

GreenDelta

sustainability consulting + software

ecoinvent 3 in openLCA

Ecoinvent 3 from the point of view of a software provider

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GreenDelta Berlin

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ecoinvent 3 in openLCA

1 Introduction

a) ecoinvent 3

b) openLCA

2 Implementation tasks for openLCA, due to ecoinvent

3 ecoinvent 3 in openLCA: status at present

4 Discussion

1 Introduction

1 Introduction, ecoinvent 3

(just some points)

1 Introduction, ecoinvent 3

Ecoinvent 3 brings

- A new, feature-rich data format, EcoSpold02
 - According to a final format specification
 - Formulas, parameters, multiple languages, own intelligence, child-parent relationships in LCA datasets,
 - New reference lists for flows, asf., now with UUIDs
 - ...
- An interpretation of the data format EcoSpold02 data format for ecoinvent 3 data sets
 - Usually of course following the specification but some modifications and additions
 - Important for the implementation

1 Introduction, ecoinvent 3

Ecoinvent 3 brings

- New types of process data sets, for markets, that typically link one process with another
- a drastically increased number of data sets in one typical product system (with the same number of LCA process data sets).

openLCA

- Professional open source LCA software, free
- Developed by GreenDelta since 2006
- So far we are the only developer but currently several projects started, e.g. by US EPA, to develop additional content
- Quite popular, worldwide, with 300 downloads / week
- Users: many universities, consultants, US EPA and other research institutes, first companies
- Last release: version 1.3.1, 28 Sept 13
- www.openlca.org

openLCA – graphical modeling

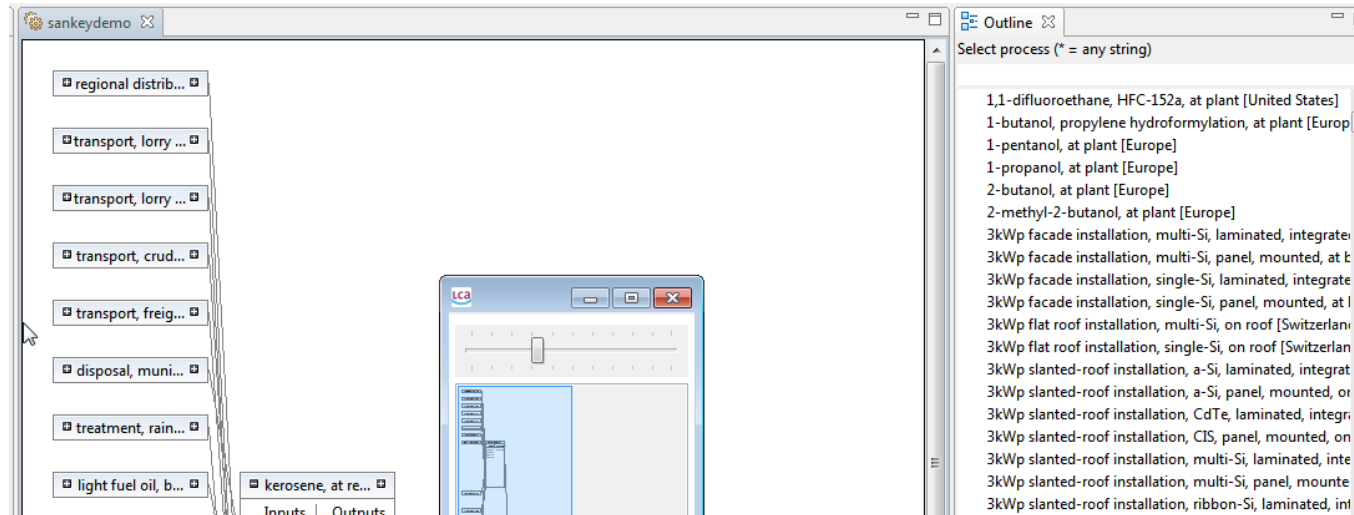
The screenshot displays the openLCA graphical modeling interface. The main window shows a list of processes on the left, including 'regional distrib...', 'transport, lorry ...', 'transport, lorry ...', 'transport, crud...', 'transport, freig...', 'disposal, muni...', 'treatment, rain...', 'light fuel oil, b...', 'kerosene, at re...', 'tap water, at us...', 'transport, barg...', and 'treatment, sew...'. The 'kerosene, at re...' process is selected, and its detailed view is shown in the center. This view includes a table with 'Inputs' and 'Outputs'.

Inputs	Outputs
disposa...	kerosen...
disposa...	
electrici...	
kerosen...	
kerosen...	
light fu...	
regiona...	
tap wat...	
transpo...	
transpo...	
transpo...	
transpo...	
treatme...	
treatme...	

The Outline pane on the right lists the following processes:

- 1,1-difluoroethane, HFC-152a, at plant [United States]
- 1-butanol, propylene hydroformylation, at plant [Europe]
- 1-pentanol, at plant [Europe]
- 1-propanol, at plant [Europe]
- 2-butanol, at plant [Europe]
- 2-methyl-2-butanol, at plant [Europe]
- 3kW facade installation, multi-Si, laminated, integrat...
- 3kW facade installation, multi-Si, panel, mounted, at b...
- 3kW facade installation, single-Si, laminated, integrat...
- 3kW facade installation, single-Si, panel, mounted, at l...
- 3kW flat roof installation, multi-Si, on roof [Switzerlan...
- 3kW flat roof installation, single-Si, on roof [Switzerlan...
- 3kW slanted-roof installation, a-Si, laminated, integrat...
- 3kW slanted-roof installation, a-Si, panel, mounted, or...
- 3kW slanted-roof installation, CdTe, laminated, integrat...
- 3kW slanted-roof installation, CIS, panel, mounted, on...
- 3kW slanted-roof installation, multi-Si, laminated, inte...
- 3kW slanted-roof installation, multi-Si, panel, mounte...
- 3kW slanted-roof installation, ribbon-Si, laminated, int...
- 3kW slanted-roof installation, ribbon-Si, panel, mount...
- 3kW slanted-roof installation, single-Si, laminated, int...
- 3kW slanted-roof installation, single-Si, panel, mounte...
- [sulfonyl]urea-compounds, at regional storehouse [Swi...
- [thio]carbamate-compounds, at regional storehouse [E...
- [thio]carbamate-compounds, at regional storehouse [S...
- acetaldehyde, at plant [Europe]
- acetamide-anilide-compounds, at regional storehouse
- acetamide-anilide-compounds, at regional storehouse
- acetic acid, 98% in H2O, at plant [Europe]
- acetic anhydride from acetaldehyde, at plant [Europe]
- acetic anhydride from ketene, at plant [Europe]
- acetic anhydride, at plant [Europe]
- acetone, liquid, at plant [Europe]
- acetonitrile, at plant [Europe]
- acetylene, at regional storehouse [Switzerland]
- acrylic acid, at plant [Europe]
- acrylic binder, 34% in H2O, at plant [Europe]
- acrylic dispersion, 65% in H2O, at plant [Europe]
- acrylic varnish, 87.5% in H2O, at plant [Europe]
- acrylonitrile from Sohio process, at plant [Europe]
- adipic acid, at plant [Europe]
- agricultural machinery, general, production [Switzerlan...
- agricultural machinery, tillage, production [Switzerland]
- air compressor, screw-type compressor, 300 kW, at plan...
- air separation plant [Europe]
- aircraft, freight [Europe]

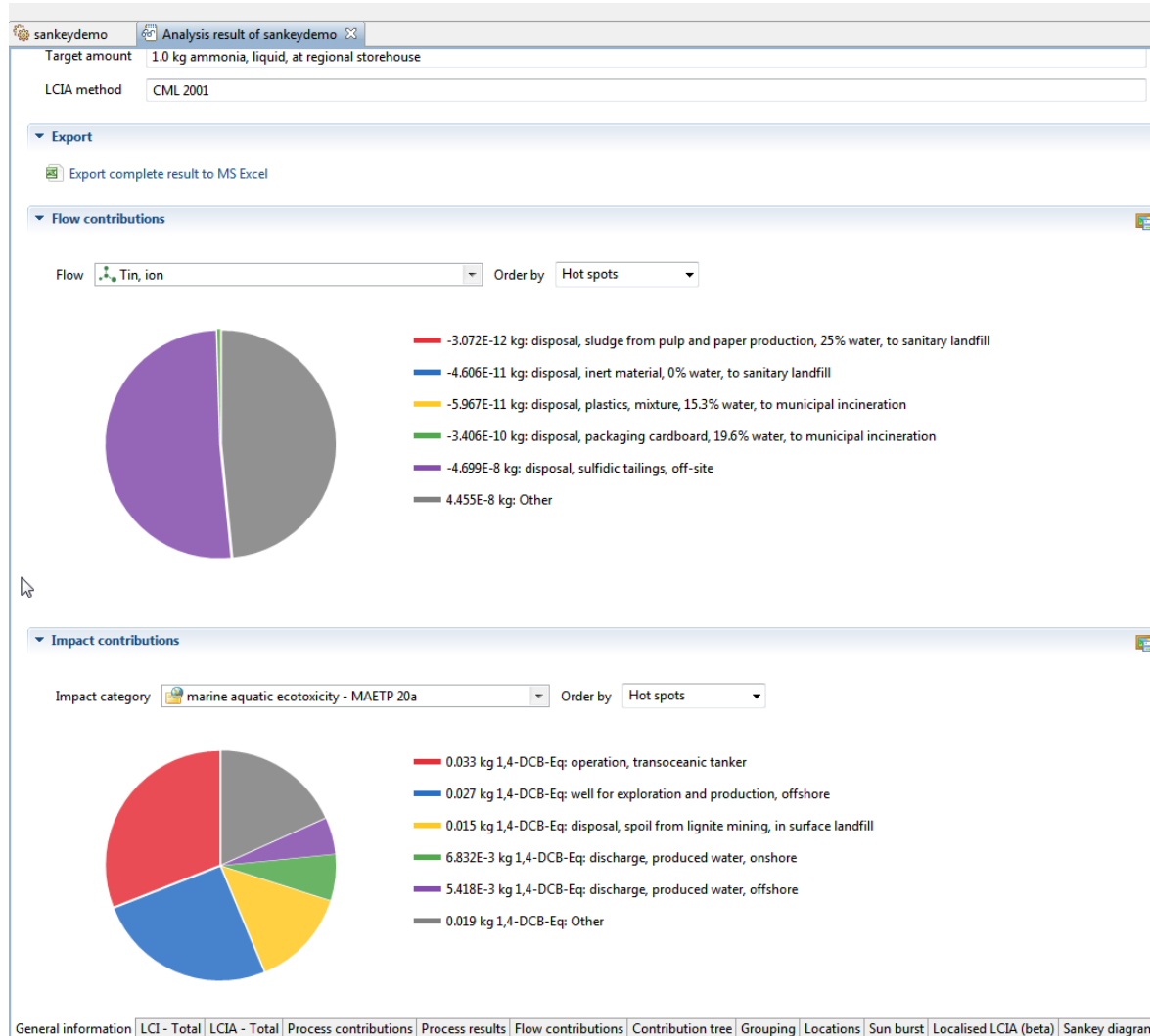
openLCA – graphical modeling



- And also automatic completion of product systems for a calculation, similar to e.g. SimaPro




openLCA – analysis features



openLCA – analysis features


sankeydemo Analysis result of sankeydemo

Process contributions

Flow  Order by Total contributions Cut-off 2 %

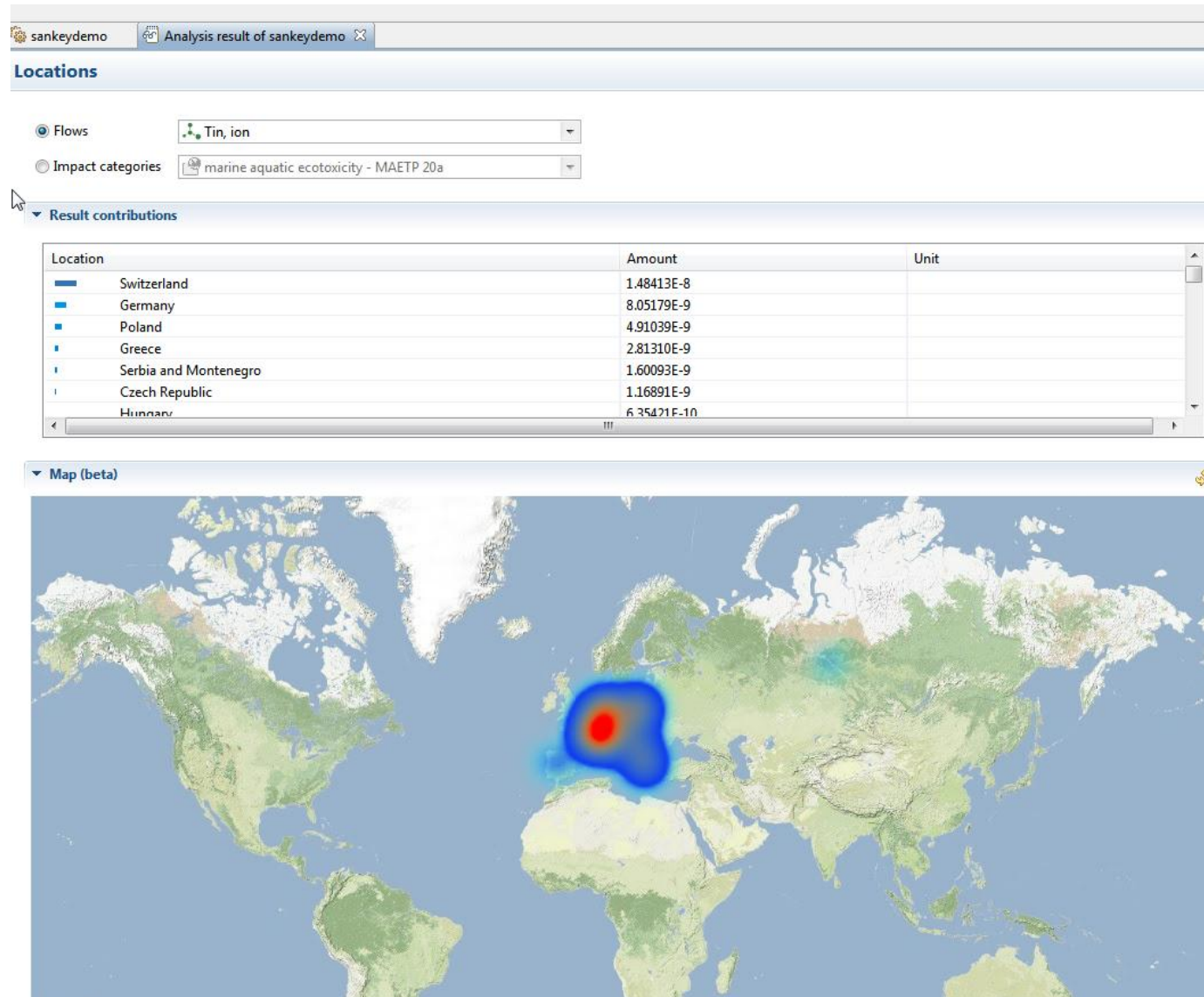
Contribution	Process	Total amount	Single amount	Unit
100.00%	kerosene, at regional storage	3.47971E-10	0.00000	kg
89.36%	electricity, production mix UCTE	3.10941E-10	0.00000	kg
88.72%	electricity, high voltage, production UCTE, at grid	3.08720E-10	0.00000	kg
86.72%	sankeydemo	3.01746E-10	0.00000	kg
82.44%	SOx retained, in hard coal flue gas desulphurisation	2.86885E-10	2.86828E-10	kg
80.87%	electricity, medium voltage, production UCTE, at grid	2.81402E-10	0.00000	kg
65.75%	kerosene, at refinery	2.28776E-10	0.00000	kg
41.38%	electricity, production mix DE	1.43973E-10	0.00000	kg
40.12%	electricity, hard coal, at power plant	1.39606E-10	0.00000	kg
40.12%	hard coal, burned in power plant	1.39606E-10	0.00000	kg
36.24%	crude oil, production RU, at long distance transport	1.26111E-10	0.00000	kg
25.39%	crude oil, at production onshore	8.83450E-11	0.00000	kg
23.28%	production plant crude oil, onshore	8.09953E-11	0.00000	kg
22.21%	transport, crude oil pipeline, onshore	7.72685E-11	0.00000	kg

Impact contributions

Impact category  marine aquatic ecotoxicity - MAETP 20a Order by Total contributions Cut-off 2 %

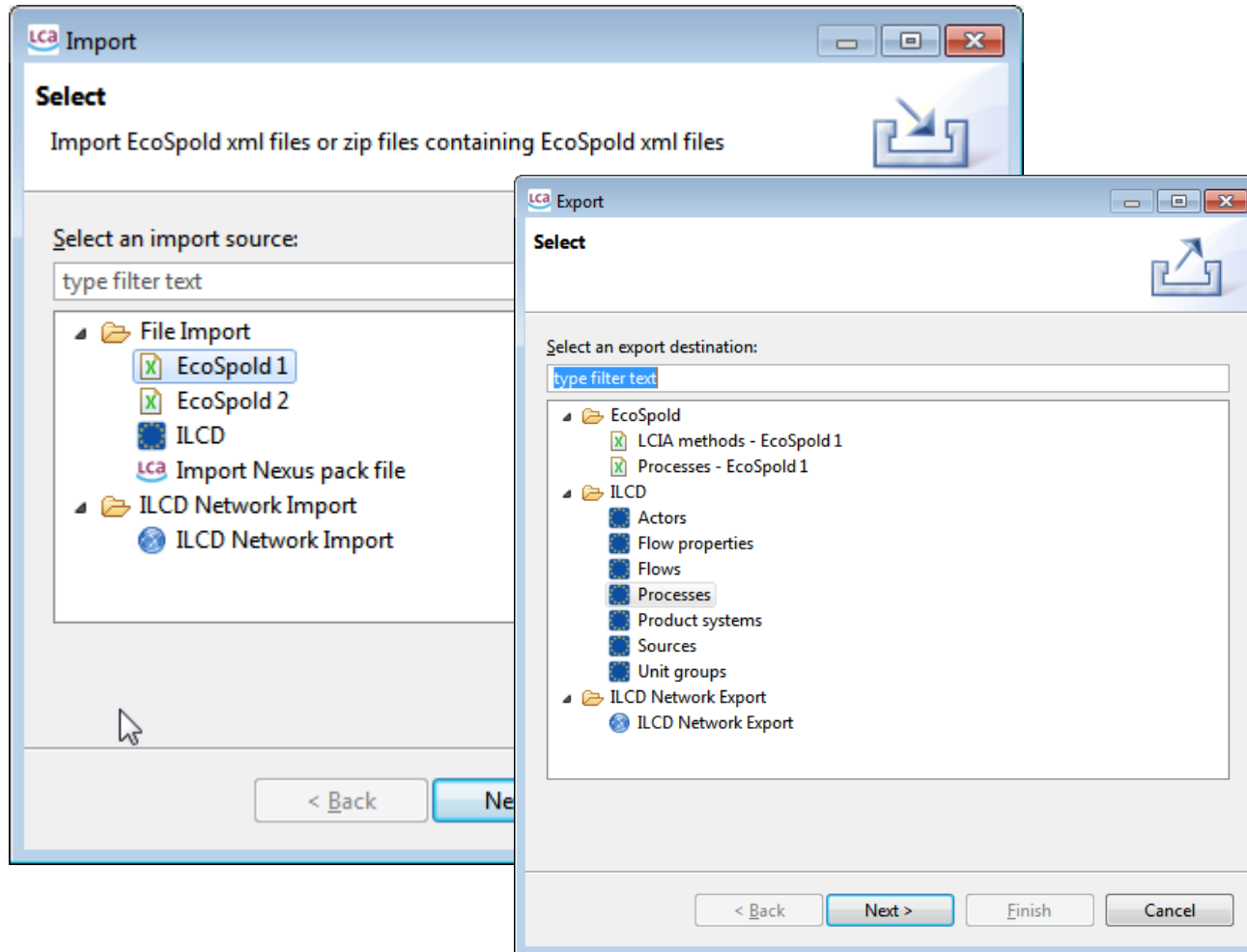
Contribution	Process	Total amount	Single amount	Unit
100.00%	kerosene, at regional storage	0.11156	0.00000	kg 1,4-DCB-Eq
94.36%	sankeydemo	0.10527	0.00000	kg 1,4-DCB-Eq
79.40%	kerosene, at refinery	0.08858	0.00036	kg 1,4-DCB-Eq
31.63%	transport, transoceanic tanker	0.03529	0.00000	kg 1,4-DCB-Eq
30.09%	operation, transoceanic tanker	0.03357	0.03260	kg 1,4-DCB-Eq
24.14%	well for exploration and production, offshore	0.02693	0.02665	kg 1,4-DCB-Eq
23.05%	crude oil, production RME, at long distance transport	0.02572	2.91738E-10	kg 1,4-DCB-Eq
20.12%	crude oil, production GB, at long distance transport	0.02245	2.07557E-10	kg 1,4-DCB-Eq
19.83%	electricity, production mix UCTE	0.02213	0.00000	kg 1,4-DCB-Eq
19.71%	electricity, high voltage, production UCTE, at grid	0.02199	0.00000	kg 1,4-DCB-Eq
19.26%	crude oil, at production offshore	0.02149	5.84530E-8	kg 1,4-DCB-Eq
18.11%	electricity, medium voltage, production UCTE, at grid	0.02021	0.00000	kg 1,4-DCB-Eq
14.71%	kerosene, at refinery	0.01641	4.36792E-5	kg 1,4-DCB-Eq
14.16%	crude oil, production RU, at long distance transport	0.01580	2.12167E-10	kg 1,4-DCB-Eq

openLCA – analysis features



openLCA

- Broad import and export features:



openLCA

- Many databases supported, including:
 - Ecoinvent
 - Other databases in EcoSpold 1 format, as NREL
 - All GaBi databases
 - Social Hot Spots Database (SHDB)
 - Ökobaumat
 - ...

Database provider

GaBi 6544

Social Hotspots 6356

ecoinvent 4087

Ökobaumat 972

ELCD 272

NEEDS 187

bioenergiedat 178

2 Implementation tasks for openLCA
suggested by ecoinvent 3

3 Implementation tasks for openLCA, due to ecoinvent

(first task: *Understand* the EcoSpold02 format and its interpretation in the ecoinvent 3 database:

- not all features are used in ecoinvent
- some features address issues that can be solved rather internally in a software than in an data exchange format (parent child datasets)
- The ecoinvent database uses additional tricks that need to be addressed
- (revisions on the ecoinvent side – a bit of a moving target)

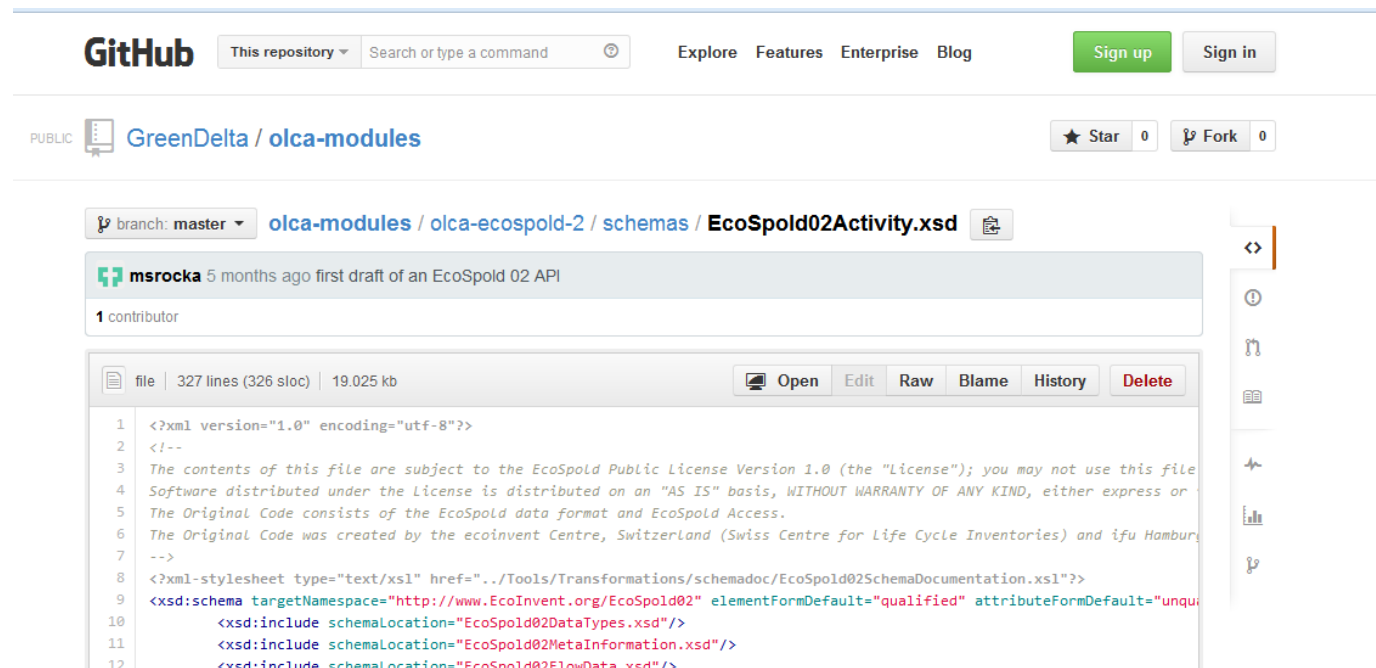
)

3 Implementation tasks for openLCA, due to ecoinvent

- Implementation of an EcoSpold 02 interface (for import and export)
- Reduction of memory space requirements
- Faster loading of product systems
- Faster calculation
- (improved treatment of parameters)

EcoSpold 02 interface

- Format specification as available in our github repository: <https://github.com/GreenDelta/olca-modules/blob/master/olca-ecospold-2/schemas/EcoSpold02Activity.xsd>



The screenshot displays the GitHub interface for the repository `GreenDelta / olca-modules`. The file `olca-modules / olca-ecospold-2 / schemas / EcoSpold02Activity.xsd` is selected, showing its commit history and content. The commit was made by `msrocka` 5 months ago, titled "first draft of an EcoSpold 02 API". The file is 19.025 kb and contains 327 lines (326 slocl). The content is an XML schema definition for EcoSpold 02 Activity, including a license notice and several `<xsd:include>` statements for related schemas.

GitHub This repository Search or type a command Explore Features Enterprise Blog Sign up Sign in

PUBLIC **GreenDelta** / **olca-modules** ★ Star 0 🍴 Fork 0

branch: master olca-modules / olca-ecospold-2 / schemas / EcoSpold02Activity.xsd

msrocka 5 months ago first draft of an EcoSpold 02 API
1 contributor

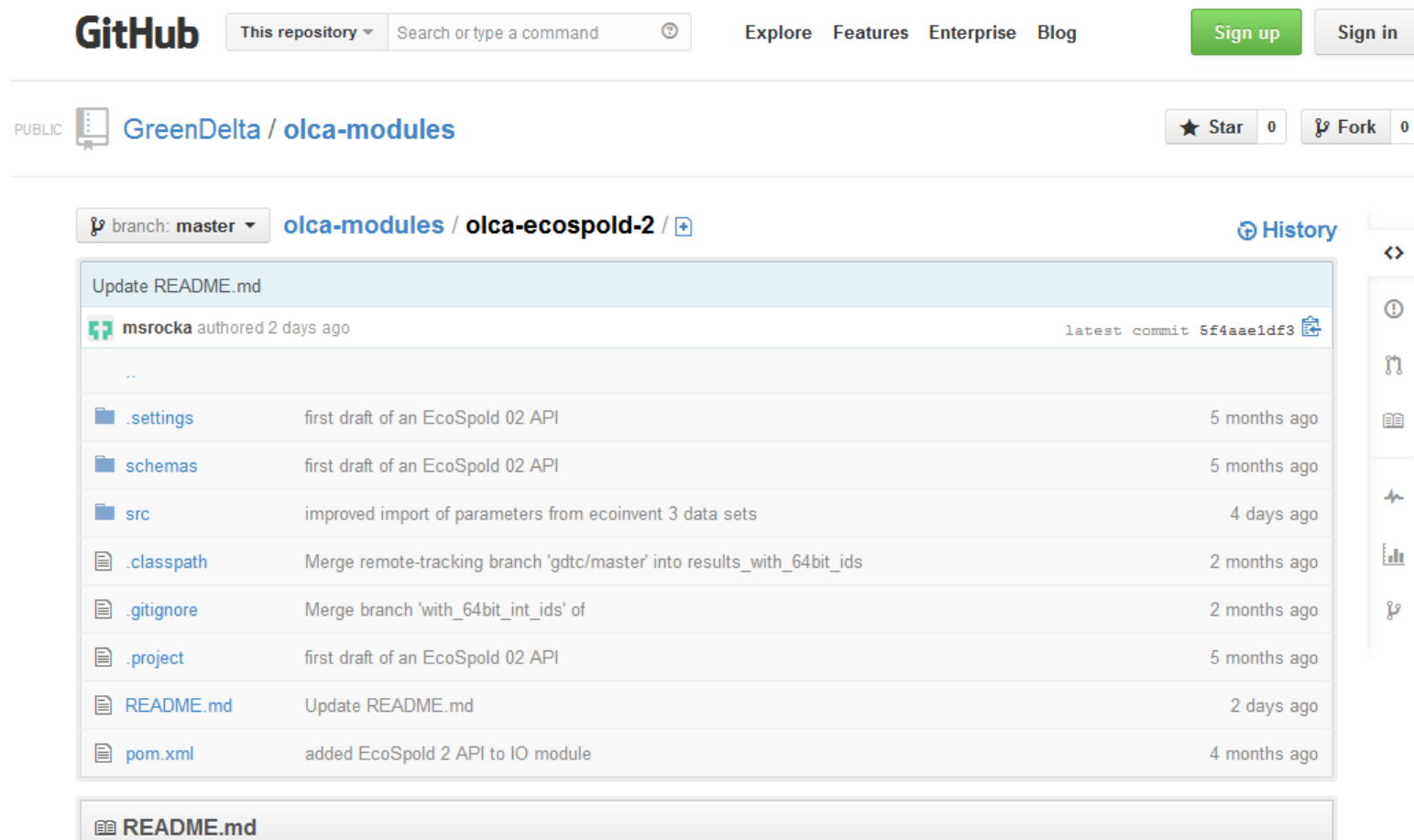
file | 327 lines (326 slocl) | 19.025 kb Open Edit Raw Blame History Delete

```
1 <?xml version="1.0" encoding="utf-8"?>
2 <!--
3 The contents of this file are subject to the EcoSpold Public License Version 1.0 (the "License"); you may not use this file
4 Software distributed under the License is distributed on an "AS IS" basis, WITHOUT WARRANTY OF ANY KIND, either express or
5 The Original Code consists of the EcoSpold data format and EcoSpold Access.
6 The Original Code was created by the ecoinvent Centre, Switzerland (Swiss Centre for Life Cycle Inventories) and ifu Hamburg
7 -->
8 <?xml-stylesheet type="text/xsl" href="../../Tools/Transformations/schemadoc/EcoSpold02SchemaDocumentation.xsl"?>
9 <xsd:schema targetNamespace="http://www.EcoInvent.org/EcoSpold02" elementFormDefault="qualified" attributeFormDefault="unqu
10 <xsd:include schemaLocation="EcoSpold02DataTypes.xsd"/>
11 <xsd:include schemaLocation="EcoSpold02MetaInformation.xsd"/>
12 <xsd:include schemaLocation="EcoSpold02FlowData.xsd"/>
```


GreenDelta

EcoSpold 02 interface

- API created to import and export EcoSpold02





GitHub This repository ▾ Search or type a command ⓘ Explore Features Enterprise Blog Sign up Sign in

PUBLIC  **GreenDelta / olca-modules** ★ Star 0 🍴 Fork 0

🔗 branch: master ▾ **olca-modules / olca-ecospold-2** / + History

Update README.md

 **msrocka** authored 2 days ago latest commit 5f4aae1df3 

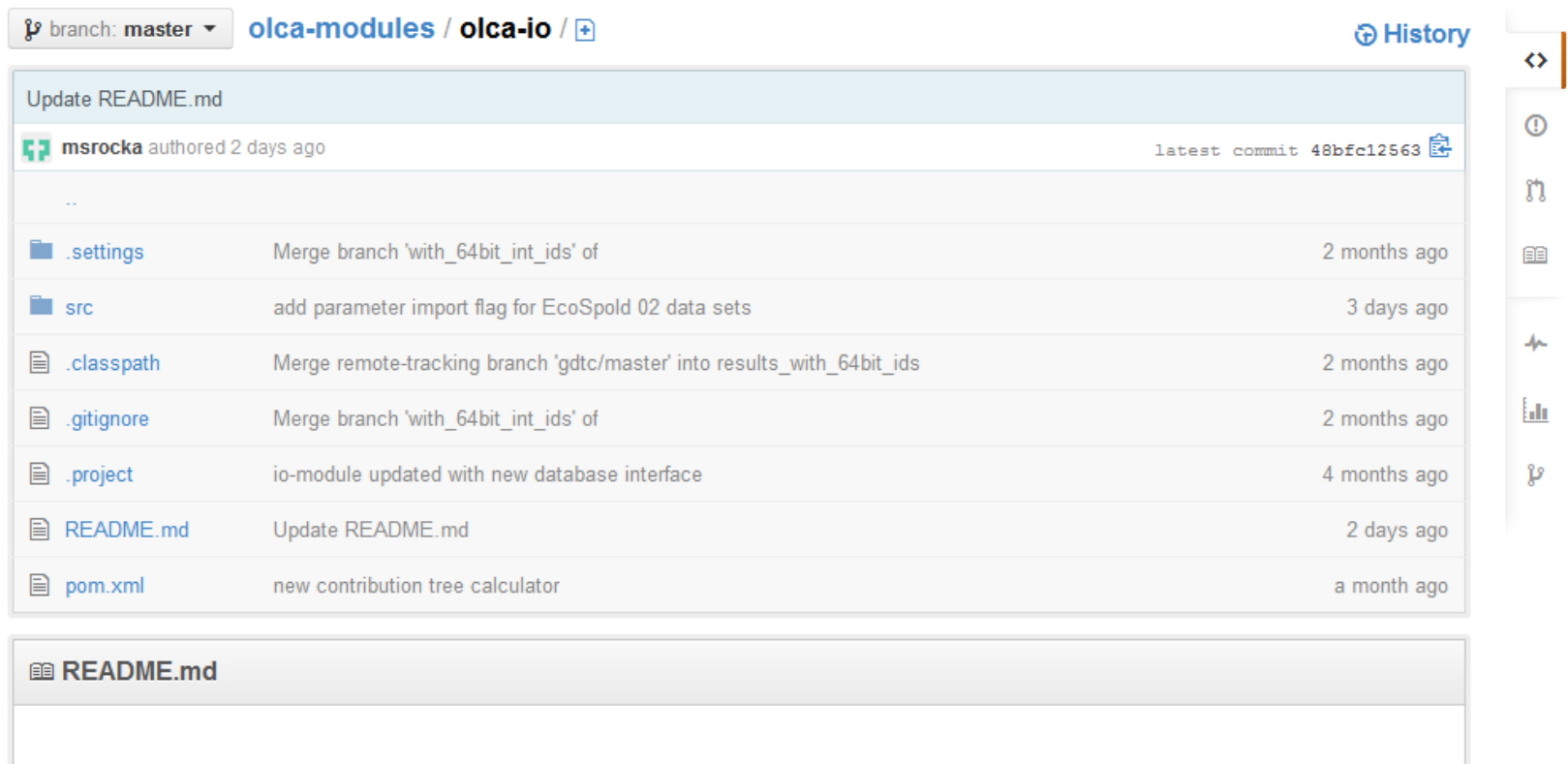
--

📁 .settings	first draft of an EcoSpold 02 API	5 months ago
📁 schemas	first draft of an EcoSpold 02 API	5 months ago
📁 src	improved import of parameters from ecoinvent 3 data sets	4 days ago
📄 .classpath	Merge remote-tracking branch 'gdtc/master' into results_with_64bit_ids	2 months ago
📄 .gitignore	Merge branch 'with_64bit_int_ids' of	2 months ago
📄 .project	first draft of an EcoSpold 02 API	5 months ago
📄 README.md	Update README.md	2 days ago
📄 pom.xml	added EcoSpold 2 API to IO module	4 months ago

📖 **README.md**

EcoSpold 02 interface

- olca-io created to map the format to the database



The screenshot shows the GitHub interface for the repository 'olca-modules / olca-io'. At the top, it indicates the current branch is 'master'. Below this, a commit history table is displayed. The table has three columns: a file icon, the commit message, and the time since the commit. The most recent commit is 'Update README.md' by 'msrocka' 2 days ago, with the commit hash '48bfc12563'. Below this, a list of files is shown, including '.settings', 'src', '.classpath', '.gitignore', '.project', 'README.md', and 'pom.xml', each with its corresponding commit message and time. A sidebar on the right contains icons for repository navigation. At the bottom, a section for 'README.md' is visible.

File	Commit Message	Time
Update README.md	Update README.md	2 days ago
..
.settings	Merge branch 'with_64bit_int_ids' of	2 months ago
src	add parameter import flag for EcoSpold 02 data sets	3 days ago
.classpath	Merge remote-tracking branch 'gdtc/master' into results_with_64bit_ids	2 months ago
.gitignore	Merge branch 'with_64bit_int_ids' of	2 months ago
.project	io-module updated with new database interface	4 months ago
README.md	Update README.md	2 days ago
pom.xml	new contribution tree calculator	a month ago

EcoSpold02 interface: noteworthy

- ActivityLink – Default provider structure: in openLCA since 1.2.9
→ fits nicely
- Flow properties (water content etc.): in ecoinvent linked to an exchange, in openLCA and ILCD linked to a flow → □
- Waste is a negatic amount in ecoinvent 3
→ change input and output in openLCA → fine
- No unit groups in ecoinvent 3
→ direct mapping to openLCA units → fine.
- Allokation factors of migrated ecoinvent 2 activities are flow properties, „EcoSpold01Allocation_undefined_XY“
→ these cannot be used in a reasonable way any more?
- Parameters: Formulas contain often hard links to specific computer hard drives → ?
- Master data often saved also in process data sets, redundantly
→ risk of inconsistencies

```

<outputGroup>2</outputGroup><CR LF>
</intermediateExchange><CR LF>
<intermediateExchange id="eb369ed2-ccf9-449f-b7ff-3a1eda104871" unitId="487df68b-4994-4027-8fdc-a
<name xml:lang="en">palladium</name><CR LF>
<unitName xml:lang="en">kg</unitName><CR LF>
<property propertyId="40ca2c51-2da6-4351-bd4c-d6f181fc7d55" amount="37.91"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_2</name><CR LF>
</property><CR LF>
<property propertyId="13706ab5-1a8c-42fd-8329-c93266943c87" amount="37.91"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_16</name><CR LF>
</property><CR LF>
<property propertyId="db2e27d1-47cd-4180-8416-4f79369de00c" amount="37.91"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_6</name><CR LF>
</property><CR LF>
<property propertyId="3db02346-808f-4eb6-9232-317a23c63484" amount="37.91"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_7</name><CR LF>
</property><CR LF>
<property propertyId="9909d836-d0a3-45ed-a8d6-62f5feb763e" amount="100"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_21</name><CR LF>
</property><CR LF>
<property propertyId="9c38ea07-adcd-4018-8636-eb32382f39a7" amount="37.91"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_5</name><CR LF>
</property><CR LF>
<property propertyId="e2bdc7a2-bfb2-4db4-9fa2-12e46f767097" amount="37.91"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_19</name><CR LF>
</property><CR LF>
<property propertyId="9676ed7d-a99c-40ed-9ff5-55081521ad8b" amount="37.91"><CR LF>
  <name xml:lang="en">EcoSpold01Allocation_undefined_8</name><CR LF>
</property><CR LF>
<property propertyId="a9358458-9724-4f03-b622-106eda248916" amount="0" unitId="577e242a-461f-44a7-922c-d8e1c3d2bf45"><CR LF>
  <name xml:lang="en">water content</name><CR LF>
  <unitName xml:lang="en">dimensionless</unitName><CR LF>

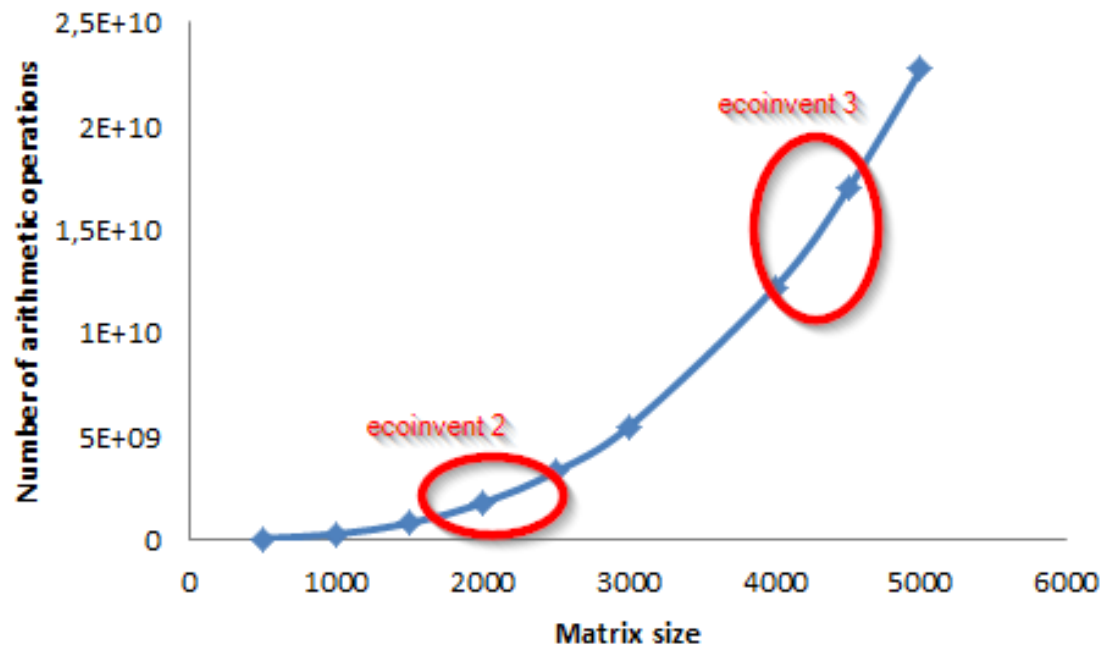
```

```
<comment xml:lang="en">calculated from mass balance</comment>
</uncertainty>
<property propertyId="335fb25a-49eb-4a6c-8c28-9a19d16c9456" variableName="amount_ash_calc_prop_kg"
amount="0.00748" isDefiningValue="false" mathematicalRelation="LiveLink('C:\Documents and Settings\treyer k\My
Documents\ecoinvent\EcoEditor\LiveLinks\electricity production hard coal LiveLinks.xls','Sheet1','C19','',
'Automatic')" isCalculatedAmount="true" unitId="487df68b-4994-4027-8fdc-a4dc298257b7" sourceId="6ad10bdb-
b629-4991-94a9-478b752cde90" sourceYear="2007" sourceFirstAuthor="Röder, A.">
  <name xml:lang="en">calculation property, kg</name>
  <unitName xml:lang="en">kg</unitName>
```

activity id="b46483cf-6b87-4898-9f8e-004dd13c4c76“, ecoinvent 3.0.1
(just one example)

Memory space requirements

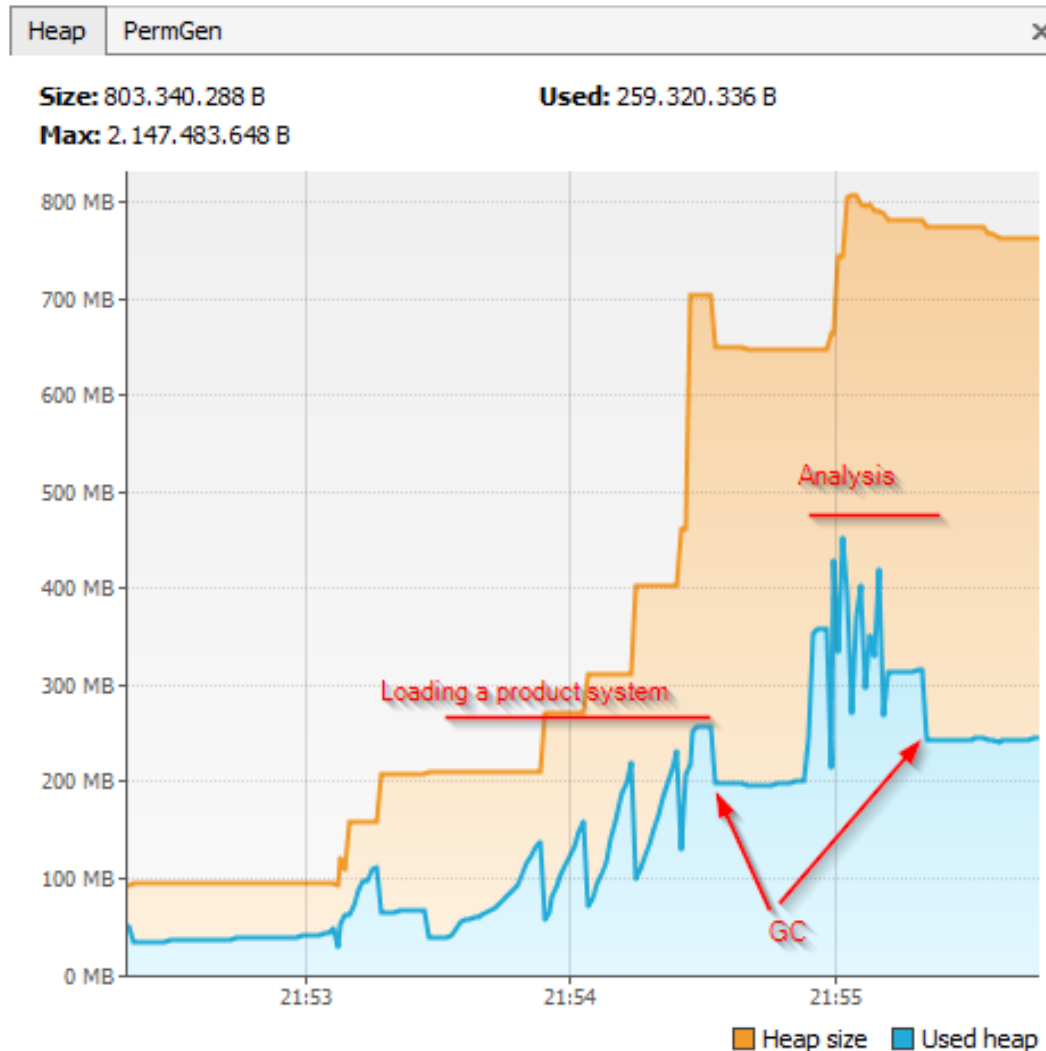
- Issue: Memory space requirements in a matrix calculation is $\sim O(n^3) \rightarrow$ cubic increase with the number of data sets



Memory space requirements

- Issue: Memory space requirements in a matrix calculation is $\sim O(n^3)$ \rightarrow cubic increase with the number of data sets
- \rightarrow Stick to matrix calculation but make element loading and calculation more efficient

Memory space requirements, example: Loading and analysing a product system, ei2



openLCA 1.3:

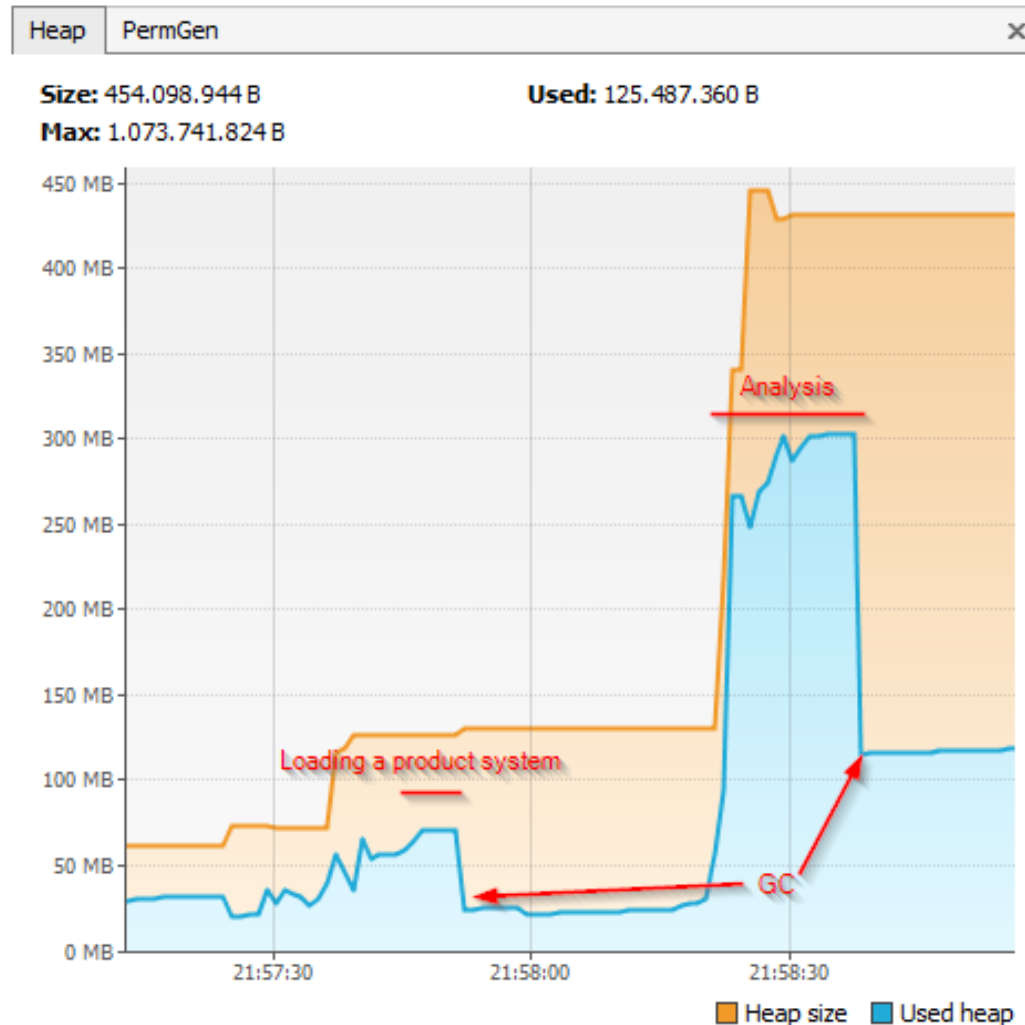
Product system
open:

200 MB

Analysis peak:
450 MB

Product system &
result open:
250 MB

Memory space requirements, example: Loading and analysing a product system, ei2



openLCA 1.4:

Product system
open:

25 MB

Analysis peak:

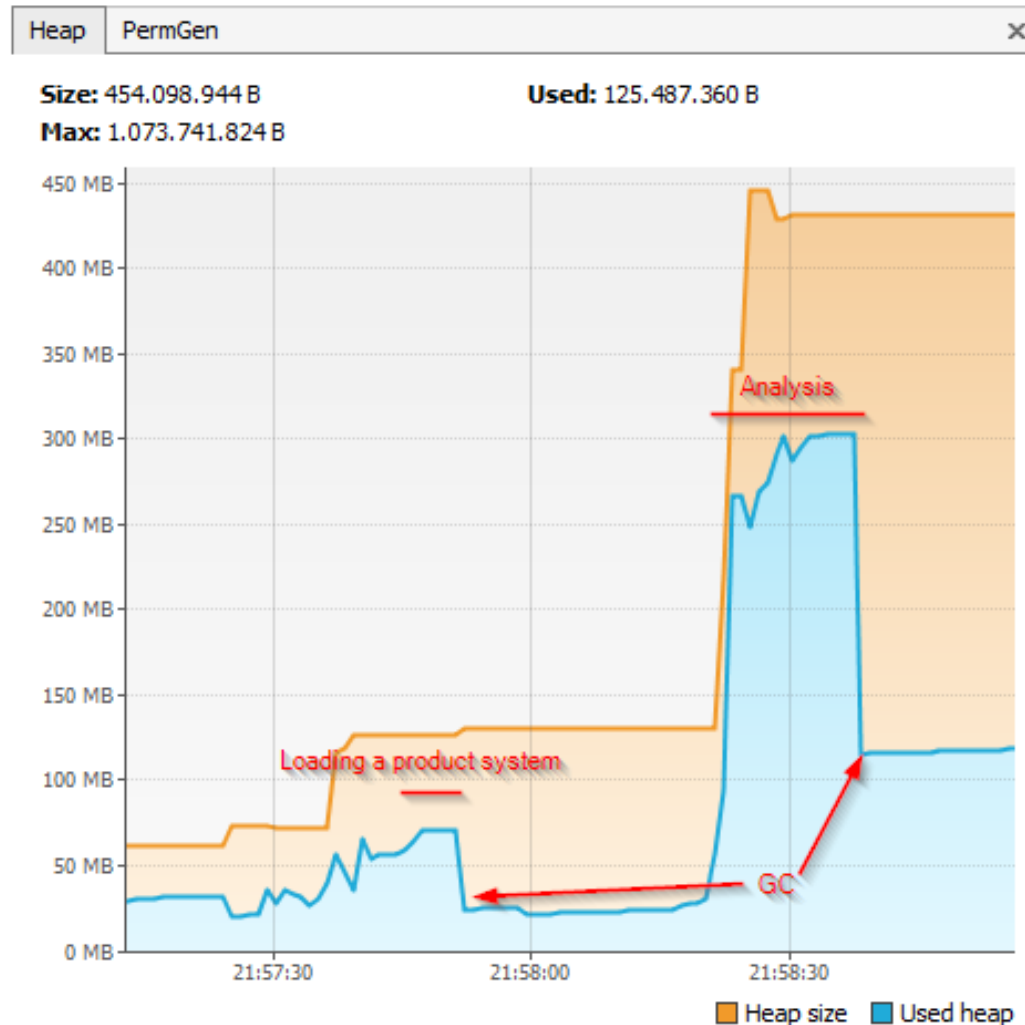
300 MB

Product system &
result open:

125 MB

(identical system)

Memory space requirements, example: Loading and analysing a product system, ei2



openLCA 1.4:

Product system
open:

25 MB

Analysis peak:

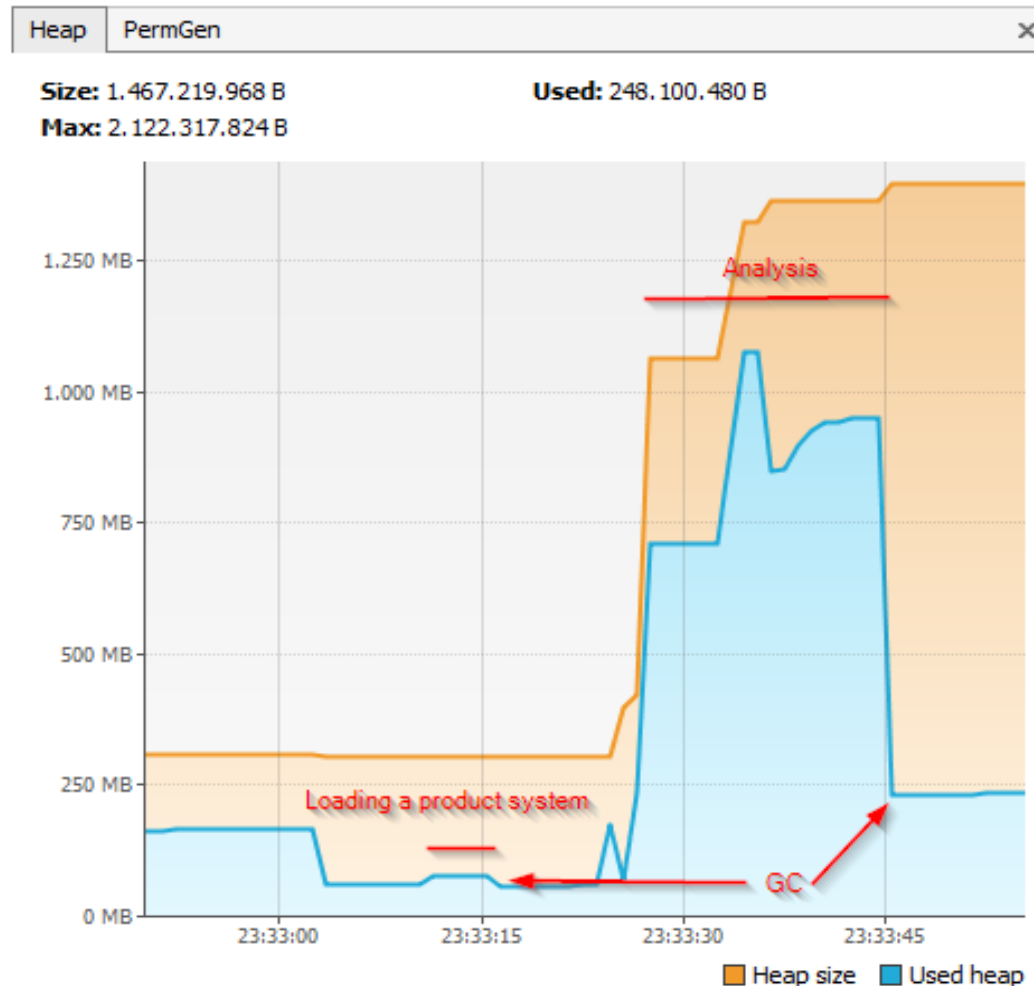
300 MB -33%

Product system &
result open:

125 MB -50%

(identical system)

Loading and analysing a product system, Ecoinvent 3



openLCA 1.4:

Product system
open:

25 MB

Analysis peak:
1100 MB (!)

Product system &
result open:
250 MB

Performance improvements

Performance improvements due to

- Improved data structures
- Improved queries (batching)
- Improved memory usage (caching)
- Improved algorithms and a faster numerical library

Performance improvements

Ecoinvent 2 example (same computer & product system)

	openLCA 1.3	openLCA 1.4
Creating a new product system	72 sec	3 sec
Opening an existing product system	8 sec	< 1 sec
Calculation and Analysis	10 sec	4 sec

Performance improvements

Ecoinvent 3 example (same computer & product system)

openLCA 1.4	
Creating a new product system	13 sec
Opening an existing product system	< 1 sec
Calculation and Analysis	17 sec

Performance improvements

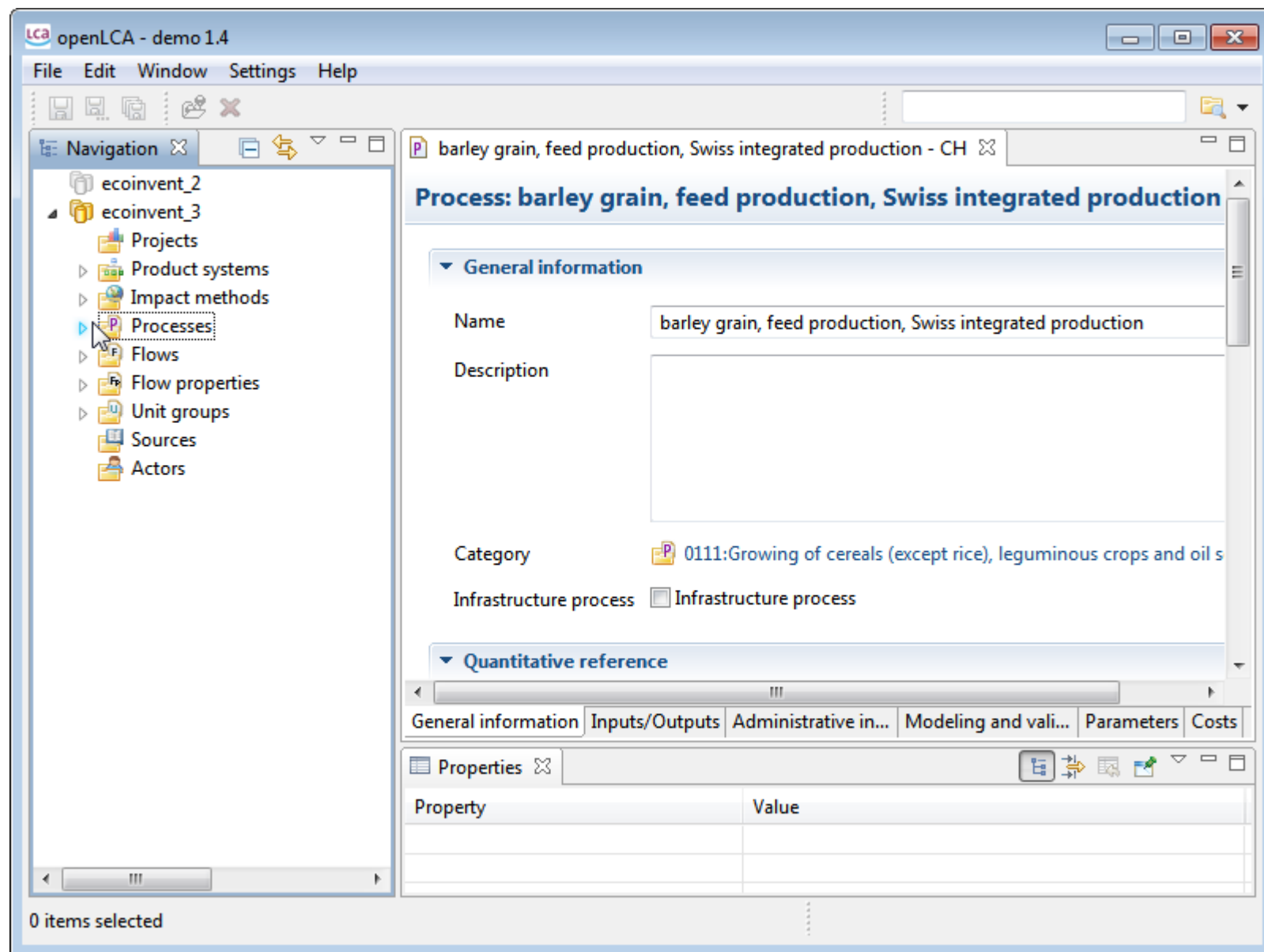
Ecoinvent 3 example (same computer & product system)

openLCA 1.4	
Creating a new product system	13 sec
Opening an existing product system	< 1 sec
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	openLCA 1.3	openLCA 1.4
Creating a new product system	72 sec	3 sec
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Ecoinvent 2 example (same computer & product system)

3 ecoinvent 3 in openLCA: Status



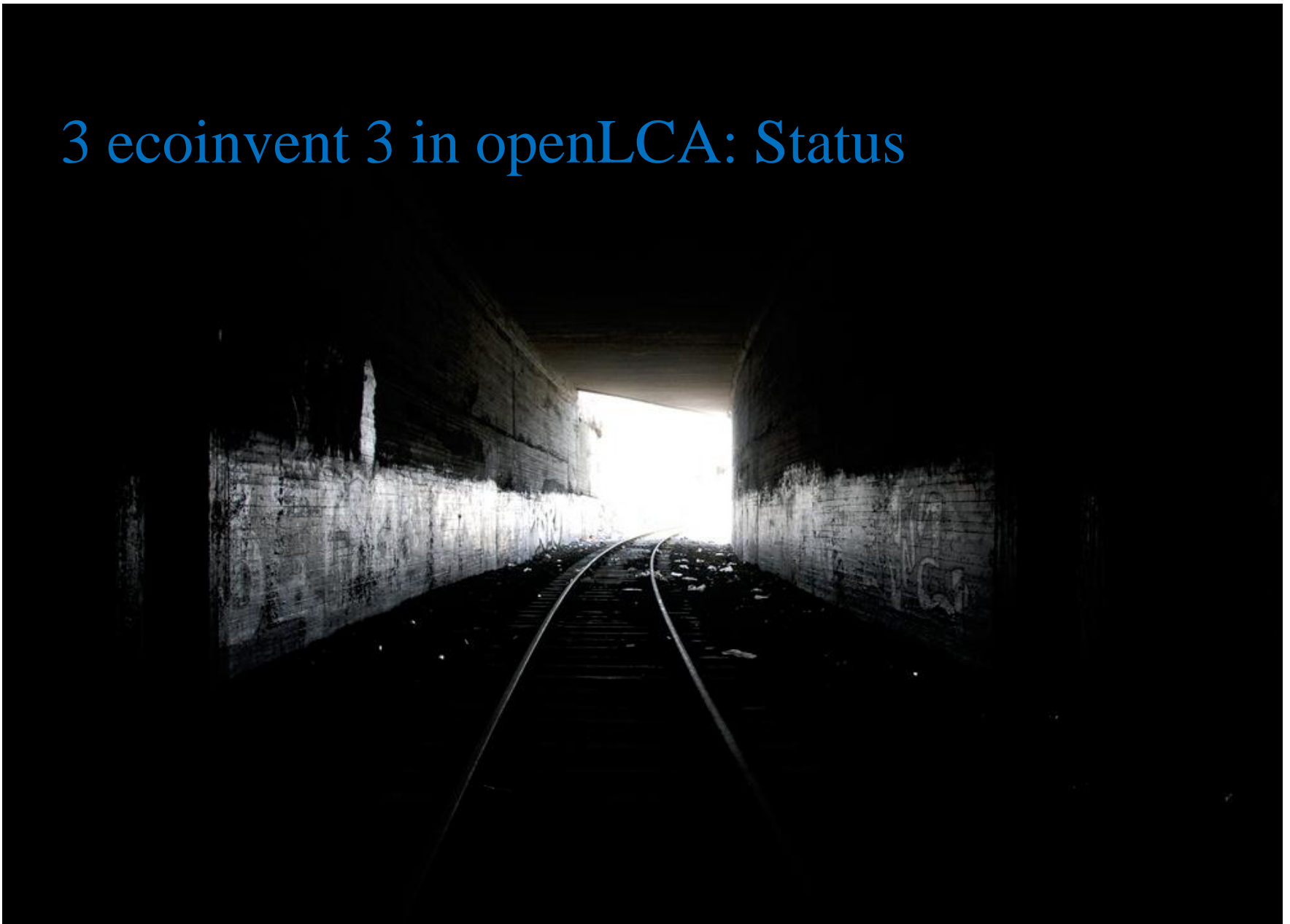
3 ecoinvent 3 in openLCA: Status

- A first version 1.4 is available since last week, for use with ecoinvent 3
- This version openLCA 1.4 contains the EcoSpold02 interface and the performance improvements
- It is not publicly released yet
- We are looking for some external testers
- And you can of course schedule a test presentation at our booth or directly with me

3 ecoinvent 3 in openLCA: Status

- A first version 1.4 is available since last week, for use with ecoinvent 3
- This version openLCA 1.4 contains the EcoSpold02 interface and the performance improvements
- It is not publicly released yet
- We are looking for some external testers – if you are interested, please let us know (openlca@greendelta.com or send me a direct email, or leave a message at our booth)

3 ecoinvent 3 in openLCA: Status



4 Discussion

4 Discussion – one remark only from my side

- The ecoinvent 3 database must be really good to make the implementation effort worthwhile
- Of course performance improvements make sense also for other databases

GreenDeLTA

sustainability consulting + software

Thank you..

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