# The Implementation and Advantages of Carbon Trading in the Concrete Industry

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## Synopsis

That we are in a global double whammy crisis few doubt. On the one hand economic malaise is starting to grip the building and construction industry and on the other, few doubt that when the ice stops melting we are in for a climate catastrophe of unprecedented proportions.

Although the author has argued elsewhere that the Kyoto process has failed and more radical action is required[1] the momentum of the process is likely to continue and so it must be factored into future thinking.

The treaty is quite flexible and defines several methods to reduce emissions and includes carbon trading for which there are significant opportunities in the building and construction industry. Unfortunately the recently shelved Australian Carbon Pollution Reduction Scheme (CPRS) does not immediately recognise offsets and the industry should pressure that it does when reinstated. There are also many other changes in the building and construction industry that have to be implemented before these opportunities can be realised and these are addressed in this article.

The conclusion is reached that objective performance criteria that can be interpreted and used for calculating valid offsets and are essential if the industry is to profit from carbon trading.

**Keywords:** Sustainable green concrete carbon trading offsets, embodied lifetime energies standards approvals

## Carbon Trading

The author has written extensively on the Kyoto protocol and possible replacement treaties and is of the view that it is essential to switch to backing new technology opportunities rather than constraint as economist Gwyn Prins points out [1].

Australia is some years behind this sort of thinking and Kyoto complaint cap and trade systems are likely to be introduced with limited trading in scope 3 emissions until offsets are recognised some time later.

If implemented successfully carbon trading attaches legal costs to emissions that will help the required migration to non fossil fuel energy sources and other green alternative technologies with credits against them attached. In Australia the proposed CPRS system limited emissions, mainly for scope 1 and 2 emitters forcing them to buy unused quotas from other emitters. At this point a significant error on the part of the Australian government has been to delay the inclusion of offsets until initially 2013 and possibly now later given that the CPRS has been shelved. (For definitions of scopes 1-3 see Appendix 1 - Carbon Accounting). Another problem is that so far the Australian government have not behaved with certainty undermining the concept of value in future carbon prices[2]. It is also uncertain if and when carbon trading will be introduced in Australia and on what scale given the initial exclusion of offsets. Regardless, the cement and concrete industry and for that matter the entire construction industry are a long way off being able to take advantage of carbon trading and this paper explains the steps required for implementation.

### *Importance of Carbon Trading in Building and Construction.*

That the building and construction industry represents low hanging fruit that can deliver significant improvements in sustainability has been pointed out by many from Stern [2] to RMIT [3]. According to ResearchandMarkets [4] "Buildings make a large contribution to the energy consumption of a country. It is estimated that, of the total energy generated in the industrialised world, 40% of it is used in the construction and operation of residential, public, and commercial buildings. Approximately one third of

[1] See http://www.tececo.com/politics.replacing_kyoto.php
[2] An example is the termination of the "Greenhouse Friendly" carbon offset scheme.

primary energy world-wide is consumed in non-industrial buildings such as dwellings, offices, hospitals, and schools where it is utilised for space heating and cooling, lighting and the operation of appliances. In the European Union (EU), energy consumption for buildings-related services accounts for between 33% and 40% of total EU energy consumption. Energy used for heating, lighting and powering buildings can account for up to half of a country's total energy consumption. In an industrial economy domestic water heating can account for over 5% of total energy use, domestic space heating up to 20% and appliances and lighting up to 30%. In terms of the total energy end use, consumption of energy in the building sector is comparable to that used in the entire transport sector."

The coal industry are extracting millions of dollars from the government on the basis of a technology that many believe cannot work because of leakage. The building and construction industry has a better alternative called concrete that is already green with a high specific heat capacity and considerable scope for further reductions in embodied energies and emissions and performance in relation to lifetime energies to the point whereby the material could even be a carbon sink as explained in the paper "Gaia Engineering - An Economic Approach to solving Climate Change, Water and Waste Problems" to also be presented at this conference.

It is time to demonstrate the advantages to government of improved concretes that can deliver massive sequestration and to get ready for financial assistance or profits that could come from carbon trading whatever form it may finally takes.

## Implementing Carbon Trading

### *Characteristics of the Industry*

The building and construction industry is characterised by a long supply and waste chain, highly dispersed profit centres and many different players. Fortunately most decisions affecting the embodied and lifetime emissions of structures are made in the design room by decision makers including architects and engineers and this represents opportunities. A significant barrier to them making better decisions for sustainability is that they lack independent, verifiable, easy to access and easy to understand, materials information including data on embodied energy, life cycle emissions and the use of materials in ways that reduce lifetime energies. (See below)

### *The Requirements for Carbon Trading*

Trading with scope 1 and 2 emissions will be relatively easy and is already on the government's agenda. Scope 3 emissions appear not to be and will be harder to implement. On the other hand scope 3 emissions in our industry promise significant abatement. Unfortunately the recently withdrawn CPRS did not include offsets until 2013. It is however doubtful that the prerequisite steps outlined in this paper could be taken by then.

At the present time there is a strong likelihood that carbon trading will be introduced in Australia. Given this it is important that the Concrete Institute of Australia and other industry groups like the Cement Industry Federation work with the other many and various materials, design, product and building groups to formulate and promote a national industry policy in relation to materials and materials in use and put forward a united view to the government so that they recognise the large contribution the building and construction industry has to global and national greenhouse emissions and incorporate scope 3 emissions and carbon offsets trading in the replacement for the now shelved CPRS. The trend to exclude materials and materials in use must be reversed.

If industry bodies do not work together to provide input and help develop a system for determining offsets for carbon trading there is a very real danger of them being overlooked and/or having inappropriate regulations thrust upon them.

### *Changing Criteria and Standards to meet the Sustainability Challenge and Engage if Offsets Trading*

Associated with implementation there will be a strong need for independent, peer reviewed, accurate life cycle emissions and other data about materials to allow easy validation of offsets with the appropriate authority

A peer reviewed materials online Wiki-style database moderated by all the peak bodies concerned including the Concrete Institute of Australia and other industry groups like the Cement Industry Federation, RAIA, Master Builders, .HIA, AGDF, GBCA, Materials Australia etc. etc. is recommended.

People create the built environment with permissions (engineering, standards, council approvals etc.) for reward (money, Leed rating, hopefully soon carbon offsets etc.). Getting the permissions and rewards systems right so that appropriate numbers are easily generated for the generation of carbon offsets is an important first step. Carbon offsets are a lever that will assist implementation of better building and construction practices and technologies so that the way we build coincides with better environmental stewardship.

In spite of the important contribution of building and construction, other than for the manufacture of cement and concrete the industry is not on the radar of most governments, including the Australian government, for carbon trading. Professional and green bodies have not helped this deplorable situation. Our standards and green point rewards system rather than working for sustainability are actually holding up progress in that direction because they are prescriptive.

There are many impediments to deployment of carbon trading including how we measure the performance of materials and buildings and encourage the urgent innovation needed. This paper address these issues in the context of aligning the permissions (standards) and rewards (green points and carbon offsets) systems we have in place with good environmental stewardship using concrete as the main example and suggests how the status quo might quickly and easily be improved so that the urgent improvements required can come about in a more profitable way.

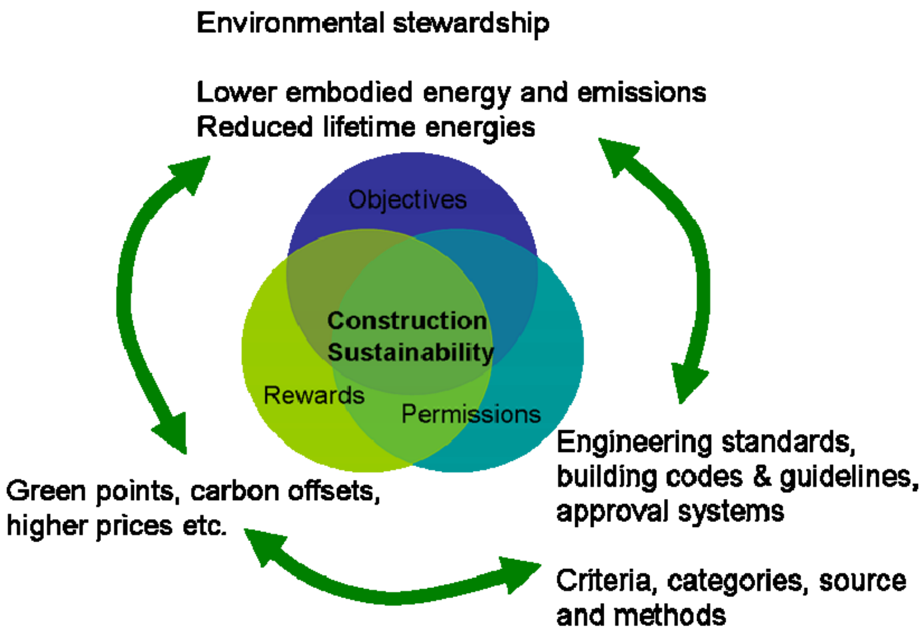



**Figure 1 - Moving Towards a Sustainable Construction Industry by Bringing into Focus Permissions, Rewards and Objectives**

Eventually all materials should be described in terms of all their properties including embodied energies and emissions and using reliable data provided by for example a Peer reviewed Wiki, engineers would then be able to specify with knowledge of the outcome in terms of greater than normal sustainability.

There will be some difficulties in documenting the effect of materials in use as a result of design to reduce lifetime energies and this area will always remain to some extent subjective but should never the less be considered.

By way of example, given permissions and the right rewards, Portland cement concrete blends in 80% of applications can easily be made 80% more sustainable[3] and that not only can this be done, but a further 80% of the 80% that are more sustainable could be net carbon sinks.

80% is not unreasonable given that in an article by Kumar Mehta from Berkeley in the February issue of Concrete International[5] who suggested a 50% reduction in clinker use could be achieved by using only three tools as hereunder:

1. The use of less concrete for the new structures (implying better design and greater durability)

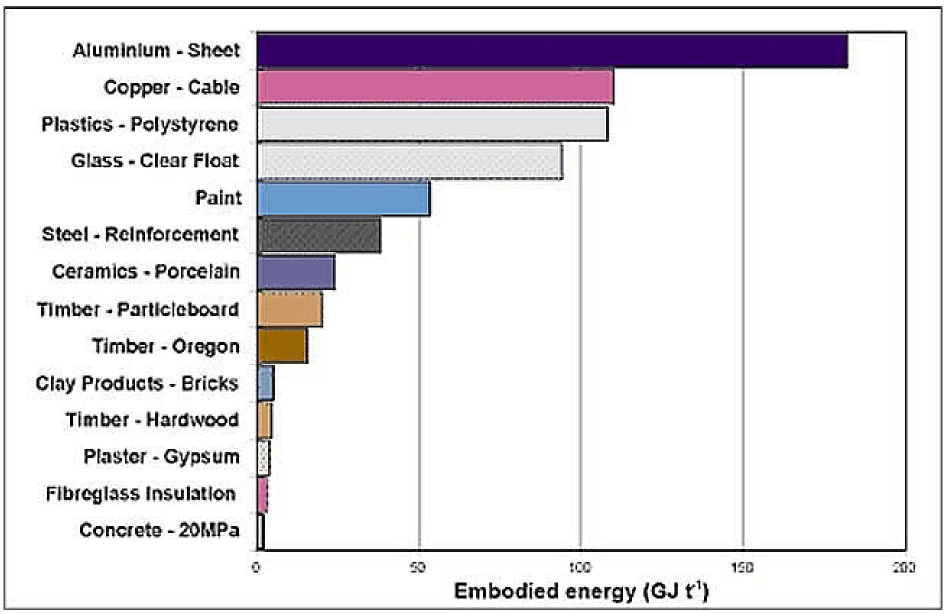
2. The use of less cement in concrete mixtures (implying less water by using high range water reducing agents), and

3. The use of less clinker to make cements (implying the use of supplementary and pozzolanic additives.

In the rest of this article I will explain why and how 80% improvement can easily be achieved in the context of permissions and rewards. First some background.

So far there has been a lack of serious effort and much greenwash in the concrete industry. Players are only just starting to realise that their biggest source of revenue in the near future could be carbon credits and that there are huge improvements that could be made to concretes to profit by them. Before carbon credits can be enjoyed however we all have a lot of work to do. Not only must our permissions and rewards systems be thoroughly overhauled to encourage the innovation required; they must also produce measurable improvements in embodied energy and emissions that quantify carbon offsets. We must be able to easily produce the numbers required to quantify what the embodied energy and emissions of materials like concrete are and address how they can be reduced and how properties that contribute to the lifetime energy savings of a building can be improved.

Concrete is one of the greenest building materials (See graph below), it could however be a lot greener and that is where the next real challenge lies.




## The Embodied Energy of Building Materials

Members of the World Business Council for Sustainable Development Cement Industry Initiative[4] have mainly been working on efficiency, fuel changes and the use of supplementary cementitious materials

[3] According to Wikipedia "The Pareto principle (also known as the 80-20 rule, the law of the vital few and the principle of factor sparsity) states that, for many events, 80% of the effects come from 20% of the causes. Business management thinker Joseph M. Juran suggested the principle and named it after Italian economist Vilfredo Pareto, who observed that 80% of income in Italy went to 20% of the population. It is a common rule of thumb in business"

like fly ash and latently cementitious materials like ground granulated blast furnace slag. This work is to be encouraged, especially the use of pozzolans.

Bringing permissions (standards and approvals) and criteria for reward (Greenpoints etc) in line with environmental stewardship will focus the industry into bringing about the green change required.

Global materials standards are generally prescriptive and this is the case for Portland cement which is usually defined as a fairly precise mixture of minerals the result of "clinker" making. Some attempts to move to standards based on performance have been made but are not yet the norm. A good summary of global concrete standards and codes of practice is to be found in Lea's, Neville and Newman's books [6] [7] [8] but none really push the advantage of performance based standards. The author has written often about this problem in various papers[5] (e.g. Do Water Problems Exist in our Minds), many submissions[6] and in newsletters[7]. Green rating systems should, but do not lead the way towards greater sustainability as they fall into the same prescriptive trap.

World rating systems, Leed in the US and in Australia the Star rating system have not in the past properly addressed the means to green in terms of performance objectives for materials focusing instead mainly on prescriptions. In relation to concrete, a few methods of greening such as the use of supplementary cementitious materials and recycled aggregates etc. are described.

Prescriptive criteria stifle innovation and leave little room for improvement. In the case of green point criteria they often leave out the obvious such as water binder ratio with no credits. It is essential that these systems be changed to a performance basis to encourage innovation and connect to LCA and other data (and thus to carbon accounting) and it is hoped that this article provides the stimulus. The route to greater sustainability is nowhere near as important as the direction and we do not therefore have to get the numbers exact.

In Australia early versions of our green rewards system such as those produced by the Green Building Council of Australia focussed on the use of supplementary cementitious materials and up to three (3) green star points were awarded in Mat-4 Concrete v2 if it could be demonstrated that the concrete to be used in a building construction or refurbishment that had a significant recycled content.

- 1 point was awarded where 20% of all aggregate used was recycled aggregate.
- Up to 2 points could also be awarded as follows:
  - 1 additional point where 20% of cement used for in-situ concrete and 15% of cement used for pre-cast concrete was replaced with industrial waste product
  - 2 additional points where 40% of cement used for in-situ concrete and 30% of cement used for pre-cast concrete is replaced with industrial waste product[8].

The current criteria for concrete are a little better. The first few lines of Mat-5 Concrete v3 read well "up to three points are available where the project has reduced the absolute quantity of Portland cement" but then the criteria falls into the trap of being prescriptive by stating "by substituting it with industrial waste product(s) or oversized aggregate as follows...." At least the role of oversize aggregate with less process energy was introduced and the role of recycled or slag aggregate recognised.

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[4] The Cement Sustainability Initiative (CSI) was formed by cement company members of the World Business Council for Sustainable Development to help the cement industry to address the challenges of sustainable development. Its purpose is to:

- explore what sustainable development means for the cement industry
- identify and facilitate actions that companies can take as a group and individually to accelerate the move towards sustainable development
- provide a framework through which other cement companies can participate
- provide a framework for working with external stakeholders

Following a period of reporting a number of "task forces" were established to move the agenda forward. More information can be found at the Cement Sustainability Initiative (CSI) website.

[5] http://www.tececo.com/document.conference_papers.php

[6] http://www.tececo.com/document.politics.php

[7] http://www.tececo.com/document.newsletter.backissues.php, particular newsletters 62 and 66.

[8] For example fly ash or ground granulated blast furnace slag.

Given the contribution of the built environment to emissions and that concrete, currently considered as part of the problem could become part of the solution; the need for change is urgent. A target rather than a prescription will not only clearly encourage urgently needed innovation, but make it easier to establish benchmarks and eventually link to the number crunching required for calculating carbon offsets and huge potential for profit through carbon trading.

When putting the need for a change in the way standards are written and green points are awarded in the context of the concrete industry it is important to note that there are some obstacles to implementation including the low level of skills in the industry. There is also a problem with units such as tonne to the tonne (tonnes $CO_2$ or C per tonne of material) as we live in 3D space not in 50 or 100 tonne buildings! Accounting for carbon in terms of 3D space is unfortunately however not suitable for some structures such as roads so I suggest composite measures may be appropriate depending on the contribution of a material to the design objectives of a structure. More research by competent people is required in this area and this may only be achieved through the co-operation of all the professional bodies involved.

The current emphasis is generally on substitution, not on the total cement used relative to aggregates and or properties which are more relevant such as strength and durability. There are many other ways to reduce the binder:aggregate ratio other than by substitution with fly ash or slag such as placing drier concretes or using high range water reducers as suggested by Mehta [5] in his recent article. It follows that prescription is inadequate on its own and targeted objectives would be much more useful. On the subject of properties durability also contributes significantly to sustainability and is not currently addressed at all even though Hawken pointed out its role in his book "The Ecology of Commerce" some years ago now [9]. An approach that encourages innovation, the recognition of a wider range of properties other than just strength and the development of new binders such as geopolymers and other innovative new cements such as carbonating Eco-Cements is required.

To further understand why performance based criteria should be mandatory for both permissions and rewards criteria consider the hierarchy of means by which concretes as we know them today based on Portland cement as well as new and innovative concretes such as Eco-Cements and geopolymers address the sustainability objective and could be further improved.

**Table 1 - Ways to Improve the Sustainability Performance of Concrete**

| **Methods:** | **Example:** | **Estimated Possible Improvement:** |
|---|---|---|
| Change fuels | Burning genuine waste that does not result in emissions of other gases. Using non fossil fuels | 10% - 70% |
| New kiln designs such as the TecEco Tec-Kiln can capture $CO_2$ and other gases | Split lime manufacture from clinker manufacture and calcine in a closed system without releases using grinding energy for calcining. Using the TecEco Tec-Kiln especially in the context of Gaia Engineering[12] | 10% - 90% |
| Improve efficiencies. | Wet to dry process for PC manufacture etc. | 10-20% |
| Change proportion minerals [9] | e.g. More aluminates less alite ($C_3S$) in Portland cement | 5-15% |

[9] The different minerals commonly found in hydraulic cement have varying pryroprocessing energies, grindability etc. At the present time for Portland Cement for example some companies are now reducing the alite (C3S) content and increasing the faster setting aluminate content (mainly C3A) resulting in lower kiln temperatures and thus less process energy.

Other than eco-cements and carbonating lime mortars that set by carbonation and therefore have a clear advantage there are a number of other novel cements with intrinsically lower energy requirements and $CO_2$ emissions than conventional Portland cements that have been developed including high belite (C2S) and calcium sulfoaluminate (C4A3S) types as shown in the table below.

| | | |
|---|---|---|
| Make cements containing more supplementary cementitious or pozzolanic materials. | Cements containing up to 60% fly ash and even higher proportions of ground granulated blast furnace slag or both can be used | 20% ~ 80% depending on the formulation. |
| Use alternatives such as geopolymers[10] | Geopolymers can have less than 2/3 the embodied energy of Portland cement concretes depending on whether wastes are used or pozzolans have to be manufactured. | 40% ~ 80% depending on the context. |
| Use alternatives such as TecEco Eco-Cements | If the magnesia for Tec or Eco-Cements is made in the TecEco Tec-Kiln they can have very low embodied energies[11]. | 50% ~ 150% depending if in the context of Gaia Engineering[12] for Eco-Cements [13] |
| Use of high range water reducing admixtures | High range water reducing admixtures can reduce water in concrete mixtures by 20 – 25% which can result in a corresponding reduction in cement usage [5] | 20 - 25% |
| Air entrainment | Air entrainment reduces water and thus binder required. | 5 - 15% |

| **Compound** | **$CO_2$ released through decarbonation in producing 1 tonne (tonnes $CO_2$/tonne Compound)** | **$CO_2$ potentially recaptured in a permeable concrete or mortar– tonnes $CO_2$ per tonne Compound** | **Net Emissions (if no capture– tonnes $CO_2$ per tonne Compound)** | **Net Emissions (if capture for MgO and CaO only – tonnes $CO_2$ per tonne Compound)** | **Example of Cement Type** |
|---|---|---|---|---|---|
| MgO | 1.09 | 1.09 | 0.00 | -1.09 (net sequestration) | Eco-cement mortar |
| CaO | 0.78 | 0.78 | 0.00 | -0.78 (net sequestration) | Carbonating lime mortar |
| C3S | 0.578 | 0.289 | 0.289 | Not feasible technically yet | Alite cement |
| C2S | 0.511 | 0.255 | 0.256 | Not feasible technically yet | Belite cement |
| C3A | 0.594 | 0.00 | 0.594 | Not feasible technically yet | Tri calcium aluminate cement |
| PC | 0.54 | 0.27 (variable) | 0.27 | Not feasible technically yet | Portland Cement |
| 1PC:2MgO | 0.99 | 0.817 | 0.173 | -0.817 (net sequestration) | Eco-cement with no pfa |
| 1PC:2MgO: 3pfa | 0.445 | .367 | .077 | -.367 (net sequestration) | Eco-cement with pfa |
| 1PC:2pfa | 0.27 | .137 | 0.137 | Only feasible for the MgO component | Very high fly ash cement |
| .05MgO:.95 PC:2pfa | 0.18 | .092 | .092 | Only feasible for the MgO component | Tec-cement assuming 1/3 (.334%) less binder required. |
| C4A3S | 0.216 | 0.00 | 0.216 | Not feasible technically yet | Calcium sulfoaluminate cement |

[10] Geopolymers use about 60- 70% less energy than Portland cement as long as fly ash remains a waste and the energy involved in making artificial pozzolans like fly ash is accounted for in relation to another process such as power generation. In some countries such as Canada this is no longer the case.

[11] The manufacture of magnesia using the TecEco Tec-Kiln solar kiln with carbon capture has very low process energies. More information on our proposed method of manufacture is to be found at http://www.tececo.com/products.tec-kiln.php.
[12] http://www.tececo.com/about.gaia_engineering.php
[13] http://www.tececo.com/products.eco-cement.php

| | | |
|---|---|---|
| Use air as an aggregate as it has low embodied energy, low weight and results in lower conductance. | Air is a good cheap lightweight low conductance aggregate. | Variable |
| Improve particle packing | More precise particle packing reduces the amount of binder required. | 15- 25% |
| Use of oversized aggregate | Large stone has lower embodied energy and makes concrete go further. | Variable |
| Use recycled, local or waste aggregate | Use of recycled aggregate | 5-10% |
| Use less concrete is structures through better design and quality especially durability. | Through better design less concrete of possible greater strength and certainly greater durability may be used to produce the same 3D space. | 15 - 30% |
| Change placement method. | Dry placing a hydraulic concrete and compacting it into place reduces the water binder ratio allowing significant reductions in binder for the same strength. Logistical embodied energy is also reduced. | 20 - 30% |
| | Various other alternatives include the use of algae. | ~20 - 30% |
| Use man made carbonates aggregates as in Gaia Engineering[12] | The more $CO_2$ that can be locked away as stable carbonate in the built environment the better. | ~>100% |
| Carbonate ordinary premix concretes | This can be done by using magnesia and is the subject matter of a patent pending | ~30% |
| Increase specific heat capacity through choice of aggregates | Some minerals have much higher heat capacities than others and could be included as aggregates. | Variable |
| Use materials as aggregates that have low conductance | Materials such as sawdust or pumice included in concretes as aggregates reduce conductance | Variable |

The above table is not meant to be inclusive[14]. It does however demonstrate that around 80% improvement in sustainability is easily achieved through reduced embodied energy and emissions as well as improved lifetime energy performance.

Like sustainability, standards should consider and green point systems should define a direction rather than a destination, they have to be in focus with rewards and environmental stewardship and at the top of a pyramid or point of an arrow with all possible methods of achieving the direction underneath or behind. So that the permissions can be connected to rewards it is important to consider the objectives in common with the objectives of environmental stewardship which should be green advocacy and government policy. Rewards such as carbon offsets must as a result of the coalescence of objectives be easy to determine. LCA fundamentals such as embodied energies and emissions should be the basis of rewards and one of several measures for permissions. Other criteria for permissions may include strength, durability and other desirable parameters for a particular material type such as R rating. Diversions in objectives should be allowed for permissions to encourage innovation and for special uses but clearly stated. e.g. strength (if an objective) may be deliberately compromised for light weight and insulation. As technologies improve through the resulting innovation targets like embodied energy and emissions can be raised. The effect of materials on lifetime energies is important but a harder concept to fully incorporate in any system.

The author has for at least the last ten years argued that what is required are changes in technical paradigms that result in less damaging molecular flows. Only innovation can achieve this and there are many examples such as the development of neon and now diode lighting that results in much lower energy consumption for the same lux[15] output. At the present time the use of prescriptive criteria by green organisations such as the Green Building Council of Australia (GBCA) for encouraging green procurement and building does not foster innovation, and neither did the proposed CPRS. As the most

[14] Any suggestions or ideas for the improvement of the table or the article generally welcome.
[15] A unit of illumination equal to 1 lumen per square meter; 0.0929 foot candle.

important agents of change it is therefore fundamental that the above organisations rapidly come to grips with the need for innovation to redefine resource use[16] and hence impacts and to redefine their ratings systems and policy accordingly.

In relation to concrete, John Phair was right when in his 2006 paper he said "Growth in the codes, standards, guidelines, training and certification programs will play a significant role in the development and acceptance of alternative cements. An emphasis-shift to long-term cost-benefit analyses and performance- based criteria for designing concrete will result in the selection of a cement for a particular application and promote the selection and familiarity of alternative binders."[10].

## Summary and Recommendations

This article is an attempt to give considerable direction to the changes required to our rewards and permissions systems for better environmental stewardship. It concludes that there is an urgent need to improve rewards rating systems and standards, approvals systems and other permissions generally and particularly for materials such as concrete [17] by making them performance based. By being prescriptive it is only possible to define known ways of improving concrete or any other method or material for that matter; new innovative ways are *a priori* excluded.

Using Table 1 as an example for the concrete industry a simple summation of the possible reductions in embodied energies and emissions and improvements to properties that impact on lifetime energies by using a combination of new cements, technologies and techniques can be assessed and demonstrate that it is possible to easily achieve at least 80% improvement. If clinker manufacture was separated from lime manufacture and lime was made using without releases, Portland cement itself could have much lower embodied energies and emissions and given the use of man made carbonate aggregate in the context of Gaia Engineering[12] concrete made with it could even be a net carbon sink.

It is time that the Concrete Institute of Australia became more active in this area. Although there are no Australian statistics that the author is aware of a recent survey of the membership of the ACI reported that 77% of members thought that sustainable design and construction will become increasingly important[11]. A similar result would most likely be the case in Australia and so the Concrete Institute should liaise with the other materials organisations in the building and construction industry which use most of the materials produced to develop the concepts presented in this paper. Such co-operation is essential if we want to solve the problems of global warming and waste.

A source of information like a materials Wiki funded collectively by the organisations concerned and to the extent possible through grants and other Federal and state government assistance would overcome the difficulties where the quality of the information available depends on the price paid.

It is also important that those involved in the building and construction industry put forward a united view in relation to other supporting initiatives including government procurement and support of research and development, and imperative if the substantial government assistance that is required is to be obtained.

## Appendix 1 - Carbon Accounting

The World Business Council for Sustainable Development and World Resources Institute published guidelines that the Australian government seem to be following.

According to the methodology:

Emissions can be accounted for on a control basis at an organisational or financial level or equity basis as in consolidations

Everything must be accounted for at an organisational or equity level in order to apply incentives or disincentives, but at a national level double counting must be eliminated.

[16] The technical paradigm defines what is or is not a resource
[17] Gaia Engineering is term covering a total paradigm in which man made carbonate is made from seawater, brine or bitterns and $CO_2$ and used to construct the built environment. See http://www.gaiaengineering.com.

To help delineate direct and indirect emission sources, improve transparency, and provide utility for different types of organizations and different types of climate policies and business goals, three "scopes" (scope 1, scope 2, and scope 3) have been defined:

Scope 1
Covers direct emissions from sources within the boundary of an organisation, such as fuel combustion and manufacturing processes.

Scope 2
Covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation. Scope 2 emissions result from the combustion of fuel to generate the electricity, steam or heat and do not include emissions associated with the production of fuel.

Scopes 1 and 2 are carefully defined to ensure that two or more organisations do not report the same emissions under the same scope (i.e. so double counting can be eliminated at a national level).

Scope 3
Includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation. These estimates are provided for information only as in Australia Scope 3 emissions are not be required to be reported under the National Greenhouse and Energy Reporting Act 2007, but may be reported on a voluntary basis.

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