



GreenDelta

software / data / know-how

Life Cycle Inventory Analysis & Building a National Life Cycle Inventory Database: Lessons learned

Dr Andreas Ciroth
GreenDelta GmbH

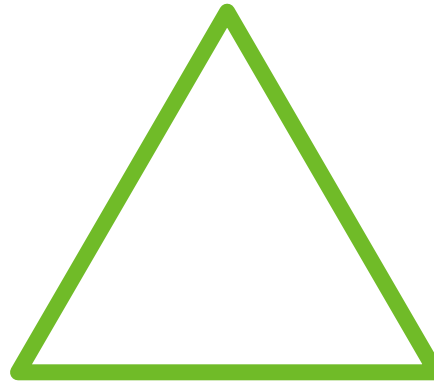
Workshop Series Sustainable Production and LCA, Nov 16 2021

GreenDelta, greendelta.com

SME, team of 20, interdisciplinary (engineers, economists, IT, architects..), international (DE, IT, FR, SP, RU, IN, BR), office in Berlin, independent capital company founded 2004

Sustainability consultancy and research

environmental LCAs, resource criticality, social LCAs, Life Cycle Costing, Circular Economy



Database development
and –distribution (Nexus)

Software development,
especially open source
(e.g. openLCA)

Points for the talk

- Life Cycle Inventory Analysis
- Building a national life cycle inventory database

Andreas Christ

Rickard Arvidsson *Editors*



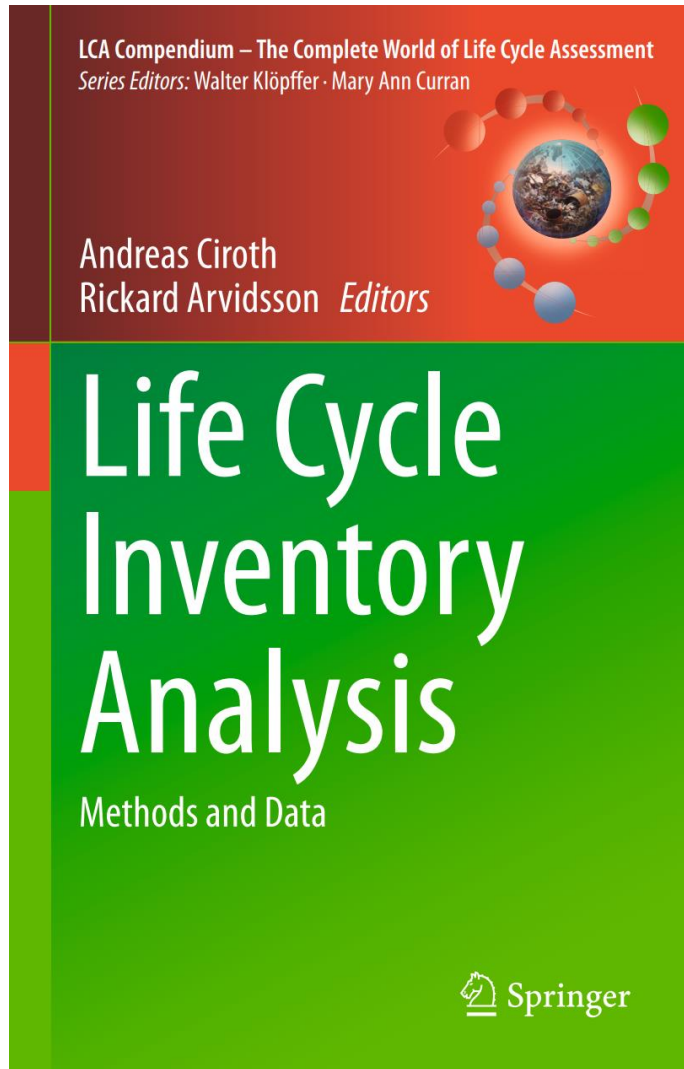
Life Cycle

Life Cycle Inventory Analysis

Inventory

Analysis

Life Cycle Inventory Analysis, 2021



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Life Cycle Inventory Analysis, 2021

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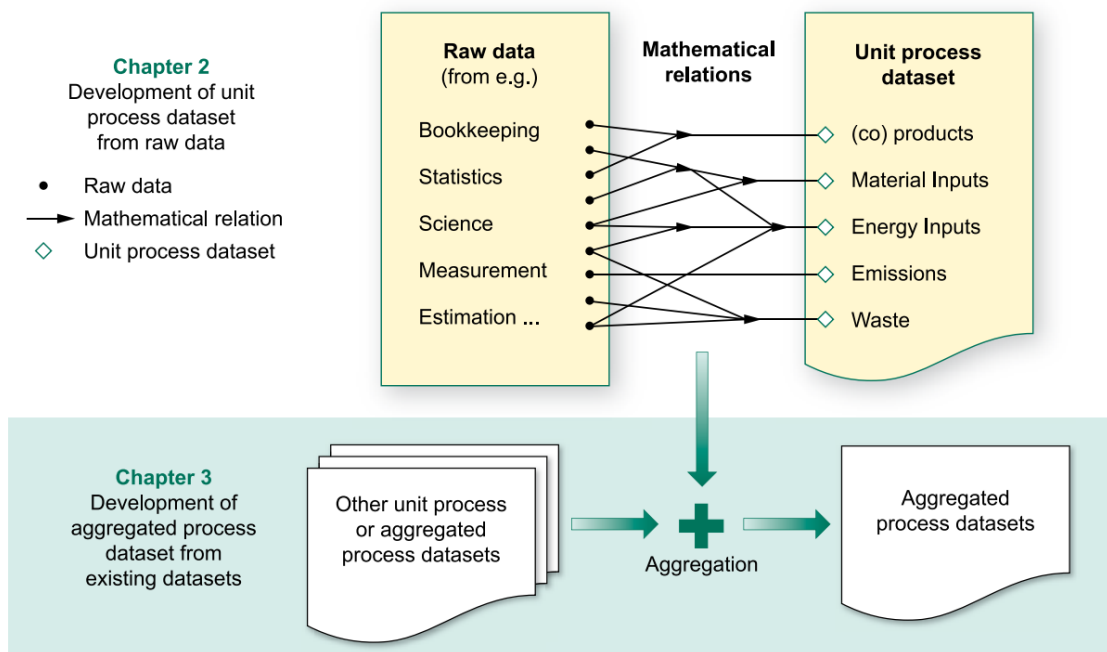
Principles of Life Cycle Inventory Modeling

- [-] Chapter 2: Principles of Life Cycle Inventory Modeling: The Basic Model, Extensions, and Conventions
 - [-] 1 The Basic Life Cycle Inventory Model
 - [-] 2 Some Fundamental Modeling Topics in the Basic LCI Model
 - [-] 2.1 Modeling Benefits and Impacts: The Functional Unit
 - [-] 2.2 Modeling Causality: Attributional Versus Consequential Perspectives
 - [-] 2.3 Setting Boundaries in an Infinite Inventory Model
 - [-] 2.4 Modeling Locations
 - [-] 2.5 When Can a Process Dataset be Considered Complete?
 - [-] 3 Extensions of the Basic LCI Model
 - [-] 3.1 Modeling Multifunctionality
 - [-] 3.2 Modeling Time
 - [-] 3.3 Low Probability Flows of High Impact, Unknown Mechanisms
 - [-] 4 Life Cycle Modeling Conventions
 - [-] 4.1 Modeling Transport Services
 - [-] 4.2 Modeling the Use Phase
 - [-] 4.3 Modeling End of Life
 - [-] 5 Conclusion
 - [-] References

Development of Unit Process Datasets

- Chapter 3: Development of Unit Process Datasets
 - 1 Introduction
 - 2 General Procedures of Developing Unit Processes
 - 2.1 Goal and Scope Definition of Unit Processes
 - 2.2 Data Collection and Accounting of Flows
 - 2.2.1 Data Sources and Selection
 - 2.2.2 Accounting Flows from Raw Data
 - Mathematical Relations
 - Special Flows
 - 2.2.3 Flows with Missing Data
 - 2.3 Matching Flows with Background Datasets (Optional)
 - 2.4 Internal Check
 - 2.5 Sensitivity Analysis (Optional)
 - 2.6 Data Quality Evaluation
 - 2.7 Documentation
 - 2.8 Critical Review
 - 3 Tools
 - 4 Conclusions and Outlook
 - References

Development of Unit Process Datasets



Data Quality

- [-] Chapter 5: Data Quality in Life Cycle Inventories
 - [-] 1 Data Quality: An Issue in Life Cycle Inventories
 - [-] 2 Definition of Data Quality and Fitness for Purpose
 - [-] 3 Addressing Data Quality in Life Cycle Assessment
 - [-] 3.1 Relevance of Data Quality in LCA
 - [-] 3.2 The Janus Property of Data Quality
 - [-] 3.3 Components of Data Quality Descriptors
 - [-] 3.4 Data Quality Topics in LCI and Generic Indicators
 - [-] 3.5 Data Quality Use Cases – Frameworks
 - [-] 3.5.1 Data Quality in the Environmental Footprint
 - [-] The Category Rules
 - [-] The Data Quality Assessment Formula
 - [-] Review in the Environmental Footprint
 - [-] 3.5.2 Data Quality in the US Environmental Protection Agency
 - [-] 3.5.3 UNEP Global Life Cycle Access to Data (GLAD)
 - [-] 4 Notes on Selected Data Quality Indicators
 - [-] 4.1 Uncertainty
 - [-] 4.2 Reliability
 - [-] 4.3 Representativeness
 - [-] 4.4 Time
 - [-] 4.5 Location
 - [-] 4.6 Technology
 - [-] 5 Conclusion and Way Forward
 - [-] References

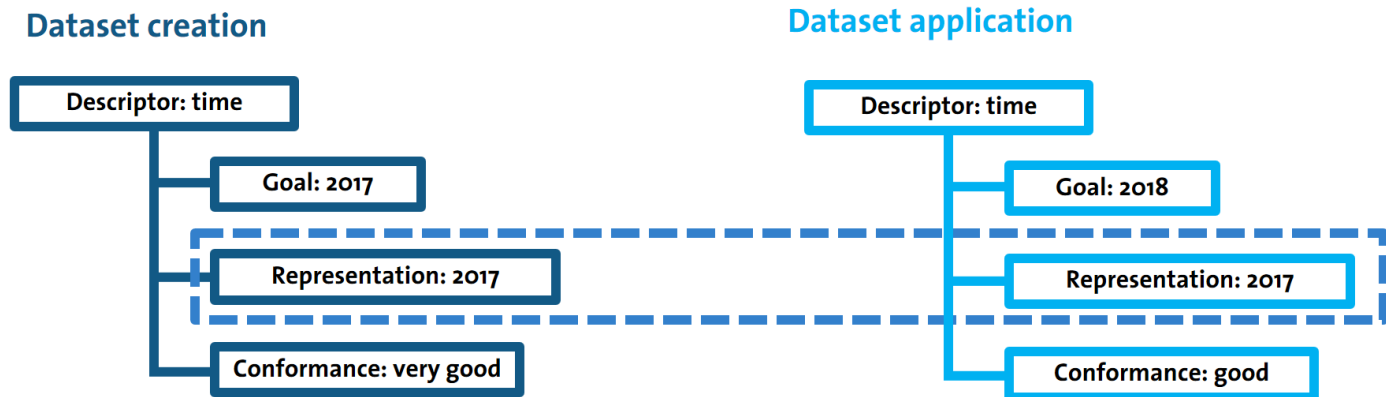
Data Quality

- Data quality is fitness for purpose
- Two sides:
 - a) When creating a dataset
 - b) When using a dataset



Data Quality

- Data quality is fitness for purpose
- Two sides:
 - a) When creating a dataset
 - b) When using a dataset



Algorithms

- Chapter 7: Algorithms of Life Cycle Inventory Analysis
 - 1 Introduction
 - 2 Calculating Inventory Results
 - 2.1 Representation with Linear Equations
 - 2.2 Reformulation with Matrices
 - 2.3 Calculating LCI Results
 - 2.4 The Sequential Approach
 - 2.5 Relations to Input-Output Analysis
 - 3 Handling Specific Characteristics
 - 3.1 Multiple Providers
 - 3.2 Multifunctional Processes
 - 3.3 Avoided Production
 - 3.4 Waste Flows
 - 3.5 Loops
 - 4 Advanced Analysis Functions
 - 4.1 Direct Contributions
 - 4.2 Upstream Contributions
 - 4.3 Contribution Trees
 - 4.4 Relations to Impact Assessment
 - 5 Performance Considerations
 - 5.1 Selection of Algorithms
 - 5.2 Precalculated Results
 - References

Algorithms

Algorithm 7.3 Calculating an upstream tree

1. **function** *UTREE* (\mathbf{A} , s_{ref} , g_k , \mathbf{m})
2. $root \leftarrow Node(idx \leftarrow ref, scaling \leftarrow s_{ref}, result \leftarrow g_k)$
3. **call** *CHILDS* ($root$, \mathbf{A} , \mathbf{m} , 0)
4. **return** $root$
5. **function** *CHILDS* ($parent$, \mathbf{A} , \mathbf{m} , $depth$)
6. **if** $depth > depth_{max}$ **return**
7. **for** $r \leftarrow 1 \dots rows(\mathbf{A})$
8. **if** $r = parent.idx$ **continue**
9. $v \leftarrow \mathbf{A}(r, parent.idx) \cdot parent.scaling$
10. **if** $v = 0$ **continue**
11. $child \leftarrow Node(idx \leftarrow r)$
12. $child.scaling \leftarrow \frac{-v}{\mathbf{A}(r,r)}$
13. $child.result \leftarrow \mathbf{m}(r) \cdot \mathbf{A}(r, r) \cdot child.scaling$
14. $add(parent.chilts, child)$
15. **if** $abs(child.result) > u_{min}$
16. **call** *CHILDS* ($child$, \mathbf{A} , \mathbf{m} , $depth + 1$)

LCI Data and Databases

- [-] Chapter 6: Life Cycle Inventory Data and Databases
 - [-] 1 Life Cycle Inventory Data and Databases, Definition and Introduction
 - [-] 2 The Role of Life Cycle Inventory Databases for Life Cycle Assessment
 - [-] 3 Types of Databases
 - [-] 4 Issues in Life Cycle Inventory Databases
 - [-] 4.1 Setup
 - [-] 4.2 Quality Assurance
 - [-] 4.3 Maintenance
 - [-] 4.4 Integration into LCA Software
 - [-] 5 Data Exchange
 - [-] 5.1 Information in LCI to Be Exchanged
 - [-] 5.2 Exchange Formats
 - [-] 5.3 Interoperability Concepts
 - [-] 6 Outlook
 - [-] References

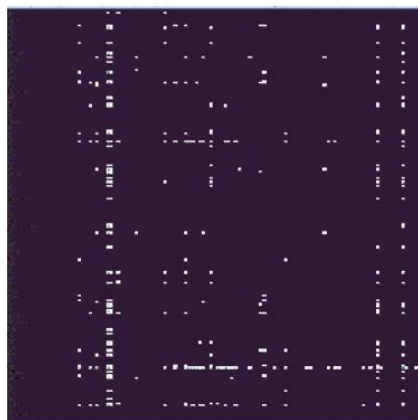
LCI Data and Databases

→ process sectors

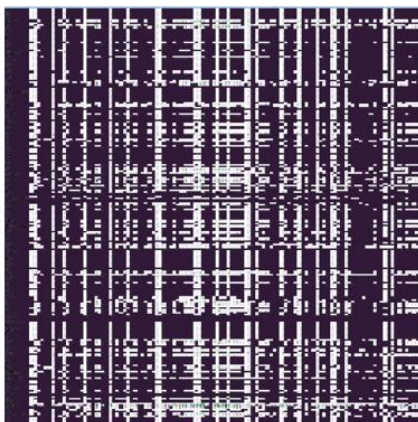
→ countries



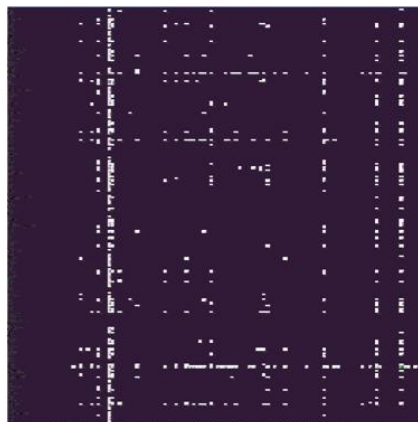
a) ELCD



b) ecoinvent v3.2



c) eora



d) ecoinvent v3.5

white = process dataset

The background image shows a city street with a green overlay. The overlay contains a semi-transparent image of a busy road with cars, a bus, and motorcycles. The text "Creating a national LCI database" is written in white on the green background.

Creating a national LCI database

Creating a national LCA database

(i.e., a database that is national reference, often provided for free, and maintained by public institutions)

- LCA databases first existed for several EU countries, US, Japan, Australia
- In other regions, processes are often very different → need for additional databases
- LCA data is like infrastructure -> free access to LCA data is a public service
- there is often need for an agreed value of e.g. electricity grid Greenhouse Gas emissions
- creating the database fosters national industry and science

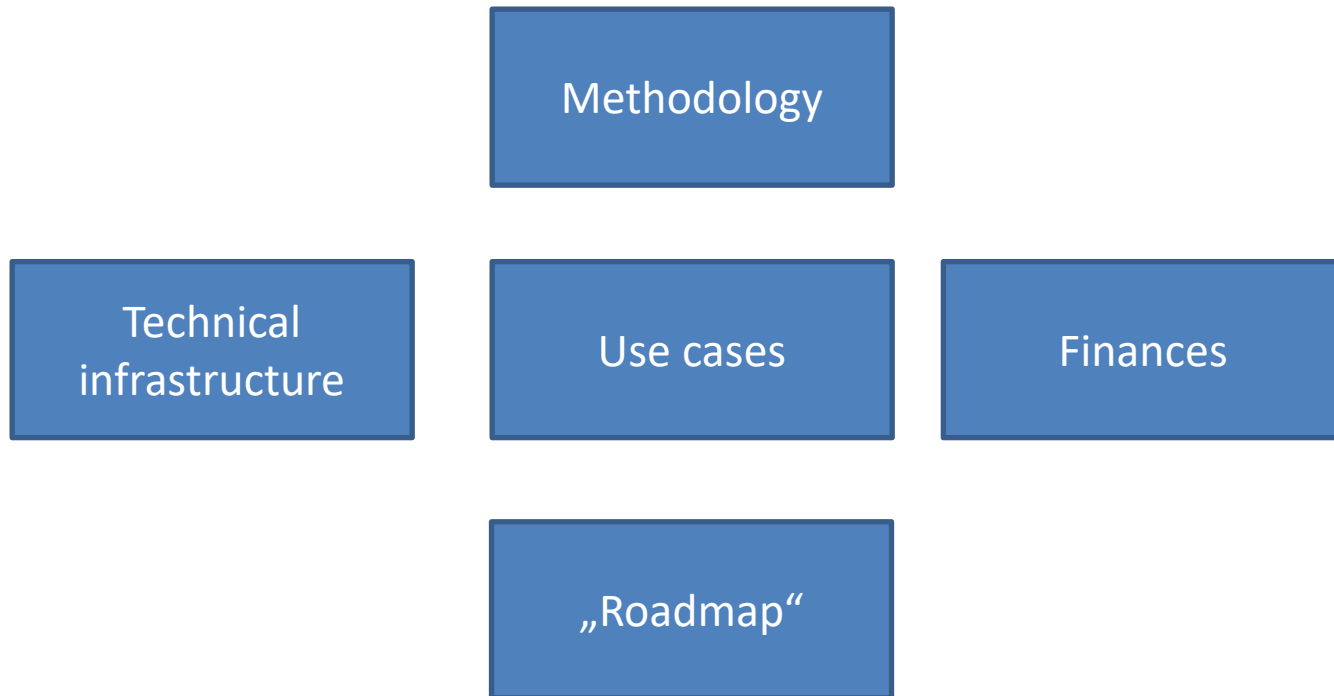
Creating a national LCI database

Quite some national databases are now created or have been created since some time:

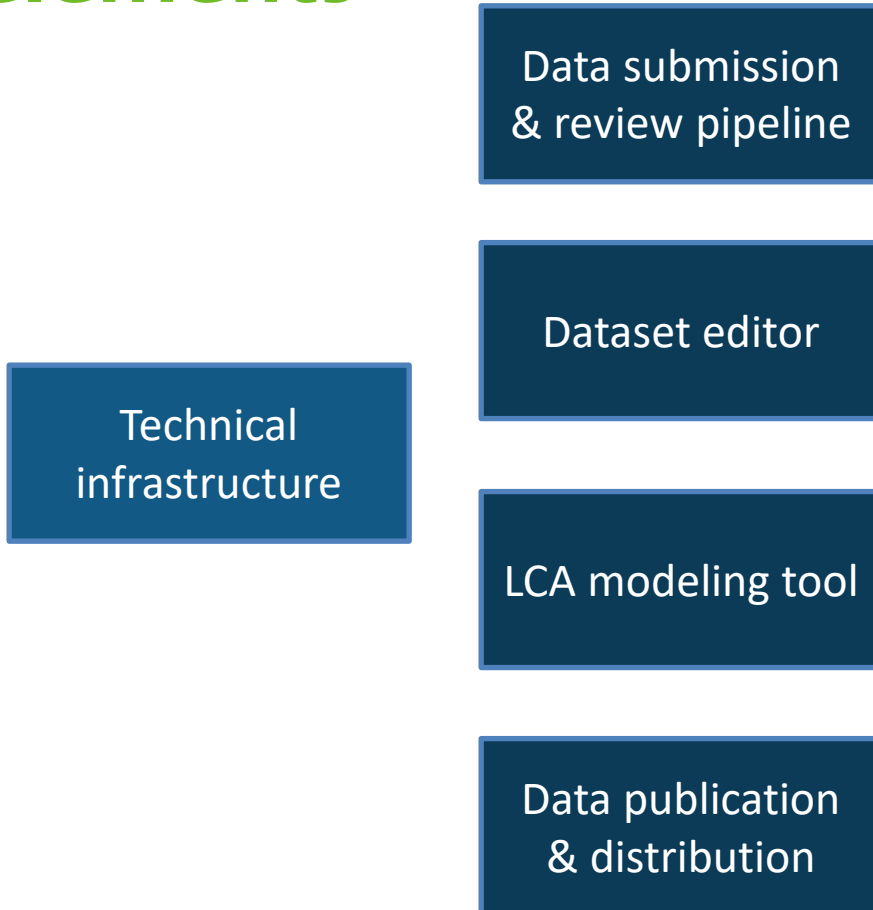
- Chile
- Brazil
- Malaysia
- Thailand
- Korea (CO₂)
- ...

This is a chance for local LCA communities, to bring in innovation, and to benefit from existing experiences at the same time

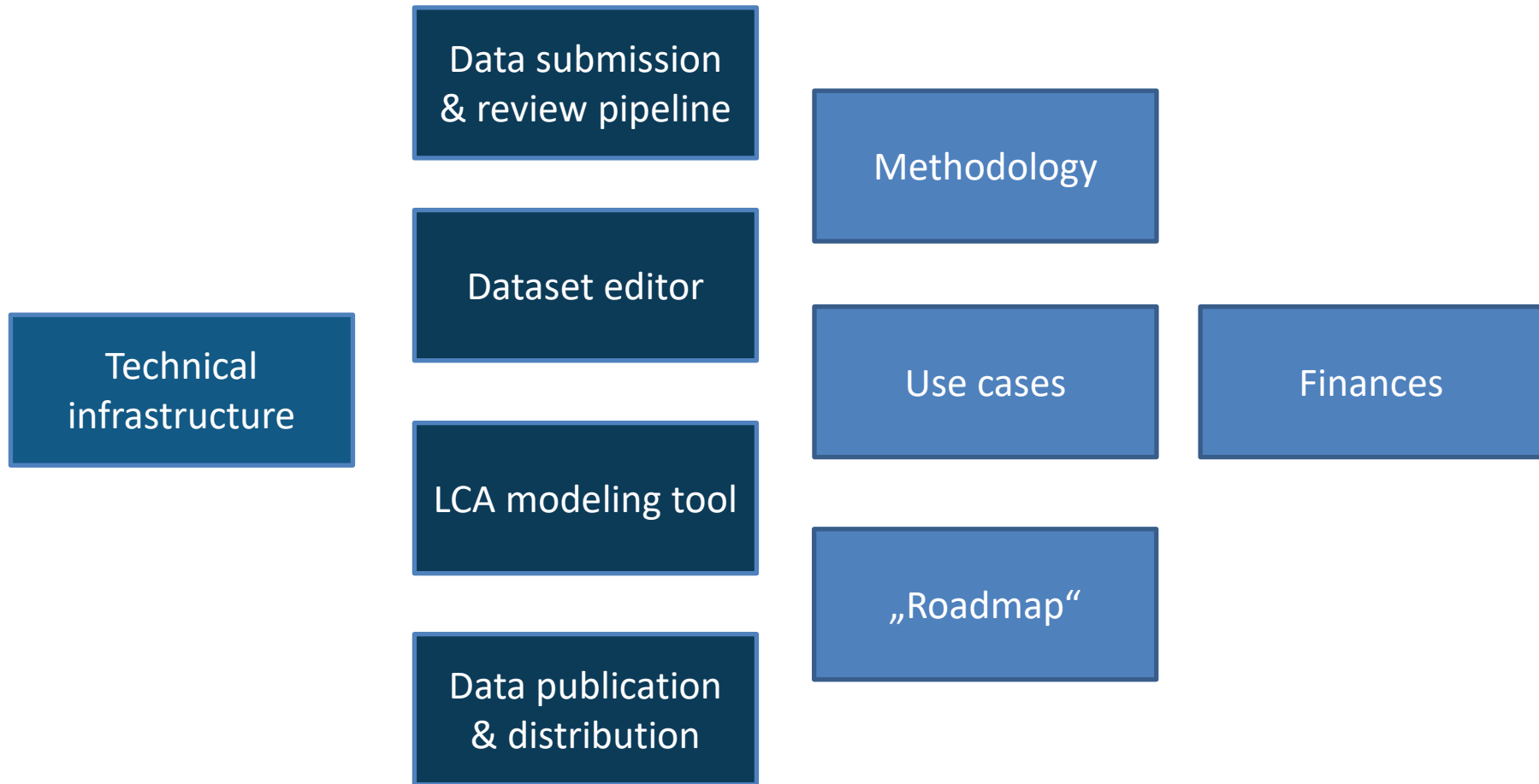
A national LCI database, elements



A national LCI database, elements

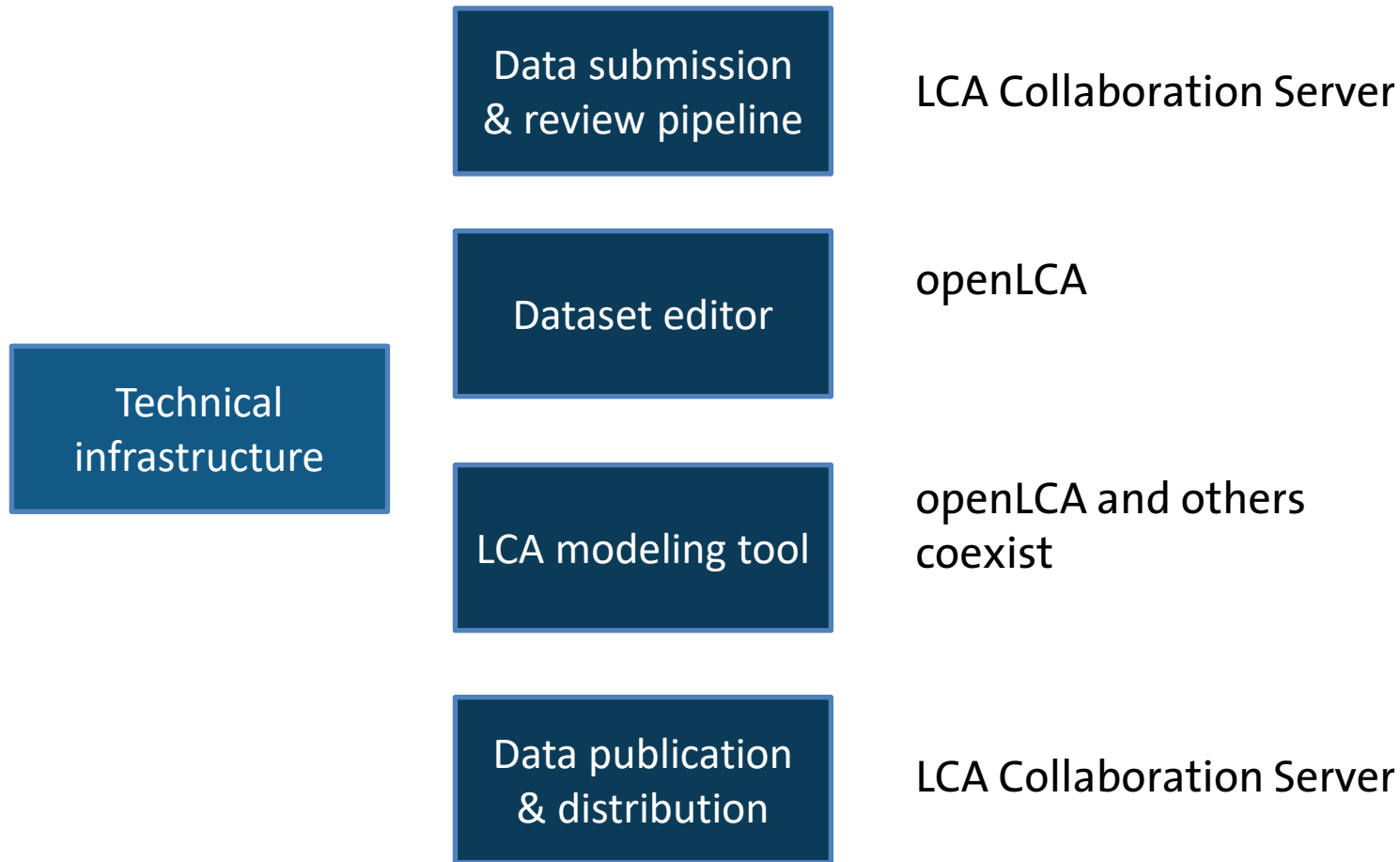


A national LCI database, elements



A national LCI database,

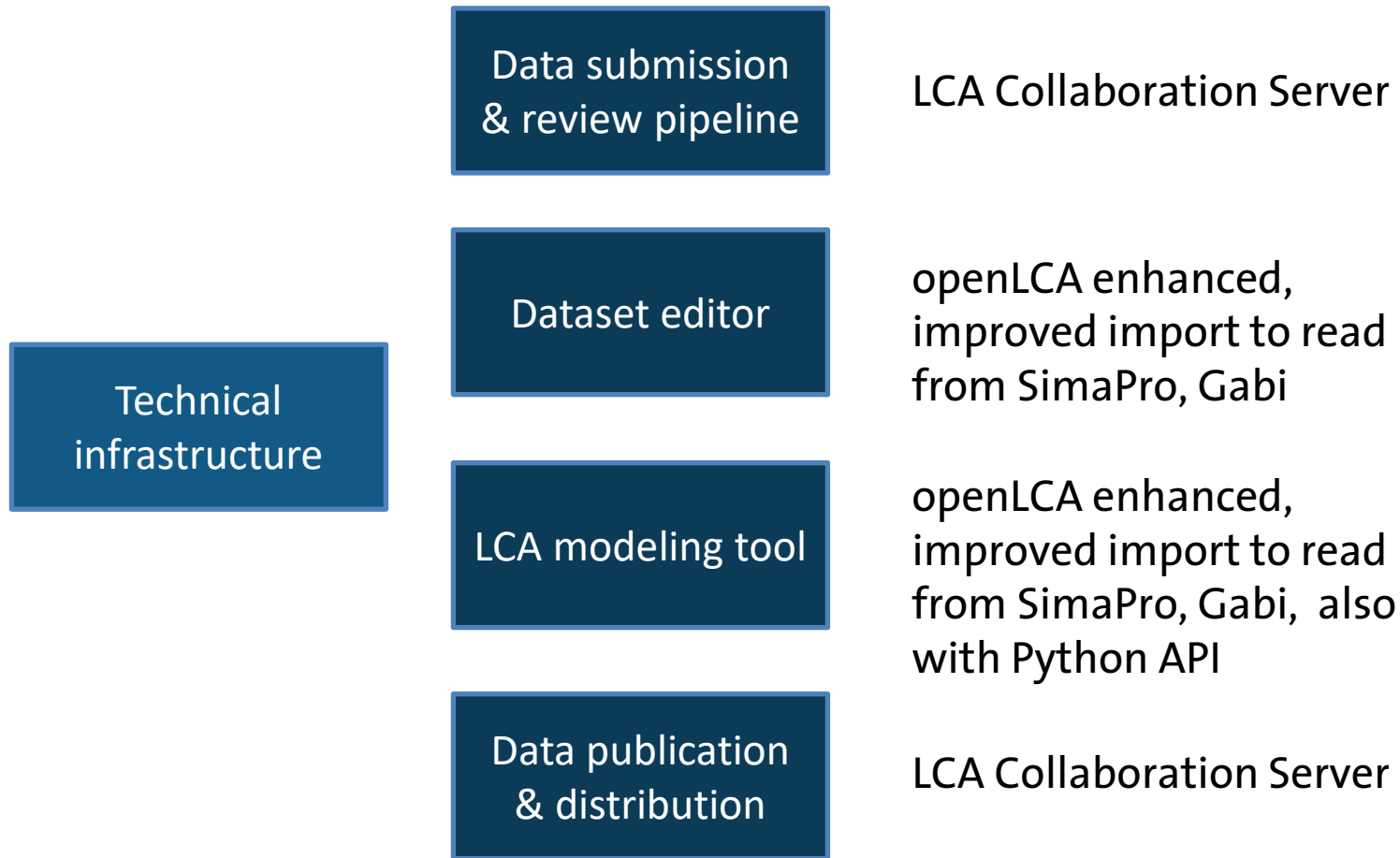
examples: USA (US Department of Agriculture, US EPA)



(project with GreenDelta, since 2015)

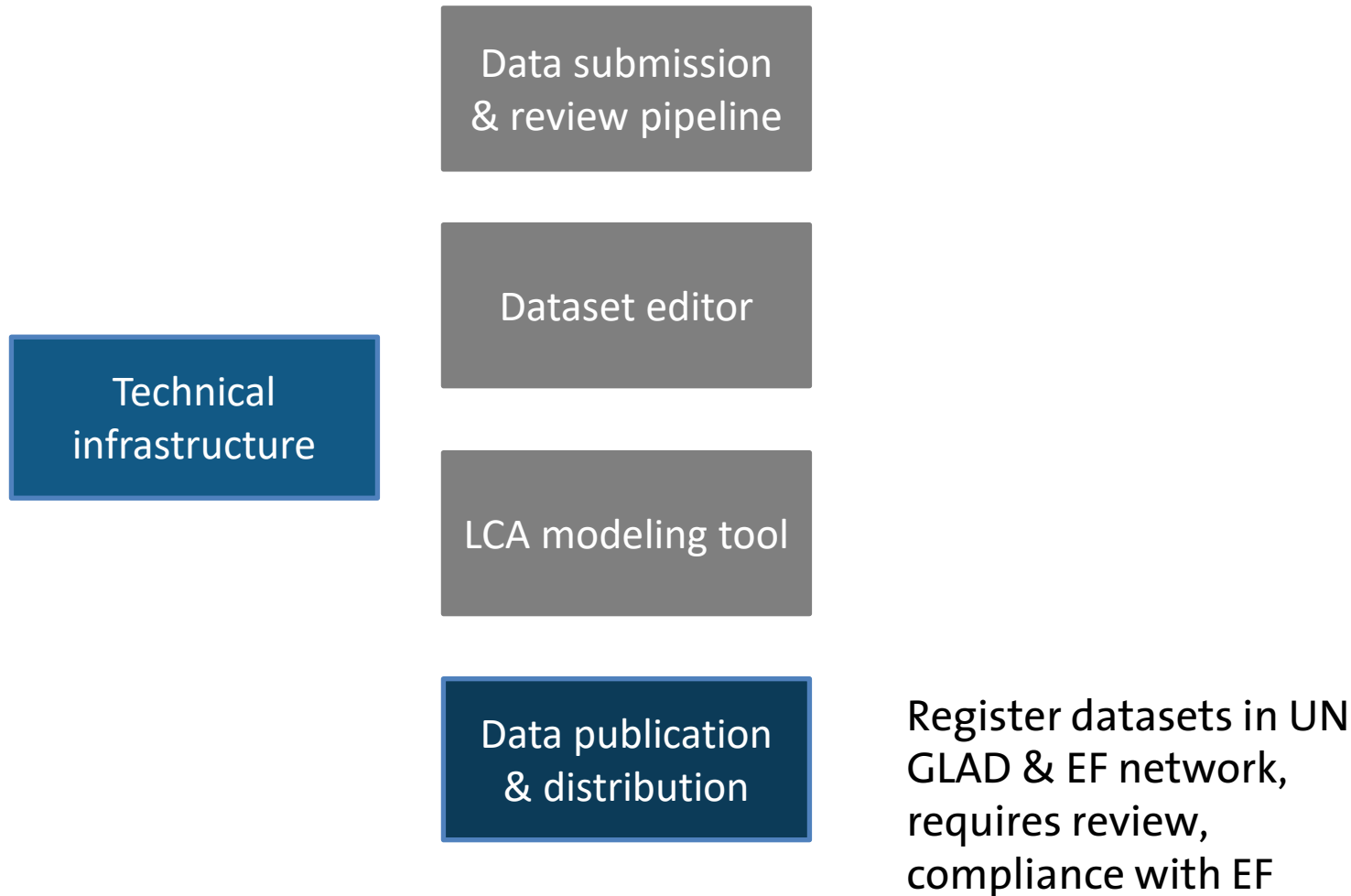
A national LCI database,

examples: Canada (National Resources Canada)



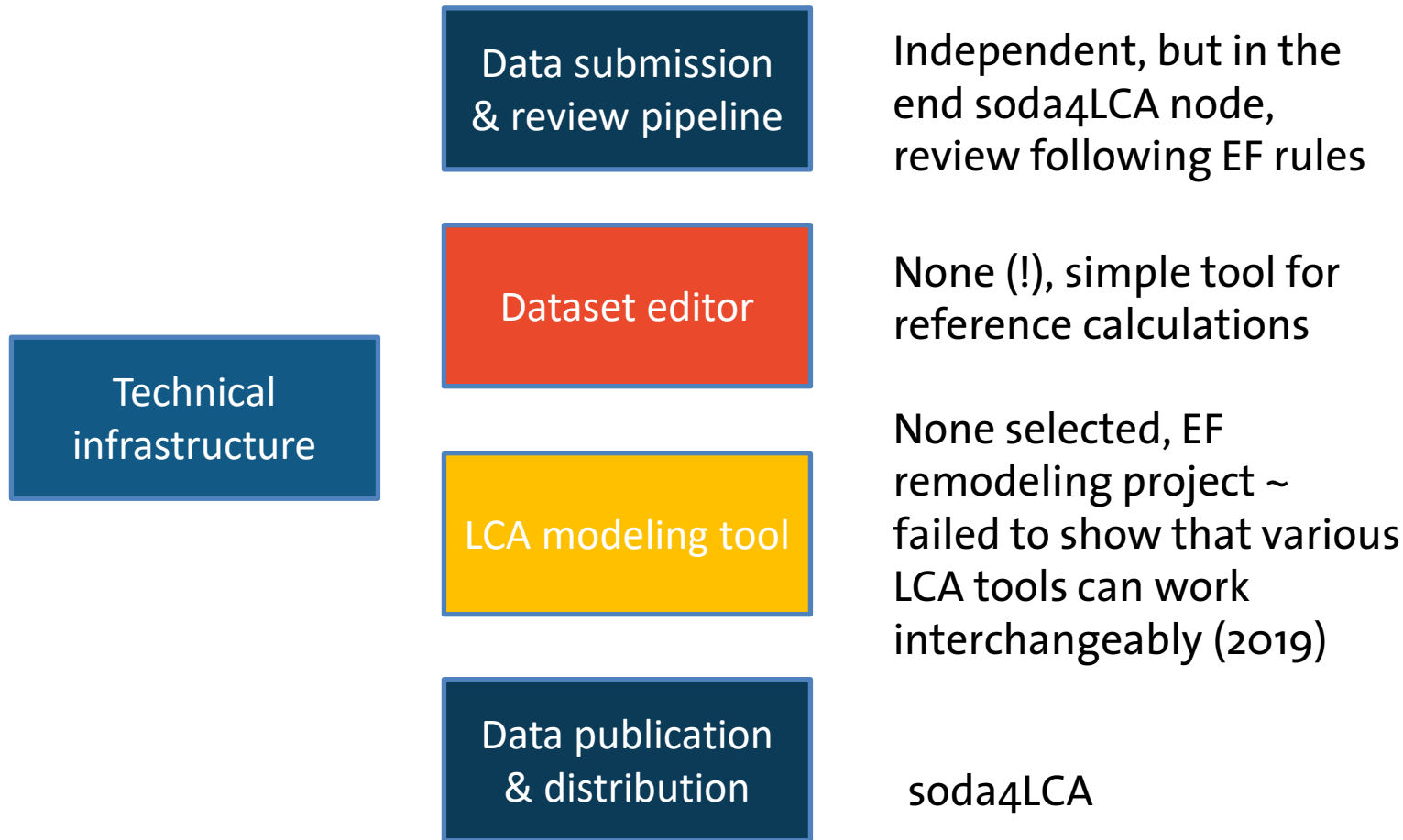
(project with GreenDelta, 2021+)

A national LCI database, examples: Korea

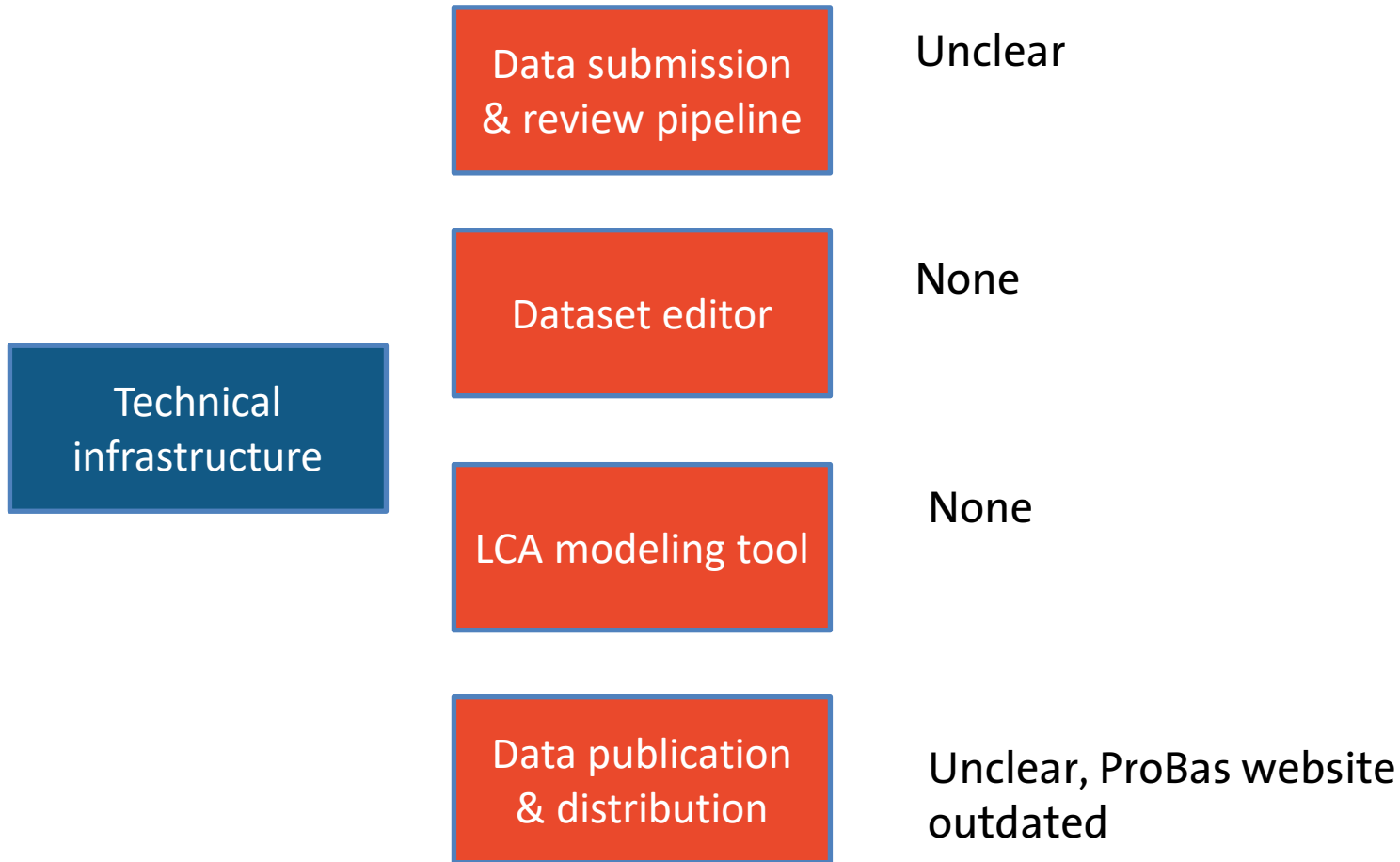


(project with GreenDelta, 2021)

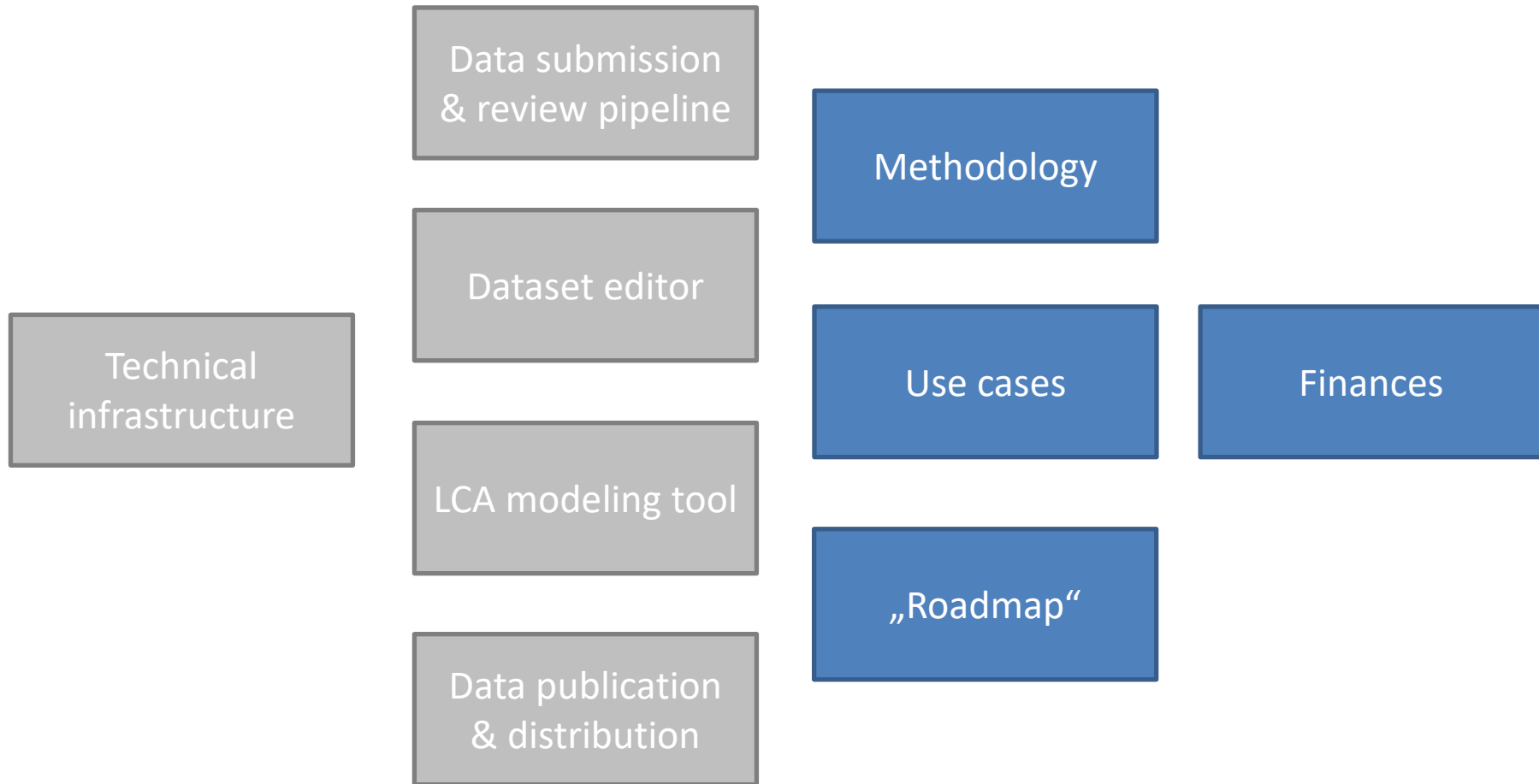
A national LCI database, examples: EU



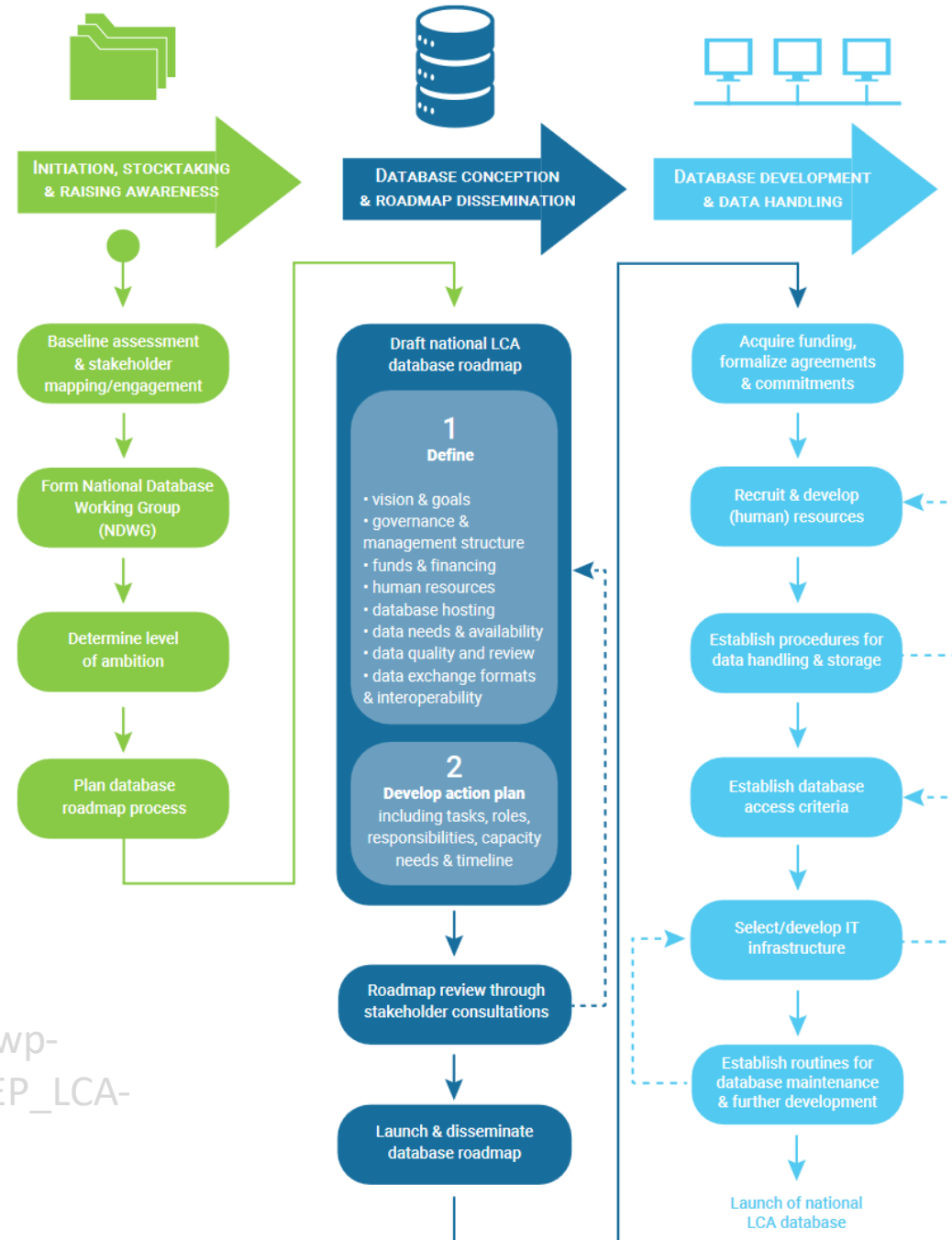
A national LCI database, examples: German



A national LCI database, elements



A national LCI database, roadmap (UN report)



https://www.lifecycleinitiative.org/wp-content/uploads/2020/11/INT_UNEP_LCA-Dev_Nov-19_WEBsml.pdf

A national LCI database, Now is the time

Never before have good data on life cycle impacts been so important.

Major companies and economies assess and improve now their carbon footprint and other life cycle impacts.

Public LCA data are like public infrastructure, they are a great benefit and advantage for local industry..

.. if done well.

There are now sufficient examples to learn from, there is also sufficient infrastructure to start from. For the start, it is important to bring main players on board.

This is also a chance to reflect Indonesian conditions and background, to and support Indonesian research and scientists.

GreenDeLta

sustainability consulting + software

Thank you very much!

Contact:

Dr. Andreas Ciroth

GreenDelta GmbH

Kaiserdamm 13, 14057 Berlin, Germany

ciroth@greendelta.com

www.greendelta.com