SUSTAINABLE COMMUNITIES: A PROPOSAL LINKING THE MANAGEMENT OF FORESTATION AND AGRICULTURAL WASTE WITH THE DEVELOPMENT OF RECYCLABLE HOUSING.

D.R. Moore[1], G. Paterson and R. Sanmarti Martinez

The Robert Gordon University, Faculty of Design and Technology, Scott Sutherland School Aberdeen, AB10 7QB, UK

Sustainable communities can be defined as meeting identified needs without compromising the survival of future generations. Buildings are amongst the largest producers of CO_2. Sustainable development at local and regional levels is suggested as being achievable through the adoption of a largely closed system approach. Carbon-neutral buildings are those where carbon emissions can be balanced out by the planting of sufficient trees to lock-in their carbon equivalent. Timber is a highly versatile construction material and its production results in various by-products. These may be diverted from waste streams and used in biomass co-firing (coal used in a power station can be reduced through replacement by a suitable biomass). The paper illustrates how materials and components could be processed to provide a timber based prefabricated house construction typology offering the potential for disassembly and re-cycling. The embodiment of progressive disassembly into design results in production of houses that can be dismantled over time to facilitate adaptation to changing need and re-use. At the end of useful life, components forming the primary structural elements such as walls, floors and roofs may be re-integrated into new housing production, diverted for biomass fuel processing, or used in mulching / composting to enhance soil fertility.

Keywords: biomass co-firing, forestry management, postponement-loop system, timber panel delamination, timber panel house construction.

INTRODUCTION

It is a stark fact that 50% of all global warming gas emissions and CFC use can be related to buildings (Edwards and Hyett 2001). Buildings are generally accepted as being amongst the largest contributors of CO_2 in particular. Such a situation can not be argued to be a sustainable approach to the provision of housing, commercial premises etc. and therefore alternative approaches are required. The focus within this paper is on the impact of the housing product and on one suggestion for a more sustainable approach to its provision and maintenance. Whilst it is fair to say that the so-called 'banana' approach (build absolutely nothing anywhere near anybody) would be classed by some as being truly sustainable, it does not respond to the real-world requirements as stated by Davoudi and Layard of sustainability '..meeting needs, while minimising the impacts of consumption, providing for people of today and not endangering the generations of tomorrow..' (Batty et al 2001).

[1] email: d.m.moore@rgu.ac.uk

Moore, D R, Paterson, G and Martinez, R S (2004) Sustainable communities: a proposal linking the management of forestation and agricultural waste with the development of recyclable housing. *In:* Khosrowshahi, F (Ed.), *20th Annual ARCOM Conference*, 1-3 September 2004, Heriot Watt University. Association of Researchers in Construction Management, Vol. 2, 1377-85.

The approach to housing provision suggested in the paper is one of a (largely) closed system reflecting the need to lock-in carbon emissions. The issue of global emissions has, in the recent past, resulted in the emergence of the so-called ‘carbon neutral’ building concept. This is not to say that the concept is restricted solely to buildings, as evidenced by the proposal of the *Edie* (an environmental news and information service for water and environmental professionals) website to become carbon neutral. This is to be achieved through offsetting the CO2 emissions from *Edie* office and staff travel activities against an energy project based on the Isle of Skye, Scotland. The Torren Energy project encourages managers of large buildings (hospitals, etc.) to use bioenergy to provide heat and hot water. This comes in the form of converted boilers capable of burning ultra-dry wood chips produced through the Forest Stewardship Council (FSC) programme (Edie 2001). Biomass as a source of energy is a factor considered by this paper in the context of both the use of forestry by-products and as a contributory mechanism to the disposal of timber panel housing components at the point where their construction lifespan has passed.

The intention of this paper is to examine the problems and possible solutions involved in creating what the authors refer to as a postponement-loop system for housing provision specific to the Queensland environment. There are two key points to consider in this intention. Firstly, what is the nature of a postponement-loop? Put simply, this is an acceptance of the, at present, considerable difficulties involved in creating a fully closed-loop system in which carbon is permanently locked-in. At some point, carbon leaks out of the system. The postponement loop concept seeks to push back this leakage, both in terms of quantity released and time taken for that release, as long as possible. Hence the term ‘postponement’. The second point is that of the environment. This term is used with both its “natural” and “systems” connotations, and therefore impacts on the postponement-loop concept from two perspectives. Such an approach will inevitably raise some difficult questions, and the paper seeks to respond positively to this whilst also acknowledging that any product that wishes to be adopted with any significant degree of success must also be grounded in a sense of what can realistically be achieved. A brief discussion of the methodology adopted will help to evidence this response.

METHODOLOGY

In order to meet the objectives of the research, a number of subject areas had to be brought together. Within this process, an overarching consideration was to avoid reinventing the wheel. Whilst it is arguably inevitable that within any research activity there will be an element of the so-called Rembrandts-in-the-attic syndrome (Moore 2002), the authors actively sought to build upon any relevant research findings already in the literature. The methodology applied was therefore one of seeking incremental development, commencing from a point determined by a honest acknowledgement that none of the authors were, or had been, architects practising in Queensland. The first stage of the research was therefore to identify a house design that could reasonably be argued to be applicable in the context of housing in Queensland. This was then further developed through the application of buildability principles, in particular the principle typified by Ferguson’s variety reduction (Ferguson 1989).

The result was then tested against production criteria that were, perhaps perversely, guided by the objective of achieving disassembly of both the structure and as many of the components forming the structure's subassemblies as was feasible. Finally, the requirement to achieve a sustainable disposal process for those materials that could no longer be recycled into "new" components was considered. This stage of the research acknowledged that the limit of the carbon locking-in process within the context of this particular approach to housing provision had been reached. The research then sought ways of diminishing the impact of carbon leakage from the system by applying the concept of carbon off-setting.

HOUSING IN QUEENSLAND

Within the consideration of the housing product in the context of Queensland, there are a number of factors to consider. Perhaps two of the key factors with respect to this paper are those of population growth and the location of the population centre. Population growth is of importance in that there is a need to consider the extent of the market for the housing product and how a sustainable approach may contribute to filling that demand, particularly if demand is expanding. Recent data from the Australian Bureau of Statistics (ABS) shows that Queensland is actually the boom state of Australia in terms of population growth (ABS 2002). Against an Australian rate of growth of 1.3%, Queensland's population grew by 1.9% between 200 and 2001. The main contributor to this was an interstate migration of 21,995 people. This factor is of relevance in that it indicates that any increase in demand for housing will come from 'mature' consumers, rather than from any intrastate 'new-birth' population growth. This type of demand should be considered in the light of Australia's ageing population.

Along with the interstate migration contribution to population growth, it is relevant to consider whereabouts in Queensland people are moving to. Australia in general has a population that is migrating to the larger cities, particularly Melbourne and Sydney. Within Queensland this trend is also reflected as the population moves away from rural areas and towards the urbanised coastal fringe. Queensland's population centre has moved approximately 14km south-east since 1991, and is now located within Gayndah Shire (ABS 2000). This migration from rural areas suggests that land not seen as being desirable for housing may now present opportunities for agroforestry activity. Such activity may well comprise the sort of timber panel production suggested within this paper. The opportunities for a postponement loop housing development system within Queensland may therefore increase over time. The question then arises as to what may prove to be an acceptable design of house for such consumers.

A possible suitable base house was selected from the Markon Homes catalogue of designs forming the Macquarie Family Homes range. The house design in its initial form was the Blue Orchid model from the Macquarie range (Macquarie Nd). The authors were particularly aware of the apparently large size of the house in comparison to its British counterpart, and were initially drawn to the opportunity to reduce the volume of the house as a relatively straightforward means of reducing materials requirements. However, it was appreciated that doing so would present a risk that the public would adversely respond to the product, and the authors contented themselves with the slight reduction that resulted from the panelisation process that was to follow. The panels used are presented in Figure 1, and the panellised form of the Blue Orchid design is presented in Figure 2. The process of panelisation in the context of buildability issues is discussed in detail in section 4.

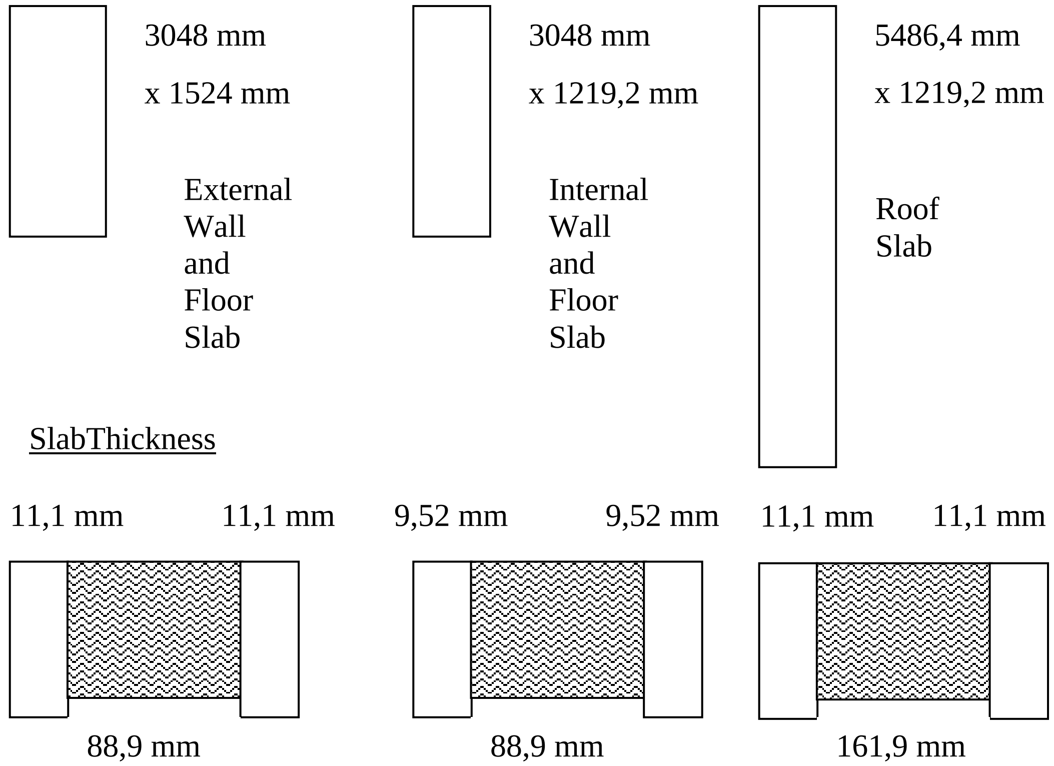

Figure 1. Panel Variety and Dimensions

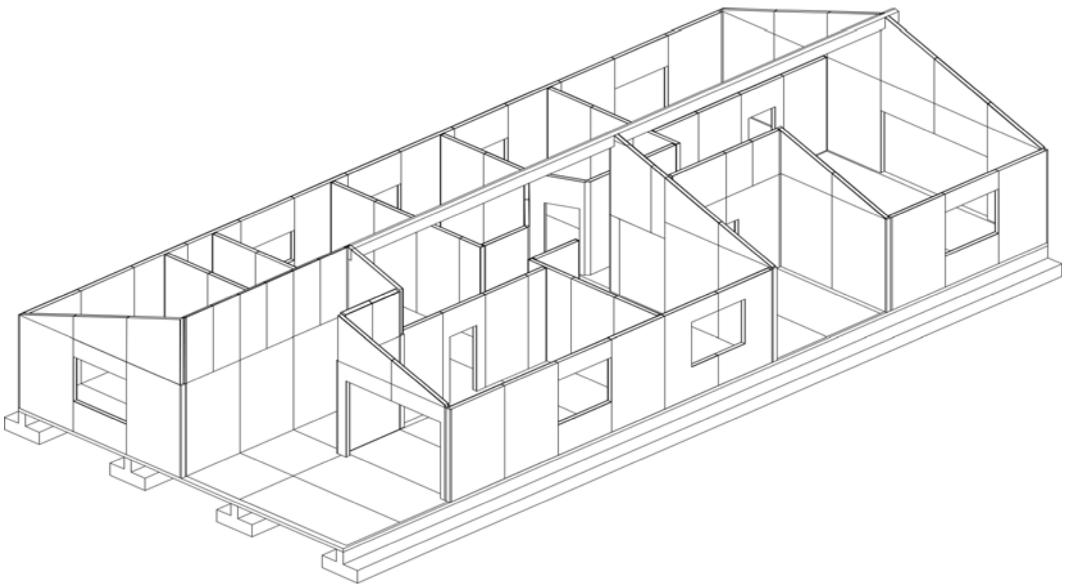

Figure 2. Panellised Form of Blue Orchid Design.

PANELISATION AND BUILDABILITY

Ferguson (1989) suggests two key strategies when approaching the application of buildability at the design stage. These are: m/c/sa and variety reduction. Considering m/c/sa first. This simply refers to the manner in which a structure gains mass and reflects the production / construction process whereby a number of materials (m) are combined to form a smaller number of components (c), and these in turn are combined to form a smaller number of subassemblies (sa). A typical house design will involve a relatively large number of materials combined to produce a variety of components. Each of these will usually involve their own specialist labour input, thereby increasing the number of interfaces inherent in the management of the construction process (Moore 1999). Reduction of interfaces is argued to produce a more efficient production system and therefore m/c/sa needs to be considered in terms of the variety reduction concept.

In this instance, variety reduction is applied through consideration of the materials involved, and the modified Blue Orchid design is constructed from timber panels in three basic sizes. All angle components (such as to provide the roof pitch) are achieved through utilising one of the basic panels and cutting it to provide the required angle. However, in order to minimise wastage the variety reduction concept is also applied to the cutting of angle units to ensure that all off-cuts can also be incorporated within the structure. This approach is also in line with the suggestions of Crowther (2000) that improved performance can be achieved through articulating a hierarchy for disassembly and reuse in the context of behavioural statements (waste reduction, etc.), performance standards (component remanufacture, etc.) and prescriptive guidelines (chronological order of application. etc.). The philosophy of buildability also provides benefits in the context of disassembly. Furthermore, an emphasis on variety reduction, with its resulting focus on timber as a key material, appears to fit well with an emerging Australian consensus that timber presents a number of environmental benefits when used as a construction material.

The National Timber Development Program (NTDP 2003) claims that timber presents a high standard of thermal comfort whilst also consuming minimal non-renewable energy consumption with regard to its extraction and manufacture. This benefit is recognised in timber house designs across a range of environments around the globe. Within Australia, timber houses can be found in all the climatic regions. However, housing in the tropics requires a different design to that in say the Snowy Mountains and the National Timber Council (NTDC 2001) suggest three house types suitable for Australia: snug, breeze, and combination, with each being suitable for a different zone. The breeze house, for example, is suitable for the coastal strip commencing south of Brisbane, passing through Cairns and on to a point approximately midway between Dampier and Perth. The coastal strip of Queensland therefore requires a breeze design while the inland rural area requires the combination design. Given the previous comments required movement of the population centre in Queensland, it seems most appropriate to consider a breeze type house. Figure 2 illustrates features of the breeze design style with its ventilation passages under the floor area and relatively large window / door openings.

DISASSEMBLY

The process of disassembly is particularly relevant in the context of the proposed postponement-loop approach to housing development. This is due to the fact that not only can the individual components be re-used, either elsewhere within the “parent” house or to form a further structure, possibly on a different site, so can the materials from which they are comprised. Specific design objectives are that the principal should be demountable, internal partitions should be independent of the principal structure, and a progressive assembly / disassembly rationale that commences at the materials level. A key component of this rationale is the use of adhesives that allow panels to be delaminated and thereby provide an opportunity to recycle timber sections into “new” components, thereby postponing the release of carbon.

Within the context of a sustainable approach to construction, any adhesives used should be “green” in nature and one consideration in this regard is that of water-based adhesives rather than solvent-based ones. A further consideration is that the constituents of an adhesive should be extracted from a finite source, and this suggests the use of plant-sourced constituents. Berge (2000) provides a detailed list of construction adhesives, amongst which are several plant-based and cellulose adhesives. Those that are water-based are also potentially water-soluble and while this presents an opportunity for ready delamination of panels, such delamination needs to be achieved in a controlled manner. A sudden tropical downpour may well result in unscheduled delamination of external components. A possible compromise would be to utilise an adhesive that resists day-to-day dampness but still allows the potential for delamination, perhaps as a result of full immersion. Soya adhesive is rated by Berge as being at level 3 on a five point scale, with 5 being a level rated as suitable for outdoor use. The use of such an adhesive also presents the possibility of growing crops locally and thereby reducing transport energy with regard to the adhesive. Panels utilising Soya adhesive would require some further protection from rain, but this does not seem an insurmountable problem and is currently the subject of further research.

FORESTRY IMPLICATIONS

Ongoing global concern regarding the classification of forests as an agricultural product can be typified through consideration of two examples. Bass (Nd) has suggested that international forest initiatives are growing globally and that such initiatives have not always maintained the link between the local and the global. The suggestion being that local initiatives should contribute towards recognised global forest problems. This is evidenced by the second example: the Tasmanian forests debate. This debate seems to be an example of how not to approach the use of forests as a resource. The essence of the debate centres around the approach of one company to the extraction of timber to fuel the global woodchip market. Unfortunately, the timber being extracted is largely oldgrowth, and the extent of this remaining is decreasing at an apparently accelerating rate. In 2000, the highest level ever recorded (5,498,654 tonnes) of woodchips were produced from Tasmanian forests. In 2000-2001 92% of public native forest logs were chipped (Wilderness Society 2002).

The postponement loop model proposed here is not one that considers timber as an immediate biomass for coal replacement (as in woodchips produced just for this purpose). The intention is that only once the timber materials of the components have exceeded their useful (in a construction sense) life is the option to convert them to biomass to be considered. At this point the management process would be one of integrating the component sourced biomass (delaminated timber sections) into a forestry by-products (remnant materials from the production of timber sections, for example) biomass “waste” stream. It is important that the contribution of biomass fuels to the displacement of more carbon intensive fuels, such as coal, does not become the sole focus of the process. In such an instance it is conceivable that short-term gains in terms of carbon displacement are at the expense of long-term gains in terms of locking carbon up in oldgrowth timber. Such a scenario appears to be at the centre of the Tasmanian forest debate.

Carbon displacement benefits from the use of biomass can, however, be significant. Examples include the two power stations (Liddell and Bayswater) currently operated by Macquarie generation. In 2000-2001 the two stations were expected to produce 100,000MWh of biomass-fuelled electricity (Macquarie Generation 2001). A heuristic of relevance here is that 1,000MWh generated through biomass co-firing roughly equates to the saving of 1,000 tonnes of greenhouse emissions. Whilst it is fair to say that the biomass contribution of a timber housing postponement loop system is never going to be huge (if it were, the postponement loop concept could be seen to have failed), the contribution none the less will reduce greenhouse emissions. The postponement loop model does raise issues that the agroforestry industry exhibits a general awareness of the need to address.

A primary issue in this regard is raised by Blinning et al (2002), when they ask, how do we move from rhetoric to reality? How should risk be shared? How do we attract new investment? Bodies such as NSW State Forests and the Department of Land and Water Conservation are claimed to be experimenting with different projects and proposals. This may well be the case, but factors such as global warming have their own time scale and contributions to the solution for such factors need to be identified sooner rather than later. A report for the Joint Venture Agroforestry program (RIRDC 2002) has identified that there appears to be an increasing appreciation across much of rural Australia of the benefits flowing from increasing tree cover on farmland areas. This is particularly so if it can be done while continuing existing farming activities such as livestock production.

The benefits of increased tree cover are stated as varying from location to location but may include: environmental improvements, such as salinity, water quality and soil protection; protection of biodiversity and remnant vegetation; and commercial opportunities for farmers to use farm forestry as an additional income stream. There is also the recognition that environmental and social benefits may well be good reasons for tree planting, but forestry activity on farms has a greater chance of adoption if commercial returns for farmers result. The postponement loop model suggested here may well allow for a commercial return from small-scale agroforestry activity. However, there needs to be the will to consider such possibilities if any progress towards sustainable agroforestry is to be achieved.

CONCLUSION

The proposed postponement loop model offers a contribution towards an integrated and sustainable approach to housing provision, energy generation and agroforestry. The perspective in this proposal is also considerate of the Queensland context, reflecting the need for locally sensitive ‘solutions’ to global problems. The Queensland context is itself relatively local within the scope of issues within the Australian debate on issues of sustainability, and evidences the complexity attendant to the development of sustainable communities. Such communities may traditionally be relatively small-scale, but the proposal is capable of functioning at differing scales of development. At the smaller scale, the benefits of the proposal are not claimed to be large, at least in ‘traditional’ economic terms, but are rather of a realistic nature and are worthy of further development and investigation.

The key objective of the research is to refine a model for sustainable housing development in the context of a carbon economy, and the proposed concept of the postponement loop starts to address the key issues related to this objective. One significant issue identified within the concept are the difficulties of achieving a fully closed loop with regard to the carbon component of both the housing development process and the creation of a sustainable agroforestry industry. Further research will be directed at plugging the carbon leakages identified thus far.

REFERENCES

Edwards, B and Hyett, P (Eds.) (2001) *Rough Guide to Sustainability*. London: RIBA Companies Ltd..

Batty, S, Davoudi, S and Layard, A (Eds.) (2001) *Planning For a Sustainable Future.* London: Spon Press Ltd.

Edie (2001) "Edie Goes Carbon Neutral" www.edie.net/news/Archive/4807.cfm

Moore, D R (2002) *Project Management. Designing Effective Organisational Structures in Construction.* Oxford: Blackwell Science Ltd.

Ferguson, I (1989) *Buildability in Practice*. London: Mitchell Publishing Company Ltd.

ABS (2002) *Queensland the boom state*. Media Release. www.abs.gov.au/Ausstats/abs@.nsf/

ABS (2000) *Queensland population centre in Gaydah Shire*. Media Release. www.abs.gov.au/Ausstats/abs@.nsf/

Markon Homes (No date) The Macquarie Family Homes Range. www.markcon.com.au/macplans.html

Moore, D R (1999) *Building Production Management Techniques.* Harlow: Pearson Education Ltd.

Crowther, P (2000) *Developing Guidelines for Designing for Deconstruction.* Deconstruction - Closing the Loop. Watford: Building Research Establishment.

NTDP (2003) *Technical Report Issue 2.* Forest & Wood Products Research & Development Corporation. Australia. www.timber.org.au/NTDP/Publications

NTDC (2001) *Environmentally Friendly Housing Using Timber - Principles.* www.timber.org.au/NTDP/Publications

Berge, B (2000) *The Ecology of Building Materials*. Oxford: Architectural Press.

Bass, S (No date) *Sustainable Development - International Forest Initiatives.* Sustainable Development International; Forestry. Edition 2. www.sustdev.org/explore/forestry/articles/edition2.html

Wilderness Society (2002) *Statistics on the Tasmanian Forests Debate.* www.wilderness.org.au/projects/Forests/tas_stats2.html

Macquarie Generation (2001) *Biomass Co-firing.* www,macgen.com.au/environment/enviro_biomass.htm

Binning, C, Baker, B, Meharg, S, Cork, S, Kearns, A. (2002) *Making Farm Forestry Pay – Markets for Ecosystem Services: A Scoping Study to Set Future Research Directions.* Barton: A report for the Rural Industries Research and Development Corporation.

RIRDC (2002) *Wood For Alchohol Fuels*. Barton: A report for the Rural Industries Research and Development Corporation.