# DEVELOPING A STRATEGY FOR 'LIVING BUILDINGS': BEYOND CRADLE TO CRADLE WITH LIVING BUILDING CONCEPT

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Quite often construction has been blamed for being unsustainable, causing high levels of waste, carbon emissions and use of resources. As in other industries, there is an urgent need to face the challenge to increase the performance of buildings. This urgency has been embraced by McDonough and Braungart (2002) in their book 'Cradle to cradle: remaking the way we make things'. The idea of cradle to cradle (C2C) is to pursue the 'right kind' of growth, and the key to that is better design of the things we make. The Living Building Concept (LBC) shares the same objectives of C2C stressing the need for good design and changing the way we build. In addition LBC offers a strategy how to apply these objectives in practice, increasing the benefit of buildings for suppliers as well as demanders, and society as a whole. The strategy is aimed at keeping built objects 'fit for purpose' and 'up to date' continuously by applying new technologies and insights for improved performance and sustainability. The strategy implies an integrated approach to the procurement and delivery of built objects. This requires construction clients as well as companies to revise their own strategies too. Clients need to revise their procurement and contracts allowing and challenging construction companies to supply integrated and sustainable products and life cycle service. Construction companies must become integrated suppliers for living buildings applying rules of product development, and the construction sector as a whole to become a 'normal' consumer products industry delivering new products fitted out with the latest technology to its customers. This paper squares LBC with C2C, and indentifies areas where LBC can add to translate the shared objectives of both concepts into an integrated strategy to achieve 'living buildings' and even 'living cities'.

Keywords: business model, cradle to cradle, construction, living building concept, sustainability.

## INTRODUCTION

The 'green performance' of the construction industry has often been subject of criticism. For instance, in the Netherlands, the contribution of the construction industry to the GNP is about 11%. The negative effect on environmental issues of construction and operation of buildings and structures is disproportional. The contribution of the industry to the national figures, are impressive: 45% of the energy consumption, 45% of the carbon emission, 35% of the waste production, and 25% to the total road transport (Lichtenberg 2006).

This poor performance is the result of the structure and culture of the construction industry. Three specific factors play a dominant role. The first factor is the

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fragmentation of the construction supply chain. Subsequently, the client determines the quantity, the architect determines the form and the technicians determine the quality. The players acting after the architect are allowed to work out the design of the architect and are selected on lowest price. In result, the buildings are suboptimal. The quality of the buildings is not what it could be when the supply chain works together on product development. Product development is only encountered at component and element level.

The second factor is that buildings are unique, one shot fabrications with a long technical lifetime. Unfortunately the world inside and around buildings changes faster than the buildings itself. These changes refer to demography, social behaviour, technology, regulations, climate, financial conditions, availability of resources etc. The static buildings can not cope with societal dynamics. The technical lifetime is substantially longer than the economical lifetime. In other words, the economical value degrades faster than the technical value. In fact, buildings are built with yesterday's technology and today's ideas for tomorrow's people. In most cases a series of interventions will be carried out during the lifetime of buildings to keep them fit for use, up to date and provided with state of the art technology. The effect of the interventions decreases in time. In other words, the older the building, the harder it is to upgrade the functionality (Figure 7). The interventions during the lifetime of buildings and structures in most cases are carried out with new materials and components. The removed components are considered as waste material, which can only be 'down cycled'. These interventions and also the eventual demolition of a building is a significant contribution to the poor performance of the construction industry with respect to environmental issues.

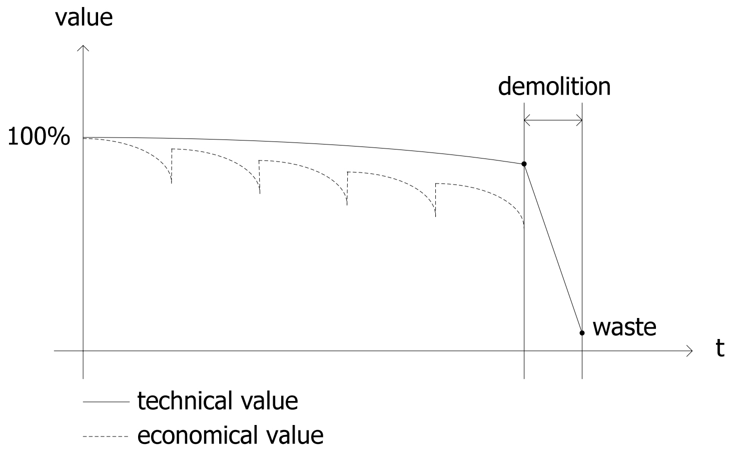


*Figure 7: Interventions in order to keep the buildings fit for use*

The third factor is that buildings are built as monoliths. All components are welded, poured, glued, sealed and cemented. This makes the building hard to change. These changes however are necessary to keep the building fit for use and up to date. There is no reason to assume that either the above figures or the factors behind these figures are significantly different for other countries. As the world on the one hand changes faster and faster where on the other hand there is a trend that contracts for construction cover longer periods with fixed output specifications, the above figures can be expected to become worse in the next decades.

With the introduction of the Cradle to cradle (C2C) philosophy, McDonough and Braungart (2002) have pointed out an important way forward towards sustainable building. In addition, the concept of "Living Building Concept" (LBC) offers a strategy to apply C2C to construction. The main aim of LBC is to resolve the difference between the shorter economical lifespan and the longer technical lifespan of buildings. The emphasis is on building parts instead of buildings as a whole, and the possibility to replace and reuse building parts for other buildings. Buildings and cities then become 'living organisms', which as such slowly age, but on the level of the 'cells' constantly renew and adapt to new circumstances and requirements. This paper aims to explain the basics of the LBC approach and give an outline of the LBC strategy to apply the concept to the demand and supply of built objects, and the built environment as a whole.

## PERFORMANCE AND SUSTAINABILITY IN THE CONSTRUCTION INDUSTRY

The performance of a building can be described by value at one side and cost at the other side (Bunge 2006, Vögtlander 2001). This model originates from research of Total Quality Management and/or Continuous Improvement. The model emphasizes the creation of more value against less cost. This double objective opens new perspectives to support eco efficiency (Vollmann 1996, Porter 1995). This separation of value at one side and costs on the other side models the normal perception of goods in the daily life. Consumers are interested in 'value for money' and producers are interested in 'money for value'. Both parties are interested in a good performance, hereafter defined as the difference between value and costs of the building. When that difference is big enough, both parties can easily find a price which is beneficial for each. In this way the total performance is divided in two partial performances: (1) the benefit for the consumer which is defined as value minus price and (2) the profit for the producer which is defined as the price minus the costs (Figure 8).

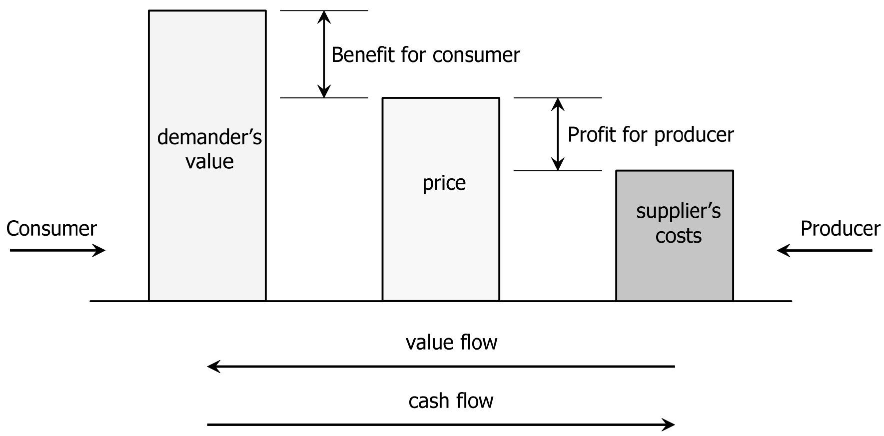


*Figure 8: Value price cost model combining consumers' benefit and producers' profit*

In the economical theory the value of a good equals the price from a producer's point of view. Here, value is money. However, from the consumer's point of view, value is consumed. As money can only be spent but not be consumed, consumer's value can not be money.

Value of buildings can be explored from different points of view. The classical theories refer to psychological, economical and technological value (Seni 2007). This can be used to define consumer's value of buildings. The psychological value is given by the architecture (form), the economical value is given by the function (capacity, quantity) and the technological value is given by quality. Costs of buildings are related with capital costs, maintenance costs and operational costs.

## LIVING BUILDING CONCEPT FOR SUSTAINABLE BUILDINGS

The performance of the construction industry can only be improved by stimulating innovation on sustainable construction with competition. Instead of the generally accepted preference for extension the lifetime of the whole building or renovation of the building, it is better to concentrate on components rather than complete buildings. This is the level where the interest of users and the interest of innovative producers of components come close together, creating a viable market place which can be compared with the 'normal' consumer market. In this view, buildings are considered as an aggregate of a large number of elements with different properties and lifetimes. In this context a construction work is considered as an intervention in the built environment. An intervention takes place at element, component or (sub)system level and is justified by calculating the change in value and the change in costs for the entire system over the design lifetime of these particular (sub)systems, components or elements. An intervention is sketched in Figure 9.

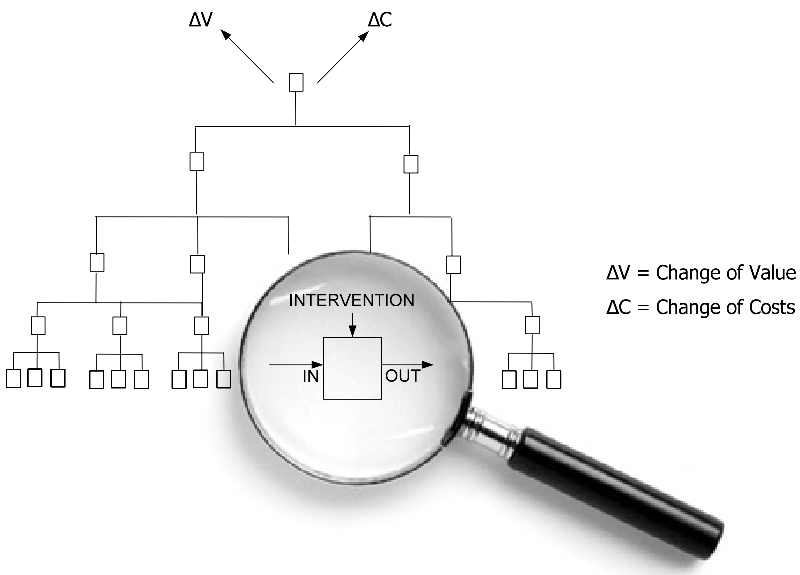


*Figure 9: Intervention with resulting change in value and costs*

The changed value as result of the intervention is subdivided in (1) architectural value (form), (2) functional value (quantity, capacity), (3) technical value (quality) and (4) the extracted value from the world around the building (system). The changed costs consists of: (1) the investment associated with the intervention and, (2) the savings in maintenance and operation due to the intervention over the design lifetime of the changed component or sub- system.

In such a setting, structures and buildings are comparable with living organisms, slowly getting older as a whole but rapidly and easily changing on cell level. The components and materials which come out are used in other buildings. In contrast to the current construction industry where value and price of buildings are fixed at the early start of a construction project, the 'Living Building Concept' (De Ridder 2006) considers the value, price and cost as variables. In this approach buildings and structures remain fit for use and up to date with state of the art technology under fast changing circumstances. This dynamic control is sketched in Figure 10.

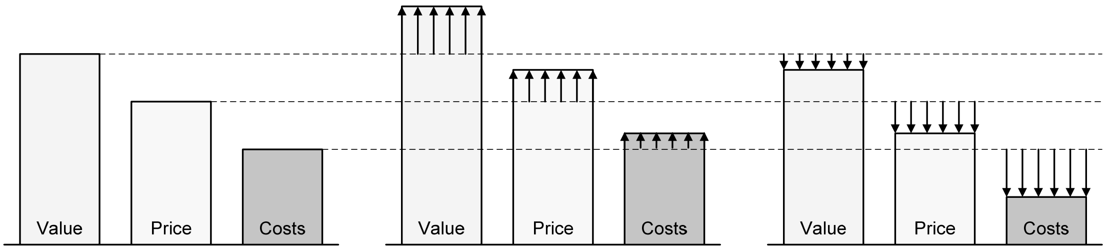


*Figure 10: Dynamic control of buildings*

The essence of dynamic control is that both parties strive either for substantial extra value against little extra costs or accepting little less value for a substantial reduction of costs. Both strategies are beneficial for the two involved parties.

## LIVING BUILDING CONCEPT FOR SUSTAINABLE BUILT ENVIRONMENT

The transaction model for individual construction projects can also be used for determining the value and costs for a set of buildings. In an ideal situation all buildings generate value for consumers (clients, users, owners). These players pay a price for 'consuming' this value, which result in an overall revenue. The set of producers (architects, engineers, contractors) gain profit which is the difference between the total revenue and the total costs. This picture for a set of buildings is given in Figure 11.

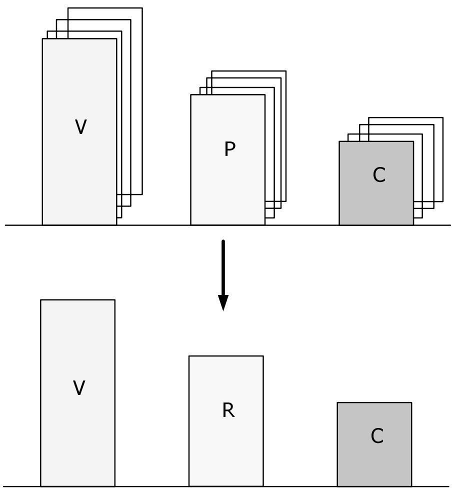


*Figure 11: Value, revenues and costs for a set of buildings*

With this model, construction works would lead to short term benefit between the parties involved. That does not lead to a sustainable built environment, because the long term value of the built environment as a whole is not included. It is also likely that value will be extracted from the environment. Therefore, the model should include a dominant role for the government. The role of the government is plural. Firstly, she takes care for the value of built environment as a whole by watching architectural value of individual buildings, developing public buildings and infrastructure and safeguarding the landscape. Secondly, she should take care for individual interests. What is valuable for one could be worthless or even threatening for another. Thirdly, she takes care for minimum requirements for the technical value by regulations. Fourthly, she takes care for a fair competition between the producing parties (Brown 1999). Last but not least, she should take care for the environment as a whole by taking into account the extraction of ecological value by construction activities.

As has been said before, a transition towards a sustainable building industry can only be achieved with an organized competition. The consumer is willing to pay a price for created value (architecture, quantity and quality). However, most of the consumers are not willing to pay a price for reduction of extracted value. Hence, the market relation between producers and consumers does not result in sustainable buildings. Therefore, the government should set a price on extracted value. The extracted value will be converted into eco-costs. It is assumed that a small public charge on extracted value is enough incentive for producers to look for eco-friendly solutions. The conversion of extracted value into eco costs is sketched in Figure 12.

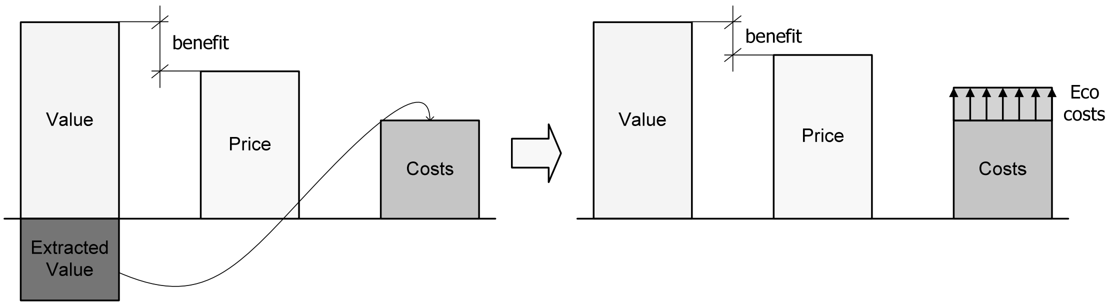


*Figure 12: Conversion of extracted value into eco-costs*

A producer will only apply the eco-friendly solution if its costs are lower than the charge. It can be seen that with a charge on extracted value the producer still has three variables available to create both added value for consumers as well as profit for himself. The eco-friendly innovations can only occur when producers are free to develop their own products and have opportunity to deliver these products in the market.

Based on the positions of the three main parties and the associated roles to be played by them, the connection with the three P's (People, Planet, Profit) of sustainable development (Elkington 1994) can easily be made (Figure 13), resulting in an overall business model. Three distinguished roles can be observed: (1) the Planet is safeguarded by the public authority that converts the extracted value into eco costs, (2) the People consume the total value and generate the total revenues by paying the prices and (3) the Profit is what companies have when controlling the cost benefit of projects.

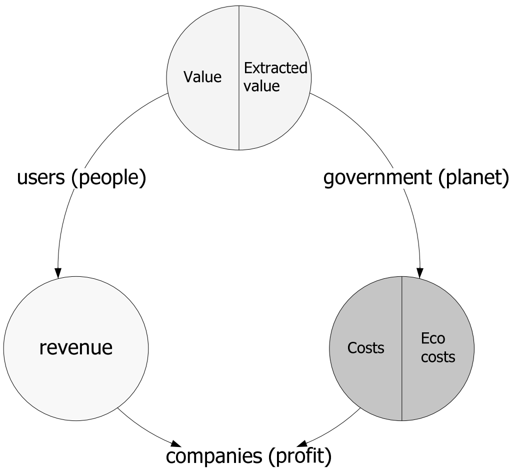


*Figure 13: People, Planet and Profit in an overall business model*

The three parties indicated in Figure 13 have specific relations with each other. There is a political relation between the government and the people, a market relation with the people and the companies and a regulation relation between government and companies.

## FOUR STEPS TOWARDS A SUSTAINABLE BUILT ENVIRONMENT

The business model proposed by the Living Building Concept should lead to a paradigm shift for sustainable built environment. The present culture and structure based on a 'cradle to grave' approach for individual buildings and structures makes place for a new culture and structure based on a Cradle to cradle approach for a large number of components and elements to be used in a set of buildings and structures. The Living Building Concept is a combination of the technical principles of IFD and the value/price/cost model. A paradigm shift can never be achieved without clear steps that can reduce the resistance against changes.. Four steps are necessary.

**Step 1: Convert extracted value into eco-costs**

As already is discussed in section 4, the government should set a price on extracted value associated with the production of elements and components. In that way, use of resources and emissions will be paid. This will lead to trade in and reuse of components by the producer. In a later phase of this transition it could be imaginable that a second hand market will be developed in marketable components and elements such as beams, piles, floors, walls, columns, windows, pipes and elevators.

**Step 2: Introduce sustainable procurement**

Secondly, the government should stimulate procurement procedures that provide design freedom for suppliers. In that way suppliers are enabled and challenged to come up with their own solutions. Unique, client specific solutions will be aggregated by a combination of fully developed products. Integrated supply chains formed by architects, contractors, suppliers, advisors and researchers together develop product modules and product families. This will transform the present capacity market of the construction industry into a product service market. In that type of market more thought is given to disassembly, reuse and recycling of components and modules because of the financial incentive for suppliers. The competitors will approach their clients with their trade mark, added value, discount, trade-in and guarantee. Buildings will be better, more beautiful, more diverse, more sustainable and substantially cheaper. That is because the partners in the integrated supply chain think and work together supported by research and development.

The proposed procurement procedure starts with defining a solution space spanned by a value axis and a price axis. Then the client sets boundaries in order to create a level playing field. The value is limited at the down side by a set of minimum requirements (internal) and at the top side by boundary conditions (external). The price is limited at the top side by the budget available (internal) and at the down side by a minimum price in order to prevent unprofessional bids. The solution space is sketched in Figure 14.

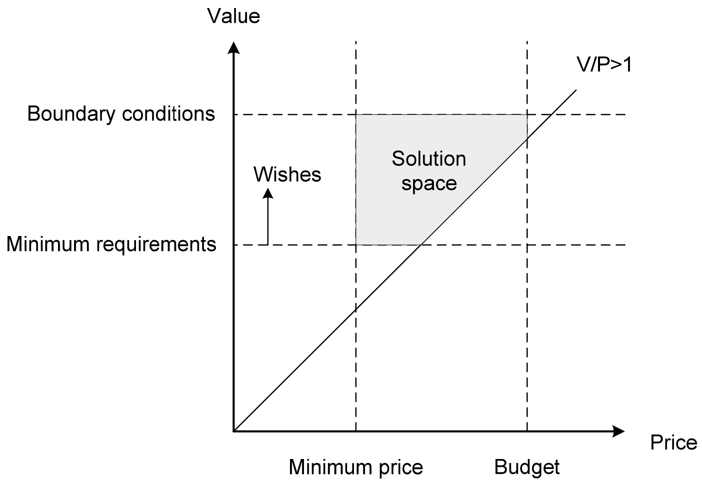


*Figure 14: Solution space for value based procurement*

Bids outside the solution space are not valid. The space between the minimum value (requirements) and the maximum value (boundary conditions) is spanned by the set of wishes (as much as, as beautiful as, as large as, etc). The client is now able to organize a competition on value against price. Wishes can be formulated on architecture, quantity and quality. The first step is a validation. The bids will be checked on a position inside or outside the solution space. Then, each bid is on the 'value' side evaluated on the scores on the wishes. This can be done with a Multi Criteria Analysis. On the 'cost' side it is obvious that eco costs, construction costs and operational costs can be added taking into account the discount rate and expenses in the future.

**Step 3: Introduction of dynamic control in construction contracts**

As has been said sustainable development means dynamic control of a series of interventions in order to cope with the fast changing world. As shown in Figure 9 an intervention results in a change of both the total value of a system as well as the total costs of a system over the design life time of the intervention. A change is always relative. The change can be measured with respect to the situation just before the intervention.

The total value is composed by three mainly independent sub-values: (1) architecture (form), (2) quantity (function) and (3) quality (technology). Quantification of change can be done by using dimensionless vectors. In a linear ortho-normal vector space it is rather simple to calculate the value after the intervention with respect to the value before the intervention, expressed in a percentage. This is shown in an example. The situation before is determined by three unit vectors. The situation after the intervention is changed: (1) architecture is increased with 10%, (2) quantity is increased with 20 % and (3) quality is increased with 10 %. The change of value in percentages is:

$$\Delta Value = \frac{\sqrt{1.1^2 + 1.2^2 + 1.1^2}}{\sqrt{1^2 + 1^2 + 1^2}} = \frac{\sqrt{3.86}}{\sqrt{3}} = 1.13$$

The total costs is the sum of the present values of: investment costs (IC), eco-costs (EC), operational costs (OC) and maintenance costs (MC) over the expected lifetime of the intervention. The change of costs is:

$$\Delta Costs = \frac{present\_value\_of\_(IC + EC + OC + MC)\_after\_intervention}{present\_value\_of\_(IC + EC + OC + MC)\_before\_intervention}$$

The intervention is useful in case: $\frac{\Delta Value}{\Delta Costs} > 1$

This dynamic quantification of both value as well costs can be the basis of a Living building contract aimed at continuous adaption of buildings. The adaption can be initiated by both the client as well as the contractor. For the price forming the extra investments associated with the intervention can be considered as costs, whereas the savings can be considered as value.

**Step 4: Living city project**

Sustainable development can hardly start with only one building. It is better to start with a number of buildings, in order to create an economy of scale for components. In that way an integrated supply chain of architects, contractors, mechanical engineers and electrical engineers can not only develop product families and standard components, but are also able to keep the buildings fit for use under changing circumstances by taking out components of one building and reuse that component for another building. In that way the gap between the short functional lifetime of a building and the long technical lifetime of a building will disappear. Because of the emphasis on components, these components will not only have a long technical lifetime but also a long functional lifetime. This should lead to a market for components and elements that can be used for new or existing buildings.

# CONCLUSIONS

The contribution of the construction industry to the Gross National Product is about 11%. The negative effect on environmental issues of construction and operation of buildings and structures is disproportional. With respect to the national figures, the energy consumption is more than 45 %, the emission of CO2 is more than 45 %, the production of waste is 35 % and the total road transport is 25 %. The poor performance is the result of the culture and structure of the construction industry. Buildings are sub optimized by different players that work subsequently on quantity, form and quality of buildings. The quality is less than it can be. Moreover buildings are built for long lifetime whereas the functional lifetime is substantially shorter. In result, buildings will frequently be adapted. For these interventions new materials must be produced with associated emissions and energy use. Interventions produce also a lot of waste material. The Living Building Concept is a business model for sustainable built environment. Based on principles of IFD, it focuses on adaptable buildings by replacing non-functional components by new ones and re-using the old ones in other buildings, possibly after repairs and upgrades. LBC keeps the building fit for use, up to date with state of the art technology in a sustainable context with small amounts of waste and emissions. The Living Building Concept requires continuous intervention that is dynamically controlled; added and extracted value at one side and investments and savings at the other side. This requires a systemic approach for the prediction of the performance in value and costs of the system in changing conditions. Sustainable development needs a stepwise approach. The first step is the introduction of a charge on extracted value for the production of building components resulting in eco costs. The second step is a sustainable procurement procedure giving producers the freedom to offer their solutions. The third step is to introduce dynamic control in construction contracts. The fourth step is to start a 'Living City' project to help integrated supply chains with the development of product families and components that can be used in a series of buildings.

## REFERENCES

Bunge, M. (2006) *Chasing reality: strife over realism*. University of Toronto Press, Toronto.

Brown, A.N. and Brown, J.D. (1999) The transition of market structure in Russia: economic lessons and implications for competition. *Proceedings 4th Annual International Conference on Transition Economics*, Beijing.

Elkington, J. (1994) Towards the sustainable corporation: win-win-win business strategy for sustainable development. *California Management Review* **36**(2), 90-100.

Lichtenberg, J. (2006) Slimbouwen: a strategy for efficient and sustainable building innovation. *Proceedings Joint 2006 CIB W065/W055/W086 Symposium*, 18-20 October 2006, Rome.

McDonough, W. and Braungart, M. (2002) *Cradle to cradle: remaking the way we make things*. North Point Press, New York.

Porter, M.E and Van der Linde, C. (1995) *Green and competitive: ending the stalemate (resource productivity)*. Harvard Business Review, Sept-Oct 1995.

De Ridder, H.A.J. (2006) *Het living building concept: een wenkend perspectief voor de bouw*. PSIBouw, Gouda.

Seni, D.A. (2007) The technological theory of value: towards a framework for value management. *Proceedings SAVE International 2007 Annual Conference*, Houston.

Vögtlander, J.G. (2001) *The model of the eco-costs/value ratio; a new LCA based decision support tool*. Doctorate Thesis. Delft University of Technology.

Vollmann, T.E. (1996) *The transformation imperative*. Harvard Business School Press, Boston, Massachusetts.