Bridport Community-led Economic Development

Local Materials in Construction

Tim Crabtree

1 Introduction

As part of a broader effort to assess local economic conditions and identify opportunities for 'relocalisation' of production and ownership in the Bridport area, Communities Living Sustainably is exploring the potential to substitute local materials and resources for imported goods that are used in construction. In particular, the research focuses on the new build housing construction sector. The aim of the research is to explore whether using local materials could have both sustainability and economic benefits, as well as opportunities for more local production and local ownership.

The research and this report has been led by Tim Crabtree, with inputs from a group of local 'Champions' – Alan Clevett, Celia Marsh, Cleo Evans, Ian Rees, John Butler, Kate Hall, Phil Christopher, Sam Wilberforce, and Vince O'Farrell.

Bridport's house prices are above average, which, coupled with lower than average wages, presents significant challenges to the local population. There are a number of community-driven initiatives, notably a completed community land trust housing development, a Co-housing project working on an imminent 64-house build, a Self-Build Group, and an annual Open Eco Homes week which facilitates information sharing and peer support. The Neighbourhood Plan process is underway, and includes a housing committee exploring new ways forward.

2 What do we mean by local?

As part of a broader effort to assess local economic conditions and identify opportunities for 'relocalisation' of production and ownership, we are generally considering the area in and around Bridport, though sometimes extending to the county or Southwest region where sourcing is concerned.

Nevertheless, it is very difficult to define "local" in terms of a specific area or radius from a defined point, and a more coherent approach is to defend local economic development against arguments that globalized trade based on comparative advantage is more rational and economically beneficial. As will be explained in the next section, there are strong economic arguments for pursuing import substitution and adding value at a local level, in terms of the effect on job creation, wage levels and the local multiplier. There are also environmental benefits from using products that are transported over smaller distances and whose processing has lower carbon and pollution impacts.

3 Rationale for the research

3.1 Forecast Housing Construction, 2017 – 2022

There are 7232 existing dwellings in the town of Bridport (including Allington, Bradpole and Bothenhampton). The local plan makes allocations for a further 944, including 760 at Vearse Farm. If we include other parishes in the Bridport "area", then at least 1000 homes could be built in the next 5 – 8 years. This offers a great opportunity to stimulate the local low carbon economy, if imported construction goods can be substituted for locally sourced and processed materials. The potential spend on construction materials for these 1000 houses is £90 million (see section 4) and this research seeks to explore whether a percentage of this could be "localised".

3.2 Using local materials in construction – economic considerations

The proposal to encourage greater use of local materials in construction can be understood through the lens of economic localisation – this has been defined as "economies that are more decentralised with more local ownership and / or control; with an emphasis on local supply chains and local market opportunities" (Localise West Midlands, 2013).

A study by Goetz & Fleming (2011) analysed 2953 counties in the US and concluded that "those with a larger density of small, locally owned businesses experienced greater per capita income growth between 2000 and 2007. The presence of large, non-local businesses, meanwhile, had a negative effect on incomes"

If existing firms are able to expand (e.g. by offering new sustainable construction approaches) or new firms can be created to add value to local products (e.g. in the creation of timber products such as SIP panels) then there is a potential local multiplier effect. The local multiplier is a way of measuring how money circulates within a network of local businesses - economic activity generating more economic activity in a given area. Rather like an ecosystem, small businesses support other small businesses and the 'local multiplier' measures this. Literature on local multipliers provides us with quantitative measurement of the economic benefit of local businesses to a given area, as explained by de Blasio & Menon (2012):

"A rise in the number of jobs in the tradable sector – either because a new firm comes in or an existing firm increases its operations – might affect local employment of both non-tradable and tradable industries. First, more local jobs imply an increase in the local demand for non-tradables (such as restaurants, real estate, cleaning services, legal services, retail, personal services, construction, etc.)……. Second, more local jobs in one industry might also affect employment in the remaining part of the local tradable sector. Local demand for intermediate inputs grows and this might foster employment in some other industries, if input providers are located in the same area."

These effects are not guaranteed, but in the case of the construction sector may depend on the development of what are known as "flexible manufacturing networks". Shuman (2006) reports on Emilia-Romagna in Italy, where "temporary production teams made up of small locally owned firms producing a wide range of complex goods that otherwise would have required a very large economy of scale" (p145) have appeared.

The Bridport region has a high number of small companies and sole traders engaged in construction. This reflects the make-up of the UK construction sector, which is currently made up of 2 or 3 tiers of main contractors and sub-contractors. If these could be linked to firms providing local materials and producing construction products (through secondary processing) then local employment could be increased. Bridport also has a significant light engineering sector, and there is the potential for such business entities to work together on the production of construction components. In particular, the emergence of new, small scale, digitally-driven manufacturing technologies, coupled with the availability of open source design, is enabling the growth of small batch and "just in time" manufacturing at a local level. From an economic point of view, the initial capital cost of new processes is dropping rapidly, and this favours the growth of smaller scale, localized production. For the housing industry this is particularly relevant in terms of the growth of "off-site construction" approaches.

3.3 Reducing the environmental impact of construction

According to the UK Green Building Council, the UK construction industry uses more than 400 million tonnes of material every year, making it the nation's largest consumer of natural resources.
The Government Strategy for Sustainable Construction (2008) stated:

"We cannot meet our declared environmental targets without dramatically reducing the environmental impact of buildings and infrastructure construction; we have to change the way we design and build."

Environmental impacts include:

- 45% of total UK carbon emissions (27% domestic, 18% non-domestic)
- 73% of current domestic emissions arise from heating space and water
- domestic use accounts for 58% of the public water supply; all other uses account for 24%, with 18% being lost in the system
- 32% of all landfill waste comes from the construction and demolition of buildings
- 13% of products delivered to construction sites are sent direct to landfill without being used.

The subsequent Construction 2025 strategy (2013) set a target of a 50% reduction in greenhouse gas emissions in the built environment, and presents a vision of an industry that is:

"dramatically more sustainable through its efficient approach to delivering low carbon assets more quickly and at a lower cost, underpinned by strong, integrated supply chains and productive long term relationships ."

While not advocating the local use of materials, Construction 2025 does also call for a 50% reduction in the trade gap between total exports and total imports for construction products and materials.

Embodied Carbon

Embodied carbon is the total greenhouse gas emissions generated to produce a built asset. According to the Green Building Council (2017), "this includes emissions caused by extraction, manufacture/processing, transportation and assembly of every product and element in an asset. In some cases, (depending on the boundary of an assessment), it may also include the maintenance, replacement, deconstruction, disposal and end-of-life aspects of the materials and systems that make up the asset. It excludes operational emissions of the asset."

In the UK, the Green Construction Board's Low Carbon Routemap (2013) and the Routemap Progress Report (2015) highlight that the sector needs to find a further 39% reduction in carbon emissions[8] from the 1990 baseline in order to meet the Government's target to reduce carbon emissions in the built environment by 50% by 2025[9]. Longer term, deeper reductions will be needed to reach the UK's Climate Change Act target of 80% reduction by 2050 from a 1990 baseline.

BRE Global's Green Guide to Specification provides embodied carbon data for 1200 construction specifications (roofs, internal walls, etc.) The embodied carbon data is provided as total GHGs on a per m2 basis over a 60 year study period including replacements and disposal.

Life Cycle Assessment (LCA)

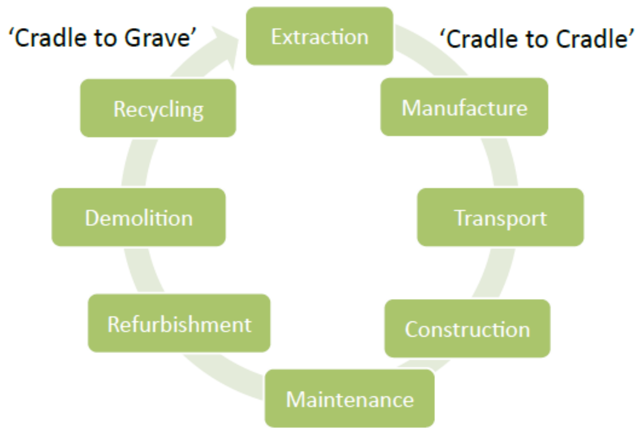
LCA is a method to measure and evaluate the environmental burdens associated with a product system or activity, by describing and assessing the energy and materials used and released to the environment over the life cycle of the product. The environmental impacts most commonly considered in a Life Cycle Assessment of a construction product are:

- Climate Change
- Acidification
- Eutrophication
- Stratospheric Ozone Depletion
- Photochemical Ozone Creation

Other impacts considered can include:

- Renewable and Non-renewable Primary Energy
- Water consumption
- Waste for disposal
- Toxicity to ecosystems and humans
- Resource Depletion (covering variously minerals, scarce chemical elements)

The diagram below the different stages in the life cycle of a construction product:



Life Cycle of a construction product

Source: Construction Products Association (2012)

4 Construction materials as a proportion of housing construction costs

Excluding land prices, the cost of building homes is around £1700 per sq m, with an average house being about 100 sq m. So average build costs are £170,000 per house. Multiplying this figure by 1000 gives a total expenditure of £170 million.
The following table provides an estimate of the materials component of this expenditure:

			Excluding developer's profit
Labour	£54,672.18		£43,737.744
Material	£113,338.04		£90,670.432
Plant	£16,739.95		£13,391.96
Subcontractor	£24,342.50		£19,474
Sundry	£750.00		£600
Grand Total	£209,842.68		£167,874.144

Source: www.mybuildingproject.co.uk

So, as suggested above, the potential spend on construction materials in the next few years in Bridport alone is over £90 million, and even sourcing 20% locally would bring £18 million into the local economy (and more once the multiplier effect is taken into account).

5 Conventional house building

A "conventional" house in the UK is constructed using a "brick and block" approach. The main stages, and key components are as follows:

Groundworks: The first stage is to dig out the foundations, usually in the form of trenches corresponding with the walls to be built above. It is rare for the earth removed to be used on site or for other elements of the building process and it is therefore usually transported to another location. This has an environmental impact due to the energy utilised in transporting the "waste".

Foundations and concrete slab: Common methods for creating foundations include a concrete slab over a hardcore sub-base (where the hardcore could be recycled materials from the locality, but the concrete will use cement sourced from centralised production facilities) or Precast Concrete Beams and concrete blocks (this obviates the need for hardcore, but the beams and blocks are unlikely to be produced locally).

Services: The foundations and slab will need to incorporate the main services – water, drains, gas and electricity. This entails pipes, now generally plastic, and wiring – none of these are made in Dorset.

Walls & openings: The walls will be made up of an inner core of concrete blocks and an outer shell of brickwork, with insulation boards in between. Openings for doors and windows will usually have concrete or steel lintels to give the required load bearing strength. These elements have very high embodied energy, are not made locally and contain raw materials that can be very unsustainable in extraction.

Floors: Floors can be concrete beams or from timber – the former have a higher embodied energy content, but add thermal mass to the house. The latter will not be from local timber.

Roof: The roofs of conventionally built houses are created from pre-fabricated timber pieces such as trusses. These will be made from C16 and C24 timber. No local timber is being used for such building elements.

Tiling: Interlocking concrete tiles are the most common.

Windows and doors: The majority of windows fitted today are uPVC, which could be sourced locally but which can be questioned on sustainability grounds due to high levels of embodied carbon. There are volume manufacturers of timber doors and windows but none are local to Bridport.

Remainder of "first fix" work: First fix entails taking a building from foundation to putting plaster on the internal walls. This includes constructing walls, floors and ceilings, and inserting cables for electrical supply and pipes for water supply. Conventional plaster and plasterboard contains a combination of gypsum, lime and cement, all of which have high environmental impacts. Cabling and pipes are not manufactured locally and also tend to use fossil-fuel derived plastics.

Second fix: Second fix comprises all the work after the plastering to a finished house. Electrical fixtures are connected to the cables, sinks and baths connected to the pipes, and doors fitted into doorframes. None of these components are currently manufactured locally.

Indicative building materials list for an average new build house.

Aggregate	Plastering
Blocks	Plumbing
Bricks	Rainwater Goods
Carcasing Timber	Roof Tiles
Ceramics	Roofing Sundries
Concrete	Roof Trusses
Concrete Products	Screws and Fixings
Decoration	Sheet material
Door Furniture	Stairs
Doors	Sundry Material
Foundation	Timber Mouldings
Insulation	Timber Various
Lintels	Windows and Door frames
Metalwork	

6 Assessing the materials used in construction

Locally available materials in the wider Bridport area include timber, fibre (such as straw and wool) and minerals (including aggregates, stone and clay). Materials from more distant sources include these three categories of building product, plus others such as cement, concrete, steel and glass. In deciding whether there is a role for local materials in construction, one of the key considerations will be whether their use increases sustainability from an embodied carbon and life cycle assessment perspective, particularly in comparison to other materials that can be shown to be less sustainable.

For construction products, a particular type of LCA, known as an Environmental Product Declaration (EPD), has been developed. An ISO standard for EPD, ISO 14425:2006 sets out standards they should meet. In the UK, the key organisation is the Building Research Establishment (BRE), which produces Environmental Profiles based on a "cradle to grave" 60 year life cycle analysis. This underpins the BRE Environmental Assessment Method (BREEAM), which uses the Green Guide to Specification as the basis for scoring the embodied impacts of construction materials.

Comparison of locally sourced materials with other construction products

We start from the assumption that timber, fibre and minerals sourced locally will have a lower environmental impact than products such as steel, concrete and imported timber, due to lower transport miles as well as lower levels of embodied carbon. However, as will be shown later, a degree of processing of these local products will be required for volume housebuilding, so a Life Cycle Analysis approach will be required.

Environmental impact of steel production

Steel is 'iron with most of the carbon removed'. Steel represents around 95% of all metals produced. 51% of global steel is used for construction.

Steel production has a number of impacts on the environment, including air emissions (CO2, SOx, NOx), wastewater contaminants, hazardous wastes, and solid wastes. 6.5% of CO2 emissions derive from iron and steel production (IEA 2010).

Environmental impact of cement and concrete production

Cement is important within mainstream construction as a binder, a substance that sets, hardens and adheres to other materials, binding them together. Cement is seldom used solely, but is used to bind sand and gravel (aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete.

Cement production is the third ranking producer of CO_2 after transport and energy generation, accounting for nearly 5% of worldwide total CO_2. Production of one tonne of cement results in 780 kg of CO2. CO_2 is produced at two points during cement production:

- the first is as a by-product of burning of fossil fuels, primarily coal, to generate the heat necessary to drive the cement-making process;
- the second from the thermal decomposition of calcium carbonate in the process of producing cement clinker.

Of the total CO_2 output, 30% derives from the use of energy and 70% results from de-carbonation.

The environmental impact of concrete is partly determined by its utilisation of cement and partly by the additional impact of the aggregates used. These can include landscape degradation, dust and noise, and use of potable water to wash aggregates, suppress dust and in the manufacturing process.

Environmental impact of glass production

The major environmental impact of glass production is caused by atmospheric emissions from melting activities: the combustion of natural gas/fuel oil and the decomposition of raw materials during the melting lead to the emission of CO_2. In addition there are local impacts such as noise, dust and transport movements. The industry is using increasing amounts of recycled glass, and some companies have achieved lower levels of embodied carbon through a range of measures.

Environmental impact of timber production

Through photosynthesis, trees absorb carbon. As long as a timber product does not burn or rot, its carbon stays ‘locked up’. So, when trees are harvested, their carbon is stored in timber, and if they are replaced by new young trees, the net effect is to remove carbon from the atmosphere. Trees absorb carbon very rapidly while they are growing, and absorb less as they age, so sustainably managed forests where trees are harvested and replaced can potentially be an even more effective carbon store than an undisturbed forest.

According to the Forestry Commission, around a quarter tonne of carbon is stored in every metre cubed of timber, which translates into almost a tonne of CO2.[1] Given that timber products are a natural carbon sink, its 'embodied carbon', that is the carbon footprint as a result of manufacturing and transport (See above, section Embodied Carbon), is the lowest of any mainstream building material.'

Environmental impact of straw production

Straw is a residue of grain production, annually renewable. It is a waste product, not contributing directly to abiotic depletion, and has a low level of embodied carbon (EC) compared to other construction materials. It should be noted that it may contribute indirectly to unsustainable activity, depending on farming practices involved in its production. Choices of finishing material may also impact its sustainability, and transport emissions can significantly increase its EC if not sourced locally (Butler, 2015).

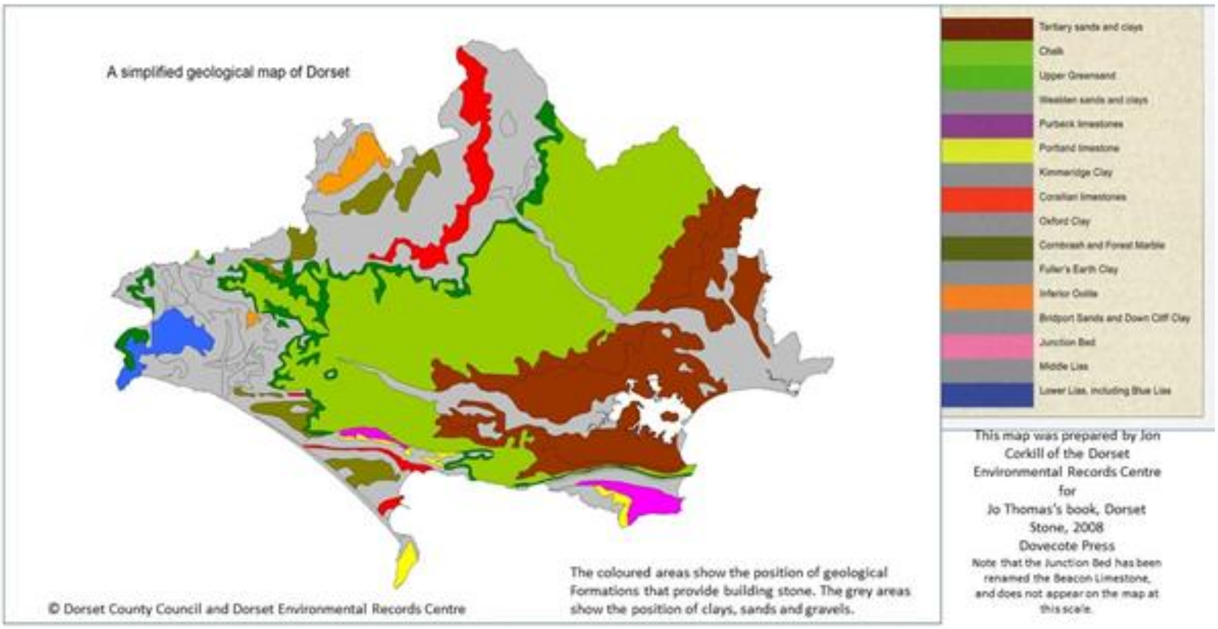
It can be used as a structural component (using baled straw) or as an insulation material within engineered panels (see below).

[1] https://www.forestry.gov.uk/pdf/13_facts_and_figures.pdf/$FILE/13_facts_and_figures.pdf

7 Construction materials available in Dorset

7.1 Minerals

The Bournemouth, Dorset and Poole Minerals Strategy (Dorset County Council et al, 2014) gives guidance as to the potential for local sourcing of minerals in the county. The map below shows the geology of Dorset, and this defines what minerals are potentially available.



It should be noted that the Minerals Strategy states that environmental considerations must be taken into account:

> "the extraction of mineral resources is tightly constrained by the valuable landscape and nature conservation interests in the county and adjoining counties. Much of the Purbeck Stone and ball clay resource is located within the Dorset AONB and is within or close to the Heritage Coast. Purbeck Stone and Portland Stone forms part of or is in close proximity to the Jurassic Coast. Much of the sand and gravel bearing areas coincide with important landscapes and designated habitats" (ibid, p.25).

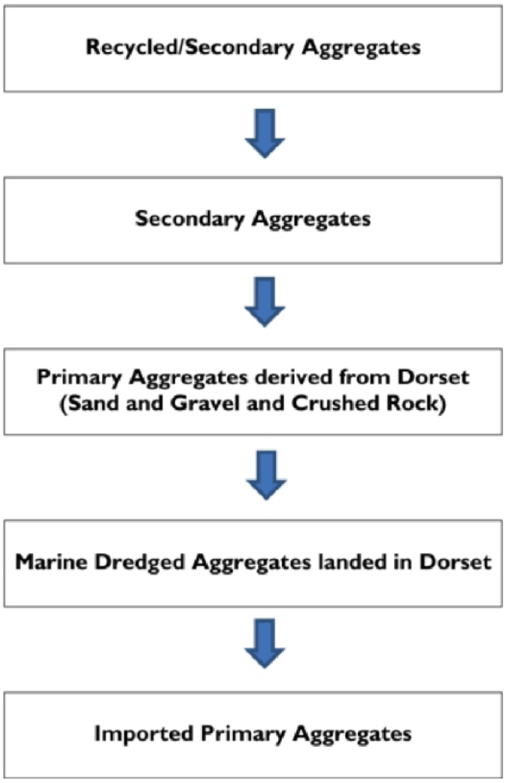
7.1.1 Stone

The majority of building stones found in Dorset are limestones but in the past there has also been extensive use of sandstone. The main limestones are Portland Stone and Purbeck Stone. Sandstone (of the Cretaceous and Palaeogene periods) are found in west, north and south Dorset.

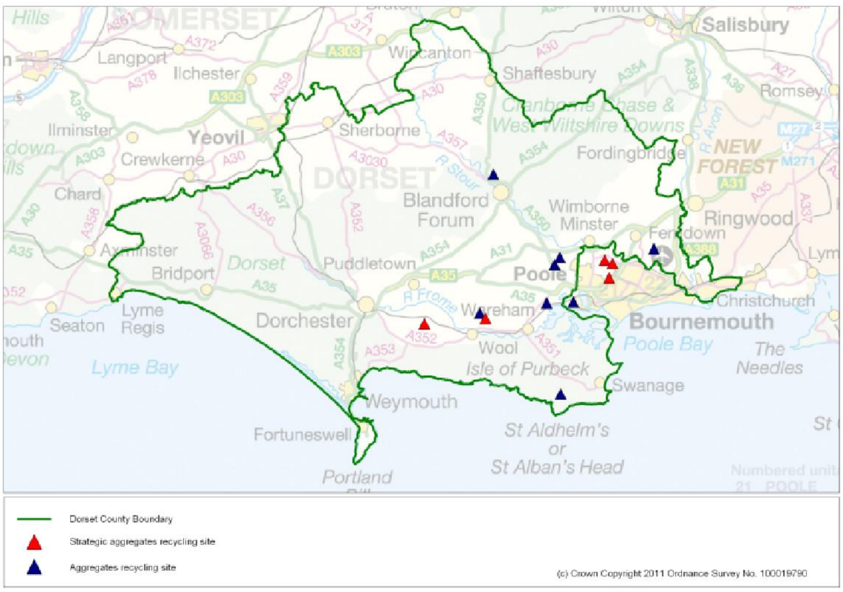
A number of old limestone quarries exist around Bridport (Sims, 1999). However these became disused following the widespread adoption of clay bricks and Portland cement.

7.1.2 Sand and gravel

As with stone, environmental factors are a key consideration when considering the use of aggregates such as sand and gravel. Dorset County Council (2014) suggests a "Preferred Hierarchy for Aggregates Provision in Dorset":

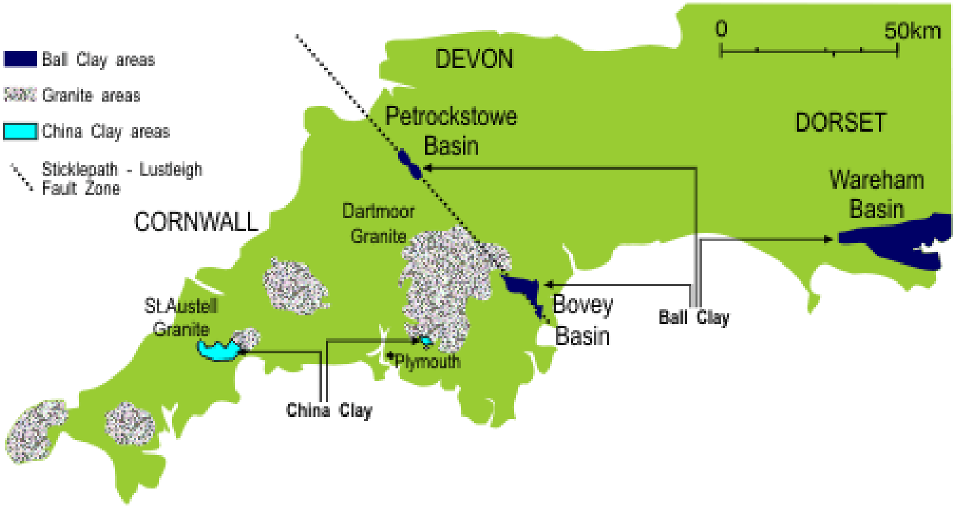


One area that has become more established is the recycling of aggregates. The map below shows the location of aggregates recycling facilities in Dorset – however, none are in West Dorset.



7.1.3 *Ball clay*

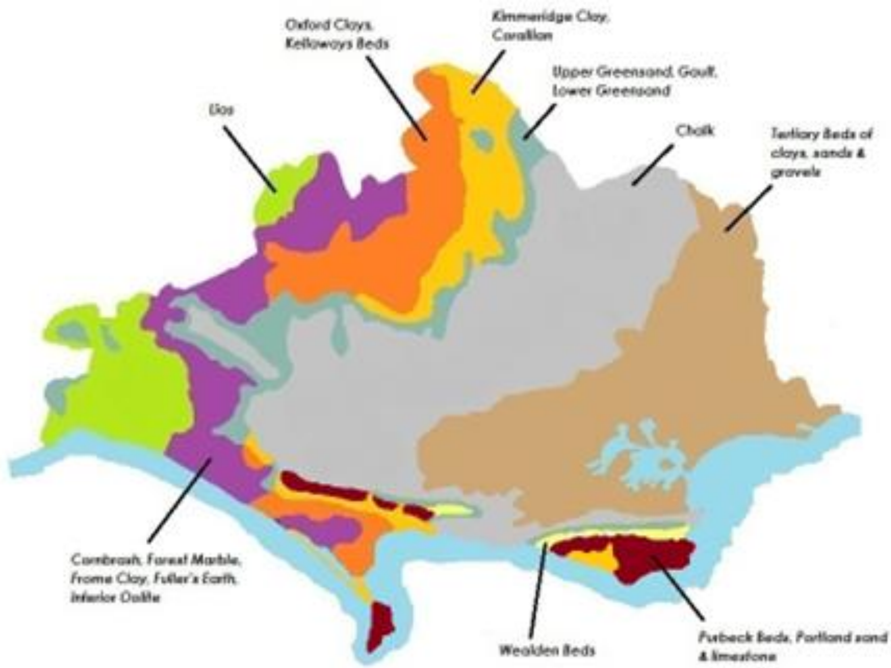
Ball clays are kaolinitic sedimentary clays, fine-grained and plastic in nature, and, unlike most earthenware clays, produce a fine quality white-coloured pottery body when fired. They are used for tableware, washbasins and toilet bowls, wall and floor tiles, electrical insulators and other ceramics.



Source: http://www.clayheritage.org/pages/whatisballclay.htm

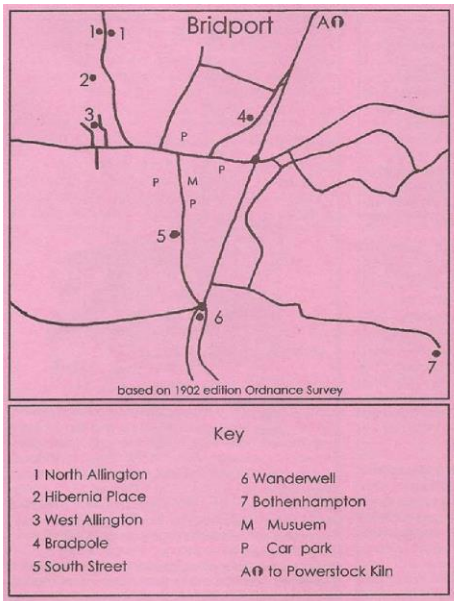
There are significant deposits in the eastern part of Dorset, so they are a potential raw material, but again environmental considerations are important to take into account.

7.1.4 *Other clays*



Source: http://www.natureofdorset.co.uk/book/export/html/29497

Clay can be used for cob walls and in later stages of construction – in finishing products, e.g. plaster and paints. According to Sims (1998), there were 7 brickworks around Bridport, although none now exist:



There is potential to use local clays, for example, in plasters. This is particularly so where clay is removed for creating foundations.

7.2 Fibre

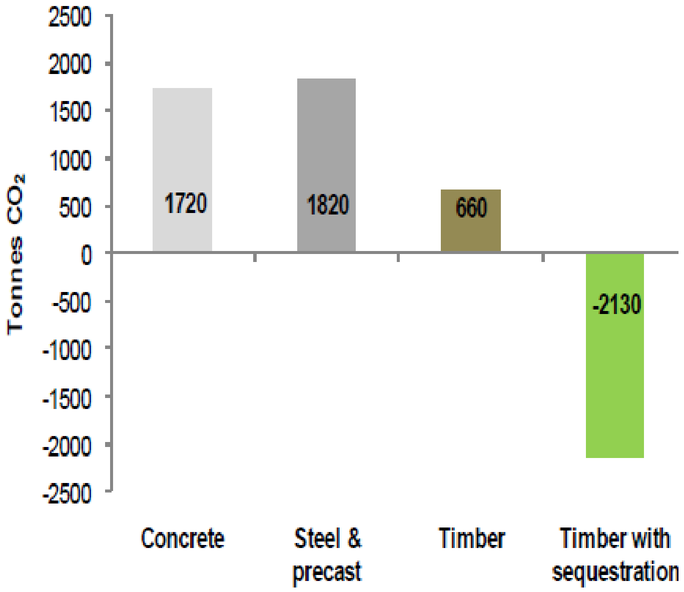
There are many different types of renewable fibre that can be used in construction, for insulation and for finishing e.g. hemp-crete. These include:

- Straw
- Reed
- Wool
- Flax
- Other

Straw is the material with the most potential, as estimates show that up to 600,000 houses could be built each using the amounts produced by farms each year. It is also a very sustainable material. It can be used as a structural block, as insulation in-fill for timber frame buildings, and within a SIP panel. The latter would require local manufacturing facilities, to support off-site construction approaches, but is in-line with current industry trends and could avoid the increasing importation of pre-fabricated panels from further afield.

7.3 Timber

As explained above, timber is the most sustainable building material. The diagram below illustrates the benefits of utilising timber in buildings:

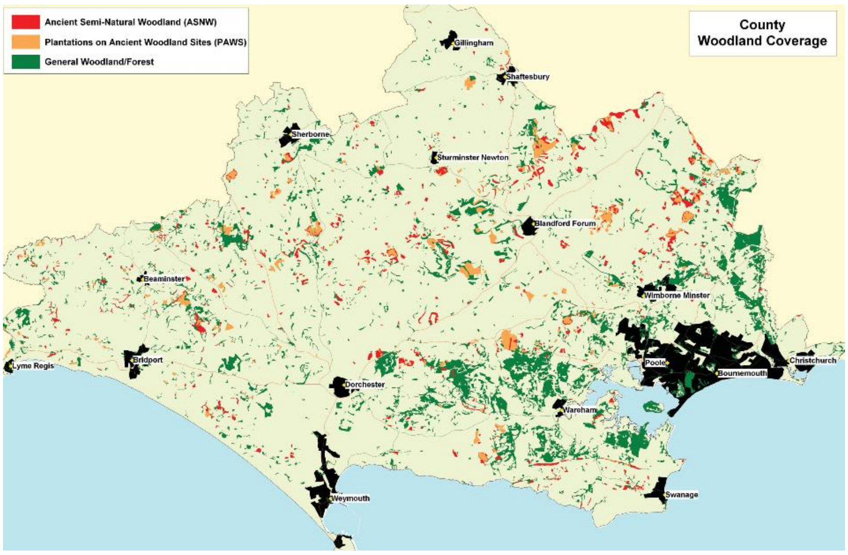


Comparative levels of embodied carbon for the Open Academy in Norwich modelled in concrete, steel and timber. Source: Hammond and Jones (2011)

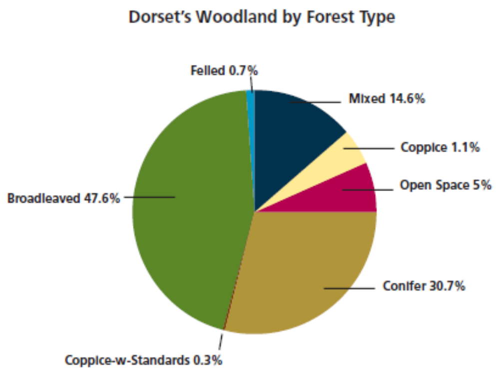
It is important to note that “timber” is not a homogeneous resource – there are hardwoods and softwoods, and within these two categories there are many different species and also differences in age and size which are significant factors. In the construction of houses, softwood is the main timber that is used. There are very small numbers of oak framed houses being built, but this is not a significant potential sector of the construction market.

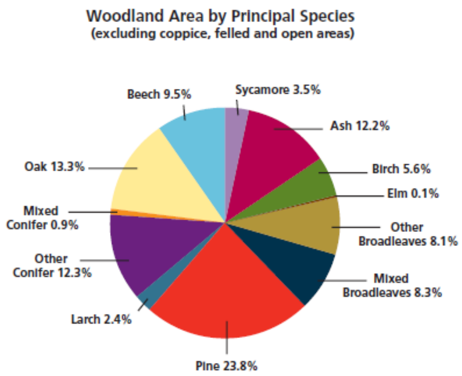
According to the National Inventory of Woodlands and Trees (2002), carried out by the Forestry Commission, Dorset has 28,758 hectares of woodland and forest over 0.1 hectare. This equates to 11% of the total county land area and 13.5% of the total woodland in the South West region. Of the total woodland cover in Dorset over a quarter, or 7,749 hectares, is believed to have been wooded since 1600 AD.

Woodlands in Dorset:



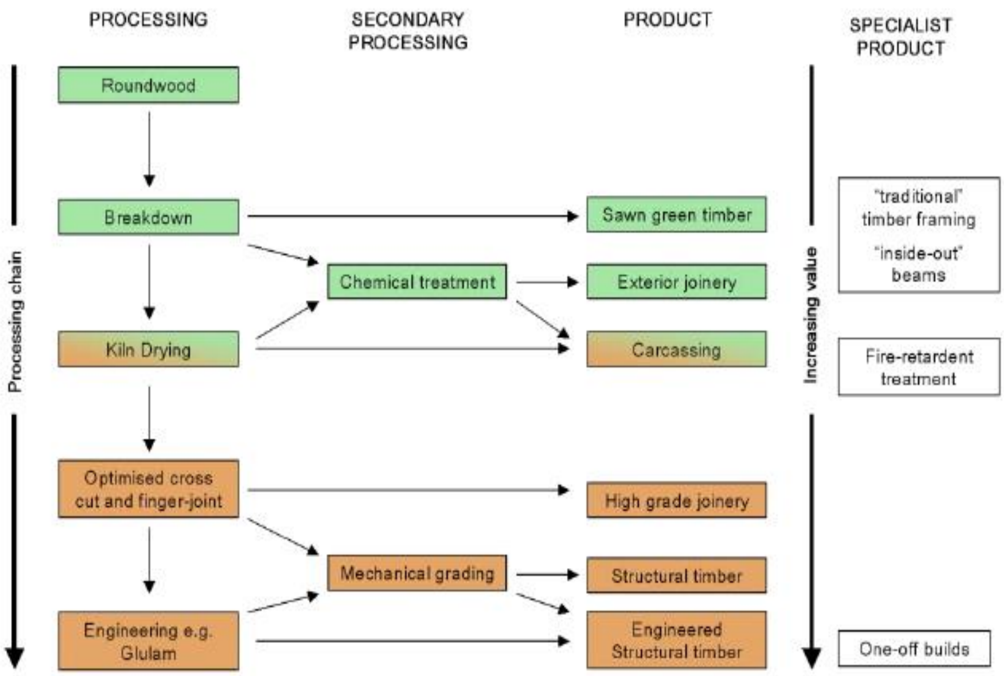
The charts below shows the woodland area by forest type, and the principal species found within these woodlands.





Source: The Dorset Trees, Woods and Forest Strategy (2006)

Once harvested, timber will enter the "forestry value chain". The diagram below illustrates the constraints in the UK timber processing chain, and this reflects the situation in Dorset:



Timber processing chain. Green represents common timber processing undertaken in England. Orange represents those processes rarely practised in England with English timber

Source: Ralph, J. (2012). *Maximising timber value for woodland owners in England.* Nuffield Farming Scholarships Trust

This is a significant constraint on the use of local timber. One reason for the limited processing capacity is that production of construction grade timber requires larger trees. However the

Forestry Commission promotes the production of fast growing, small diameter trees such as larch and sitka spruce, and has encouraged saw mills to adapt to such trees. Technically this means organising the processing around a single pass, whereas larger diameter trees require equipment that operates through a double pass. The resultant timber is used for fence panels, garden buildings, etc but not for the structural elements of a house.

The nearest sawmill with the capacity to deal with larger trees and produce C24 construction grade wood is BSW in Southampton. However, East Brothers near Salisbury are currently investing in the relevant equipment and will soon be able to deal with larger timber from Dorset and the South West. This will be significant as currently no Dorset timber is used for construction by the main builders.

It could be argued that financial support should be sought to create primary processing capacity in Dorset, so that timber grown in Dorset can be sawn in the county. However, there is perhaps a stronger case for using southwest grown timber sawn in Wiltshire, and to focus efforts on increasing the secondary processing capacity in Dorset.

This would require enterprises that are able to produce construction grade, engineered timber products at a viable scale. These engineered products are explored below.

8 New sustainable build methods

This report proposes that the focus for local use of materials in construction should be timber, used as a key structural element, together with straw used for insulation and minerals such as clay and aggregates used for finishes and other elements of the build process.

There are other construction approaches which are also sustainable, such as building with cob walls, oak frames or straw bales as structural (load bearing) elements. However, these are likely to remain, for the foreseeable future, niche products for one off build projects or extensions. They are unlikely to be adopted for the 1000 houses that will be built in Bridport over the next 5 years. Hence this report focuses on approaches that might be adopted for larger scale developments.

The recommendation to focus on local timber reflects not only environmental considerations but also a shift in the construction industry towards new forms of timber frame housing. This replaces the concrete block "core" of a building with different types of wooden "frames" – there are a number of different approaches, described below. The external wall may be brick, but can also be tiles or wooden weather-boarding. The insulation can be rock wool or synthetic panels, but can also be straw or other fibrous material. Hence, these newer methods of construction have the potential to be more sustainable, to use local materials (timber and fibre) and to create local employment if off-site construction can be carried out within a certain distance.

A key consideration is the one mentioned above - that timber grown in the southwest is not processed into construction grade timber. Hence the need to work with regional sawmills and also to create the capacity locally to produce timber products, such as frames and panels, that meet building regulations.

There are a number of different timber frame methods, illustrated below:

Open-Panel: At its most basic, timber frame walls consist of timber studwork fixed in place with sheets of plywood or, more usually, orientated strand board (OSB). This creates a strong rigid box known as an open-panel, into which insulation is added on site. This timber frame is wrapped on the outside with a waterproof barrier and then wrapped around this are the external wall elements, which can be either built up out of the ground (brick or stone), or hung off the timber frame wall using timber cladding or tiles.

Closed-Panel Systems: This takes the open panel system to the next level, with the walls being finished in the factory. The floors and the roof are also delivered in semi-finished panels and even the electrical wiring and the plumbing is pre-installed so that there is very little to do on site after the house is delivered. The more work that is carried out in the factory, the less time is spent on site.

Structural Insulated Panels: These are usually pre-cut structural OSB sandwich panels, usually with either polystyrene or polyurethane insulation factory-fitted. Structural rigidity is provided by the combination of the board and the insulation, and it may not require a timber "frame".

Cross-Laminated Timber: Engineered timber that can be used in panels or for posts and beams.

Engineered Timber: Manufactured to improve strength allowing longer spans.

This report recommends that the focus for Bridport be the local "off-site" manufacture of SIP panels and engineered timber, as the necessary facilities require less capital investment than large factories producing cross-laminated timber or glulam beams. SIP panels can also work well with straw insulation.

9 Offsite construction

Off-site construction (prefabrication) was advocated as long ago as 1998 in the Egan Report (*Rethinking Construction)*, which was an influential report on the UK construction industry produced by an industry task force chaired by Sir John Egan. The report advocated the use of off-site construction and its recommendations were taken up by the industry body Constructing Excellence[2], now part of the Building Research Establishment (BRE).

In July 2013, the Government published: Construction 2025, Industrial Strategy: government and industry in partnership, setting out its long-term vision for '…how industry and Government will work together to put Britain at the forefront of global construction…'.

According to the Designing Buildings Wiki[3], off-site prefabrication is believed to be preferable to traditional construction methods in a number of ways:

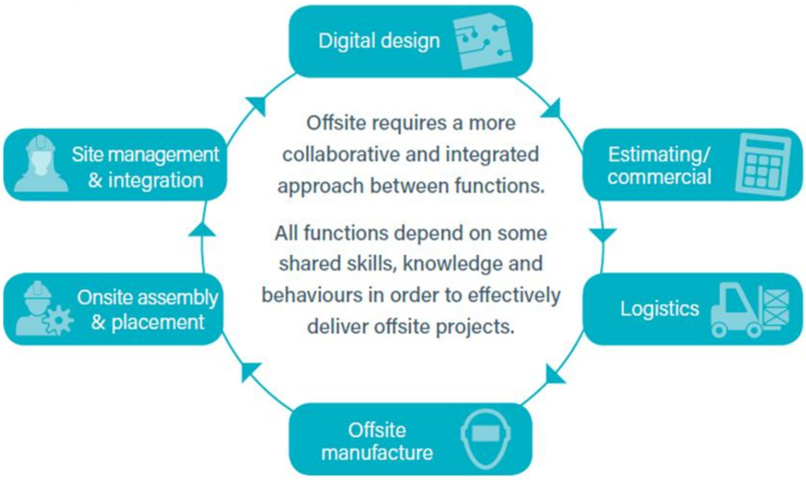
- Quality – Higher-quality finishes with defects eliminated prior to completion.
- Safety – Safer working environment under factory conditions.
- Cost – Repeated use of moulds or jigs through standardisation reduces formwork materials, preliminaries, site storage and on-site facilities.
- Waste – Reduced off-cuts from formwork and the introduction of prefabricated reinforcement bars.
- Programme – Increased predictability due to reduced external factors such as weather.

[2] http://constructingexcellence.org.uk
[3] https://www.designingbuildings.co.uk/wiki/Prefabrication

- Local disruption – less environmental impacts such as dust and noise pollution.
- Accuracy – Increased accuracy with templates produced using Computer Aided Design (CAD) systems.
- Timescale – Components built off-site leading to reduced on-site construction time.

The Construction Industry Training Board recently (2017) produced a report detailing the range of functions associated with off-site construction and the associated skills requirements:

Figure 3: Key offsite functions



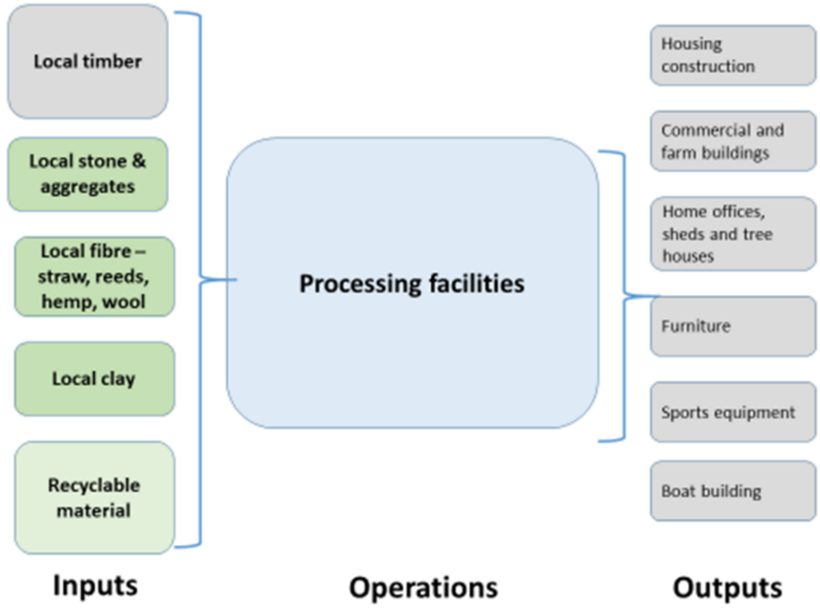
Source: Construction Industry Training Board (2017)

10 Conclusions

From the analysis of materials carried out, it appears that there is an opportunity to utilise greater quantities of local timber, straw, other fibres and minerals in construction. Local stone is also available, but its extraction can have a detrimental landscape and biodiversity impact so is not being recommended as a major resource. There is an issue about the notion of a "local vernacular", which in Dorset often entails the use of stone, and we would argue that this needs to be updated to reflect the materials which now need to be promoted from a sustainability and landscape perspective. In particular, the use of timber needs to be promoted.

However, there is a major constraint, which is the capacity locally to process timber into structural components and process fibres such as straw, wool and hemp into insulation materials.

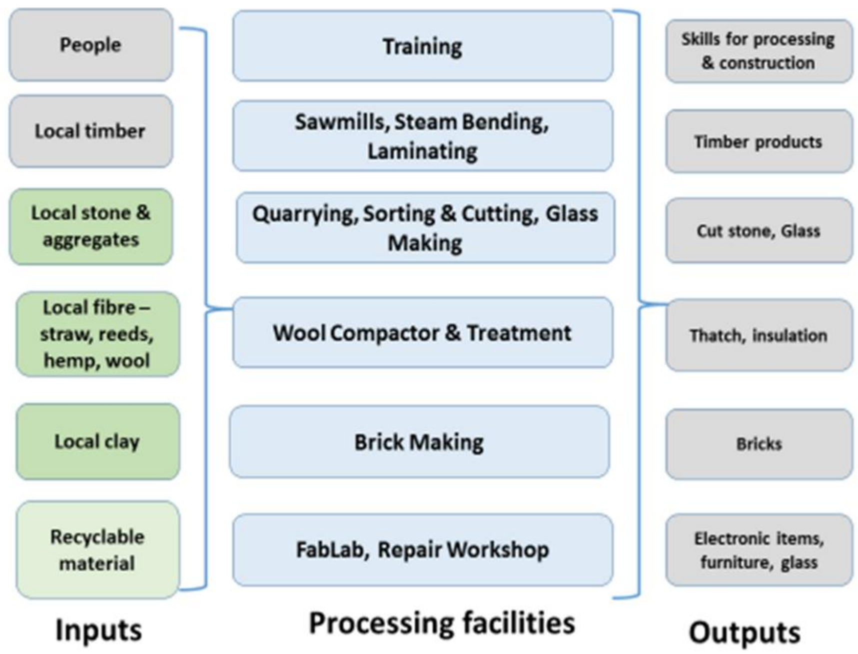
At the Communities Living Sustainably workshop in Bridport on 7 December, 2016, participants highlighted the requirement to process much of the raw materials identified as being available locally, before they could be used in construction. This would necessitate processing infrastructure, as the following diagram shows. The diagram also lists potential manufacturing outputs which could use local raw materials, as furniture making, sports equipment and boat building are sectors present in the local economy:



One area that has not been explored in depth in this report is the need for appropriate recycling facilities. There is a growing emphasis within the construction industry on recycling and circular economy approaches. However, there is little data available locally, so future research will be needed to clarify:

- What percentage of demolition materials from buildings are going to landfill?
- What percentage are being recycled, e.g. timber, steel, concrete, glass?
- How could a higher percentage be achieved?

At the workshop on 16 December, participants produced the following diagram, which gives guidance for further research that will be required, looking at existing capacity and the feasibility of developing new infrastructure.



As explained above, this report recommends the development of a localised facility capable of supporting the off-site construction of SIP panels using local timber and straw as an insulation material. Large companies such as Legal & General are investing in a centralised facility for off-site construction in Leeds[4], but for places such as Dorset this will preclude the use of local materials or the creation of local employment. Therefore it is recommended that other options be explored. There are a number of examples of companies setting up localised facilities which could provide guidelines for how to proceed.

The architect Bill Dunster has developed pre-fabricated ZEDpods[5], aimed at providing first homes for young people and key workers – these are erected above existing parking lots close to amenities and jobs. They use components manufactured at distance, but Dunster has designed a "flying factory" to assemble the houses locally. So although it is unlikely that local materials will be used, local labour is trained to assemble the components by the ZED Pod team.

Ecomotive, based in Bristol, have developed their own version of pre-fabricated homes and have also designed a "flying factory" approach to localise the final assembly: http://www.ecomotive.org/snug-homes/snug-factory-community-hub/

Other examples include:

Modcell, which has been used in two recent developments:

- LILAC: http://www.lilac.coop/about-lilac/house-design.html
- Shirehampton: http://www.modcell.com/projects/shirehampton-eco-homes-bristol/

Eco Cocon (http://www.ecococon.lt/english/) which is a Lithuanian based company

The Ecofab system (http://www.eco-fab.co.uk/ecofab-system.html) which is linked to Cornish architects ARCO2.

Whilst these examples use localised flying factories, the components are manufactured elsewhere, and they also seek to create patented systems. This is in contrast to open source approaches such as Wikihouse (https://wikihouse.cc/), which makes their designs freely available (see appendix 3). However, Wikihouse also does not meet the objectives to both use local materials and localise construction.

The need to develop local processing facilities using local materials has been addressed in other parts of the UK, for example by the Welsh organisation Coed Cymu which has developed the Ty Unnos project (www.tyunnos.co.uk/). This project aimed to establish the feasibility of producing efficient, social housing using local "home-grown" softwood. Coed Cymru worked with Bangor University and the Design Research Unit at Cardiff University, and developed a whole house construction system using engineered home-grown timber components designed to accommodate the characteristics of softwood timber grown in Wales. Subsequent funding from a wide range of sources turned the feasibility study into a number of projects on the ground, built by a range of partners.

One of these was Western Solar, which has built the Pentre Solar hamlet of 6 homes in Glanrhyd, Pembrokeshire. The houses were recently completed and are let to those on the social housing register. The company created a factory in nearby farm buildings and employed

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[4] https://www.legalandgeneral.com/modular/our-vision/
[5] http://www.zedfactory.com/zed-pod

local people as workers and apprentices. https://westernsolar.org.uk/ty-solar

In Dorset, students at the Architectural Association's Hooke Park College constructed accommodation from local timber using a SIP panels approach and also recycled double glazing units.

Following the research outlined above, and discussions at the CLS meeting in December and the three meetings of the project "champions" group, it is proposed that further business planning research be carried out to support the development of a timber fabrication facility in the Bridport area. Such a facility could offer:

- Access to specialised timber fabrication technology.
- Access to training and apprenticeship opportunities.
- Access to technical support.
- The potential to take inspiration from designs emerging from Architectural Association courses at Hooke Park.
- The creation of a "cluster" effect, for businesses within the workspace.

It is also proposed that partners to this research project explore the feasibility of a "construction innovation network", which would organise, for example, training events, continuing professional development, site visits and exhibitions.

11 The Vision that has emerged from the Research

Based on the research summarised in this document and the conclusions outlined above, we have developed the following vision going forward:

By 2025 a new "construction innovation" programme will have enabled increased use of locally sourced/processed materials for domestic housing in West Dorset, and facilitated the adoption of new construction technologies to take advantage of these materials.

This will have resulted in:

- A reduction in the amount of embedded/embodied carbon in local domestic housing.
- The establishment of a new vernacular style for that housing.
- More woodlands becoming better managed.
- More local employment and inward investment.

12 Action Plan

The action plan below summarises the recommended next steps, which fall into 2 main areas:

- The development of a sustainable construction network linked to training, exhibitions and public engagement projects.

- The development of a timber fabrication workspace, offering units to businesses working with wood and containing specialist equipment for the off-site production of engineered timber products and the processing of fibre such as straw.

Action plan

The following next steps are recommended:

Project	Status	Resources	Timescale
Facilitate the development of a sustainable construction innovation network, engaging with existing retailers and building contractors and sub-contractors as well as suppliers of local materials and new-start processing and building enterprises.	Arrange meetings to discuss with potential partners, e.g. AA, Arts University Bournemouth, DCC, WCA, Sustainable Dorset.	Wessex Community Assets will arrange initial meeting with housing associations	Autumn 2017
Promote local materials and new construction methods to housing associations	Contacts with various housing associations are being pursued. WCA to speak to Hastoe, Magna, Aster and Yarlington.	WCA and DCA/Alan Clevett Associates to help.	Autumn 2017
Produce on-line directory of local materials, showing where they can be purchased.	DCC Community Energy Team is updating their pages on the Dorset County Council website; Sustainable Dorset website has been revamped.	Lead: DCC Community Energy Team? Sustainable Dorset website?	End 2018
Organise training courses, sustainable construction exhibitions and seminars.	Would be key element of network.	Potential for funding through LEP?	End 2019
Demonstration building	West Dorset Open Eco Homes, run by Transition Town Bridport each September, currently involves some 20 homes. One or two of these could potentially be used as initial 'demonstration' until a bespoke building is created.	TTB Open Eco Homes (Sam Wilberforce) and local skills database. DCC, DCE, WCA, AA @ Hooke – student accommodation? Indoor skatepark Approach LEADER for funding.	2017
Produce business plan for timber fabrication facility, which could	Initial concept idea underway (WCA), and funding application for	Wessex Community Assets seeking funding. Possible	Autumn 2017

incubate new secondary processing enterprises as well as provide workspace and access to specialist machinery for existing companies.	business plan awaiting decision.	ESIF Programme match funding. For the facility, could use Community shares, and bid for match funding from Power to Change	
Link with training and apprenticeships	Skills Training Bridport (STB), an IPS set up in 2012 following feasibility work by BLAP and the LSC in training needs in the area, runs the job club and is able to put on other training where funds are available.	STB steering group includes KMC, Weymouth and Yeovil college representatives	2019
Explore the feasibility of other processing facilities and equipment, e.g. for the creation of small straw bales, the compacting of wool, the making of bricks or the recycling of construction materials.	There is demand for community workshops, and also for Repair Café. This could be linked with proposals for timber fabrication facility.	Huff n'Puff Construction for straw. Bridport Repair Café steering group.	2018
Explore ways to encourage public engagement with local materials.	Link with Dorset AONB and the Arts Development Company Cleo Evans	Sustainable Development Fund (12 May annual deadline)	2018
Work with co-housing group and self-build group: use of local materials	Co-housing group has recently secured permission to build 64 homes, of which at least half will be self-build.	Co-housing group and Bridport self-build group.	2018

13 Impact Framework

<table>
<tr><th></th><th>Baseline</th><th>Outputs</th><th>Outcomes</th></tr>
<tr><td>Economic</td><td>The local construction sector is in competition with large scale external competitors, and vulnerable to the shift to off-site construction located at some distance from Dorset. This could also affect future employment prospects.</td><td rowspan="3">Construction Innovation Network
Continuing professional development
Exhibitions & seminars for professionals & the general public
Support for “flexible manufacturing networks”

Timber Fabrication Makerspace
New workspace created
Training
Apprenticeships
Job creation
Expansion of existing firms
New start ups</td><td>A stronger local economy, with increases in gross value added (GVA), higher levels of employment and an increase in the local multiplier.

The creation of new infrastructure for processing and manufacture.</td></tr>
<tr><td>Environmental</td><td>Housing is a significant contributor to resource depletion and climate change.
Woodlands are not optimally managed, from a sustainability perspective, as the end uses of timber are low value.
Straw is not being used as a building material, instead being seen as low value “waste”.</td><td>Reduction in the amount of embodied carbon in local domestic housing.
More woodlands becoming better managed.
Straw becomes a valuable resource with financial (for farmers) and sustainability benefits.</td></tr>
<tr><td>Social</td><td>Little support for collaborative working by people in the construction sector.
Communities having to accept standardised, “box-like” new housing.</td><td>Emergence of new forms of networking and collaboration.

Support for a new vernacular style for local housing.</td></tr>
</table>

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Appendix 1:
Sources of building materials within 25 miles of Bridport (from research by John Butler).

Sand, gravel and other aggregates
• Hanson Aggregates Masters Quarry Binnegar, Wareham, Dorset, BH20 6AH
• Hills Quarry Products Limited, Woodsford Quarry, Woodsford, Dorchester, Dorset, DT2 8FR
• Warmwell, Warmwell Quarry, Moreton Road, Warmwell, Dorchester, Dorset, England, DT2 8HU

Limestone
• Albion Stone PLC, Independent Offices, Easton Street, Portland, Dorset, DT5 1BW.
Material: Portland Stone of various types.
• Ashen Cross Quarry, Catsgore Road, Somerton, Somerset, TA11 7JW.
Material: Blue Lias.
• Hadspen Quarry Ltd., Grove Farm Quarry, Lime Kiln Lane, Hadspen, Castle Cary, Somerset, BA7 7NX.
Material: Blue Lias, Cary Stone.
• Ham & Doulting Stone Co Ltd, Monument Quarry, Ham Hill, Stoke-sub-Hamdon, Somerset, TA14 6RW.
Material: Ham
• Ham & Doulting Stone Co Ltd., Tout Quarry, Charlton Adam, Somerton, Somerset, TA11 7AN.
Material: Blue Lias.
• Harvey Stone, Ham Hill Masonry Works, Ham Hill, Stoke-Sub-Hamdon, Somerset, TA14 6RW,
Material: Ham Stone
• Portland Stone Firms Ltd, 99 Easton Street, Portland, Dorset, DT5 1BP – several quarries.
Material: Portland Stone of various types.
• Shapwick Grange quarry, Uplyme, Lyme Regis, DT7 3SP.
Material: chalk.
• Stalbridge Quarries Ltd, Sherborne Road, Henstridge, Templecombe, Somerset, BA8 0PH.
Material: Cotswold Forest Marble.
• Whitesheet Hill Quarry, Maiden Newton, Dorchester, Dorset.
Currently dormant but permission to extract chalk.

Timber
• Architectural Association School of Architecture, Hooke Park, Hooke, Dorset.
Material: Material: timber
• Melbury and Rushmore Estates

Straw
• Widespread availability around Bridport, as wheat or barley.

Earth
• Clay-rich earth generally available around Bridport.

Wool
• Various sheep farms in the area.

Appendix 2: Further information on proposed timber fabrication makerspace

A new timber design and fabrication makerspace is proposed. It will draw inspiration from the growing number of “rural studios” and design/build workspaces, and will support the creating of a wide range of innovative timber buildings and products. This will create training and employment opportunities, a market for local timber and a range of environmentally sustainable products.

Two entities are envisaged:

- A fabrication facility, offering workspace to small businesses and access to the latest technology such as a 3-axis CNC router and, possibly, in the longer term, a robotic arm. The lab will also be available for hire to individuals and companies not based in the makerspace.
- A design and make company, which will lease workshop space from the fabrication facility, and produce a range of products. This will provide an anchor tenant for the makerspace.
-

Potential products that could be produced in the new makerspace:

Housing construction: There is the potential to provide pre-fabricated frames, panels, windows, doors and other components. One key area is the possibility of supporting community self-build groups seeking to construct affordable housing.

Commercial and farm building construction: The Big Barn at Hooke demonstrates the potential to replace steel framed farm buildings with timber framed buildings using local materials and with a much lower environmental footprint. Similar possibilities exist with commercial buildings, for example on industrial estates.

Home offices, sheds and tree houses: There is a growing market for these sorts of structures, and they are very suited to pre-fabrication.

Furniture: There is already a cluster of furniture makers in West Dorset, though many of the companies are focused on bespoke, design-make pieces. There is the potential to support the use of new technologies, thus making existing companies more viable. There is also the potential to use techniques developed at Hooke to create new products.

Boat building: There is the potential to create a partnership with the Boat Building Academy in Lyme Regis, which is training new craftspersons, many of whom are then looking for suitable workspace to move into.

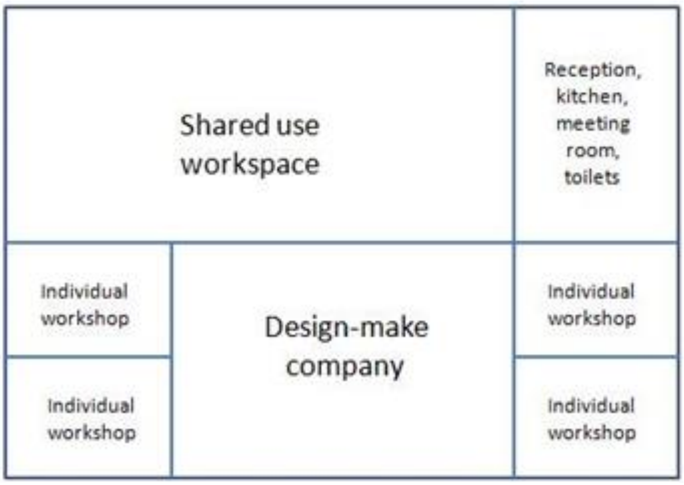
Sports equipment, including bicycle frames: Bridport has a historic association with the manufacture of sports equipment linked to the rope and net industry. Companies such as Edwards Sports and Huck Nets (now amalgamated) produce, for example, tennis and football nets. However, there is potential to produce products such as posts. In addition, there is growing interest in specially engineered wooden bicycle frames, and this would be possible with a robotic arm.

Facilities and equipment requirement

It is proposed that the timber design and fabrication lab would have two main components:

- The fabrication facility with large scale equipment such as CNC machines.
- A set of specialist timber workspaces, one for a design-make company and others for rent to other producers. Each of these would have basic equipment.

There would also need to be common spaces such as kitchen, toilets and reception area/meeting area.



The Sylva Foundation has developed a similar facility, the Wood Centre in Oxfordshire (https://sylva.org.uk/wood), which offers the following facilities:

- Size of individual unit: 450 sq ft / 42 m2 (Dimensions: 9.6 x 4.4m) (though the Centre can be reconfigured to provide smaller or larger workspaces).
- Additional outdoor covered space available (optional): 500 sq ft/46 m2.
- Large roller-shutter door access to outside.
- Access to well-equipped Machinery Workshop, including panel saw, planer, thicknesser and band saw.
- Internal double door access to community space.
- Access to community kitchen. Toilets and Shower.

The proposed Woodlab at Dartington (www.thewoodland.co) will have the following elements:

Appendix 3: Open Source Design Principles from Wikihouse Foundation

Design Principles

Share global, manufacture local

'It is easier to ship recipes than cakes and biscuits' – John Maynard Keynes

Be lazy like a fox

Don't keep reinventing the wheel. Take something that already works, copy, adapt, give credit and re-share. (Thanks Linus Torvalds via Eric S Raymond)

Design to lower thresholds

Design to lower barriers of time, cost, skill, energy and resources at every stage. Elvis Costello wrote all his songs to be played on the cheapest transistor radio.

Share and make shareable

Publish your work under an open source sharealike licence, documented and codified so as to make it as easy as possible for others to understand, modify, improve, distribute and use it, including commercially.

Open standards

Where possible, work to existing standards or seek to establish intuitive new ones.

Open materials

Design for cheap, abundant, standardised, sustainable, and, ideally, circular materials.

Human friendly

Seek to preserve and maximise the safety, security, health and wellbeing (physical and mental) of all participants at every stage of a product's life.

Start somewhere

No one can solve everyone's problems. Design something that works where you are, then share so others can adapt it for their own economy, climate and culture. Let solutions adapt like Darwin's finches.

Modular

Design hardware and software that is robust, interoperable, product-agnostic and flexible, so elements can be independently altered, substituted or upgraded.

Include, keep including

Look for ways in which age, race, gender or disability might be barriers, and try to design them out. Try to design products, processes and documents that are accessible, intuitive and non-discriminatory.

The new 'normal'

Avoid design which would be considered 'alternative', 'boutique' or only for the rich or poor. Instead, design for the new normal: products most people would consider desirable and affordable. As beautiful as Apple, as open as Linux.

Mistake proof

Make it impossible to get wrong, or not matter if you do. (The Japanese call this 'Poka-Yoke')

Whole life design

'A home is not something you finish' – Stewart Brand Design for the entire life-cycle of the product, from manufacturing to assembly, use, maintenance, adaptation, disassembly and re-use.

Superpower the users

'Give power to the fine tuners' – Cedric Price. Afford as much power as possible to the end users, from procurement to privacy to electricity. Democracy is a design diagram.

If you can't mend it, you don't own it.

Try to avoid 'black box' products. Try to make it easy for the user to learn how it works.

Appendix 4 - Advisory group supporting this CED research process.

This research process forms part of a wider investigation into three sectors of the local economy spearheaded by CLS. www.dorsetcommunityaction.org.uk/community-led-economic-development

The process has been led by Tim Crabtree, consultant, who is involved with Wessex Community Assets, Schumacher College, Dorset Community Energy etc. A workshop was held on the topic, plus three meetings of the champions who have supported and advised on the findings:

Celia Marsh	Neighbourhood plan Housing group; Bridport self-build group.
Cleo Evans	Arts Development Trust – Arts & Environment Hub.
Ian Rees	Dorset AONB; CLS community woodlands lead.
Kate Hall	Dorset County Council, Community Energy Team leader.
Monica King	Bridport Co-housing Group.
Phil Christopher	Huff n' Puff Construction Natural Building expert.
Sam Wilberforce	Transition Town Bridport; Open Eco Homes organiser.
Vince O'Farrell	Symene Community Land Trust.
John Butler	Sustainable Build consultancy; CAT research re Bridport area.

Information has been gleaned from various sources quoted in the text, with inputs from Dorset County Council Research & Consultancy department, John Butler, Hooke Park Architecture Association, and Clevett Associates.