Greening Illinois

Abstract

Underlying all the “material” things we do on the planet are molecular flows in the global commons (our air and water) that are out of balance and polluted.

Unless we become proactive in not only reducing our net emissions and wastes of all kinds the planet will continue to become much less hospitable and eventually we will go the way of the dinosaurs.

Cities are out footprint on the planet and there is a lot we can do in them and surrounding areas to reduce our impacts on the planet. With a strong adherence to the principles of biomimicry and a willingness to explore new technologies we can continue to thrive more sustainably.

John Harrison will explore “material” solutions including a discussion about the significant role of eco-cements to not only sequester carbon and utilize our wastes but in a new streetscape provide porous pavements that will cleanse and reduce the rate of flow of water.

Keywords

Biosphere, built environment, geosphere, economics, supply, material, demand, value, impact, utility, economies of scale, legislation, sequestration, abatement, sustainable, sustainability, CO_2, concrete, embodied energy, lifetime energy, eco-cement.

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John Harrison has degrees in science and economics, is the managing director and chairman of TecEco Pty. Ltd. and is known around the world for the invention of tec, eco and enviro-cements. He is an authority on sustainable materials for the built environment, has been a speaker at many conferences and is committed to finding ways of “materially” improving the sustainability of the built environment.

The Past

A long time ago forests and grassland covered most of our planet. When it rained much of the water naturally percolated though soils that performed vital functions of slowing down the rate of transport to rivers and streams, purifying the water and replenishing natural aquifers.
Life was much simpler and humans lived harshly but in harmony with the planet. The waste from one plant or animal was the food or home for another and global systems were apart from the odd volcanic eruption, meteor impact or other cataclysmic event characterized by balance. The rate of climatic variation was slow and all was well with the world.

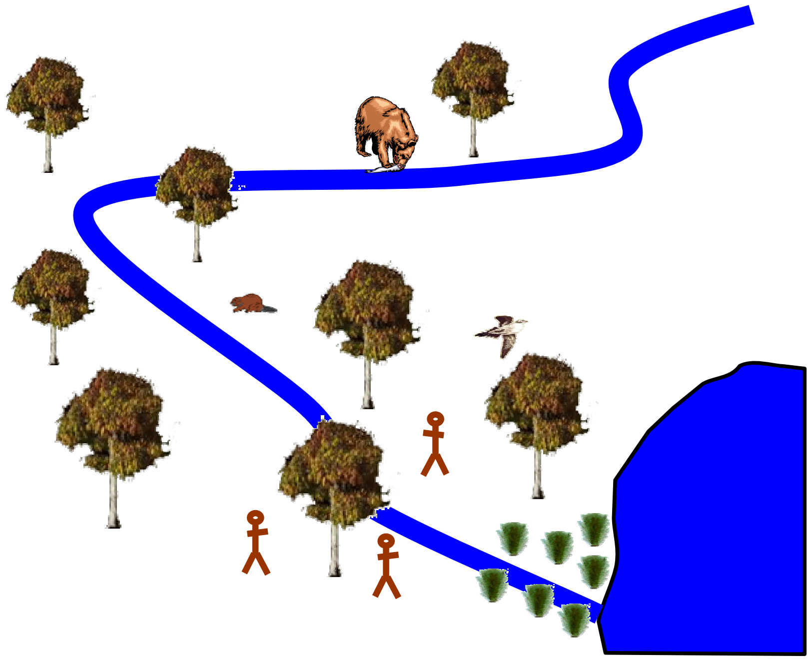

Figure 1 – The Past

The Present

We started to change earth systems a long time ago, perhaps when the village smithy belched smoke from his fires. The techno process really got going when James Watt invented the steam engine, somebody else said the black stuff you can move around in a barrel was better and we started our period of dependence on fuels which have not only resulting in the release of billions of years of accumulated combustible fossil carbon to the atmosphere in a just a few short years but driven techno processes that result in the pollution of the global commons.

We are cutting our forests down ruining our water sheds and then wondering why we are running out of water to supply our farmers and cites. Many of our rivers are no longer clear and some can no longer support life having become drains to our mines, paper mills and industries. The overuse of pesticides and fertilizers is affecting the ability of our soils to grow food and pollution is pervasive.

Our roads and drainage networks cover the land and conduct water away as quickly as possible without cleansing to the sea.

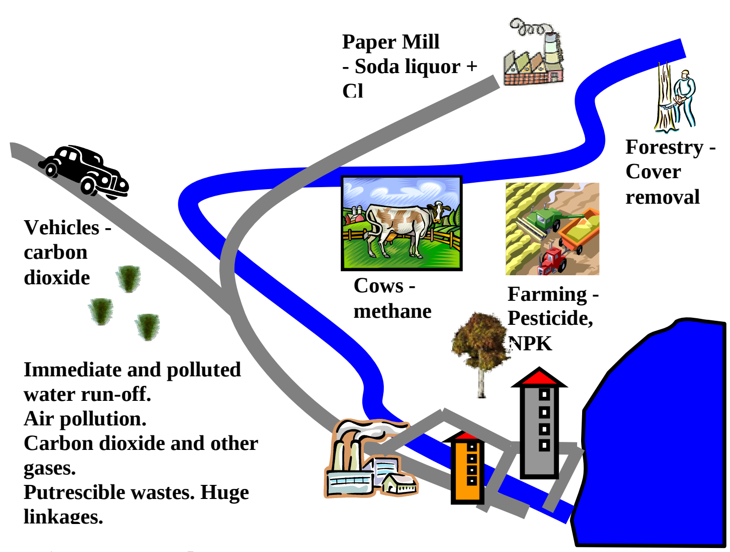

Figure 3 – The Present

The Future

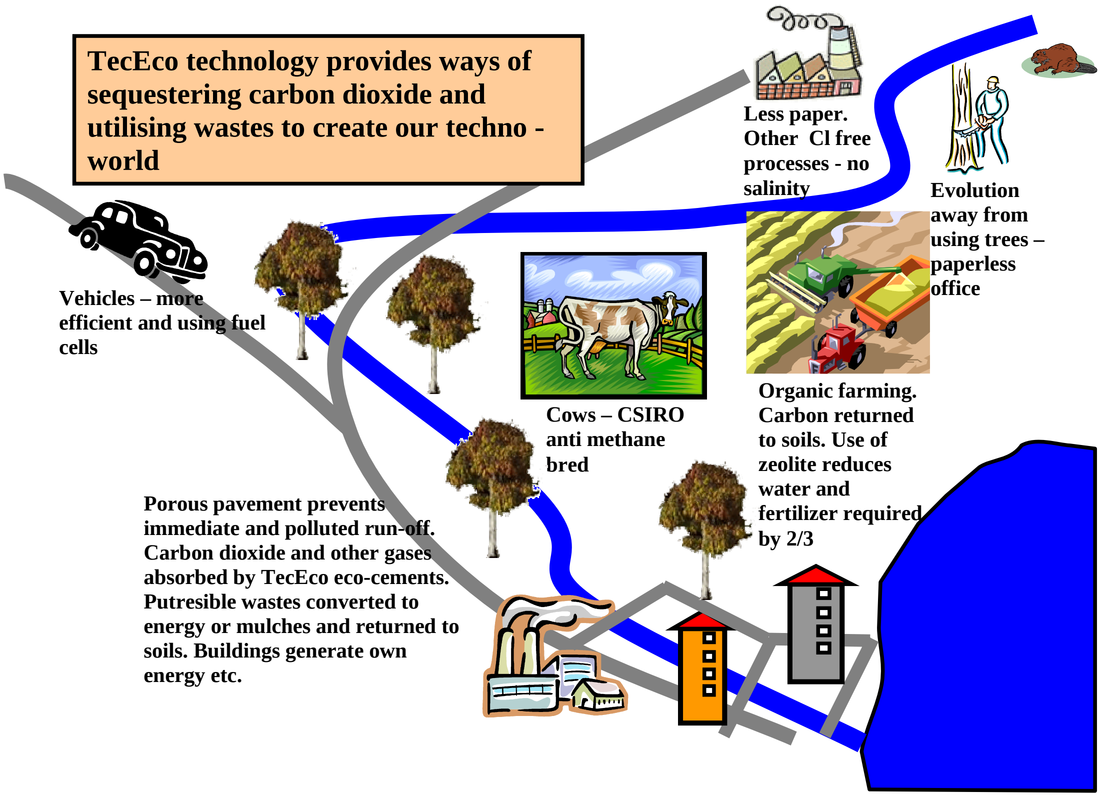

Figure 4 – The Future

“The concept of striving for sustainable development is not so much a ‘destination’ at the end of a road but like life, more a ‘manner of travelling’ (CICA, 2002)".

We can say however we are succeeding when our footprint is reduced, when trends are reversed such as the level of CO_2 in the atmosphere and when water quality, sanitation and other benchmark measures improve.

To survive we must live more sustainably and in harmony with the planet. We must understand the value of the “natural capital” it provides (Hawken, P., Lovins, A. et al., 2000).

As a way of explaining how we can meet the sustainability challenge let me follow a stream from the mountains to the river and eventually through a large city to the sea and explain some of the changes we must make to the way we are altering the environment to build ours.

Tree Cover

In the mountains and hills we must stop destroying trees which are the lungs of the planet and essential for the efficient capture of clean water in our watersheds or risk, amongst other perils, water crises as is occurring in Australia where I live in cities like Melbourne Sydney and Perth where the available water has dwindled significantly.

Do we really need paper? TecEco, my company, have been running an almost paperless office for some time. Maybe we just need more reliable software and computers and others will cross this boundary. If we used less paper we could chop down fewer trees.

Wood is the supreme example of a material engineered for after use. Yet we only get a little over one life out of it. Apart from having utility as furniture, a building component or paper, wood has calorific value for the production of energy or when mulched could return much needed humus (organic carbon) to our soils. We should either burn wood and wood product waste as a biofuel or return it to soil as mulch. At the moment much of it just goes up in smoke or to landfill.

Farming Practices

Our farming practices are ruining the ability of soils to efficiently deliver water and nutrients to plants. Instead of using more nitrogen fertilizers that pass straight through thin impoverished soils and pollute aquifers and rivers, we need to think about conditioning soils with organic carbon wastes which would in this manner do far more good than just being pumped out to sea, burned or worse, taken to land fill where they eventually become methane as is the practice in many countries.

To catch up on the past we need to be more efficient than nature and this may require the use of other soil conditioners like zeolites which are a naturally occurring abundant mineral that should also be considered as a means of reducing fertilizer use and water demand.

Dairy cows produce between 150g and 350g of CH_4 (methane)/cow/day or about 90kg CH_4/cow/year. The energy content of this methane equates to about 120 litres of petrol which means a 200-cow herd would produce enough methane (24,000 litres petrol equivalent) per year to run an average sized car for 10 years (Woodward, S., 2003). Reducing the methane generation of cows by adjusting the bacteria in their rumens, what we feed them and how we handle their wastes would not only result in more efficient milk production but less methane gas which is some 21 times worse than CO_2 as a global warming gas.

Cities

Moving down the rivers to our cities, I am pleased to see that architects in particular are doing a great job pushing the boundaries of design and planers are starting to understand how cities live and breath. Living in the same paradigms as the past will not however significantly change the future.

Emissions, Sequestration or Both

A significant problem is the emissions from vehicles; the affects are everywhere in the air but most noticeable in cities. We will not give our vehicles up in a hurry but fortunately they are rapidly becoming much more efficient and within a few years hybrids or hydrogen driven vehicles will hopefully become the norm. Even if we did give up our vehicles before we run out of fuels, power stations, planes and ships to reduce our dependence on fossil fuels, according to climate scientists global warming is already inevitable. Given this unlikely scenario and because carbon dioxide lasts for between 50 and 200 years in the atmosphere they predict that global temperatures will rise 0.5 degrees C from now to 2100 because of what we have already released to the atmosphere.

Although we must reduce as much as possible our releases of gases that adversely affect our atmosphere, it follows from the above that it is essential that we consider ways of getting CO_2 an other gases out of the air. Adding value to carbon dioxide and methane is one way to achieve this and why TecEco's eco-cement contribution is so important.

Eco-Cement Concretes

Eco-Cement is a new type of cement which incorporates reactive magnesia and concretes made with it are more environmentally sustainable. Wastes such as fly and bottom ash, slags etc. can be included for their physical property as well as chemical composition without problems such as delayed reactions. Eco-cement used to make porous concretes absorbs CO_2 from the atmosphere to set and harden and can also be recycled back to eco-cement. TecEco hope to make magnesia using solar energy in a new kiln that combines heating and grinding and captures CO_2, and given this production scenario eco-cement concretes have the capacity to become a huge carbon sink.

Making the built environment not only a repository for recyclable resources (referred to as waste) but a huge carbon sink is an alternative that is politically viable as it potentially results in economic benefits.

The idea of using carbon and wastes in building materials came from nature. During earth's geological history large tonnages of carbon were put away as limestone and coal by the activity of plants and animals building homes such as the shells of shellfish and wood in trees.

Figure 5 - Biomimicry - Houses of Carbon

These same plants and animals wasted nothing as food and nutrients moved around and the waste from one was the food or home of another. It was easy to conclude that the answer to greenhouse gas and waste was to use them both in building materials.

Eco-cements are made by blending reactive magnesium oxide with conventional hydraulic cements like Portland cement. They are environmentally friendly because in porous concretes the magnesium oxide will first hydrate using mix water and then carbonate forming strength giving minerals in a low alkali matrix. Many different wastes can be used as aggregates and fillers without reaction problems. The reactive magnesium oxide used in eco-cements is currently made from magnesite (a carbonate compound of magnesium) found in abundance. Down the track TecEco hope to make eco-cement using magnesite produced by power stations as a result of their carbon storing or sequestration activities.

Magnesia hydrates to magnesium hydroxide in any concrete but only in porous materials like bricks, blocks, pavers and porous pavements will it absorb CO2 and carbonate quickly. The greater proportion of the elongated minerals that form is water and carbon dioxide and they bond aggregates such as sand and gravel and wastes such as saw dust, slags, bottom ash etc. Eco-Cement can include more waste than other hydraulic cements like Portland cement because it is much less alkaline reducing the incidence of delayed reactions that would reduce strength. Portland cement concretes on the other hand can't include large amounts of waste because the Portlandite[1] causes delayed and disruptive reactions.

The more magnesium oxide in eco-cement and the more porous it is, the more CO_2 that is absorbed. The rate of absorption of CO_2 various with porosity from quickly at first to slowly towards completion. A typical eco-concrete block would be expected to fully carbonate (i.e. full absorption of CO_2) after a year or so. Eco-cement has the ability to be almost fully recycled back into cement, should the concrete become obsolete.

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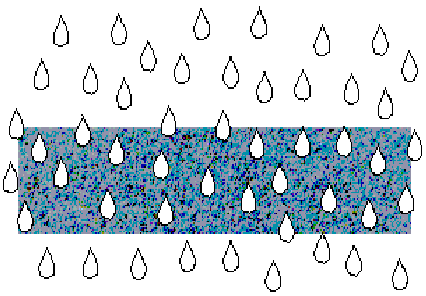
[1] alkaline lime that forms in concretes

Porous Pavement

The use of porous pavements will allow eco-cements to absorb the CO_2 they need to set. There are significant other benefits of porous pavements. Our legacy has been to pave the ground which had previously acted as a natural bio filter, redirecting the water that fell as rain as quickly as possible to the sea. Given global water shortages, problems with salinity, pollution, volume and rate of flow of runoff we need to change our practices so as to mimic the way it was for so many millions of years before we started making so many changes.



The use of porous pavements will reduce the overloading of our present drainage system, cleanse water before it enters aquifers or streams and rivers, improve safety, reduce maintenance on buildings due to seasonal ground movement and reduce the costs of watering street trees. Enlightened engineers around the world are seriously considering using porous pavements as a way of reducing run-off and improving safety. I believe porous pavements are essential.

Without porous pavements, reduced drainage areas bring more water into fewer drainage systems at a faster rate, eroding the banks of streams and rivers, and adding more sediment into the water. "If you increase an impervious surface near a stream by creating a paved parking lot, for example, you directly affect the quality of life in the stream because of the runoff that surface will generate" (Goetz, S. and Smith, A., 2001).

Researchers have shown that when 10 percent to 15 percent of an area is covered by impervious surfaces, the increased sediment and chemical pollutants in runoff have a measurable effect on water quality. When 15 percent to 25 percent of a watershed is paved or impervious to drainage, increased runoff leads to reduced oxygen levels and harms stream life. When more than 25 percent of surfaces are paved, many types of macro and microorganisms in streams die from concentrated runoff and sediments.

Figure 6 - Porous Pavement

Ideally a porous pavement should be made with stone aggregates and a cementitious binder[2] and be similar to concrete to handle and install. In cold areas it is important that the pavement should not trap water otherwise in winter the water would freeze and cause cracking. It is also important to detail a porous structural base and sub base for the pavement that has a high void ratio as this acts as a reservoir, and provide underground drainage as required.

The experience of many engineers is that with relatively minor control and maintenance clogging will not reduce the infiltration rate below a design rate within the lifecycle of the pavement. Why are we not thinking about porous pavement?

Hot City Syndrome

Ever walked up a pebble beach on a hot sunny day? The heat held by the stones can be unbearable! It’s the same in large cities. There are so many materials with high specific heat that during hot sunny weather and with no natural transpiration due to the fact that we have paved all the ground large cities just get hotter and hotter.

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[2] Because of the problems of bitumen as a carcinogen

As architects, engineers and designers of cities we need to come to grips with the macro impacts of the materials we use. Hot city syndrome is one of a number of man made phenomena that the use of porous eco-cement pavements will reduce. The solution is to let the ground breathe and porous pavements do this. Evaporation after all is still the principle behind many cooling systems – so why do we pave the ground and prevent moisture entering or exiting?

Factors for Sustainability

To survive the next century we need to rethink our technical paradigms. It is the technology that we are using that is delivering heavy metals and other pollutants, carbon dioxide, methane and other gases to the global commons. This is because underlying materials flows are molecular flows which are released to the biosphere geosphere through all stages of extraction, manufacture, use and especially wastage.

I have given two substantive examples of where changes in the technology paradigm would affect resource use as well as systems on the planet. An important characteristic of eco-cement and porous pavement given is that they are both potentially economic

We have to get each and every one of living out our lives more sustainably so that the direction becomes an every day process. In order to achieve this, doing so must increase the wellbeing of individuals in identifiable ways.

There are two key factors for success - political acceptability and economic viability.

In relation to global warming, politically sequestration is the most acceptable as it does not involve one person, state or country attempting to regulate the consumption of carbon by another.

According to Maria Atkinson of the Green Building Council of Australia the figure nationally of waste going to landfill from construction and deconstruction activities (predominantly the churn of refurbishments) was around 40% (Atkinson, M., 2003). The figure is similar for other industrialised nations

Landfill is the technical term for filling large holes in the ground with waste. Landfills release methane, can cause ill health in the area, lead to the contamination of land, underground water, streams and coastal waters and give rise to various nuisances including increased traffic, noise, odours, smoke, dust, litter and pests.

Figure 7 - Landfill - The Visible Legacy of not Recycling

Because the flow of unwanted or waste materials is affecting our planet, we need to consider not just our buildings but the wastes produced when we construct and deconstruct them. The solid wastes that are not incinerated generally go to landfill and pollute water courses and the local area. Liquid and gaseous pollutants are more insidious and spread invisibly in the global commons.

How then can we add value to carbon dioxide so that all of us recycle or sequester it? Can we as part of this process reduce landfill and incineration by utilising more other wastes?

Underlying economic processes are human behaviours. What this means is that if harnessed, human behaviour would deliver greater sustainability. If sequestration and waste utilisation on a massive scale was economic each and every one of us would be contributing as often as possible

Economics is both a servant and a master. Economic forces have been behind most wars and most people are slaves to economics, yet we can be the masters. Working for sustainability, market orientated forces will make all the difference as people would demand much more sustainable products.

Through technological change the supply curve would shift to meet what was demanded and eventually a new more sustainable equilibrium would become established (See Figure 8 below). The challenge is how to move the supply and demand of resources towards more sustainable outcomes.

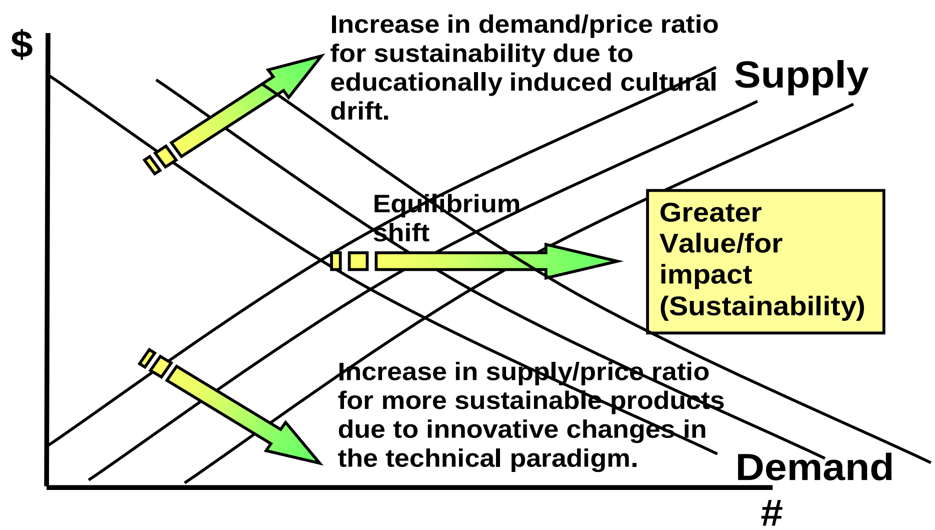

Figure 8 - Achieving Sustainability as an Economic Process

To move towards economically driven sustainability we need to:

- Get over the idea that we are helpless and can't do anything about the problem and understand that sustainability is good business.
- Culturally change. As individuals we should demand more sustainable products; as communities stimulate and harness human behaviours which underlay the demand for sustainable products. This can be achieved through cultural change push by the media, educationalists, governments and other leaders.
- Deliver sustainability by using new and innovative technologies. Eco-cements are one answer.

This conference is about sustainable building. Lots of people have talked about design, how one building has reduced lifetime energies just a little more than another. Architects in particular have done a very good job in improving the lifetime energies of buildings.

Materials the Key

The next frontier will be materials. We move some 5 or 600 billion tonnes of stuff around the planet every year, of this some 50 billion tonnes is actually utilised. Materials in the built environment are some 70% of this flow and represent significant opportunities for improvement to reduce the impacts of their movement through the supply chain on the environment.

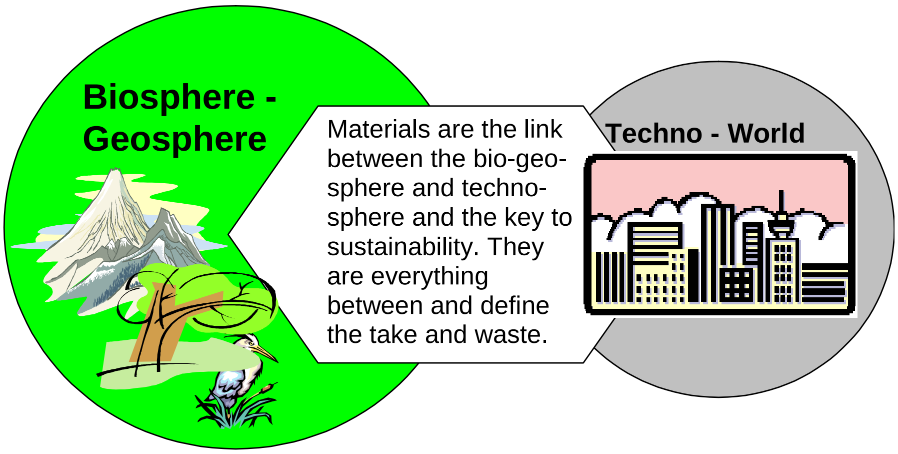

Figure 9 – Materials define the take and waste impacts.

By re-engineering many materials with after use in mind we can substantially reduce the high proportion mentioned earlier as going to land fill and therefore need to think about what our new more sustainable buildings are made of.

Conclusions for the Building Industry

To maintain perspective in the race to sustainability we need to understand more about how natural systems work and as much as possible mimic them in every way.

Materials will be pivotal in improving the sustainability of the built environment which is after all our footprint on the planet. By mimicking nature, letting water be cleansed naturally and finding uses for polluting and global warming substances such as carbon we can start reducing rather than increasing many of the problems of the planet.

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