Mieke (M.B.G.) Ketelaars, Deltares, Unit Strategy and Policy

Arjan (A.A.M.) Venmans, Deltares, Unit Geo-Engineering

MAKING CRADLE-TO-CRADLE WORK: FIRST STEPS FOR DUTCH INFRASTRUCTURE CHALLENGES

SUMMARY

The Dutch government and in particular the Dutch Directorate-General of Public Works and Water Management (Rijkswaterstaat, RWS) have set ambitious goals with respect to sustainability. One very significant goal is that from 2010 100% of their purchases is sustainable. RWS has specific goals with respect to reduction of CO_2 emissions, energy neutral design, sustainable use of materials and spatial quality of infrastructures. Deltares – the Dutch research institute for enabling Delta life – and the Water INNovation programme (WINN) of RWS are working together to realize (more) sustainable infrastructure. Together they have applied the inspiring Cradle-to-Cradle (C2C) concept [3] to two infrastructures projects in order to embed the RWS sustainability ambitions in the program of requirements.

In this paper we show how the C2C concept can help RWS to achieve its sustainable ambitions with regard to infrastructure projects. We describe the process and the practical applications the C2C concept has for the redesign of a lock and construction of a motorway.

1. SUSTAINABILITY

Sustainable development has been defined by the UN commission Brundtland (Our common future) from 1987 as: *a development that fulfils the needs of the present generation, without compromising the ability of the future generations to fulfil their needs*. The Brundtland definition is commonly accepted, and is used in Dutch national environmental policy. Some of the core principles of sustainability are [1]:

- no transfers of negative effects in time and space;
- interdependency between scales: sustainability at the local level does not necessarily means sustainability at the higher level, or vice versa;

Sustainability is a multi-actor problem, because it is about the needs of people. Consequently, an integral approach is needed, because sectors are only one piece of the whole puzzle.

Sustainable development and especially the realization of sustainable infrastructure is a complex problem. The main characteristic of the realization of infrastructure projects is the large amount of soil that has to be moved and the large amount of materials needed to realize roads, fly-overs, underpasses, dams or bridges.

In this chapter, we will introduce the Cradle-to-Cradle approach. The Cradle-to-Cradle concept provides guidance and heuristics for identification of concrete sustainability ambitions of a project. However, to translate C2C into concrete and practical solutions is still problematic.

In 2002 Michael Braungart en William McDonough – the founding fathers of the C2C concept published the book “Cradle to Cradle, Remaking the Way We Make Things [3]”. Braungart and McDonough claim that economical growth, sustainability and enjoying life can go together. The Cradle-to-Cradle approach states that we should not make our industrial systems less bad (”eco-efficiency”), but we should make them good (“eco-effectivity”). This implies a transition of the current industrial systems towards sustainable systems. Braungart and McDonough argue that all materials used fall into one of two categories: “technical” or “biological” nutrients. Through better designs and smarter usage of materials technical nutrients can be strictly limited to non-toxic, non-harmful synthetic materials that have no negative effects on the natural environment. They can be used in continuous cycles as the same product without losing their integrity or quality. In this manner these materials can be used over and over again instead of being "downcycled" into lesser products, ultimately becoming waste. Biological nutrients are organic materials that, once used, can be disposed of in any natural environment and decompose into the soil, providing food for small life forms without affecting the natural environment.

The three principles of Cradle-to Cradle are:

- Closing the biological and technical cycles;
- Making use of renewable energy and specially the abundance of the sun's energy;
- Creating more (bio)diversity.

The next section evaluates the usefulness of this approach to account on the ambitions of Rijkswaterstaat.

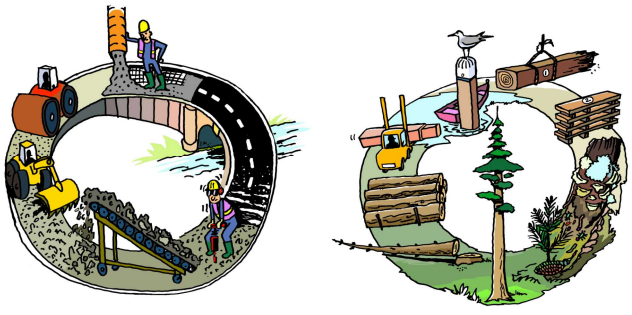


Figure 1: Closing the biological and technical and biological cycles

2. THE SUSTAINABILITY GOALS OF RIJKSWATERSTAAT

The Dutch government and in particular the Dutch Directorate-General of Public Works and Water Management (Rijkswaterstaat, RWS) have set ambitious goals with respect to sustainability. The Dutch national government wants 100% of their purchases to be sustainable. RWS has specific goals with respect to reduction of CO_2 emissions, energy neutral design, sustainable use of materials and spatial quality of infrastructures. In their strategic programme “RWS Sustainable [4]” RWS states their ambitions as follows:

- Energy: objects are self-sufficient or supply their own energy; there should be a significant contribution from RWS to the national ambition of 20% energy use from renewable sources;
- Sustainable use of materials: minimizing the amount of materials needed, maximize re-use of materials and management of the material chain;
- Sustainable production methods, according to the national ambition of a reduction of 20% CO_2 emissions; and
- Spatial quality of the infrastructure; a positive contribution to the surroundings and the society.

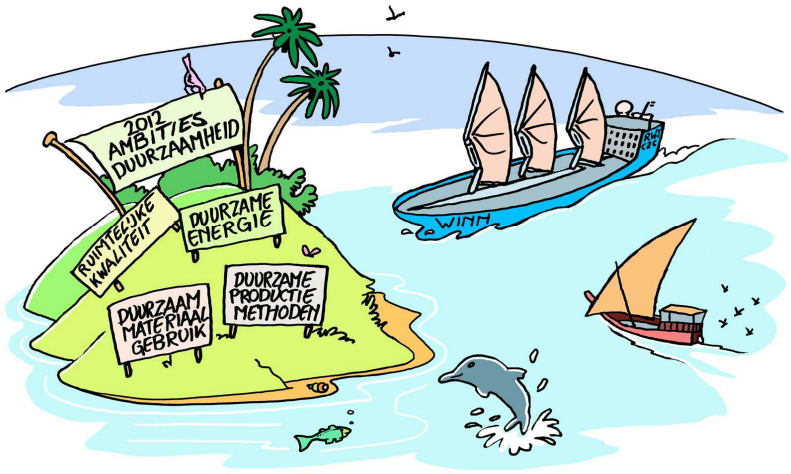


Figure 2: The sustainability ambitions of Rijkswaterstaat.

3. APPLYING THE C2C CONCEPT TO INFRASTRUCTURE PROJECTS, GENERAL APPROACH

In 2008 Deltares and RWS have studied the challenges of applying C2C to infrastructure works to push sustainability a step further [5]. The main conclusion of this study was that the C2C approach can make a real difference, provided the concept is applied in an early stage of the process of decision-making. Knowing that, a general approach to implementing the C2C concept was developed and applied to different infrastructure projects. This chapter explains the general approach. Examples for a lock and a motorway are presented in chapter 4.

Any practical application of C2C to infrastructure projects needs to take into consideration that each project is unique, since each project is a tailored response to a particular infrastructure need. Accordingly, in practical applications the requirements of the project and wishes of the project organisation and other stakeholders are guiding and of decisive importance.

A general approach was developed to translate sustainability ambitions to design alternatives. This approach involves the following steps:

a. *Create an image of the present situation*
   Collect information about the present situation and the surroundings, including facts about the present value of the area (historic, ecological or cultural), stakeholders' wishes and present problems or needs.

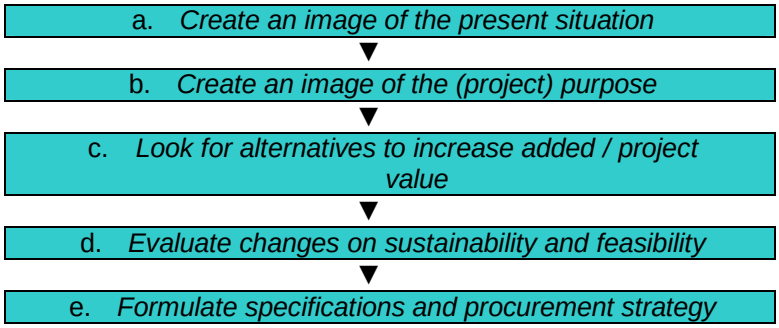
b. *Formulate a set of C2C principles*
   Project organisation and a variety of specialists (for example, ecologists or energy experts) sit together to conceive new (ideal) designs of the construction. The ideas and design constraints generated by this group are translated to a number of (graphical) designs by a landscape architect or an artist. All wishes, requirements and ideas of the participants will be listed and sorted out.

c. *Look for alternatives to increase added/project value*
   The new design(s) of the construction are developed further by looking for possible combinations of functions, for example the combination of the function of flood protection with the ecological or recreational function of an area. Also, possibilities are investigated to increase (bio)diversity, close material cycles, reuse material in beneficial ways and decrease energy usage and dependence on non-renewable resources.

d. *Evaluate changes on sustainability and feasibility*
   The project organisation evaluates the changes introduced by the ideal C2C designs with respect to their sustainability ambitions and the project constrains. These constraints may have a financial, planning, legal or technical nature. The project organisation decides what aspects of the ideal designs will be realised or stimulated in the project. Questions raised in the evaluation may be:
   - Which elements in the design do best match the RWS sustainability goals?
   - What priority do we give to the designs within the limitations of our budget?
   - Which parts of the design can we expect to be realised with the current knowledge of the contractors, at this specific project site, within the time provided?
   - How do the designs contribute to longer term goals on the way to true C2C motorways?
   - Which uncertainties exist in the performance of the design and how can we deal with those?
   - Can we offer a testing ground where elements of the designs can be demonstrated, monitored and evaluated?
   - Which conflicts do the designs cause with previous agreements with stakeholders, procurement rules or RWS policy? How can these be solved?

e. *Formulate specifications and procurement strategy*
The selected aspects are translated into a set of project specifications ('Programma van Eisen', PvE). Additionally a reference design may be supplied as part of the invitation to tender. The procurement strategy is adapted to provide stimuli for the contractor to develop creative solutions to fulfil the sustainability ambitions. This may include including bonuses for the best score on a certain ambition or dialogue rounds with RWS to detail the design.

Up to this point in time, the approach has been used to develop tailor-made specifications. Eventually, a set of specifications will emerge which is generic for similar infrastructure projects of RWS. This generic set will probably consist of a combination of baseline specifications, defining a minimum ambition, and specifications that contain incentives reflecting advanced ambitions. Even with this set of generic specifications we highly recommend that the approach described above is applied to every new project. This will create awareness and enthusiasm in the project organizations and stimulate them to consider their own ambitions. We consider mobilizing the enthusiasm of the people in the project organizations a major success factor in developing the RWS sustainability ambitions. In several projects we visited the project organization stated they wanted to be "best-in-their-class" with respect to sustainability, meaning they wanted to perform above the current standards. The approach is depicted in the following scheme.



4. EXPERIENCE WITH THE USE OF CRADLE-TO-CRADLE

4.1 Redesign of locks at Eefde

4.1.1 The challenge

Shipping to the eastern part of the Netherlands passes through the locks in the Twente canal near Eefde. The locks at Eefde are notorious for their long and unpredictable waiting time. Therefore, both the Twente canal and the locks will be renovated to make it suitable for more and larger ships. Traditionally solutions are focused on a better utilization of the current locks or the construction of a second wider set of locks. The challenge here is to explore whether a C2C-design would be possible.

4.1.3 The Cradle-to-cradle approach step by step

The general approach given in the previous chapter was applied to the design problem.

Step a: image of the present situation

- The construction of the second lock chamber will release an amount of 20.000 m^3 soil.
- New lock doors and new banks have to be made.
- The present locks and the operation buildings are historical monuments.

Step b: formulate a set of C2C principles

In order to close the technical cycle and to avoid transport, beneficial applications of the released soil need to be found close to the site;

- Renewable materials should be used for the shore and the lock doors, and
- The locks should be in harmony with and add value to its surroundings.

Figure 3: Looking for alternatives to increase added / project value to the Eefde lock project

Step c: look for alternatives to increase added/project value

Opportunities identified in workshops:

- Maximize the reuse of materials (soil) for beneficial use in the surroundings;
- Production of solar energy, and
- Increase spatial quality: ecological and recreational values.

Step d: evaluate changes on sustainability and feasibility
The project organisation has decided to ask tendering contractors for a proposal for 13 topics related to the following three principles:

- Closing the biological and technical cycles: materials. Example: in what aspects will the proposal exceed the Dutch national baseline requirements?
- Making use of renewable energy: water and energy. Example: how will the design reduce water loss during operation of the locks below the baseline of 30%?
- Creation of more (bio)diversity. Examples: how does the proposal increase ecological and natural values above those in the present situation (= baseline); how will the proposal make the locks more attractive for smaller recreational vessels than at present?

Step e: formulate a program of requirements and procurement strategy
For this project, a so-called ambition document is written. For each subject:

a. A minimum requirement is formulated ('baseline');
b. An incentive to challenge the contractor to exceed the minimum requirement;
c. Some suggestions for inspiration are given in the document;
d. Examples of the state of the art are given, if necessary documented with a photo, and
e. References of literature with more background are given.

4.2 Construction of a motorway

4.2.1 The challenge

In order to relieve / reduce traffic congestion on one of the main motorways in the western part of the Netherlands a new parallel motorway will be built. The project is currently in the tender phase, so exact details on the actual design cannot be given at this moment. The challenge in this project is: how can a C2C vision help in the development of a generic but coherent set of measures for Dutch highways?

4.2.2 Cradle-to-cradle step by step

Step a: image of the present situation

- The construction of this motorway will release an amount of nearly 1 million m^3 soil.
- A new 8 km road, a land tunnel of 1 km length, 2 flyovers and an aquaduct have to be built.
- The motorway passes both through a rural area of high ecological and recreational value, and through one of the most densely populated parts of the Netherlands.

Step b: formulate a set of C2C principles
A first workshop was held with the project organisation to create an image of the project purpose, ambitions of the team and interests of the stakeholders. The following opportunities are identified in the first workshop:

1. Optimal integration of the road in its surroundings and the creation of benefit for the landscape.
2. Optimisation of the energy system (construction and operation) where the minimum possible of energy is needed from outside the system.
3. Optimal balance of materials where released materials are used as efficiently as possible.
4. Sharing of the benefits of the road with the public.
5. Limitation of damage and inconvenience to the public during the construction phase.
6. Limitation of damage and inconvenience to the public during the operation phase.

Step c: look for alternatives to increase added/project value
After the workshop a multidisciplinary team elaborated alternative designs. Examples of the designs related to the opportunities identified in step b are:

1. Create transit zones for animals along and across the motorway; integrate the water management system of the motorway into the water management system of the surrounding polder.
2. Harvest solar energy by placing PV panels and integrating heat collectors in the pavement.
3. Make a balance of released and incoming soil and concrete; reward re-use of excess material in the vicinity of the project.

4. Communicate the added value of the motorway in local media and information centres.
5. Minimize transport of raw materials; stabilize the ground water level.
6. Prevent disruption of the separation between surface water and groundwater systems.

The original design mainly addressed the opportunities integration in the landscape (1) and limitation of damage and inconvenience (5 and 6). The added value of the alternative designs is in energy use (2) and material re-use (3), with contributions to integration in the landscape (1) and communication (4). The added value of the alternative design could have been higher if the analysis had been performed in an earlier stage of the project.

Step d: evaluate changes on sustainability and feasibility
In a second workshop with the project organisation, the alternative designs were evaluated. The project organisation decided to concentrate on three main points that deal with:

1. Use of materials;
2. Making use of renewable energy; and
3. Creation of more (bio)diversity.

Step e: formulate a program of requirements and procurement strategy
For this project, a program of requirements and a procurement strategy has been made to challenge the (building) contractor. Special attention in the program of requirements is given to: the reuse of materials, the integration of a motorway within its environment, avoiding hindrance during the construction of the road and the minimizing of energy during the construction and during the use of the road.

5. EVALUATION OF THE IMPACT OF THE C2C APPROACH ON THE RIJKSWATERSTAAT AMBITIONS

As we could see in chapter 2, the C2C approach fits well to the Rijkswaterstaat ambitions with respect to sustainability, mainly because many RWS projects involve the reuse of large volumes of materials. However, the strength of the C2C approach is to inspire the project team to create a design with more value. The additional value is usually found in adding more functions to the design.

The challenge of applying an approach to sustainability in practice, especially the C2C approach, is to really account for the sustainability ambition of Rijkswaterstaat. These ambitions on energy, sustainable use of materials and spatial quality of the infrastructure were the starting points in the workshops in both cases. In the first place, the C2C approach helps to create an image of the opportunities for sustainability for the project. Second, the approach is useful to determine our ambitions according to sustainability for infrastructure projects. Finally, the concept provides tools and examples how to make these ambitions more concrete.

However, the additional question of how Rijkswaterstaat can stimulate contractors to act in a C2C-way is at this moment not quite clear. Because of the fact that Rijkswaterstaat is the biggest customer in the Netherlands, there is a big market for the contractors to get a good return on their investments. The challenge for Rijkswaterstaat is to search how to stimulate contractors to offer solutions which account to the ambitions on sustainability of Rijkswaterstaat. Rijkswaterstaat also has to invest in sustainable solutions.

6. SOME REMARKS WITH REGARD TO THE USE OF THE CRADLE-TO-CRADLE CONCEPT FOR INFRASTRUCTURE PROJECTS

1. The concept of Cradle-to-Cradle is inspirational. Using the C2C concept a real good contribution can be achieved to the sustainable ambitions with respect to heighten the spatial quality of the infrastructure and to close cycles. Especially the closing of the technical loop is important for Rijkswaterstaat because of the large amounts of soil that has to be replaced and the materials is needed to realize roads, fly-overs, underpasses, dams or bridges.

2. The cases presented have shown that Cradle-to-Cradle can support the achievement of the ambitions or goals of the Dutch government on sustainability. However the contribution of the C2C concept to lower the CO_2 emission has not (yet) been determined besides the saving of CO_2 by closing the technical loops. In addition, the use of renewable energy for infrastructure projects at this moment is minimal.

LITERATURE

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