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THE NOT-SO-EASY GUIDE TO CIRCULAR INTERIOR DESIGN

Guest edited by
Marieke van den Heuvel

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CONTENTS

DAVID VAN NUNEN

A CRASH COURSE LIFE CYCLE ASSESSMENT (LCA)-II: THE WHAT AND THE HOW

By this point in this not-so-easy guide to circular interiors you should be familiar with circular design strategies such as the 10-R model. These kind of strategies are very useful for making sustainable design considerations. But a strategy alone does not quantify the effect on the environmental impact of your design. Imagine you want to design an interior, with minimal environmental impact. How do you start and how can you assess the effect of circular strategies? There are many factors to consider. For example, which choice of material is most suitable for the interior: wood, recycled plastics, another material..? And what is the most effective way to utilise circular strategies? The 'Life Cycle Assessment' – in short 'LCA' – provides information to handle these questions effectively.

LIFE CYCLE ASSESSMENT – LCA

Life Cycle Assessment is a systematic and standardised approach to evaluate the environmental impact of a product, or a process over its entire life cycle. It considers all life stages: from the extraction of raw materials to the production phase, transportation, use, and the end-of-life stage at disposal. For each step in the life cycle, the corresponding materials, energy and emissions are considered. LCA-studies can be valuable for multiple goals and at multiple stages.

In the design process

LCA is used in the design phase to quantify the impact of design decisions on all life cycle phases. By conducting an LCA in an early phase, sustainable design decisions can be substantiated.

For communication of environmental performance

LCA-studies are the base study for composing environmental product declarations (EPDs). Environmental declarations can be important for being awarded tenders, for building assessment schemes and for transparently communicating the environmental impact of a product. (See section 'A deep dive in the normative LCA framework' > 'Environmental declarations')

Process evaluation

An LCA can be used to gain further insights in material and energy inputs and outputs and the underlaying supply chains. These insights can be used to setup a material passport for a product, or to make substantiations in environmental management schemes, like ISO 14001 for environmental management systems.

THE PRINCIPLES OF LCA

This section offers an introduction to the principles of LCA. More information on the principles can be found in the different international and national norms such as the ISO 14040, the ISO 14044 and the EN 15804 (See section 'A deep dive in the normative LCA framework'). All LCA-studies can be divided into the following steps:

1. Scope & goal determination

Why do you need an LCA, and what should be included in the LCA? This section describes the product in question. For example, the product in the scope can be a chair, but also a complete interior. Choosing the right unit is important for comprehensibility and comparability between environmental declarations.

2. Reference lifetime

How long will a product last? If a product needs to be replaced during the lifetime of a building or interior, then this needs to be taken into consideration. The product's lifetime does not affect the total impact, yet it is a main determinant when calculating the impact per year. For example, an interior renovation may have a carbon footprint of 50 kg CO_2-eq/ m². If the interior will be removed after 7 years, the annual carbon footprint would be 7,1 kg CO2-eq/m²/ year. If the same interior would last for 15 years the annual impact would be 3,3 kg CO2-eq/m²/year. This example shows the relevance of making long lasting (durable) products, renovations and buildings.

3. System boundaries

Which life cycle stages are to be included in the LCA study? Some LCA-studies only focus on the production phase, while others focus on the entire life cycle, including the end of life stage. The life cycle phases that should be followed are mentioned in the specific norms. For example, in the Netherlands an LCA for buildings and building products is always performed over all life cycle stages. Only the operational water and energy usage is not (yet) mandatory in LCAs in the Netherlands. The table below shows an overview of all considered life cycle stages.

CONSTRUCTION WORKS ASSESSMENT INFORMATION, EUROPEAN NORM: EN 15804:A2
For more information see section: 'A deep dive in the normative LCA framework'

Production stage			Construction stage		Use stage							End of life stage				Module D
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	
Raw materials supply	Transport	Manufacturing	Transport	Construction and installation process	Use	Maintenance	Replacement	Repair	Refurbishment	Operational energy use	Operational water use	De-construction	Transport	Waste processing	Disposal	Benefits and loads beyond the system boundary

4. Life cycle inventory (LCI)

Once you know what you are about to analyse, you need to gather all the data to quantify each stage in the life cycle. For example, when considering the LCA for an interior you need to quantify the bill of materials – a centralized source of information containing a list of items used to manufacture a product – for all products in the scope, the production processes, the production waste, transportation distances, the usage and the end-of-life stage. Having a detailed data inventarisation is key for performing a standardised LCA study. Yet, rough data will often be sufficient for a 'quick scan' LCA. The inventoried data alone often does not directly translate to the environmental impact. For example, if your inventory includes imported timber wood, the manufacturing steps from cutting the tree towards the finished timber element are not inventoried. Therefore, we rely on background environmental processes from datasets like Ecoinvent[1] or Sphera[2] to model the inventoried data. When performing a 'quick scan' LCA we will rely on European average background environmental processes from Ecoinvent. In a detailed LCA we would consider the inputs from the specific suppliers to further specify the environmental processes. Further specifications are common on the used raw material, the energy consumption in the manufacturing process and the manufacturing losses from practice.

5. Life cycle inventory analysis (LCIA)

LCA-software like Simapro[3] is used to model the complete data inventory. Each environmental process – like timber wood – is built up out of substances: materials and emissions. These substances are divided into impact categories.

Characterisation

All environmental substances are converted into a set of 19 environmental indicators or categories[4]. For example, the impact indicator 'Global Warming Potential', with the unit 'CO2-eq' is built up out of different emissions that contribute to this indicator: CO2 emissions are converted 1-to-1, but for example the emission of 1 kg of methane will also be converted to the unit CO2-eq, based on standardised factors. After the characterisation, the environmental indicators of categories can be weighted.

Weighting

The Environmental Cost Indicator (ECI) is a single-score indicator expressed in Euros. It unites all relevant environmental impacts into a single score of environmental costs, representing the environmental shadow price of the product or the project. The environmental shadow price covers the necessary costs to undo the environmental damage of the product. Weighted results are often used for comparing the environmental performance of products and to evaluate the relative impact of the different environmental indicators.

Life cycle interpretation

As a final step in the LCA study the results need to be interpreted. The main processes that contribute to the environmental profile need to be identified. The completeness and consistency of the study both need to be checked and a sensitivity analysis must be performed to show possible deviations due to uncertainties in assumptions that had to be made to conduct the LCA.

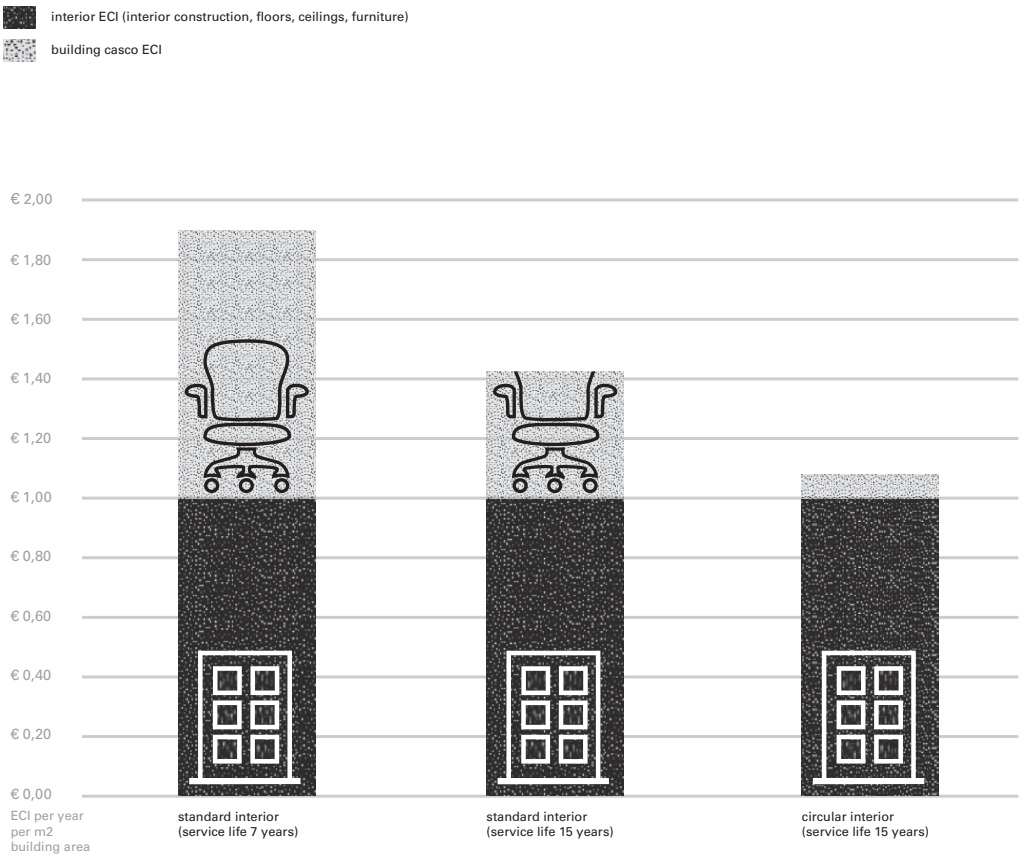
1 https://ecoinvent.org/the-ecoinvent-database/
2 https://sphera.com/life-cycle-assessment-lca-database/
3 https://simapro.com/
4 The number and the used environmental indicators differ per assessment scheme and the applicable product category rules (PCR). 19 indicators is common within the EN15804:A2 (see textbox: 'A deep dive in the normative LCA framework')

LCA FOR (INTERIOR) DESIGNERS

Based on the results of the LCA and the interpretation of the data, designers can evaluate the environmental impact of their designs. By doing so, the designs can be further optimised to minimise environmental impact.

Making a detailed life cycle assessment is an intensive process. However, a 'quick-scan' LCA can be used to shortly evaluate the effectiveness of circular design approaches and for comparing different options. In this short evaluation a designer can, for example, focus on the comparison of different materials, or solely on the impact of circular design strategies.

Building and interior ECI, different scenarios for the interior



The first scenario is the status quo for offices where all interior is renewed every seven years. In the second scenario, the interior lasts 15 years. In the third scenario, the interior also lasts 15 years and is designed to minimise the environmental costs indicator (ECI). The circular scenario is based on the results of Nationale-Nederlanden.

A DEEP DIVE IN THE NORMATIVE LCA FRAMEWORK

The LCA-methodology is grounded on international and national standards for ensuring consistency, reliability and comparability of study results. In this section we include an (slightly simplified) overview of the LCA-frameworks.

Global frameworks

The ISO 14040:2006 and the ISO 14044:2006 are the main LCA-standards issued by the International Standards Organisation in 2006. ISO 14040 considers the principles and framework of life cycle assessments. ISO 14044 considers the requirements and guidelines of life cycle assessments. These norms offer a framework and requirements for the scope definition of the LCA, the life cycle inventory methodology (LCI), the life cycle impact assessment content and methodology (LCIA) and the data interpretation phase.

European norms

For specific product systems there are more detailed, or specific rules in place for the LCA methodology – the so-called 'Product Category Rules'. Based on ISO 14040 (LCA, principles and framework) and ISO 14044 (LCA, requirements and guidelines), the EN 15804+A2:2019 standard specifies the core product category rules for construction products. For specific product categories there are additional European product category rules, for example for timber products and for thermal insulation products.

National norms and platform demands

Environmental declarations are commonly declared in a specific environmental product declaration (EPD) programme. Each EPD programme defines specific category rules for the scope of its programme. Several European countries have an EPD programme that defines the national product category rules. In the Netherlands the NMD sets the category rules for the Dutch situation and for defining specific scope and calculation demands for the LCA study.

ENVIRONMENTAL DECLARATIONS

Once the LCA study has been conducted, the study can be used to make environmental declarations. There are three main types of declarations.

Type III, environmental product declaration (EPD)

An EPD (environmental product declaration) is a type III environmental declaration, based on the ISO 14025 framework and grounded on an LCA study. Type III environmental declarations are always verified by a recognised third party, following the demands of a specific programme operator. The verification approach and the usage of EPDs differs per country. EPDs are often required, or beneficial, for public procurement, tenders and building assessment schemes such as BREEAM and LEED.

Type II, self-declared

Type II environmental declarations are self-declared, without third party verification, in accordance with ISO 14021. Due to the absence of verification, type II environmental declarations are not common to be used for tenders and assessment schemes.

Type I environmental labelling

Type I environmental labels and declarations are setup in accordance with ISO 14024. A type I environmental declaration or label considers the awarding of a license to use specific environmental labels. Third party programmes determine the demands for the environmental label and the independent assessment criteria. Type I environmental labels do not have to be based on LCA-studies. Examples of type I environmental labels are the EU Ecolabel, the Marine Stewardships Certification (MSC), Fair Trade, and the Forest Stewardship Council (FSC).

For interior design, LCA studies are less common practice than for building products. Although the life cycle of an interior commonly has a lower environmental impact than the building itself, it also lasts a much shorter period of time. With all the replacements during a buildings lifetime, the impact can be significant. Based on our experience with LCAs for interiors and buildings, **the impact of the interior – considering furniture, interior walls and non-constructive floors and ceilings – can range from 10% up to 100% compared to the impact of the construction of the building**. All decisions taken by the interior designer, such as the used materialisation and the design efforts taken, influence the environmental impact. These decisions can prolong the expected lifetime and recyclability. By making high quality interiors that are adaptable and less prone to short-lived fashion trends, the products may also be reused more often.

As a designer you should also consider reusing materials and furniture from previous renovations or from other buildings. If all office interiors are built in an adaptable manner, then it should be possible to do most of the renovations by designing the interior out of the already existing products.

The offices for Nationale-Nederlanden (p.120–151) show the potential of using LCA methodology throughout the design phase to minimise the environmental impact of renovations. The figure below shows an overview of the Environmental Cost Indicator (ECI) of an office interior for different scenarios in relation to the ECI of the building. The ECI of the building is based on current (Dutch) regulations of being maximum € 1,- per m^2 per year for office buildings (see textbox: 'The principles of LCA' > '5. Life cycle inventory analysis (LCIA)' > 'Weighting'). The ECI of the building can also be lowered by using recycled, or reused materials and by implementing circular design strategies, such as design for reuse.

THE USE OF ENVIRONMENTAL PRODUCT DECLARATIONS (EPDS) FOR BUILDING PRODUCTS

In the Netherlands, environmental declarations are commonly declared in the National Environmental Database (NMD). The data of the NMD is used to evaluate the environmental impact of a new building. In the Netherlands the environmental impact calculations are mandatory and the maximum ECI (environmental costs indicator) per m^2 is limited by regulations. Different countries have their own rules for the application of EPDs. Specific regulations, tender demands or sustainable project ambitions often motivate contractors to select sustainable building products based on EPDs. Environmental product declarations can also be used for green building assessment schemes like BREEAM (Building Research Establishment Environmental Assessment Method).

COMPARING LCA DATA CAN BE CHALLENGING

Once you know the environmental impact of a product, you may want to compare the results to alternative products. For this comparison you can look at published LCA studies and EPDs (see section 'How to get started' for relevant platforms). There are several focus points when comparing environmental declarations. For comparisons, the studies should be based on the same set of rules (the product category rules (PCR)) and the same background datasets. All EPDs in the Dutch National Environmental Database are based and examined on the same set of rules. As a result, it should be possible to compare the EPDs. Still, several other questions need to be considered in comparisons: Are all results converted into the same measurement unit, such as kg or m^2? Do the products in the studies fulfil the same function? Are the studies still up to date?

Beyond the digits

LCA is a powerful method to evaluate environmental impacts of a product and to effectively move towards impact reductions. Yet, when evaluating a products or systems impact, it is important to stay mindful of possible limitations in the scope of an LCA. For example:

Are all impacts covered? Social factors like human rights are not part of the standard LCA, as well as potential effects on the loss of biodiversity.

Will there be consequential system changes? Mainly for large (policy) decisions, the indirect effects of a system change should be considered. Will the decision have an effect on resource availability? What will be the effects on (indirect) land use? What will be the effect on the market? A consequential LCA can be used to research a scenario on a system level.

May technological shifts result in impact changes in the coming years? For example, we can foresee the national energy mix to change over the years. If LCA studies include energy usage over a products lifespan, then we should be aware that the current energy mix data may not be representative for future practices.

FUTURE DEVELOPMENTS OF LCA

The need for objective environmental comparisons is more relevant than ever before. LCA studies will even become more of a key driver to aid the European Green Deal and the circular transition. With the coming European Environmental Footprint (EF) framework, the Ecodesign for Sustainable Products Regulation (ESPR) and the Construction Products Regulations (CPR) LCA will gain a more prominent role in many product categories.

Call to Action: embracing LCA

LCA studies are already essential for many companies to gain environmental insights, in tender processes and for sustainable assessment schemes. In the coming years the demand for transparent environmental data will increase and the role of LCAs will become more prominent. In this light, companies are best prepared if they perform an LCA for their products or systems, assess their impact, and to work towards circular and sustainable design solutions.

How to get started

There are several open source LCA data platforms available, like the 'Self-Assessment tool for LCA' from Circonnect[5]. There are also different training programs for getting hands-on with circular design principles. With CIRCO-tracks[6] for example, companies discover new circular business opportunities using a circular design approach.

Often EPDs are published by national or international organizations. In the Netherlands, EPD results on the environmental cost indicator (ECI) can be found on the National Environmental Database[7]. Ecoplatform offers a wide variety of EPDs from different programmes[8]. This could be a good start when searching for EPDs.

More information on the European developments can be found on the website of the European Commission, for example for the Environmental Footprint methods[9], the ESPR[10] or the CPR[11].

Set 1 (NMD)

Environmental Indicator	Unit
001. abiotic depletion, non fuel (AD)	kg Sb eq
002. abiotic depletion, fuel (AD)	kg Sb eq
004. global warming (GWP)	kg CO_2eq
005. ozone layer depletion (ODP)	kg CFC-11 eq
006. photochemical oxidation (POCP)	kg C2H4
007. acidification (AP)	kg SO2 eq
008. eutrophication (EP)	kg PO4---eq
009. human toxicity (HT)	kg 1,4-DB eq
010. Ecotoxicity, fresh water (FAETP)	kg 1,4-DB eq
012. Ecotoxicity, marine water (MAETP)	kg 1,4-DB eq
014. Ecotoxicity, terrestic (TETP)	kg 1,4-DB eq
MKI	**€**

Set 2 (15804:A2), PEF

Environmental Indicator	Unit
051. Climate change	kg CO_2eq
052. Climate change - Fossil	kg CO_2eq
053. Climate change - Biogenic	kg CO_2eq
054. Climate change - Land use and LU change	kg CO_2eq
055. Ozone depletion	kg CFC11 eq
056. Acidification	mol H + eq
057. Eutrophication, freshwater	kg P eq
058. Eutrophication, marine	kg N eq
059. Eutrophication, terrestial	mol N eq
060. Photochemical ozone formation	kg NMVOC eq
061. Resource use, minerals and metals[2]	kgSb eq
062. Resource use, fossils[2]	MJ
063. Water use[2]	m3 depriv.
064. Particular matter	disease inc.
065. Ionising radiation[1]	kBq U-235 eq
066. Ecotoxicity, freshwater[2]	CTUe
067. Human toxicity, cancer[2]	CTUh
068. Human toxcity, non-cancer[2]	CTUh
069. Land use[2]	Pt

Indicators (15804:A2), PEF

Environmental Indicator	Unit
111. Energy, primary, renewable, excluding usage as mat	MJ
113. Energy, primary, renewable, used as material	MJ
101. Energy, primary, renewable (MJ)	MJ
112. Energy, primary, non-renewable, excluding usage as	MJ
114. Energy, primary, non-renewable, used as material	MJ
102. Energy, primary, non-renewable (MJ)	MJ
108. Secondary material (kg)	kg
109. Secondary fuel, renewable (kg)	MJ
110. Secondary fuel, non-renewable (kg)	MJ
104. Water, fresh water use (m3)	m3
106. Waste, hazardous (kg)	kg
105. Waste, non hazardous (kg)	kg
107. Waste, radioactive (kg)	kg
120. Components for re-use (kg)	kg
121. Materials for recycling (kg)	kg
122. Materials for energy recovery (kg)	kg
Exported energy, electric (MJ)	MJ
Exported energy, thermal (MJ)	MJ

5 https://www.circonnect.org/kennisbijdrage/self-assessment-tool-voor-levenscyclus-analyses/ Available in Dutch
6 https://www.circonl.nl/international/
7 https://milieudatabase.nl/nl/viewer/
8 https://www.eco-platform.org/epd-data.html
9 https://green-business.ec.europa.eu/environmental-footprint-methods_en
10 https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_en
11 https://single-market-economy.ec.europa.eu/sectors/construction/construction-products-regulation-cpr_en

Volume 63: THE NOT-SO-EASY GUIDE TO CIRCULAR INTERIOR DESIGN
Guest edited by Marieke van den Heuvel

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In 2004 Archis, the Amsterdam based architecture magazine with a pedigree reaching back to 1929, joined forces with OMA's think tank AMO and C-Lab – a think-tank at the GSAPP of Columbia University – based on the shared ambition to redefine and re-establish architecture's relevance. Volume was created by Archis Editor in Chief at the time, Ole Bouman in collaboration with Rem Koolhaas (AMO) and Mark Wigley (Dean of GSAPP). From 2017 Archis/Volume changed its structure into more theme-based forms of collaboration, expanding the network of partners. Since 2023 Volume is a collaboration between Archis and Nieuwe Instituut.

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ABOUT THIS PRINT

Limiting the environmental footprint of this guide was key in its design and production. The dimensions of the book were optimized for the most efficient use of the larger printing sheets. The paper, Recystar Nature by Papyrus, is a recycled paper that was considered dead or unsellable existing stock by the printer. Recystar Nature is uncoated, FSC®-certified, and made with Elemental Chlorine Free-pulp.

The use of two main colors throughout the guide limits the number of aluminium printing plates used in the printing process. Making these plates is one of the more energy and material intensive elements of printing. Full color versions of images are made available through QR codes.

The inks used by our printer, die Keure, are made from renewable sources and contain as little chemical additives as possible. 100% of the electricity used at die Keure is from (on-site) renewable sources and the company has pledged to become climate neutral by 2025.

Still we recognize that not all elements of this guide are 100% circular, i.e. the glue used in the binding, plastic wrapping we use to send the guide to subscribers, and (limited) paper waste during the cutting process. In future guides we want to seek further improvements to extending our footprint reduction.

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Volume #63 Tracked Changes

Volume #62 The Ultimate Guide to Guides

Volume #60 The world in reviews
from architects becoming bakers to the face of Jesus in China, and everything in between...

Volume #59 Futures implied
Media architecture and digital culture

Volume #58 Legacy
Looking back to move on

Volume #57 Bye Default
In search of architecture's added value

Volume #56 Playbor
Play at work

Volume #55 Intangible Cultural Heritage
A tool to use

Volume #54 On Biennials
Its Effects, Power and Audiences

Volume #53 Civic Space
There is no such thing a society...

Volume #52 The End of Informality
Part of the systems design?

Volume #51 Augmented Technology Tech is pushing, but who's driving?

Volume #50 Beyond Beyond
Goodbye Beyond, Welcome ...

Volume #49 Hello World!
When algorythms start taking over

Volume #48 The Research Turn
Rethinking productivity

Volume #47 The System
Lobbying isn't enough to make change happen

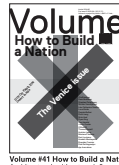
Volume #46 Shelter
For whom, against what? Shelter is a verb!

Volume #45 Learning
From the learning of architecture to the architecture of learning

Volume #44 On Display
Architecture as both content and container

Volume #43 Self-Building City
Housing and self-building as field of interaction

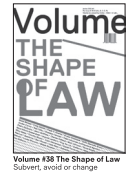
Volume #42 Art & Science of Real Estate
Towards a developer's ethics



Volume #41 How to Build a Nation
Architecture's ultimate role?

Volume #40 Architecture of Peace Reloaded
Complexities and considerations

Volume #39 Urban Border
Architecture as urban catalyst



Volume #38 The Shape of Law
Subvert, avoid or change

Volume #37 Is This Not a Pipe?
Building mechanics

Volume #36 Ways To Be Critical
When everyone's a critic

Volume #35 Everything Under Control
Building with biology

Volume #34 City in a Box
Corporate takeover of public domain

Volume #33 Interiors
Think inside the box

Volume #32 Centers Adrift
Centers are on the move: are you in or are you out?

Volume #31 Guilty Landscapes
The creative use of guilt

Volume #30 Privatize!
We are all individuals

Volume #29 The Urban Conspiracy
The grey take-over of city and society

Volume #28 Internet of Things
When things start talking back ...

Volume #27 Aging
Life beyond the nursing home

Volume #26 Architecture of Peace
How can we materialize peace?

Volume #25 Getting There Being There
Living on the Moon

Volume #24 Counterculture
How protest informs architecture

Volume #23 Gulf Cont'd
The Gulf inside-out: forces, experiments, influences

SOLD OUT!

Volume #22 The Guide
Architect as guide, guide as architecture

Volume #21 The Block
Housing for the billions: mass-produced, custom-made

Volume #20 Storytelling
Another way of understanding our era

Volume #19 Architecture of Hope
Design for a multicultural society

Volume #18 After Zero
A new contract with ecology

Volume #17 Content Management
Collecting, organizing and sharing information through architecture

Volume #16 Engineering Society
New options for social engineering

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Method and canon for the architecture of library 2.0

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Volume #14 Unsolicited Architecture
Unsolicited Architecture the pro-active practice

Volume #13 Ambition
Architect's ambitions in a landscape of misguided purpose

Volume #12 Al Manakh
History, culture and architecture of the Gulf region and beyond

Volume #11 Cities Unbuilt
Architectural dimension of destruction — special focus on the Caucasus, Kosovo and Lebanon

Volume #10 Agitation
Agitation as vitalizing condition for architecture

SOLD OUT!

Volume #9 Suburbia
On opportunities for suburbia after the crash

Volume #8 China
New ideas about the future of the Chinese city

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Volume #7 Power 3
On architectural thinking as foundation of power structures

Volume #6 Power 2
Power at the scale of the building

Volume #5 Power 1
A photographic essay focusing on the relationship between power and architecture

Volume #4 Shareware
A portable exhibition of ideas to break through architecture

Museum for architecture, design and digital culture.

Nieuwe Instituut

Museumpark 25, Rotterdam
The Netherlands

Garden Ashram College, Alphen aan de Rijn, 1978-2021, Louis Le Roy archive.

The National Collection for Dutch Architecture and Urban Planning is one of the largest architecture collections in the world, with four million drawings, models and photographs. Nieuwe Instituut takes care of collecting, managing and making this collection available to the public: in the Research Centre, online and through exhibitions. Read more about the collection and the stories it contains on our website.

If reality were solely based on LinkedIn announcements, design biennials, and conferences, you'd think design and architecture are nearing perfection in terms of complete sustainable design. In contrast, the actual practice of circular building is messy, complicated, stacked with dilemmas, and still far from achieving its goals. This guide helps readers and designers untangle the intricate web of interlocking issues that keep us from realizing most of our ambitions. It takes an inside-out approach to architecture, starting from the interior. This is particularly important as interiors are characterized by high turnover rates, driven by trends, and consist of highly customized components made from a variety of materials, making implementing circular principles even more challenging.

Organized into three levels of expertise – beginner, intermediate, and expert – this guide will help you navigate circular design based on your own practice and experience. This structure is linked to three in-depth circular interior design case studies featuring interviews with different actors involved in the projects. From clients to contractors, designers, architects, makers, sustainability accountants, and demolition crews, they all pinch in and share their learnings. Additional contributions delve into key findings from the interviews and look in depth at circular calculation tools, developments in bio-based materials, as well as the role of cleaning and maintenance culture, financial models, and the importance of adapting our understanding of aesthetics.

Guest edited by Marieke van den Heuvel

Interviews with Fiction Factory, Circu-leren, Hollandse Nieuwe, NICE, Fokkema & Partners, Superuse Studios, LBP|SIGHT, and Opera amongst others

Contributions by David van Nunen, Jaapjan Berg, Material Cultures, Ruth Baumeister, Simon J. Barker, Remy Heijer, Jingshi Liu, Aylin Cakanlar, Gergaa Nenkov, Pascal Leboucq, ROTOR, and Stephan Petermann