Final Report

Tevina Hill
Crackington Haven
Bude
EX23 0LB

JULY 2019

Irebuild Building Company

Contents

Overview

Tevina Hill has been an ambitious project that has achieved enormous social and environmental goals. From locally-sourced materials to tree planting to the Hitz programme, this project is the antithesis of everything that Irebuild Building Company stands for.

The report contains:

- An outline of the scale and scope of the work completed
- The property's environmental credentials
- Embodied energy calculations
- Details of Tevina Hill's social outreach programme, particularly its contribution to Exeter Chief's Hitz participants

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Scope and scale of the project

Although we have managed to retain much of the property's original exterior, Tevina Hill has been complete transformed, extended and modernised.

Tevina Hill in its original state before work began

Original south perspective

Original porch/entranceway

Original fireplace

The property was originally built as an 1860s barn and was later converted into three houses in the 1980s. A small run-down cottage sat adjacent to this main structure.

Rather than demolishing the entire estate and starting from scratch, which comes at enormous environmental cost, the Irebuild team converted the three small homes into a single family home.

An additional extension was built by demolishing the cottage and recycling its materials.

The home’s carpark was created using reclaimed materials from the site itself.

A key part of the scope was to create an environmentally-sound building that would produce minimal carbon emissions.

Progress on Tevina Hill in the snow

Key works include:

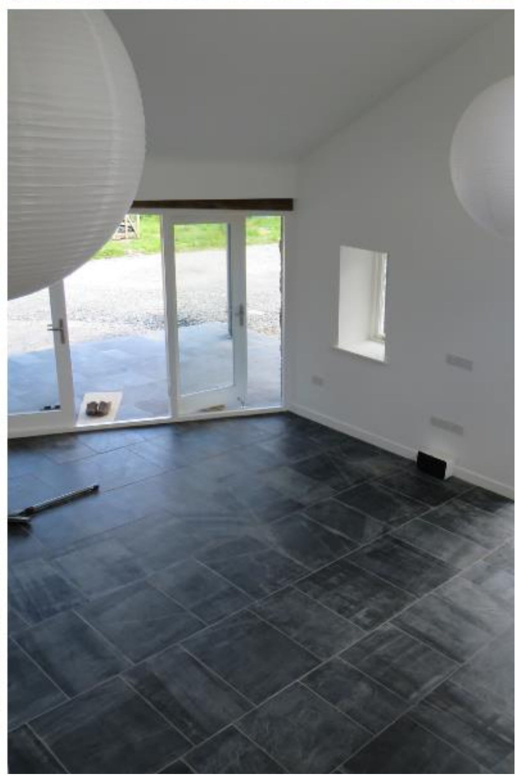
- Rose Cottage demolition and removal
- Recycling of Rose Cottage’s materials for extension and other features
- Gutting of existing property
- Retrofitting insulation and passive house infrastructure
- 1km of green tech, including rainwater capture, solar and thermodynamic systems
- Three plant rooms
- Complete internal reconstruction of the main building, including repositioning of the main staircase
- Chimney removal

- Underfloor heating
- New windows, including skylights
- Maintenance and sandblasting of original 1980s trusses
- New roofs on barn, shed and house (although many of the original rag slates have been carefully maintained on the house)
- Insulation and soundproofing
- Cobb wall
- Three WCs/shower rooms on the ground floor, one upstairs WC and an outside shower
- Kitchen installation
- Bespoke pantry
- First floor decking/balcony with staircase to ground level

Before and after

After – south perspective

Looking into the new entranceway and extension



Entranceway and extension

Entrance hall and ground floor corridor

Cob wall into close boarding

First floor living space

Kitchen

Built-in cupboards and larder/pantry

Office

Tevina Hill’s environmental credentials

Tevina Hill is now a passive house. This means that it requires very little energy for heating and cooling. There is a passive house database where you can learn more about the concept and even register your property for free:

https://passivehouse-database.org/

About Irebuild’s passive house technology

When you go out on a cold day, you wear a raincoat and zip it up, and when you start sweating you undo the zip to let some air in. This breathability is often combined with a fabric such as Gore-Tex.

Within a house the same principles should apply. Certain walls need to breathe more than others – for example, kitchens and bathrooms where there is a lot of moisture; areas where you sleep; south-facing walls which are often hotter than north-facing walls – so a generic seal of one-insulation-fitting-all is not practical. Hence, many modern builds feel like sweat boxes – they absorb and trap warm air without allowing any out, even when VHR systems are installed.

Irebuild uses a unique combination of technologies and materials to build breathable, passive homes:

- Intelligent insulation throughout, including thermal and acoustic wood fibre wool insulation, Steicoflex, Celotex and Actis. The combination of the Steicoflex with wood wall and lime enables us to achieve very comfortable, natural living spaces. These are coupled with standard, affordable plasterboards and plastering on internal walls and ceilings. The final result is a cost-effective and pragmatic solution to something that is often perceived as being unaffordable

- Damp proof membranes
- Old stone is coated in lime - a natural product that enables the walls to breathe by drawing out moisture
- Large cavity between external and internal walls to enable breathability
- Lime mortar. As it's produced at lower temperatures than cement, it has a 20% lower carbon dioxide output. It also absorbs moisture so it is able to draw out water from the structure, keeping the masonry dryer and lessening the risk of spalling
- Cob wall – cob acts as a natural passive heat sink
- Cork flooring – a natural thermal and acoustic insulator
- Instacoustic rock wall
- Soundproofing ensured through double plasterboard in ceiling
- Larch cladding. Larch is a long-lasting sustainable wood that is naturally water-resistant and provides insulation
- Self-cooling larder. Utilises cool air from pipe on northern aspect of the building (as per a Victorian milk window)

Circular energy system

Thanks to the home being a passive building, Tevina should require very little energy to keep it warm. However, it is fitted with Uponor underfloor heating for when it gets cold.

It also has its own self-contained circular energy system, making the property almost entirely self-sufficient. This consists of:

- More than 1km of water and electric pipes that run underground
- A thermodynamics system
- Solar panels and sonnen battery-power wall
- A rainwater collection system
- Three plant rooms (labelled as primary, secondary and "the hub")

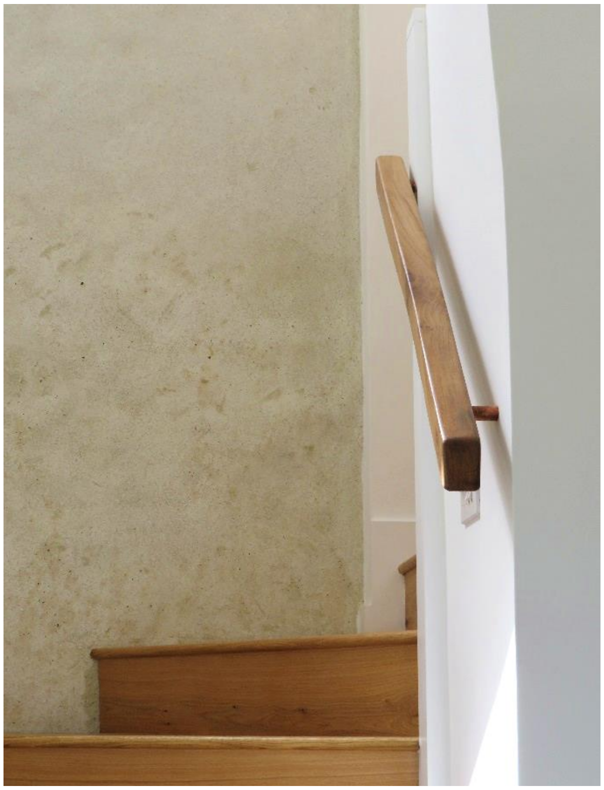
- Both the main water harvesting tank and the overflow/backup tank are connected to the thermodynamics system. This enables the water to be heated and then returned to the house
- If electricity from the solar panels and/or the water harvesting tanks run dry, the mains will automatically kick in

Cornish rocker system for solar panels enable 30% more energy

Sourcing materials

Much has been built from reclaimed and recycled materials. All new materials and features have been sourced as locally as possible.

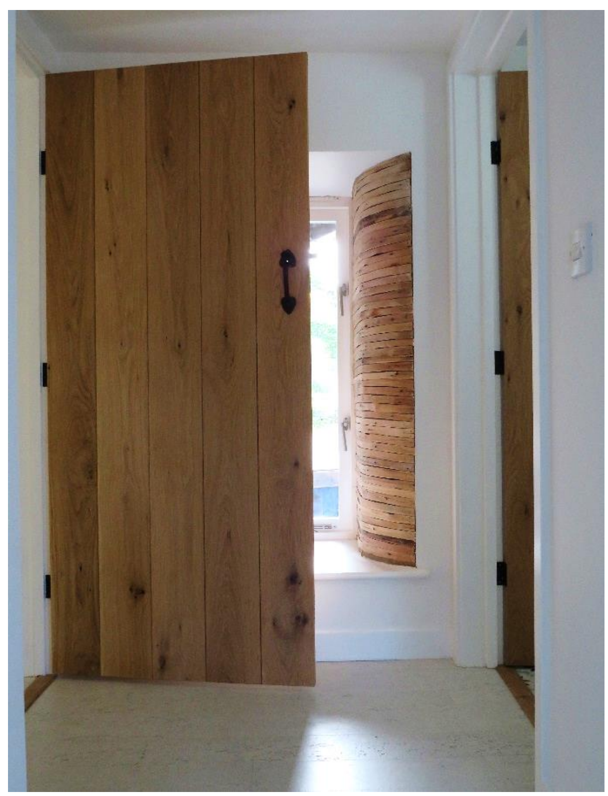
- Original exterior maintained rather than demolished – with the exception of plaster, the external walls are composed entirely of reclaimed and recycled materials
- The cottage's materials (approx 100 tonnes) were re-crushed and recycled to create hardcore for the foundations of the extension
- 150mm crushed stone from existing blocks
- Old floorboards from cottage re-appropriated for walls in various rooms including office
- Oak lintels reused
- Clay for cob wall sourced onsite. All cob mixed and created onsite
- Many of the original rag slates have been maintained by carefully labelling and replacing each one
- Slate flooring sourced from Cornwall
- Timber and oak sourced from Gidley Forest and local suppliers
- Oak reclaimed from Rose Cottage and included in lintels, stair bannister, etc
- Larch for cladding and soffits sourced from Okehampton (used as there has been clear felling of all larch throughout UK due to disease). Burned using traditional Japanese burning technique to improve longevity
- Lathe features bent and re-appropriated from Irebuild demolition
- Original 1980s trusses maintained and restored
- Original septic tanks maintained
- Many of the internal doors and features were also reclaimed and recycled, both from the old cottage and some of Irebuild’s other demolition sites



Handrails recycled from Rose Cottage

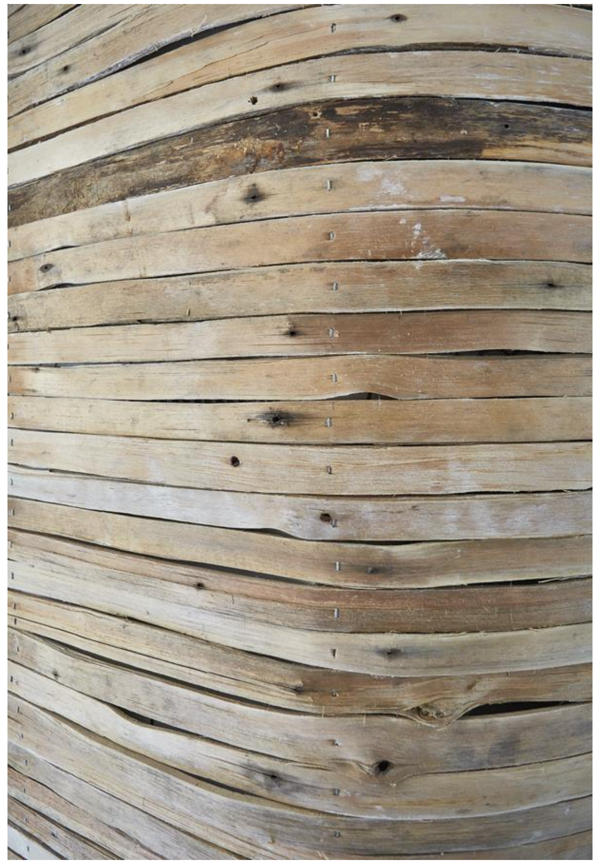
Floorboards from Rose Cottage recycled to create wall features

Reclaimed doors



Reclaimed lathe details

Ire newbuild passive cob heat-sink wall



Closeup of reclaimed lathe features

Reclaimed oak from Rose Cottage

Reclaimed chapel doors

Minimising the environmental impact

We took significant steps to minimise the impact of the project on the surrounding landscape and wildlife.

- 7 acres of tree planting and habituate enhancement has commenced and will continue
- A family of sparrows and other wildlife have been preserved

First floor balcony

Embodied energy

What is embodied energy?

Embodied energy is the energy consumed by all of the processes associated with the **construction** and **maintenance** of a building.

The construction embodied energy includes the mining, manufacturing, transport and delivery of materials, as well as any other carbon emissions (for example, workers' diesel emissions).

The maintenance embodied energy includes the building's ongoing energy consumption and its structural upkeep.

Please note that the embodied energy calculation in this report refers to the construction phase only**.**

Thermodynamic system on refurbished, reinforced barn roof

Variations in embodied energy calculations

Some reports claim that a new build emits approximately 50-80 tonnes of carbon dioxide.[1] However, it is difficult to ascertain the average carbon emissions produced due to:

1. **Differences in size and scope of buildings** - for instance, a 2-bedroom bungalow versus a four-bedroom detached house

2. **What is included in calculations varies**. Most calculations only include the main materials such as bricks and cement, and exclude details such as wall fixings, screws and paint. Moreover, few building contractors actually take the time to calculate and publish the embodied energy of their projects, making the pool of data very limited

This makes it difficult - if not impossible - to ascertain a reliable benchmark.

However, it is a good benchmark for contractors and clients who are looking to minimise their environmental impact.

Your embodied energy spreadsheet and calculation allows you to see:

- Which materials produced the highest amounts of carbon on your project
- How much higher your carbon footprint would have been if you had not recycled or reclaimed materials
- How much higher your carbon footprint would have been if you had sourced materials from further afield

How we calculate embodied energy

We use an embodied energy calculation spreadsheet created by the UK Environmental Agency.

We have included all of the materials used to build the structure and envelope of your home. This includes materials like concrete, brick, slates, timber, screws, fixings and even adhesives.

Where material suppliers have failed to provide relevant information regarding the weights of their products, we have either had to find equivalent items on the market or make estimates.

Distances have been calculated by identifying all of the deliveries involved in each type of material, rather than only looking at the overall number of deliveries.

Unfortunately, calculating all materials and transportation can be difficult. The following items have had to be omitted due to time and resource restrictions:

- Individual sub-contractors' diesel emissions (though we do know that these were greatly reduced due to the nearby flat rental and our workers volunteering to sleep on-site)
- Interior decoration and fixings (for example, kitchen, bathrooms, tiles, fireplace, paint, etc)
- Solar panels
- Uponor underfloor heating system
- Machinery diesel emissions
- Toilet waste disposal with Andy Loos

More importantly, this embodied energy calculation does not indicate the carbon footprint of your home over the course of its lifetime. Many of the initial carbon outputs – for example, from building the circular energy system – will be counterbalanced by energy savings made over the course of the building's lifetime. This is indicated when relevant.

[1] **Citu, *What is the carbon footprint of a house?*** https://citu.co.uk/citu-live/what-is-the-carbon-footprint-of-a-house

The embodied energy of Tevina Hill's construction phase

The total carbon footprint of the project (including transport of materials to site) is **41 tonnes of fossil CO2e**.

This is **50% less than the average newbuild**. One article estimates that building a new two-bedroom cottage will produce 80 tonnes of CO2.[2] Similarly, another states that constructing the average new build results in 50-80 tonnes of CO2.[3]

When we factor in that Tevina is a large 5-bedroom home, complete with its own circular energy system, the property has a very small footprint.

This low embodied energy is largely due to the maintenance of Tevina's original exterior and the recycling of the cottage's materials, which meant that the project utilised almost no quarried materials.

*Using the site elevation drawings, it would take approximately **34,829 bricks** (just over **80 tonnes**) to build a single exterior brick wall for the house. This would have produced **19.2 tonnes CO2** (plus diesel emissions)*

There were no bricks, stones, or hardcore brought onto site. The only quarried materials were 18.4 tonnes of sand and 0.56 tonnes of aggregate, both of which have a very low embodied energy.

The majority of Tevina's carbon footprint comes from plastics (9.1 tonnes or 22% of the project's total CO2). Whilst we did not use much in terms of tonnage, plastics have a higher carbon footprint high due to their intense production processes. However**, it is essential to note that all of Tevina's plastic use is in relation to insulation materials and the PVC pipes for the rainwater collection system**. This means that this carbon spending is actually an investment: the 9 tonnes of carbon should be counterbalanced by the building's energy savings over the course of its lifetime.

The second highest CO2 output comes from metals (8.6 tonnes or 21%), used for structural purposes and ensuring the longevity and integrity of the building. **The actual tonnage of metals used was relatively small (2 tonnes)** – especially for a project of this magnitude – but their production processes mean that they have a high embodied energy. For example, the embodied energies for copper, aluminium and stainless steel are 2.7, 9.18 and 6.15 respectively. Thus, even small amounts of metal have a big impact on CO2 emissions.

We even calculated the weight of all of the **screws and fixings: 1.4 tonnes**. This includes nuts, bolts, screws, nails, connectors, bars and rods, etc. These sorts of items are rarely ever included in embodied energy calculations, but we believe that it is important to show how even small items add up.

Interestingly, the project entailed **7.2 tonnes of plasterboard and more than 1 tonne of plaster, yet these materials had only a very small impact on the project's carbon footprint**. This is because both materials have a low embodied energy: 0.13 for plaster and 0.39 for plasterboard.

6% of Tevina's carbon footprint (2.3 tonnes of CO2) was generated by the transportation of materials. In some cases, the diesel emissions had a bigger impact than the material itself. 18.4 tonnes of sand produced only 0.094 tonnes of CO2 – an insignificant amount. However, transporting it resulted in 0.5 tonnes of CO2. Bringing its overall total closer to 0.6 tonnes.

Whilst diesel emissions could have been lessened by reducing the number of deliveries, the **short distances from the supplier to site made huge carbon savings**. For example, Tevina's 18.4 tonnes of sand was transported across multiple deliveries that added up to approximately 250km. However, it would take 500km to make a single journey from Sheffield to Crackington Haven. Transporting 18.4 tonnes of sand across a single trip from Sheffield to Crackington Haven (500km) would result in a 50% increase in diesel, producing 1 tonne of carbon. If it had been transported across multiple deliveries of that distance (which is inevitable on a project of this scale), it is likely that it would have been closer to a 100% increase in carbon emissions.

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[2] **The Guardian, 2010, *What's the Carbon Footprint of…Building a House***
https://www.theguardian.com/environment/green-living-blog/2010/oct/14/carbon-footprint-house
[3] **Ibid**

How these insights will help our future projects

We will take this embodied energy calculation as a benchmark for future projects.

Some ways that we can reduce carbon emissions is by:

- Reducing plastic
- Minimising the number of trips made by our team and sub-contractors to reduce diesel (encourage carpooling, etc)
- Sequencing of deliveries – this is a tenuous balance between ensuring that the site is not overloaded with materials and having clear safe areas, and overcrowding and bulk storage of materials onsite, which can become damaged and weather-beaten.

Embodied energy savings

100 tonnes of hardcore reclaimed from original cottage. This made a saving of **0.5 tonnes of CO_2**, plus transportation emissions

Zero red bricks or stones used.

Lime mortar versus cement. Aside from providing breathability for the walls, lime mortar has a lower carbon footprint than cement

Cork flooring. A natural insulator with a minimal production process, giving it a lower carbon footprint than synthetic floor insulation

Local suppliers meant low diesel emissions

Using Cornish slate. Slates and other natural stones are often sourced from countries such as India. This is particularly true of Indian sandstone. Aside from the environmental cost, there is a good chance that it will be quarried by exploiting child labour and poor working conditions[1]

Reduced waste costs by recycling and reclaiming project waste

Long-term energy savings. It's essential to note that some of the property's biggest CO_2 emissions have come from items that will ensure its long-term sustainability and low-impact. For example, insulation; damp proof membrane; all of the plastic and metal required to build the circular energy system. Over the course of the building's lifespan, these short-term energy expenses will be offset by energy savings

Social impact

Tevina Hill has made a big difference to many lives.

Phill directing one of the school groups

Both Morgan and Niall successfully completed their carpentry apprenticeships and are now fully qualified carpenters. Morgan has already moved onto building his own clientele whilst Niall will be combining his site experience with a future in architecture.

14 national qualifications in plant operations, and dumper, digger and handling driving were achieved, including one by the client.

Two school groups visited the site in Summer 2018 and had a fantastic practical days learning about environmental construction and having some hands-on fun with cob.

Most importantly, 67 students from the Exeter Chiefs Hitz programme have benefitted from days out at Tevina Hill. They helped start the tree planting and also the traditional larch burning. All of the students participated in surfing, kayaking, paddle boarding and boogie boarding with both our team, a number of whom are qualified instructors. The gratitude from Hitz students and organisers has been enormous, and it’s clear that the opportunities offered have been both appreciated and beneficial to all.

Finally, we hope that we have passed along some of our expertise so that the clients can continue with their project, just as we have learned so much working with them. Both clients have been a terrific asset to this project, embracing our ethos of circular construction (environment-people-building), and we trust that they will continue with this.

Hitz days

School kids playing with cob

Hitz kayaking

Jonathan King explaining geotechnical strata to Hitz

Hitz students making cob onsite

Hitz wood burning

Standing up with Andy

Morgan after surf session with Hitz