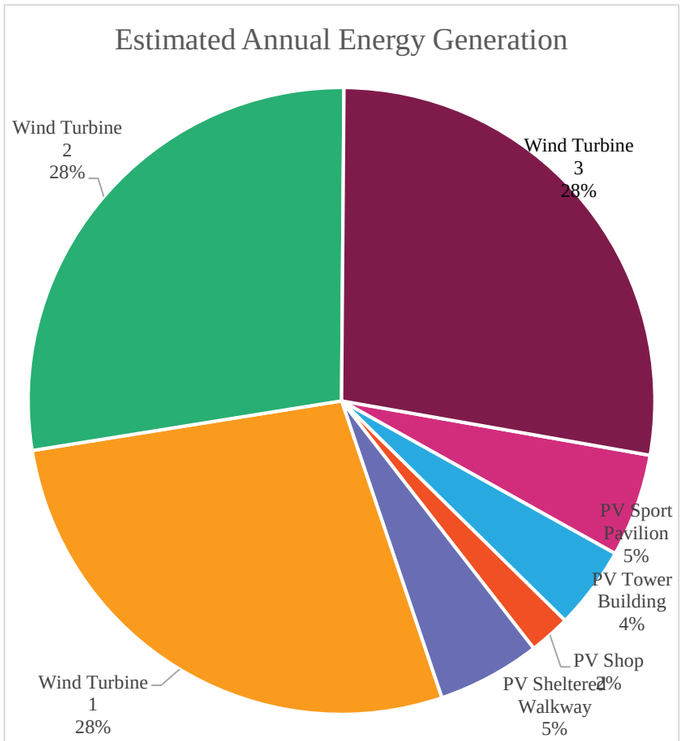
Demand



Total: 131,000 kWh/ annum

Figure 9: Demand – Estimated Annual Energy Demand

Supply



Total: 133,174 kWh/ annum

Figure 10: Supply – Estimated Annual Energy Generation

The strategic vision for energy infrastructure in Fernhill Garden is summarised in Figure 11 – Renewable Energy Masterplan

FERNHILL PARK & GARDENS

Renewable Energy Master Plan (Indicative sketch)

Batteries will be installed in the Plant and Store to optimise the use of energy generated by the wind turbines. The PV installation will have their own battery storage installed in their repective buildings.

Log-burning stoves will provide a secondary heat source for the Main House and Cafe Building.

PV panels on the roof of the Sports Pavilion, Tower Building and Shop.

A sheltered walkway acts as a platform for PV installation.

3 25kW wind turbines to be installed in the play area of 9 acre field.

Geothermal piping area providing a heating source to the cafe, tower building, shop and plant and store.

A hydro-power turbine at this location would act as a demonstration device with possibilities of powering a light on the bridge/walkway.

Geothermal piping area providing a heating source to Fernhill House.

4 Waste Minimisation and Recycling

"DLR will examine the existing water that permeates the Park with a view to making some light touch interventions in relation to providing opportunities for flood attenuation, hydro-electrical energy generation, habitat creation, and aesthetically pleasing water features."

4.1 Overview

Waste matter and its management presents a number of different opportunities for Fernhill Park and Gardens to become exemplary in demonstrating best practice in design of a self-sustaining ecosystem. Waste generated in the Park and Gardens will include; sanitary waste, grey water, food and garden waste. A range of sustainable technologies have been selected for use within the Park and Gardens in order to both: minimise the waste generation and to facilitate the reuse of waste products, where plausible.

Waste generated in the Park and Gardens will be treated on site by means of a centralised, nature based wastewater treatment system. However, where possible the quantity of waste directed to the centralised treatment system will be minimised through the incorporation of waste recycling and reuse options throughout the park and gardens.

Dry composting toilets which will be used in the Sports Building and the Tower building embody this idea of 'minimisation and recycling' of waste as they require minimal water, they generate less waste than conventional toilets and the solid waste generated from them can be utilised as composting material.

Grey water generated from sinks, wash hand basins and showers throughout the Park and Gardens could be reused to supply toilets and urinals with water for flushing. Grease traps will be fitted to greywater sources from the restaurant located within the Coach House to minimise the oils and greases from food waste which is directed to the wastewater treatment system.

Food scraps from the restaurant will be treated by Wormeries to generate compost which will be reused for growing of plants and vegetables within the Park and Gardens.

4.2 Waste sources

The Gate Lodge (25), which will generate small amounts of sanitary waste and grey water waste, is connected to the public sewer thus this waste will not be treated on site. All other development in the Fernhill Park and Gardens is not connected to the public sewer and as such all waste generated on site, excluding that generated at the caretaker's residence, will be treated on site.

A significant portion of the waste from the Park and Gardens will be generated in the cluster which includes; the Coach House Café (28), The Tower Building (29) and a domestic dwelling (32). The waste generated in this cluster will include grey water waste from sinks and wash hand basins and food waste.

4.3 Solutions for managing waste treatment

A range of innovative technologies and solutions which reflect the sustainable, eco and holistic ethos of the Fernhill Parks and Gardens project have been considered for the site ensuring that the waste generated on the site can effectively be minimised, recycled and treated within the site itself.

4.3.1 Grey water reuse and treatment

Grey water is defined as wastewater that comes from sinks and washing machines, i.e. the wastewater that contains some bleach and detergents. Grey water will be generated at all the buildings in the Park and Gardens.

Grey-water recycling involves reuse of water from baths, showers and wash hand basins. Often grey water is reused for flushing toilets. This practice promotes water conservation and reduces the demand on the water supply system. A grey water recycling system would be useful at the sports building (6) and at the cluster which includes the dwelling (32), the tower building (29) and the coach house (28) and could reduce the scale of the centralised treatment system required. However, it is critical that the quality of the recycled grey water does not pose a health risk and as such under EPA code of practice all grey water sources are considered a pollutant. The EPA require grey water to be treated in the same manner as sewage.

Specific grey water treatment systems are available on market however these systems are expensive and regular maintenance of the treatment system is required. It is generally more economic to reduce water use by fitting more water efficient appliances and changing habits and behaviours before considering the use of grey water re-use systems. As such all grey water generated at the Fernhill Park and Gardens will be directed to the centralised treatment system.

4.3.2 Dry composting toilets

Dry composting toilets are slightly larger than conventional flush toilets however, they are a suitable replacement particularly in remote locations, as they eliminate the need for further treatment of sanitary waste by means of central wastewater treatment plants (sewers) or septic tank systems. The use of dry composting toilets at the sports building (6) and in the tower building (29), will significantly reduce the loading and ultimately the size of the Fernhill Park and Gardens centralised waste treatment system, whilst generating compost and fertiliser by-products which can be reused in the growing of plants and vegetables in the Park and Gardens.

Dry composting toilets generally rely on a controlled natural process to treat and stabilise urine and excreta. A composting toilet is an aerobic processing system that treats excreta, typically with no water or small volumes of flush water, via composting or managed aerobic decomposition. The use of composting toilets with urine diversion is proposed for use at the sports building (6) and tower building (29) in Fernhill Park and Gardens in order to prevent the creation of anaerobic conditions that can result from over saturation of the compost, which leads to odours and vermin problems.

In the urine diversion system solid and liquid waste are separated inside the system and composting of excreta occurs within the receiving fixture.

Ventilation is required to avoid foul odours and to add oxygen to the composting process. Some units use fans for aeration. A constant air flow partially evaporates the liquids and dehydrates the solids, working to reduce odours. This is usually a more efficient process than the anaerobic decomposition at work in most wastewater systems, such as septic tank systems.

The composting unit consists of four main parts:

- A storage or composting chamber;
- A ventilation unit;
- A leachate collection or urine diversion system to remove excess liquid; and,
- An access door for extracting the compost.

"Starter" cultures consisting of peat, wood shavings and soil are often used to ensure composting bacteria are in the process. Operators of composting toilets commonly add a small amount of absorbent carbon material (such as untreated sawdust, coconut coir, peat moss), often referred to as "bulking agent" after each use to create air pockets for better aerobic processing, to absorb liquid, and to create an odour barrier.

Over time most of the solid organic material is converted into carbon dioxide and water, and evaporates. A minimum of secondary treatment is required if the compost is to be reused. This process may be as simple as prolonged storage with the duration of 1.5 to 2 years. After 5-10 years only a small amount of end product remains containing the kind of minerals you find in ordinary soil. The processed compost when removed from the tank can be used in gardens as soil.

The required degree of treatment for the collected urine depends entirely on whether this product will be reused in agriculture. If it is not reused, but only infiltrated, then no further treatment is required. Urine should always be treated for pathogen removal if it is going to be reused. The simplest and most common method of urine treatment for pathogen removal is via storage in closed vessels. Recommended storage times to kill pathogens in urine vary from one to six months depending on ambient temperatures, the scale of the urine collection system and which crops will be fertilised with the urine.

There are a number of regulatory documents which should be referenced in relation to the use of composting toilets, these include:

- International Organization for Standardization ISO 24521 (2015) Activities relating to drinking water and wastewater services — Guidelines for the management of basic onsite domestic wastewater services
- ISO 24511 (2007) Guidelines for the management of wastewater utilities and for the assessment of wastewater services.
- The International Association of Plumbing and Mechanical Officials (IAPMO) (2015) Proposed Composting and Urine Diversion Toilet Code.

There are several suitable manufactured composting toilet models are on the market and available in Ireland including; Kazuba Waterless Toilets and Clivusmultrum Dry Toilet System.

4.3.3 Grease traps

High levels of fats, oil and grease (FOG) are often present is wastewater from restaurant kitchens where food is prepared. The FOG is problematic as septic tanks are not designed to treat FOG and as such the inclusion of grease traps in systems treating water from restaurants, hotels and any other businesses that supply food is best practice.

Grease traps are receptacles which capture FOG from the flow of wastewater by slowing down the flow through trap. Grease is 10 to 15 percent less dense than water does not mix with water. As a result, fats and oils float on top of water. The captured grease and oils fill the trap from the top down, displacing “clean” water out of the bottom of the trap and into the sewer line or towards a septic tank where it is treated.

Grease traps will be fitted to greywater sources from the restaurant located within the Coach House (28) to minimise the oils and greases from food waste which is directed to the wastewater treatment system.

Grease recovery units are available on the market (Thermaco’s Trapzilla Hydromechanical). The units should be sized and fully serviced in accordance with manufacturer’s recommendations. Generally, grease trap equipment requires regular cleaning and checks to ensure that they function properly.

4.3.4 Composting

“The design and management ethos of Fernhill will ensure that the reuse of site resources will be explicit throughout the Park. This will be through composting, natural decomposition within the wilder areas, and the use of wormeries to facilitate the recycling of food waste, using the silt from the streams to surface the garden paths, re-use of suitable timber arising, etc.”

Food composting using a wormery is an ideal way to turn kitchen waste into a rich compost. It is proposed to include a wormery at the Fernhill Park and Gardens to produce compost from the food waste generated at the restaurant located within the Coach House (28).

A wormery is a closed system which eliminates any potential problems with vermin. To avoid attracting vermin cooked food or egg shells should not be disposed on in the wormery. The wormery should also be located in an area which is passed frequently as vermin will be deterred by disturbances. For best results it is also best to locate the wormery in a sheltered with partial daily sunlight.

The worms needed for composting are known as tiger or brandling worms. For a 70-90 litre bin it is recommended to use 250g of worms. Worms are expected to process approximately half of their body weight in organic matter each day. So 1kg of worms will process 1/2kg of organic waste per day.

Two end products result from the wormery which can be reused for growing of plants and vegetables: Vermi-compost which is fertile material and can be used to enrich soil in the garden or vegetable plots and a by-product of the process, a brown liquid which is drained from the Wormeries which is rich in minerals and nutrients ideal for plant growth.

More information on wormeries can be found on the following website:

http://www.ipcc.ie/advice/composting-diy/composting-using-a-wormery/

Composting of leaf, grass-cuttings and biodegradable waste from the management of Fernhill Park and Gardens will be managed on site. Wood chipping of cuttings and tree-lopping will be re-used as mulch cover for garden beds. Larger cuttings from trees and branches will be put aside in a drying store for use in log fires and stoves during winter.

Biodegradable bags will be made available. Walking of dogs is encouraged in the 9-acre field. Collection points will be provided for dog droppings. These will feed a dedicated animal waste composting facility.

4.3.5 Centralised waste treatment system

It is proposed to locate the centralised waste treatment system within the area of Fernhill Park and Gardens designated as ‘natural wetland area’ (24). This location is the most suitable as there is sufficient space, the area is low lying allowing waste to gravity drain to this point from each of the development buildings proposed in the Park and Gardens and the biodiversity associated with a wetland will assist in masking both visibility and odour of the treatment system. Geotechnical surveys of the underlying terrain indicate that there is a rocky sub-strata close to the surface. Further assessment of the potential for constructed wetlands is required taking into account the hydrogeological characteristics of the proposed location.

Based on recommended wastewater loading rates from commercial buildings as outlined in EPA Waste Water Treatment Manuals – Treatment Systems for small communities, business, leisure centres and hotels (1999) and considering the waste minimisation innovations being introduced to the park it is estimated that a maximum of 15 population equivalent (P.E.) of wastewater is to be treated onsite by means of the centralised treatment system.

The EPA Urban Waste Water Treatment Act (1992) S.I 419 Regulations (1994) were made to transpose in Irish Law EU Directive 91/271/EEC concerning Urban Waste Water Treatment: These provide a framework for action in relation to; collecting system, treatment plants and monitoring of discharges in order to deal with pollution threat from the wastewater. EPA Code of Practice (EPA, 2009) outlines a methodology for assessing site suitability, in terms of soil type, for different treatment systems in order to provide an acceptable level of treatment for wastewater effluent.

Individual site treatment systems are common in remote areas. In the context of Fernhill Park and Gardens this represents an opportunity for the management of waste on site and the use of sustainable innovations in order to minimise waste treatment requirements by exploring waste reuse options. Individual onsite treatment systems typically consist of treatment with a septic tank (or a form of mechanical aeration system), followed by filtration through a soil percolation area, as a minimum. However, depending on the sensitivity of the receiving waters and degree to which nutrients and micro-organisms in the waste water are to be reduced further this can be achieved by inclusion of secondary or tertiary treatment post septic tank.

4.3.6 Septic Tank

Septic tank systems are sized according to the following formula. C = 150 x P + 2000

Where: C is the capacity (l) of the tank and P is the design population, with a minimum of 4 persons. A septic tank with a capacity of 5m3 is required to treat the waste generated in the Fernhill Park and Gardens which is directed to the centralised waste treatment system.

Septic tanks need to be registered within 90 days of connection of the premises to the system. Septic tanks can be registered on line at http://www.protectourwater.ie

The proposed septic tank will precede secondary treatment of the wastewater.

4.3.7 Secondary Treatment

Secondary treatment can be provided by Packaged Wastewater Systems available on market (Activated sludge systems, Biological/Submerged aerated filter (BAF/ SAF) systems, rotating biological contactor (RBC) systems, Sequencing batch reactor (SBR) system, Peat filter media systems, Plastic, textile and other media systems, Membrane bioreactor (MBR) systems) or by inclusion Secondary Treatment Site which is constructed on site. Secondary treatment systems constructed on-site are the most suitable for the Fernhill Park and Gardens Project as these systems tend to be more natural, passive systems such as; soil filters, sand filters, intermittent filters, constructed wetlands, reed beds or willow beds. One of the following or a combination of the following systems will be assessed for their potential to serve Fernhill Park and Gardens. The maximum size of the secondary system would be approximately 40m long and 8 m wide, but could be significantly smaller depending the system selected.

4.3.8 Constructed Wetland

A constructed wetland is a soil-based wetland or form of filtration system which can be used to treat effluent from septic tanks. Also referred to as a Free Water Surface (FWS) constructed wetlands, as the surface of the wastewater lies below the surface of support media. The main difference between a constructed wetland and other filter systems is the planting of vegetation in the media where the thick root mass acts as a pathway for the transfer of oxygen from the atmosphere to the root zone (rhizosphere). Constructed wetlands are designed to have 0 surface discharge. They normally include a mix of plant species which promotes diversification and enhances the aesthetic of the landscape.

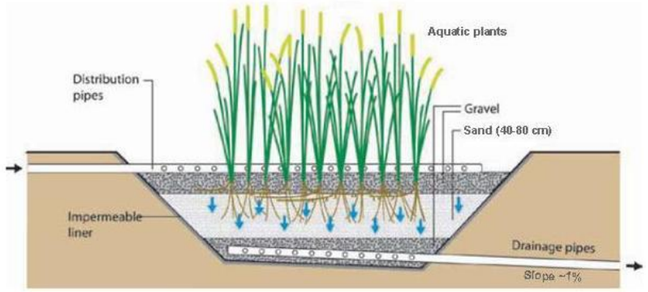


Figure 12 Schematic Cross Section of Constructed Wetland

Figure 13 Constructed Wetlands

4.3.9 Reed Beds

Reed beds are a form of constructed wetland or open filter system planted with exclusively reeds (macrophytes). Reed beds are not as aesthetically pleasing as constructed wetlands due to the lack of diversity in plant species but can provide the same degree of treatment with a much small footprint. Types of reed beds are subdivided based on the direction of flow and the media in which the reeds are planted which include; horizontal flow reed beds – gravel, vertical flow reed bed – gravel and vertical flow reed bed – sand. Hybrid reed bed systems are the most efficient at removing all contaminants and normally incorporate one or two stages of vertical flow, followed by one or more stages of horizontal flow in series.

Figure 14 Reed Beds

4.3.10 Willow Beds

Willow beds are also a form of constructed wetland planted with exclusively willows. Similarly, to the reed beds, willow beds are not as aesthetically pleasing as constructed wetlands due to the lack of plant diversity. The footprint required for the Willow bed lies between that of the smaller reed beds and the larger constructed wetland. There is less guidelines available around the use of willow beds as opposed to the other constructed wetland options. However, in recent years' successful pilot sites for willow beds have been developed by third level institutions in Ireland (DIT, TCD) and the merit of willow beds lies in the fact that they are considered the most ecologically friendly and sustainable way to treat septic tank wastewater particularly in sites where the percolation of the soil is high (greater than 90) willow beds are considered the best solution to ensure zero discharge due to evapotranspiration to air in summer and full storage in winter. A hybrid reed bed / willow bed system have successfully been trailed to achieve zero discharge over a 2-year period in a Co. Dublin pilot (Hogain et al., 2011).

O'Hogain, S, McCarton, L, Reid,A; A review of zero discharge wastewater treatment systems using reed willow bed combinations in Ireland, Journal of Water Practice and Technology, Volume 6, No. 3, 2011. doi:10.2166/wpt.2011.048

Figure 15 Willow Beds

Picture references:

1. https://environmentalconsultingohio.wordpress.com/2013/02/25/an-overview-of-constructed-wetlands/
2. https://arrow.dhttps://environmentalconsultingohio.wordpress.com/2013/02/25/an-overview-of-constructed-wetlands/it.ie/cgi/viewcontent.cgi?referer=https://www.google.ie/&httpsredir=1&article=1028&context=engschcivcon
3. https://www.reedbeds.co.uk/page/do-i-have-to-apply-to-the-environment-agency-for-an-environmental-permit-in-order-to-discharge-the-treated-effluent-or-wastewater-from-my-reed-bed-system-to-a-watercourse-or-to-surface-ground.php
4. http://heartandsoil.blogspot.com/2010/07/permaculture-allotment-from-weeds-to.html

5 Water Conservation

Water is required in the Fernhill Park and Gardens for a range of uses including: for wash hand basins, for tap water in the restaurant, for the flush of toilet facilities, for irrigation of sports fields and watering of plants and vegetables.

Water supplied to the Fernhill Park and Gardens is to be supplied from the Dún Laoghaire-Rathdown public water supply network, which is among the best in Ireland in terms of quality, reliability and leakage control. This supply will be supplemented by a rainwater collection system collecting rainwater from the roofs of the Coach House and Tower Buildings and the reuse of greywater generated within the Park and Gardens.

The reduction of the water demand of the Park and Gardens has rendered to the use of facilities which require less water where possible and otherwise the retrofit conventional systems with water saving technologies such as: self-closing taps, dual flush toilets, waterless and flush control urinals.

5.1 Rain water harvesting

Rainwater harvesting is a technique used for collecting, storing, and using rainwater. There is approximately 780mm of rainfall per year in Dublin. The recommended minimum amount of rain required for a rainwater harvesting system is 400mm per year (United Nations Environmental Programme, 1997).

Rainwater harvesting at Fernhill Park and Gardens presents a potential source of water which could relieve the demand on the Dún Laoghaire-Rathdown public water supply network. The rainwater collected can be used for irrigation of the sports fields or for flushing toilets within the Park and Gardens.

Generally, rainwater harvesting systems are low cost and easily maintained. A roof acts as a catchment area and rainfall which falls onto the roof area is directed to storage tank where fine particles settle out of the water prior to its use.

The roof of the Coach House (28) has an approximate surface area of 162m2. Rainfall is distributed unevenly throughout the year ranging from approximately 50mm in April to approximately 80mm in October.

The calculation of the potential rainfall which could be collected from the Coach House (28) roof is influenced by the following factors as described in the Rainwater Harvesting Systems – Code of Practice (BS 8515:2009+A1:2013):

- Runoff coefficient is the ratio of the rainfall which is collected as some rainfall may be lost to splash, evapotranspiration and infiltration. The runoff coefficient is reflective of the roof material type for a standard pitched roof this can be taken as 0.8.
- Depression storage loss is the rainfall depth before runoff occurs for each rainfall event. This is taken as a maximum of 0.5mm for a standard pitched roof.
- Filter coefficient accounts for the loss of rainfall in the filter system and can be verified by the filter supplier. A typically filter coefficient is 0.9.

Based on the above assumptions the daily collectable water volume in tank from the Coach House roof (28) would range from 0.19m3 per day in the dryer season to a maximum of 0.31m3 per day. This accounts for approximately 10% of all water demand on the Dún Laoghaire-Rathdown public water supply network for use in sinks, showers and toilet facilities in the Fernhill Park and Gardens. This capture of rainfall would require a storage tank of approximately 10m3.

There are several suitable rainwater harvesting systems on the market and available in Ireland including; Bio Pure Tech Rainwater Harvesting Systems (http://biopuretech.ie/rainwater-harvesting-systems/) and Rainman Rainwater Harvesting Systems (https://rainman.ie/).

5.2 Self-closing taps

Self-closing taps or push taps turn off after a pre-set period. The user pushes down on the tap head to deliver flow. The tap automatically closes off after a delay period of approximately 8 – 10 seconds. This mechanism helps to reduce water use by up to 75% compared with conventional tap use. It is proposed that self-closing taps are used for all wash-hand basis (WHB) in the Fernhill Park and Gardens.

5.3 Aerators

Aerators are a type of flow regulator which can be fitted to taps or showerheads. The aerator is a small attachment which is fitted inside the spout of the tap or showerhead. They control the amount of water that flows through the tap/showerhead without affecting the water pressure as they mix the water with air. Aerators can save as much as up to half your water usage through this way. It is proposed that aerators are fitted to the following taps and showerheads in the Fernhill Park and Gardens.

5.4 Dual flush toilets

Dual flush toilets present another water saving mechanism as the dual flush gives the user the option of a regular flush or a low flush. A regular flush utilises 7 or more litres whereas a low flush utilises less than 5 litres. It is that all conventional toilets installed in the Fernhill Park and Gardens are dual flush.

Dual flush mechanisms are available as new and retrofit designs. To ensure that they are used properly it is important to raise awareness amongst the users.

5.5 Waterless and Flush control urinals

Convectional urinals waste large quantities of water, up to 864 l/day for single unit. In attempt to reduce the water demand of urinals, waterless or flush control urinals can be considered. Flush control urinals minimize the quantity of water utilised through use of flush control options which include; manual flush, timed flush and sensor flush options.

Waterless urinals require no water but do require a block or barrier. Three common types of waterless urinal include microbial blocks, oil barrier and mechanical barrier. Waterless urinals contribute to significate water savings, minimise odour normally associated with urinals, and also the by-product if properly stored, can be used as fertilizer. The smell which is normally associated with urinals is the smell of ammonia which is generated when urine is mixed with water, the block or barrier mechanism in the waterless urinals helps to minimize odour.

5.6 Cistern displacement devices

If older toilets (prior 2001 installation) are being maintained the installation of a Cistern displacement device would assist in reducing the volume of water used per flush. The insert works by displacing water (the volume of the immersed object will be equal to the volume of the displaced fluid). Newer toilets are less wasteful of water and this device is less effective.

6 Green Transport Infrastructure

"The design ethos for Fernhill explicitly encourages walking and cycling as the main modes of transport for accessing the Park. DLR through its existing Green Infrastructure Strategy seeks to maximize the potential for walking and cycling routes throughout the County, and has through good Planning and Design already ensured a strong network of pedestrian routes through the residential areas of Belarmine and Aiken's Village among others. Fernhill will expand on this strong off-road network by ensuring that the most prominent access points into the Park are for pedestrians and cyclists.
Equally the car parking provision is carefully designed to fit into the Parks existing topography and woodland at the eastern boundary. It should be noted also that the carpark entrance is at the eastern boundary of the Park, cars will not therefore traverse and dominate the infrastructure within the Park. Notwithstanding this, vehicular access will be provided where necessary to facilitate access for the elderly or mobility impaired Park users in line with best practice in universal accessibility."

6.1 Local public transport amenities

6.1.1 Dublin Bus

Bus

The Stepaside area is serviced by several bus routes running to and from the city centre. The nearest of which runs from the Bellarmine housing development adjacent to Fernhill, through Stepaside village. Adequate public transport services will discourage private car use and promote more sustainable transport methods. Pedestrian crossings are being installed outside the pedestrian entrances to create a safe route from the entrance to the bus station on the far side of the Enniskerry Road.

6.1.2 Luas Green Line

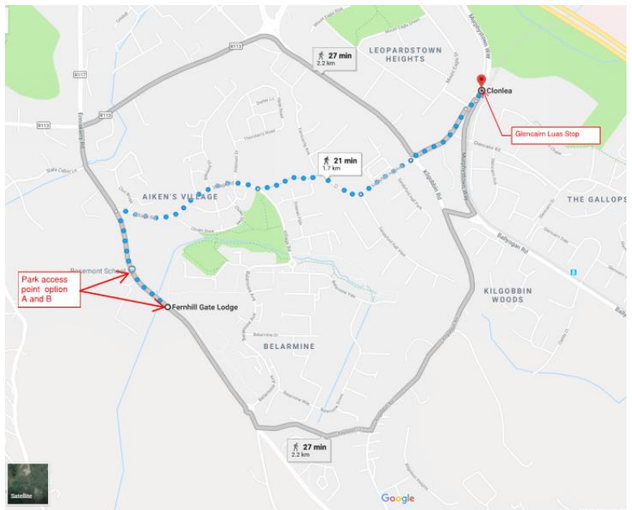


Figure 16: Public transport amenities' in the vicinity of Fernhill Park and Gardens – as shown in the Feasibility Study Fernhill Gardens.

There are two light rail stops within walking distance of Fernhill. These are The Glencairn and Gallops stops on the Murphystown Way and Ballyogan roads respectively. Bus services from Bellarmine and Stepaside also serve the Glencairn LUAS stop. There are a number of ways the public could be encouraged to choose the Luas as their mode of transport to the park and gardens.

- Map signage at the station with directions to Fernhill Park and Gardens.
- Discount on food or beverage at the cafe for those who travelled by public transport – bus/luas
- A shared bike scheme between the Luas station and the gardens. This could be exclusive between the two places or an extension of the Dublin Bike scheme. Some of these bicycles could be fitted with battery assisted motors.

6.2 Cycling routes

Cycling should be encouraged as part of Fernhill Park and Gardens objectives to promote health and activity as well as sustainable transport. A cycle lane runs along the Enniskerry Road and by the entrances to the park. The park management should ensure this route is well maintained – ensure the vegetation is cut back from the road and that fallen leaves are cleared and not allowed to let the surface become slippery and unsafe. Ample sheltered bike racks should be provided for at a location close to the amenities of the park.

Station-less bike share schemes could be employed within the park or used to provide transport from the park to local public transport stops. These schemes are cheaper to employ than providing the necessary infrastructure for the docking stations. With an app on the users phone the bike can be unlocked and then manually locked when the user has reached their destination.

Electric bike use is the largest growing segment of the cycling industry in Ireland. E-bikes can improve the mobility for the elderly or less able cyclists. Charging facilities for e-bikes in the park would encourage their use as a mode of transport to the park and again reduce private car use. E-bike charging could be facilitated close to the cluster buildings as there would be sufficient power capacity in that area for charging as well as being a prime parking location.

6.3 Car Parks -EV charging

3 new carparks are being provided with access to Enniskerry Road through a new entrance next to Rosemount School, refer to figure below:

EV charging is being provided for in each of the three car park segments of the park. DLR County Council typically provide a minimum of 10% of carpark spaces with electric charging points. The EV car parking spaces will be given priority locations in the carpark where possible to encourage their use over petrol and diesel cars.

Parking will also be available for DLR Parks vehicles near the coach-house where a controlled charging point will be made available to draw from wind power when available and during the night.

6.4 Autonomous Vehicles

"It is acknowledged that Fernhill is a large Park of 83 acres with a wonderful variety of challenging topographies and micro climates, from open pastoral areas to winding woodland walks to outstanding horticultural trails as first laid out by the Darleys and expertly improved and conserved by the Walker family. It should be noted therefore that not everyone is physically able to access all of the areas. It is therefore proposed to review the feasibility of providing internal transport via electric vehicles within the Park to maximize access particularly for anyone with mobility issues."

With the advent of Connected Autonomous Vehicles (CAVs), there is a lot of ongoing research to overcome the digital communications and decision making processes required to make this a safe and environmentally friendly method of travel.

Provision will be made for electric charging and data communications infrastructure to support a local CAV circuit within Fernhill Park and Gardens. This will enable those who may not have full physical ability to access the upper and lower levels of the park.

7 Digital / Smart trends and technologies

7.1 Introduction

Digital technologies are increasingly pervasive in our day to day lives, helping us navigate, schedule, find out about places, play games and connect to active interest groups. The visitors to Fernhill will expect digital support for their activities in the park, as well as before and after their visits. Digital technology will be used by DLR Parks to enhance the visitor experience in selected areas of Fernhill Park and Gardens such as at the Tower building and the Coach-house café. Due consideration will be given to immersion of visitors in the natural environment on the various walkways throughout the gardens and care will be taken to avoid digital distractions in areas of natural solitude.

7.2 Principles

It is important that the use of digital technologies supports DLR Parks ambitions for Fernhill Park and Gardens, and, in particular, its ambitions for low carbon energy solutions, peaceful space and community participation, all the while balancing accessibility and conservation. There will be sensitive use of smart technologies to support Fernhill and the wider network of public parks. Digital technology can be thought of as an overlay to the park, in that new services may be rolled out over the life of the park with little impact on physical infrastructure. An approach to ensuring that new digital services adhere to the original ambitions could be to set some principles to guide the use of technology within the park. Below are principles developed for a semi-rural development in Denmark with a strong emphasis on nature and liveability:

1. Citizen Tech—Smart citizens at the core
2. Humble Tech—In service of the city
3. Adaptive Tech—Agile and adaptable
4. Catalytic Tech—Valuable, scalable, replicable
5. Participative Tech—Shared, legible and secure
6. Reflective Tech—Continuous learning.

These kinds of principles could be developed further with stakeholders and the community. Privacy and transparency of what (if any) data is collected will be important to build trust and gain acceptance.

7.3 Experience and operations within the park

The use of digital technologies within the park should support the following aspects:

- Providing practical information about the park
  - Navigation to the park and around the park
  - Providing information about events and facilities
- Telling the story of Fernhill Park and Gardens
  - Education about the horticulture, biodiversity, animals, ecology
  - Education about the history of the park
- Influencing and managing park visitors in how they use the park
  - Information about the making and upkeep of the park—materials, energy data, how it is managed and why
  - Understanding how people are using the park and devising mechanisms to encourage them to use it in a responsible way, e.g. influencing visitors and their dogs to stay out of certain areas while bulbs are planted.
  - Managing biodiversity and collecting and recording biodiversity data.

7.4 How?

Providing practical information about the park

- A map of the park, as well as information about events and facilities will be featured on the DLR Parks section of the DLR County Council website. Many people will access this site while they are in the park, so it will be important to make sure all the information is updated and accessible through mobile devices
- Third party websites such as Google Maps: At the moment, the park does not appear properly on Google Maps making navigation difficult—this will no doubt be addressed through Google's usual updating mechanisms by the time the park opens fully, but in the meantime, it may be worth applying for it to be inputted to support Sunday visitors:

  https://support.google.com/maps/answer/6320846?hl=en&co=GENIE.Platform=Desktop
- Information about sustainable routes to the park, including the locations of bicycles should be included in the map and on the website.
- Internal paths should also be included in third party maps to allow people to use the apps they are familiar with for navigation.
- Allow people to measure physical activity—for example how many laps have people run that day- similar to the Dublin bike lane signage on the Rock Road.
- Booking facilities and participating in the community gardens should be facilitated through the website.
- Accessibility to different user groups could be encouraged through text messages and emails. For example, in the Queen Elizabeth Olympic Park in London, the Ecological Sequestration Trust worked alongside Groundwork London to design a tailored, holistic intervention. They convened a series of workshops using participants who had been identified as being at risk of social isolation (and were over fifty years old). Based on their findings, they developed an SMS service that encouraged participants to visit the park. Each weekly text provided a weather forecast, suggested travel routes (including disruptions), activities and the telephone number of QEOP information line.
- E-ink signage could be used to keep signage within the park updated with information about events, temporary works or new routes. Below is a prototype developed by the Future Cities Catapult in London.

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7.5 Telling the story of Fernhill

- An app which allows for gamification of the park visit could be developed to support educational and operational objectives. It could allow users to take photos of particular plants, find out what they are, collect points (somewhat like Pokémon Go). It could be dynamic in that it could be used to encourage people away from particular places, understand where people are and what they're interested in. DLR Co County Council, together with other Dublin councils is making good use of SBIR procurement to run challenges around smart technologies. This could potentially be procured through an SBIR challenges and extended to cover all DLR parks and beyond.

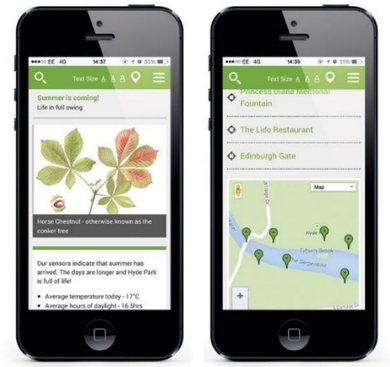
Other options would include procuring a system to create a trail for smartphones and tablets around Fernhill.

- Audio tours could be provided to highlight particular routes and seasonal features. This has been done by South Dublin for Heritage Walks. The online platform and app provide access to a series of audio guides that take the listener on a heritage walk through nine of the County's historic villages. It may be possible to produce audio tours in collaboration with local schools, as was done by The Queens' Gallery in London with London schools for some of their exhibitions.

- Cameras could be installed in specific sites in the park to showcase particular park features, for example to show nocturnal animals or rare plants. These video feeds could be made available on the Fernhill website, and through an app.

7.6 Influencing and managing park visitors

- Environmental monitoring could be used to support management and experience. For example, Intel has partnered with the Future Cities Catapult and The Royal Parks to implement an Environmental Monitoring project focusing on London's Hyde Park. Designed to prototype and test an innovative network of wireless sensors, including soil, air, water and more, the project collects near real-time data on the park's eco-system and social fabric, and explores how technology can help manage and experience urban parks in new ways. Anonymised and aggregated mobile phone data is used to track the flow of people through the park. Live sensor data was used to drive responsive story telling in the park via a City-Insights app. This could be extended to influence how people move around the park by guiding them towards or away from particular features and feeding back real-time information to them.



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A similar approach could be trialled in Fernhill Park and Gardens, perhaps in partnership with the Smart Dublin network and industry partners (perhaps Intel). Further engagement to determine specific objectives and metrics would be needed to evaluate whether this would be the right approach. Other vendors such as ThinkSmarter.io can also provide footfall and dwell time analytics in particular so a more comprehensive approach would need to be explored with regard to the business case.

7.7 Managing biodiversity

- DLR Parks are already using specialist software to map their tree inventory and record the tree surveys, as well as species-specific information on climate and mitigation. It may be possible to make this information public to educate the public on challenges. For example, the City of Melbourne maintains more than 70,000 trees. Their website enables people to explore this dataset and some of the challenges facing Melbourne's Urban Forest.

http://melbourneurbanforestvisual.com.au/

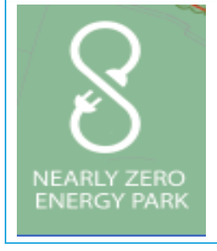
- There may be other opportunities to use technology to monitor various animals. For example, another Intel and Future Cities Catapult project developed the world's first end-to-end open source system for monitoring bats. Echo Beach, the bat classification device, works like a "Shazam for bats". Over 300,000 bat calls have been detected since deployment at the start of June 2017, with an average of 7,000 bat calls per night and a maximum of 20,000+ calls recorded in one evening.

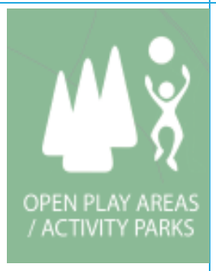
https://futurecities.catapult.org.uk/project/capstone/

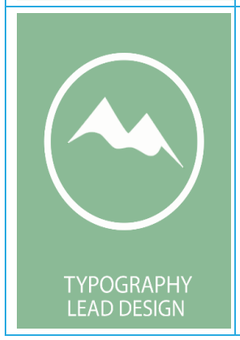
- Collecting information on animals and birds spotted, mosses, insects/bees etc. could be done using gamification through an app (described above). In Melbourne, the cost of doing biodiversity assessments was $1m+ so council decided to crowdsource – they ran a Bio Blitz initiative twice and collected 4,000 data sets – they then went onto to develop a platform to increase understanding of biodiversity. In Ireland, there was an Island BioBlitz in June 2016 organised by the. National Biodiversity Data Centre More information available at https://bioblitz.ie/

8 SMART Goals for Fernhill Park and Gardens

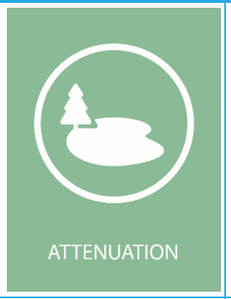
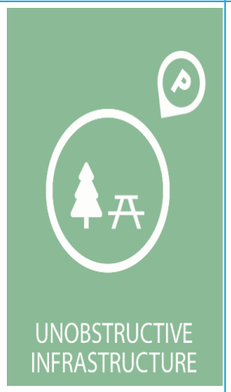
The following table provides an outline plan for implementation of SMART principles in setting out the sustainability goals and objectives for Fernhill Park and Gardens:

	Specific	Measurable	Achievable	Realistic	Timely
	Develop a community garden for growing organic produce; managed by local community groups.	Measure the number of time spent or users/ groups involved in the gardens Measure the produce of flowers or food grown -year on year.	The garden will need to be managed and maintained by an experienced gardener who can provide expertise and guidance to the community group.	Community gardens are now common place in public parks – they can be made into or a single garden operated by a group. With sufficient management of a well-coordinated group, a community garden could be very realistic for Fernhill Gardens.	The community garden is in its early days of establishment. There are existing kitchen gardens and a greenhouse. A committee has been formed to coordinate and manage the garden, taking account of the annual cycle in the gardening calendar.
	Reduce waste and work towards becoming a zero-waste park.	Measure of the amount of recyclable and non-recyclable waste leaving the park premises per year. – number of bin collections etc.	All food waste could be composted for reuse as fertilizer in the gardens. Minimising the use of non- recyclable materials such as plastics, disposable food/drink packaging in the cafés and shop.	With the use of and other composting methods, as proposed in wormeries the report, all food waste could be kept away from bins and composted for reuse in the gardens. This is a very realistic goal with the correct management. There are recyclable alternatives to most packaging. Once the system is established it will be easy to maintain.	This can be implemented early with recycling bins in the park and awareness campaigns to reduce waste The composting facilities and wormeries should be introduced at the same time as the café is built.
	Reduce the use of fossil fuel dependant transport methods by visitors traveling to and from the park.	Document the transport methods used by visitors commuting to and from the park. Monitor of the number of electric vehicles using the charging facilities.	Survey transport methods used by visitors, year on year and monitor the trends towards sustainable transport methods. Encourage public transport and cycling. Develop a clear strategy to encourage sustainable transport methods	If any sustainable transport methods are made simple to use, incentivized and/or reduce commute time their uptake will increase. Improved accessibility to Luas line with signage and way-finders to help visitors find their way to and from Fernhill Park and Gardens.	Incentivising the use of public transport and bike can be implemented immediately when the park opens. EV charging will be implemented in the infrastructure of the car parks.
	Reduce water use in the park and optimise opportunities for efficient water use, reuse and recycling.	Installation of water meters – measure the amount of mains water used in the park year on year.	See report for number of detailed methods for water conservation. Demand can be reduced though management techniques and behavioural change.	The technologies are readily available for water conservation.	The implementation of these technologies are subject to the phasing of the project.
	Become nearly zero energy park	Measure and record the fossil fuel use on the park. Gas and oil should not be used on site so this will be done by keeping a record of imported electricity use and checking the carbon intensity of the electricity used.	Employ someone to monitor energy use on site, implement smart meters, make constant improvements to reduce imported energy use.	The zero energy balance is a difficult target to achieve. Storage of energy on site will play an important part in working towards this goal. Use of digital control systems such as a SCADA will be required for management of the campus energy systems.	Working towards a Nearly Zero Energy Park can be started from Phase 1 of the project with the adoption of the most energy efficient technologies where possible. This is a goal that can constantly be improved on over time.

	Specific	Measurable	Achievable	Realistic	Timely
	Have the park used for education programs for all age groups.	Count of the number of programmes run at the park – year on year. Monitor the quality of the educational programmes run with surveys and general feedback.	There are a number of schools in the locality who will avail of the amenities of the park if the facilities for learning are made evident. There should be educational programs for all age groups showing support for lifelong learning.	A number of Irish parks have a varied and detailed program of events and educational activities. A good model for this would be Farmleigh House and Airfield House where they run painting, gardening and food educational programs.	This will be subject to the building of the tower building community centre for the use of classroom space. Outdoor classrooms in the park will be provided for group learning during the summer months.
	Increase the number of walkers and runners in the park and ensure all parts of the park are visited.	A count of the number of visitors on foot to the park. The on-foot visitor could be counted by a sensor at the gate, or using mobile phones – see digital section of report.	Highly achievable with the advertising and publicity of the park when it opens. Sports events in the park will bring in walkers and runners and create an environment for activity.	The trails will need to be marked or signposted to create an easy to follow loop. Distances travelled along the loop could be shown to motivate runners and walkers.	These can be established with the opening of the park.
	Create a playful landscape that will encourage children to create their own play and adventure. The goal of the play experience in this park will be to bring children closer to a more nature rich experience. A tactile, risk balanced experience with an emphasis on natural materials with a very limited need for any man made elements.	A comprehensive public consultation will be held, taking into account as much feedback from local children and young teenagers as possible. Headcounts and interview type surveys can be conducted with users to track the usage and track if the play areas can instil a sense of responsibility in the children.	There is precedent in other parks and other local authorities for a more nature based play with an element of risk integrated to challenge the children.	All of DLR County Council. main parks have playground facilities. The challenge with this park will be to create a play experience that is unique to Fernhill and may challenge some perceptions of what a play facility should be. In recent years, there was a move towards very sanitised play areas where the element of risk was almost eliminated. A clear concept for this play areas has to be established and promoted. This may be achieved through public consultation or in the form of park ranger interaction.	The natural play areas will be ready for the opening of the car-parking facilities in late 2020.
	Use digital technology to improve the user experience and to achieve the sustainability goals for the park.	Measure the number of users of any digital interfaces implemented. Website, graphic interfaces around the park, mobile app.	See report for a number of suitable digital/smart technologies suitable for Fernhill Park and Gardens	There are many examples of where digital technologies are being integrated into amenities like Fernhill Park and Gardens. Olympic Park, Melbourne Urban Forest.	The implementation of the website, app or graphic interface will be subject to the phasing of the project.
	Generate enough energy from renewable sources onsite to meet the energy demand of the park.	Measure of the kWh generated on site - daily, monthly and yearly – and compare them to energy demand.	Installation of 3 number 25kW wind turbines, PV on the Sport Pavilion, Tower Building, Shop and Sheltered Walkway. Air source and geothermal heat pumps.	The use of RE technologies is increasing and costs are decreasing. There are a large number of PV and small wind turbine suppliers in Ireland. Fernhill Park and Gardens has sufficient space and resources for the implementation of RE technologies.	The installation of the RE technologies – subject to the phasing of the project.

	Specific	Measurable	Achievable	Realistic	Timely
	Source local, sustainably produced materials where possible – eg. FSC Certified Wood. Reuse and recycle materials from the locality where possible. Ensure all workers on site are briefed in the waste minimisation ethos of the park prior to commencing their work.	Track the materials entering and leaving the site throughout the works. Track the distance travelled of the goods to the site.	This goal required a good level of administration and documentation with thorough checking of all materials brought on site. This goal will require strong motivation and clear and simple tracking systems.	We have set the task of sourcing everything within a 75km radius of the park. This is a very challenging task and has required some compromise. Where this isn't possible, as with the new metal estate railing, a sufficient logic has been provided. It is important to set this goal as it has focussed the team on locally sourced material. It has also had a trickle-down effect with contractors and suppliers. With a large organisation such as DLRCOCO making these demands it may have a positive impact on other industries. Sustainable in this instance may also mean quality. The quality of the material ties in with durability and longevity. A simple life cycle analysis may help inform the decision on which products and finishes are used.	As with many aspects of modern society and the convenient consumer world we have built up around us, trying to source material which isn't 'off the shelf' is always challenging. The search for quality, locally produced material is quite arduous and is usually achieved with a degree of compromise on time frame.
	The sustainable execution of work implies work that is efficiently implemented with minimum waste of materials. time and with the lowest possible impact on the landscape. The key to the efficient execution of work is in front loading the project. Thorough planning, design and management will eliminate any superfluous material and actions. Meticulous method statements at the time of construction will also help avoid any complications.	This can be illustrated through the sheer volume of supporting research that has already been completed by DLRCOCO.	Most of this has already been achieved. There are supporting documents for built heritage, landscape, horticulture, public meetings, accessibility etc.	So far, new projects have been completed without any unnecessary impact on the estate. Going forward this will be the ethos with any new intervention.	Projects are ongoing.
	The elevated location of the park in the foothills of the Dublin Mountains dictates and informs every aspect of the project. The core idea of this park project is to let the landscape lead the design rather than a stark man made imposition.	The elevation has challenged the team to design the park in a certain way. If any new feature isn't fully resolved it will become apparent as the park begins to be used and matures. This may become apparent in terms of unwanted desire lines; new areas of erosion; or circulation routes/steps that are causing access issues.	The challenging topography is leading to a set of interventions that respects this fragile landscape. The topography will ensure there is no complacency and lazy decisions made in design and implementation. This goal is a set of interventions that underpins the environment and embellishes the landscape. This mantra is at the forefront of every project we are implementing at present.	We have designed the infrastructure for the proposed park around the challenging topography along with the sensitive preservation of the natural and built heritage in the site. The topography isn't too extreme that a balance between access and preservation can't be reached. It is a realistic goal that a public park can exist in this sensitive location while balancing access and permeability with the careful preservation of the site.	This has been taken into consideration from the very beginning and is ongoing. It will also be embedded in the management of the park once all the project work is complete.

	Specific	Measurable	Achievable	Realistic	Timely
	A playful landscape will be provided for children to create their own play and adventure. The goal of the play experience in this park will be to bring children closer to a more nature rich experience. A tactile, risk balanced experience with an emphasis on natural materials with a very limited need for any man made elements. As much as possible the play area should sit seamlessly into the landscape. A goal of such a playground is to make the younger generation more aware of the natural environment and instilling a sense of pride and guardianship. Integration of turbines into the play area.	A comprehensive public consultation taking into account as much feedback from local children and teenagers as possible. A stewardship programme may help manage the park and prevent vandalism and damage in the future. Headcounts and interview type surveys can be conducted with users to track the usage and track if the play areas can instil a sense of responsibility in the children. Education programmes conducted in the natural play areas.	There is precedent in other parks and other local authorities for a more nature based play with an element of risk integrated to challenge the children.	All of our main parks have playground facilities. The challenge with this park will be to create a play experience that is unique to Fernhill and may challenge some perceptions of what a play facility should be. In recent years, there was a move towards very sanitised play areas where the element of risk was almost eliminated. There can be public pressure for safety surfaces such as rubber crumb and other risk adverse features. A clear concept for the play areas has to be established and promoted. This may be promoted at the public consultation. It's may be in the form of interpretation and park ranger interaction.	The natural play areas will be ready for the opening of the car parking facilities in late 2020.
	The healthy ecology and biodiversity of the site will be enthusiastically preserved and improved wherever possible.	There have been several flora and fauna surveys produced so far. These have included counts and statistics which can provide a base point for any future surveys and analysis.	The goal of preserving and improving the ecology and biodiversity of the park is very achievable due to the elevated, rural and relatively inaccessible nature of the site. Human impact on the site can be more easily managed. There is ongoing pressure to develop sporting and parking facilities in other parks within the county. These parks are relatively flat, open spaces where there is scope for pitches etc.	There is a strong precedent already in place with such an established old woodland and historic collection of built heritage. Compared with other parks, where there is too much emphasis on sports facilities, this park can be maintained in its wild undeveloped state without any public pressure for pitches or other facilities that require infrastructure.	As mentioned already, the precedent for this was in place from the very beginning but will require ongoing, committed management.
	This site is distinct due to the unique and nationally significant collection of plants that is now in public ownership. The challenge will be to balance the management of the trees and plants. Allowing the public access to enjoy and experience the trees in close proximity but also provide a level of protection or restricted access when needs be.	We have a comprehensive tree survey and plant survey. This is the baseline which will be used as a reference point. A key challenge will be to document and record all the new additions to the collection.	Another challenge will be to source relevant plants. This means plants of Irish provenance, of historic association and that are of a unique horticultural quality befitting of such an important collection.	As mentioned already, we have detailed surveys of the existing horticultural collection. This has provided us with a clear understanding of the amount, quality and type of plants we can build on into the future.	The collection has been carefully managed from the beginning and will be added to in time.
	Tree pruning and removal has been undertaken since the estate came into DLR control. The management of the tree collection needs to be balanced with H&S, ecology, amenity& historic value.	We have a comprehensive tree survey which was one of the first reports completed on acquisition of the park. Aerial photos and old maps are used as reference points for tree cover at different times throughout the history of the grounds.	Monitoring the tree population involves visual surveys by parks staff on a regular basis particularly in high use areas and a more comprehensive survey by an arborist at intervals. The tree survey advises on the condition of every individual tree and what sort of management each tree needs as well as what priority it is in the overall scheme.	The relevant experience to conduct formal tree surveys are within the skillset of the Parks staff. The larger comprehensive surveys are undertaken by a full time consultant arborist.	On an ongoing basis

	Specific	Measurable	Achievable	Realistic	Timely
	Install an attenuation pond to reduce the flood risk downstream of the Ballyogan stream.	Monitor and record the water level of the attenuation pond, particularly in periods of heavy rainfall. This will track 'flood risk abated' in terms of the volume of water restricted from flowing downstream in event of heavy rain and flood conditions.	This will require civil and infrastructure works in the construction of the pond. A Flood Attenuation Assessment Report has been compiled to assess the feasibility of an attenuation pond in reducing flood risk.	Natural flood management has gained recognition in many countries as a viable and cost effective approach to flood risk management, with extensive projects across Europe and further afield that have restored peat bogs, planted riparian woodlands, restored and created new wetlands, re-profiled rivers and their floodplains to hold back floodwaters.	The works will be completed in the later phase of the park's development.
	The key statement of intent in the park layout is the decision to locate the parking to the fringes of the park in the least significant piece of land close to the boundary. It is less convenient but will avoid impact on any of the important elements of the site. It seems a simple, innocuous decision but public pressure to provide additional car parking space is an ongoing issue across all parks in the county. A suburban county where there is a large dependency on cars to travel can have negative implications for the park.	A survey to map the modal split accessing the park will create a clear baseline. In the future it is hoped that there are more patrons walking, cycling and using public transport to access the amenity.	A greater effort needs to be put in place to promote sustainable journeys to and from the park. This may be the provision of more bike stands and e-bike charging stands, maps with clear and simple routes to local public transport and maybe other incentive schemes. The park should act as a catalyst for change in the broader community	The use of combustion engines is being slowly phased out but electric cars will still create the same challenges in terms of the provision of car parking space, conflict with pedestrians and potential damage within the grounds.	An initial survey when the park and the car parking area officially open will provide a good base line from which sustainable transport goals can be developed. The idea is to change attitudes to how parks are accessed. People come to parks to experience a more nature rich environment but the paradox occurs where the same people want more convenient parking spaces which is detrimental to the park. This needs to be clearly spelt out to the public and park users.
	At the core of any good design is the mantra 'As little as possible but as much as necessary'. This is acutely relevant in a site such as Fernhill where any new intervention will have a stark impact on the special site. Anything that is not essential is to be omitted. It would be very easy to include facilities that would bring an extra layer of convenience to the park, a conscious decision has been made to strip everything down to the bare essentials. Showing this level of discipline in the beginning illustrates a clear path for the park and how it is used going forward.	The light touch approach could be measured with a calculation of the areas of hard surface and buildings before and after all the proposed works in the site are finished, the topographical survey produced early on in the project can act as a baseline.	The light touch approach will be achieved with a consistent, committed and clear approach to all works completed in the park.	The implementation of all the projects is being managed by the same group of staff which implies that there is a consistent approach to all the projects using the same ethos. It is important that everyone is clear at all times what the goals for the project are. This document itself will provide a clear and concise guidebook for all staff with input into the park design and management.	On an ongoing basis

Appendix A
Heating Options for Fernhill Garden

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Heating Options for Fernhill House and Gardens

Considerations for decision on heating system in Fernhill Park and Gardens

The table below displays a summary of the different heating options based on 7 different criteria one would consider when choosing the optimal heating option for the site. The criteria have been listed in order of priority, hence 'Carbon Intensity' is the highest priority, 'Space Requirements' are the lowest. The 4 heating options have been scored under each criteria, 1 (green) is the best and 4 (red) is the worst. Following the table is an explanation of the pro's and con's of the different heating options to aid in the understanding of the different considerations for each option.

Summary table of the 4 different heating options

	Biomass	Heatpumps	BioGas	Wood burning Fireplaces
Carbon Intensity	1	2	2	1
Labour Intensity	4	1	2	4
Operational Cost	3	2	4	1
Capital Cost	3	3	3	1
Reliability	3	2	2	1
Longevity	2	2	3	1
Space requirements	4	2	2	1

Explanation of the pros and cons to each heating option:

Biomass Boiler
Positives

1. Low Carbon Intensity – Electricity or fossil fuel would not be required, other than for the processing and transports of fuel and pumping of heating water.
2. Fuel could be produced on site or from other parks/woodlands in DLRCoCo.

Negatives

1. Large footprint required for boiler house and fuel store.
2. Higher maintenance requirement, ash removal, wood collection and chipping facility in Sandyford Depot.
3. Fuel supply will need to be delivered monthly/bi-monthly, this could be less reliable in storm or bad weather and delivery by truck will require a suitable delivery route and space for tipping/blowing into the fuel store.
4. Would have flue gas emissions on site.

Heat Pumps – using a hybrid air and water dual heat pump arrangement
Positives

1. Reliable heat source as heat can be extracted from the air and ground even at low temperatures
2. Low maintenance
3. Lower space requirements than for biomass boiler.
4. No flue gas emissions
5. Uses electricity which can be sourced from green source (both on site and from grid)
6. Heat pumps can be controlled to operate during times of low cost electricity (e.g. when excessive wind generated energy is available on grid).

Negatives

1. The power required for the heat pumps will increase the demand beyond levels that will be met with on-site renewables
2. Ground works are required to lay the geothermal piping. These can be laid in areas where planned ground works are being carried out.
3. Delivers lower temperature heating water which requires building heat demands to be minimised. Restoration of the main house will need to keep heat demand to less than 50W/m^2.
4. Heat delivered to space through either underfloor heating or fan assisted convector radiators.

BioGas Boiler

There are two options with a BioGas boiler – both will involve the purchasing of Certificates of Origin (CoO), where a premium is paid to ensure that you have purchased BioGas.

The first option is to have a Natural Gas pipeline brought to site. Gas Networks Ireland will have BioGas included in their grid in the coming years, where CoO will be able to be purchased.

The second option is to have gas tank deliveries. This will reduce the wait for Gas Networks Ireland to bring BioGas to the market as Calor gas have shipments of BioGas to Ireland as of April 2018.

As we discussed, DLR Parks would prefer not to have a fossil fuel pipeline brought to site, the BioGas option would be that of deliveries of LPG and purchase CoOs.
Positives

1. Certification received that the gas you purchased is 100% renewable and has a 50-80% reduction in carbon intensity on the standard LPG.
2. This can be used for gas cooking and for instantaneous water boilers

Negatives

1. The gas you actually use is not fossil fuel free.
2. LPG requires a gas tank on site and the necessary security measures to prevent tampering.
3. There will be flue gas emissions on site.

Fireplaces

Log Stoves could be installed in the rooms of Fernhill house as a secondary source of heat. The chimneys will need to be sealed to prevent unwanted venting of heat which leads to excessive heating requirements.

Positives

1. Simple, well understood method- little training involved
2. Could be fed with stock on site – logs and chippings
3. Creates a positive atmosphere in an old house

Negatives

1. Considerable work involved inside the old house - Installation of stoves and running a flue up the chimney.
2. High maintenance as fuel is fed manually and ash must be removed regularly.

Cross System Considerations:

District heating

All buildings could be connected to a central heating plant.

Positives

1. Modular plant arrangement would lead to improved resilience.
2. A larger, more consistent base load would benefit biomass heating option.

Negatives

1. Ground works required to link all buildings to a central heating system
2. Ideal location for larger plant facility is near the main house. Limited space at Coach house cluster which is being renovated first.
3. Introduces considerable administration effort in managing energy cost (thermal energy metering which is inherently unreliable) and charging to each end user.
4. There would be heat loss on district heating ring mains which can be minimised with pre-insulated pipework.

Micro-grid system management

The use of an electricity micro-grid for the estate would benefit from use of heat pump technologies coupled with underfloor heating. With the introduction of smart metering technologies at a national scale by 2024, Fernhill Park and Gardens could serve as a demonstrator project to show the opportunities of using smart grid technologies to utilise renewable energy at lower costs.

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