Just Transition Fund
End of Financial Year
Project Report

Findhorn
Ecovillage
Feasibility Studies
April 27, 2023

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INTRODUCTION/OVERVIEW OF 4 FEASIBILITY STUDIES

The Feasibility Studies were divided into 4 distinct Projects. Each Project is summarized in the same colour block throughout the report as set out below. In this Introduction section a link is provided to the Full Feasibility Report of each Project.

Project 1: The Feasibility Study for an Ambient Ground Loop District Heating System in the Findhorn Park investigated designing and installing a communal district heating system in houses currently using fossil fuel based heating (mainly LPG). The Ground Source system was seen as a primary means of decarbonising the Findhorn Community in the Park. **[Click here for a link to Project 1 Feasibility Study.]**

Project 2: The Findhorn Microgrid and Strategic Framework was designed to produce a new development plan to transition from temporary mobile homes with low energy efficiency to highly energy efficient permanent housing. The capability of the existing networks within the Findhorn Ecovillage required a full review and assessment to determine the existing capability and future upgrades required to provide the desired outcomes for a Net Zero 2030, carbon neutral initiative. Best practice sustainability features as upgrades to the Findhorn Ecovillage's infrastructure were key objectives. As part of the Strategic Frame, the Low Voltage (LV) electrical microgrid was assessed to incorporate the Ambient Loop District Heating Scheme (Ambient Loop) using Ground Source Heat Pumps (GSHP) crucial to the elimination of fossil fuel (LPG) based heating systems still currently employed by many households in the Findhorn Ecovillage. Multiple EV car charging stations are planned so that all electric modes of transport in the future can be met sufficiently as part of the Carbon Neutral 2030 objective. V2G (vehicle to grid) electrical storage will be incorporated into the microgrid. In addition, significant electrical battery storage and thermal storage will be evaluated. **[Click here for a link to Project 2 Feasibility Study.]**

Project 3: The Nature House Feasibility Study had Park Ecovillage Trust re-imagine and advance the Nature House concept developing a sustainable, closed-loop and energy efficient housing design as a community project, with the object of providing a model solution to affordable housing needs in many Scottish rural communities. **[Click here for a link to Project 3 Feasibility Study.]**

Project 4: The Scaling Organic Food Feasibility Study focused on the building of a resilient local food economy around the Findhorn Ecovillage including identifying key capital investments to boost horticultural and livestock production. These investments are large-scale composting machinery and protected crop greenhouse within a regenerative agricultural mixed farming system.. **[Click here for a link to Project 4 Feasibility Study.]**

Assumptions About Green Jobs Calculations: [Click here for Assumptions.]

1. **Main Expected Outcomes**

The expected outcomes of the studies are summarized below.

Project 1: Ambient Loop

- 5th generation district heating, called 'Ambient Loop District Heating' supplies heat to connected end-users through an Ambient loop at temperatures of 10-25 °C. Ambient loop systems have negligible heat losses in the loops and much greater efficiencies and economic benefits compared to traditional district heat networks. This Feasibility Study for Ambient Loop in the Findhorn Park has investigated the design and installation of six alternative communal heating systems for houses currently using LPG.
- The full Ambient Loop design from consultants Town Rock Energy (TRE) for 121 houses in four loops, including 56 new-build units is described in DocumentAL as Phase 1. The TRE Report contains analysis of the geothermal potential of the Findhorn Park leading to our current preferred district option to heat 44 existing houses in two loops using open loop wells for the Field of Dreams area (FoD) and 21 existing houses with closed loop wells serving the Bagend, Soillse and Barrel area. This is the full complement of existing permanent houses in the Findhorn Park, with estimated financial performance of CAPEX £1.58m, OPEX £71.8k, Lifetime cost £3.2m, NPV £2.0m, IRR 7.5% with ongoing carbon saving from switching from LPG fuel of 127.6 tCO2e pa & compared to ASHPs of 33.7 tCO2e pa . Each house has a GSHP and the high efficiency design keeps householder electricity costs low (DocumentAL).
- For residential caravan sites, such as exist in the Findhorn Caravan Park, the experience of installing the individual closed loop systems for Bagend/Soillse will inform this application for low cost housing sites, addressing social inclusion and fuel poverty.

Project 2: Microgrid and Strategic Framework

- 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.

Project 3: Nature House

- The feasibility study project for a Nature House model of sustainable housing delivered significant results for its expected outcomes, with a particular focus on **decarbonisation, resilience and jobs**.
- The Nature House demonstrated a high degree of **decarbonisation and efficiencies** in both embodied and operational carbon in comparison to current typical house building. It achieved operational energy efficiencies even better than current best practice (e.g. Passivhaus) whilst remaining within an embodied carbon budget less than current best practice (e.g. RIBA 2030 Challenge).
- The Nature House delivered key values for **citizens, communities and place** through the creation of multi-generational, communal living arrangements with generous common facilities. These contribute to a strong sense of identity and a supportive community of neighbours. The self-build dwellings and self-grown food strongly empower citizens to support themselves.
- The Nature House builds in strong characteristics of **adaptation and resilience** to the risks of climate change through increased food and energy security. Energy security is achieved by reducing heating needs to a fraction of typical current values and providing renewable energy on site. Food security is achieved by providing residents with access to greenhouse-enclosed growing areas sufficient to more than meet their needs for annual fruit and vegetable consumption.
- **Jobs, skills and education** are delivered through the self-build and self-grow aspects of the project as well as the educational value of a prototype design that reaches new levels of sustainability. The use of reclaimed materials in construction could ultimately create an industry to support 20,000 new jobs in Scotland.

Project 4: Building a Resilient Local Food Economy

- The feasibility study has produced a design (outlined here) for a **resilient** model of vegetable and meat production for 250 households in the Findhorn Ecovillage, with a particular focus on **decarbonisin**g the current food system, using regenerative agriculture principles to **restore** soil and wildlife habitats and creating a **financially viable** local food economy.
- The model demonstrated **decarbonisation of typical food production systems** through creating a short journey of food from field to fork and creating opportunities for sequestering carbon through: mob-grazing ruminants on grassland pasture, including human wastewater effluent from a bio wastewater treatment plant and application of compost to soil for vegetable growing. This system will create a closed nutrient cycle loop, with significant environmental gains.
- The **business** plan for vegetable production shows that £64,000 of wholesales can be generated per annum from vegetable and egg production. The livestock activities will be profitable in year one and will increase significantly in year 2.

- To meet targets for **fair distribution of costs and benefits**, our plan is to replicate this model in other communities across Moray, in line with the Moray Food Strategy 2020, which includes socio-economically disadvantaged areas. This will deliver hundreds of meaningful **jobs and provide training and skills** to growers and youth.
- Mindful of the precariousness of UK food supplies in the face of climate change and economic disruption, the model will build resilient local food economies, increasing access to nutrient-dense fresh produce with significant environmental and health benefits for local people.

2. Milestones

The key Milestones delivered by the studies are summarized below.

Project 1: Ambient Loop

1. Preliminary engineering and geothermal analysis have been completed. TRE has recommended boring a 100m test well to measure temperature and abstraction flow as a next step which will inform required geothermal infrastructure and project scale.

2. & 4. The Heat Networks (Scotland) Act 2021 targets heat network deployment in 2027 and 2030, equivalent to an estimated 120,000 and 650,000 additional homes being connected to heat networks. Networks of the 65 homes scale of this Study would translate to 1,800 networks deployed by 2027 and 10,000 by 2030, with each network creating 8 FTE jobs, which shows a massive potential.

3. The 65 homes project will save 127.6 tCO2e pa compared with current LPG fuel, 33.7 tCO2e pa compared with ASHPs and estimated embedded carbon of 14.8 tCO2e as detailed in DocumentAL

5. Electrification of heating increases the loading on the electrical microgrid, which is covered in that feasibility study.

6. Contact has been made with communities in Scotland who have completed or are currently involved with GSHP district heating through our consultants TRE, Pragmatic Energy, Collective Architecture and the GSHP supply chain.

7. FIRE is already in conversation with Moray Council and a Glasgow district with interest expressed through contacts in the heating industry and from the Ecovillage Network. Of particular interest is our generation of renewables through wind and solar for electrifying heating.

Project 2: Microgrid and Strategic Framework

- Projected number of people that could benefit from proposed activities: the electrification and decarbonisation of small settlements through the use of small scale decentralised renewable energy generation (wind and solar) combined with smart grid technology has wide applicability throughout Scotland.
- If conservatively applied to 500 settlements of an average size of 500 population the number of affected could be 250,000. But there is no reason that this number could not be easily increased given maturing of the technology and wide spread adoption.
- Green jobs: see section 3 below.
- Emissions savings from elimination of LPG for heating for 65 homes is estimated at 128 t/yrCO2-e as detailed in the Ambient Loop feasibility study.

- Replacement of 66 mobile homes with highly efficient permanent homes in the Findhorn Ecovillage will further reduce emissions by 132 t/yrCO2-e.
- Emissions savings from electrification with renewable energy sources of 500 small settlements (with an average of 100 dwellings each) currently heated by fossil fuels (heating oil, natural gas and LPG) can be estimated at 175,000 t/yrCO2-e.
- Smart grid technology is being widely explored within Scotland with expertise developed by our partners: U of Strathclyde, Heriot Watt University, and Pragmatic Energy. Findhorn Ecovillage as a demonstration site for new sustainability and renewable energy technology will have unique value as an early adopter to many communities throughout Scotland.
- The elimination petrol and diesel cars and migration to electric vehicles has the potential of massively reducing emissions without loss of mobility in rural settlements. Findhorn Ecovillage currently has approximately 130 vehicles. Conversion of all cars to EV will result in a carbon reduction of approximately 126 t/yr CO2-e.

Project 3: Nature House

- The Nature House feasibility study explores the delivery of sustainable, self-built timber homes inside a greenhouse enclosure that also provides space for food growing. Three Nature Houses with a combined total of 18 dwellings are proposed in the Findhorn Ecovillage. The projected outcomes are estimated for these three buildings as well as for a scenario in which the Nature House principles could be scaled up to deliver 100 dwellings in Moray and Aberdeenshire and 420 dwellings across Scotland.
- **Residents Benefits** - Findhorn: 54 people, Moray & Aberdeenshire circa 300 people.
  - Residents of Nature Houses enjoy multiple benefits, see Sections 5 and 7 below.
- **Emissions Savings** - Findhorn: 1,050 tonnes CO_2e, Moray & Aberdeenshire 5,830 tonnes CO_2e. The construction industry contributes 40% of carbon emissions globally and it must be transformed. Embodied carbon from construction of new dwellings can be reduced by the amounts shown above following the Nature House model.
- **Green Jobs** – See Section 3 below.
- **Green Jobs** – Glass Reclamation Business
  In order to procure glass for the greenhouses, a pilot project has been studied to reclaim waste glass from Moray demolition/refurbishment sites, thereby securing glass with almost zero embodied carbon. Such a business could sustain 19.6 jobs in Moray and if scaled up across Scotland 1,215 jobs. This could be part of a wider circularity industry in reclaimed construction materials worth around 20,000 Scottish jobs.
- **Emissions Savings – Glass Reclamation Business**
  If all waste construction glass in Scotland were reclaimed and reused there would be carbon emission savings of around 30,000 tonnes CO_2e.

Project 4: Building a Resilient Local Food Economy

- A food production system for 250 households is highly feasible on the available land. The project will commence initially at the Ecovillage, with a leasing agreement for cattle with a neighbouring landowner.

- The business plan projects a viable system using regenerative farming methods, which can be replicated to build food resilience in communities across the county.
- **Number of people benefiting:**
  - Findhorn Ecovillage – 250 households eating nutrient dense, chemical-free food.
  - Scotland-wide: 350,000 people eating locally grown food produced from 845 sites employing local people.
- **Projected emissions savings**: the proposed whole-system approach to food production will **save 22.5 tons in year 1. Thereafter, 32.3 tons.**

Contact has been made with local businesses to purchase a consistent supply of produce to meet market demands. Other local growers / neighbouring landowners will participate. Our community survey of 50 Households in the Findhorn Ecovillage highlighted food practices and demand.

Results:

- *Quantity of compost produced: 31 tonnes annually, which meets 41% of growing requirement.*
- *New covered cropping area (Keder Greenhouse) will increase growing area to 5,389m^2 and increase overall* ***covered cropping productivity*** *from £25/m^2/annum to £33m^2/annum (33% rise),*
- ***Turnover of vegetable sales per year*** *= £12.77/ m^2 overall: comprising Existing Polytunnels = £25/m^2, Keder Greenhouse = £32/m^2, outdoor growing - £7 /m^2, Micro-greens = £177/m^2.*
- ***Turnover of meat sales per acre of land*** *- £16,800/annum of income from 9.73 acres = £1,726.61 / acre.*

3. Green Jobs

Just Transition Fund projects at the Findhorn Ecovillage will create an estimated 83 Green Jobs locally and 12,800 Green Jobs as similar models are scaled across Scotland, supporting government efforts.

1. Ambient Loop District Heating System

A community district heating system will be installed at the Findhorn Ecovillage which will serve 65 houses. Approximately 8.4 green jobs will be created through the project, including 4 Ambient Loop Heat Pump & Pipe Installers, 3 Laborers, and .20 full-time equivalent (FTE) Heat Pump Trainers to train plumbers to become Heat Pump Installers. The project will create .25 FTE Geothermal & Civil Engineers and Geologist to survey and design the system; .25 FTE Project Manager; .10 maintenance and administration, and .35 FTE Community Carbon Reduction Outreach Workers to engage households and communities to take up district heating.

Given the Heat Networks (Scotland) Act 2021's target to connect 770,000 homes by 2030, a similar ground source community district heating system model could be replicated at a rate of 1,100 systems per year. This would require 4,150 green jobs. Given the slow uptake in heat pumps and district heating in Scotland, additional

strong measures would need to be taken by the government and associations such as Home Energy Scotland to reach the 2030 goal.

Ambient Loop	Jobs Created	
	FTE JOBS	***Activity***
CAPEX		
	0.2	Survey, design, engineering
	7.2	Installation
	0.3	Project Management
	0.4	Household & Community Engagement for District Heating
OPEX		
	0.1	Maintenance of ambient loops
	0.2	Training of Heat Pump Engineers
	8.4	Green Jobs Created - Findhorn
	4,150	Potential Green Jobs - Scotland

2. Microgrid and Strategic Framework

The Findhorn Microgrid Model is a decentralised approach for small villages, communities, and neighbourhoods with population of 50-750 to produce or buy clean energy and manage production, consumption, and storage of energy to optimise load shifting and SMART application ("Self-Monitoring, Analysis and Reporting Technology"). While Findhorn Ecovillage has both solar and wind energy, energy produced will depend on the conditions at each location.

The Microgrid will create 13.7 FTE jobs, including: 1.4 Community Carbon Reduction Outreach Workers; 1.07 Microgrid Manager and Sustainability Planners; 1.81 Energy Systems and Electrical Engineers; .59 Environmental and Civil Engineers/CAD; 1.75 Construction Workers; 4.78 Energy/Electrical Contractors; .47 IT/Energy Specialist; .61 Energy Systems Maintenance; 1.21 Accounting/Administration; and .05 Electrical Trainer.

Building on the Positive Energy District (PED) model and strong community engagement in Scotland, the Findhorn model can be scaled, in clusters of 200 households and community buildings, across Scotland in 475 localities with less than 750 people and 620 neighbourhoods in localities with greater than 750 people, resulting in 2,150 jobs to construct 1,095 microgrids by 2030 to help Scotland achieve its target to double clean energy production by 2030.

Microgrid	Jobs Created	
	FTE JOBS	***Activity***
CAPEX		
	0.9	Master Planning
	0.8	Microgrid Creation & Community Engagement
	2.7	Microgrid Modeling & Construction

	2.0	Photovoltaic Installation & Wind Turbine
	3.0	Car charging battery stations
OPEX		
	0.7	Maintenance
	0.4	Project Management
	1.8	Administration/accounting
	1.3	Technical oversight
	0.1	Training/Education
	13.7	Green Jobs Created - Findhorn
	2,150	Potential Green Jobs - Scotland

3. Nature House Affordable, Green Housing

The Nature House affordable housing project will create 56 Green Jobs at Findhorn Ecovillage and potentially 1,010 Green Jobs across rural Scotland. The affordable homes are self-built including a greenhouse for food growing.

Benefits of the unique Nature House model include delivery of new affordable, sustainable homes and creation of green jobs, skills and education for a wide range of people over an extended period. The design and construction phase is two years, after which the buildings are inhabited and food grown. The outreach phase follows, creating 1,010 jobs through training, education, and outreach to other rural communities to design a Nature House for their context.

Green Jobs include architects, engineers, and other building professionals during the design phase, creating 12.5 jobs; and contractors and installers during the construction phase, creating 33 jobs. Construction work is assisted self-build which spawns both jobs and training, leading to future jobs. The growing, maintenance, and outreach phase creates 9 jobs locally and spurs additional job generation nationally. Additionally, a glass reclamation business will be founded, generating 1,200 jobs to collect, process and reuse waste glass from building refurbishment/ demolition sites thereby significantly reducing carbon emissions.

Nature House	**Jobs Created**	
	FTE JOBS	***Activity***
CAPEX		
	12.5	Design of 3 Nature Houses
	33.3	Installation of 3 Nature Houses
	1.2	Project Management
OPEX		
	5.2	Growing
	2.1	Maintenance / Facilities Management
	0.5	Training, education and outreach
	29.2	Green Jobs Created (paid) - Findhorn
	25.5	Green Jobs Created (exchange) - Findhorn
	1,010	Potential Green Jobs - Scotland
	1,200	Potential Green Jobs - Scotland: Glass Reclamation Business

4. Building a Resilient Local Food Economy

The local food system pilot, modelled in the Findhorn Ecovillage, will create 6.3 FTE paid jobs in fulfilling, meaningful roles. The pilot is financially sustainable, with funds from sales of food grown using organic methods and related business activities.

Roles entail composting, growing (Garden Grower Manager/Sales job, and Garden Grower / Instructor job) and chicken rearing, all generating 2 green FTE jobs. Livestock activities generate 0,35 Regenerative Livestock jobs. Food-related businesses, including added-value products and catering, will generate 2.6 jobs. Additionally, Carefarm activities will create 1.35 FTE jobs.

In year 3, we will replicate the model across Moray, with a 'Growing/Scaling Team' trained by the Ecovillage team. They will develop 12 new sites in year 3, continuing over a 7-year period, expanding to 26 sites in Moray and 845 sites across Scotland, resulting in 5,500 jobs.

The team will employ youth to encourage local engagement in healthy food consumption, through learning-by-doing, which is more effective than demonstrations. The NHS is expanding social prescribing in Scotland, which will increase access to Carefarming by the public.

This supports local Council Food Strategies and will transform the national food system, with 350,000 people eating locally grown food (6% of the population).

Resilient Food	**Jobs Created**	
	FTE JOBS	***Activity***
CAPEX		
	0.1	Compost Plant Construction
	0.1	Keder Greenhouse Installation
OPEX		
	2.3	Composting, growing, livestock activities
	4.0	Food-Related Businesses
	6.3	Green Jobs Created (paid) - Findhorn
	.1	Green Job Created (exchange) - Findhorn
	5,500	Potential Green Jobs - Scotland

4. Finance unlocked through funding

Additional funding that has been unlocked through Scottish Government funding for these project are summarized below. (This included additional funding our organisations put into deliver the projects, or third parties coming in to support the delivery alongside Scottish Government funding.)

Project 1: Ambient Loop

1. FIRE has submitted a grant application called "InterPED" to the European Commission in April for total eligible costs of €428,000. This application is centred on the technologies of the Microgrid and Ambient Loop Studies, with

emphasis on citizen participation and community engagement in demand response interventions and decarbonisation of heating and transport. If successful InterPED will enhance our reach to be members of European Positive Energy District (PED) networks and will enable trading of surplus renewable energy within the networks at better rates than available from local grids.

2. Discussion is in progress with SNRG, whose focus is investing and building of microgrids. There will be a meeting in Findhorn on May 23rd between SNRG, Pragmatic Energy, Ekopia and FIRE. SNRG bring many contacts in the energy industry and have expressed early interest in funding parts of Microgrid and Ambient Loop implementation, with a particular interest in energy storage.
3. Ekopia is Findhorn's in-house investment arm and has already jointly funded Findhorn Wind Park. Ekopia has agreed in principle to invest up to £500,000 in FIRE's energy sector requirements, given the right circumstances, such as not being the sole source of funds.
4. Because of the transformative nature of the Feasibility Studies, there are investment opportunities for private donors through Ekopia and/or the Ecovillage Findhorn Membership Benefit Society.
5. TRE has recommended an approach to the Heat Network Support Unit. Other potential funding sources include Highlands and Islands Enterprise, who have supported Findhorn's water company Biomatrix Water and solar energy company AES.

Project 2: Microgrid and Strategic Framework

- Integrated master planning for electrification and decarbonisation of settlements using renewable energy and Smart Grid technology has wide applicability within Scotland and a number of other funding sources have been identified above.
- In addition to funding already outlined Findhorn Ecovillage has received funding for its Carbon Neutral 2030 project from the National Lottery Fund and tsiMoray.
- Early adoption of new technology will require financial support from the Just Transition Fund or other funding bodies.
- Approaches for additional funding have been or will be made to
  - Moray Local Action Fund (roger)
  - Moray Funders Forum
  - Carbon Community Priorities (tsiMoray)
  - Carbon Neutral Communities (tsiMoray)
  - BE-ST (Built Environment Smarter Transformation)
  - Community and Renewable Energy Scheme (CARES)
- In particular elements needing funding will be smart grid control system, EV charging, the large scale solar photovoltaic arrays and the 200 kWh electric battery store.
- Funding could either be in grant form or long term low interest loans.
- Funding from within the Findhorn Community has already been successfully used in our existing Wind Park and could also be applied to any of the above projects.
- Sponsorship will also be explored with suppliers of the technologies.
- There will be a business case for the EV charging and solar farm with the most likely organisation being the Findhorn Wind Park.

Project 3: Nature House

- As the project is a feasibility study at this stage any funding is pending.
- If the development of one or more Nature Houses were to proceed, there are several possible sources of funding that might be available.
- Private investment may be available to fund the purchase and development of residential sites with return on investment from long and/or short-term leasehold.
- Finance has been indicated from the Rural Housing Fund.
- Investment may be available from the local community benefit co-operative, Ekopia.
- Funding would be provided by the purchase of leasehold plots by residents.
- The self-build aspect of the development unlocks value from purchasers using their own labour.
- Self-builders may source finance from the Scotland Self-Build Loan Fund.
- The use of reclaimed glass to build the greenhouse(s) is a new approach to construction that does not yet have a supply chain. Developing this supply chain would create a new business model that might secure investment from major international glass companies such as Saint-Gobain, Pilkington (NSG) and Guardian Glass as well as private investment.

Project 4: Building a Resilient Local Food Economy

- As the project is a feasibility study at this stage any funding is pending.
- If the growing potential of Cullerne Gardens is fulfilled and a leasing agreement for Cullerne Farm fields were to proceed, the project would work to a viable business model.
- The returns involved in food production alone would not be sufficient to pay interest on loans.
- Additional revenue streams will be generated through food growing training courses designed for the public and from clients attending Findhorn Foundation education programmes, part of which are spent in Cullerne Gardens.
- However, capital assets would need to be purchased with seed funding. Our relationship with TSI Moray will signpost us to potential funding sources, such as the Local Action Fund. Other community groups have funded compost machinery with funds received from the Scottish Landfill Fund and the National Lottery Nature & Climate Fund.
- There may be Scottish Government Rural Payments available for Cullerne garden's use for horticultural production.

5. Community Benefits and Regional Impacts

Positive regional impacts on communities that resulted from the projects are summarized below.

Project 1: Ambient Loop

- Our project has deepened partnerships with Heriot Watt University (HWU) and University of Strathclyde (UoS). HWU, through Pragmatic Energy delivered scoping for the controls and optimisation systems for the Microgrid and Ambient Loop studies. HWU is the academic partner with FIRE for InterPED (DocumentAL). UoS has delivered modelling of the Microgrid energy generating

capacity for extra wind, solar PVs renewables and electrical storage. They also modelled the smaller microgrid for North Whins development including off-grid Natur Housing.

- The project has involved a widening number of design engineering and supply chain partners. The principal is Town Rock Energy (TRE), introduced by HWU and cemented through close working on the geothermal and heat distribution engineering. TRE will use the Findhorn design work as a reference for similar Scottish projects. Thermal Earth and NIBE have mutually benefited our approach to the electrification and decarbonising of Findhorn Park heating and potential outreach to other projects.
- Planning discussions with Moray Council will guide and benefit the Community's approach to strategic planning of the site. Moray Council has requested collaboration on their own district heating projects.
- In a broader context our work is of interest to the Global Ecovillage Network and positive energy districts in Spain, Switzerland and Serbia, through the growing PED networks.
- Through contacts with Rural Housing Scotland community benefits are realizable for low carbon district heating, particularly for the affordable housing sector.
- Through initiatives, such as the Lilac model, local and regional housing can adopt technologies pioneered in Findhorn and applied to fuel poverty and social inclusion.

Project 2: Microgrid and Strategic Framework

- The Findhorn Ecovillage has long had a significant profile and resource in the sustainability world.
- With the adoption of the Strategic Framework and aspiration of Carbon Neutrality within ten years, the community will be able to assume a new level of leadership in terms of positive response to the climate crisis.
- Already a United Nations recognised training centre with two Best Practise awards from UN Habitat, the additional implementation of all four of the current feasibility studies will have not just a significant national impact but also international.
- The Findhorn Ecovillage was on the cover of the IPCC Sixth Assessment Report published in 2022.
- As a demonstration site for sustainable technologies for many decades, the partnerships with universities, technology suppliers and professional bodies will add to and increase the regional impact.
- The electrification of transport for rural communities as well as innovative alternatives to car ownership through car sharing (Moray Car Share) and community transport schemes will have wide application to other settlements throughout Scotland.

Affordable EV car charging as proposed for a pilot at the Findhorn Ecovillage will have the best chance of success if it is applied to a wider catchment in the Moray area and as part of the pilot approaches will be made locally to engage with the implementation.

Project 3: Nature House
Direct Benefits from Feasibility Study:

- The feasibility study raised awareness in the local community of the importance of reducing carbon emissions, sustainable homes, self-building and self-grown organic food.
- The study raised awareness with major international glass manufacturers (Saint-Gobain, NSG and Guardian Glass) and engineers (Arup and Eckersley O'Callaghan) of the potential to reduce carbon emissions by using reclaimed glass in construction. NSG and Arup in particular expressed interest to be involved in pilot projects to reclaim glass.

Potential Benefits from Nature Houses:

- The self-build homes model has significant community benefits in reducing costs and making homes more affordable plus providing skills and training to self-builders. This training has been shown to enable people to create new jobs in construction industries.
- The communal arrangement of homes inside the common space of the greenhouse supports creation of close neighbourhood communities. These bring benefits of resilience, mutual support, mental health and increased productivity.
- The grow-your-own food model has significant health benefits for residents:
  - Better nutritional values from fresh food eaten soon after harvest.
  - Lower cost food means that those on low income can still eat high quality, organic food.
  - Heathier spaces inside the greenhouse than typical homes: better air quality, higher natural light levels, more space for active lifestyles.
- The Nature House also provides sufficient space to allow residents to scale-up food production, beyond their own needs, to create small businesses in the food sector.
- Excellent thermal performance of Nature House could apply to wide application in Scottish climate.

Project 4: Building a Resilient Local Food Economy
Direct Benefits from Feasibility Study

- We surveyed 1/5th of households in the Findhorn Ecovillage raising awareness of the importance of reducing carbon emissions from our current food system.
- We discussed with local businesses about increasing the supply of local produce for wholesale purchase, which will help them to expand their market.
- Discussions with the neighbouring Army base have revealed that they are interested in food growing for military personnel and engaging our training services. We will explore this further with them in the future.

Potential Benefits from Building a Resilient Local Food Economy

- Local people will have increased access to nutrient dense, locally produced food, compared with lower quality food purchased from supermarkets. This will lead to significant improvement in health and wellbeing outcomes.
- We will collaborate with local shops to generate growing plans that meet their commercial market requirements.

- The feasibility study highlighted that Carefarms are more effective when linked to a commercially viable production unit due to improved sense of purpose. This indicates that the existing Carefarm in Cullerne Gardens will continue and expand in a more conducive setting.
- Contact has been made with Moray Council regarding the implementation of their Food Growing Strategy (2020), some of which is aimed at socio-economically disadvantaged areas such as New Elgin East and Buckie Central East. Once a profitable model is demonstrated on the land at Cullerne Garden, it can be replicated in the areas they have identified for food growing in local communities.

6. Obstacles

Key obstacles in completing the projects and how our teams addressed them are summarized below.

Project 1: Ambient Loop

- Most current Ambient Loop district heating installations have been in new-build high-rise buildings, where pipework routes are short. TRE has informed FIRE that we are the first “village scale and village layout” Ambient Loop project in Scotland. Pioneering presents its own obstacles.
- The short 5-months to complete the Feasibility study was an obstacle to engaging industry experts to concentrate on the Findhorn project. This included the site survey, engineering of multiple alternative technology strategies and having sufficient design work completed to cost alternatives. This work needed to be dovetailed with Microgrid Study close to the deadline.
- Retrofitting a district heating system to existing houses is more difficult and expensive than new-build potentially involving costly connections. Because existing houses have diverse designs, levels of insulation and age, detailed surveys of house types are necessary, involving the recalculation of many thermal loads. This is time consuming and expensive.
- Heat pumps generally operate at lower delivery temperatures and for longer times than LPG fired boilers. This frequently requires upgrading existing heating installations in houses with larger and different radiators, increasing CAPEX. Retrofitting a district system is an obstacle because of the considerable necessary disruption caused by installing pipes in the ground, along with upgrading radiators in houses.
- The layout of existing housing structures presents many obstacles for pipework access and often the requirement for “hard dig” in asphalt covered roads.
- Naturally, the advantage of overcoming these obstacles that replace fossil fuel heating with electrification optimises the utilisation of on-site renewable energy.

Project 2: Microgrid and Strategic Framework
Strategic Framework Obstacles:

- Key consultants were located in Glasgow which made site meetings less frequent and expensive
- Gathering information on infrastructure from a multitude of sources within the community and digitising information to CAD took significant time and delayed

the engagement of the key civils and traffic consultants, resulting in extension of the proposed schedule.

Microgrid Obstacles:

- The short time frame for completion of the feasibility meant some of the key research with U of Strathclyde was not available until later in the project.
- Delay in fitting meters due to supply issues for real time monitoring of the existing grid meant that much of the modelling had to be done with older data.
- Smart Grid controls report from Pragmatic Energy was also only available late in the project and is still ongoing.

EV Charging Obstacles:

- Technology review showed that most existing systems for management, billing and operations are geared for much larger projects of many hundreds or thousands of charge points.
- Our project with less than a hundred charge points meant that the more mature and sophisticated systems will not be affordable for our scale.
- A bespoke software solution will need to be developed, with the benefit being it will be affordable for smaller communities and there may be a business opportunity to be able to provide services to small projects.
- Hardware for charging stations is evolving rapidly and designing a ten-year implementation programme is not feasible given changing technology both software and hardware, as well as changing electricity prices.

Increasing Renewable Energy Capacity Obstacles:

- The export limitation of 975kW is a challenge that needs to be overcome to increase renewables at any real scale.
- The highly fluctuating energy prices has made reliable economic forecasting for various options very difficult.
- This is particularly true for battery storage to avoid exporting with poor feed-in tariff (which may change) and for installation of new renewable generation (wind or solar).

Project 3: Nature House

The feasibility study itself experienced few obstacles beyond time which it overcame by additional person/hours. The study, however, highlighted potential problems of Nature House development and strategies for overcoming them.

- Embodied carbon of construction is a significant obstacle and many recent “green” projects have counterproductively achieved low operational carbon emissions from buildings (e.g. heating systems) at the expense of high embodied carbon from the construction itself. The Nature House model overcomes this problem by achieving high thermal performance with low-embodied-carbon materials such as wood, cellulose, reclaimed glass and reclaimed/recycled aluminium. Steel and concrete use is strictly limited.
- Recycled content is common in some construction materials but this has only marginal savings to embodied carbon. What is urgently needed is the reclamation and wholesale reuse of construction materials from one building to another – an end to the practice of demolition. The study identifies how valuable it could be to pioneer these circularity industries and proposes that

pilot projects be carried out in key materials such as glass, steel and aluminium.
- The capital cost of the greenhouse enclosure is a potential obstacle and the principle for overcoming it is to find savings in the construction of the inner dwellings so that the combined cost of dwellings and enclosure approaches the cost of highly sustainable homes not inside a greenhouse. The obstacle has been overcome by three key cost savings:
    - Self-building.
    - Inner dwellings require less materials as already protected by greenhouse.
    - Smaller homes are feasible because supplemented by generous common spaces.

Project 4: Building a Resilient Local Food Economy

- While the carbon benefit of composting our own waste is significant, the compost model itself is not financially viable at small-scale. This could be overcome via 3 options: i) a larger-scale option that shifts from collecting residential waste to gathering bulk from large-sized businesses in Forres. A larger compost machine would be required for the larger volume of biomass; ii) a smaller scale operation whereby households in the Ecovillage deliver waste to the composting unit, housing a small Riden composter which consumes no power. This would also be relevant to the small community gardens proposed in Moray's Food Strategy. However, this will only produce 1/8 of compost required; iii) buy in compost, which is financially viable, but with greater carbon emissions.
- Reaching local customers is a significant challenge. Our community survey showed that 74% of respondents buy a proportion of their vegetables from Tesco, with 34% using that supermarket as their primary source of vegetables. To overcome this, we have made tentative agreements with two small local shops, which have captured a proportion of the local market and thus have the capacity to wholesale purchase all our potential produce. Our wholesale prices will have to be competitive to allow our retail clients to offer attractive prices.
- Increasing production area is challenging because the thin, sandy soils of much of the property is not currently suitable for growing vegetables. To overcome this, we have included an egg production component as a cost effective method for importing fertility into the gardens.

7. Lessons Learned

The main lessons learned from the feasibility studies are as follows.

Project 1: Ambient Loop

- FIRE should have established budget bandwidths at the start of the project as engineering consultants were appointed to set CAPEX cost targets per house for each house type variation. These GSHP targets could have then been compared with installing ASHPs, which have a lower house CAPEX. GSHPs have a higher efficiency and so lower OPEX than ASHPs, potentially justifying the investment. Discounted cash flow calculations conducted at the end of the design, should have been scoped at the beginning (DocumentAL).

- Scale is a driver of design as shown in six engineering configurations (DocumentAL). High house densities result in access restrictions, requiring differing pipework solutions and mixtures of open loop and closed loop wells.
- There are advantages and disadvantages of closed loop and open loop systems to extract ground heat. Closed loop wells are generally used for single house installations involving a small diameter well of up to 100m depth, with U-tube pipe to pick up heat from elevated temperature groundwater. This is cost effective for small clusters of houses, where the wells can be 12m to 15m apart. Open loop systems are designed with larger abstraction and reinjection wells many hundreds of meters apart, with pipework feeding a central pump station with pumps, thermal storage and controls. Sunk cost of open loop determines increased system scale. Recommendations for Findhorn Park include a mixture of open loop for high-density housing and closed loop for small clusters of houses at the site edges, as shown in the site plan (DocumentAL).

Project 2: Microgrid and Strategic Framework
Strategic Framework:

- Wide community engagement is essential to the successful planning process and was achieved but the resources required (time and people) were quite significant and more than anticipated.
- Outside experts particularly with urban planning, traffic management, trees & ecology are essential not just from a statutory point of view (required reporting) but also to develop community understanding of complex issues.

Microgrid:

- Smart grids are still in the development stage and are extremely complex.
- a robust comms system between elements of the grid is going to be required and is a significant cost that has not previously been considered.
- Some level of technical expertise in controls and software will be needed ongoingly within the community to ensure the reliable operation of the smart grid.
- carbon emissions saving from implementation of smart grid technology is difficult to quantify and out with the scope of the feasibility at this time.
- at the same time the optimisation of the grid to minimise peak demand and make best use of renewable energy is essential more from an economic perspective than a carbon emissions perspective (both are important).
- through careful modelling we found that our existing grid is mostly adequate despite very significant addition loading from the ambient loop and EV charging, saving significant capital costs to upgrade.

EV Charging:

- scale is very significant and small projects are best done in small steps so that solutions can be tried and adjusted from learnings gleaned.
- the business case for small scale communities is difficult to justify and should be considered more as a service needing to be provided than a potential business.
- a potential business opportunity does exist if a number of small projects in a local area could be linked.

Increasing Renewable Energy Capacity:

- there are still considerable work to be done with regulatory bodies to make it easier for more small scale distributed energy generation systems linked to local communities to go forward.
- Wind and solar PV are well developed and mature technologies that can be widely applied to small communities.
- Battery storage technology is now widely available and becoming more affordable but will more than likely require some grant funding to proceed.

Project 3: Nature House

- The Nature House glazed enclosure can halve the energy needs of the dwellings within.
- Embodied carbon is now far more significant than operational carbon in new-build construction. Reducing it requires building with local wood and plant-based materials and designing-out concrete and steel.
- Reducing embodied carbon also means building with reclaimed materials of which almost no meaningful supply chains yet exist. There is an entire industry of "construction circularity" waiting to be born and it could have a value to Scotland in the region of 20,000 jobs: a 10% increase in the current Scottish construction workforce.
- Self-building homes brings a wide range of benefits:
  - Cost savings.
  - Easier access to home ownership for young and less well-off.
  - Skills and training that lead to future jobs.
  - Self-determination and self-expression of the character of people's homes.
- Grow-your-own food brings a wide range of benefits:
  - Lower-cost food.
  - Higher quality and better nutritional value food, even for those less well-off.
  - Access to better light and air.
  - Encouragement towards a less sedentary lifestyle.
- Building planning and design can strongly support the creation of communities of neighbours through generous common spaces and groups of dwellings with a clear common identity. The benefits include.
  - Social resilience through mutual support.
  - Preventing social isolation of vulnerable groups.
  - Skill and knowledge sharing to improve productivity.
  - Mental health benefits from being part of a social group.

Project 4: Building a Resilient Local Food Economy

- Our approach to innovation is not to focus on individual technologies as a magic bullet to solve food production problems, rather to harmonize existing technologies that have become disparate, and create a whole systems approach that delivers net zero outcomes and financial viability.
- Significant expectations exist that communities will grow their own food voluntarily and shift to organically grown food through education. We believe that financial incentives (jobs) need to be created for communities to engage. People will buy produce if prices are competitive and it is convenient to do so.
- While small scale projects are useful, there is a need for environmentally sound large scale projects. For instance, organic carrots grown locally for Tesco have an

extremely high carbon footprint before they reach the local shop, compared to locally produced carrots which have a very short journey from field to shop.·

- Small-scale vegetable growing / meat production does not lend itself to loans for capital inputs because food prices are kept low by supermarkets, which benefit from monopoly / vast economies of scale.
- Although organic food is an aspiration for all food systems, achieving organic standards is expensive and administration is time consuming. As such this project will maintain financial viability by using organic methods but not strive for organic certification.
- It is not profitable to heat greenhouses for producing warm season crops through a Scottish winter. Geothermal heating systems might provide a solution and further research is required to understand this methodology.

8. JTF Process Feedback

An assessment of the JTF process for these feasibility studies includes these considerations:.

Projects 1, 2, 3, 4

- For Feasibility Studies, the process worked well, in being open to the exploration of innovations with an emphasis on “transformative”. The main question then “is the innovation feasible”? This needs to cover the technology – “does it work” and the budget – “do CAPEX and OPEX numbers stand up when measuring Discounted Cash Flow numbers?” If promising, then the questions relate to funding of CAPEX. While the big picture of £50m/year for 10 years is highly attractive, it would be really helpful now to know the next steps for securing finance from JTF and the terms of payment. This would then inform FIRE of what is needed to prepare a funding proposal, that is open to acceptance, and can be made in a few months.
- We understand that pilots are funded 100%, which is extremely helpful. If the solutions are truly innovative and transformative, there is the inevitable question of technology and budget risk. A pilot could be a good next step. It would be helpful, therefore, to know the criteria that JTF will apply to securing pilot funding and the process criteria for moving on to a capital grant application.
- For potential JTF loans, what are the collateral requirements, the conditions and loan terms – “holiday time if any”, period of the loan, interest rate and reporting requirements?
- We appreciated the dialogue with the JTF staff and accessibility of the Minister to discuss and clarify some of the questions and uncertainties we faced, given that we are only in year 1 funding and the fund is just starting.
- With the very innovative and cutting-edge technologies and combination of technologies we have been able to consider in the feasibility studies, we believe there is very wide applicability to other communities in Scotland far beyond the Findhorn Ecovillage. But the uncertainty of capital funding from JTF has made the implementation of the studies a very real concern.

- Lack of certainty about year two funding has led to a reduction in the specificity of our feasibility studies. If we had certainty that capital funding would be available, for example, we could have focused the study on capital projects and gone deeper with the research. As it was, we have tried to cover pilot and capital projects at a range of scales so as to be more adaptable to the unknown funding situation.

9. Changes in milestones and outcomes

In addition to the milestones and outcomes set out in our EOI, our teams also identified these:.

Although FIRE has had only a Year 1 grant, there are a number of Pilot opportunities that look promising as a Year 2 step. These include:

I. Expanding the resilient local food economy from the Findhorn Ecovillage to land identified in the Moray Council Food Strategy
II. Soillse Research greenhouse, which will inform the local food economy system across Moray. This greenhouse will create several microclimates in order to foster highly diverse forms of life, including soil types, insects acting as integrated pest management, fungi, solar-algae ponds, fish, frogs, worms and of course horticultural crops of vegetables and herbs. The idea is to inspire ourselves and future gardeners to be transformative.
III. Nature House on one of three Park alternative sites,
IV. Enclosing Cullerne House within a greenhouse structure,
V. North Whins renewable energy microgrid, serving up to 22 new-build houses and supplying electricity to off-grid Nature Housing.

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Annex A – Expenditure Report

Please provide a detailed breakdown of the actual expenditure compared to the planned expenditure detailed in your Grant Award Letter.

Agreed Grant Funding	£ £226,775

Expenditure Category	Planned Expenditure	Actual Expenditure
Ambient Loop	**£55,171.49**	**£55,171.49**
Microgrid Strategic Frame	**£78,516.55**	**£80,311.42**
Nature House	**£37,143.63**	**£37,143.63**
Scaling Organic Food	**£26,892.61**	**£26,892.61**
Project Mgmt Overhead	**£29,050.72**	**£27,255.85**
TOTAL	**£226,775.00**	**£226,775.00**

If your project is multi-year, please provide below your planned monthly or quarterly claim profile for next financial year.

N/A

Month/Quarter	Planned Expenditure
TOTAL	**£** 0

Annex B – Just Transition Outcomes

Citizens, communities and place: support affected regions by empowering and invigorating communities and strengthening local economies;

Jobs, skills and education: equip people with the skills, education and retraining required to support retention and creation of access to green, fair and high-value work;

Fair distribution of costs and benefits: address existing economic and social inequality by sharing the benefits of climate action widely, while ensuring that the costs are distributed on the basis of ability to pay;

Business and Economy: support a strong, dynamic and productive economy which creates wealth and high quality employment across Scotland, upholds the UN

Guiding Principles on Business and Human Rights, and continues to make Scotland a great place to do business;

Adaptation and resilience: identify key risks from climate change and set out actions to build resilience to these risks, ensuring our economy is flexible, adaptable and responsive to the changing climate;

Environmental protection and restoration: commit to act within our planetary boundaries while protecting and restoring our natural environment;

Decarbonisation and efficiencies: contribute to resource efficient and sustainable economic approaches that actively encourage decarbonisation, support low-carbon investment and infrastructure, and avoid carbon 'lock-in';

Further equality and human rights implementation and preventing new inequalities from arising: address fuel poverty and child poverty in a manner consistent with Scotland's statutory targets on each, while furthering wider equality and human rights across all protected characteristics.