Micro Hydro Electricity Potential in County Clare
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1. Executive Summary

- This report has been commissioned by Limerick Clare Energy Agency with support from the Clare Local Development Company, for the purpose of identifying the useful micro hydro electric potential at domestic and commercial scale in County Clare.
- The report has identified and analyzed 5 commercial and 5 domestic sites suitable for hydro-electricity generation.

<table>
<thead>
<tr>
<th>Site Types</th>
<th>Total Annual Electricity Production</th>
<th>Total Project Costs</th>
<th>Total CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 x Commercial</td>
<td>1232 MWh</td>
<td>€1,035,916</td>
<td>663 tCO₂e</td>
</tr>
<tr>
<td>5 x Domestic</td>
<td>116 MWh</td>
<td>€148,281</td>
<td>63 tCO₂e</td>
</tr>
</tbody>
</table>

- It is estimated that a further 10 commercial and 100 domestic sites exist in County Clare, representing €5 million in economic activity.
- The sites reviewed are financially viable given the correct development structure.
- Financial support for one commercial and one domestic project would assist in kick-starting the development of micro-hydro in County Clare. This support could be managed via the Limerick Clare Energy Agency.
- The opportunity exists for Clare to become the leader in micro-hydro, an energy sector with untapped national potential, with the creation of knowledge-based, high-value employment.
- The development of micro-hydro enhances the positioning of County Clare as a low-carbon region in keeping with the Mid West Regional Climate Change Action Plan¹, 2009. The 10 projects in this report represent an annual reduction of 726 tons of CO₂ for County Clare.
- Clare County Council and the Limerick Clare Energy Agency play a crucial role to play in raising public awareness of the potential of the hydro-power resource and in providing support to individuals/companies who are interested developing hydro-power sites.
- For the purpose of this report the following criteria apply:
  - Commercial: Turbine typically rated at greater than 50kW, serving a commercial enterprise.
  - Domestic: Turbine typically rated at less than 50kW, primarily serving a domestic electricity user,
2. Introduction

This report has been commissioned by the Limerick Clare Energy Agency for the purpose of identifying the useful micro hydro electric potential in County Clare. While County Clare has a long history of hydro-electric generation, dating back to the creation of the Ardnacrusha power station in 1929, little further development has been carried out since then apart from a small number of private developments of a relatively small scale. The county lacks rivers suitable for large scale hydro-electric generation with the notable exception of the Shannon River.

In recent years, it has come to be accepted that the current fuel mix used in Irish electricity generation is in need of review. SEI figures from 2008\textsuperscript{ii} show 89% of Ireland’s electricity generated from imported fossil-fuels with associated sustainability issues relating to security of supply, economic cost and greenhouse gas emissions.

This report will serve to suggest the potential to offset the use of fossil fuels at a distributed small-scale. Owing to the lack of large hydro resources this report will investigate the potential at the sub-100 kW size. In terms of scale this compares to the Ardnacrusha power plant which, on its own, produces 85,000 kW of power.

2.1. Limerick Clare Energy Agency

The Limerick Clare Energy Agency (LCEA) was established through investment from:

- Clare County Council
- Limerick County Council.

The agency is also fortunate to enjoy the support of LEADER groups in Clare, West-Limerick and Ballyhoura. The University of Limerick and Aerobord Ltd. also support the work of the agency.

"Energy solutions for sustainable development" is the core value of the agency. The top ten areas of interest for the agency are:

- Establish Public Awareness of The Agency
- Evaluate Energy Consumption in Clare & Limerick.
- Evaluate Energy related emissions for Clare & Limerick
- Develop a Climate Change Strategy for Clare & Limerick
- Support & Develop Renewable Energy Training Programmes.
- Energy Audits of Public buildings and facilities in Clare & Limerick.
- Establish Cooperation and links to community groups (LEADER etc.)
- Establish Partnerships with Third Level Education Bodies.
- Promote Energy Efficiency training and environmental awareness to large energy consumers.
2.2. Carbon Tracking Ltd.
Carbon Tracking Ltd. is an independent energy- and carbon-management consultancy, based in Ennis, Co.Clare offering the following services:

- Advice on potential renewable-energy solutions in the client's energy profile including full financial profiling.
- Carbon-footprint analysis and reduction strategies for businesses, organisations, events and private individuals.
- Guidance through the existing and emerging standards in carbon-management i.e. PAS 2050, ISO 14064-1, WRI/GHG-Protocol
- Evaluation of potential carbon-offset providers covering benefits and pitfalls of the path to “carbon neutral” or “carbon-positive” status .
- Auditing of existing energy-management processes to maximise efficiency gains
- Advice on implementation of energy-management standards such as I.S. 393 and relevant parts of ISO 14001

3. Data sources.
A relatively large body of data is available from different sources and all figures relating to flow-levels in rivers are derived from the sources listed below. No independent measurement of the hydro resource was made for the purpose of this report.

- “Smallscale Hydro-electric potential of Ireland”iii. Published in 1985 by the then Department of Energy. While hydro resource data from this source is still relevant much of the site classification work was recalculated to take into account the changed electricity generating environment and changes in turbine technology.
- The Office of Public Works(OPW) provides flow data which is accessible from the OPW websiteiv. The site presents data for 9 rivers in County Clare but in reality the data is of limited quality for 5 of these rivers.
- The Environmental Protection Agency(EPA) provides hydro related data through one of its websites’. The data is of limited use in relation to County Clare.
- Clare County Council refers to the OPW and EPA for all river flow data.
- Ordnance Survey Irelandvi maps (OSI). The 1:20000 scale maps for County Clare were studied to identify further potential sites not previously cited in other data sources. The historic 1842 map set was studied to identify historic mill sites which would give an indication of a certain kind of hydro resource.
4. Methodology

In order to assess a given site for its hydro resource it is necessary to assess the average flow in the river (measured in cubic metres) and the height that the water drops, referred to as the “head”. The theoretical maximum energy that can be produced at a given point is calculated as follows:

Potential Energy(kW) = \text{flow(m}^3\text{/s)} \times \text{head(m)} \times \text{gravity(m/s}^2\text{)}

4.1. Assessing Flow

A river drains a defined catchment area and the flow in the river is proportional to the rainfall in the catchment area. Since some of the rainfall is lost to evaporation and/or retained by vegetation it is accepted practice to assume that 66% of the total rainfall will be drained through the river. The catchment areas can be calculated from hydrographic maps such as that in Figure 1. The annual average rainfall figures are available from Met Eireann\textsuperscript{viii}.

For example, if a river at a given point has a catchment area of 150km\textsuperscript{2} and an average annual rainfall of 1200mm/m\textsuperscript{2} then we may calculate the total volume rainfall in the catchment area as

\[ 150 \times 1,000,000 \times 1.2 = 180,000,000 \text{ m}^3 \text{ of rainfall.} \]

Assuming that 66% of this flows through the river we get a total annual flow of 120,000,000m\textsuperscript{3}.

Flow is measured in m\textsuperscript{3} per second so we will divide this figure by 8760 (for the number of hours) and then by 3600 (for the number of seconds per hour).

We can now say that our fictitious river has an average flow of 2.94m\textsuperscript{3}/s.

There are also many methods to directly measure the flow in a river at a given time. Such measurements need to be taken over a sustained period of time, ideally one year, to ascertain the mean annual flow. Details of the different measurement types can be found in reference hydropower literature(see section 13).

Once the mean flow is ascertained the specific nature of a given site will dictate how much of that flow can be diverted for the production of energy.

4.2. Assessing Head

A number of techniques exist for measuring the potential head at a given site. (see section 13). Invariably the useful, or net, head is somewhat less than the potential head. For each of the sites assessed, the extent to which potential head is lost is explained. Reasons for loss of potential head are:

- Full head occurring over a long distance of river which renders civil works excessively expensive
- Turbine type.
- Part of head occurring over terrain which renders civil works excessively expensive.
4.3. Turbine Technology

A turbine unit consists of a runner connected to a shaft that converts the potential energy in falling water into mechanical or shaft power. The turbine is connected either directly to the generator or is connected by means of gears or belts and pulleys, depending on the speed required for the generator.

The choice of turbine depends mainly on the head and the design flow for the proposed microhydropower installation. The selection also depends on the desired running speed of the generator. Other considerations such as whether the turbine is expected to produce power under part-flow conditions also play an important role in choosing a turbine. Part-flow is where the water flow is less than the design flow. All turbines tend to run most efficiently at a particular combination of speed, head and flow. In order to suit a variety of head and flow conditions, turbines are broadly divided into four groups (high, medium, low and ultra-low head) and into two categories (impulse and reaction). Impulse turbines are driven (impulse) by a jet of water whereas reaction turbines are immersed in the water and react to its flow.

Pelton, Turgo and crossflow turbines are the most commonly used impulse-type turbines in micro-hydropower systems. These turbines are simple to manufacture, are relatively cheap and have good efficiency and reliability. To adjust for variations in stream flow, water flow to these turbines is easily controlled by changing nozzle sizes or by using adjustable nozzles. Pelton turbines are used for sites that have low flows and high heads.

Most small reaction turbines (Francis/Kaplan/Propeller/Hydrodynamic) are not easy to adjust to accommodate for variable water flow, and those that are adjustable are expensive because of these units’ variable guide vanes and blades. An advantage of reaction turbines is that they can use a site’s full available head. This is possible because the draft tube used with the turbine recovers some of the pressure head after the water exits the turbine. Some of this type of turbine are now being manufactured that can generate power at head as low as 1 m (3 ft.).

<table>
<thead>
<tr>
<th>Turbine Runner</th>
<th>High Head (more than 100m)</th>
<th>Medium Head (20 to 100m)</th>
<th>Low Head (5 to 20m)</th>
<th>Ultra-low head (less than 5m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impulse</td>
<td>Pelton</td>
<td>Cross-flow Turgo</td>
<td>Cross-flow Multi-jet Turgo</td>
<td>Cross-flow Multi-jet Turgo</td>
</tr>
<tr>
<td></td>
<td>Turgo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction</td>
<td>-</td>
<td>Francis</td>
<td>Kaplan Hydrodynamic</td>
<td>Propeller Kaplan Hydrodynamic</td>
</tr>
</tbody>
</table>

Further details of the different turbines technologies can be found in the literature referred to in section 13.

While the table above attempts to classify suitability for different turbine technologies, the competitiveness of the turbine market has lead manufacturers to propose variations of practically all turbines for any given head/flow situation.
Figure 1: Hydrographic regions of County Clare

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5. Site Identification: Commercial Sites.

The report remit is to identify and discuss sites that have a typical hydro-electric potential of 50kW or greater. Sites of this scale are deemed “commercial” to the extent that their production would far exceed the requirements of a private dwelling and would be exploited with the intention either of supplying electricity to a commercial premises and/or selling the electricity production to the national grid.

The different legal structures which could be used to develop potential sites is discussed in section 11.

5.1. Commercial Sites: Summary Data

The sites considered are detailed in the following table.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>tCO₂e avoided per annum</th>
<th>Cost/kW</th>
<th>Cost/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Falls, Ennistymon</td>
<td>412 MWh</td>
<td>116.7 kW</td>
<td>€326,667</td>
<td>221 tCO₂e</td>
<td>€2800/kW</td>
<td>€66.86</td>
</tr>
<tr>
<td>Old Mill, Ennis</td>
<td>259 MWh</td>
<td>72.0 kW</td>
<td>€216,000</td>
<td>139 tCO₂e</td>
<td>€3000/kW</td>
<td>€70.27</td>
</tr>
<tr>
<td>Clondegad, Ballynacally</td>
<td>241 MWh</td>
<td>67.0 kW</td>
<td>€214,400</td>
<td>130 tCO₂e</td>
<td>€3200/kW</td>
<td>€74.96</td>
</tr>
<tr>
<td>Moananagh, Inagh</td>
<td>232 MWh</td>
<td>64.5 kW</td>
<td>€193,500</td>
<td>125 tCO₂e</td>
<td>€3000/kW</td>
<td>€70.27</td>
</tr>
<tr>
<td>The weir, Sixmilebridge</td>
<td>88 MWh</td>
<td>25.1 kW</td>
<td>€85,349</td>
<td>47 tCO₂e</td>
<td>€3400/kW</td>
<td>€81.75</td>
</tr>
<tr>
<td>Total</td>
<td>1232 MWh</td>
<td>NA</td>
<td>€1,035,916</td>
<td>663 tCO₂e</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Table 1: Summary of production data, Commercial Sites

Of the five sites selected, three already have an association with hydro-power (The Falls, Ennistymon / Old Mill, Ennis / Clondegad, Ballynacally). This is the recommended course of development, i.e. re-developing existing sites, due to the facilitated planning process and re-using existing infrastructure.

Note that the project costs are estimates of the cost of site-development using industry standard guidelines. Each site will have specific characteristics which will influence the total project cost at the planning, commissioning and operation stages. The Cost/MWh figure given assumes a 20 year project lifespan, 100% financed at an interest rate of 5% and a 5% additional annual cost for operation and maintenance.

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5.2. Financial payback

The outline project costs indicated in Table 1 above allow an estimation of the financial viability of the different projects presented.

From a financial payback point of view the “worst-case” scenario is that all electricity produced is sold to the national-grid at a price of €72/MWh as guaranteed by the state under the Renewable Energy Feed-In Tariff scheme\(^x\) (REFIT). In this scenario the first three sites are self-financing but not the Ballynacally and Sixmilebridge sites.

When the value of the avoided \(\text{CO}_2\) emissions is included the financial picture changes. As of Dec 2009, a ton of \(\text{CO}_2\) is valued at €15 in Ireland, reflecting the EU Emissions Trading Scheme\(^x\). By incorporating the value of the avoided emissions, e.g. the 125 t\(\text{CO}_2\)e avoided by the Inagh project would have a revenue value of €1875/year, all of the sites become feasible under the REFIT scenario. The value of a tone of \(\text{CO}_2\) is projected to rise as emissions reductions are prioritized in the Kyoto protocol and its successors which will in turn increase the value of low-emissions electricity production projects.

Where some or all of the electricity produced can be used to reduce the amount of electricity purchased from the national grid, the financial feasibility improves considerably. An SME pays ~€150/MWh\(^x\) so by reducing the amount of electricity purchased from the grid each MWh produced is now worth €150 instead of €72.

In the following chart, we see the impact of using increasing proportions of the production onsite on the time it takes to repay the cost of an installation.

![Chart showing reduction in project repayment time by using electricity onsite.](chart.png)

**Figure 2**: Reduction in project repayment time by using electricity onsite.

It can be noted that even in the “best-case” scenario, i.e. replacing grid electricity and including value of \(\text{CO}_2\), the value of each MWh for a commercial installation is inferior to that which is paid to a domestic installation under the domestic REFIT program. In this program, the first 3MWh generated is given a REFIT of €190/MWh.
5.3. Site 1: The Falls, Ennistymon

The Falls in Ennistymon is long associated with Hydropower as the nearby Falls hotel had a 30kW turbine in operation from 1955 until falling into disuse in the 1980’s. The Cullenagh, also known as the Inagh River, flows through the waterfalls or cascades.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls Hotel, Ennistymon</td>
<td>174.0 km²</td>
<td>1332 mm</td>
<td>4.86</td>
<td>12.0</td>
<td>116.7 kW</td>
<td>412 MWh</td>
<td>50 m</td>
</tr>
</tbody>
</table>

![Existing Hotel](image)

![Previous hydro plant](image)

Figure 3: The Falls, Ennistymon. Aerial view of potential hydro location

The site presents a large hydro resource with a head of 12m and an average flow of 4.86m³/s. This presents a theoretical energy yield of 570kW. However, the 12m head occurs over a distance of 50m and not all the river bank along this distance is owned by one person, which could cause project and contractual difficulties.

The river is also an important fisheries resource so the level of water abstraction would be strictly controlled to avoid any impact on the migration of spawning fish. The matter of fisheries impact is discussed further in section 8.
The recommendations/projections for the Falls site are as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>(^{\text{CO}_2}) avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Falls, Ennistymon</td>
<td>412 MWh</td>
<td>116.7 kW</td>
<td>€326,667</td>
<td>221 t(^{\text{CO}_2})e</td>
</tr>
</tbody>
</table>

The annual production would be absorbed by the hotel complex meaning that the project becomes very attractive commercially, i.e. the hotel owner gains maximum value from each kWh generated. Planning permission has been granted to the hotel owner to redevelop the hydro-power installation. He is currently awaiting clarification from the Shannon Regional Fisheries Board on conditions that are attached to the planning permission.

A suitable type of turbine for this site would be a Francis turbine\(^{\text{xii}}\) which is suited to the head-flow combination of the site. The project costs are very low due to the minimized civil works required by using the existing fish weir and turbine buildings.

As a high-profile location in North Clare, this site can serve to highlight the potential of hydro-power in general.
5.4. Site 2 : The Old Mill Site, Ennis.

The Old Mill site, on the Mill Road in Ennis, has witnessed various types of hydro-power activity since at least 1659 until 1899 and the cornmills in the 19th century were sufficiently famous, or infamous, to merit a mention in Karls Marx’s “Das Kapital”.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Mill, Ennis</td>
<td>615.0 km²</td>
<td>1265mm</td>
<td>16.33</td>
<td>1.5</td>
<td>72.0kW</td>
<td>259 MWh</td>
<td>3 m</td>
</tr>
</tbody>
</table>

Figure 4: The Old Mill, Ennis. Aerial view of potential hydro location

The historical location of the mill reflects the excellent hydro resource at this point, downstream of the confluence of the Claureen and Fergus rivers. The theoretical average power of the river is 240kW. Again, the recommended turbine size is considerably less for the following reasons.

- Head losses at low-head sites are proportionally higher than at medium/high head sites.
• Minimising visual and noise impact at a historical and highly frequented site.
• Consideration for the fisheries resources of the river.

The recommendations/projections for the development of the Old Mills site is as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Mill, Ennis</td>
<td>259 MWh</td>
<td>72.0 kW</td>
<td>€216,000</td>
<td>139 tCO₂e</td>
</tr>
</tbody>
</table>

A suitable type of turbine for this site would be a Hydrodynamic screw given its suitability to low-heads. This turbine type, will deliver high-efficiencies in this site and has the advantage of having a low rotational speed, minimizing noise. Such turbines have already been used successfully in similar scale projects in the UK (see section 13).

Because of the central location of the proposed site, and the high volume of traffic that passes through daily, a hydro-power development at this location would give a very strong indication of support for the micro-hydro industry in County Clare.
5.5. Site 3: Clondegad, Ballynacally

This site is located at a natural waterfall on the Owenslieve River near Clondegad in Ballynacally. A hydro-electric installation operated onsite to supply electricity to the private dwelling of the landowner but has not been used for over 20 years and the original turbine has been removed. The penstock, the pipe that carries the water to the turbine, is still in place as is the turbine house.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clondegad, Ballynacally</td>
<td>47.7 km²</td>
<td>1453 mm</td>
<td>1.45</td>
<td>8.0</td>
<td>67.0 kW</td>
<td>241 MWh</td>
<td>5 m</td>
</tr>
</tbody>
</table>

Figure 5: Location of Clondegad, Ballynacally site.
This is an excellent hydro-site where a reasonable mean flow, 1.45 m$^3$/s, is coupled with a vertical drop of 8 metres combine to give a theoretical average power of the river of 115kW. Also the vertical nature of the drop presents an impassable barrier to migrating fish life meaning that a larger proportion of the average flow can be abstracted for the purpose of energy production.

The recommendations/projections for the development of the site is as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO$_2$ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clondegad, Ballynacally</td>
<td>241 MWh</td>
<td>67.0 kW</td>
<td>€214,400</td>
<td>130 tCO$_2$e</td>
</tr>
</tbody>
</table>

A suitable type of turbine for this site would be a Hydrodynamic screw. This turbine type is well suited for head of this scale and simplifies the civil engineering required as the screw can accommodate large debris without the need for complex screening mechanisms. The site would also suit a Francis type turbine.
5.6. Site 4: Moananagh Bridge, Inagh

The site at Moananagh, Inagh has not previously been developed for hydro-power but has been mentioned in “Smallscale Hydro-electric potential of Ireland” as a site with development potential.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m$^3$/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moananagh, Inagh</td>
<td>140.0 km$^2$</td>
<td>1352mm</td>
<td>3.98</td>
<td>5.5</td>
<td>64.5kW</td>
<td>232 MWh</td>
<td>50 m</td>
</tr>
</tbody>
</table>

Figure 7: Location of Moananagh, Inagh site.

The site presents a large hydro resource with a head of 5.5m and an average flow of 3.98m$^3$/s. This presents a theoretical energy yield of 215kW. However, the 5.5m head...
occurs in two distinct drops over a distance of 50m meaning that either a relatively costly channel would have to be constructed or the simpler approach of harnessing each drop separately could be envisaged.

The river is also an important fisheries resource so the level of water abstraction would be strictly controlled to avoid any impact on the migration of spawning fish. The matter of fisheries impact is discussed further in section 8.

The recommendations/projections for the site are as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moananagh, Inagh</td>
<td>232 MWh</td>
<td>64.5 kW</td>
<td>€193,500</td>
<td>125 tCO₂e</td>
</tr>
</tbody>
</table>

A suitable type of turbine for this site would be a Hydrodynamic screw. This turbine type is well suited for head of this scale and simplifies the civil engineering required as the screw can accommodate large debris without the need for complex screening mechanisms.

The costing given above relates to the installation of a single screw with potential for the installation of a second screw, further down the river, at a later date.
5.7. Site 5: The Weir, Sixmilebridge
The weir in Sixmilebridge is at the center of a stretch of the Owenogarney River which has a hydro-power history dating back to 1664 with the first recorded record of a mill at Ballintlea, 2 miles to the south of the village of Sixmilebridge. The 1842 map of the area shows six mills in the 4 mile stretch centered on the village.

The characteristics of the hydro resource at the site are as follows:

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>The weir, Sixmilebridge</td>
<td>161.8 km²</td>
<td>1261 mm</td>
<td>4.27</td>
<td>1.0</td>
<td>25.0 kW</td>
<td>88 MWh</td>
<td>2 m</td>
</tr>
</tbody>
</table>
The site presents a reasonable hydro resource with a head of 1m and an average flow of 4.3m³/s. This presents a theoretical energy yield of 42kW. Again, the recommended turbine size is considerably less for the following reasons.

- Head losses at low-head sites are proportionally higher than at medium/high head sites. 1m of head is barely exploitable for electricity production.
- Minimising visual and noise impact at a historical and highly frequented site.
- Consideration for the fisheries resources of the river, discussed further in section 8

The recommendations/projections for the site are as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>The weir, Sixmilebridge</td>
<td>88 MWh</td>
<td>25.1 kW</td>
<td>€85,349</td>
<td>47 tCO₂e</td>
</tr>
</tbody>
</table>

A suitable type of turbine for this site would be a Hydrodynamic screw. Again, the minimal head limits the turbine choice.
5.8. Man-made settings.

The sites examined thus far are all in natural settings and as such are subject to strict control from the planning, environmental and fisheries authorities. In contrast to this, hydro-electric developments have been carried out in man-made settings, specifically in water supply and treatment networks.

A notable example is the Dublin City Council’s Vartry Waterworks has provided the city and surrounding areas with potable water since the 1860’s. The treatment plant is situated below the impounding reservoir and because of this, the pressure of the incoming water must be reduced before treatment. Vartry Small Hydro Project consisted of the installation a turbine on the plant intake to convert this excess energy to electricity.

A Kaplan turbine was selected, which regulates the incoming flow to any required preset level by means of hydraulically operated guide vanes linked to a flow meter. Water treatment at all times takes precedent over power production and to ensure the water supply is never interrupted, gravity operated body valves are incorporated to provide automatic failsafe operation of a bypass in the event of the turbine stopping.

The turbine was commissioned in November 2007 and has been operating continuously since early 2008. The generator capacity is 90kW and average plant usage is 35kW with surplus power exported to the National Grid. The project will have an estimated payback period of approximately 8 years. The turbine both regulates the incoming flow to the treatment plant and harnesses a renewable source of energy previously destroyed. It will result in a net reduction in CO₂ emissions of 380 tons per year.

Furthermore, it should be noted that peak water demand is generally from 6-8 p.m. which corresponds exactly with peak electricity demand.

The Vartry Project operates on the water supply system. Examples of hydro-electric generation from the runoff of water treatment plants also exist. These sites are characterized by low head /high flow and may be suited to the use of Hydrodynamic screw turbines.
6. Site Identification: Domestic sites.

The report remit is to identify and discuss sites that have a hydro-electric potential suitable for a domestic dwelling. A typical Irish home has an annual electricity requirement of 5600 kWh\textsuperscript{xiv}. A hydro-power site with a turbine rated correctly at 1–2kW would supply this amount of electricity.

In total energy terms, including heating and domestic hot-water requirements, the typical Irish home has an annual requirement of 25,000 kWh. A hydro-power site with a turbine rated correctly at ~5kW would supply this amount of energy, i.e. enabling total self-sufficiency of a home in energy terms.

For the purpose of this report, it has been decided to identify sites that can have an installed capacity of 5kW in order to illustrate the potential for total self-sufficiency from hydro-power at a domestic scale.

Site identification was carried out on an anecdotal basis as the small hydro-power resource required would not be identifiable from any of the data sources listed in section 3.

The data in the sections that follow in no way seeks to represent the total potential for hydro-power at the domestic scale. Given the typical rainfall in the county and the large amount of streams capable of providing electricity at a domestic scale, the true potential of the county can only be assumed to be well over one hundred suitable sites. In section 12, the use of public meetings is recommended to allow the public access to the information which would allow them to assess and quantify the full potential at a county scale.

Note that all sites discussed in this section are grid-connected, i.e. no recommendations are made for off-grid electricity generation systems.

6.1. Domestic Sites: Summary

The sites considered are detailed in the following table.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO\textsubscript{2} avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glebe, Ennistymon</td>
<td>35 MWh</td>
<td>4.8 kW</td>
<td>€28,800</td>
<td>19 tCO\textsubscript{2}e</td>
</tr>
<tr>
<td>Mt.Callan, Inagh</td>
<td>25 MWh</td>
<td>6 kW</td>
<td>€30,800</td>
<td>13 tCO\textsubscript{2}e</td>
</tr>
<tr>
<td>Annagowney, Sixmilebridge</td>
<td>26 MWh</td>
<td>7.5 kW</td>
<td>€41,419</td>
<td>14 tCO\textsubscript{2}e</td>
</tr>
<tr>
<td>Kiluran</td>
<td>16 MWh</td>
<td>4.6 kW</td>
<td>€25,300</td>
<td>9 tCO\textsubscript{2}e</td>
</tr>
<tr>
<td>Ballyea, Inagh</td>
<td>14 MWh</td>
<td>4.0 kW</td>
<td>€21,962</td>
<td>8 tCO\textsubscript{2}e</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>116 MWh</strong></td>
<td><strong>NA</strong></td>
<td><strong>€148,281</strong></td>
<td><strong>63 tCO\textsubscript{2}e</strong></td>
</tr>
</tbody>
</table>

Table 2: Summary of production data, Domestic Sites

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6.2. Site 6: Glebe, Ennistymon

The site is an unnamed stream which flows some 50m to the rear of a private dwelling. The owner of the dwelling, whose land bounds the stream for over 400 metres has already made, and been granted, a planning application for a hydro-power site. The owner is currently awaiting clarification from the Shannon Regional Fisheries Board on conditions that are attached to the planning permission.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ennistymon</td>
<td>1332mm</td>
<td>0.12</td>
<td>0.12</td>
<td>8.4</td>
<td>4.8kW</td>
<td>35 MWh</td>
<td>300 m</td>
</tr>
</tbody>
</table>

Figure 9: Glebe, Ennistymon

While the flow in the stream is sufficient, the long distance over which the head occurs will add considerable cost to the project. Furthermore, the penstock carrying the water to the turbine cannot be laid in a straight line due to the undulating terrain.
The recommendations/projections for this site are as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glebe, Ennistymon</td>
<td>35 MWh</td>
<td>4.8 kW</td>
<td>€28,800</td>
<td>19 tCO₂e</td>
</tr>
</tbody>
</table>

A suitable type of turbine for this site would be a Crossflow.

**6.3. Site 7: Mount Callan, Inagh**

This private dwelling received all of its electricity supply from a 5kW Pelton-wheel based hydro system from the 1920’s until 1997 when the electricity grid was connected to the house. The original system is no longer functional. Dams and pipework from the original system could be renovated for re-use.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Callan, Inagh</td>
<td></td>
<td></td>
<td>0.03</td>
<td>32.0</td>
<td>7.5kW</td>
<td>28 MWh</td>
<td>150 m</td>
</tr>
</tbody>
</table>
The recommendations/projections for this site are as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mt. Callan, Inagh</td>
<td>25 MWh</td>
<td>6 kW</td>
<td>€30,800</td>
<td>13 tCO₂e</td>
</tr>
</tbody>
</table>

The project costs above refer to a full/new installation. These costs may be substantially reduced by re-using existing facilities, i.e. dams/pipeworks. A suitable type of turbine for this site would be a Pelton-wheel.
6.4. Site 8: Annagowney, Sixmilebridge

This site is located adjacent to a renovated miller’s dwelling which attests to the previous existence of a hydro-power site. Located near the Owenocarney River, remains of the earthen channel which supplied the water to the mill-wheel can be seen.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annagowney, Sixmilebridge</td>
<td>161.8 km²</td>
<td>1261 mm</td>
<td>4.27</td>
<td>1.0</td>
<td>7.5 kW</td>
<td>26 MWh</td>
<td>200 m</td>
</tr>
</tbody>
</table>

Figure 11: Annagowney, Sixmilebridge
The recommendations/projections for this site are as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annagowney, Sixmilebridge</td>
<td>26 MWh</td>
<td>7.5 kW</td>
<td>€41,419</td>
<td>14 tCO₂e</td>
</tr>
</tbody>
</table>

The low head which can be exploited leads to lower efficiencies and hence a higher cost of an installation which could meet all energy requirements for the dwelling. The flow figure has been significantly reduced with respect to the flow available. There may be potential to relocate the penstock and turbine from the historic location to enable a higher energy yield. A suitable type of turbine for this site would be a Hydrodynamic screw turbine.

6.5. Site 9: Killuran, Broadford.
This site was originally included in the recommendations for commercial sites in the 1985 document “Smallscale Hydro-electric potential of Ireland”iii. However due to its prohibitive distance from the 10kV network, it has been reviewed for domestic use only, as there is a domestic dwelling within 200 meters. A couple of powerful mountain streams coupled with two natural waterfalls of more than 3 meters combine to give an excellent hydro resource which, regrettably, cannot be fully exploited due to insufficient on-site demand.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiluran</td>
<td>7.5 km²</td>
<td>1250mm</td>
<td>0.20</td>
<td>4.0</td>
<td>4.6 kW</td>
<td>16 MWh</td>
<td>25 m</td>
</tr>
</tbody>
</table>
Figure 12: Killuran, Broadford.

The recommendations/projections for this site are as follows:

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO₂ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiluran</td>
<td>16 MWh</td>
<td>4.6 kW</td>
<td>€25,300</td>
<td>9 tCO₂e</td>
</tr>
</tbody>
</table>

Given the reduced onsite demand and the excellent resource, it could be envisaged to install a smaller turbine which would meet electricity requirements at a substantially reduced project cost. Otherwise a suitable type of turbine for this site would be a Crossflow turbine.
6.6. Site 10: Ballyea, Inagh

This site is located on a small stream which goes through a vertical drop of 8 metres. The stream itself may disappear at times of prolonged dry weather but this is relatively infrequent.

The characteristics of the hydro resource at the site are as follows.

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>Catchment Area</th>
<th>Annual Rainfall</th>
<th>Mean Flow, m³/sec</th>
<th>Head, m</th>
<th>Turbine rating</th>
<th>Annual output</th>
<th>Distance for head, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascades, Ballyea</td>
<td>3.0 km²</td>
<td>1352mm</td>
<td>0.08</td>
<td>8.0</td>
<td>4.0kW</td>
<td>14 MWh</td>
<td>5 m</td>
</tr>
</tbody>
</table>

Figure 13: Ballyea, Inagh

The recommendations/projections for this site are as follows:
### Site Name Table

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Annual Production</th>
<th>Turbine Rating</th>
<th>Project Cost</th>
<th>CO$_2$ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballyea, Inagh</td>
<td>14 MWh</td>
<td>4.0 kW</td>
<td>€21,962</td>
<td>8 tCO$_2$e</td>
</tr>
</tbody>
</table>

Since the almost vertical 8m drop presents a natural barrier to fish, the entire flow can be captured and used for electricity generation. This simplifies the civil engineering required as a small weir can be constructed at the top of the fall and only 10m of penstock will be required to supply the turbine.

A suitable type of turbine for this site would be a Crossflow turbine.
7. Emissions reductions

The electricity produced from the hydro-power sites detailed previously may be considered free of greenhouse gas emissions. It is accepted that there are emissions related to the embodied energy of the equipment used in site development and manufacture, i.e. life-cycle emissions analysis. Since a comparison will be made with the average emissions from grid electricity it must be recognized that the emissions figures for grid electricity do not include life-cycle emissions analysis either so the comparison is believed acceptable.

Grid electricity has an emissions intensity of 0.54kg CO$_2$e for each unit of electricity, or kilowatt-hour(kWh). As we assume that each unit of electricity generated from hydropower displaces one unit of grid electricity the total emissions reduction from the sites proposed in this report can be calculated.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>CO$_2$ avoided per annum</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Falls, Ennistymon</td>
<td>221 tCO$_2$e</td>
</tr>
<tr>
<td>Moananagh, Inagh</td>
<td>125 tCO$_2$e</td>
</tr>
<tr>
<td>Old Mill, Ennis</td>
<td>139 tCO$_2$e</td>
</tr>
<tr>
<td>Clondegad, Ballyacally</td>
<td>130 tCO$_2$e</td>
</tr>
<tr>
<td>The weir, Sixmilebridge</td>
<td>47 tCO$_2$e</td>
</tr>
<tr>
<td>Mt. Callan, Inagh</td>
<td>13 tCO$_2$e</td>
</tr>
<tr>
<td>Glebe, Ennistymon</td>
<td>19 tCO$_2$e</td>
</tr>
<tr>
<td>Annagowney, Sixmilebridge</td>
<td>14 tCO$_2$e</td>
</tr>
<tr>
<td>Kiluran</td>
<td>9 tCO$_2$e</td>
</tr>
<tr>
<td>Cascades, Ballyea</td>
<td>8 tCO$_2$e</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>726 tCO$_2$e</strong></td>
</tr>
</tbody>
</table>

Table 3: Total Emissions Reductions

The total reduction of 725 tons of CO$_2$e is the equivalent of removing the emissions from 300 cars every year$^{xvi}$.

While the number of potential commercial sites is limited in the county, perhaps three times the amount stated in this report, the number of potential domestic sites is far higher given our climate and terrain is estimated to be over 100.
Using these figures the total potential emissions reduction for County Clare rises to 3240 tons CO$_2$e/annum.

The indirect benefits of a higher penetration of micro-hydro sites goes beyond the low-emissions electricity produced. All micro-generation leads to greater energy awareness, due to its proximity to the public. Greater energy awareness leads invariably to reduced, or better managed, energy consumption patterns. These indirect benefits apply not only to the person developing the hydro-power site but also to the local community.

In section 5.2, the concept of placing a financial value on emissions avoided was introduced. Taking the price per tCO$_2$e of €15, as fixed in the Budget of December 2009, it was seen that the financial payback period for micro-hydro projects was reduced considerably. This price of CO$_2$e is considered a starting point and will in all probability rise over the coming years. The Stern Report $^{xvii}$ from the UK government in 2006, places a value of ~€57/tCO$_2$e and it is accepted that the price used in carbon taxes will converge towards this figure.

The potential for emissions reductions is in keeping with the goals of the Limerick Clare Energy and Emissions Balance & Climate Strategy $^{xviii}$, 2006.
8. Fisheries Related Issues

The Shannon Regional Fisheries Board\textsuperscript{vix} (SRFB) is consulted for all hydro-power planning applications. Contact was made with the SRFB, Michael Fitzsimons, to include the SRFB’s viewpoint on micro-hydropower in County Clare. The Central Fisheries Board (CFB) has previously published a set of guidelines for hydro-power development which is accessible on the CFB website\textsuperscript{xx}. The SRFB is charged with responsibility for the conservation and development of the wide variety of fish species available in the waters of the region covering a catchment area of over 7,000 sq miles. Their roles include protection, management, promotion and education.

The two main areas of concern to the SRFB are the following:

- Guaranteed upstream movement of fish
- Sustainable abstraction system

8.1. Upstream movement of Fish

In order to maintain fishlife in a river system, any new hydro-power development must not impede the ability of fish to migrate upstream. Where construction of a weir is required to manage the flow to the turbine, a fish pass must be integrated which provides an attractive upstream path the fish. The fish pass must be designed to accommodate the requirements of the fish species found in the river.

![Figure 14: weir and pool pass similar to the Old mill site in Ennis](image1)

![Figure 15: Denil fishpass similar to Falls, Ennistymon](image2)

Fish will be attracted to a certain level of agitation in the river and will identify such locations as suitable for upstream movement. To accommodate this, it is essential that the water exiting from the turbine does not fool fish into thinking that they should try to migrate in the direction of the turbine. A combination of spreading the outflow from the turbine over a sufficiently large area and maintaining a recommended flow in the fish pass can resolve this issue.
It must be noted that the issue of upstream fish movement is a seasonal one and the potential exists to control the flow through the fishpass on a seasonal basis meaning that in non-migration seasons more flow can be diverted through the turbine increasing power output at that time. Such dynamic flow control should be carried out according to the recommendations from the SRFB and the extra costs associated, if the flow control is to be automated, may be an impediment.

8.2. Sustainable Abstraction method

When water is abstracted from a river/stream it may provide a hazard to fish life. Often, metal grills or racks are used to ensure that debris and fish do not enter the penstock leading to the turbine. If the rack spacings are too large then fish of a small size may be drawn into the turbine increasing fish mortality rates.

Furthermore if the water passes the point of abstraction at too high a velocity, fish may be damaged by being projected onto the grill/rack.

To avoid both of these issues the SRFB recommends the use of mesh/screen systems (Johnson/Coanda) over large areas parallel to the river/stream flow. This ensures that water is abstracted at a slow velocity and that no fish can enter the penstock/turbine. These mesh/screen systems also remove problems associated with debris/flora entering the penstock/turbine and/or clogging the intake thereby reducing flow to the turbine.

The Hydrodynamic screw turbine presents notable advantages in terms of fish protection during abstraction. Since the turbine turns at a slow speed it allows the downstream passage of fish and debris with damage neither to fish nor turbine. This dramatically simplifies the issue of abstraction management where the site is suitable to a Hydrodynamic screw turbine.

The quantity of water abstracted for the purpose of electricity generation must also match the presence and type of fishlife in the river. The CFB guidelines\textsuperscript{xx} describe in detail the different levels of abstraction that can be applied to different river/categories.

8.3. Fisheries Related Conclusions

The SRFB clearly indicate that their goal is not to impede the development of hydro-power in County Clare but to ensure that such development is done in a sustainable manner with regard to the fisheries resource. The SRFB highlight that the process for handling planning applications is not clearly defined by the County Councils and would welcome this. They also recognize that individuals developing hydro sites can become partners in the management of rivers/streams through the provision of flow data to the County Council and SRFB.
9. Planning issues

Any hydro-power development is subject to the necessary planning and statutory consents. Contact was made with the Clare County Council Planning Department to ascertain what particular issues arose when assessing a planning application for a hydro-power site.

- The applicant should first check if the proposed site is proposed development located in a designated area e.g. National Heritage Area (NHA), Special Area of Conservation (SAC), Special Protection Area (SPA). This information can be obtained from the National Parks and Wildlife Service (NPWS).
- If so, then the Council is obliged to inform a number of statutory bodies including the NPWS, the Department of the Environment, Dúchas, EPA. These bodies may recommend a full Environmental Impact Assessment and/or an Architectural Impact Assessment which may add considerable cost to the total project cost.
- Clare County Council will also consult the Shannon Regional Fisheries Board (SRFB).
- If the proposed development is located within 30 meters of a recorded monument an Architectural Impact Assessment will also be requested.
- Clare County Council will also assess the visual impact of the development so matters such as turbine-siting/cables/channels will be addressed at this stage.
- All relevant statutory bodies have a period of 5 weeks within the planning process in which to submit comments and/or objections. It is often the case that a statutory body will reply that they do not object to granting of planning permission but that all work once planning is granted is dependent on recommendations to be agreed with the statutory body.
- Clare County Council has no supervisory role in the definition of these recommendations and cannot impose any time-limit on the statutory bodies for their definition.
10. Connection to Electricity Grid

In the case of a commercial installation where the majority of the electricity produced is to be sold to the national grid, proximity to the low-voltage 3-phase grid is a key factor in assessing the viability of a hydro-power project. Simply put, if the site is too far from a suitable grid, then the cost of the extra cabling required will render the project financially non-viable.

A map of the 10kV/20kV grid is available on the ESB Networks website\textsuperscript{\textit{xxi}} and will allow an assessment of the proximity of a suitable grid connection. A grid map of County Clare is included in Appendix A.

The full procedure for connecting a micro-hydro site to the national grid can be consulted on the ESB Networks website\textsuperscript{\textit{xxii}}.

In the case of a domestic installation, the cost of cabling relates to the distance between the turbine and the electricity distribution box in the home. It is accepted that cable costs are not prohibitive for any distance less than 500m. The method of cable laying, i.e. buried or overground on poles, will also have a bearing on the total cable related costs.
11. Structuring development

A number of different structures are available to develop hydro-power sites at the kind of commercial scale discussed previously.

11.1. Private Developers

In this scenario a private company would negotiate a rental agreement with the landowner, finance the planning-application/site-development and derive income from the sale of the electricity generated to the national grid. A Renewable Feed In Tariff (REFIT) is in place which guarantees a minimum price of €72/MWh generated. In the case of the Old Mill site in Ennis, the developer would derive an income of ~€18,000 from the electricity generated, representing a return of ~8.5% on the estimated project costs. If provision is made for planning costs and a 5% annual O&M cost, a more realistic return is of the order of 8%. Such a rate of return would not be expected to attract private investment.

11.2. Community-based

A number of examples exist where community based structures such as co-operatives are formed to develop a hydro-power site (see section Error! Reference source not found.). Reasons for the formation and success of such structures include:

- A desire to see the benefits of a local power resource shared amongst the community.
- A willingness to accept a lower rate of financial reward than a private company.
- The ability to fully finance the project through community shareholders removing the need for external, and potentially costly, financing.
- A local-authority’s desire to increase energy awareness within the local population.
- Local support leading to a smoother planning process.

11.3. Route to market

As the Irish electricity de-regulates, the number of options of for supplying and selling electricity have increased and two examples will be discussed.

**Energy Service Company (ESCO)**

Recent years have seen a growth in the number of ESCO’s in Ireland. An ESCO finances the installation and operation of an energy project on behalf of a site-owner who contracts to buy the energy generated for a fixed period at a pre-defined price. An example from this report would be where an ESCO develops a hydro site and sells all electricity generated directly a local large electricity consumer. Such a site would remain the ownership of the site owner and the ESCO would operate it for a defined period before handing control of the site back to the site owner. An ESCO is most suitable when the totality of the energy production can be consumed by the client. The advantage to the client is no upfront costs and a guaranteed, and presumably lower, electricity price.
Electricity Supply Company

Current electricity regulations permit the relatively easy creation of electricity supply companies who may compete with incumbent suppliers such as ESB and Airtricity. In this structure, the hydro-power site developer would also become the electricity supplier to any electricity consumer, in the same manner that consumers can currently choose from a number of electricity suppliers. The production wing of the structure would sell to the supply wing of the structure who would then supply the electricity over the existing electricity grid at competitive retail rates. While slightly more complex to create, this structure ensures the best return on each unit of electricity produced.
12. Conclusions

The report has highlighted the realistic potential for micro hydro-electric generation in County Clare taking a number of potential sites for detailed study with the following conclusions.

1. Where a suitable resource exists, with suitable access both to the electricity grid and to a corresponding electricity demand, a hydro-power site can provide a strong financial return. In order to accelerate the process of development it may be useful to grant-aid a number of developments.

2. The 10 projects detailed in this report represent economic activity of €1.2 million with an estimated potential of a further €5 million over the next 5 years. If the County Council facilitates the fulfillment of this potential it can position Clare at the forefront of a renewable energy sector which has huge potential nationwide.

3. The opportunity exists to grow a local base of expertise in hydro-power site assessment and development, high-value jobs with potential to capture a nationwide market with Clare showing the way forward.

4. Clare County Council has a crucial role to play in raising public awareness of the potential of the hydro-power resource and in providing support to individuals/companies who are interested developing hydro-power sites. This can be done through the Limerick Clare Energy Agency.

5. A number of public meetings will be held throughout the county to present this report to any members of the public who may believe that they have a suitable hydro-power resource.

6. It is of importance that the potential of the county’s waterways, be they agricultural, energy-generation, leisure activities or fisheries, be realised in a sustainable manner. The report’s authors recognise the important role played by the SRFB in this area.

7. Clare County Council may grant planning permission but it is common that conditions are attached to the permission for ongoing cooperation/liaison with relevant statutory bodies.

8. Developers of hydro-electric sites would be well advised to avail of free pre-planning enquiry service from Clare County Council during which the main planning/procedural issues in determining an application will be raised and the list of Statutory Bodies concerned by the development can be defined. Contact should also be made with these Statutory Bodies during the pre-planning stage.

9. The definition of the timeframe after planning, with agreement from relevant Statutory Bodies, would be useful. A standard 10 week period should suffice for Statutory Bodies to define the conditions they will apply to allow development.

10. The requirements of the Statutory Bodies are often separate to and outside the remit of Planning Authorities and applicants should note that the Statutory Body may require a separate consent/licensing requirements over and above those required by planning permission.

11. It is recommended that developers establish a working relationship with the relevant Statutory Bodies as they will be an important part of any development.

12. For the purpose of assisting in overall river management it is recommended that the developers of hydro-electric sites over a certain size, e.g. 25kW, be obliged to incorporate some method of regular flow-measurement with the data derived being
submitted to the County Council on an annual basis. This data can then be made available to other stakeholders such as the SRFB, the OPW, the EPA etc.

13. Literature

- A Guide to UK mini-Hydro Developments: [http://www.british-hydro.co.uk/download.pdf](http://www.british-hydro.co.uk/download.pdf)
- Examples of Hydrodynamic screw installations:
  - New Mills, Derbyshire, UK: A community owned 63kW turbine. [http://westernrenew.co.uk/Case_Study.pdf](http://westernrenew.co.uk/Case_Study.pdf)
ii SEI « 2008 : Provisional Energy Balance »

iii Currently out of publication. A softcopy can be downloaded from
iv OPW Flow data : http://www.opw.ie/hydro/index.asp
vi OSI online viewer : http://ims0.osiemaps.ie/website/publicviewer/main.aspx
vii Can be downloaded from
ix EU Emissions Trading Scheme : http://ec.europa.eu/environment/climat/emission/

x ESB General Purpose Business Tariff :
xi Here is one example of such a turbine.
http://www.newmillshydro.com/products/item/5/francis-turbines
xii http://www.fingleton.ie/pdf/hydro/607-VARTRY-HYDRO.pdf and
http://www.sei.ie/Your_Business/Sustainable_Energy_Awards/Winners_2008/Category_B/
xiii Pg 1 of “Energy in the Residential Sector” SEI, 2006 :
http://www.sei.ie/News_Events/Press_Releases/energy_in_the_residential_sector_FNL.pdf
xv Assuming average emissions of 0.16kgCO2e/km and 15,000 km/year
xvii Energy and Emissions Balance / Climate Change Strategy :
xviii Shannon Regional Fisheries Board : http://www.shannon-fishery-board.ie/


xviii ESB Networks Distribution Network Map :
xxiv ESB Networks :
http://www.esb.ie/ebnetworks/generator_connections/micro_gen_connections.jsp
xxv REFIT 1 : http://www.dcenr.gov.ie/Energy/Sustainable+and+Renewable+Energy+Division/