Book Review:
The New Carbon Architecture: Building to cool the climate

Bruce King
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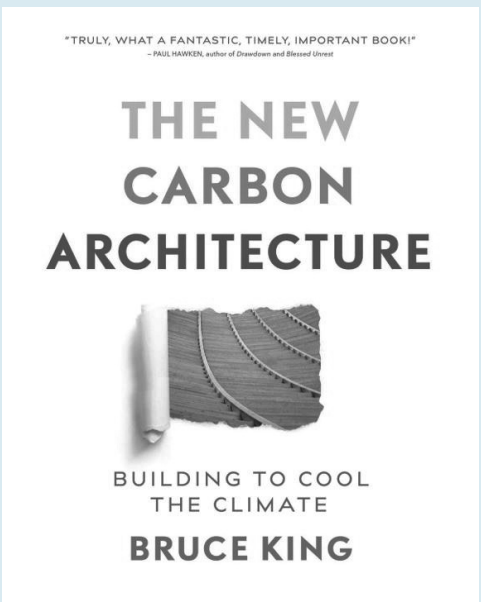
The review

The New Carbon Architecture was released in late 2017, and is the most recent book by this author. He also wrote many books about sustainable materials, such as Make better concrete, Building of Earth and straw, and Design of Straw bale building in 2015. It seems that his interest in Sustainability in construction materials has been for quite sometimes, even before the SDGs came to signing agreement in 2015. Bruce King is the author, whose background and practice is a structural engineer. He also brought up a great team that have been greatly co-authoring many portions of this book. They are a group of architects, engineers, many specialists in timber, sustainability, and innovative materials, Professor, researchers, and so on. From witnessing content of this book and other books, he seems to play a writing role as the active environmentalist, focused particularly on the built environment aspect. The style of writing has few technical terms, simple, and resemble storytelling, while no readers have to be architects and engineers, so they can understand. It resembles non-fiction genre, but is rather academic side.



The book title, New Carbon Architecture, may sound very Chemistry because carbon is the basic element of everything in this world, including buildings. Carbon is always a good substance, however it can turn bad if it is in the wrong place, such as Carbon dioxide (CO_2) or Methane (CH_4). The book discusses not only buildings to emit carbon, referred as

the operational carbon, but also about the entire building process not to create carbon at the first place, referred as the embodied carbon. This thinking out loud ideas are the proposal to new and future way of making architecture. The book has sub-entitled as Building to cool climate. Since, we all heard that global warming partially comes from building sector, this book is interesting enough to reveal how buildings are able to help cooling down climate. Answer can be found in this book that will turn around the result if the action plans and proposed ideas will be implemented. Author broke down the content into 3 major portions that I make my own judgement. Firstly, author provided background information on the Carbon, the emission, Zero energy concept, and why we should change the perception for future, that cover first two chapters. In the next 5 chapters from 3 to 7, author proposed new construction materials to make the carbon architecture. Author pulled great samples of alternative materials; Wood, Straw or other fibers, reinvented concrete, and bio-plastic. They are hoped to be the materials of future that can surely minimize impacts from carbon emission. Last portion is quite varied where he discussed the impact to health, if we do not do anything or make any changes. It is also where he suggested in turning these ideas to become real implementation, such as adopting technology, taking real action plan, and working towards the legitimated process to launch building codes and conducts. Overall, the journey of 176-page story telling is realistic and promoting self-awareness in built environment, so that it can motivate not just stakeholders in building industries, but also everyone who will make contribution to changes for future. This book is definitely not only a book shall be placed on the architectural section in library shelf, but it should be used as leisure reading for classes in basic education around the world.

This book provides many points and interesting contents; however the review will bring up some major important contents. Author started with good background of understanding of Carbon and the initiative to reduce carbon in greenhouse gases in the first COP meeting in Paris. The statistics show carbon emission has gone less and less, showing that global effort has been doing well. It is hoped for the world to have zero carbon emission in 2050. However, this is only the operation carbon, which is carbon to operate buildings. There is also the Embodies carbon that many people still do not realize.

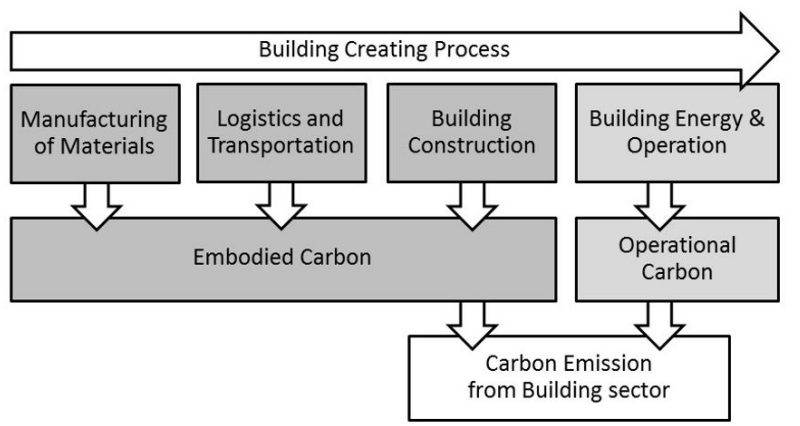


Figure 1. The entire Building creating process create both embodied carbon and Operational carbon, while embodied carbon is major, but seems to be less thought of, comparing with operational carbon.

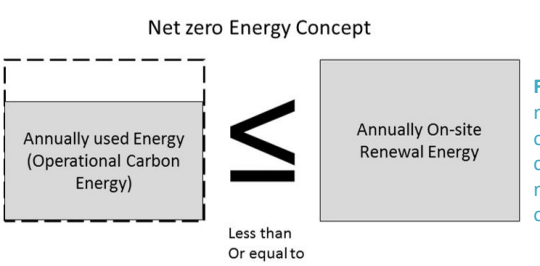


Figure 2. Net zero energy is rather referred to zero balance or less to operate energy comparing to amount of renewal energy that is doing on-site.

The importance of the Embodied carbon Design community, architects, and engineers are putting great effort and did a great job trying to design buildings using less energy and reducing environmental impact during building creating process. This evidence shows that carbon emission is decreasing. However, we are talking about the way we operate buildings, and that is only one mean of carbon contributions, called the operational carbon. Major portion of carbon production also comes from processes of how materials are manufactured, how materials are transported, and also how energy is used in construction process. This is called the Embodied carbon, and it has not been discussed much. Author wisely suggested that this embodied carbon needs to be brought on the table to look at. Later on, author suggested new perception of building materials that reduce the embodied carbon, such as less manufacturing materials and more natural, materials requiring less transportation, etc.

Net Zero Energy Building is not really using zero energy

When design community is trying to aim the design of Net Zero Energy (NZE) building, the misperception is that buildings are using no energy that does not seems possible. Author defines a Net Zero energy building is rather an energy-efficient building where, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

It is seen that the embodied energy is not included in the picture, and transportation energy and other components of energy as well. This NZE concept also ignores the embodied carbon, while author thought that operational carbon is still much less that the embodied carbon that I also agree. Setting goals for Net zero to embodied carbon seems to be more urgent to do.

Carbon from Construction materials

The discussion on new concept of construction materials seems to be the highlight of this books, where he proposed many material ideas to accommodate less embodies carbon and operational carbon. Due to modern days, building materials are commonly used concrete and steel in the concern of their strength and workability, however in the environmental stand point, we are rather looking into the index of the Embodied Carbon Coefficients (ECC), expressed as emissions per unit weight, steel has the worst ECC which is 1.5 $kgCO_2e/kg$, while concrete and lumber are 0.15 $kgCO_2e/kg$ and 0.1 $kgCO_2e/kg$. They are 150% less than steel. It seems that concrete and lumber create embodied carbon quite similar in quantity, but if we look at 1 kg of material, concrete and lumber are largely different in quantity. That is why author trying to suggest construction material to go more naturally, especially wood, straw, other fibers, clay, etc. If materials' strength is the concern; reinvented concrete, polymer like plastic can be reconsidered. This way we can seek appropriate technology to make it happens.

Wood or Timber

We all know that trees are absorbing carbon and also produce cooling environment, which seems to be the subject of this book that we should build buildings that cool the climate. This book indeed really put emphasis on wood or timber to be the ideal material for the future. Author pulled the result from Life Cycle Assessment (LCA) study of construction material that show timber is reducing carbon significantly in the entire process from the growing trees to the installation in buildings, while concrete material is in the opposite that is rather providing carbon emission to create climate warming, from left diagram below.

The proposal to use timber quite makes senses and positive, however in reality it is still hard to do and can create negative impact if not done properly, from right diagram above. Timber can be good carbon under the particular condition, such as tree growing in restricted environment, by FSC as example, and also will be better if acquiring timber within local distances. However, it is clear that the material is good, but it is unclear how it will be used, which will depend on adaptability of each project, such as integration or hybrid materials. Author also suggested manufactured wood, but also come with consequences of manufacturing process, glue as extra additive, indoor air quality effect, and so on. Bring more timber is great, but still will need more well-rounded effects.

Straw and other fiber

Author seems to be in favor of using the straw material, since he also wrote another book particularly about this material. Straw is the production of the world because we grow these plants, such as wheat, rice, oats, and barley, to eat their seeds, so straw is the remained stems left after the harvest. We all eat their seeds, so most part of the world have access to it. Author claimed that straw has superb quality in CO_2 bio-absorption, instead of releasing carbon like other materials. He does not limit to

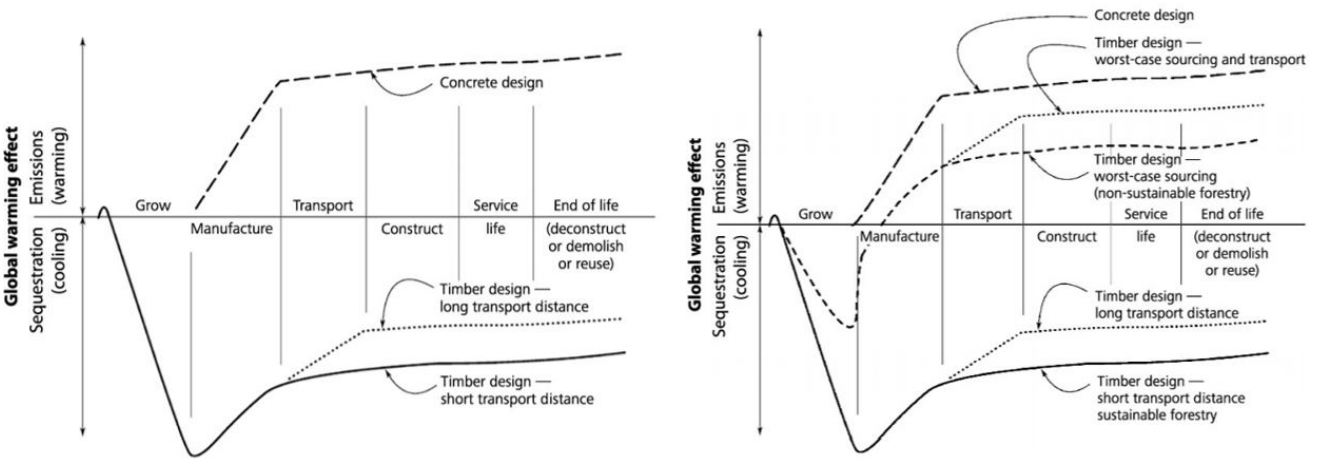


Figure 3. (left) Timber can help cooling climate, comparing to concrete in the opposite, studied by author in the carbon emission of materials' life cycle; (right) However, further study shows if timber design is not managed properly, it can produce worst carbon impact.

only straw, but other crops or fibers that human grow can have similar absorption quality as well. Straw also can benefit building construction in 3 advantages; being lightweight, hollow and strong stems, and abundant. It is a nice idea that turn agricultural waste into something more useful that is also to absorb carbon, rather than destroy them to produce carbon. Author brought the term "sequestered carbon" as the carbon that embedded in the material itself and not releasing to the atmosphere. This is considered negative carbon emission and is quite a character of plant-based fiber materials. That is why opportunity is not limited to straw, but also hemp, cork, bamboo, etc. However, these fiber materials are not definite to be only fiber boards or insulation. It requires more research, innovation, and testing to create interesting materials and fit current trends and applications. That allows future development to bring up backyards waste into building materials that will less impact to the environment.

Reinvented cement

We all know that concrete is one of the most carbon problems because it comes from cement and aggregate that require much manufacturing process, especially cement. Each material in concrete is doing their own duty. If problems in carbon cement, we can look into cement that it gives the bonding function in concrete. To alter the way we create concrete, we must understand that concrete uses similar old-fashioned method in history, such as adobe, clay, and rammed earth. In this sense, clay may be the first cement used in history. Author interestingly suggested to create clay concrete instead, since they serve the same function. There have been researches from many distinctive universities to produce alternative cement called Limestone-Calcined Clay Portland cement (LC3). LC3 is composed of gypsum (50%), calcined clay (30%), and limestone (20%). LC3 is proved in lab to gain their mechanical properties similar and more durable to Portland cement. LC3 offers the CO_2 emissions reduction by 25–35% during manufacturing. LC3 may not be new to environmental people, but for concrete industry. It will still be the challenge for the construction industry to accept this new alternative low embodied carbon cement. The variation of clay cement used can be multiple ways, not limited to only concrete, which can maximize the benefit of this innovation. Concrete blocks, mortar, plaster are as such.

Bio-Plastic

Plastic is integrated to human life by making everything so terrific that we do not realize. In environmental stand point, plastic is horrific because most of them

are non-degradable, synthetic, ocean-life threatening, and using fossil fuel as its resources. Plastic may not be major part of building construction, but many small components and systems in buildings are made of plastic, especially packaging to transport. Author discussed bio-related materials, such as timber, wood, straw, clay, so why not bio-plastic. Bio-plastic is in the hope that are made from corn or other commodity crops, sometimes are referred as the regenerative agriculture. That means they are types of farming practice that preserves soil rich in organic matter, in which carbon is sequestered. Author also suggested turning GHG into plastic as a way to already reduce carbon. Though, they are still in experiment but existing, such as polyurethanes partially made from CO_2 and PHA plastic from waste methane. Plastic has particular characters that are suitable for construction. The initiative is great, but still ongoing experimenting.

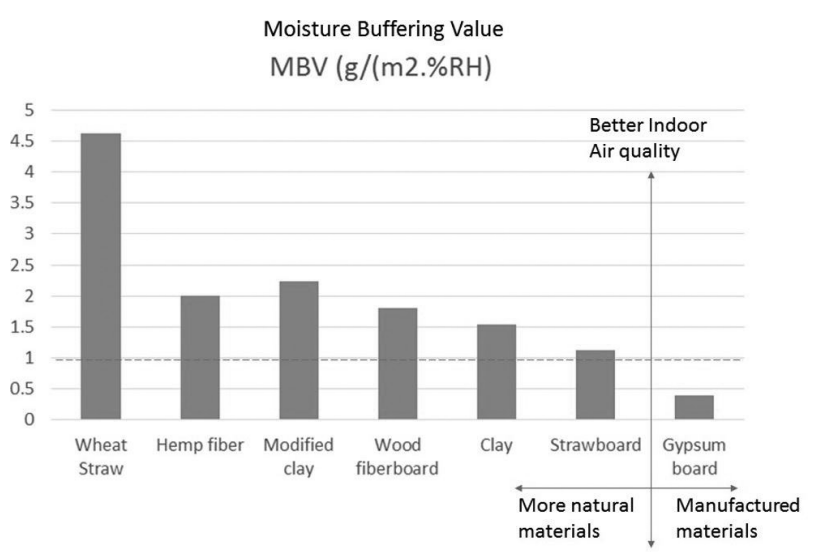


Figure 4. Comparison of MBV of natural materials that offer much better indoor air quality than typical manufactured material, leading to better human's health impact.

Simultaneously, we are trying to seek alternative plastic, the reused and recycled plastic campaigns are also ongoing, and the statistics shows that human is still not doing well in plastic recycling. Only 10% of plastic in the US. got recycled. In addition, we have admit the fact that reuses and recycling are not an easy process because they require collecting and manufacturing process. Agreeing with author, both initiatives, bio-plastic innovation and existing recycling plastic campaign should be running in parallel to make the difference in carbon emission.

What is on next step?

In the last 4 chapters of the book, author discussed on why we are doing this and how we can get there. Surely, the effort on searching for new carbon architecture are not only for zero-aiming carbon emission for less global warming, but also benefit directly to human's health. Simply more natural-based materials will make positive impact to users, especially indoor air quality because human spend 90%of their time indoor. Construction materials have effects directly on indoor air quality. The discussion is focused on VOC and moisture. Author convinces us that natural building materials, such as clay, wood fiber, straw, and timber, are considered the hygroscopic materials. They can adsorb and desorb water vapor from the surrounding air, so they beneficially can regulate the indoor moisture, called Moisture Buffering. They were indexed by moisture buffering Value (MBV), of which the more the better, see comparison in figure 4.

Captures of moisture in interior can slow down the process of material deterioration and decomposition, so that air will be less contaminated with VOC, toxic fumes, radioactivity, and dust, in comparing with fossil fuel manufactured materials. With so many health benefits to alternative carbon materials, they can raise awareness and expedite the initiative to adopt these new perception easier and sooner.

Author discusses the sizes of carbon architecture that should be mediated. Basically, it should be down in height or scale. The larger components are good, but will hard to manage. Small buildings are skin-dominated while tall buildings are rather internal load-dominated. A new design approach shall be the balance or middle ground between internal loads and enclosure loads. If breaking down tall or large buildings into smaller components, carbon energy can be manageably in control and balance.

Global warming also occur because of the development of technology. The greenhouse gases are also the product of the development, but we also cannot live without technology. Another proposal is to use more advanced technology to solve problems from technology. Author suggested many invention of future materials that may require scientific approach. It is possible that design community may have to be investing in innovative technology, such as Nano technology and Biomimicry, when we are dealing material sciences. It is indeed that architectural education in the future may not only involve design and technical aspects, but also integration of technology applications.

What the Action plan should be is the question. This discuss is out of the picture of building development, but it is rather about how what is thinking can be the incentive or the mandatory thing to do. LEED has become one of means to encourage having more green projects, but it is only for recognition. How future buildings must be carbon architecture, not can be. Author suggested mechanism of enforcing codes and regulation and providing tax exempt for permits as incentives. I doubt it will work, but it is better than nothing. In my opinion, I also agree, but I think further that the idea of providing knowledge and education of this carbon radical to basic education in global level will help. It may not only benefit the architecture subject, but can be integrated to all discipline, that later on all development are sharing the same goal in a holistic approach.

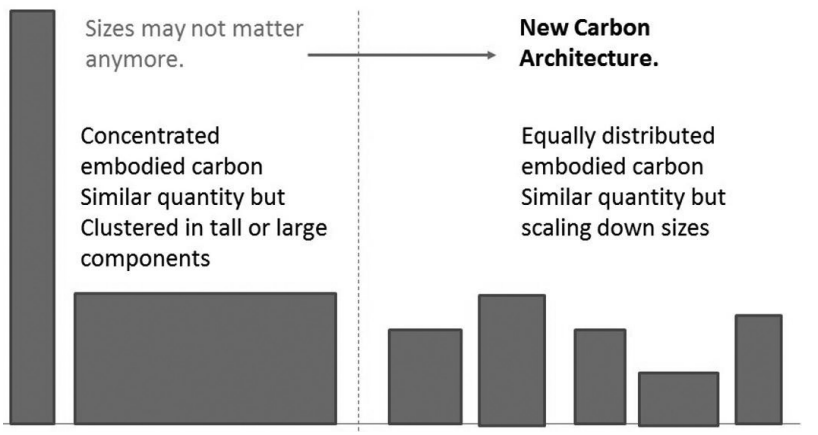


Figure 5. Future carbon architecture may need to be broken down to smaller components, so the embodied carbon is not concentrated and in scale that is much easier to manage.

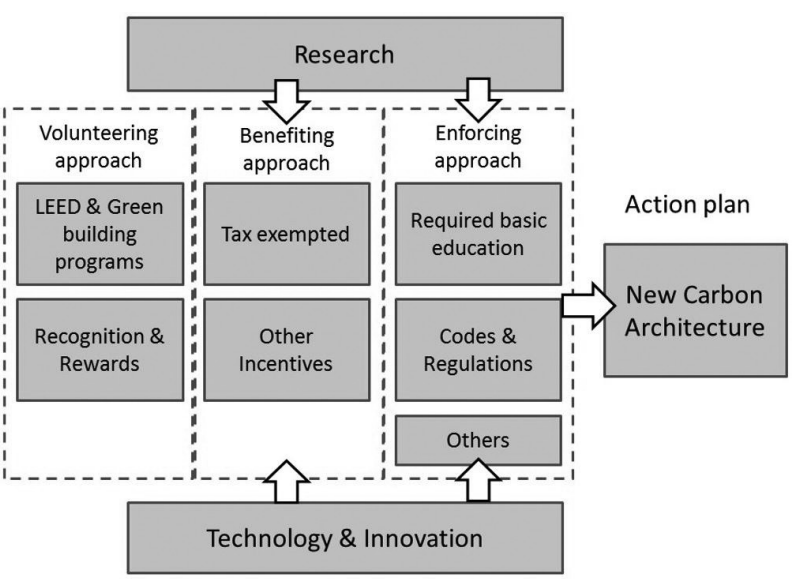


Figure 6. Action plan working towards future of having New Carbon Architecture

Last Wrap up

Overall, the journey through the New Carbon Architecture book is quite pleasant. It is where the technical reading with scientific evidences and everyday reality meet. All the statistic information and citation are reliable and valid. Combining with co-authors from variety of different fields providing the substantial endorsement to the writing, the book offers another levels of its gravity. It is a mindset changer of how future of buildings should be. It is not something like in futuristic movies, but rather buildings are responding to basic environment preserving. Buildings will be using technological advanced materials that create less or zero carbon footprint, if possible.
I agree with author mostly in guidelines of future building and materials should be. We are all in the same page to take serious action on carbon absorption or sequestration, rather than releasing them. Again, I do not see this book only presented itself as the architecture book in the library, but it can be a research reference book, non-fiction book for pleasure reading, or even a coffee table book. It is also recommended that book shall be used for schools in primary education, so that when students are grown up, these ideas and materials will not be foreign to them, because new carbon architecture and concept will surely be on its way.