Cononsyth Farms

The Case Study

Presented By

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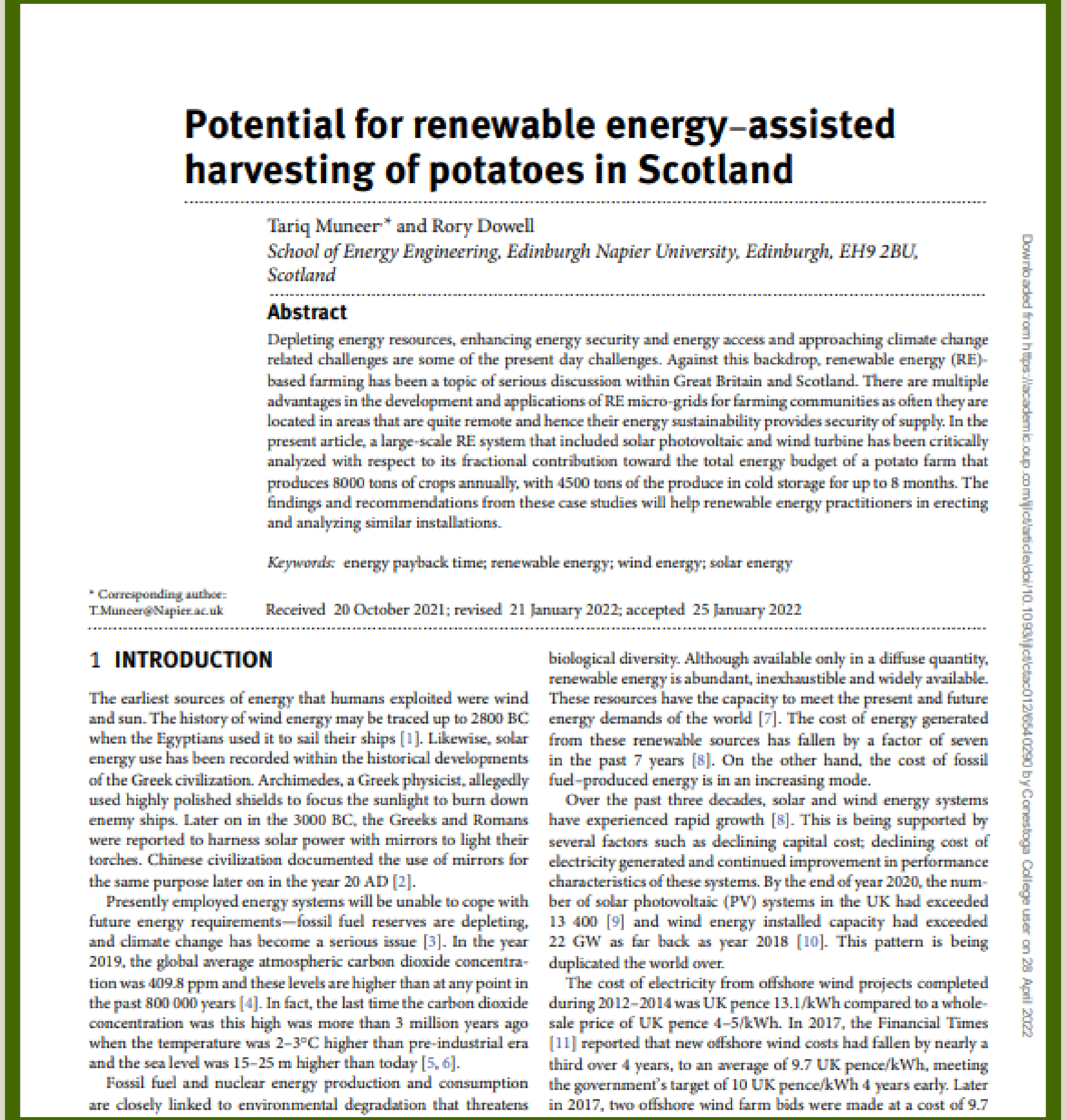
Cononsyth Farms

Muirden Energy

- 400 acres of potatoes
- 900 acres cereals
- 64,000 hens
- 330kW wind generation
- 350kW solar generation
- 3MW biomass heat



Potential for renewable energy–assisted harvesting of potatoes in Scotland

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Abstract

Depleting energy resources, enhancing energy security and energy access and approaching climate change related challenges are some of the present day challenges. Against this backdrop, renewable energy (RE)-based farming has been a topic of serious discussion within Great Britain and Scotland. There are multiple advantages in the development and applications of RE micro-grids for farming communities as often they are located in areas that are quite remote and hence their energy sustainability provides security of supply. In the present article, a large-scale RE system that included solar photovoltaic and wind turbine has been critically analyzed with respect to its fractional contribution toward the total energy budget of a potato farm that produces 8000 tons of crops annually, with 4500 tons of the produce in cold storage for up to 8 months. The findings and recommendations from these case studies will help renewable energy practitioners in erecting and analyzing similar installations.

Keywords: energy payback time; renewable energy; wind energy; solar energy

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1 INTRODUCTION

The earliest sources of energy that humans exploited were wind and sun. The history of wind energy may be traced up to 2800 BC when the Egyptians used it to sail their ships [1]. Likewise, solar energy use has been recorded within the historical developments of the Greek civilization. Archimedes, a Greek physicist, allegedly used highly polished shields to focus the sunlight to burn down enemy ships. Later on in the 3000 BC, the Greeks and Romans were reported to harness solar power with mirrors to light their torches. Chinese civilization documented the use of mirrors for the same purpose later on in the year 20 AD [2].

Presently employed energy systems will be unable to cope with future energy requirements—fossil fuel reserves are depleting, and climate change has become a serious issue [3]. In the year 2019, the global average atmospheric carbon dioxide concentration was 409.8 ppm and these levels are higher than at any point in the past 800 000 years [4]. In fact, the last time the carbon dioxide concentration was this high was more than 3 million years ago when the temperature was 2–3°C higher than pre-industrial era and the sea level was 15–25 m higher than today [5, 6].

Fossil fuel and nuclear energy production and consumption are closely linked to environmental degradation that threatens biological diversity. Although available only in a diffuse quantity, renewable energy is abundant, inexhaustible and widely available. These resources have the capacity to meet the present and future energy demands of the world [7]. The cost of energy generated from these renewable sources has fallen by a factor of seven in the past 7 years [8]. On the other hand, the cost of fossil fuel–produced energy is in an increasing mode.

Over the past three decades, solar and wind energy systems have experienced rapid growth [8]. This is being supported by several factors such as declining capital cost; declining cost of electricity generated and continued improvement in performance characteristics of these systems. By the end of year 2020, the number of solar photovoltaic (PV) systems in the UK had exceeded 13 400 [9] and wind energy installed capacity had exceeded 22 GW as far back as year 2018 [10]. This pattern is being duplicated the world over.

The cost of electricity from offshore wind projects completed during 2012–2014 was UK pence 13.1/kWh compared to a whole-sale price of UK pence 4–5/kWh. In 2017, the Financial Times [11] reported that new offshore wind costs had fallen by nearly a third over 4 years, to an average of 9.7 UK pence/kWh, meeting the government's target of 10 UK pence/kWh 4 years early. Later in 2017, two offshore wind farm bids were made at a cost of 9.7

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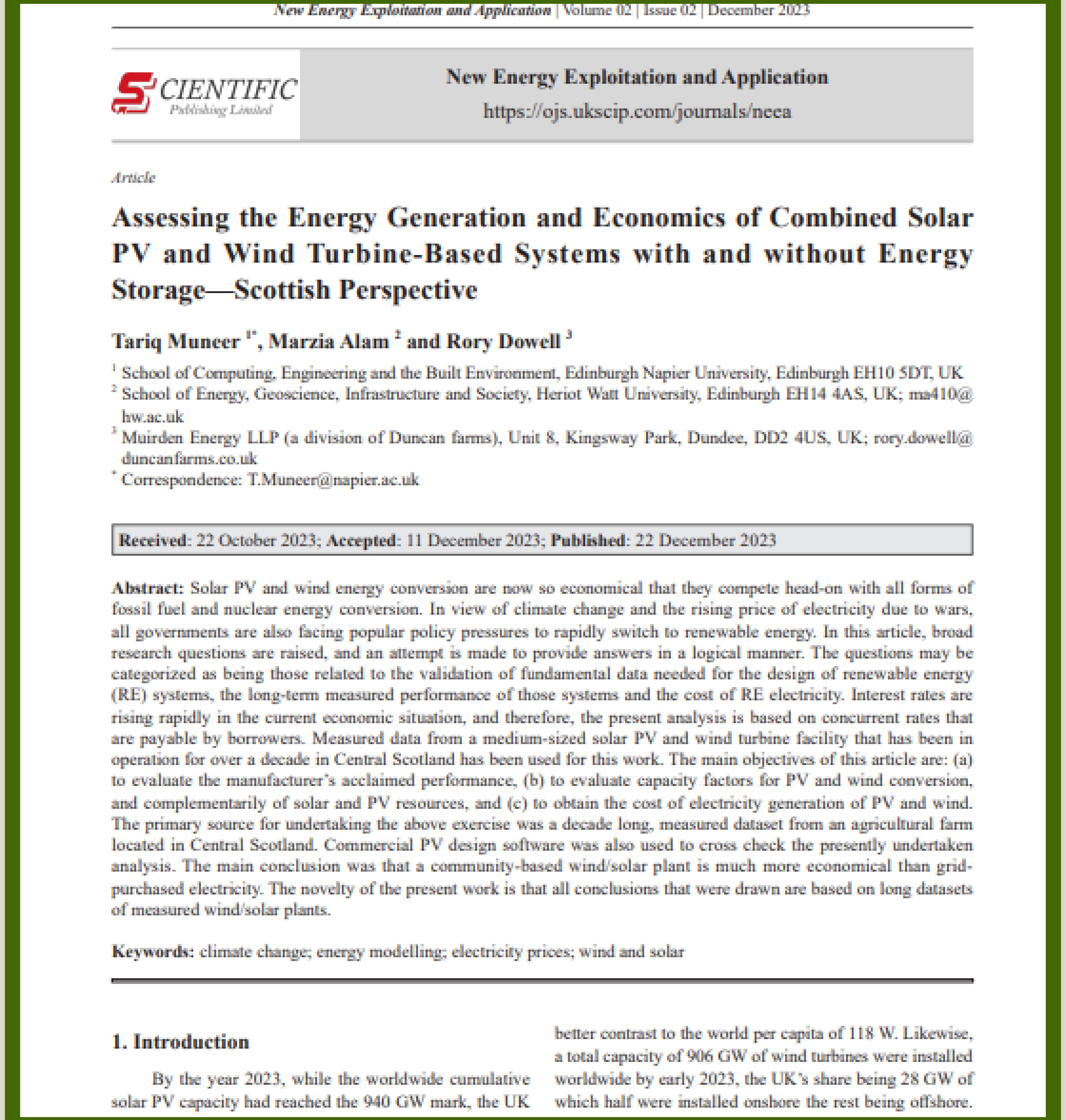

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Article

Assessing the Energy Generation and Economics of Combined Solar PV and Wind Turbine-Based Systems with and without Energy Storage—Scottish Perspective

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Abstract: Solar PV and wind energy conversion are now so economical that they compete head-on with all forms of fossil fuel and nuclear energy conversion. In view of climate change and the rising price of electricity due to wars, all governments are also facing popular policy pressures to rapidly switch to renewable energy. In this article, broad research questions are raised, and an attempt is made to provide answers in a logical manner. The questions may be categorized as being those related to the validation of fundamental data needed for the design of renewable energy (RE) systems, the long-term measured performance of those systems and the cost of RE electricity. Interest rates are rising rapidly in the current economic situation, and therefore, the present analysis is based on concurrent rates that are payable by borrowers. Measured data from a medium-sized solar PV and wind turbine facility that has been in operation for over a decade in Central Scotland has been used for this work. The main objectives of this article are: (a) to evaluate the manufacturer's acclaimed performance, (b) to evaluate capacity factors for PV and wind conversion, and complementarily of solar and PV resources, and (c) to obtain the cost of electricity generation of PV and wind. The primary source for undertaking the above exercise was a decade long, measured dataset from an agricultural farm located in Central Scotland. Commercial PV design software was also used to cross check the presently undertaken analysis. The main conclusion was that a community-based wind/solar plant is much more economical than grid-purchased electricity. The novelty of the present work is that all conclusions that were drawn are based on long datasets of measured wind/solar plants.

Keywords: climate change; energy modelling; electricity prices; wind and solar

1. Introduction

By the year 2023, while the worldwide cumulative solar PV capacity had reached the 940 GW mark, the UK better contrast to the world per capita of 118 W. Likewise, a total capacity of 906 GW of wind turbines were installed worldwide by early 2023, the UK's share being 28 GW of which half were installed onshore the rest being offshore.

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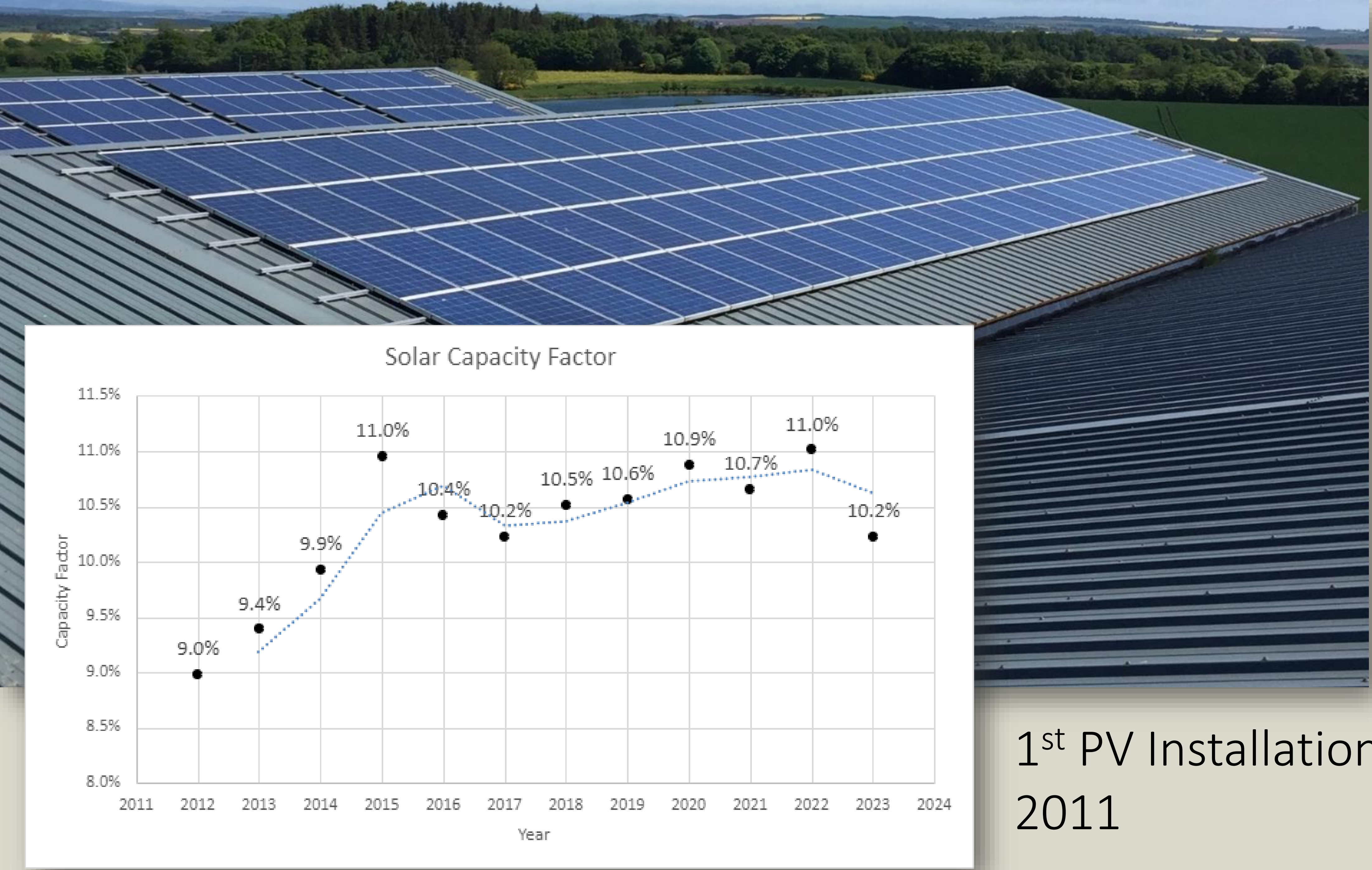


1st PV Installation 2011

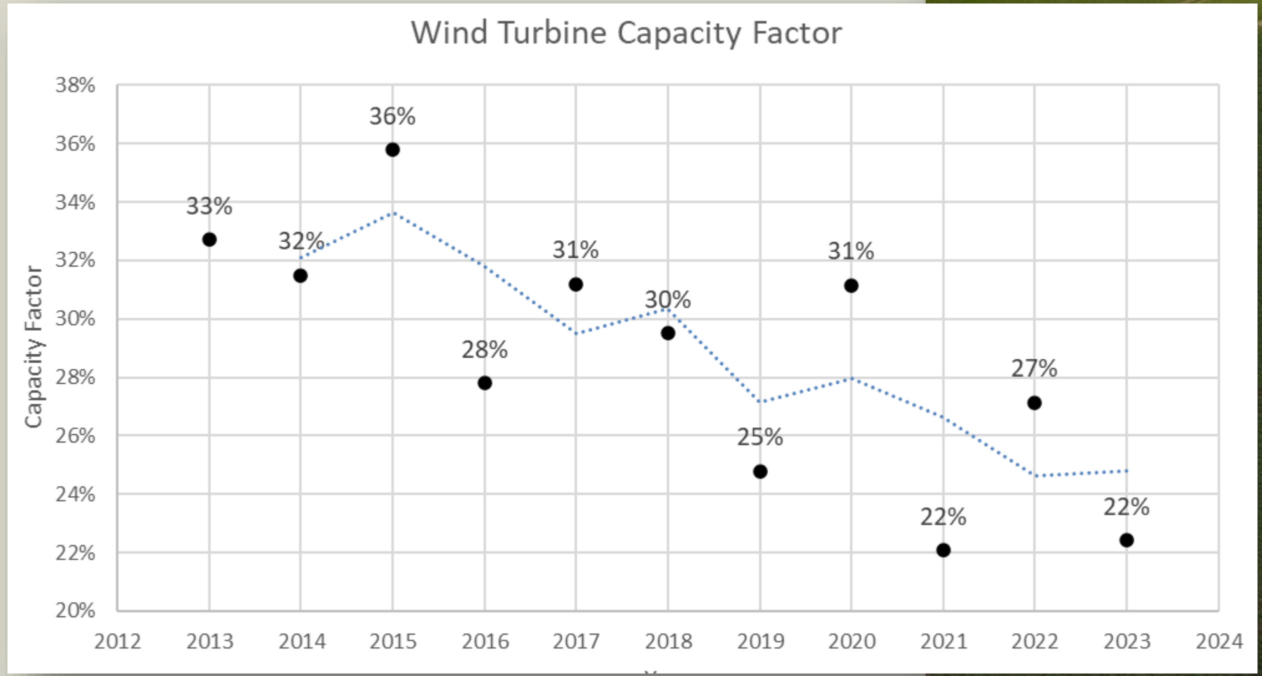
330kW Wind Turbine

- 2012: 330kW Enercon E-33

  FiT 30 p/kWh
- Total installation cost

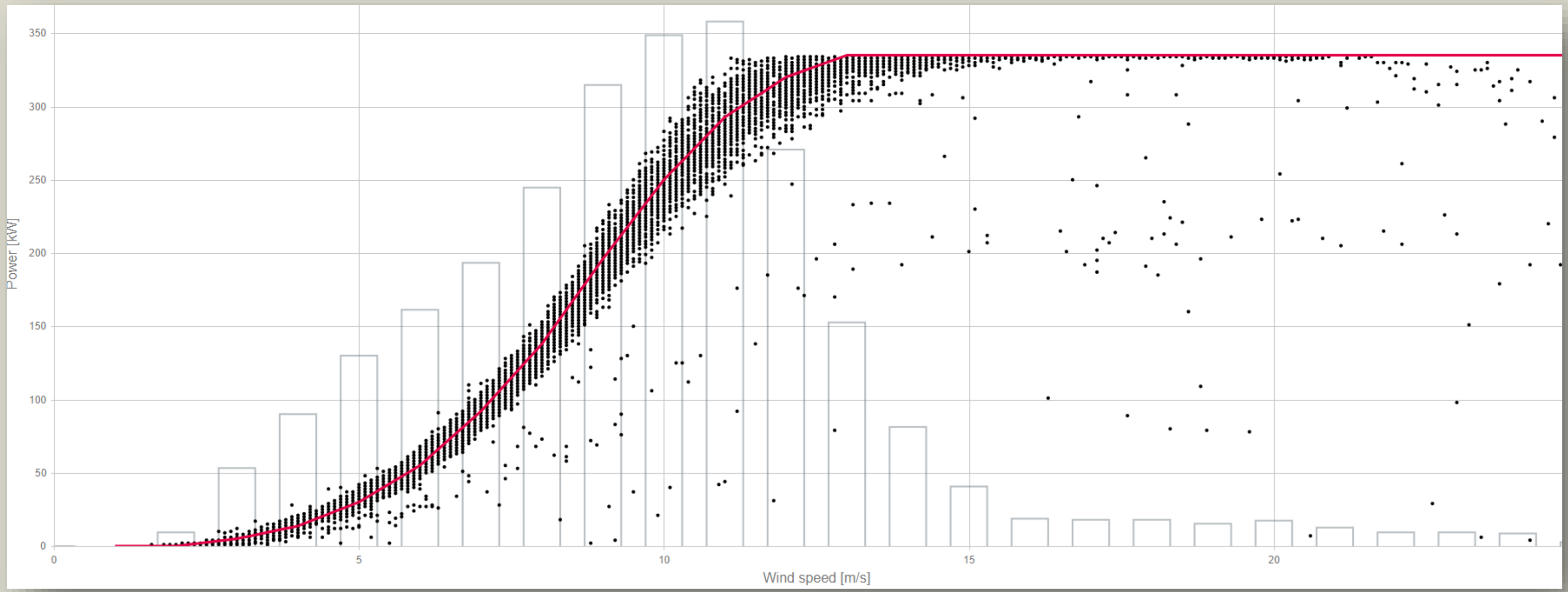
  £800,000
- Annual Generation

  900MWh

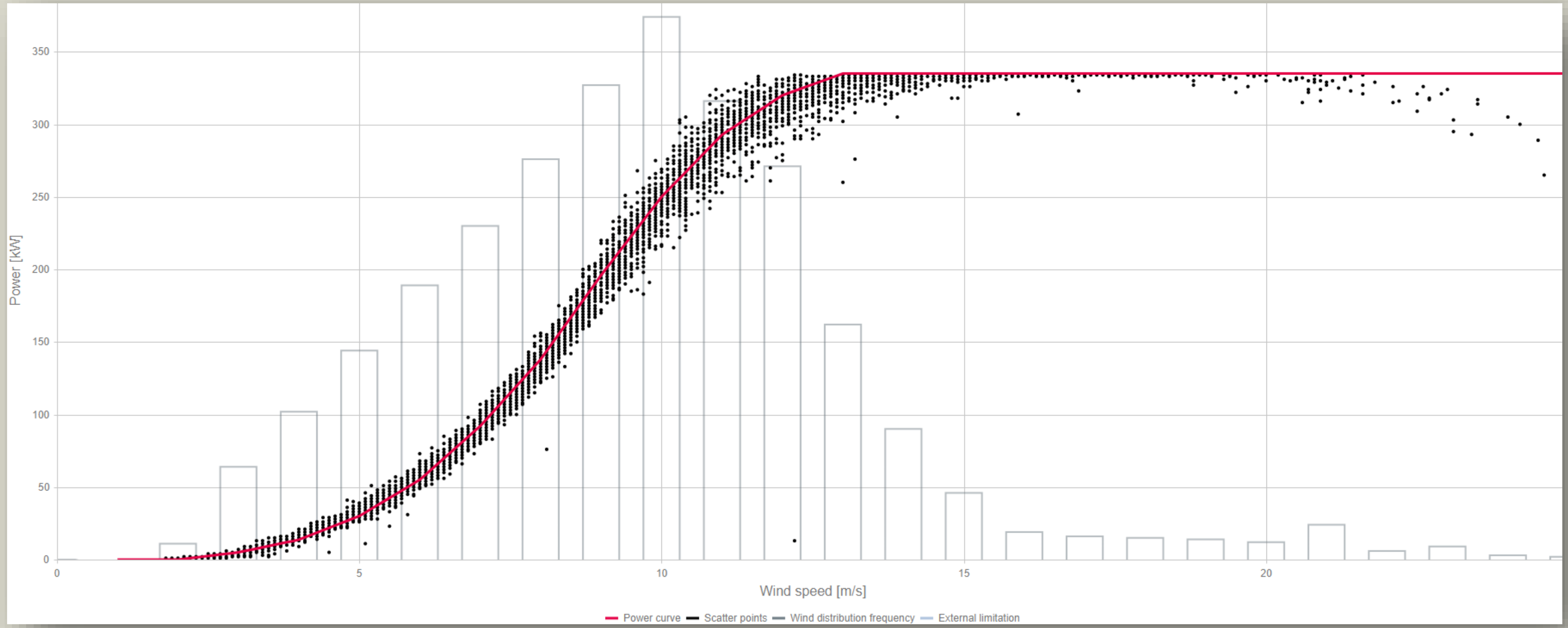


CONONSYTH FARMS

2023
Power Curve



2024
Power Curve



CONONSYTH FARMS

2nd PV Installation in 2015 (Cononsyth Farm)

CONONSYTH FARMS

330 kW Wind

Thermal Store Sizing - Six Year Average - 20% (66kW)

Percentage of The Month Covered (%)

Store Size (hours)	4	8	12	16	20	24	28	32	36	40	44	48
DEC	81	86	89	92	93	94	95	96	96	97	97	97
NOV	74	80	85	88	90	92	93	94	94	95	96	96
OCT	71	77	82	85	87	88	90	91	92	92	93	93
SEPT	65	71	76	79	81	83	85	86	87	88	89	90
AUG	65	73	78	82	85	87	89	91	92	93	94	94
JUL	58	66	72	77	80	83	85	87	88	89	90	91
JUN	50	57	63	67	70	73	76	79	81	83	84	86
MAY	61	68	74	79	82	85	87	88	90	91	93	94
APR	66	73	78	81	85	87	89	91	92	93	94	95
MAR	73	78	83	86	88	89	91	92	93	94	94	95
FEB	78	82	85	87	88	90	91	92	93	94	94	95
JAN	81	86	89	91	92	93	94	95	95	96	96	96

Average percentage of the year covered: 74.7

330 kW Wind + 250kW Solar

Thermal Store Sizing - 2018 - 20% (66kW)

Percentage of The Month Covered (%)

Store Size (hours)	4	8	12	16	20	24	28	32	36	40	44	48
DEC	75	83	89	92	94	96	97	98	99	100	100	100
NOV	76	85	91	95	97	98	99	99	100	100	100	100
OCT	84	94	98	100	100	100	100	100	100	100	100	100
SEPT	88	95	99	100	100	100	100	100	100	100	100	100
AUG	80	87	92	96	99	99	100	100	100	100	100	100
JUL	79	91	97	100	100	100	100	100	100	100	100	100
JUN	72	84	93	98	100	100	100	100	100	100	100	100
MAY	82	91	98	100	100	100	100	100	100	100	100	100
APR	82	91	97	100	100	100	100	100	100	100	100	100
MAR	82	90	95	97	97	98	98	99	99	100	100	100
FEB	82	88	92	94	95	96	98	99	99	100	100	100
JAN	81	87	91	94	96	97	98	99	100	100	100	100

Average percentage of the year covered: 89%

Key:

95-100	dark green	80-85	yellow
90-95	green	60-80	pink
85-90	light green	< 60	red

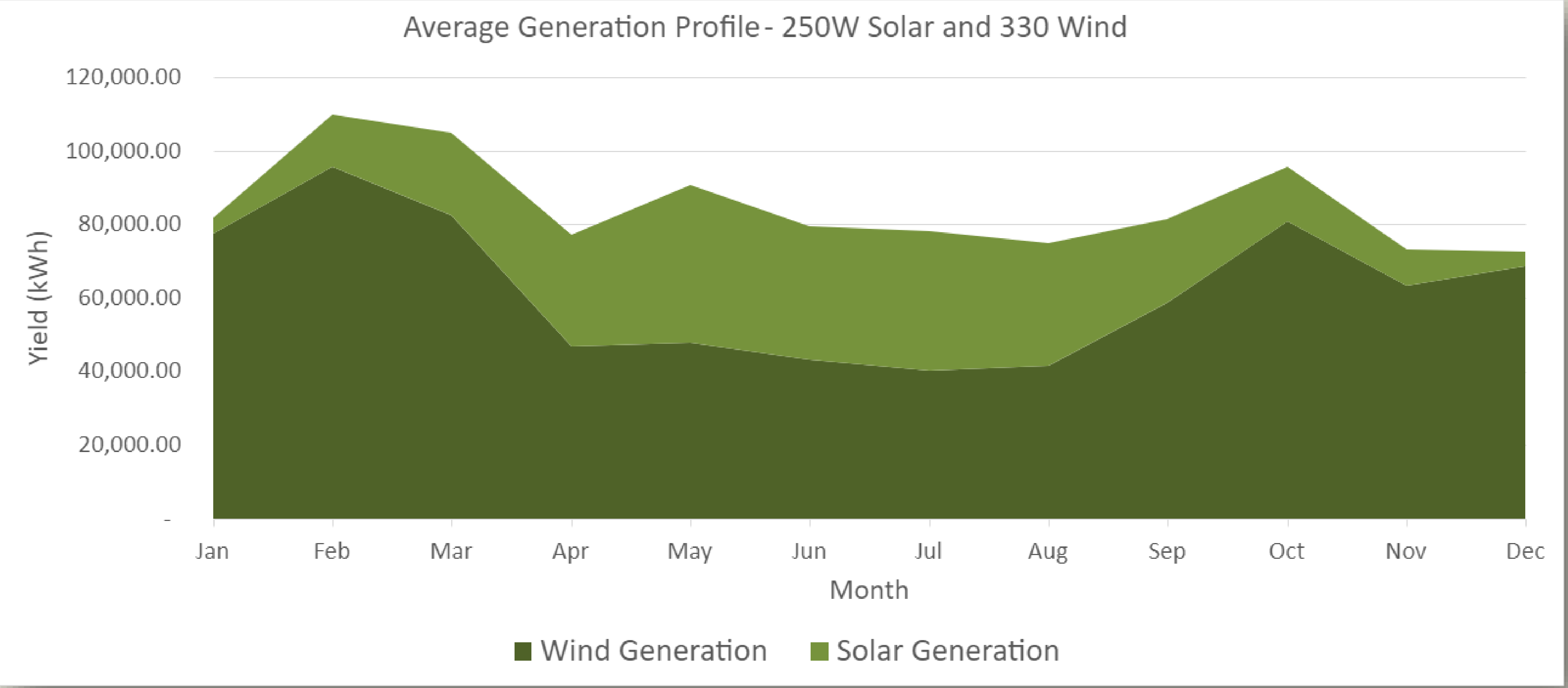
CONONSYTH FARMS

3rd PV Installation March 2019: Additional 250kW

CONONSYTH FARMS

Combined Generation

Shared 330kW export, only 5% reduction in generation



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Electric Forklifts

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64k hens – Installed 2023

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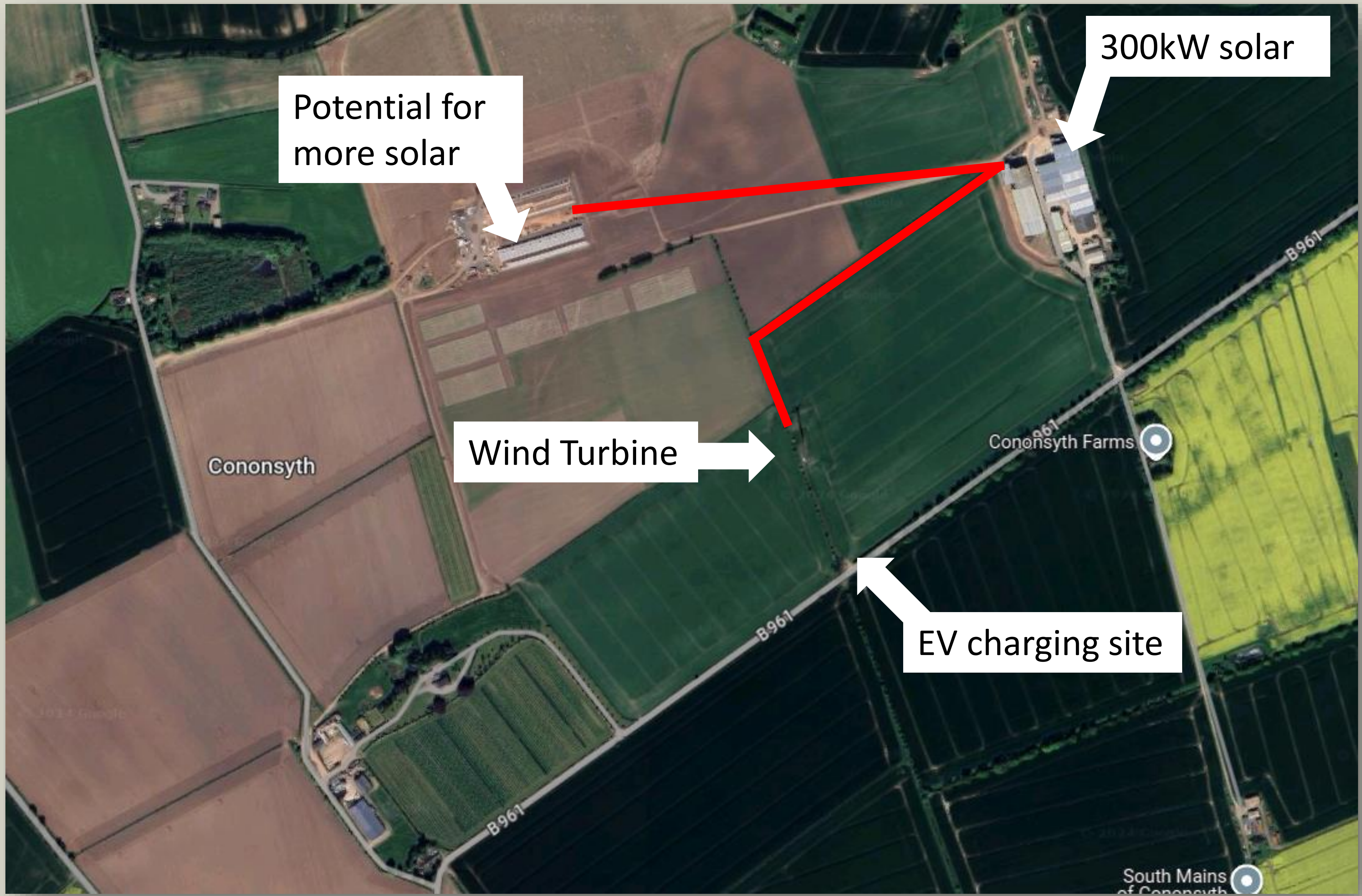
Farm network with potential for EV charging



EV Charging Concept

3.75% cars electric (Zapmap, 2024)

~15 EV on B961 per day (ATC survey set out 03/01/2021 and collected 02/02/2021)

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Thank you

Happy to answer any questions

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