West Kerry Dairy Farmers Sustainable Energy Community Energy Master Plan

DCSix Technologies

Contents

Chairman's Address 3
Glossary of Terms 4
Introduction 6
  Aims and Objectives 6
  Methodology 7
  Energy Tariffs 9
Energy Baseline 10
  Tractor Diesel 11
  Electricity 11
  Oil 11
  Natural Gas and LPG 11
The Farms 12
The Milking Parlour 13
  Milk Cooling 13
  Plate Coolers 13
  Bulk Tanks & Ice Banks 14
  Water Heating 15
  Milk Pumping 16
The Dwelling House 16
  Micro Generation 18
Farm Energy Audits 19
  Water Heating 19
  Plate Cooler 20
  Bulk Tank & Ice Bank 20
Energy Monitoring 22
  How it works 22
  Cooling 25
  Water Heating 25
  Milking 26
  Water Pumping 26
  Lighting 26
  The Dwelling House 27
Register of Opportunities 29
  Quick Wins 29

Electricity Tariff ... 29
Insulation ... 29
Plate coolers ... 29
Bulk Tank/Ice Bank ... 29
Water/Compressed Air Leaks ... 29
Energy Efficiency Upgrades ... 30
Retrofit Dwelling House ... 30
Heat Recovery ... 30
VSD ... 30
Lighting ... 31
Micro Energy Generation ... 31
Micro Generation Solar PV ... 31
Micro Hydro ... 33
Micro Wind ... 33
Community Renewable Energy Generation ... 34
Tractor Fuel Source ... 34
Roadmap ... 35
Dwelling House Retrofit ... 36
Heat Recovery ... 36
VSD Pump ... 37
LED Lighting ... 37
Micro Gen Solar PV ... 37
Micro Hydro ... 37
AD Plant & Biogas Tractors ... 38
References ... 38

Chairperson's Address

A Chairde

As Chairperson of the West Kerry Dairy Farmers Sustainable Energy Community, I would like to sincerely thank DC6 Technologies for all their work to deliver a comprehensive and in depth Energy Master Plan.

I would like to acknowledge the strong support of the Sustainable Energy Authority of Ireland and our SEAI Energy Mentors, Seamus O'Hara and Ed O'Connor throughout this process. Our Secretary, Catríona Fallon gave generously of her time and expertise and we are very grateful for all her work and commitment.

Our sincere thanks to Kerry Agribusiness, ESB Network, and Dovea Genetics for their financial assistance and to the Steering Committee, who with their support and advice, kept the whole project going through the pandemic. Also, a word of thanks to the dairy farmers of West Kerry for supporting this EMP and participating in energy monitoring and survey data collection on their farms. Finally, to my colleagues at the Dingle Hub for their help and assistance; to Deirdre de Bhailís, the Manager of the Dingle Hub who reached out to the farming community initially – thank you for giving the farming community a voice for the future.

Engaged research support from MaREI, the SFI Research Centre for Energy, Climate and the Marine, has provided invaluable access to energy and engagement expertise throughout this work – many thanks for all your help and guidance. Sustainable food production and carbon emission reduction will be important to all of us going forward. I believe the work to date will be a great help to the dairy sector locally and nationally. It has also helped us focus on all other types of work here on the peninsula. I'm proud of the achievements to date and will continue to pursue our goals. It has been a pleasure working with all of you. Health and happiness to all concerned.

Dinny Galvin (October 2022)
Chairperson, West Kerry Dairy Farmers' SEC
Agricultural Liaison Officer, Dingle Hub.

Steering Committee Members: Dinny Galvin (Chair), Michael Kelliher (Treasurer), Michael Dowd, Colm Murphy, Claire McEligott, David Garner, Deirdre de Bhailís, Catríona Fallon (Secretary) .

Glossary of Terms

WKDF – West Kerry Dairy Farmers

SEC – Sustainable Energy Community

EMP – Energy Master Plan

TED – Total Energy Demand

MW – Megawatt

MWh – Megawatt hours

kW – Kilowatt

kWh – Kilowatt hours

DX – Direct Exchange Bulk Tank

IB – Ice Builder

HRU – Heat Recovery Unit

VSD –Variable Speed Drive

PHE – Plate Heat Exchanger

CFL – compact fluorescent light

LED – Light Emitting Diode

PV – Photovoltaic

RESS – Renewable Electricity Support Scheme

AD – Anaerobic Digestion

Introduction

The West Kerry Dairy Farmers (WKDF) Sustainable Energy Community (SEC) was created in 2019 with support from SEAI, ESB Networks, Kerry Agribusiness and Dovea Genetics. A steering committee was formed consisting of nine people representing the Dingle Hub, ESB, SEAI, the local community and four Dairy farmers.

Aims and Objectives

The goal of the Energy Master Plan (EMP) was to firstly review the existing energy practices undertaken by the community and to then provide a roadmap for efficient, practical, cost-effective recommendations for energy efficiency measures for the West Kerry Dairy Farmers SEC. The first step was to provide a high-level overview in the form of the Energy Baseline. This will provide a breakdown of the overall energy demand of the community. Further detail on the farm and home energy processes will be established from conducting energy audits and installing energy monitoring.

This goal can be further broken down into the following objectives.

- Install energy monitoring in five dairy farms
- Carry out energy audits on five dairy farms
- Provide a baseline of energy usage estimates for participating dairy farms as a whole
- Provide detailed recommendations for energy efficiency at an individual farm level
- Establish a Register of Opportunities for the reduction of energy demand and the transition to renewable energy supply by the SEC members
- Provide a roadmap with a five-year action plan to implement the recommended Register of Opportunities.

Methodology

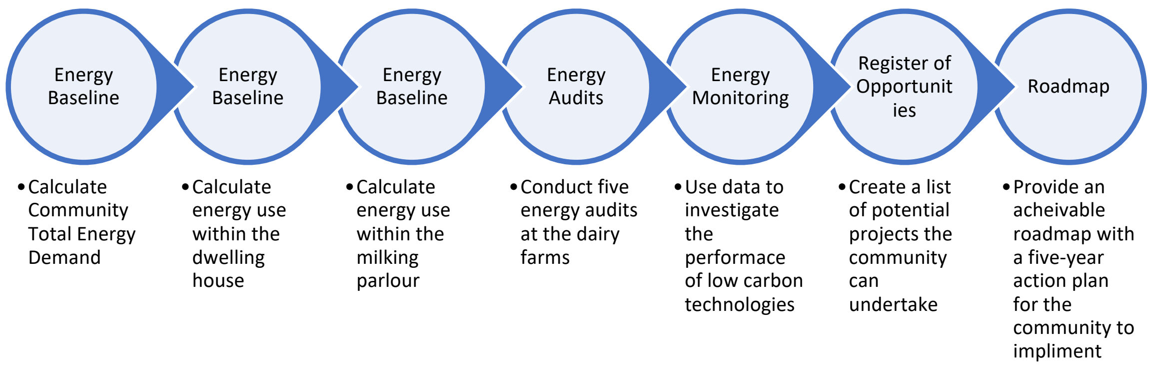


Figure 1

The WKDF SEC was founded in 2020 and has 106 signed-up community members. This is a very high proportion of the dairy farmers in West Kerry.

We are aware that an EMP has already taken place on the peninsula and was undertaken by the 'Dingle Peninsula SEC'. Our approach was to avoid any duplication of work between this pre-existing EMP and that proposed for the 'West Kerry Dairy Farmers SEC'. The focus of this EMP should be the general energy use on dairy farms, milking and associated processes, and energy use in the farm homes.

The Energy Baseline for 2019 in the study area includes the following energy sources.

- Electricity
- Liquid Petroleum Gas
- Natural Gas
- Oil
- Tractor Diesel

Due to the unique nature of a dairy farming community, this EMP exclusively addresses energy demand for residential, agriculture and transport. The energy usage profile of each sector was developed using bottom-up data, based on actual fuel bills from 2019. This information was gathered using an energy questionnaire that was emailed to all community members. Over 50% of the community members submitted their fuel consumption for 2019.

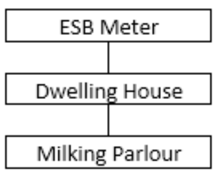
The only significant energy source consumed by the community that was omitted from our Energy Baseline was petrol and diesel consumption from private cars. This is in recognition of work previously undertaken as part of the Dingle Sustainable Energy Community Energy Master Plan (MaREI, 2018). It addresses private car transport for the entire peninsula and any analysis conducted on this sector of the WKDF SEC would be a repetition of the earlier work, only using a significantly smaller sample size.

Of the community members that completed the questionnaire, five were selected to have energy monitoring installed at the farm for the duration of the project and have an energy audit carried out. Four other farms within the community also opted to have this equipment installed and have made their data available to this project. Table 1 provides a summary of the nine farms that had monitoring installed.

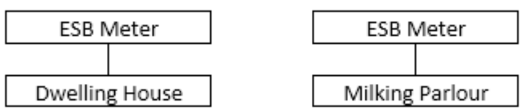
Table 1

Farm	Herd Size	Cooling Technology	Heating Technology	VSD Pump	ESB Connection Type	Other Comments
A	55	DX Bulk Tank	NS Electricity & Heat Recovery	No	Type C	
B	90	DX Bulk Tank	Gas	No	Type B	
C	45	Ice builder and 2nd stage plate cooler	NS Electricity	No	Type B	
D	60	DX Bulk Tank	Gas & Heat Recovery	Yes	Type B	
E	75	DX Bulk Tank	NS Electricity	Yes	Type A	Robotic, LED Lighting
F	25	DX Bulk Tank	Electricity	No	Type C	
G	120	Ice builder and 2nd stage plate cooler	Electricity	Yes	Type C	
H	50	DX Bulk Tank	Electricity	No	Type C	
I	260	Ice builder and 2nd stage plate cooler	Oil	No	Type A	

Type A = Shared ESB connection where supply enters milking parlour first before going onto the dwelling house.



Type B = Shared ESB connection where supply enters dwelling house first before going onto the milking parlour



Type C = Separate ESB connection for milking parlour and dwelling house.

Energy Tariffs

Energy tariffs changed dramatically over the course of the project. For all energy baseline calculations values are based on data submitted by community members. For all return of investment calculations on energy efficiency upgrades, the SEAI's Domestic Fuel cost report was used +VAT. (SEAI, April 2022)

Table 2

Energy Source	€/kWh
Electricity	0.28
Right Rate Electricity	0.14
Kerosene	0.16
LPG	0.16
Tractor Diesel	0.16

Energy Baseline

The Total Energy Demand (TED) of the community in 2019 was estimated to be 10,521 MWh, €1,676,160 and 2,845 tonnes of CO_2. The breakdown of each is shown below.

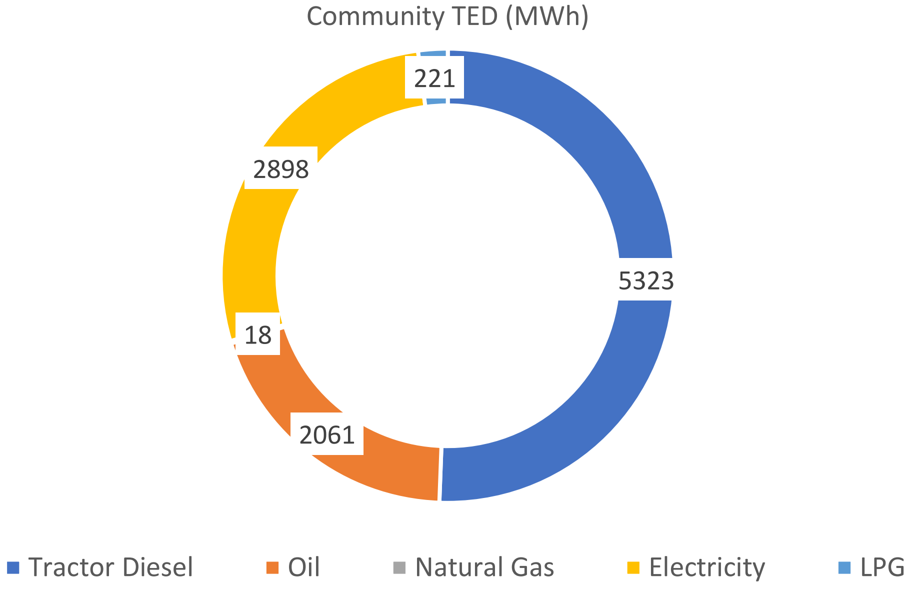
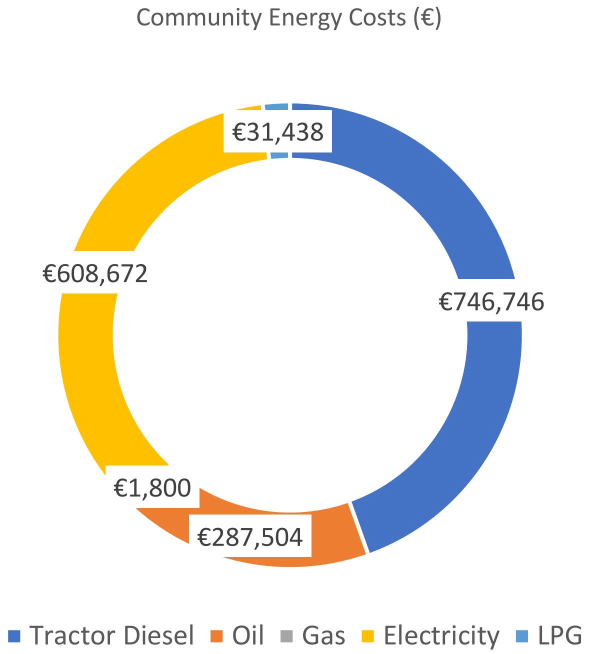


Figure 2



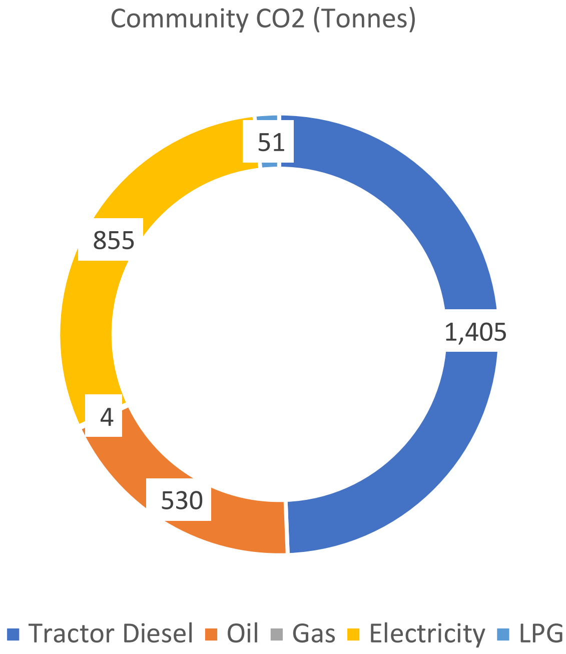


Figure 4

Figure 3

Tractor Diesel

Tractor or agricultural diesel is the single biggest energy usage, accounting for 52% of the TED. The significant contribution transport, including agricultural vehicles, makes to the peninsula TED was also highlighted in the 2018 Dingle SEC EMP (MaREI, 2018). A suggestion from this report was to investigate the construction of an anaerobic digestor. Since then, a feasibility study has been carried out (XD Sustainable Energy Consulting Ltd, 2020).

It is estimated that slurry from six cows is enough to provide 4,000 kWh of biogas each year - enough to power the average home. This is an energy vector with huge potential on the peninsula, both in terms of energy demand and reducing the environmental impact associated with dairy farming. Although the report does highlight the challenges this type of development faces (such as finding a suitable site, planning permission and the lack of a support scheme to subsidise the production of biomethane), it is still probably the most achievable pathway towards significant reduction and decarbonisation of this energy source.

Another potential change that would reduce the amount of tractor diesel within the community is the reduction of land fragmentation. Many farmers on the peninsula don't own a contiguous site, instead they own patches of land that are scattered throughout the peninsula.

Electricity

Electricity is the next biggest energy source accounting for 2,898 MWh and costing the community €600,000 annually. From the community members that have separate revenue meters for the parlour, we were able to estimate that the split between electricity use in the parlour accounted for 62% of the electricity use and the remaining 38% was consumed in the dwelling house.

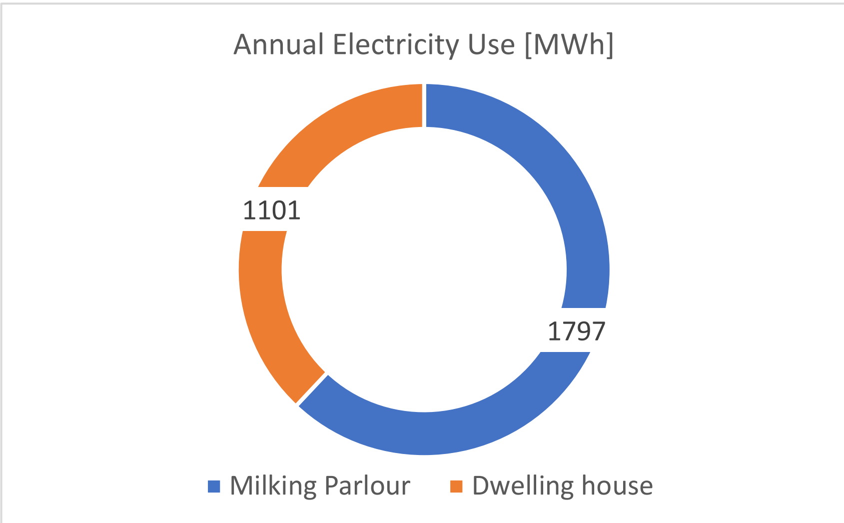


Figure 5

Oil

Oil is the largest contributor of the thermal fuels with an energy demand estimated to be 2,061 MWh in 2019. This is mostly associated with home heating as only one community member is using oil to heat the water in the milking parlour for cleaning.

Natural Gas and LPG

Both energy sources only account for just over 2% of the community's energy demand although 13% of farms are using natural gas to heat the water in the milking parlour.

The Farms

Within the community there are 130 dairy farms and total herd size for the community is estimated at 7,816, with an associated milk production of 26,522,766 litres of milk per annum.

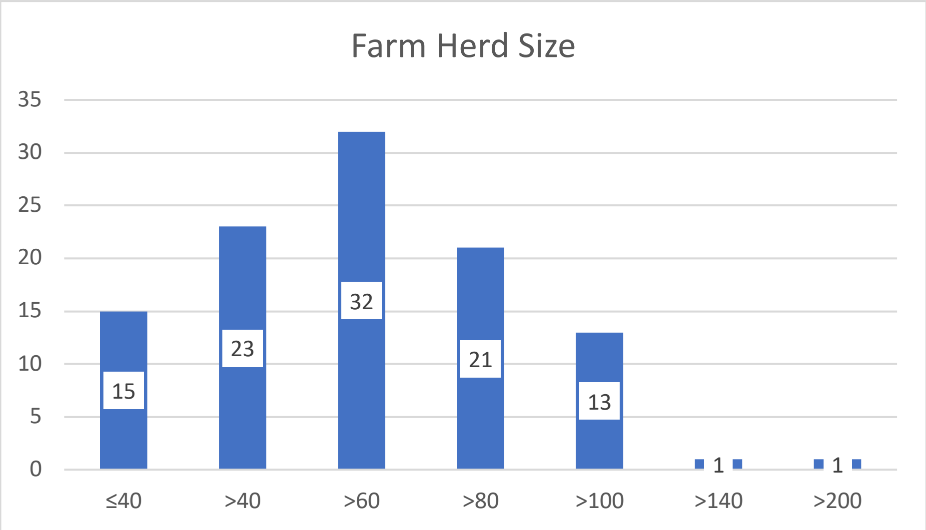


Figure 6

The Milking Parlour

Improving productivity efficiency by managing specific energy consumption should be a priority on the farm. Specific consumption refers to the amount of energy consumed to produce one unit of a product, for example kWh/litre of milk. The key to achieving this lies in linking energy information obtained with production information. The resultant value can then be used to benchmark a farm's energy efficiency. Then the production efficiency, equipment, and work process can be assessed from an energy perspective employing production energy efficiency as an indicator of improvement.

According to Teagasc, the average cost of electricity usage on Irish dairy farms is €5 per 1,000 litres milk produced (Teagasc, 2018). But there is a large variation in that figure – from €2.60 to €8.70 per 1,000 litres produced, or from €15 to €45 per cow per year. This fluctuation indicates that there is potential to reduce electricity consumption by making some technological and behavioural changes.

Opportunities were identified through information gathered. As previously mentioned, specific consumption refers to the amount of energy consumed to produce one unit of a product, so it would be expected that as milk production rates fluctuate throughout the year the specific consumption should stay the same. If this is not the case, then there may be an opportunity for improving bulk tank controls.

Milk Cooling

Whilst the principle of milk cooling is straightforward, the equipment used and its efficiency can vary between farms, dependent on size, age, location etc. During the energy audits we aimed to group farms into 'types' based on either technology utilised or the size of the dairy herd. This information was gathered from the questionnaire the SEC members completed.

Milk leaves the udder at approximately 35°C, but only rapid cooling to a storage temperature of around 4°C prevents or minimises bacterial growth, milk temperature should reach 4-5°C within 30 min of milking. (O'Brien, 2014). Refrigerating milk on the farm in this manner allows for extending milk storage on the farm and reducing transport energy consumption by reducing the number of collections.

Dairy farms use a combination of plate coolers, ice builders (IB) and direct expansion (DX) bulk tank to reduce the milk temperature.

Plate Coolers

Plate coolers use a series of stainless-steel plates sandwiched together, water (from either a well or council mains supply) and milk flow in opposite directions through alternate spaces between plates. Of those who completed the energy questionnaire it was found that 98% had plate coolers.

A plate cooler can remove up to 60% of the heat from the milk, dropping the temperature to as low as 16°C, depending on the temperature and supply of water and the operational efficiency of the cooler, e.g. water to milk flow rate. However, using ever increasing water to milk flow rate isn't without impact, council mains water is metred and well water needs to be pumped, a balance needs to be found.

Bulk Tanks & Ice Banks

Both IB And DX tanks pump heat using the refrigeration cycle outlined in Figure 7 below.

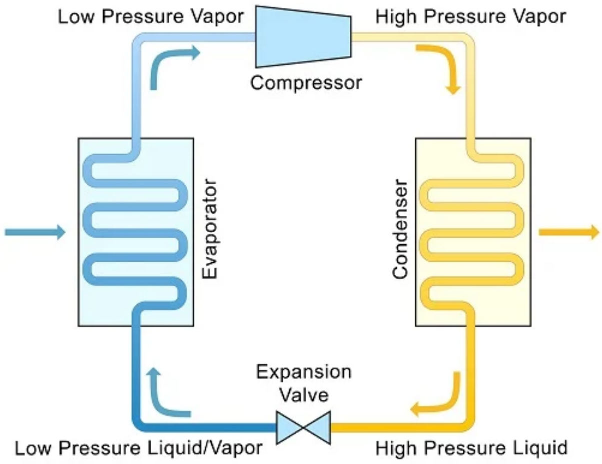


Figure 7

Direct expansion (DX) tanks have the evaporator plates at the bottom storage tank in direct contact with the milk. As the refrigerant expands inside the evaporator it removes heat from the milk. Generally, this milk cooling system cannot cool the milk as fast as the milk enters the tank, and typically the bulk DX system will run for some time after milking and occasionally turn on during storage to maintain the temperature set point. DX cooling systems are the most efficient cooling system in terms of energy consumption per litre milked. However, this energy will be day rate electricity unless some of the morning milking is done early enough to take advantage of the night rate. Figure 8Figure 8 shows vacuum pump consumption in blue, with DX bulk tank in purple.

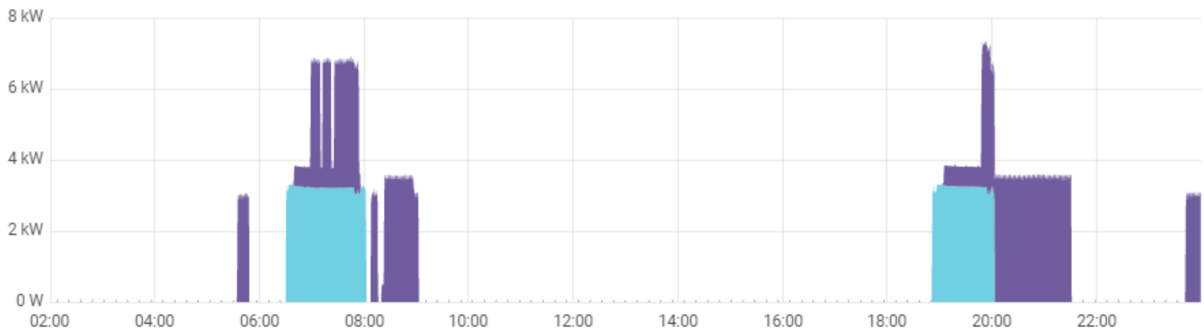


Figure 8

Ice Banks (IB) work by using the same refrigeration cycle principle as the DX tank, but instead use a smaller compressor to build up a reserve of ice over a longer period (7+ hours/day). The ice is formed on copper pipes through which the refrigerant passes. The ice in turn is surrounded by water at close to freezing point. When milk cooling is required contact between the chilled water and the outer surface of the milk holding vessel is facilitated. Although this process is typically less energy efficient than a DX due to the holding vessel absorbing heat from its surroundings, it can take advantage of night rate electricity which is typically about half the cost of the day rate. Figure 9 shows vacuum pump consumption in red, with IB in blue.

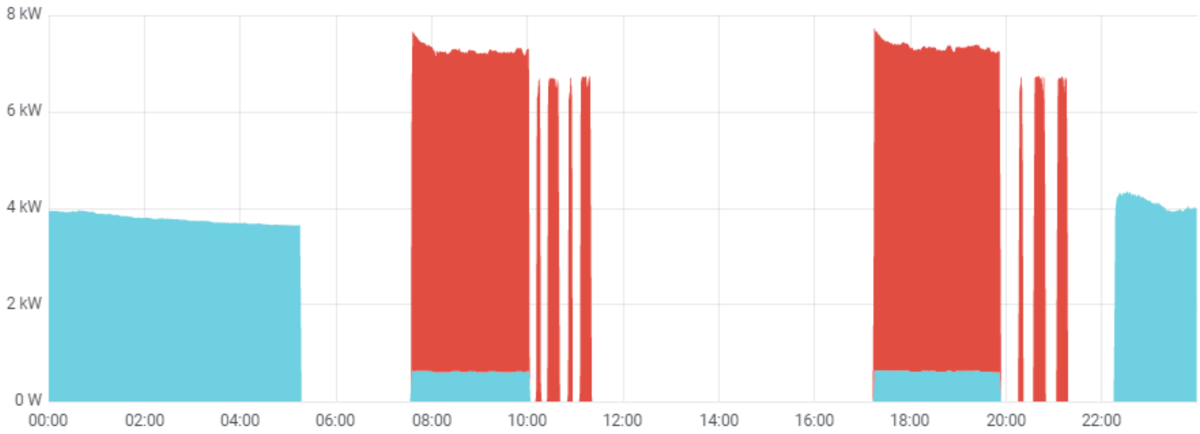


Figure 9

Water Heating

Figure 10 below gives a breakdown of the different energy sources used to heat water. Over 84% of them were using electricity to heat water in the parlour, making it the predominant energy source for this task. However, it can be noted that almost half of these aren't making use of the off-peak night rate and are instead on a standard 24-hour tariff.

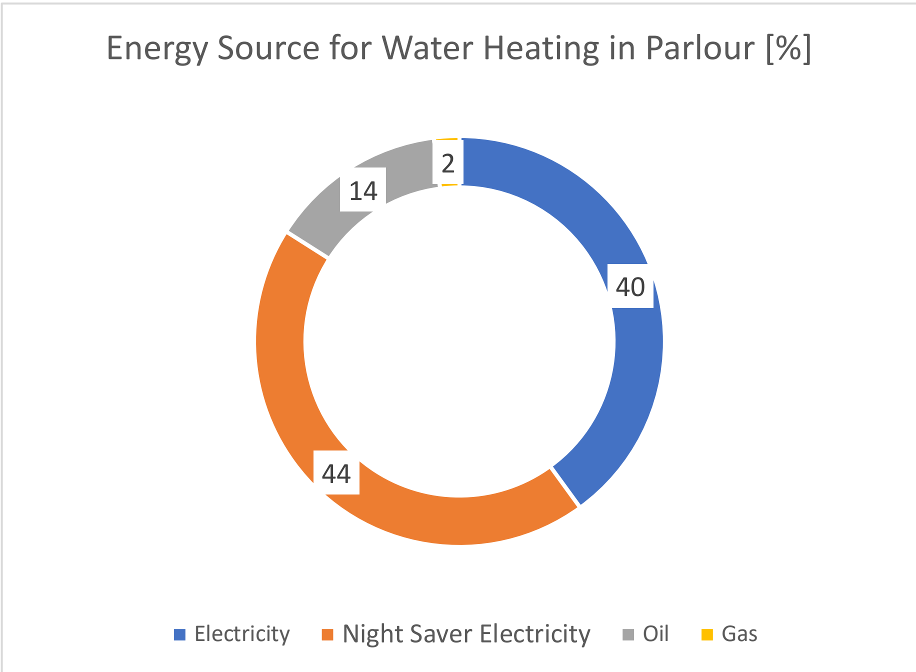


Figure 10

We also asked which farms had a heat recovery unit (HRU) installed and discovered it was a modest 8%. Cooling milk in the bulk tank releases heat that is normally evacuated into the air by the condenser of the refrigeration unit as shown back in Figure 7. This is energy that could be used to pre-heat water before it enters a water heater. The (HRU) transfers this energy from the refrigerant to water in a storage tank, raising the water temperature.

The most common type of HRU is essentially a large, insulated water tank that recovers heat from the refrigerant whenever the compressors run. Using a heat recovery system means that instead of water being heated to 80°C from 12°C it is starting from 55°C.

The recovery of heat from the cooling compressor is widely practiced in various industries and is becoming an economic option in our larger dairy units. The economic benefit will be greater in larger herds where greater amounts of heat can be recovered from the larger volume of milk.

Milk Pumping

Variable Speed Drive (VSD) *Vacuum Pump* creates a vacuum to harvest milk from the cows. The milk, however, cannot transfer from a pipeline that is under a vacuum to a bulk tank that is at normal atmospheric pressure. To compensate for the difference in pressure, milk can flow into a receiver bowl that triggers a *Milk Transfer Pump* to push the milk from the receiver bowl either through a heat exchanger or directly into the bulk tank. Both the Vacuum Pump and the Milk Transfer Pump can be either a Fixed Speed (FS) and Variable Speed Drive (VSD). Currently in the community 29% of parlours have VSD.

FS vacuum pumps run at a fixed speed, to maintain a set vacuum level. The pump must remove air from the milking system at the same rate as air is being admitted. Since the air admitted is dynamic and the pump out rate is constant, a vacuum regulator is necessary to admit the difference between the pump capacity and the air load. When the air load is low, the regulator must admit nearly the entire pump capacity. When the load increases the regulator must close and admit less air.

VSD can adjust the rate of air removal from the milking system by changing the speed of the vacuum pump motor to equal the rate air is admitted to the system at a given vacuum level. Hence all the energy used to move air through the conventional vacuum regulator is saved.

Most literature online will advise that installing a VSD will save up to 60% in the milking energy demand.

The Dwelling House

In 2020 the average Irish home used 20,955 kWh of energy — split into 76% from direct fuel (non-electric) and 24% from electricity (SEAI, 2020).

Residential energy demand can be determined by taking the BER of each individual dwelling house and giving it an associated energy demand. For the purpose of this report all houses were considered as detached houses and average floor area by period of construction was used (CSO, 2017). In situations where the homeowner was unable to share the BER of the dwelling house it was given an assumed BER based on the age of the house (SEAI, 2014). A BER assessment does not include electricity used for purposes other than heating, lighting, pumps and fans. Therefore, the energy used for electrical appliances such as cookers, fridges, washing machines and TVs is excluded.

Table 3

Year Of Construction	Typical Energy Rating
2012+	A3
2010-2011	B1
2008-2009	B3
2005-2007	C1
1994-2004	C3
1978-1993	D1
Pre 1978	E1

Table 4

Rating	Assumed Energy Demand (kWh/m²/year)	Assumed Floor Area (m²)	Number of houses	Energy Demand (kWh/year)
A1	20	208	1	4,160
A2	37.5	208	1	7,800
A3	62.5	208	1	13,000
B1	87.5	208	0	-
B2	112.5	190	5	106,875
B3	137.5	190	0	-
C1	162.5	190	0	-
C2	187.5	177	5	165,938
C3	212.5	161	1	34,213
D1	242.5	149	4	144,530
D2	280	142	7	278,320
E1	320	139	26	1,156,480
E2	360	139	0	-
F	415	139	0	-
G	450	139	0	-

Using this approach, we find the average energy demand of the dwelling houses to be 37,838 kWh. In comparison, the average dwelling house heating energy demand provided from the energy questionnaire was 19,069 kWh and the national average of 15,926 kWh.

This led us to believe that the dwelling homes are either low occupancy or being kept at a temperature lower that what would typically be deemed ‘comfortable’.

Micro Generation

Information also collected during the Energy questionnaire about the potential deployment of microgeneration on the farm. From the questionnaire we discovered:

- There is no significant penetration of micro generation within the community, there were only two instances of solar thermal.
- 43% of the milking parlours have South facing roofs.
- 48% of farms have streams passing through them, this is of interest both for micro hydro and water-to-water heat pumps.
- It was found that exactly 50% of the houses have an ESB connection that is independent of the milking parlours and the other 50% are shared connections.

Farm Energy Audits

Following on from the energy baseline, energy audits took place in accordance with SEAI recommendations and ISO 50001. The five farms audits were broken down into four key areas:

- Water Heating
- Plate Cooler
- Bulk Tank & Ice Bank
- Compressors & Pumps

Water Heating

Regardless of which energy source is used to heat the water, pipework should be well insulated, both the straight lengths of pipe and the joints or bends. Insulation is a very low cost intervention and quick and easy to install. All farms that were audited had insulation on the pipework, but we found numerous cases where some of it had deteriorated over time or come loose.

Where possible, the distance the hot water must travel should be minimised. Figure 13 is a good example of an oil boiler being located near the bulk tank.

A final note on water heating is to ensure you're not overheating. Keep up to date with industry best practice but reducing the setpoint of the boiler will make a linear impact on energy reduction.

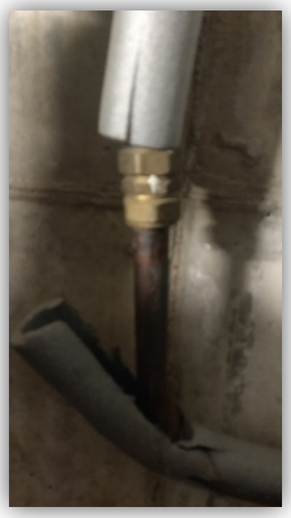


Figure 11

Figure 13

Figure 12

Plate Cooler

Temperature of the milk entering the bulk tank - The temperature of milk exiting an efficient plate cooler should be within 4°C of the incoming water (Dairy Industry South Australia, 2008).

Water flow rate - The ratio of flow rates between the water and milk is critical. A ratio of between 2:1 and 3:1 of water to milk is required. The specific design and size of the plate cooler will determine the best ratio, so refer to manufacturer's recommendations.

Correct sizing - The size (number of plates) of the plate cooler should be matched to the maximum flow rate of the milk pump(s).

Plate cleanliness - Contaminants from either the water or milk that adhere to the plates will affect their heat exchange capacity and reduce their performance.

Maintaining the cooling tower - Regular cleaning and general maintenance is required to ensure performance is not compromised. Regularly monitor the temperature of the cooled water.

Figure 14

Bulk Tank & Ice Bank

Bulk tanks are typically set to 4^{o}C. However, it's important to make sure the bulk tank thermostat is accurate as over-cooling the milk can lead to ice formation and significant extra electricity costs. All the farms audited had accurate bulk tank thermostats.

Another thing to consider when looking at both the performance of the DX or IB is the condensing units. The condensing unit is designed to dissipate heat and its heat exchanger has a very large surface area with thin metal walls, like the plate coolers. Ensure its surface is clean of dirt and debris as this acts as an insulator making the compressor work harder. Figure 15 below shows a heat exchanger that needs some attention, also worth noting is the heat exchanger of an IB is in a room that isn't well ventilated and has two large FS vacuum pumps which produce a significant amount of heat during operation. Although very challenging to move this post install, it's a good example of what needs to be considered when installing this equipment.

Figure 15

As with the water heating, you should aim to insulate pipes containing cooled water such as those going to and from an IB. During the energy audits some small water leaks were noted. Again, this is a source for energy loss and possible corrosion around the equipment.

Figure 16

Compressors & Pumps

Compressors and pumps have various uses within the milking parlour. Whether it's the vacuum pump, water pumps, or air compressor used to operate parlour doors, it's important to ensure the same basic principles. Primarily avoid any leakage, as even small leaks can lead to significant increases in a device's energy consumption.

In many cases the source of the leaks can be extremely difficult to locate. One step that can be taken with regard to air compressors is to ensure the operational pressure isn't any higher than it needs to be, if unsure check the manufacturer's manual.

Finally, if any compressors and pumps utilise filters as shown in Figure 18, ensure they're kept free of debris.

Figure 18

Figure 17

Energy Monitoring

How it works

Here at DCSix Technologies, we have been working with farms since 2018. We have found that energy and environmental monitoring is essential in assisting farms to find potential for energy reduction, which in turn helps them determine required energy efficiency improvements.

Our Wattrics energy monitoring product is used by our clients in the agriculture sector to conduct feasibility studies, carry out energy audits, create alerts and build awareness around energy efficiency. It measures power use in both real and reactive terms flowing through up to 14 individual circuits using a passive sensor that clips around one of the insulated wires in the distribution board. There is no need to switch out the power during installation. Electrical usage data is then securely forwarded to our cloud and stored in a designated database. This is accessible via a fully customisable web interface.

Monitoring builds on the information gathered in the energy audits. Energy audits alone will not provide information on the performance of specific energy using devices on the farm. For example, a 2017 study from Teagasc found that most plate heat exchangers were performing at only a fraction of their full cooling effectiveness. Before considering the installation of new energy saving equipment it should be confirmed that farm plant is operating optimally.

Once a farm has made energy efficiency a goal, energy savings should be pursued in four steps:

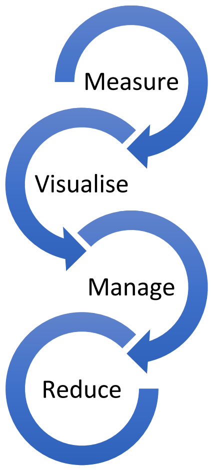


Figure 19

An important factor of energy measurement is the collection of energy data in connection with production information, rather than simply gathering energy use data from the farm. Energy use should be measured in terms of production conditions and the operating status of the equipment.

In the visualization step, the energy and production information collected in the measurement step must be analysed and then visualized by part, process and equipment.

In the management step, which pursues improvement by correlating energy information and production information, it is important to monitor the specific consumption and energy used by the farm and equipment. It is a continual improvement step that becomes more dynamic if you have a night rate tariff as you can benefit from cheaper off-peak electricity.

Proper assessment of energy usage requires precise measurements and the installation of numerous measurement points. Real-time monitoring of a farm's total and specific energy consumption is critical to linking production information and energy information, and then making improvements. This allows the facility to discover problems, find where to make improvements, focus on reducing consumption and decide what improvements to make.

DCSix Technologies offers a comprehensive portfolio of products and technologies designed to help farms achieve optimum productivity and total cost reduction through effective deployment of energy information. Figure 20 and Figure 21 below are just some examples of how this information is presented to the user.

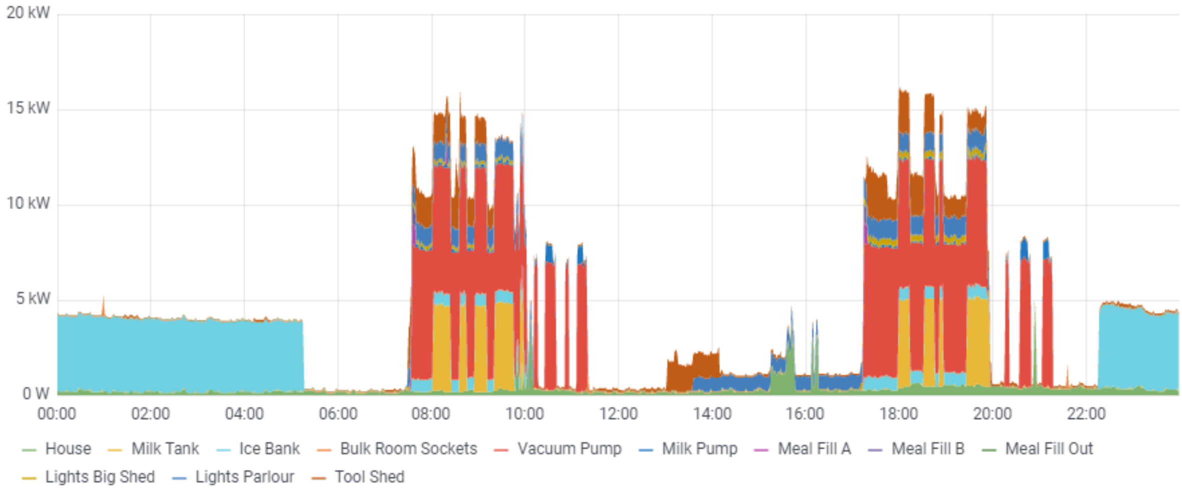


Figure 20

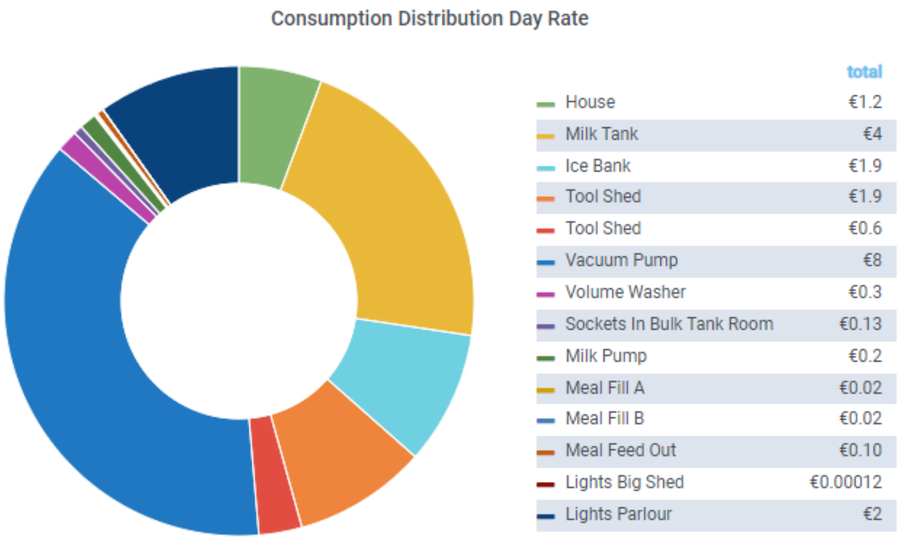


Figure 21

By installing monitoring in different farms that already had different milking, cooling and heating technologies in place we could gather data on how these devices preformed in the real world. We could also compare and rank the different farms to each other. In the interest of making the results comparable from farm to farm everything was normalised to a 100 cow dairy farm.

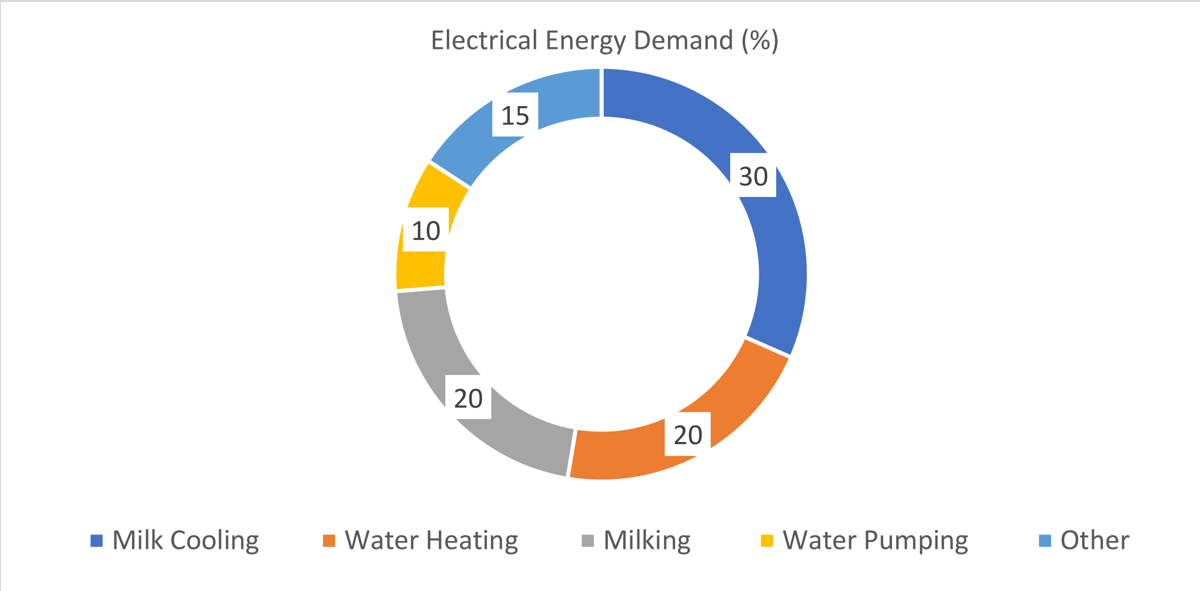


Figure 22

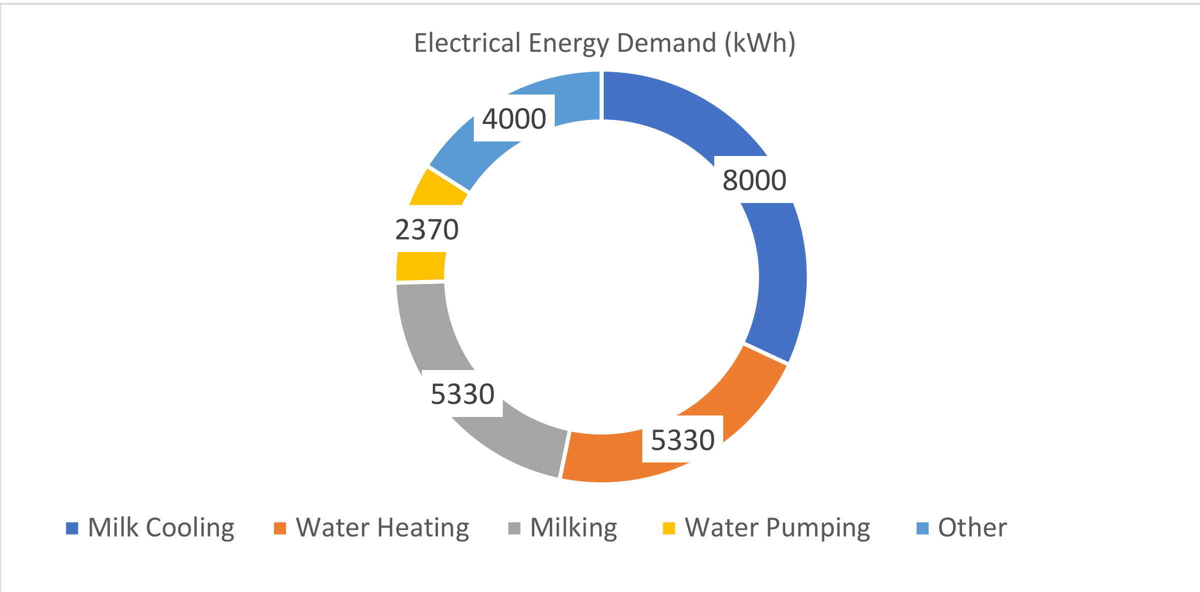


Figure 23

Table 5

Farm	Cooling Energy Demand [kWh] @100 cow herd (24 Hr)	Heating Technology [kWh] @100 cow herd (Single Wash)	Vacuum Pump [kWh] @100 cow herd (2 Milkings)
A	30	*13*	17
B	32	-	19
C	-	-	-
D	26	*11*	*8.4*
E	30	25	*8.1*
F	34	23	17
G	35	-	15
H	-	30	13
I	36	-	17

Cooling

The data gathered from the energy monitoring showed that cooling demand once normalised varied from 26 kWh to 36 kWh. Although this is significant it's important to note that Farm I uses an ice bank and was making use of night rate electricity for his cooling energy.

Excluding those with IB we find that the cooling demand varied from 26 kWh to 32 kWh. it's worth noting that the highest performing bulk tank had both a HRU and a VSD milk transfer pump installed. In theory the VSD should enable the plate cooler to work more efficiently by providing a steadier flow of milk through the plate cooler, secondly having a HRU installed on the condenser can improve the DX compressors overall coefficient of performance. In fact, the other DX bulk tank with heat recovery installed performed well in the cooling category.

Water Heating

For water heating we normalised it not only to a 100-cow farm, but also for a single wash. What was noted from the data coming back from the water heaters that were monitored is that some tanks were washed more frequently. This can be down to a few factors but most notably how frequently milk is collected from the farm. Frequent collections typically result in more frequent washes.

The difference between those that have a HRU and those that don't is clear to see. HRU installs consumed 50-60% less energy on water heating.

Also noted from the energy monitoring was that some IB and electrical water heaters (immersions) were coming on outside of the night rate, this is something all dairy farmers should keep an eye on as it doubles the cost of running the apparatus during that time.

Milking

We were keen to explore the performance of the VSD and FS vacuum pump as part of this project. What we found was surprising; both VSDs that we monitored were the top performers, but how far behind the FS fell varied from 35-55% depending on which FS vacuum pump you compare it too.

Water Pumping

Pumping water can be a very significant cost on the farm, with some farms spending up to €2/day on the process. Alerting was enabled from the monitoring platform for farm water pumps. If consumption breached a predefined value an email was sent to the farmer. We successfully identified a water trough that had been upturned using this method as shown in Figure 24

below.

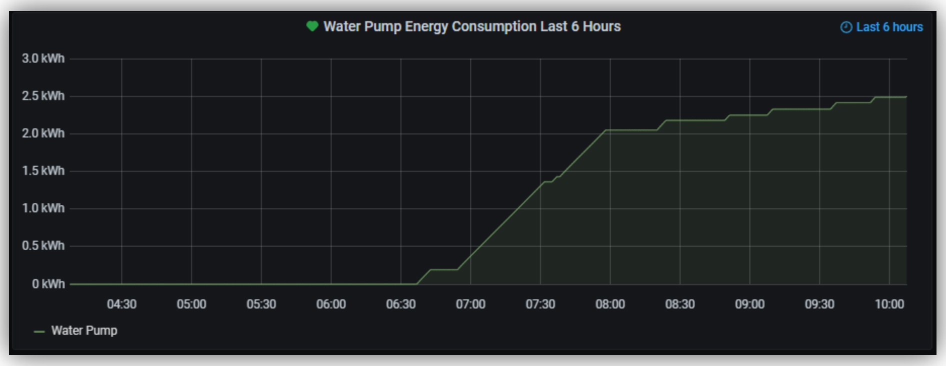


Figure 24

Lighting

For most of the project lighting made a small contribution to the dairy farms over all energy demand. However, not surprisingly, from October onwards we saw a very significant rise in the lighting energy demand. Lighting costs towards the end of the year were up to €2/day on the bigger farms. LED lighting consumes 40% less energy than CFL, although 33% of farms had LED lighting installed CFL is still the most prevalent.

From the energy monitoring we were also able to note inconsistent light practices, as can be seen in Figure 25 . If you require a yard light to be left on at night, it is a good idea to put it on a time/sensor for both energy efficiency and security practices.

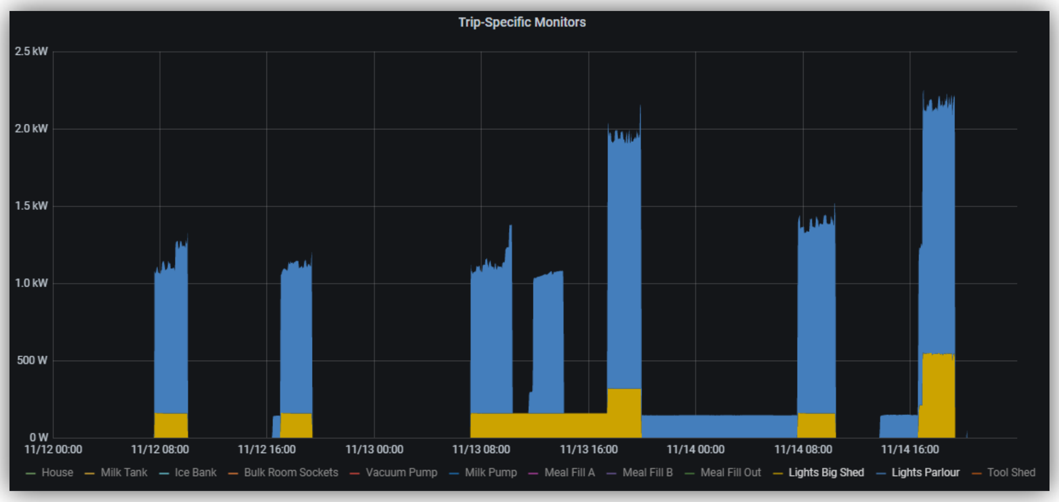


Figure 25

The Dwelling House

Out of the 9 installations of energy monitoring, 3 were directly monitoring the energy consumption of the dwelling house.

Farm	Dwelling House Energy Demand [kWh]	Comments
C	4300	Young family, used night rate electricity to heat water, highest consumption during lunch and dinner hours. Poorly performing deep freezer identified using energy monitoring and owner was notified.
E	3970	Young family, used night rate electricity to heat water, poorly insulated hot wate cylinder was identified using energy monitoring and owner was notified, see Figure 27 below.
I	2480	Older family, on 24 hour tariff, significantly lower energy consumption in this dwelling house.

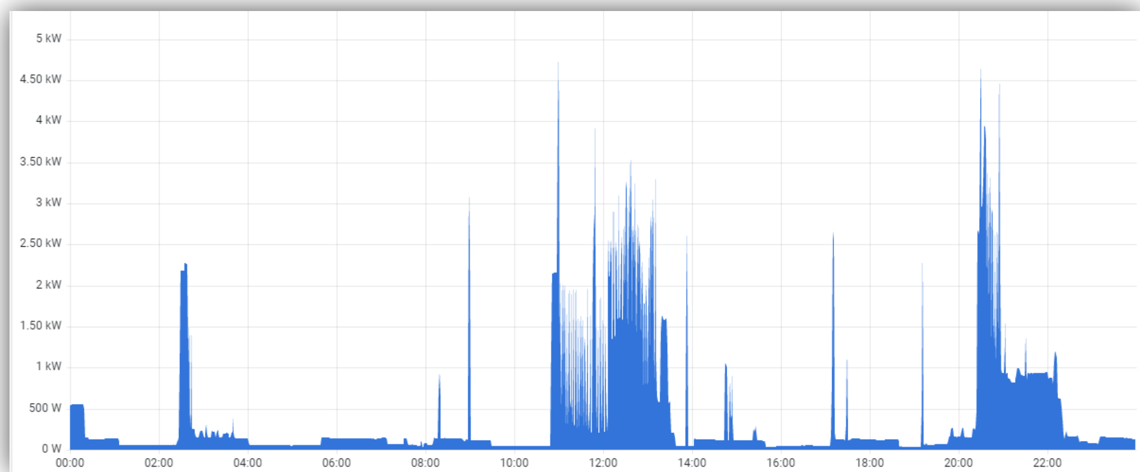


Figure 26: Typical consumption profile of dwelling house in Farm C

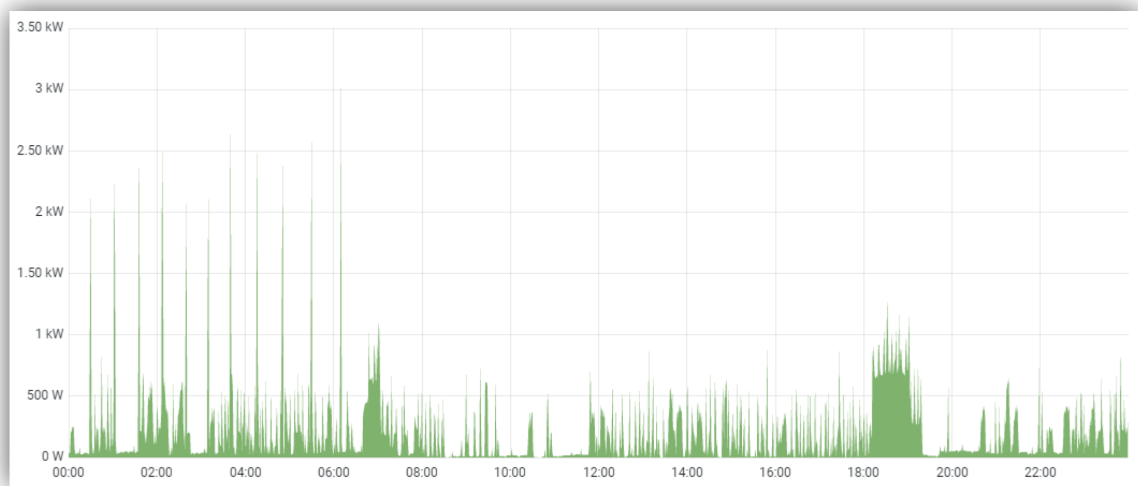


Figure 27 Typical consumption profile of dwelling house in Farm E

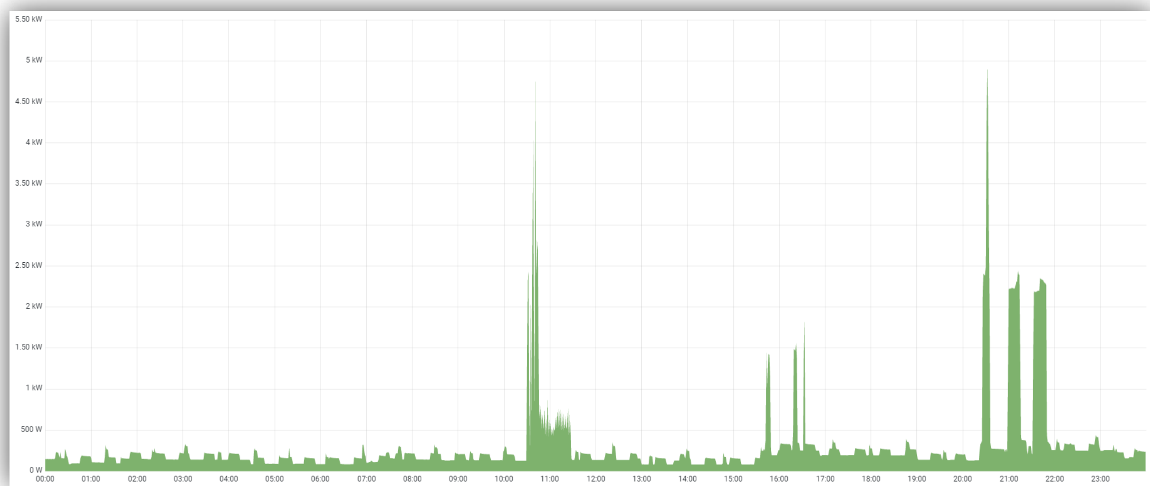


Figure 28: Typical consumption profile of dwelling house in Farm I

Register of Opportunities

The aim of the register of opportunities is a process used to prioritise projects and highlight key metrics that will be important elements for any future grant application or decision-making process. This approach assists with resourcing, planning, and budgeting for projects over a multi annual plan.

Quick Wins

Electricity Tariff

A night rate tariff is more cost effective for anyone who consumes at least 30% of their electricity during 'off peak' times. During the winter these times are from 11pm to 8am and in the summer from midnight until 9am.

Not all farmers fall into this category but those that meet any of the following criteria do

- Heat water using electricity (84% of farms)
- Use an Ice Builder (26% of farms).
- Farmers that finish milking by 8am.

As a result, most farms should be on a night rate tariff, but questionnaire results show the figure to be only 42%.

Insulation

Insulating hot/chilled water pipes can maintain delivered water temperature, directly reducing energy consumption energy. Another effective way to cut heat loss is ensuring the hot water cylinder is insulated with a lagging jacket. These are easy to install and with prices starting at €15.00, this is expenditure that will be paid back through savings in a very short period.

Plate coolers

It is evident from the questionnaire results that there is already a very high penetration of plate coolers within the community. Having a plate cooler reduces energy demand from the bulk tank/ice bank by 60%. Those without a plate cooler will spend up to 60% more on milk cooling, costing an additional €400/month.

Bulk Tank/Ice Bank

Maintenance and cleaning should be implemented around the Bulk Tank or Ice Tank to improve efficiency and save energy. A clean heat exchanger allows the condensing temperature to be kept lower. Increaseing condensing temperature by 1° typically increases running costs by between 2% and 4%. (SEAI, 2017). Typical bulk tank consumption is on average 30kWh/day, a 4% increase in consumption equates to 1.2 kWh increase per day, roughly €10/month.

Also, it is worth cross checking bulk tank/Ice Bank thermostat with a second thermometer to confirm that the target set point is being achieved.

Water/Compressed Air Leaks

Leaks from water and compressed air circuits were identified using Wattrics energy monitoring, for those without energy monitoring things to lookout for include:

- Audible or visible leaks
- Pressure drops; is the pump or compressor running periodically when there is no demand?
- Is the system operating at the minimum acceptable pressure?

Energy Efficiency Upgrades

Retrofit Dwelling House

If all community dwelling homes are retrofitted up to a B2 standard it should reduce the overall energy demand of the dwelling houses by 66%. This will lead to a reduction on the annual community TED of 1,388 MWh and 357 tonnes of CO2.

The National Home Energy Upgrade Scheme offers increased grant levels of up to 50% of the cost of a typical B2 home energy upgrade with a heat pump. The scheme introduces a hassle free way to undertake home energy upgrades with One-Stop-Shops providing an end-to-end service for homeowners. This includes surveying the home; designing the upgrades; managing the grant process; helping with access to finance; engaging contractors to deliver the work; and quality assuring the work.

A home retrofit requires and investment of between €50k – €90k depending on how much the fabric of the building needs to be upgraded and the size of the building etc. Energy savings will differ depending on the heating energy demand of the home. For homes with high occupancy hours that are heated throughout the day, expect to reduce your heating bill by up to 70%. Expect to also experience and improved level of comfort within the home. In the questionnaire result we found the heating energy demand of the dwelling house didn't match up to the level of consumption that was expected from the BER data. This is possibly because older houses aren't regularly being heated to what would be considered a comfortable level because of the cost of doing so.

For those interested in retrofitting the dwelling house, the first step is to have an assessment of the property carried out. The assessment typically takes 1-2 hours, and you will receive a report recommending various efficiency upgrades. This will be tailored to your home and your requirements, with an estimate of the costs and what grants are available. There is an SEAI grant available of €350 towards the cost of a Home Energy Assessment.

Heat Recovery

Water heating makes up 20% of the electrical energy demand within the parlour and for a 100 cow dairy farm this typically equates to 5330 kWh/year. From monitoring the farms with and without heat recovery we found up to a 60% reduction in energy required for water heating where heat recovery was deployed. Currently within the community, only 8% of farms have heat recovery deployed. Increasing this to 100% would reduce the electrical energy demand of the community by 229 MWh and its CO2 production by 68 tonnes.

This equates to a saving of 3,200 kWh per year and up to €830 depending on what fuel source is being offset by the heat recovery, most farms are using electricity. A typical heat recovery system will cost in the region of €5,500. Expect a payback of 6.6 years before any grant aid.

We also believe there is a great opportunity to make use of heat recovery systems from bulk tank to provide space and water heating where the dwelling house is located close to the milking parlour.

VSD

Milk pumping makes up 20% of the electrical energy demand within the parlour and for a 100 cow dairy farm this typically equates to 5330 kWh/year. From monitoring the farms with and without VSD pumps we found that the VSD typically consumed 40% less energy. Currently within the community only 29% of farms have VSD pumps deployed. Increasing this to 100% would reduce the electrical energy demand of the community by 118 MWh and its CO2 production by 35 tonnes.

This equates to a saving of 2,132 kWh per year and up to €555. A VSD vacuum pump will cost in the region of €8,500, it should be up to 40% more efficient, saving €400/year resulting in a payback of 20 years before any grant aid. As an added benefit a VSD Vacuum pump will improve the efficiency of the PHE and make less noise.

Lighting

Lighting consumption varied from farm to farm, but on average for a 100 cow dairy farm it was in the region of 2,000 kWh/year. 33% of parlours already use LED lighting, most farms audited were already using LED lighting for any outdoor security lights that have the longest operating hours. Deploying LED lighting throughout all farms should reduce TED by around 86 MWh/year and its CO2 production by 25 tonnes

- Price varies depending on wattage and number of bulbs.
- Payback period depends on hours of use.
- Suggest switching at a minimum to LED as CFL come to end of life.
- If using outdoor security lighting switch to LED.
- The average lifespan of CFLs is about 8,000 hours, compared to the 25,000 hour lifetime of LEDs.

Micro Energy Generation

Micro Generation Solar PV

Solar PV is the most prevalent form of microgeneration in Ireland today. It can present a very attractive investment opportunity provided the rate of self-consumption is high. A 6 kW installation will typically generate 5,200 kWh/year in southwest Ireland. Self-consumption is the proportion of the electricity that is consumed within the house/farm. If all the energy from the solar PV is self-consumed it should result in a payback period of less than six years. Using the energy profiles gathered from the energy monitoring we're able to simulate how PV might have performed if it was installed on each of our sites, our findings can be summarised into three groups below:

Shared ESB Connection

Figure 29 below is a graphical representation of a single day of analysis, the area in orange is the profile of a site that contains both a dairy parlour and a dwelling house, this is a good example of a site that is suitable for solar PV, as much of the solar energy will be self-consumed.

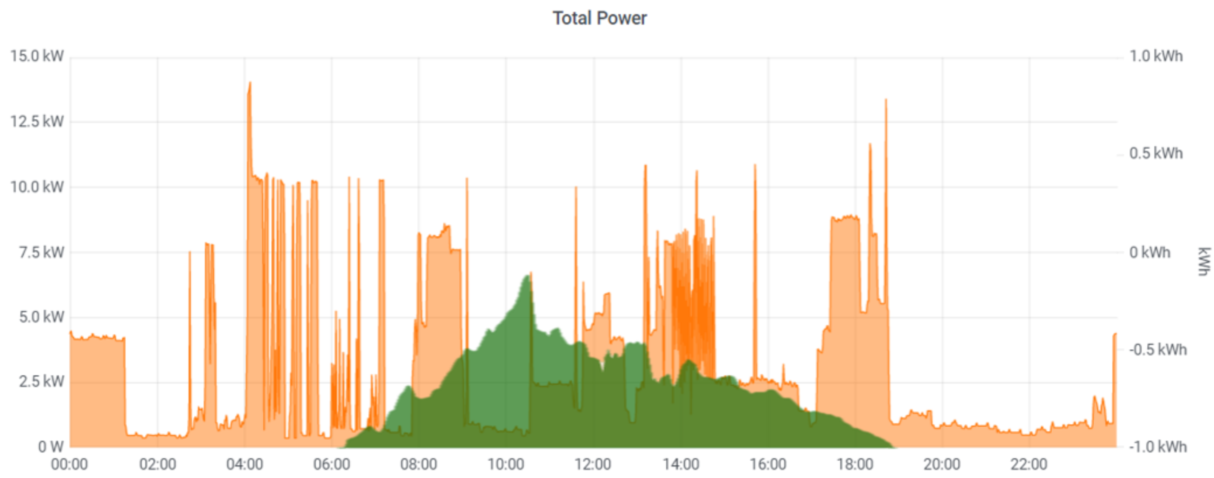


Figure 29

Standalone ESB Connection

Figure 30 below is a similar graphical representation except this site only contains a dairy parlour, without significant energy storage here either in the form of battery energy storage or thermal storage of hot water or even ice in the form of a bulk tank being operated by a VSD compressor this location won't lead to an economically sensible deployment of solar.

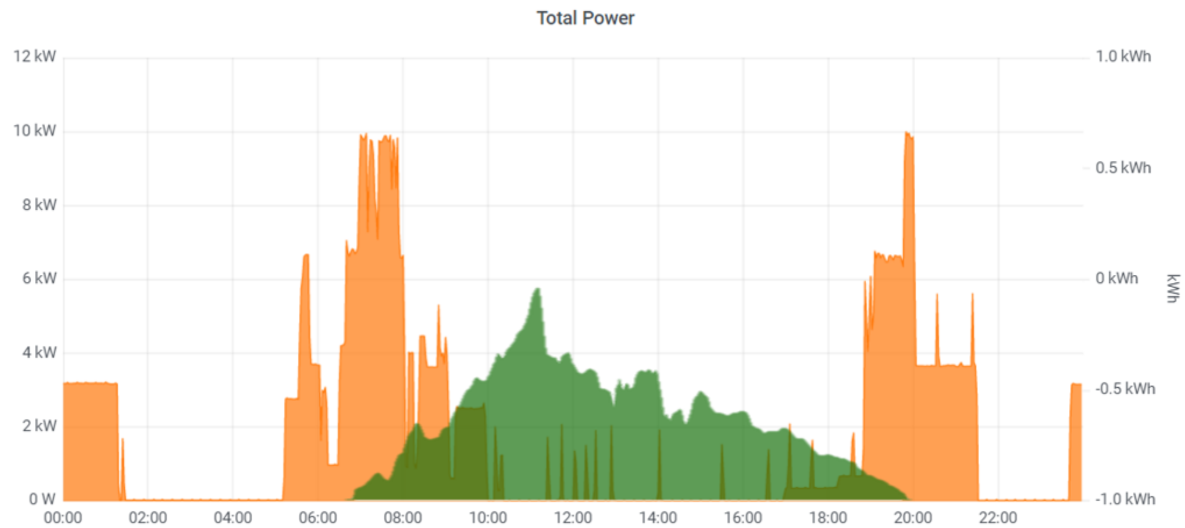


Figure 30

Robotic Parlour with Shared ESB Connection

The final one of these worth sharing is Figure 31 this site has a dwelling house and milking parlour on the one site, but in this instance the milking parlour is autonomous and operated by a robot. A robot changes two things about the energy profile of the farm. Firstly, it significantly increases the energy demand of the parlour. The robot we monitored consumed on average about 30 kWh per day. However, it also flattens out the energy profile of the milking parlour as milking is happening throughout the day and not just in the morning and in the evening, making it a more attractive proposition for solar. You'll see how almost all the energy produced by the solar would have been consumed on this day.

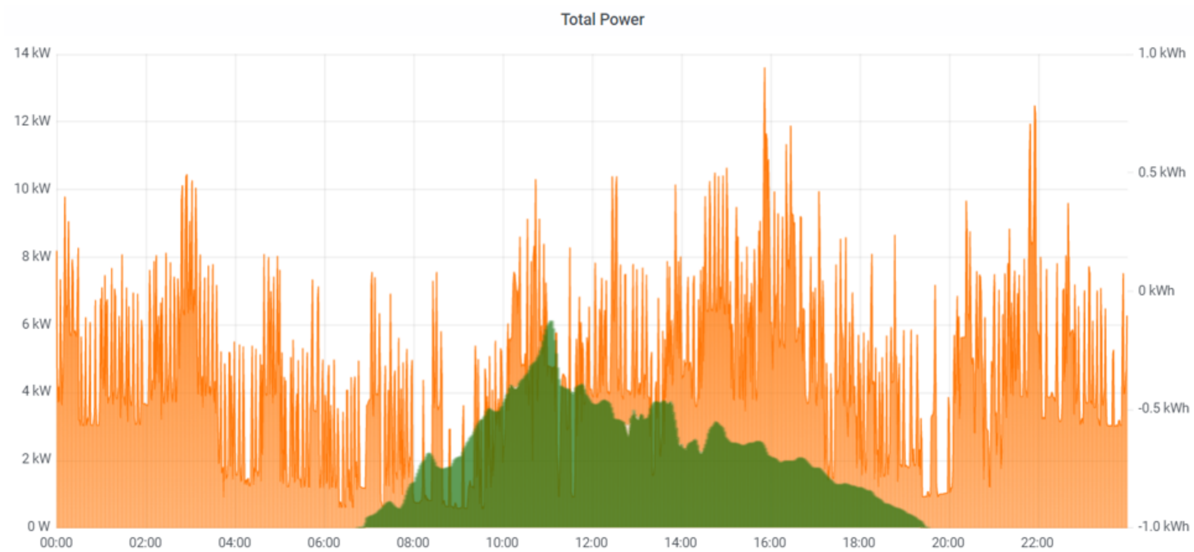


Figure 31

Micro Hydro

Hydropower is a very reliable resource, as unlike wind and solar, it provides a much more constant supply of electricity. SEAI's small-scale hydro map shows six suitable sites on the peninsula (SEAI, 2021). However as we know from the energy questionnaire, 48% of dairy farms have streams passing through them so the potential here for smaller applications is much higher.

Micro Wind

The Dingle Peninsula shows great potential for small scale wind energy, many farms will likely have an exposed location on their farm with annual average wind speeds greater than 6 m/s (SEAI, 2021). Wind unlike Solar PV will operate day or night, but typically expect to have a capacity factor of about 15%.

Community Renewable Energy Generation

Communities like the WKDF SEC can become involved in renewable generation projects via the Renewable Electricity Support Scheme (RESS). Community led projects are sized between 0.5 and 5 MW and typically receive more lucrative rates for the electricity generated that purely commercial enterprises.

Dingle Peninsula is a challenging location for the development of onshore wind because of the Special Areas of Conservation on the peninsula and the impact they might have on the scenic mountainous landscape the area relies on for tourism.

Community solar potentially represents a more attractive opportunity on the peninsula. The approximate cost of such a project would be €900k per MW install capacity, and in RESS1 such a project would have received around 100 €/MWh of electricity generated. For reference a 1MW solar with a capacity factor of 10.8% would produce 946 MWh of electricity per year, or €94,600 under RESS1.

This in addition with the 'Community Benefit Fund' a contribution of €2/MWh, towards investment in local renewable energy, energy efficiency measures and climate action initiatives, must be provided by all projects successful in a RESS auction.

Tractor Fuel Source

The single largest CO2 emitter and cost for the community was tractor diesel. Unfortunately there isn't any solution readily available at present to allow the community to address this issue. The community has expressed great interest in exploring the feasibility of an anaerobic digestor, and much work has been carried out by Dingle Peninsula 2030 on this topic. (XD Sustainable Energy Consulting Ltd, 2020).

Roadmap

From the Register of Opportunities, we have identified the following potential suitable projects. Combined, they stand to reduce the TED of the community by 7,422 MWh, a reduction of over 70%. A breakdown of this reduction both in energy source and device is shown in Figure 33 and Figure 33.

Table 6

Project	***Target Number of Deployments***	***TED Reduction (MWh)***	***CO2 Reduction (t CO2)***
Dwelling House Retrofit	94	1,388	357
Heat Recovery	120	229	68
VSD Pump	98	118	35
LED Lighting	86	86	25
Micro Gen Solar PV	65	338	98
Micro Hydro	1	20	6.000
AD Plant & Biogas Tractors	130	5,323	1,405

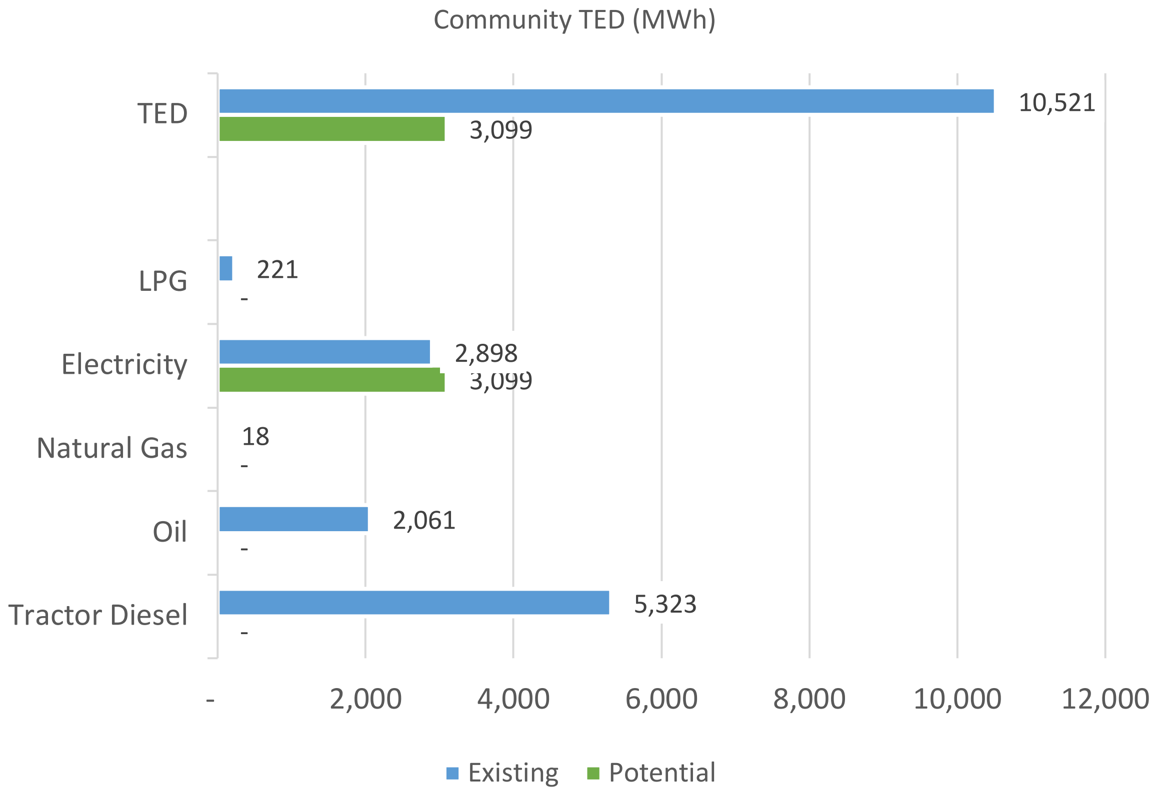


Figure 32

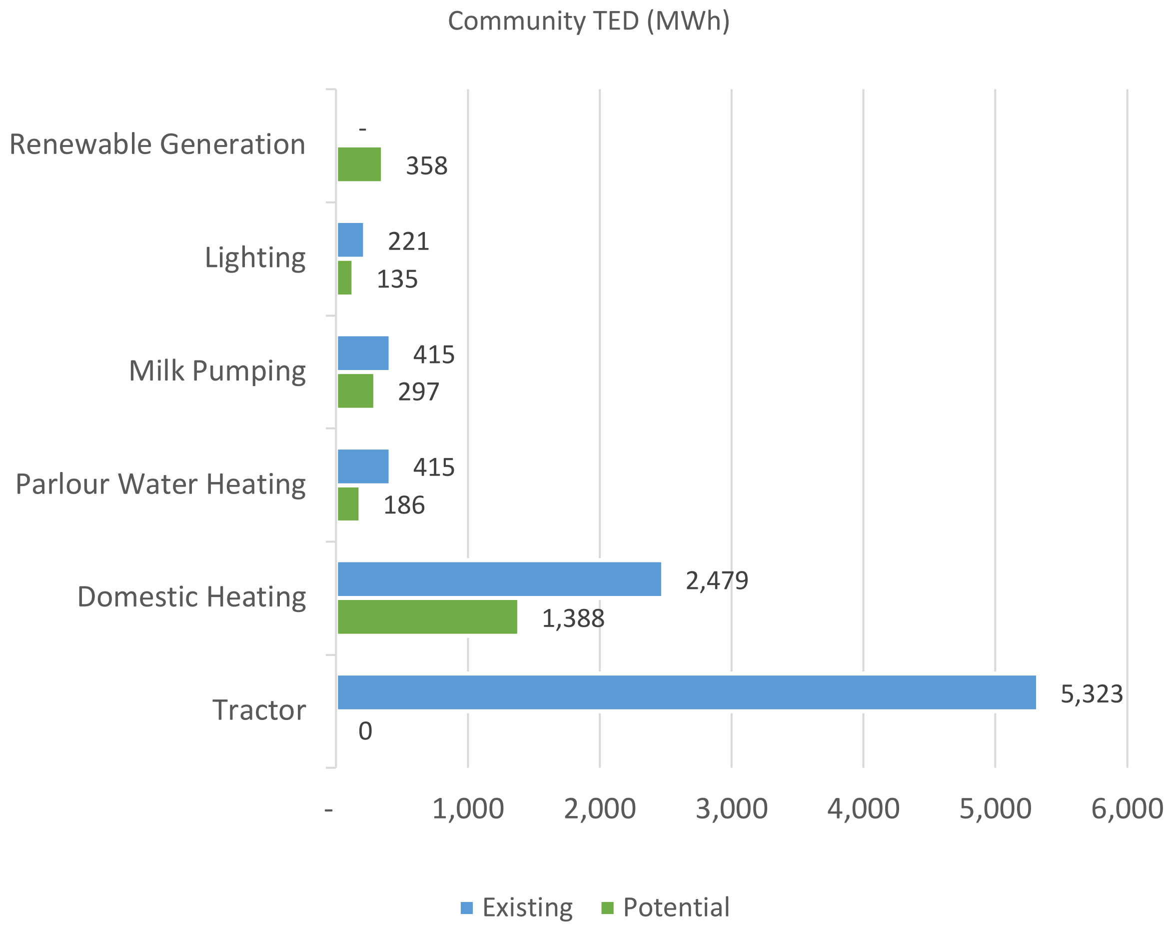


Figure 33

We now need to assess each project based on what the individual or the community needs to do to execute and deliver the project.

Dwelling House Retrofit

First you need to understand what home energy upgrades would benefit your home the most. A BER assessment comes with an advisory report, tailored to your home. SEAI support BER assessments with a €50 grant, but if you complete three measures your grant value will be increased by €300. If you complete four measures your grant value will be increased by an additional €100. This report gives you a roadmap to achieve a minimum B2 energy rating for your home. Use the report to decide which upgrades you want to carry out. SEAI grant aid can cover up to 30% of the costs associated with a dwelling retrofit.

Heat Recovery

This report found heat recovery to be one of the most cost effective upgrades that can be made in the parlour. Installing a HRU is a specialised job and should be done by a registered refrigeration technician with experience of heat recovery equipment. Incorrect installation will stress the compressors and drive higher power consumption as well as decreasing compressor life. Installation by anyone other than the original manufacturer/commissioner of the system will almost certainly void the warranty. A guarantee should be sought for heat recovery installations. First step in pursuing this option is to contact your local registered refrigeration technician and have a conversation about your parlour's suitability for a HRU.

VSD Pump

Although installing VSD can significantly reduce the energy demand of milk pumping, overall cost of installation is relatively high and can lead to longer payback periods than some of the other technologies being assessed. It is likely more advantageous to make the switch to VSD when an existing FS pump reaches its end of life, or, if you have a larger farm with a 3-phase supply, VSD can be more cost effective . A simple calculation to assess potential energy savings for VSD vacuum pump is given below, you can then work out the payback period of installation by contacting your local VSD retailer.

Pump Rating (kW) x Pump Annual Operational (Hours) x Electricity Tariff(€\kWh) x 0.4 = Annual Savings

LED Lighting

LED lighting is the lowest cost and quickest project to deploy from the list. First step to switch to LED lighting is to contact your local electrician and get a quotation to upgrade all light fixtures to LED. Focus on fittings that have the greatest number of operational hours each year first as they will have the quickest payback. For areas like storerooms that might only have lighting switched on occasionally and for a short period of time, upgrading is lighting is less impactful.

Micro Gen Solar PV

Solar PV can have very attractive payback periods, however this payback is dependent on two factors.

1. The amount of sunlight that falls on the PV panels.
2. The proportion of electricity generated by the PV panels that is consumed onsite.

To maximise the generation potential of your site you want your panels to be as close to south facing as possible and not to be impacted by shading from nearby trees or other structures at different times of the year or day.

If you find your site is suitable for generating electricity from solar PV, you should then assess how much of the energy generated by the PV you'll be able to consume. This report found that the only site that was never suitable for solar PV was the stand alone milking parlour without robotic automation. Dwelling houses, just like all other domestic homes in Ireland, can benefit from solar PV. Those that will benefit the most are homes that have people in the house during the day. If your milking parlour and dwelling house are behind a single ESB connection (Type A or Type B) this is a bonus for maximising the rate of self-consumption of solar PV. SEAI grant aid can cover up to 30% of the cost of a solar PV installation.

Micro Hydro

Micro hydro won't be as widely applicable as some of the other technologies listed and deployment time will likely be much longer, however, where the site is suitable the owner can benefit from a very attractive payback period. Enough falling water must be available. Determine the amount of power that you can obtain from the flowing water on your site. The power available at any instant is the product of what is called flow volume and what is called head. The best sites have a reliable water supply year round and a large vertical drop in a short distance. A rough estimate of the power available at a specific micro-scale site can be calculated from the following equation:

$$\text{Power (kW)} = 6 \text{ X head (m) X flow } (m^3/\text{sec})$$

If the potential output of a scheme is attractive, then one needs to be certain that permission will be granted. It is wise to commence informal discussions with planning and fishery board authorities early in the assessment to get a better feeling for their attitude towards the project. The relevant local authority will decide if an environmental impact assessment is required.

AD Plant & Biogas Tractors

The construction of an anaerobic digestion facility and the conversion of the tractor fleet to operate on biogas is the most ambitious project identified, however it has the potential to remove the community's reliance on tractor diesel, which makes up almost 50% of the community TED. A huge amount of work has already been undertaken by Dingle 2030 and its partners in the feasibility study for anaerobic digestion on the peninsula (XD Sustainable Energy Consulting Ltd, 2020).

Some of the key findings at this point are that the production of combined heat and power is not a financially viable option and so more detailed designs will focus on plants that produce biogas. The report recommends a gradual deployment starting with a plant that operates with non-animal by-product (ABP) feedstocks to produce biogas initially for grid injection and compost from the digestate. In parallel, local markets for compressed biomethane should be developed and national markets will further mature. Once these markets are available, it becomes financially viable to move to a plant incorporating ABP (i.e. slurry from dairy farms).

The next step for this project is to develop a roadmap for the project development including a 5-year action plan will be produced to help guide the community through project implementation. The West Kerry Dairy Farms will be key stakeholders in this project.

Figure 33: Anaerobic Digestion Pathway for development on the Dingle Peninsula

References

CSO. (2017, January). *Domestic Building Energy Ratings.* Retrieved from Central Stastics Office: https://www.cso.ie/en/releasesandpublications/er/dber/domesticbuildingenergyratingsquarter42016/

Dairy Industry South Australia. (2008). *Infosheet B4: Efficient Dairy Layour & Design.*

MaREI. (2018). *Dingle Peninsula Sustainable Energy Community Energy Master Plan.* Retrieved from https://dinglepeninsula2030.com/wp-content/uploads/2020/02/Dingle-SEC-Energy-Master-Plan-February-2020.pdf

O'Brien, B. (2014). *Milk Quality, Bacterial Contamination.* Teagasc.

SEAI. (2014). *A Guide to Building Energy Rating for Homeowners.* Retrieved from https://www.seai.ie/publications/Your-Guide-to-Building-Energy-Rating.pdf

SEAI. (2017). *Energy Audit Handbook.* Retrieved from https://www.seai.ie/publications/SEAI-Energy-Audit-Handbook.pdf

SEAI. (2020). *Resedentail Key Stastics.* Retrieved from SEAI - Data & Insights: https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/residential/

SEAI. (April 2022). *Domestic Fue Cost Comparison.* Retrieved from https://www.seai.ie/publications/Domestic-Fuel-Cost-Comparison.pdf

Teagasc. (2018). *Dairy Farm Energy.* John Upton, Dairy Research Officer.

XD Sustainable Energy Consulting Ltd. (2020). *Feasibility Study on Anaerobic Digestion for the Dingle Peninsula.* Retrieved from https://dinglepeninsula2030.com/wp-content/uploads/2020/07/XDC_Dingle-AD-Feasibility-Study_final-report.pdf