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Sustainable Energy Authority of Ireland

National Energy Research, Development & Demonstration Funding Programme

FINAL REPORT TEMPLATE

SECTION 1: PROJECT DETAILS – FOR PUBLICATION

Project Title	Agricultural Energy Optimisation Platform
Lead Grantee (Organisation)	Cork Institute of Technology
Lead Grantee (Name)	Dr Michael D. Murphy
Final Report Prepared By	Dr Philip Shine
Report Submission Date	21/12/2020

	Name	**Organisation**
Project Partner(s)	Dr John Upton	Teagasc
Collaborators	Dr Eleanor Murphy Mr Keith Lambkin	Bord Bia Met Éireann

Project Summary (max 500 words)

The agri-food sector is Ireland's largest indigenous manufacturer and export industry accounting for 23% of all manufacturing turnover, 10% of all exports and 7.7% of total employment. Agricultural activities are also responsible for 35% of overall greenhouse gas (GHG) emissions, with absolute emissions expected to increase by 2030, due in part to ambitious targets for the agri-food sector, aiming for large increases in overall production and an 85% increase in exports by 2025. As Ireland's 2020 GHG emissions are set to be significantly less than the targeted 20% reduction compared to 2005 levels, focus has now turned towards ensuring Ireland achieves its 30% GHG emission reduction target by 2030 to ensure compliance with EU GHG emission allowances. However, it is projected that Ireland's 2030 GHG emissions will only be 13% below 2005 levels. Further measures are therefore required across the entire agri-food supply-chain to help mitigate GHG emissions, while a considerable challenge exists in relation to mitigating GHG emissions in agriculture.

This project focused on the development of the Agricultural Energy Optimisation Platform (AEOP), which bridges the gap between farmers, researchers and policy makers, and cutting-edge scientific outcomes related to the farm-gate economic, environmental and energy impact of dairy, beef and sheep farming systems in Ireland. AEOP highly aligns with Ireland's Climate Action Plan, National Energy Efficiency Action Plan, and National Renewable Energy Action Plan, through knowledge sharing and encouraging the rapid deployment of renewable energy and energy efficient technologies throughout the Irish agri-sector via informed decision making.

Prior to AEOP, the state-of-the-art in agri-energy decision support systems was the Decision Support System for Energy use in Dairy Production (DSSED), which allowed dairy farmers, researchers and policy-makers assess monetary, environmental and energy applicability of energy efficient and renewable energy technologies on a farm-to-farm basis. AEOP has made significant improvements to DSSED, through: 1) incorporating empirical models for estimating farm-level energy use, energy cost and CO_2 emissions on beef, sheep and dairy farms. 2) incorporating optimisation functionality to allow dairy farmers autonomously identify the optimum milking times, water heating system, water heating start time and solar PV system size to either maximise return on investment or minimise energy related CO_2 emissions. 3) Summarising key performance indicators related to energy, cost and energy related carbon emissions on Ireland's beef, sheep and dairy farms, allowing for farmers, researchers, industry professionals or policy makers easily identify impacts of various agricultural activities. 4) Incorporating additional significant upgrades including: a complete platform redesign, an upgraded solar PV model, demand-side management functionality, localised technology assessments, improving futureproofing features such as dynamic CO_2 intensity values and an updated AEOP help section to aid users in the proper utilisation of AEOP. These upgrades further enhance the tool's ability to provide cutting edge research outputs to farmers and researchers looking for information related to dairy, beef and sheep farming, and provide policy makers with the necessary tools to make informed decisions related to agricultural policy such as the expected impacts of measures related to grant aid and feed-in-tariffs.

AEOP is available at: https://messo.cit.ie/agri-energy.

Keywords (min 3 and max 10)	Energy in agriculture, energy optimisation, energy simulation, researched informed policy, sustainable food production.

SECTION 2: FINAL TECHNICAL REPORT – FOR PUBLICATION (max 10 pages)

2.1 Executive Summary

The following report provides a comprehensive description of the background, implementation and dissemination of project RDD/317. This project focused on the development of the Agricultural Energy Optimisation Platform (AEOP), an online platform, providing agricultural stakeholders comprehensive information and advice relating to energy use, electricity costs, carbon emissions, renewable energy and potential on-farm technology investments. With the Irish government aiming for large increases in overall food production and an 85% increase in exports by 2025, the importance of decision support mechanisms for members of the farming community, scientific researchers and policy makers has become extremely important to ensure the increased production is carried out with consideration to its overall environmental sustainability [1].

The first phase of the project involved a complete redesign of state of the art Decision Support System for Energy use in Dairy Production (DSSED) to improve its overall performance and user experience while incorporating added functionality such as a localised assessments and demand side management features [2].

The second phase involved the compilation of a combined database pertaining to the energy use, cost and carbon emissions of approx. 900 Irish beef, sheep and dairy farms. The results of this analysis are available as part of the aforementioned platform, with energy consumption, cost and carbon emissions data presented over a four year timeframe spanning 2014 to 2017.

The third phase of the project involved the development of the modelling and optimisation functionality of AEOP. a) the integration of empirical models allowing for the estimation of beef, sheep and dairy energy, cost and carbon emissions per head and/or per hectare to be estimated and compared. B) an upgraded solar PV model, improving overall prediction efficiency by 40% while utilising data from panels with a greater efficiency to reflect future trends of solar PV systems in Ireland. c) the assessment, selection and application of the most suitable optimisation technique to allow users autonomously identify the optimum solar PV system size, water heating strategy and managerial decisions to either maximise return on investment or minimise carbon emissions over a 20 year time horizon [3].

Decision support tools are becoming increasingly important mechanisms for packaging advanced scientific methods in an easily understandable way for the end-user, helping guide decision making. As such, AEOP has proved to be hugely popular tool with members of the farming communities, while providing government bodies and agri-stakeholders access to cutting edge decision support information. AEOP is currently deployed and available at: https://messo.cit.ie/agri-energy.

Figure 1 AEOP Homepage

2.2 Introduction

In 2015, government policy set out targets for increasing the overall output from Ireland's agricultural sector by 60% and related food exports by 85% [1]. These ambitious targets have resulted in robust growth across the entire agri-foods sector, with a 25% increase in milk production, a 10% increase in beef output and an 11% increase in sheep meat output recorded in 2019 compared to 2015 levels [4], [5]. However, this increase in food production has had an adverse impact on the sector's environmental impact, whereby sustainability consideration is likely to play a much greater role in subsequent government strategies [6]. Agriculture is Ireland's largest producer of GHG emissions, responsible for 35% of national output in 2019, compared to an average of 10% across EU-28 countries [7], [8]. Irish beef, dairy and sheep farms are the largest contributors to agricultural related GHG emissions, with 72,400, 16,700 and 15,200 farms, respectively [9]. These farms produce GHG emissions due to eccentric fermentation, agricultural soils management, manure management, fuel combustion, liming and urea application. However, Ireland's dairy and beef production are some of the most sustainable production systems in relation to GHG emissions compared to other EU-28 countries due in part to its grass growing capabilities allowing for pasture based livestock systems to be carried out for much of the calendar year [10].

The Climate Action Plan has set out a target to work towards a carbon-neutral Irish economy as a 'horizon point' for 2050, covering emissions related to agricultural activities as well as those related to electricity use/generation, transport, buildings, enterprise and services, and waste and the circular economy [11]. Within this Climate Action Plan, sets of counter measures aimed towards mitigating GHG emissions are identified for each sector of the economy, heavily referencing the Teagasc Greenhouse Gas Marginal Abatement Cost Curve (GHG MACC) report for mitigation strategies related to agricultural related emissions [12]. The Teagasc GHG MACC report quantified the extent of GHG reduction that can be achieved through cost-effective agricultural mitigation measures, categorised by agricultural mitigation, land-use mitigation and energy mitigation strategies. As the global demand for dairy and meat products is forecasted to increase by more than 66% and 74%, respectively by 2050 [13], reducing livestock numbers in Ireland would be counterintuitive from a global GHG emissions perspective, as dairy and meat production is likely to be supplied from other, less sustainable regions. Coupled with this, reducing livestock numbers would have a largely negative effect on production and export targets, resulting in reduced employment and income of Irish agricultural stakeholders. Lanigan et al. [12] therefore suggested reducing agricultural related GHG emissions through the adoption of new technologies, favouring those technologies that can also increase financial productivity to improve the likelihood of adoption when compared to those which would negatively affect the farmer's income [14].

Farmers are therefore required to produce greater volumes of milk and/or manage greater numbers of livestock while producing less GHG emissions, while at the same required to prepare for potential periods of reduced income. This exacerbates the importance of offering decision support to farmers looking to manage increasing livestock numbers both environmentally and cost efficiently. AEOP is useful tool in tackling this problem by offering members of the farming community decision support and access to key performance indicators (KPIs) in relation to energy consumption, energy costs and energy related carbon emissions associated with dairy, beef and sheep farming activities. AEOP also provides Irish policy makers and researchers access to cutting edge research outputs and next generation energy simulation and optimisation tools. These tools provide direct guidance and support to policy makers in regards to issues pertaining to the optimal utilisation of energy technologies, and the monetary and environmental implications of various levels of grant aid. This is essential to ensure the long-term sustainability and growth of Ireland's agri-food sector in line with Ireland's Climate Action Plan while having the added dual benefit of 1) helping to reduce the agricultural sector's contribution to overall GHG emissions through improved energy efficiency, and 2) increasing the penetration to renewable energy on Ireland's electrical grid. Thus, AEOP also directly aligns with Ireland's National Energy Efficiency Action Plan, National

Renewable Energy Action Plan, while also supporting the objectives of the Irish government's Energy White Paper. Where AEOP particularly aligns with the Energy White Paper is on the topic of implementation, where "*policy will seek to achieve optimum benefits at least cost*" and "*policy measures will be evidence based and subject to rigorous analysis and appraisal prior to being implemented*". With this, the objectives of this project were to:

1) Compile an agri-energy database
2) Agri-energy modelling and validation
3) Testing and application of optimisation tools
4) Development of open-source web application (AEOP)
5) Final product testing and feedback
6) Dissemination promotion and engagement

AEOP development leveraged over 10 years of scientific research carried out by Teagasc and Cork Institute of Technology based researchers, including the prior state of art DSSED [2]. The backend of AEOP tool was developed and implemented through RStudio [15], an open-source, flexible and powerful software foundation for statistical computing and it's Shiny [16] package, which allows for the development of interactive web applications. AEOP will fill the gap in the agri-sector when it comes to rigorous analysis and appraisal in order to select the energy technologies that yield the optimal benefits for both farmers and policy makers. AEOP provides members of the farming community, researchers and policy makers:

1) Access to historical data collected from approx. 900 Irish beef, dairy and sheep farms, allowing for KPIs such as energy use, cost and CO_2 emissions, per head and per hectare and absolute values) to be easily identified. Statistical breakdown information of dairy farm electrical energy consumption, cost and related CO_2 emissions data is also provided.
2) A dairy technology calculator to quantify the impact of producing milk, and assess the applicability of various energy efficient and renewable energy technologies on a farm-to-farm basis. This technology calculator requires farm specific information related to infrastructure, herd size and managerial decisions in addition to cost and sizing information related to specific energy technologies, and monetary variables such as the availability of a feed-in-tariff and/or grant aid which impact return on investment calculations.
3) A beef, sheep and dairy analysis portal for estimating annual farm-level energy use, energy cost and CO_2 emissions and contrasting with national averages. This analysis portal requires information related to beef, sheep and/or dairy herd sizes, land use (hectares), and farm type (e.g. dairy cows and cattle rearing, sheep rearing only, etc.).
4) A dairy energy optimisation tool to autonomously select the optimum autonomously identifies the solar PV system size, water heating system, water heating system start times, and milking times to either maximize return on investment or minimize energy related CO_2 emissions over a 20 year time horizon.

One of the core doctrines of the Energy White Paper is to put the citizen and communities at the centre of the energy transition. AEOP empowers farmers to make informed decisions regarding their future energy investments while providing a clear path towards improving the sustainability of their business.

Project Outcomes

The following section highlights ten of the key outcomes from this project.

Platform redesign

AEOP was developed through RStudio [15], a flexible and powerful software foundation for statistical computing with website and mobile app development functionality. A complete platform overhaul was carried out on the prior the state-of-art DSSED [2], as shown in Figure 2. This was a direct result of feedback we received from key stakeholders, whereby outputs are now clearly and effectively displayed for the user, while performance has also been considerably improved. AEOP has five primary sections: 1) *About*, 2) *Technology Calculator*, 3) *Energy Optimisation*, 4) *Dairy Energy Statistics*, 5) *Beef, Sheep and Dairy Statistics*, and 6) *Help*. Outputs of the technology calculator shown in Figure 1 include: return on investment, investment payback period, net investment cost, total farm energy and technology energy use/generation, farm load profile, CO_2 emissions, grid vs renewable energy penetration, CO_2 saved over 20 years and cost per tonne of CO_2 reduction. Other platform upgrades include the incorporation of a progress bar and help section offering users tips to ensure AEOP's correct utilisation. The help section displays an embedded instructional video/tutorial [17] and user manual, providing users with full details pertaining to this platform redesign and correct utilisation of AEOP features.

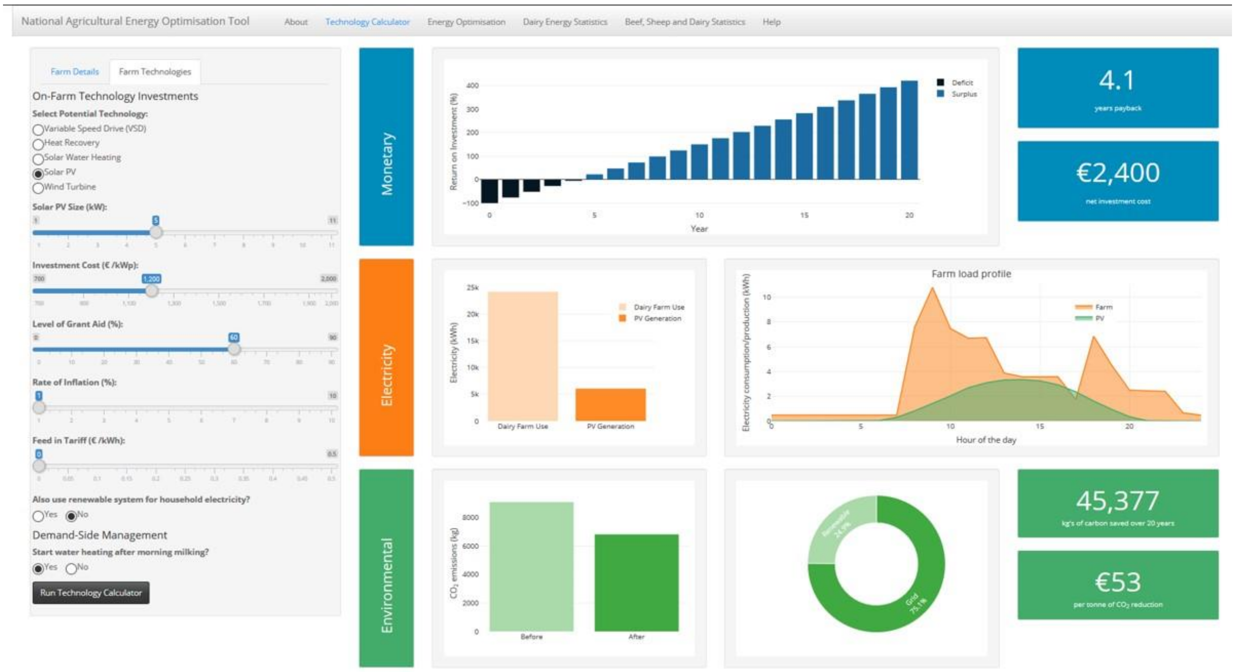

Figure 2 AEOP Technology Calculator Dashboard

Optimisation functionality

Optimisation functionality was successfully integrated to AEOP through the *Energy Optimisation* tab, as shown in Figure 3. The practicality of the Genetic Algorithm, Particle Swarm Optimization, Simulated Annealing, Tabu Search and Dynamic Programming algorithms were all assessed [3]. Dynamic programming was found to be the most powerful technique for AEOP, while focus was specifically given to optimising the installation of solar PV systems on dairy farms, due to the importance of managerial practises and solar PV system size on optimal operation. Optimisation is carried out over a 20-year time horizon, whereby the optimum milking times, water heating system, water heating start time and solar PV system size may now be autonomously identified to either maximise return on investment or minimise CO_2 emissions, on a farm-to-farm basis utilising specific input settings such as level of available grant aid, average solar PV cost (€ / kWp), and availability of a feed-in-tariff, and/or demand side management. Optimising dairy farm operations has been found to increase return on investment in energy technologies by more than 25% [3]. This functionality is not available anywhere internationally representing a highly novel decision support, and leverages extensive Irish based research recently published in this domain [3], [18].

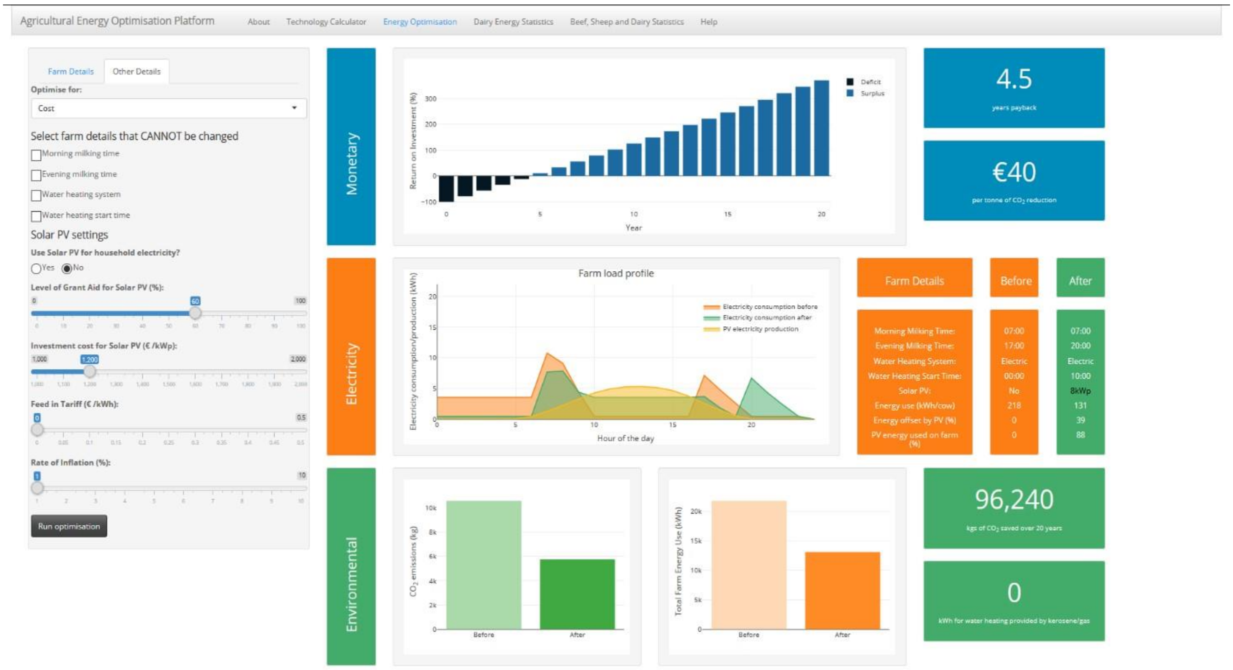

Figure 3 AEOP Energy Optimisation Dashboard

Agri-energy use, cost and CO_2 emissions models

Utilising historical data, empirical models were developed allowing AEOP users estimate annual electricity use, cost and CO_2 emissions per head, per hectare and overall use, for particular farm type and herd sizes, allowing Irish dairy farmers to make comparisons with the national averages. Multiple linear regression was employed to estimate electricity consumption on beef, sheep and dairy farms, whereby prediction accuracy was calculated using 10-fold cross-validation. This model was found explain 78% of the variability of unseen farm-level electricity consumption, with a concordance correlation coefficient value of 0.87 suggesting substantial prediction capability [24].

This model is readily available in the *Beef, Sheep and Dairy Statistics* tab within AEOP, where users can explore various livestock numbers and their impact on electricity, cost and CO_2 emissions per farm, per head and per hectare.

Updated PV model

The solar PV model described by Villalva et al. [19] was utilised within AEOP for *Technology Calculator* and E*nergy Optimisation* calculations, representing a significant upgrade of the state of the art. The solar PV model's overall prediction efficiency was improved by 40% to a value of less than 5% (relative prediction error), calculated through stratified 10-fold cross-validation [20]. This was achieved by utilising larger and higher quality dataset, from solar PV panels with a greater efficiency to reflect future trends of solar PV systems in Ireland. Irradiance (W/m^2), wind speed (m/s), ambient temperature (°C) and power output (W) data were acquired from the National Institute of Standards and Technology campus in Gaithersburg, Maryland, USA, with recordings carried out at one minute intervals for two years (July 1, 2013 to June 30, 2014; February 1, 2015 to January 31, 2016) [21]–[23]. Further details related to the solar PV model development and validation methodologies are available in Breen et al. [20].

Table 1 Solar PV model validation results at one hour resolution

RPE	CCC	MAPE	RMSE	n
4.9%	1.00	2.9%	225 W	5,768

Relative Prediction Error (RPE); Concordance Correlation Coefficient (CCC); Mean Absolute Percentage Error (MAPE); Root Mean Square Error (RMSE); Number of data points (n)

Historical beef, sheep and dairy data

Historical data from Teagasc national farm surveys (2014 – 2017) carried out on approx. 900 farms representative of the overall farm population detailing average electricity use, cost and CO_2 emissions per farm, per head, per hectare have been incorporated to AEOP. This provides AEOP users access to previously unknown KPIs related to the use of electricity consumption on beef and sheep farms in Ireland. While electricity consumption per head on beef (-1%) and sheep (+5%) farms remained relatively unchanged between 2014 and 2017, consumption on dairy farms reduced by 13%. This reduction reflects the greater opportunity for energy/cost/CO_2 savings on dairy farms, whereby on average, dairy farms required approx. 22,000 kWh, beef specialist farms used 2,400 kWh, while sheep rearing farms used 2,300 kWh, as shown in Table 2.

Table 2 Beef, sheep, and dairy farm energy related key performance indicators

Farm Type	kWh / Farm	kWh / unit output	kWh / Hectare
Beef	2,400	0.14 kWh/kg CW*	57
Sheep	2,303	0.16 kWh/kg CW*	45
Dairy	21,938	0.041 kWh/ litre of milk	359

* Carcass weight (CW)

Demand Side Management functionality

Demand side management functionality was incorporated to AEOP, by setting a synced timer for the electrical water heating system, aiding in the facilitation of PV generation via load shifting, as shown in Figure 3. Its application on dairy farms is highly innovative whereby significant ROI improvements are possible, while having the potential to lessen battery storage requirements. For example, a dairy farm in West Cork with 75 dairy cows, milking twice a day (7am and 5pm), with 12 milking units, direct expansion milk cooling, electric water heating, hot washing once per day, and pre-cooling milk to 21ºC with a pre-cooling system could reduce the investment payback period of a 5kWp solar PV system by almost 5 years (50%) by implementing DSM practices. This example assumed flat rate electricity pricing of €0.18/kWh, 60% grant aid availability, with a solar PV cost of €1,200/kWp and no feed-in-tariff availability.

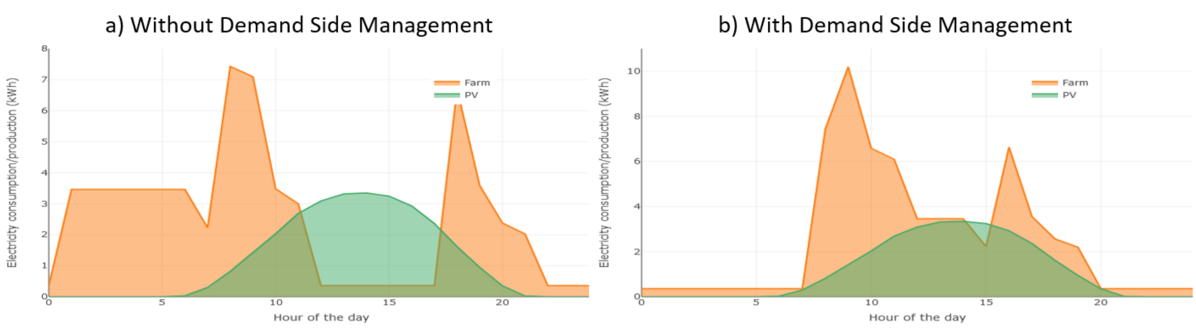

Figure 4 Farm load profiles and solar PV energy generation without (a) and with (b) demand side management

Localised technology assessments

Localised technology assessment functionality was incorporated to AEOP through utilising wind speed (m/s), and ambient temperature (°C) data from 26 Irish meteorological stations between 2009 and 2018 [25]. Irradiance (W/m^2) data from a further six meteorological stations spread throughout Ireland were attained from the World Radiation Data Centre between 2012 and 2018 [26]. County specific coordinates were attained and linear distance to each meteorological station calculated, and data from the nearest station utilised for solar PV, solar water heating or wind turbine calculations within the *Technology Calculator* or *Energy Optimisation* tools. This strengthened the precision of calculations on a farm-to-farm basis when estimating energy generation from these technologies.

Dynamic milk pre-cooling temperature set point levels

The applicability of AEOP to infer real-world scenarios was further improved through offering users the ability to input the performance level of their plate cooler systems. These levels include fair (21°C water output set point), good (18°C), and excellent (15°C), covering both older and new more efficient systems. As milk cooling is a large proportion of overall energy use [27], pre-cooling performance can have a significant impact on ROI of energy technologies, as shown in AEOP.

Incorporation of household electricity use

An annual household energy input was incorporated to AEOP, a values easily obtained through energy bills. AEOP infers a typical domestic household energy demand profile obtained from the retail market design service [28], and factors this into payback calculations.

Dynamic CO_2 intensity

Both the *Technology Calculator* and *Energy Optimisation* tools now allow for customizable electricity CO_2 intensity values to be selected prior to carrying out calculations. This helps futureproof AEOP calculations by allowing the tool to keep up to date with changing CO_2 intensity levels from year-to-year as well as allow users to input CO_2 intensity values unique to their own electricity supplier. The default energy intensity values is currently set at 331 $gC0_2$ / kWh (2019 average), as reported by SEAI [29].

2.3 Project Impact

With Irish GHG emissions set to be 2% - 4% less than 2005 levels (compared to an initial target of 20%), focus now turns towards 2030 where the Irish government has pledged to reduce overall GHG emissions by 30% compared to 2005 levels [30]. With the agricultural sector and energy industry projected to be responsible for more than 50% of overall GHG emissions in 2020 [30], AEOP has a direct impact on Ireland's long-term objective of transitioning towards a carbon neural economy by 2050 [11]. Accelerating the proliferation of energy efficient and renewable energy technologies through informed decision making has the dual impact on the Irish energy sector of: 1) reducing the required load from the electrical grid (NEEAP) and 2) improving the penetration of renewable energy contributing to overall consumption (NREAP).

AEOP strongly aligns with Ireland's National Energy Efficiency Action Plan (NEEAP), National Renewable Energy Action Plan (NREAP), and the objectives of the Irish government's Energy White Paper and Climate Action plan. In addition, AEOP also highly compliments SEAI's own remit to support solutions to overcome barriers to market deployment of sustainable energy technologies. In addition, the purpose and outcomes of AEOP directly supports the objectives of the government's Energy White Paper [31].

Societal

AEOP will have an immediate impact on Irish dairy, beef and sheep farmers. AEOP allows dairy farmers identify optimal managerial strategies in conjunction with renewable energy and energy efficient technologies on a farm-to-farm basis. This is expected to result in a substantial uptake in the deployment of state-of-the-art energy equipment. This proliferation in energy technologies will lead to improved energy efficiency and increased renewable production in turn leading to reduced energy costs and more environmentally friendly food production.

Responsible for 7.7% of national employment and 10% of total exports, the societal importance of the agricultural industry in Ireland is manifested in Ireland having the only sustainability programme (Origin Green) in the world operating on a national scale, uniting government, the private sector and food producers [32]. AEOP provides agri-stakeholders and government bodies and state agencies such as the Department of Agriculture, Food and the Marine, Bord Bia and Teagasc with the means of calculating the monetary, environmental and energy related impact of Irish dairy beef and sheep farming for sustainability reporting or marketing Irish dairy products abroad [1]. The continuous monitoring of these industries allows for their continual improvement to be tracked, further strengthening Ireland's sustainable agricultural systems.

Economic

The abolishment of milk quota's in April 2015 resulted in a volatile milk pricing system, responsive to the supply and demand of milk and dairy products. Milk price levels have yet to recover to 2014 levels, whereby 2016 saw an average milk price decrease of 26% resulting in a 16% reduced average dairy farm income compared to 2015 [33]. Thus, dairy farmers are required to produce greater volumes of milk to remain competitive, while preparing for potential periods of reduced revenue while having less of an environmental impact. AEOP provides farmers with decision support information to help alleviate some of this financial stress through calculating the long-term monetary impact of investing in energy efficient and renewable energy technologies on dairy farms. AEOP encourages farmers to become more energy independent, thereby reducing potential negative impacts of future increases in energy costs due to increased fuel costs or time-of-use and real-time-pricing tariff structures. The expected uptake in renewable technologies by Irish farmers will have a knock on benefit to Irish energy companies, adding energy jobs to local economies and increasing the viability of small and medium energy businesses across Ireland. This increase in participation within rural economies will help to foster energy communities centring around local companies.

Technological

AEOP provides the Irish and international energy research community and policy makers with a tangible decision support tool, leveraging over ten years of scientific research in the agri-energy domain. AEOP packages complex data, mathematical modelling and optimisation methodologies in a neat, tidy and easily interpretable platform, which may otherwise have remained theoretical in scientific journals. All methodologies involved in the development of AEOP have been peer-reviewed in scientific journals, fortifying the evidence-based ethos employed throughout AEOP's development [3], [20], [34], [35]. Open-sourcing AEOP removes any barriers surrounding access to decision support, thereby helping to maximise knowledge transfer and its positive impact on Ireland's agri-foods sector.

2.4 Recommendations

Data showed that electricity consumption on dairy farms was almost ten times greater on dairy farms compared to beef and sheep farms (Table 2), as both beef and sheep farms do not require the cooling and pumping of milk or vast quantities of hot water. Thus, due to lighting being one of the primary electricity consuming loads on these farms, and the added absence of a controllable electrical load, it was found that beef and sheep farms would not benefit from decision support. A simple solution to reduce energy requirements on these farms would be to upgrade existing lighting systems to LEDs.

AEOP shows the significant impact demand side management practices can have on reducing the payback period when investing in a solar PV systems of dairy farms. More specifically, to aid in the facilitation of PV generation via load shifting, AEOP's demand side management feature simulates a synced timer for the electrical water heating system, while AEOP's *Energy Optimisation* tool also assesses the financial/environmental impact of shifting milking times. Load shifting can therefore maximise the on-farm consumption of solar PV electricity generated, reducing battery storage requirements therefore providing further monetary benefits even in a Day/Night pricing tariff structure.

2.5 Conclusions and Next Steps

This report detailed background information, project outcomes and key impacts related to the development of the Agricultural Energy Optimisation Platform (AEOP). Developmental upgrades successfully carried out over the course of this project including: the platform redesign, model upgrades, expansion to beef and sheep farming systems and integration of optimisation functionality considerably advanced decision support in this domain. AEOP was developed with a range of users in mind ranging from farmers, policy makers and members of the scientific community, while consideration was given to balance advanced modelling software and user practicality. In its current form, the utilisation of AEOP by members of the farming community relies on the farmer's own initiative to locate energy, cost and carbon related details and energy technology investment decision support through AEOP. However, work is currently been carried out to help remove this barrier through the development of the National Artificial Intelligent Dairy Energy Application (NAIDEA) which will integrate macro-level survey information collected as part of Bord Bia's Sustainable Dairy Assurance Scheme, with advanced machine-learning methodologies. NAIDEA will efficiently and cost effectively quantify the energy related carbon footprint of milk production as required for Ireland's Origin Green programme. NAIDEA will support government bodies such as Bord Bia to firstly identify energy inefficient dairy farms, and secondly, the ability to direct those inefficient dairy farms towards AEOP, with the potential to provide financial incentives for carrying out energy efficient activities through a credit-based system.

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