Microgrid
&
Strategic Framework

Feasibility Study 2

Internal Report

2 - Microgrid & Strategic Framework

Feasibility Study Report - April 2023

Overview

The Microgrid and Strategic Framework feasibility study involved the following Work Packages outlined in the JTF grant application:

2.1. Developing a Strategic Framework or development masterplan for The Park Ecovillage Findhorn to increase high thermal efficiency, affordable residential accommodation, and commercial premises, with the aim of achieving a carbon neutral settlement within ten years.
2.2. Establish current and future electrical base load to the microgrid for new development, ambient loop district heating and electric vehicle (EV) charging.
2.3. modelling of the low voltage microgrid to understand the impacts on the network increased electrification for heating and transport and modelling to establish the right size of battery for the various likely scenarios.
2.4. exploration of EV charging solutions and an implementation plan to progress towards full adoption of electrified transport solutions.
2.5. modelling to identify the required increase in renewable generation to counteract the increase in electricity demand (and in general the decarbonisation of electrification and heat)
2.6. Identify microgrid control strategies and costing to optimise the existing network and identify which parts of the microgrid will require upgrading.
2.7. Documentation and digitisation of existing infrastructure networks (electrical, water, wastewater).
2.8. Financial consideration and business cases for the indicative solutions arising out of the above.

This report presents the findings of the above work. It should be noted that the communications and control context for this feasibility study was held by Pragmatic Energy/Trilemma Consulting and their report should be referred to in that regard.

Executive Summary

The major findings show:

- The Strategic Framework (masterplan) is currently underway and expected to be completed by June 2023. Main development areas have been identified with indicative numbers of new dwellings to inform the impact on the microgrid for predicting future electrical load, requirements for the ambient loop heating (Project 1) and new renewable energy generation required for carbon neutrality.
- Replacement of 66 poorly insulated mobile homes with high standard permanent accommodation reduces energy requirements by 91% on a m2 basis.
- Additional loading has been calculated for combined ambient loop, EV charging and estimated new construction to increase peak load from 300 kW to 510 kW with diversity considered, or an increase of 70%.
- Modelling by U of Strathclyde has confirmed capacity of the LV grid for new loading, though two areas have been identified as requiring some management or upgrade.
- Electric Vehicle Charging Stations need to be smart controlled to operate outside the peak demand to avoid increasing cable capacities.
- An EVCPs pilot (8-16 charge points) is proposed to allow learnings in hardware, controls, billing and community cooperation towards adoption of EVs.
- The benefits of a battery storage on increased renewable consumption and reduced imports and exports implies a storage capacity of 200kWh.
- There is a positive opportunity for research in relation to the roll out of heat pumps and EVCPs on the microgrid and possible collaborations with University of Strathclyde, Power Networks Demonstration Centre, Scottish and Southern Electricity Networks and Scottish Power Energy Networks.
- New renewable generation to achieve carbon neutrality for electricity would be 225kW wind and 75kW solar.
- Smart Controls for the microgrid have been estimated by Pragmatic Energy at £146k.
- Digitisation of existing infrastructure has been completed.
- Embodied carbon for new dwellings should be considered to provide an accurate picture of the settlement's carbon footprint. A preference should be given to materials with low embodied carbon / embodied energy through our design review process in Park Planning Group.
- That the electrical cables in the Field of Dreams appear to have capacity to accommodate a large electrification of current LPG heating.
- Pineridge electrical cables on the other hand appear to be constrained in the context of significant redevelopment and the use of electrified heating (i.e., heat pumps).
- Electric vehicle charge points (EVCP) should be smart controlled to operate outside the peaks in electrical demand to avoid the need to increase cable capacities at significant expense.
- An EVCPs pilot is a good next step to achieve learnings in hardware, controls, billing, and community cooperation in the progression to electric vehicles. The migration to 60 EVs reduces 56t/yr CO2-e.
- There is a positive opportunity for research in relation to the roll out of heat pumps and EVCPs on the microgrid and possible collaborations with University of Strathclyde, Power Networks Demonstration Centre, Scottish and Southern Electricity Networks and Scottish Power Energy Networks in this regard.

- Post North Whins and with a full ambient loop, a significant redevelopment of Pineridge and around 60 EVs before 2030, the required renewable generation to achieve carbon neutrality for electricity would be 225kW wind and 75kW solar.
- If a new wind turbine is not possible then 470kW of solar would be required to achieve the same result.
- If ASHPs were rolled out instead of ambient loop, then the required renewable generation to achieve carbon neutrality for electricity would be more like 225kW wind and 175kW solar.
- At the expected longer term future electricity tariffs a new 225kW wind turbine appears to be a financially viable project for FWP. A possible JTF loan with an attractive interest rate could support the business case. Further work is required to build a strong business case.
- A solar farm is marginal and would likely require some grant assistance to stack up financially. A solar farm project is likely best held by Findhorn Wind Park (FWP).
- The export limitation of 975kW is a challenge that needs to be overcome to increase renewables at any real scale. With 675kW of wind and 85kW of solar we have 215kW remaining before reaching the limit. Several options exist with the cheapest likely to be a G100 export limitation system.
- Due to the nature of renewable generation and demand for The Park, the benefits of a battery on increased renewable consumption and reduced imports and exports implies a battery of around 200kWh. The simple payback at current prices is around 10 years and financing cost would only increase the payback. Without some form of financial support, it is unlikely that a battery will stack up.
- A solar carport with batteries and EVCP could be a good project for supporting constrained networks in Field of Dreams and Pineridge whilst providing more renewable generation and EVCPs.
- Future electricity pricing might level out at around 35-37 pence per kWh. This needs to be factored into any business cases for electrification of heat or transport.
- Shared EVCPs are essential for some areas of The Park where home charge points are not possible. Establishing a shared EVCP system will promote the switch to EVs.
- Establishing a shared EVCP system early may ensure microgrid capacity is not taken by private EVCPs in areas of constraint. This will support the electrification of transport across all areas of The Park and levelise the cost of EV charging across the community.
- AC charging of 7kW will meet most needs, however the additional cost of 3 phase versions charging at up to 22kW is minimal. 22kW EVCPs offer better phase balancing and the possibility of faster charging where the microgrid has capacity and should be the norm for a shared EVCP system.
- DC charging at 50kW
- The Easee charging system may offer the most flexible and reliable smart control options to integrate with The Park microgrid.
- The Easee charging system offers of access control and the possibility to develop a simple PAYG payment system suitable for residents. This will avoid the need for a back-office system that increases costs to users significantly.
- An Easee API based PAYG payment system could be enhanced to be offered as a service or licenced software. It could be useful to housing associations and flat dwellers - wherever shared parking is used by a defined group and direct connection of a home EVCP to individual consumer units is not cost effective.

- Initial phase installation of shared EVCPs must include planning for future expansion. This can reduce the cost of adding further EVCP capacity by 70 to 85%.
- Initial EV Charge Point (EVCP) Pilot project to include six EVCPs in East Whins and 2 EVCPs (combined with solar PV Canopy with battery storage over Centini Parking lot) in Field of Dreams with preparation to double the EVCP count in each location in a subsequent phase.

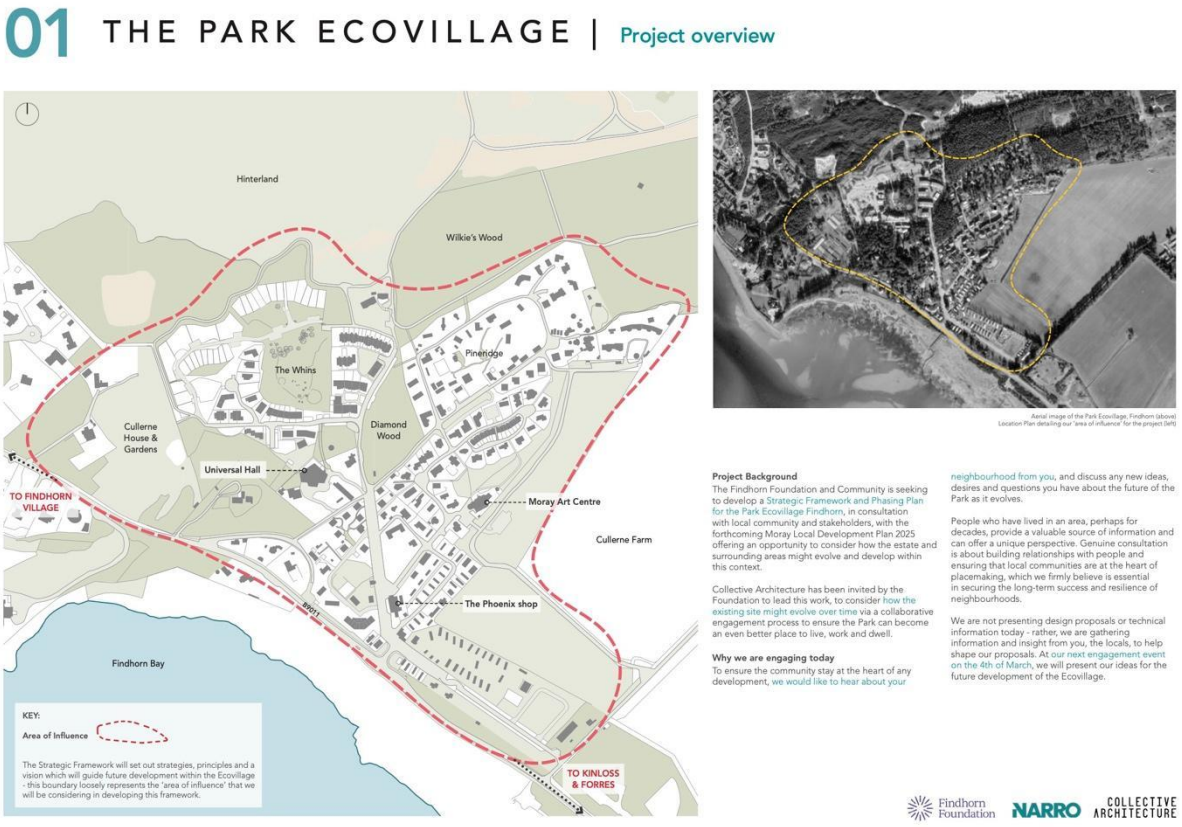
2.1. Strategic Framework/Masterplan

Written by John Talbott

The Park Ecovillage residents and titleholders in collaboration with the Findhorn Foundation engaged Collective Architecture (CA) as the principal consultant to undertake a strategic framework for development of the remaining areas of the Ecovillage, including issues of traffic, resident and visitor parking and the replacement of ageing residential mobile homes and buildings on the site with high standard and affordable residential accommodation. The strategic framework has since been identified as a good fit with a Local Place Plan (LPP), whose purpose is:

> *To allow communities to have a more direct role in the decisions that influence their place, when preparing the next Local Development Plan, the Council must consider any registered Local Place Plan. These are community-led plans, setting out proposals for the development and use of land and offer communities the opportunity to develop proposals for their local area, expressing their aspirations and ambitions for future change. Once they have been registered by the planning authority, there is a legal responsibility to take them into account in the preparation of the Local Development Plan.*

The Strategic Framework, now adopting the Local Place Plan approach, requires a wide community consultation that commenced in November 2022. With an internal design group of key community stakeholders (DevCom) working with CA the consultation process was designed for the first half of 2023. This started on 30th January 2023 with the first event and has now included five separate face to face meetings, numerous individual surgeries with individual community members and groups.



Meetings with external stakeholders such as Moray Council departments of planning, traffic & flooding, the MOD, Findhorn & Kinloss Community Council, local residents and neighbours have also been held.

Final development of LPP to be presented to Moray Council is ongoing and outside the scope of the JTF feasibility study. However, it is expected to result in a submission of Call for Ideas on 30th June 2023 and final submission of a LPP for Findhorn Ecovillage by the end of July 2023.

The early studies of the site have resulted in what was required for our feasibility study, namely identifying the number of potential new buildings that could be accommodated on the site, either through infilling current vacant lots or by replacing existing residential mobile homes. This has allowed the assessment of potential future loading on the microgrid and other services and allowed the modelling of various scenarios of energy provision through solar, wind and battery storage.

Loads from the Ambient Loop study have been calculated on both existing buildings currently being heated with LPG and for future buildings also to be heated by ground source heat pumps supplied from the ambient loop.

Implementation of the developments anticipated from the LPP is expected to take between 5-10 years. The resulting benefits in addition to the significant upgrade in housing quality include:

- Replacement of 66 poorly insulated mobile homes with high standard permanent accommodation reduces energy requirements by 91% on a m2 basis and will result in a reduction of carbon emissions by 132 t/yrCO2-e.

- Emissions savings from elimination of LPG for heating for 65 existing homes is estimated at 128 t/yrCO2-e as detailed in the Ambient Loop feasibility study.

2.2. Low Voltage Infrastructure

(Covering work packages 2.2, 2.3, 2.6)

Written By Paddy Atkinson

Electrical Cables

Load Modelling

University of Strathclyde (UoS) performed load modelling for the entire Findhorn LV microgrid to assess potential supply constraints caused by the large-scale adoption of heat pumps (assuming an ambient ground loop system) and EVs.

A critical factor in the modelling of expected loading of the network is the assumed diversity factor. UoS deferred to industry tools offered by Scottish Power Energy Networks (SPEN) and Northern Power Group (NPg) to arrive at realistic After-Diversity-Maximum-Demand (ADMD) figures for the electrical network. The NPg tool was chosen as the best option for the load modelling and can be found here. The NPg and SPEN ADMD approaches were triangulated with CIBSE diversity assumptions used by Town Rock for thermal diversity and there is a general consistency between the different approaches.

It should be stated that ADMD figures are crude, and the industry is still learning how to design for heat pumps and EVs more accurately. An example of how the theory deviates from reality is captured in the example of East Whins which has 26 ASHPs. When modelling using NPg ADMD figures the maximum load is expected to be 182kVA whereas real time logging showed a peak in March 2021 of 52kVA (30% of the theoretical maximum).

The encouraging thing to note is that, assuming all future EVCP are smart controlled to avoid operation during peak periods, the modelling shows that all Field of Dreams and Pineridge existing cables are likely to have adequate capacity (from a current carrying capacity point of view) to accommodate the entire ambient ground loop system. It should be noted that the Pineridge newbuilds are expected to be thermally very efficient (e.g., Passive House standard or greater) and the NPg load modelling is probably very conservative (in reality the peak loading would be expected to be considerably lower given the intended housing standards) which adds further confidence of the existing infrastructure being adequate (from a purely current carrying capacity point of view).

Another standard providing guidance and information on the design and planning for new Low Voltage (LV) networks is the Independent Networks Association (INA) Low Voltage Design Policy (found here). It offers an alternate method for calculating ADMD (ref section 5.10.2). This method is arguably cruder than the NPg and SPEN tools, but it does provide another means to triangulate the ADMD results. Using the INA method the total ADMD for Pineridge redevelopment is 182kVA as shown here (note that the INA methodology only addresses ASHP and not GSHP, thus ASHP numbers have been used). Comparing this to the UoS models it is significantly below the estimate of 253kVA. For Field of Dreams the total INA ADMD is estimated at 122kVA as shown here. This is compared to 138kVA as calculated

by the UoS models. This supports the notion that the UoS model is more likely the worst case compared to the INA method.

It should be noted that the INA estimates for East Whins is 67kW which matches quite closely to East Whins logging data in the late winter months, which showed a 52kW peak. This may imply that INA numbers are more indicative for new build housing with good thermal performance however more investigation is needed.

The UoS load modelling spreadsheet can be found here.

Voltage Drop

Voltage, however, is another story. Typically, industry guidance designs for a maximum voltage drop of 5%. Note however this is a simple "deemed to comply" value as far as the regulations are concerned and in some circumstances engineering judgement may be applied to permit a larger voltage drop. In the case of The Park an HV-DNO supply via a private transformer exists and a larger figure is acceptable if Electricity Safety, Quality and Continuity Regulations (ESQCR) are maintained.

> *... '(b) in the case of a low voltage supply, a variation not exceeding 10 per cent above or 6 per cent below the declared voltage [230] at the declared frequency.*

This condition allows for a range of 216V to 254V. Logging at the Earthship substation in April 2021 showed a minimum voltage at the Earthship of 240V. This indicates that a voltage drop of 24V may be allowable up to the furthest point/s on the network.

Voltage drop calculations for Field of Dreams and Pineridge for the entire ambient ground loop system indicates a voltage drop of 16V for Field of Dreams and 35V for Pineridge:

Area	Calculated Voltage Drop
Field of Dreams	16V
Pineridge	35V

As can be seen the expected voltage drop for Pineridge would exceed the limits which would likely require cables to be upsized. That said more detailed modelling is recommended for the new housing which may actually have a significantly lower ADMD (as per INA numbers above) which would therefore reduce voltage drop and may reduce the need for upsizing of electrical cables.

Cable Replacements

Potentially constrained cables are communicated on this map.

As communicated in the above modelling summary the Field of Dreams cables may have adequate capacity from a current and voltage perspective. However, Pineridge appears to suffer from too much voltage drop. If Pineridge cable replacements were required the cost would be in the order of £55K as shown here.

With a large electrification of heat via heat pump and un-controlled EVCPs the modelling results indicate that cables in both the Field of Dreams and Pineridge might exceed capacity. Which could lead to a cost in the order of £75K (as shown in the above linked document). This reinforces the need for smart control of EVCP.

Embedded Batteries to Support a Constrained Grid

Looking at historic logging data for Pineridge it shows 7:30-9am and 5-6pm peaks. An embedded battery system could be used to support constrained infrastructure during peak periods. Such a battery would need to be able to discharge a suitable amount of power to keep the cables within their rated capacities and keep voltage drop within acceptable limits. Such a battery installation could also be coupled with a solar carport and EVCP. This is a possible R&D project and a neat pilot project. A system of this kind is envisaged in north Pineridge and the Centini carpark in the Field of Dreams.

In the context of Pineridge, if a system of this kind could be delivered for less than £55K then it probably represents a capital saving against installing new cables. Other benefits of renewable generation, batteries and EVCP may also result, thus further justification for such a solution.

Cable Losses

Heavily loaded smaller cables will suffer higher losses than lesser loaded larger cables and it is recommended that cable losses be investigated further during detailed design phases.

Detailed Engineering

Whilst the above-mentioned modelling results provide some steering regarding the impacts on existing infrastructure due to the electrification of heat and transport, detailed engineering is required.

Future Research Opportunity

There are several research angles that could be leveraged in support of a funding application for the ambient ground loop and smart control system.

1. As aforementioned the science behind ADMD is crude and detailed network monitoring (via the newly installed sub-metering and other planned metering) presents an opportunity for valuable learning in the national context.
2. Learnings about the effect of large-scale heat pump roll out on harmonics, power factor and voltage flicker are valuable learning in the national context.
3. Learning about the impact of electrical ‘noise’ created by heat pumps in relation to power-line communications (being proposed by Trilemma Consulting for control and monitoring) would be valuable learning in the national context.
4. The use of embedded batteries in the microgrid to mitigate overloading and other electrical engineering challenges would be valuable learning in the national context.

Early conversations have been held with Energy Systems Research Unit (ERSU) personnel at University of Strathclyde (UoS) about the research benefits of the above points and they expressed interest in a project as described above. There may be opportunities for ESRU via Innovate UK and EPSRC to engage in such work. Being a department of UoS, ESRU has a direct relationship with The Power Networks Demonstration Centre (PNDC) who work with Scottish and Southern Electricity Networks (SSE) and Scottish Power Energy Networks which may be a way to engage SSE in a project to learn from a microgrid with embedded wind and solar generation in the context of export limitation.

2.4. Electric Vehicles

(Covering work packages 2.4)

Written By Duncan Easter with contributions from Paddy Atkinson, JR Fulton & John Talbott

Starting Point and Future Demand

There are approximately 135 private residential vehicles in The Park with a conservative estimate of 170 private vehicles by 2036 given the additional residences that are likely to be built. However, a more widely adopted car sharing scheme and community EV shuttle bus service could significantly reduce this number. Reducing the reliance on cars for personal transport and thus the overall numbers of vehicles is by far and away the best option to be pursued whilst creating infrastructure for the transition to electric vehicles.

Our existing car sharing entity, Moray Car Share (MCS) has six vehicles: 3 are EV with dedicated EV Charge Point (EVCP) that are used cooperatively and hope to transition all vehicles to EV. Guest and Visitor vehicles are more seasonal but can be more than 100/per day.

Typical EV Charging Demand

Average UK mileage is decreasing and has recently been affected by the pandemic. At 8,000 miles pa, a typical EV will require 2,400kWh of charge. On a 7kW EVCP this will take 343 hrs pa - just 4% of the year or 13% of the night rate electricity hours from midnight to 07:00. A survey forming part of the NFD Energy Technology Partnership (ETP) study in 2021 showed average annual mileage at The Park is 5,300 miles, 70% of the above figure.

Either figure suggests that there is considerable scope for shared EV charging facilities at The Park if it is restricted to the use of residents, their guests (including trades) and possibly the staff of Park businesses. The number of EVs that can be served per charge point will depend on the particular lifestyle and requirements of the individual drivers. It is not realistic to expect drivers to go out at all hours or traverse large distances to facilitate connecting another's car to a charge point.

Private Charging Stations

MCS currently has two dual port EVCPs at The Park on the Charge Place Scotland network. Running a car share scheme requires dedicated parking spaces and EVCPs. MCS currently have three EVs based at The Park and are looking to further electrify their fleet. MCS makes a significant contribution to lowering CO2 emissions from Park based driving but is unable to make charging capacity available to other residents in the future. Rather, MCS is likely to require further private dedicated EVCPs.

In the absence of suitable shared EVCPs for Park residents, EV owners at The Park must install private charge points, delay purchase of an EV or arrange their driving habits to make use of public charge points, mainly off site. Private charge points can be a solution, but present a hierarchy of apparent challenges:

1. Plot sizes at The Park are typically small and many homes have been designed **not** to include/allow a car parking space on the plot. Two neighbourhoods, (FoD and The Whins) were designed to specifically prohibit on-lot parking. The Central Area and Pineridge have yet to have any coherent parking policy.
2. About a third of existing homes are terraced properties, flats, or tightly clustered units, such that it is not possible to create a private parking space on the plot even if allowed. Existing parking arrangements at The Park are mainly small parking areas spread across the site. This is sometimes linear parking (parallel or more commonly orthogonal), but the separation from the homes served varies, from 10m with many over 50m.
3. The shared parking areas created are currently owned by the Findhorn Foundation or Duneland Ltd. Purchase of a plot or house gives the owner a right to use the shared parking rather than legal ownership. The number of car spaces provided in the two areas that have been through planning approval (FoD and The Whins) are considerably less than would be normally required by Council. The Central Area and Pineridge have not gone through a dedicated parking provision process, though it is anticipated that this will happen during the current Local Place Plan (Strategic Framework) planning process.
4. In general, parking spaces are not allocated to individuals or specific properties.

The first challenge creates a necessity for shared EVCPs as EVs become the norm. Park Planning Group guidelines and policies could be changed to avoid this problem for future homes, but the need for shared EV charging points will not go away.

The second challenge of terraced properties and flats makes the cost-effective installation of private charge points difficult or impossible.

The third challenge and legal issues of parking areas not being controlled or owned by homeowners, adds complications and potentially further expense, and making cost effective private charge points less likely.

The fourth challenge of parking spaces not being allocated to individual owners/residents is a matter of policy that could be changed. However, the existing shared parking system allows more flexibility and can accommodate a greater parking demand with the same number of parking spaces. Nevertheless, disabled spaces exist and have been created for specific residents. when needed. This has been both on plot when possible, or at the nearest shared parking space available.

The significant challenge that is less obvious is the capacity of the microgrid to support EVCPs. If spare capacity is allocated to early adopters of EVs for private charge points, it may become more difficult to meet the overall demand for EV charging in the future. This will particularly be the case in Pineridge and the Field of Dreams where the microgrid will become more and more constrained with the electrification of heating to replace LPG gas

systems. Home charge points typically are 7kW single phase devices. This means the phases will likely not be balanced and for some connections phase balancing measures may be needed.

Private EV charge points may also be shared with neighbours. It may be possible to mandate this for future private installations, however there is no guarantee that early adopters of EVs will be in the same neighbourhood of The Park.

Convenience and the lower VAT payable on electricity supplied via a domestic consumer unit may lead to a push for private EV charge points. Domestic supply is rated at 5% VAT whereas commercial public EVCPs is rated at 20% VAT. Private EVCPs may be a necessary part of the mix. A parity charge agreement for private EVCPs may be a solution to remove the VAT advantage. The likely level of a parity charge is considered in the costs section. The capital cost of private EVCP installations is also compared to that of shared EVCPs.

Shared Charging Stations

Grouping charge points in a parking area is likely to draw a variety of usage profiles to one place, increasing the number of EVs that can be served. Appropriate spacing of charge points within the car park will allow access to a single charge point from more parking spaces. This reduces the need for EVs to be moved solely to allow access by another driver.

It will be a matter for experimentation, including neighbourly cooperation, but it is hoped that at least five EVs can be served by each ‘residential’ EV charge point at The Park. If average annual mileage at The Park is 5,300 miles, this could be achieved by each EV being charged for 3.5hrs each night.

In practice this might mean a group of five EV drivers agreeing one night of the week for their own priority use. This would leave two nights of the week and all the day time charging still available. As one of several such arrangements, this will likely meet the needs of the less predictable real driving patterns.

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Advantages of shared charging stations include:

- Lower capital investment per EV served.
- Better use of microgrid capacity, particularly in constrained areas.
- Simplified integration of smart grid controls (demand side response).
- More efficient load balancing of the microgrid using 3 phase chargers.
- Faster charging when local load and the EV allow using 22kW chargers.

The disadvantages of shared charging stations include:

- Greater capital investment per charge point.
- A significant NFD connection charge (which may be waived or reduced).
- Capital investment is required in advance of demand.
- Domestic 5% VAT rated electricity cannot be used.
- Some form of billing / back-office system is required for invoicing users.

AC Charging (Maximum of 22kW per socket)

AC EV charge points are typically offered as 22kW (3 phase) or 7kW (single phase), though the actual power delivered depends on the capability of the EV connected, its state of charge and the capacity of the local grid. Relatively few 22kW capable EVs are now being produced as home charging at 7kW (single phase) is proving to meet most needs. (Where higher charge rates are needed this is usually top-up charging using public DC charging stations.) Nevertheless, three phase chargers have the advantage of phase balancing the EV charging load. The additional cost compared to a single phase 7kW unit may only be about £100 (depending on the brand) which is small when installation costs are considered.

Various suppliers were contacted about shared charging infrastructure including PodPoint, Egg, Bumble Bee, Charge My Street, Connected Kerb and Easee. Many only provide charge points linked to their own back-office system. The back-office systems are linked to an app, but most provide limited tariff options and lack the facilities to integrate smart control on a private microgrid.

Connected Kerb offers quality UK made charge points using the Ampeco 'white label' back-office system and app. They provide on street charging and do not supply home charging hardware. Ampeco was the only back-office system found to offer the full suite of options that might be required for a smart microgrid at The Park: dynamic load management and multiple tariffs to allow for time of use, grid import/export and type of user.

The Easee Commercial EV charging is offering is a Norwegian system allowing up to 101 chargers to be connected to a single cable. Easee makes a single phase 7kW version suitable for home charging. Easee provides a user app giving the user's charging history and an API providing access to information on who charged when and the kWh used. They do not provide a back-office system of their own but work with third parties where one is required.

Easee commercial chargers form local networks that are programmed with the supply cable rating at commissioning. These local networks share information on the demand at each charger and ramp back charge rates as necessary to protect the supply cable. Whilst charge rates may become unacceptable, there is no practical limit on the number of chargers that can be safely connected on a single cable.

In contrast, Connected Kerb suggests no diversity connections to avoid tripping the supply circuit when all charge points are in use. This would result in all EVs connected to the circuit receiving no charge until it is reset. The Independent Networks Association (INA) best practice recommendation allows 0.8 diversity for EV charging circuits.

In either case, the cost of connections for groups of shared EV charge points will be much lower for Easee chargers than for other systems.

Public DC Charging (50kW per socket or more)

DC charging is typically used for rapid top-up charging whilst making longer journeys away from home. This is often during the day, as most EVs can be fully charged overnight from a 7kW home charger. DC EV charging will be important for visitors to The Park and will be a useful facility for residents needing rapid top up charging when they have high mileage peaks in their driving pattern.

The installed cost of a DC-EVCP is significantly higher than an AC-EVCP by a factor of about 6. Significantly higher kWh rates will be needed to cover the much higher installation cost.

The usage profile means DC charge points must be installed in areas where the microgrid is not constrained. Both the increased per kWh cost and the likelihood that a DC-EVCP may be further from home make them unattractive for routine use by residents, workers at Park based businesses or Moray Car Share.

Neither Easee nor Connected Kerb make DC chargers, though the latter can integrate them through the Ampeco back-office system. DC chargers will need a separate maintenance contract to AC chargers, though this could be from the same provider.

As part of installation costs, for each connection to The Park three phase microgrid for either shared EVCP or Rapid DC EVCP, NFD currently requires a £5,000 connection fee for either a 22kW currently requires a £5,000 connection fee for either a 22kW or a 50 kW three phase AC supply or a 50 kW three phase DC supply. However given the nature of providing EVCPs as community service, the figure could be negotiated downwards.

Locations

A map can be found here that proposes six initial EVCPs for shared charging stations across the Park for a pilot project.

EVCP installations at two of the shared parking areas have been costed: immediately to the south of East Whins and the Centini car park. The microgrid at the Centini car park location is likely to be constrained by the addition of heating loads from the ambient loop GSHP project and is also a location considered for a solar PV carport and battery to support the microgrid.

EVCP Parking Layout Strategy: For residential vehicles, a single EVCP on a column will be placed at head of central in parking place of 3-5 contiguous/adjacent parking spaces. The single EVCP will either serve three unmoved vehicles with standard 6m cable or five unmoved vehicles with custom 12-20m cables. Use of this configuration will reduce need for an additional “rollover parking space.”

Infrastructure

As per the section of this report on load modelling it is recommended that all EVCPs be smart controlled to avoid the peaks. This is because EV charging during peaks could quickly lead to cable capacities being exceeded and introduce the need for new cables to be installed at significant expense. The future rapid charging locations shown on this map here are in locations that are expected to allow un-curtailed charging (or at least only minimal control to avoid exceeding infrastructure capacities).

Billing

All EVCPs sold in UK are OCPP compliant. This means they can connect to suitable back-office systems to provide access and billing functions independent of existing community billing systems such as NFD's or Moray Car Share's. However, these back-office functions come at a price which is loaded onto kWh rates and/or licence fees.

For 7/22kW AC charging the loading is often in the cost range 30-60% over the current NFD electricity cost. The Easee EV charge system includes control of access to charging using RFID tags. A free API can be used to download usage data including the user and time of use. This information could be used to bill residents and workers through NFD for a modest administration fee. This should be the lowest cost, but NFD may not be willing to do this. Another invoicing/payment system would then be required.

One possibility that could work for Park residents and workers is a prepayment-based system. Like most EV chargers, Easee comes with a free app that allows drivers to monitor their charge history. This would allow EV owners to know when their credit was low and to top up. A minimum credit equal to six weeks typical usage would be affordable and allow for monthly routine administration.

If a 50kW DC-EVCP is provided it would be available to both the general public and to residents. Use of an OCPP compliant back-office linked to the charge points will be the practical solution. Residents would be charged through this mechanism in the same way as other users.

Smart Controls for EVCPs on The Park microgrid

Communications Platform

A communications test is scheduled for early May with Trilemma Consulting whereby power-line communications, LoRa and industrial wireless system will be installed and tested over a period to inform data collection from Modbus metering, possible control communications within the microgrid and communication with the wind park. This test should provide a good indication of the appropriate way forward for a communications platform for The Park.

Smart control also requires loads on the microgrid to be able to respond to the data shared via the communications platform. This is considered for different types of EVCPs in the following sections.

7kW and 22kW EV Charge Stations

EVCPs sold in the UK must be smart chargers, Open Charge Point Protocol (OCPP) being the industry standard. They must default not to charge during the peak periods (between 8am and 11am, and 4pm and 10pm on weekdays) **or** have a Demand Side Response (DSR) agreement in place at the time of sale. The default off peak charging can be overridden by the user.

Ideally, we would like to have full control of EVCPs through the features offered by OCPP 2.0:

- Communicate prediction of local available capacity for production and generation
- Fitting production and generation of flexibility resources to grid capacity
- Acts between Flexibility Providers and Capacity Providers
- Applicable for site owners, utilities and more

Currently chargers on sale are mostly OCCP 1.6 compliant, which does provide smart charging support for load balancing and the use of charge profiles. A few use its update OCPP 2.0.1 with improved features. Whilst these are open protocols, their implementation is the domain of specialist software companies. Many offer the back-office billing functions, but fewer currently offer the ability to implement smart controls.

Ampeco is one such company that does, with a quality 'white label' offering aimed at medium to large EV charging network operators. Connected Kerb is a UK operator using the Ampeco platform with their own quality on street charge points. Collaboration would be needed to integrate input signals from the microgrid (such as cable loadings and site import/export) via internet. Connected Kerb do not offer home charging solutions.

Direct switching of the EV charging circuits is likely to cause problems with OCPP charge points. During a power outage (be it planned as part of a control strategy or otherwise) the cable will not be locked into the charge point. However, depending on the model, charging sessions may not resume reliably or at all. Connected Kerb charge sessions must be restarted manually.

Easee chargers are made in Norway and have a high level of intelligence built in. Up to 101 Easee chargers can be connected on a single supply. The chargers on a supply are configured as a local WIFI network and are collectively managed so as never to exceed the cable capacity programmed at commissioning. An 'Equaliser' device can be installed that effectively allows this cable capacity to be changed dynamically.

The Easee Equaliser is available as a 3 phase kit including a meter and either 100A CTs or 500A Rogowski coils. Comms with the meter is by Modbus RTU (RS-485) connection. Wiring details for connection to a variety of Modbus meters are available here. The use of Modbus meters means the data can be accessed for other purposes. It opens the possibility that an Easee Equaliser might be made to control the connected Easee chargers in response to signals from remote parts of the microgrid, e.g., reducing site demand during peaks. This would be subject to trials.

If controls need to be applied to each circuit, private charge points will be more costly to integrate into the smart grid than groups of shared chargers. The Easee One is a home charging solution sharing much in common with the commercial chargers and may be easier to integrate through the API provided than others. This would also be subject to trials.

50kW Charge Stations

One or two 50kW charge stations would allow visitors to The Park to top up their EV whilst shopping, visiting the cafe, etc. They would also be useful for residents when needing a faster charge. This usage and the need to recover the capital investment mean controls to limit the power available are undesirable. Moray Car Share may occasionally wish to use a 50kW DC charger if a car has not been successfully charged on their own EVCP after use.

Budget

Quotes were requested for EVCP installations at two contrasting shared parking areas: East Whins and Centini car park shown here. The microgrid at the East Whins site is not constrained unlike the Centini car park. The end user monthly costs are tabled below for the Connected Kerb and Easee systems and a private installation.

End User Costs

Monthly Operating Cost Per EV	Unit Basis	Private (Std Rate Connection)	Connected Kerb 8 Sockets	Easee 8 Sockets	Connected Kerb 16 Sockets	Easee 16 Sockets	Charge My Street
No. of cars served by a single charge point.		1	5	5	5	5	5
Capex Cost over 10 years	Per Socket Per Mth	£12.00	£69.05	£52.45	£43.29	£29.23	
Licences and Maintenance	Per EV	£0.00	£7.40	£7.00	£7.40	£7.00	
Typical Network Operator kWh Levy	Per Month	£0.00	£16.50	£0.00	£16.50	£0.00	£20.00
NFD Electricity Cost for 6,000 miles pa	Per Month	£45.11	£44.50	£44.50	£44.50	£44.50	£44.50
Total Cost Per Month	Per EV	**£57.11**	**£82.21**	**£61.99**	**£77.05**	**£57.34**	**£64.50**
Monthly Parity Charge	Per EV using a private EVCP	Parity Charge	**£25.10**	**£4.88**	**£19.95**	**£0.23**	**£7.39**
Cost Per EV Mile		**£0.114**	**£0.164**	**£0.124**	**£0.154**	**£0.115**	**£0.129**
Cost Per kWh		**£0.381**	**£0.548**	**£0.413**	**£0.514**	**£0.382**	**£0.410**

The assumptions used in the calculations are:

- Capital costs spread over 10 years, including NFD connection charges.
- The initial phase of 8 sockets (6 at East Whins and 2 at the Centini car park) includes civils and other preparation for the second phase doubling the capacity at each site.
- Operating costs based on full utilisation. Inevitably this will take time to be the case. (The way Connected Kerb licence and maintenance charges are made will increase this system's operating costs further when EVCPs are underutilised.)
- Electricity costs at the NFD rates applying in March 2023.
    - Private installation on an NFD standard rate 5% VAT domestic supply.
    - Shared installations on NFD dual rate 20% VAT supply, using 90%-night rate.
- The ‘parity charge’ is the difference between the cost to the typical EV driver using the shared EVCP and one with a home charger. If adopted, the charge would be paid by those using a private EVCP and used to support the shared EVCP network at The Park.

The installed cost of a 50kW DC-EVCP is likely to be from £33k to £38k.

Business Case

Public 50kW DC Charging

- There is more risk in providing DC-EVCPs at The Park. It may be better that Park businesses (individually or in partnership) evaluate the likely benefits of a DC charge point.
- 50kW DC charging by residents is unlikely to be significant.
- Parking issues mean it is highly unlikely that shared residential charge points would be available to visitors. An agreement to this effect might support business investment in DC chargers.

Residential EV Charging

- The end user costs of a Connected Kerb system are 33% higher than an Easee system: up to 54.8p/mile compared to 41.3p/mile for Easee with 8 EVCPs serving 40 EVs.
- For both systems, the per socket capital costs of installation falls significantly when the second phase is completed. The fall is greatest for the Easee system at 44%. This brings end user costs down to 15.4p/mile for Connected Kerb and 11.5p/mile for Easee.
- If 16 Easee charge points are installed at end of Phase I the capital cost per socket is 2.5 times that of a typical home EVCP installation, but it is expected to serve 5 EVs. Long term zero interest loans would be needed to bridge the gap between installation and utilisation of such charging capacity. Potentially, these loans could be paid back by EV drivers joining the system. Instead of installing a private charge point, they would pay a lump sum off the loan.
- Grant funding (such as has been available for private installations) will likely be needed to install shared community EVCPs. A pilot scheme may show that more than five EVs can be served per socket. This could open the way for lower cost community owned EV charging infrastructure that might strengthen communities.
- The Easee system is costed to include local labour to maintain and administer the Park EVCP network, creating local part time opportunities. These functions are built into the Connected Kerb offer and will be provided remotely, including overseas.
- The billing arrangement envisaged for the Easee system may be offered as a service or supported software to other communities. The system would be of benefit anywhere with communal parking arrangements where private EVCP connections are difficult or impossible and where costs need to be kept to a minimum. These could include flats and housing associations.
- The 20% VAT on electricity for shared EVCPs encourages private home EVCPs where the VAT payable is only 5%. This reduces the demand for shared EVCPs.
- Introducing a ‘parity charge’ agreement for private EVCPs would reduce the risk of investing in and running shared EVCPs. However, the full cost to create true parity with a Connected Kerb system is thought to be unacceptable. It would be a 35% (16 socket system) to 44% rise (8 sockets) in the cost/mile for the typical EV driver. With 8 Easee EVCPs the cost/mile that all EV drivers would pay is 12.4p - just 1p/mile more than the 11.4p/mile for the typical EV driver with a home EVCP. Once 16 Easee EVCPs are installed the cost falls to 11.5p/mile, almost identical to home EVCP costs.
- Modelling is presented here to demonstrate the income potential from shared EVCS in The Park. The modelling presents a couple of hypothetical EV adoption scenarios and assumes that shared EVCP would charge at a tariff of 25% above the NFD tariff

to cover operating costs and overheads. It also highlights the increase in cash flow for NFD and FWP because of EVCP. The results indicate that:

- The income potential for shared EVCP is not large which raised the argument that perhaps the community should see EVCP as a service rather than a business. The service could be supported via other means including the NFD distribution charge and any benefit that FWP achieved via flexing assets within the microgrid.
- There are potentially 3 separate benefactors of the income; a shared EVCP organisation (if applicable), NFD and FWP which implies that a partnership would be required to share the costs and benefits.

Conclusion & Follow On Work

- DC charging is likely best owned by existing Park based businesses and would be available to residents, particularly at night when visitors to The Park will be fewer.
- Resident charging needs can be met largely through shared AC EVCPs.
- A pilot project of 16 socket Easee installation in two locations has the potential to encourage the transition to EVs by keeping per mile costs competitive with both private home chargers and petrol/diesel costs.
- Third party billing functions operated through OCPP add to high kWh rates through monthly per socket fees.
- Residential area EV charging for those who cannot install a home EVCP will create inequalities if it is seen as a business rather than a service.
- EV charging for workers at Park based businesses could be met through the same system as residents, but additional EVCPs in alternative locations may be needed to avoid conflicts over parking spaces.
- A pilot project could establish a shared EV charging network for residents.
    - At least two locations will be needed to serve Park residents.
    - The initial installation phase should include connections suitable for future expansion.
    - The Easee charging system presents the lowest cost option over the long term.
    - The Easee system would require development of a PAYG platform using the API provided. This offers the potential for a service to be developed offering lower cost EV charging to housing associations and flat complexes across Scotland.
    - Note that on 15th March 2023 sale of Easee chargers was banned in Sweden and the ruling may have ramifications across Europe. Easee are challenging the basis of the ban and an assessment should be made before committing to the Easee system.
- Park stakeholders including the Titleholders Association, Park Planning Group, New Findhorn Directions and Duneland should agree who will own and who will operate shared EVCPs for Park residents. If a new organisation is required, it is essential these stakeholders agree to make parking spaces available and to support the community transition to EVs through appropriate policies and/or rules. This may include restrictions on the connection of private home EVCPs and/or the availability of electrical capacity.

Public Charging Stations

No Rapid 50kW+ DC-EVCPs are currently Planned for pilot. Future phases may include up to three Rapid EVCS but require further study.

Equipment for Pilot

Six Easee Commercial 22kW single port EV Chargers and posts- 3 at East Whins and 3 at Centini car park on the Field of Dreams. All to be three phase and OCPP Compliant.

Centini pilot also includes creation of a canopy capable of supporting solar, photovoltaic solar electric panels, with battery storage located adjacent to the site.

Long Term EVCP Plan for the Park

(Additional consideration for work packages 2.4)

written by J R Fulton

To begin mitigating our Climate Crisis, WE need to Decarbonize Everything and Transition to All Electric for heating, hot water, industrial processes, and transportation (EVs). Collectively, we also need to move towards fewer privately owned vehicles and create a "very Smart Grid", locally monitoring, coordinating, and managing EV charging and other higher use devices.

Vision for EV Charging System

- An integrated system of EV Charging Points (EVCP) that can be used to test, coordinate, modify and manage innovative methodologies for reducing EV charging impact on the Findhorn Wind Park (FWP) Micro Grid.
- An EVCP Cooperative model to meet escalating EV charging needs for all local participants-Residents, Moray Car Share (MCS), Workers and Guests/Visitors at the Park Ecovillage, Findhorn (Park).

EV Charging Points (EVCP) Plan Parameters

- EVCP plan anticipates large scale EV transition at The Park by 2036 with currently anticipated future of 170 Residential vehicles, up to 10 MCS vehicles and up to 100 guest/visitor vehicles.
- EVCP plan to provide adequate/appropriate charging stations implemented in four phases plus pilot. 2024, 2027, 2030 and 2033.
- EVCP plan is a multi-player cooperative model that can be used by other communities.
- EVCP plan incentivizes transition away from private vehicles to Moray Car Share (SCIO) cooperatively shared vehicles by providing MCS dedicated EV charge points and assisting MCS in transition to a near term 100% EV fleet.
- EVCP plan is dynamic, allowing for integrating and quickly transitioning to dedicated chargers for MCS from shared residential chargers in neighbourhood parking areas at any time.
- Optimise FWP Micro Grid, EVCP will require multiple and dynamic use tariffs depending on availability of FWP electricity capacity, time of day, profits, etc. Commercial tariff funds future EVCP.
- Residential/MCS EVCP will predominantly be 22kW EVCS provided in neighbourhood parking areas with some 7KW connected to private homes. In all cases each charging port will be shared by 3-5 resident vehicles or dedicated to one MCS vehicle, as required by MCS business model.

- Associated FWP/microgrid software required to integrate, control, coordinate and optimise EVCPs will be included in another portion of the JTF microgrid proposal.
- EVCP plan targets an “agnostic” software for billing and controls system that will function with most EVCPs and will be based on appropriate Open Charge Alliance OCPP (Open Charge Point Protocols). OCCP provides for dynamic billing, multiple tariffs, and integration/optimization with the Findhorn Wind Park (FWP) Micro Grid to reduce cost to system. Software may be sharable with other cooperatives.
- EVCP plan intends for one entity to bill and/or maintain the entire system on behalf of EVCP cooperative for all Park residents, MCS and guests. Whether this entity is a stand-alone local organisation, part of a larger Scottish cooperative or ultimately utilises a single commercial vendor to provide services is yet to be determined.
- EVCP plan will also provide Commercial Rapid 50+kW DC charger(s) for visitor/guest usage and occasional Residents. Rapid 50+kW DC chargers will charge at a higher tariff. This higher tariff will be used to develop future EVCS implementation phases.

EVCP Pilot Implementation Strategy

- To create shared charging for 3-5 Residential vehicles/charge point, which is convenient to user as possible and to reduce the need for providing an additional parking space for relocating the “charged” vehicle, the following strategies, including layouts is proposed for EVCS in residential parking areas. All Residential Parking Areas and Private Residences to use the same or compatible integrated EV chargers in four phases plus JTF Pilot.
- Preference is to have single port EVCP centred on 3 on 5 contiguous parking places per charge point.
- Single charge point EVCP column should be located approximately 600cm beyond parking place and protected.
- Future “parking lots” could utilise narrow raised island between charging vehicles on both sides.
- Single 50kW DC-EVCP should be installed with adequate wire/capacity for future second charge point on original column.

Innovations for Findhorn Wind Park

Goals include reducing cost for FWP energy purchases and better use of FWP surplus electricity on site.

Potential Innovation and Improvements to Managing FWP Energy include:

- Use of multiple dynamic variable tariff rates “control” use based on user preference, surplus power availability, and personal vehicle charge demand in shared EVCP control and automated billing system.

- Using controls to “shut off” EVCP during peak electrical use in evening and morning,
- Using controls to primarily allow charging by EVCP at a lowest rate only during times the Findhorn Wind Park is generating surplus energy. May require more EVCP as vehicles sit longer.
- Using controls to reduce number of selected vehicles that can be charged simultaneously. Could require more EVCP as vehicles sit longer.
- Balancing available energy to multiple charge points (3 or more).
- Future Vehicle to Grid (V2G) using EV batteries for storage and discharge of electricity based on our dynamic renewables microgrid. V2G would essentially require dedicated EVCP for each Residential EV to allow for discharging into the grid when needed. i.e., “Everyone plugged in.” V2G would also require bi-direction EVCP and EV batteries with charge/discharge capability. V2G can also be coordinated with other non-EV batteries. SEE Alternative Dedicated EVCP for all vehicles.
- Storage in separate batteries during periods of surplus energy could also be used for commercial and residential EVCP use.
- Developing local EVCP trained technicians to maintain Park EVCP system and other local EVCP systems. Possibly create a regional training centre.

Private Residence EV Charger

While the majority of EVCP will need to be in shared parking areas, some private Park residential EVCP can also benefit the EVCP cooperative if meeting the following criteria:

- Provide appropriate and Park Planning Group (PPG) approved parking space near residence.
- Install a compatible 7kW EVCS, preferably same EVCP installed in parking area.
- EVCS meets approved EVCP meets system hardware, software, and connectivity requirements of FWP/microgrid (similar to commercial EVCP).
- Agreement to privately provide and install approved EVCP.
- Agreement to share private EVCP with two other Park Residents.

Residential EVCP Advantages

- A person parking an EV at their home with EVCP connected to house panel pays 15% less VAT but requires private billing of others using private charger. Though the government may add VAT or other “road tax” in future EV charging.
- Parking at home does not require an additional significant NFD connection fee.
- Parking at home can allow use of EV battery as home battery for photovoltaic connection or discharging to house to save energy/cost.

- Dedicated home EVCP can also allow for future Vehicle to Grid (V2G) system for discharging to The Park microgrid.

Moray Car Share (MCS)

MCS is a regional community-based car sharing cooperative and registered Scottish charity founded in The Park.

- There are currently 120 MCS members with Park address, approximately 60 members use MCS for source of their primary vehicle needs.
- MCS currently has dedicated 22kW EVCP for their EV fleet.
- MCS intends to electrify the rest of their MCS Park Fleet in near future as well as increase their fleet size to meet growing Park community/regional need for shared vehicles in the future.
- MCS will use the same 22kW EVCP platform with port dedicated to single MCS vehicle. Scattered EVCP colocation will allow for MCS to locate MCS vehicles closer to Park clients as well as providing flexibility of transferring residential EVCP to meet dynamic need for increased MCS shared vehicles.
- The actual split of MCS and Residential EVCP for each phase will be based on analysis of need at the time of implementation and can also be easily revised mid phase as required.

Following the pilot, the long-term plan through 2036 will require approximately equal number of chargers in four separate phases three years apart.

In addition to The Park, Phase I would Ideally include a few EVCP for Cluny Hill College in Forres, where the Findhorn Foundation operates multiple shuttle buses/transit service to The Park. Findhorn Foundation is currently transitioning their petrol bus fleet to all electric.

Early EVCP implementation will occur where there is current electrical availability. Future EVCP will require additional infrastructure improvements.

Consideration of Alternative Plan where all MCS/Residential Vehicles would have Dedicated EVCP.

FIRE also considered an EVCP system where all vehicles had a dedicated EV charger. We are also looking into multiple ways in the future to improve EVCP charging related to our variable microgrid and renewables systems. For some of these innovations to work, the Park will generally require a dedicated EVCP for every Residential vehicle.

- The optimum Dedicated Plan would require a port for each of the projected 170 Residential and MCS vehicles. Only Guest/Visitor and Rapid EVCP would be shared.
- Future Dedicated EVCP plan maximises innovation opportunity and allows for future Vehicle to Grid (V2G) use of EV batteries to discharge to the LV

microgrid when there is NO on-site capacity to further reduce costs. V2G requires a specialised EVCP charger unit that can both charge and discharge each EV battery to and from FWP microgrid as appropriate. V2G will also require that Vehicle batteries are capable of discharge with only a few current vehicles available that allow discharge without modification.
.

Associated Parking and Parking Lot Strategies

1. Follow existing parking patterns and maximising EVCP in already constructed parking places.
2. Enhance existing street/lot parking making it safer and targeting small changes/added spaces to existing.
3. Additionally allow/create parking at home where an appropriate parking space is available, and owner pays for initial installation to house electricity. owner can have lowest cost of electricity for EV and can pay for their own approved charger using the house as infrastructure. This is a No cost to community for charger or infrastructure.
2. Provide new parking “lots” for visitors and guests, determining who/how these are paid for.

Additional Notes:

- The UK Government has identified no new petroleum vehicles will be sold after 2030 with planned full EV transition by 2036.
- EVCP is seen as a critical component of the overall New Infrastructure Plan for the Park and represents a significant portion of our need to Electrify Everything.
- The studies above relate only to fully electric vehicles. Hybrids that require slower charging after each use are not accommodated in these studies.
- There are three speeds of EV chargers: Slow which is >7kW(house current), Fast which is 7kW to >50kw AC: and Rapid which is 50+kW DC. DC is direct current which “forces” the charge Rapidly into the battery. AC is alternating current which “accepts” slower charge.
- No funding for Residential EVCP installation and infrastructure is currently identified under Title Holders Association (THA), Duneland Ltd., or New Findhorn Directions(NFD) or any other associated Park organisation.
- Private EV charging ports will be limited to 7kW. EV charging below 7kW is not included in Cooperative. Shared EVCP will be 22kW.
- The shared parking lots were established and standardised without an understanding of the future need/requirements for EVs.
- There are no universal rules for parking vehicles at The Park, though most recent understanding suggests that home parking is not allowed in Field of Dreams or the Whins, though there are a dozen vehicles that do so.
- Home EVCP would best create an equitable rule for the entire Park that allows an owner to create a private parking space within 20m of your home if you can

create an appropriately sized and appropriately accessed parking space and utilise an approved EVCP with connection to LV microgrid.

- Not all existing residential locations can appropriately accommodate EV parking space at homes. For these shared parking areas, we will still need to create enough EVCP charging points for all remaining vehicles.
- Standards, approval methodology and identification of approved “home” EVCP and controls will be necessary. Standard allowed parking could be a simple as identifying location on plot and roadway connection , minimum parking space size required (2.8 x 6.8m), easy access from existing roadway without creating hazards, and agreement to privately funding appropriate EVCP. Privately built EVCP is zero cost to greater community for charger or infrastructure.
- Additional Parking paving costs for individuals at home and larger lots need to be considered.
    - The cost of asphalting one parking place (2.8m x 7m=20m/space) of an existing road is approximately £60+/m2 or £1200/home space. The cost of creating a parking lot, including spaces and shared access requires approximately 30m2/parking + access drive but is slightly less expensive at £45+/space or £1350/lot space. Underground parking structure with building above it is approximately £18,000/parking space.·

- There are three types of EVCP users at The Park:
    - Residential users who generally live and work at The Park and use private vehicles for short trips, park in shared spaces near housing, requiring 7-22kW EVCP.
    - Moray Car Share (MCS) vehicles that are cooperatively shared/used by multiple users throughout the day require a single dedicated 7kW or 22KW EVCP port for each vehicle to ensure charge/useability.
    - Visitors and guests, who either require Rapid charge (50+kw DC) while here for short/few hour durations and Holiday Park overnighters who can charge vehicles at caravan pitch (3kW) or overnight with 7-22kW EVCP.
    - Guests/Visitors EVCP system could be operated as a commercial venture/service by NFD or contribute toward future EVCP implementation.

Moray Long Term Development Plan 2020 (pg. 37).
Development must be planned and coordinated with infrastructure to ensure that places function properly and proposals are adequately served by infrastructure and services.

> iv) Electric car charging points must be provided at all commercial and community parking facilities. Access to charging points must also be provided for residential properties, where in-curtilage facilities cannot be provided to

any individual residential property then access to communal charging facilities should be made available. Access to other nearby charging facilities will be taken into consideration when identifying the need for communal electric charging points.

2.5 Increased Renewable Generation

(Covering work packages 2.5)

Written By Paddy Atkinson and Duncan Easter

Export Limitation

Written By Duncan Easter

The Park grid connection is the responsibility of Findhorn Wind Park (FWP). The current export agreement is for 975kW (wind). 675kW of wind and 85kWp of solar PV (see here) is currently installed. Scottish and Southern Energy Networks (SSEN) are aware of the PV and have never raised it as an issue.

In Oct. 2019 an ENA application was made by AES on behalf of FWP. Triggered by a chemical flow battery (CFB) research project, the application sought to both increase the export capacity (to 1475kW) and to allow the connection of a somewhat flexible mix of wind, PV, and battery technologies. This application resulted in a connection offer of £70k (see here), of which £29k was for a new metering RMU with a £2k metering panel and £5k GRP housing. A £26k permanent comms link was the other major part of the non-contestable works.

On advice that a greater than 25% increase to the existing allowable installed capacity triggered such high costs, the application was amended to request 1,218kW total installed capacity, with no increase to the export capacity. The resulting offer (including offer expenses) was for less than £2k to cover design approval and witness testing of a G100 export limitation system (see here).

Estimates for installation of a G100 system from Argand Solutions were from £20-25k. At the time this could not be justified by the battery research project or FWP. The offer was allowed to lapse.

In Oct. 2020 a further ENA application was made. This did not request any change to the export capacity but sought to convert the site from a G59 to a G99 connection. This would regularise the situation of the existing PV and remove the constraint of the wind only connection. However, advice from FWP's consultant at Verdant Engineering was that it may not be possible for the existing V29 turbines to pass the required G99 witness testing. The application was dropped.

Verdant Engineering were contacted again as FIRE as part of the JTF grant wished to consider the possibility of adding a fourth V29 wind turbine. The current advice is that it is difficult to predict what measures DNOs will require for such a connection. Verdant Engineering's direct experience is that it is hard to get informal advice from SSEN, even on very straightforward matters. FWP has always used third parties to prepare ENA applications, but the experience seems to be similar.

A G100 export limitation system will likely be required by SSEN to usefully increase the maximum total installed capacity of generation on the site. The large on-site load means it is unlikely that export limitation will ever be triggered in practice. SSEN requires the G100 design to ramp back generation progressively, rather than trip the HV breaker to all the turbines (which also serves Soillse). This means a reliable and fast communication link between the Earthship substation (The Park's grid connection point), and the wind turbines is essential and will form part of SSEN design approval and witness testing. A possible communication link is planned to be tested by Trilemma consulting in early May '23 which should provide some useful learning in this regard.

Wind Generation

Written By Duncan Easter

Grid Capacity

Completion of the Findhorn Wind Park Ltd (FWP) nacelle refurbishment programme in summer 2023 will result in one of the existing nacelles (including hub and blades) being available. This presents a possibility to erect a fourth V29 turbine at Findhorn utilising existing transformer and HV cable capacity.

Connection of a fourth V29 would bring the FWP installed wind capacity to 900kW. With the PV already installed (private and FWP), this would exceed our current export agreement of 975kW and require an ENA application to increase the total installed generation allowed at The Park.

A formal ENA application may be the only way to find out what will be required to connect a fourth V29 turbine. This can likely be prepared by AES or Verdant Engineering for £2k - £2.5k including the compulsory Cost of Offer Expenses that will be invoiced by SSEN. Assuming a maximum total installed capacity of 1,218kW is requested and that a G100 system is required to ensure the present 975kW export capacity is not exceeded (as per 2019/20 offer), the total cost for the grid connection is estimated at £30k, including fees and project management.

The addition of solar and batteries (including private installations) will also impact on the site export and total installed capacity agreement. Ideally any ENA application should reflect the total installed generation anticipated for the site, including batteries. It may be reasonable to share the cost of the application and (more significantly) the cost of implementing any resulting connection offer between different projects requiring the application.

Planning Permission: Site

Planning for a fourth V29 may be eased by the precedent of the original V17 turbine on the Bichans' land from 1989 to 2017. However, the Bichans' prefer that a fourth V29 is sited further from their home which is 250m distant from Moya's site, the original V17 turbine. The closest existing V29 to the Bichans' is the South turbine (closest to Kinloss Barracks) at 380m.

See here for a map showing land ownership boundaries and the locations of the existing V29s and former V17 wind turbines. The existing V29s are ~110m apart, complying with the general rule that turbines should be separated by 3-4 rotor diameters. Possible sites for a fourth V29 would be:

- **In an area of open dunes to the north of the existing North turbine as shown here.** It is likely that a maximum separation from the existing North turbine of 100m cannot be achieved before crossing onto Land in the ownership of the Findhorn Dunes Trust (more like 80m separation) and the turbine production could be significantly affected by the proximity of Wilkies Wood. For example, the North turbine has around 15% less lifetime production when compared to the South turbine.
- **On land owned by Duneland Ltd (DL) identified as potentially contaminated.** This site would be sheltered from the prevailing south westerlies by the existing V29s that form a line broadly NW to SW. The turbine production would therefore be reduced by being in the wind shadow of the existing turbines.
- **On land forming part of Kinloss Barracks.** Reed beds were constructed just a track width beyond the north-south military fence in the years following the existing V29 installation in 2006. These are estimated to be ~85m from the South V29 at closest approach. The preferred site would be south of the reed beds and form an extension of the rough NW to SW line of the existing V29s.

Assuming planning issues for all sites can be overcome, points favouring the site on Kinloss Barracks are:

1. It is likely to offer the best production from a fourth V29 turbine. This should be checked by modelling considering the effect of the neighbouring turbines, trees and any other significant terrain factors, e.g. using Openwind.
2. The distance to Cullerne Farm, the Bichan's home, may be similar to that of the South V29 and the turbine would likely be hidden by outbuildings belonging to them.
3. The existing access across the barracks for cranes and HGVs will likely pass very close to the turbine site, reducing civils costs.
4. Construction of the reed beds on the barracks site required heavy plant and adjacent materials storage. This may significantly reduce the environmental impact of construction of a fourth V29 compared to the other sites considered.

However:

- No approach to the MoD or Defence Estates has been made.
- The Kinloss Barracks site will be closer to the Kinloss runway.
- Service and repair access would need to be agreed in addition to construction.

Planning Permission: Environmental Impact Assessment

No information has been received from Moray Council on the requirements for environmental impact assessment. The application for the existing V29s in 2005 included consideration of the development effects on:

- Visual impact
- Noise
- Wildlife, plants, and ecosystems
- Archaeology

- Contaminated land
- Aviation
- Radio communications

General advice on planning for onshore wind turbines in Scotland is available here. To understand more would require formal pre-planning advice from the Moray Council, for which a fee of £1,671 is payable. Current planning application fees for wind generation projects are £500 for each 0.1ha or part thereof. The ePlanning site fee calculator suggests a fee of £2,500 for a single 45m high wind turbine.

It is understood that the cost of the studies conducted around 2005 and their project management was ~£60k. It is unlikely that there will be significant savings on the cost of studies for the addition of a single V29, compared to considering adding three in 2005. Any savings may come from acceptance by the Moray Council that significant elements of the reports remain valid. If it is required to repeat the full suite of studies, allowing for inflation it is estimated the cost might be £105k, including project management of the planning phase.

Project Cost Summary

Both the planning and construction costs are presented on the budget page here. The costs for the track and cabling may vary significantly depending on the site of a fourth V29 turbine. The other construction costs are more reliable.

Best estimates in April 2023 are:

Project Phase	Work Package	Cost
Pre-Planning	Pre-planning advice ENA application	£4,000
Planning	Planning application preparation inc. Environmental Impact Assessment Planning application fee	£108,000
Construction (Highly Site Dependent)	Access track Cable track and cabling	£49,520
Construction (Largely Independent of Site)	4th Nacelle WindTech refurbishment Foundations Tower Erection G100 System Project Management	£396,545
	Total	**£558,065**

The construction costs include £28k for a Deif control system. This is recommended but not necessary.

Business Case

Several factors are involved and would need to be investigated further but the following table demonstrates some hypothetical business cases for an additional 225kW wind turbine:

Scenario	Addition	Import (MWh/yr.)	Export (MWh/yr.)	FWP Cashflow	Cost	Simple Payback	Return on Capital employed	IRR
Current demand	Additional 225kW V29	386	830	£58,960	£558,065	9.5	10%	7%
Post North Whins	Additional 225kW V29	440	782	£60,720	£558,065	9.2	10%	7%
Post JTF (inc. full ambient loop and Pineridge redevelopment)	Additional 225kW V29	600	700	£65,120	£558,065	8.6	11%	9%

The above assumes:

- siting north of the existing North turbine (and thus reduced production due to proximity to forest; -12% assumed)
- 15-year project life
- 5% loan interest rate, e.g., JTF low interest loan
- Expected electricity tariffs based on research during JTF.

The assumptions underpinning this analysis along with the full analysis can be found here.

Solar PV Farm

(Covering work packages 2.5)

Written By Paddy Atkinson

Pricing

The AES quotation works out at £1780/kWp ex VAT. Official statistics from BEIS on Solar PV pricing shows data for 21/22 with a cost of closer to £1,100/kWp:

Table 1c. Cost per kW, 10-50 kW installations (pounds per kW installed) [note 1]

Year	Month	Number of installations	Median	Mean	Lower CI	Upper CI
2021	4	136	1,018	1,231	1,138	1,325
2021	5	135	993	1,126	1,040	1,213
2021	6	103	1,008	1,149	1,053	1,246
2021	7	148	957	1,024	952	1,096
2021	8	150	1,011	1,089	1,030	1,148
2021	9	168	966	1,039	981	1,097
2021	10	139	1,012	1,122	1,043	1,201
2021	11	186	1,018	1,117	1,051	1,182
2021	12	110	1,115	1,176	1,078	1,273
2022	1	153	1,131	1,176	1,111	1,240
2022	2	153	1,092	1,182	1,109	1,256
2022	3	253	1,054	1,165	1,107	1,222
2021/22	**Total**	**1,834**	**1,016**	**1,132**	**1,111**	**1,153**

It should be noted that BEIS cost data excludes any extended warranty or any other material or works carried out on the solar equipment. The AES price includes the ground mount system which would represent a percentage of the total cost. JTF should request a breakdown of cost.

New BEIS data for 22/23 is expected to be released around May ‘23.

Groundworks and Ground Mounting

AES has specified Sunfixings Park Tegra Ballast. When speaking to the manufacturer they advised that they propose the layout and ballast quantities based on the site. JTF should endeavour to find a site for layout and ballast quantities.

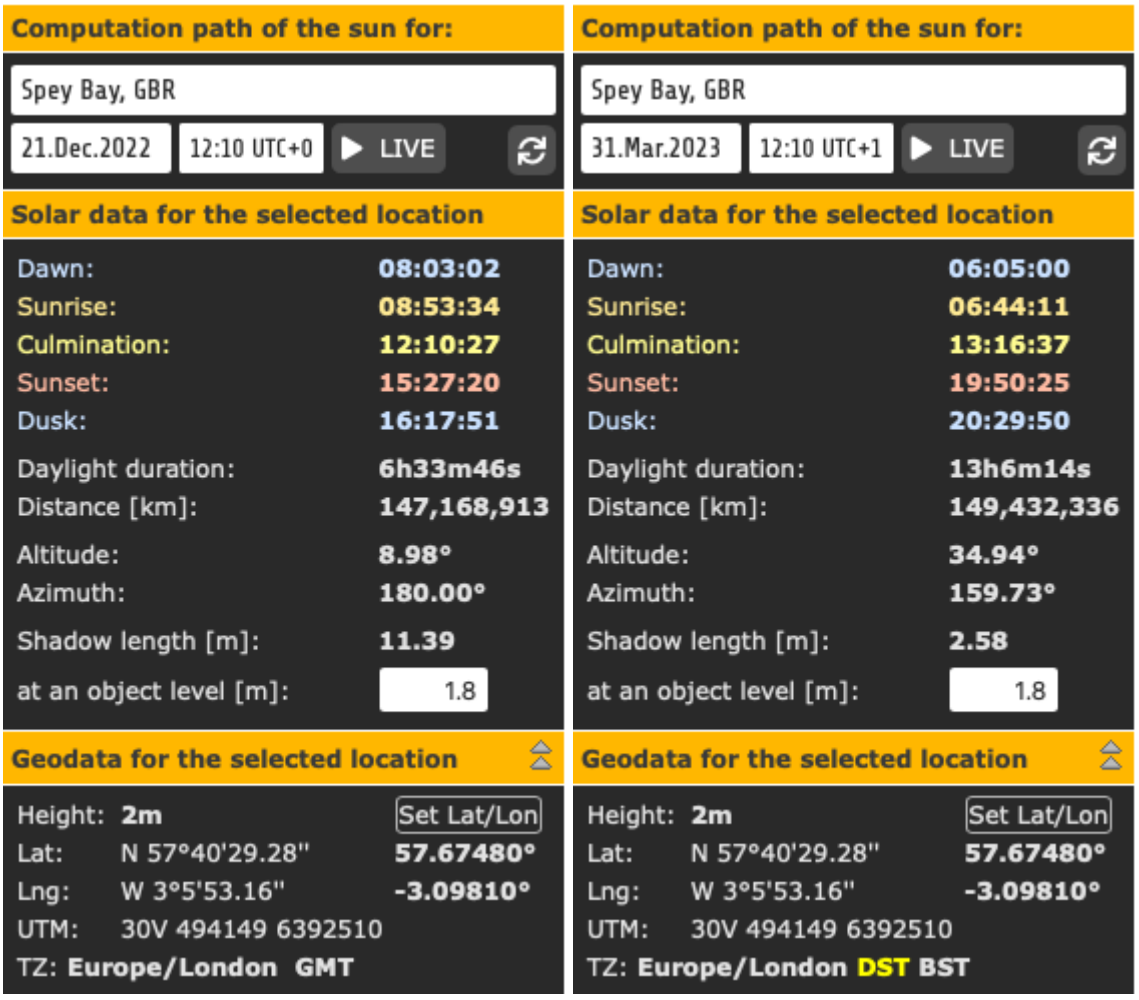
Siting

Shading and Row Spacing

The obvious location for a large array is out by the wind turbines.

Assuming these JA Solar panels, a 30 degree array angle and ground to panel starting height of 600mm the top of the array could be expected to be around 2.4m. Shading analysis via this online tool shows a shadow length of around 12m at the winter solstice (for a shadow

starting 2.4m elevation and affecting the first panel at 0.6m elevation). The shadow length drops to less than 3 meters by the end of March. A detailed shading analysis and modelling exercise should be undertaken to find the ideal distance however JTF siting work has determined 12 metre separation between rows.



The shading from the wind turbines needs consideration and modelling to inform the conversation about siting.

Groundworks and Ballast

Sunfixings generally specify the spacing, layout and ballast required for a system and the concrete would be poured in-situ into a trench to provide the required ballast. Once a location is determined the Findhorn team should approach Sunfixings to specify the spacing, layout and ballast required. This would then allow for quotations for groundworks and concrete.

For the purposes of JTF cost estimates are based on “2400kg per frame" (1m3) with one frame being two posts.

Duneland Contaminated Land

Duneland Ltd is open to a solar farm on the contaminated land as shown here. There are challenges relating to the radioactive contamination and SEPA would need to be consulted

and radiological protection specialists engaged. The concrete ballast would need to be pre-cast and placed in-situ with appropriate machinery. It is doubtful that any groundwork would be possible to achieve a level site and the ground mount system would need to be able to cope with unlevel ground. The removal of gorse would probably be possible with the gorse topper but not uprooted.

Findhorn Foundation Land

The most obvious location for solar arrays would be on the north side of the dispersal runway running roughly from the end of the woodland to near the Centre turbine/transformer compound as shown here. This would limit shading from the wind turbines and minimise cable runs. Obviously, this requires consultation with FF as the landowner and other stakeholders.

Electrical Considerations

The FWP transformer is a 1000kVA, 11kV / 690V unit as shown here. Based on previous work for the Chemical Flow Battery it was identified that an isolation transformer would need to be introduced to connect the 415V, 3-phase equipment. The wind park network also operates without a neutral. During the flow battery project, the transformer being specified was:

- *Primary 690 Vph-ph with Y (star) winding configuration (no neutral provided)*
- *Secondary 400V ph-ph with Y winding configuration for single-phase 230V loads, but with it star point grounded to be used as Neutral for these loads.*

This may have to be altered to facilitate three-phase loads but likely addresses most of the challenges present. Electrical engineering would need to be undertaken to determine the requirements for a solar PV farm.

Two historic quotes from McDonald and Munro for power connections and 50kVA and 150kVA transformer transformers can be viewed here (50kVA) and here (150kVA). There were £12.9K and £20K respectively.

The transformer price with IP65 enclosure via a supplier (A.M Transformers Ltd) was £6600 (ex VAT) for a 50kVA and £9900 for a 90kVA. Assuming a notional 10% markup by M&M the other power connections cost is around £5,600 for a 50kVA scenario (or 43% of total cost). Presumably then the non-transformer costs for 150kVA connection might be around £8,600.

It should be noted that the battery installation also required another secondary winding on the transformer (i.e. 3 winding transformer) due to the battery operating at 230 Vph-ph (see here). This meant the transformer was a bespoke unit rather than off-the-shelf. Given a solar farm would be 690V / 400V it is likely an off the shelf transformer could be sought and this could save on the cost of power connections.

Up to date quotes were sought for 50-250kVA transformers and can be found here and range between £117 per kVA to £74 per kVA.

The proposed location for the transformer and switchgear is adjacent to the FWP transformer compound. This would require consultation and approval from FWP and Findhorn Foundation as the landowners.

It should be noted that the FWP transformer is 1000kVA. The current generation is 675kW. If a new 225kW V29 wind turbine were to be installed the total generation capacity would be 900kW for wind which would leave only 100kW of capacity at peak generation. However, it is envisaged that with a suitable control system could be installed that limited generation to a maximum of 1000kVA at any time which would allow for the continued use of the existing HV transformer. Also, wind and solar are rarely generating at capacity at the same time so in reality such a control system may not even be triggered. It is worth noting that if HV switching is required the estimated cost for Enervo engineers would be about £1,600.

OFGEM

Any change at the wind park would trigger an OFGEM amendment relating to FWPs ROCs. The cost to amend FWP's ROC registration is estimated at £500.

Glare

In the past glare was a consideration for solar farms in the vicinity of runways. However, this is no longer the concern it once was with information available here.

Business Case

The estimated budget for a 50kW and 75kW solar farm can be found here with the estimated project cost of £115K for 50kW solar farm and £156K for a 75kW solar farm.

Given the expected electricity tariffs for FWP the business case for a 75kW solar farm is positive albeit a bit marginal. It can be summarised as follows:

Scenario	Addition	Import (MWh/yr.)	Export (MWh/yr.)	FWP Cashflow	Cost	Simple Payback	Return on Capital employed	IRR
Current demand	75kW solar farm	386	830	£14,000	£156,000	11.1	8%	4%
Post North Whins	75kW solar farm	440	782	£15,000	£156,000	10.4	8%	5%
Post JTF (inc. full ambient loop and Pineridge redevelopment)	75kW solar farm	757	553	£16,000	£156,000	9.8	9%	6%

The business case for a 50kW solar farm is also positive albeit a bit marginal. It can be summarised as follows:

Scenario	Addition	Import (MWh/yr.)	Export (MWh/yr.)	FWP Cashflow	Cost	Simple Payback	Return on Capital employed	IRR
Current demand	50kW solar farm	515	644	£9,700	£115,000	11.9	7%	2%
Post North Whins	50kW solar farm	440	782	£10,000	£115,000	11.5	7%	2%
Post JTF (inc. full ambient loop and Pineridge redevelopment)	50kW solar farm	757	553	£10,500	£115,000	11.0	7%	3%

The assumptions underpinning this analysis along with the full analysis can be found here.

Car-Port Solar PV System

Some possible locations exist for a carport solar PV system. An obvious location is the shared car park in the Field of Dreams opposite the Centini terraced houses. The car park has an area of approximately 15m x 15m which could accommodate an array of 104 panels (assuming JA 370W panels - 8 deep by 13 wide) providing an output of 38.48kWp. AES advice is a roof structure with an east and west pitch of around 5º pitch. This seems applicable for the Centini location.

Electrical board B408 is supplied by a 35-sqmm 4-core cable and could easily accommodate a 38.48kWp 3-phase load. A trenching/cable distance from B408 to the parking area is about 30m.

Generation would be in the order of 28.5MWh per annum.

This location could also be a site for integrated battery storage to support the constrained electrical supply (if the ambient-ground-loop) system is realised. It could also support vehicle charging in the vicinity.

It is recommended that this could be a good pilot project for taking forward. The learnings gained could be useful when redeveloping Pineridge in relation to working within existing cable capacity.

Battery Storage

(Covering work packages 2.3)

written by Paddy Adkinson

Context

The introduction of a large battery within the microgrid would result in greater utilisation of generated renewable energy, reduced exports, and reduced imports of electricity. This has financial benefits for FWP and has the potential to reduce carbon emissions for the community.

Capital Cost References

The following is a summary of real project quotes to inform the business case for a battery.

Size	Cost	Source
650kWh / 250kW	● £260K hardware ● 10% install ● 10% container and pad ● **£310K**	Trilemma
400kWh / 200kW	● £200K hardware ● 10% install ● 10% container and pad ● **£240K**	Trilemma
250kWh / 125kW	● £120K hardware ● £30K enclosure and install ● **£165K-180K**	Trilemma
100kWh / 50kW	● £85-100K hardware, enclosure and install ● **£85K-100K**	Trilemma
300kWh / 120kW	● £150K hardware ● £13K BoS ● £18K install and commission ● (no enclosure or pad) ● **£181K**	Eaton / Duncan Easter

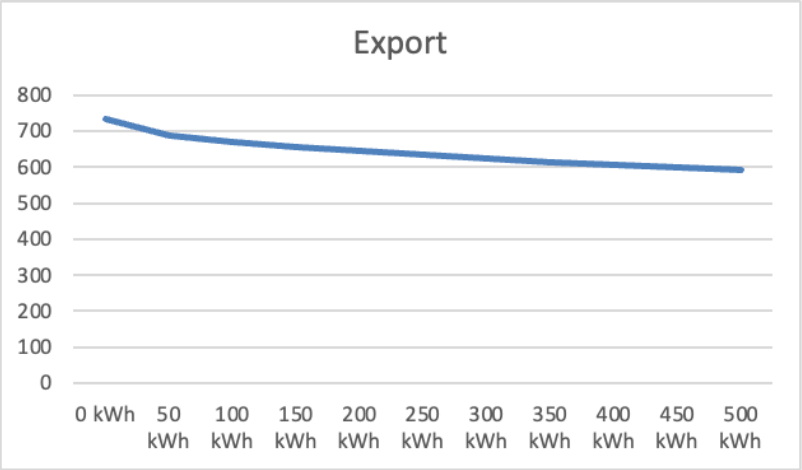
The general trend here shows battery hardware costs of around £500 per kWh and other costs equivalent to + 40% of hardware costs; kWh x £500 x 140%

Modelling

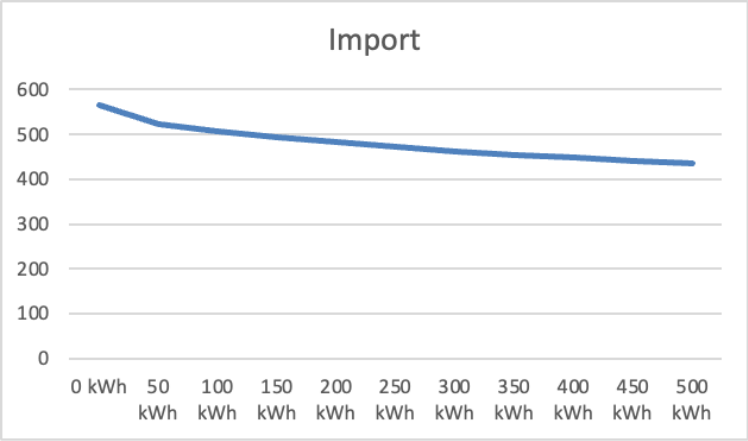
The modelling results below are derived from the UoS sitewide model and indicate that (with the widespread electrification of heat and transport explored by JTF) the optimum size of battery is around 200kWh. The benefits of increased utilisation of local renewable generation, reduced exports and reduced imports and the increased cash flow are diminishing after about the 200kWh mark.

It should be noted that a very large battery could work but the main benefit would be arbitrage with the grid. Without a partnership with an organisation with experience in the wholesale energy market such an undertaking is not likely to be feasible.

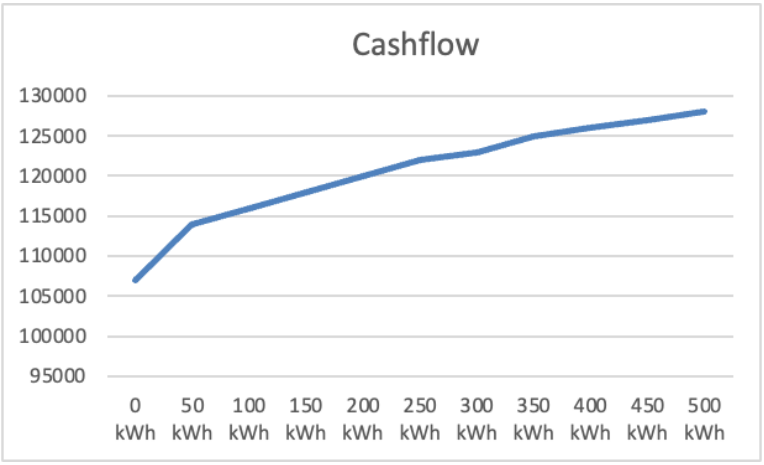
Export (225kW wind, 75kW solar)		
	JTF Full-scale	Change
0 kWh	735	
50 kWh	689	-46
100 kWh	671	-18
150 kWh	657	-14
200 kWh	645	-12
250 kWh	634	-11
300 kWh	624	-10
350 kWh	615	-9
400 kWh	608	-7
450 kWh	600	-8
500 kWh	594	-6



Import (225kW wind, 75kW solar)		
	JTF Full-scale	Change
0 kWh	565	
50 kWh	522	-43
100 kWh	506	-16
150 kWh	493	-13
200 kWh	482	-11
250 kWh	472	-10
300 kWh	463	-9
350 kWh	455	-8
400 kWh	448	-7
450 kWh	442	-6
500 kWh	435	-7



Cashflow (225kW wind, 75kW solar)					
	JTF Full-scale	Change	Cumulative	Capex	Simple Payback
0 kWh	107000				
50 kWh	114000	7000	7000	50000	7.1
100 kWh	116000	2000	9000	90000	10.0
150 kWh	118000	2000	11000	105000	9.5
200 kWh	120000	2000	13000	140000	10.8
250 kWh	122000	2000	15000	175000	11.7
300 kWh	123000	1000	16000	210000	13.1
350 kWh	125000	2000	18000	245000	13.6
400 kWh	126000	1000	19000	280000	14.7
450 kWh	127000	1000	20000	315000	15.8
500 kWh	128000	1000	21000	350000	16.7



Location for Battery

If a solar farm were to be developed in the vicinity of the wind park then an isolation transformer would need to be introduced to connect the 415V, 3-phase equipment. This would provide a good opportunity for the connection of a battery also and there could be a

consideration to use a hybrid inverter/s (which allows PV and battery on a single inverter) which could save £5-10K between the two projects.

The other opportunity for smaller batteries is embedded batteries in Pineridge and Field of Dreams to support a constrained grid after a large roll out of electrification of heat and transport. The idea of coupling this is a solar carport and EVCPs has been presented in the solar PV section of this report.

Sitewide Modelling

(Covering work packages 2.3 and 2.5)

Written By Paddy Atkinson with contributions from Duncan Easter

University of Strathclyde Model

The UoS ‘Sitewide’ model is useful for testing various future scenarios including renewable generation, batteries, EVs, electrification of heat (heat pumps) and replacement of housing. It can also test the above against nominated tariff data.

The model has been checked by Paddy Atkinson and Duncan Easter and they consider it to be an accurate model for high level decision making. It is recommended that detailed modelling be performed for any specific projects being considered.

The model can be found here. Attention should be paid to the ‘Ref’ and ‘Results’ tabs as well as the main modelling tab.

Modelling Assumptions

North Whins metrics included here. Assumed new Pineridge properties are found here. Existing property conversion numbers are based on results here. This assumes all firewood use ceases (air pollution and CO2). Centini heat is treated like night storage as it is on an off-peak tariff.

Results

- Modelling results indicates that for post-North Whins with a full ambient loop, redevelopment of Pineridge ~60 properties and around 60 EVs the required renewable generation to achieve carbon neutrality for electricity would be 225kW wind and 75kW solar.

- If a new wind turbine is not possible 470kW of solar would be required.

- If ASHPs were rolled out instead of ambient loop, then the required renewable generation to achieve carbon neutrality for electricity would be 225kW wind and 175kW solar.

As already mentioned, the optimum battery capacity is in the 200kWh range.

Scenario	Solar PV	Wind	Battery
Post JTF inc. North Whins complete, full ambient loop, Pineridge redevelopment and 60 EVs - Wind possible	75kW	225kW	200kWh
Post JTF inc. North Whins complete, full ambient loop, Pineridge redevelopment and 60 EVs - Wind not possible	470kW		200kWh
Post JTF inc. North Whins complete, ASHPs, Pineridge redevelopment and 60 EVs - Wind possible	175kW	225kW	200kWh

Future Electricity Pricing

In the context of electrification of heat and transport the issue of future electricity prices is important.

Research as well as consultations with UoS during the JTF project indicate future prices at about double 2021 rates (see here - current 1 and 2 year futures prices shows the drop happening slightly faster than indicated but not by much as indicated here). UoS have advised that this probably means tariffs about 50-75% higher than 2021 rates.

June 2020 prices were 17.8ppu day and 10.7ppu night. Assuming 50-75% above these prices would mean:

- 26.7-31.2 ppu for day and
- 16.1-18.7ppu night.

Given most people aren't on dual tariffs the day rate is more relevant.

When the 3.88 ppu distribution charge and 5% vat is included we could be looking at something between 32-37ppu for end users in The Park.

A summary of historic and current electricity tariffs for The Park is shown here.

Electrification of Heat

In the context of electrification of heat, it is important to compare the current cost for LPG heating in The Park.

Right now LPG is costing about 15.5p/kWh delivered as shown here.

At 37ppu for electricity and a COP of 3 (local observations) for GSHP the cost would be around 12.3p/kWh which is cheaper than LPG heating.

At 37ppu for electricity and a COP of 2 (local observations) for ASHP the cost would be around 18.5p/kWh which is more expensive than LPG heating.

Electrification of Transport

As an example, a Nissan Leaf consumes about 0.24kWh/mile or 24kWh per 100 miles. At 37ppu this equates to £8.88 per 100 miles which is considerably below the cost of petrol and diesel cars.

However, if communal chargers are installed there are some operational costs to be covered and this could increase the cost to £12.5 per 100 miles which is closer to that of petrol and diesel. See here for an example scenario.

2.7 Documentation and digitisation of existing infrastructure networks

(Covering work packages 2.7)

written by John Talbott

The Park infrastructure has evolved somewhat organically over the last sixty years and has grown increasingly complex through the transition from caravan park to ecovillage. As new areas were developed upgrades to existing networks were carried out in addition to the new supplies, but often mapping was either not fully completed or integrated into the existing networks. Most of this work was done pre digitisation of plans on hard copy documents.

The large-scale infrastructure projects contained in the Just Transition Fund grant created an urgent need to consolidate the historic plans into a master digital format to allow for analysis of existing capacities in the water, sewer and electrical networks and future management. This is particularly relevant for this feasibility study for The Park microgrid.

Description of Work

An extensive search plans was undertaken in the community to locate all the hard copies of maps and that have been produced over several decades. Many dozen were located, and photographic images were made of each. These were reviewed and passed to CAD operators to transfer to digital format, plotting by areas and type of service and rationalised to produce what was assumed to be the correct layout.

Each service plan for individual areas were then ground-truthed with NFD services staff with knowledge of the site to establish that they were accurate. At this writing most of Pineridge and the Central Areas where the most uncertainty of layouts existed because of the long history of piecemeal extension are largely completed. The Field of Dreams services installed in the late 1990s were accurately documented in hard copy during development and needed only to be digitised. The Whins (Magic Triangle) was done digitally from its inception and only required to be incorporated into the base plan.

A drawing numbering system along with issue or revision number for document and version control has been adopted to ensure accuracy and that the management of drawings is as clear and easy to read and identify as possible.

An example of the numbering protocol by a breakdown of what each part means is:

Drawing Number Example : PR-SEW-001-REV1

PR	This is the area of The Park, ie Pineridge in this instance.
SEW	This denotes the type of service, in this case it stands for Sewer/Foul Drainage.
001	Numeric sequence in case we have more than one sewer drawing for Pineridge.

Below are the annotations for The Park areas:

PR Pineridge
FD Field of Dreams
CA Central Area
HP Holiday Park
TW The Whins
CU Cullerne House & Gardens
PAR Whole Park settlement

Below are the annotations for the services:

SEW Sewer/Foul Drainage
WAT Water
IW Irrigation Water
RWA Recycled Water
SWA Storm Water
DH District Heating
GAS Gas
SAF Life Safety (Fire hydrants, Fire Stations, Assembly)
ALH Ambient Loop Heating

ELE Electricity
ELV Low Voltage
EHV High Voltage
ESL Street Lighting
BT BT Telephone

COM Combined Services

ARC Archetypes (used in district heating drawings)

Further details and mapping protocols will be instituted through the infrastructure management group proposed for NFD Ltd or another body, to be determined.

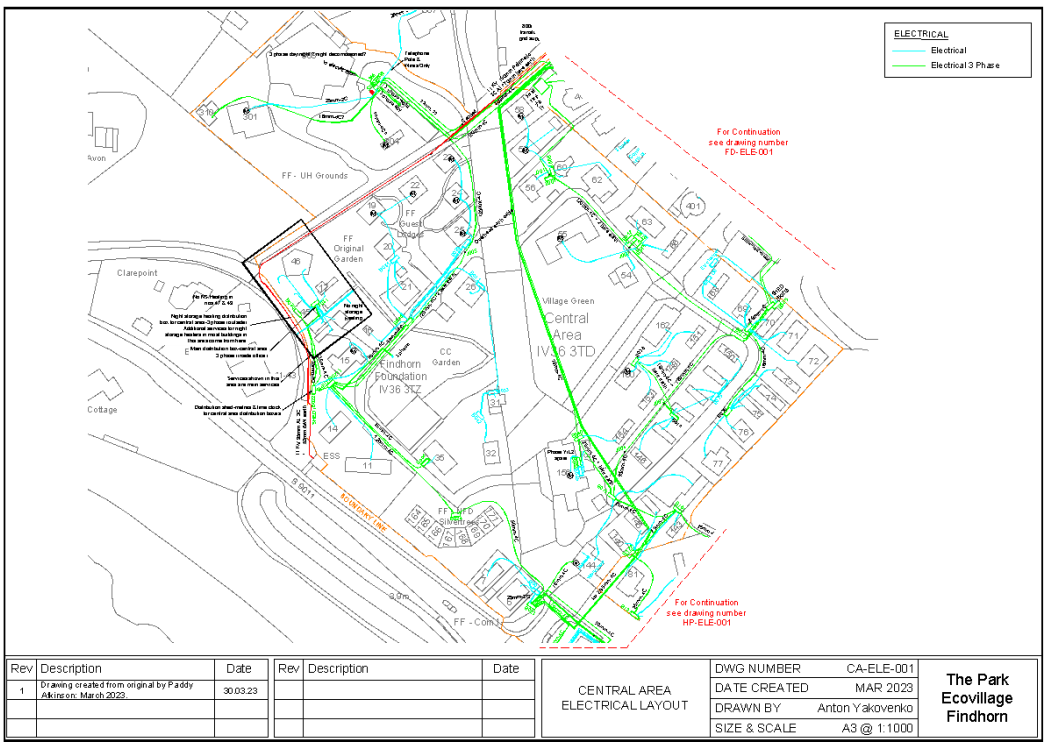
Current protocols for drawing numbering, a drawing register, electronic filing protocol and checklist can be found here.

Full set of current drawings can be viewed (only) here.

examples:

Central Area

electrical



Rev	Description	Date
1	Drawing created from original by Paddy Atkinson: March 2023.	30.03.23

Rev	Description	Date

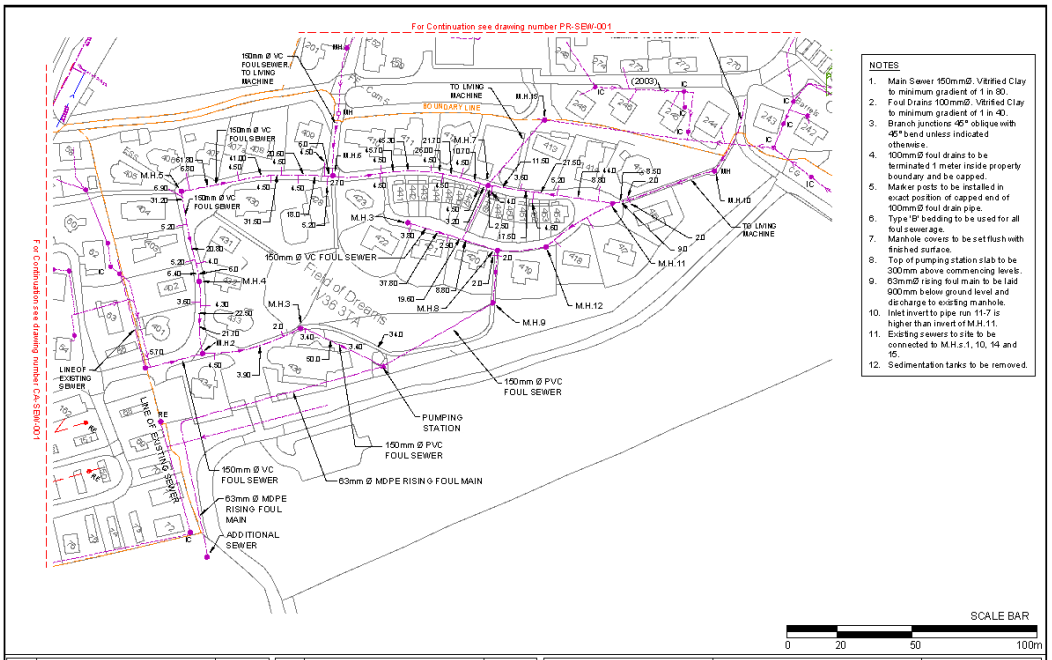
CENTRAL AREA ELECTRICAL LAYOUT

DWG NUMBER	CA-ELE-001
DATE CREATED	MAR 2023
DRAWN BY	Anton Yakovenko
SIZE & SCALE	A3 @ 1:1000

The Park Ecovillage Findhorn

Field of Dreams

sewer



Rev	Description	Date
1	Services taken from As Built drawing created in 1998 by Eco-Village Limited.	30.03.23

Rev	Description	Date

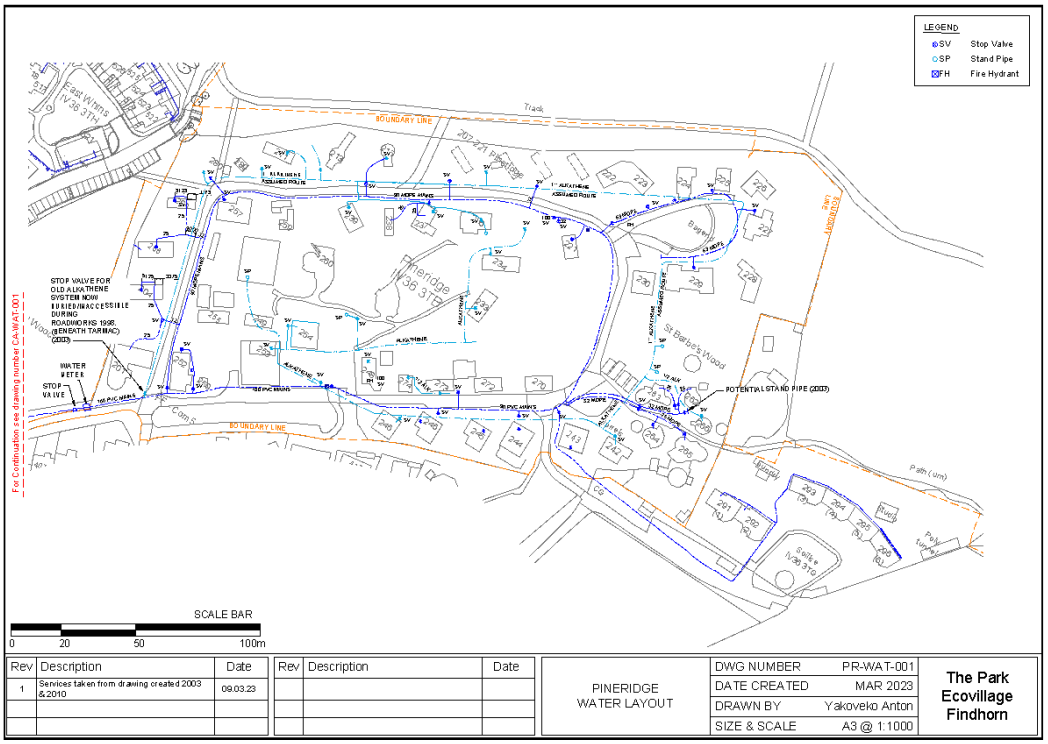
FIELD OF DREAMS FOUL SEWERAGE LAYOUT

DWG NUMBER	FD-SEW-001
DATE CREATED	MAR 2023
DRAWN BY	Kate Waring
SIZE & SCALE	A3 @ 1:1000

The Park Ecovillage Findhorn

Pineridge

water



Rev	Description	Date
1	Services taken from drawing created 2003 & 2010	09.03.23

Rev	Description	Date

PINERIDGE WATER LAYOUT

DWG NUMBER	PR-WAT-001
DATE CREATED	MAR 2023
DRAWN BY	Yakoveko Anton
SIZE & SCALE	A3 @ 1:1000

The Park Ecovillage Findhorn

2.8 Financial consideration and business cases

See references in main report for the following financial and business cases:

Additional Wind Turbine – see pages 32-33 with full analysis here.

Solar PV Farm – see pages 37-38 with full analysis here.

Battery Storage - see pages 39-42

EV pilot project – a pilot project has been identified but has not been costed at this time.

Microgrid controls – Full costing of smart grip controls including new ambient heat loop district heating was carried out by Pragmatic Energy and can be found here.