

# Using online scientific notebooks for LCA calculations

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This is an annotated set of slides which has been slightly modified from the presentation to make it more understandable as a handout.

# Some basic propositions

- LCA is a tool for decision support
- LCA decisions help decide conflicts over resources
- LCA goods are not captured in market prices
- LCA is therefore a political activity

## **Controversial pipe LCA claims concrete is better than PVC**

**ENDS Report 262, November 1996**

1 November 1996



**Concrete sewer pipes have a markedly better environmental performance than PVC pipes across a range of impacts, according to a life cycle assessment (LCA) published by the Dutch association of concrete pipe manufacturers, VPB.<sup>1</sup> Its case has been weakened by a refusal to publish key raw data, but the study adds to the PVC industry's problems in portraying its product as environmentally benign.**

## **New Life Cycle Assessment Study Shows Replacing Wood Utility Poles With Steel Significantly Lowers Key Environmental Impacts**

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**SOURCE** Steel Market Development Institute

LCA claims are put forward by many parties, including parties which could be considered as less than neutral. This is promising for LCA – it means that it matters in policy decision-making – but means that LCA claims must be understandable and transparent.

## Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles

Troy R. Hawkins, Bhawna Singh, Guillaume Majeau-Bettez, and Anders Hammer Strømman

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**Keywords:**

batteries  
electricity mix  
global warming  
industrial ecology  
life cycle inventory (LCI)  
transportation

 Supporting information is available on the JIE Web site

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**Summary**

Electric vehicles (EVs) coupled with low-carbon electricity sources offer the potential for reducing greenhouse gas emissions and exposure to tailpipe emissions from personal transportation. In considering these benefits, it is important to address concerns of problem-shifting. In addition, while many studies have focused on the use phase in comparing transportation options, vehicle production is also significant when comparing conventional and EVs. We develop and provide a transparent life cycle inventory of conventional and electric vehicles and apply our inventory to assess conventional and EVs over a range of impact categories. We find that EVs powered by the present European electricity mix offer a 10% to 24% decrease in global warming potential (GWP) relative to conventional diesel or gasoline vehicles assuming lifetimes of 150,000 km. However, EVs exhibit the potential for significant increases in human toxicity, freshwater eco-toxicity, freshwater eutrophication, and metal depletion impacts, largely emanating from the vehicle supply chain. Results are sensitive to assumptions regarding electricity source, use phase energy consumption, vehicle lifetime, and battery replacement schedules. Because production impacts are more significant for EVs than conventional vehicles, assuming a vehicle lifetime of 200,000 km exaggerates the GWP benefits of EVs to 27% to 29% relative to gasoline vehicles or 17% to 20% relative to diesel. An assumption of 100,000 km decreases the benefit of EVs to 9% to 14% with respect to gasoline vehicles and results in impacts indistinguishable from those

A great example of open and transparent LCA is this study of electric vehicles (<http://onlinelibrary.wiley.com/doi/10.1111/j.1530-9290.2012.00532.x/abstract>).

	Steel	Iron	Aluminum	Copper	Lead	Magnesium	Zinc	Metals	Pt-group metals	Neodymium oxide	Glass	Plastic	Rubber	Paint	Other
Base Vehicle:	470.2	10.6	18.1												
Body & Doors	172.5	-	-												
Brakes, Friction type	-	-	-												
Chassis, FWD	-	-	-												
Final Assembly	70.6	-	-												
Fluids	47.0	-	-												
Exterior	-	-	-												
ICEV Powertrain:															
Transmission Casing	8.0	-	-	16.4	-	-	-	-	-	-	-	-	-	-	
Material/Component	Units	p	p	p	p	p	p	p	p	p	p	p	p	p	p
Rolled steel	kg	0	19.12	0	0	0	0	0	0	0	0	0	0	0	0
EAF steel	kg	0	10.32	0	0.367	4.217	4.217	0	0	0	0	0	0	0	0
galv steel	kg	211.2	4.578	8.433	0	0	0	0	93	0	0	0	0	0	0
hot rolled steel	kg	0	33.46	0	0	0	0	0	0	0	0	0	0	0	0
stainless steel	kg	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0
Cast iron	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wrought Aluminium	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cast Aluminium	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copper	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Magnesium	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Platinum	kg	0	0	0	0.06	0	0	0	0	0	0	0	0	0	0
Lead (Pb)	kg	0	0	0	6.151	3.425	3.425	12	0	0	0	0	0	0	0
Glass	kg	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0
Plastic	kg	0	4.017	0	0	0	0	0	0	0	0	0	0	0	0
Rubber	kg	0	2.168	0	0.077	0.886	0.886	0	0	0	0	0	0	0	0
Scrap	kg	44.38	0.962	1.772	0	0	0	19.54	0	0	0	0	0	0	0
Scrap, Rolled steel	kg	0	7.029	0	0	0	0	0	0	0	0	0	0	0	0
Scrap, EAF steel	kg	0	0	0	0.017	0	0	0	0	0	0	0	0	0	0
Scrap, galv steel	kg	0	0	0	0.003	0	0	0.004	0	0	0	0	0	0	0
Scrap, hot rolled steel	kg	0	0	0	0	0	0	0	0	0.038	7E-04	0.022	0	0	0
Scrap, stainless steel	kg	0	0	0	0	0	0	0	0	0.003	3E-05	9E-04	0	0	0
Scrap, glass	kg	0	0	0	0	0	0	0	0	0	0.124	0	0	0	0
Final As	kg	0	0	0	0	0	0	0	0	0.258	0.005	0	0	0	0
Oxygen	kg	0	0	0	0	0	0	0	0	0.239	0.129	0.102	0	0	0
Acetylene	kg	0	0	0	0	0	0	0	0	3.052	3.605	8.001	0	0	0
Nitrogen	kg	0	0	0	0	0	0	0	0	0	8.491	0	0	0	0
Carbon dioxide	kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural gas	m³	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drinking water	m³	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating water	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tech. heat	MJ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Room heat	Nm³	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Comp. air 6 bar	Nm³	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Comp. air 12 bar	Nm³	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	kWh	0	0	0	0	0	0	0	0	190.2	139.3	113.8	0	0	0

It has an incredible amount of supporting information, allowing interested parties (e.g. electric car manufacturers) to examine the input data and suggest updates. Industry-provided data led to an update (<http://onlinelibrary.wiley.com/doi/10.1111/jiec.12011/abstract>). However, printed tables still require significant work to reproduce manuscript results.

# Bjorn Lomborg: Green Cars Have a Dirty Little Secret

Producing and charging electric cars means heavy carbon-dioxide emissions.

Article

Video

Stock Quotes

Comments (986)

MOR



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By Bjorn Lomborg

Electric cars are promoted as the chic harbinger of an environmentally benign future. Ads assure us of "zero emissions," and President Obama has promised a million on the road by 2015. With sales for 2012 coming in at about 50,000, that million-car figure is a pipe dream. Consumers remain wary of the cars' limited range, higher price and the logistics of battery-charging. But for those who do own an electric car, at least there is the consolation that it's truly green, right? Not really.

For proponents such as the actor and activist Leonardo DiCaprio, the main argument is that their electric cars—whether it's a \$100,000 Fisker Karma (Mr. DiCaprio's ride) or a \$28,000 Nissan Leaf—don't contribute to global warming. And, sure, electric cars don't emit carbon-dioxide on the road. But the energy used for their manufacture and continual battery charges certainly does—far more than most people realize.

A 2012 comprehensive life-cycle analysis in *Journal of Industrial Ecology* shows that almost half the lifetime carbon-dioxide emissions from an electric car come from the energy used to produce the car, especially the battery. The mining of lithium, for instance, is a less than green activity. By contrast, the manufacture of a gas-powered car accounts for 17% of its lifetime carbon-dioxide emissions. When an electric car rolls off the production line, it has already been responsible for

Of course, being open also allows those more interested in political points than scientific claims to selectively pull results. This is an inevitable part of democratic discussion.

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► The Power of Negative Thinking

► Technology Shapes Kenyan Elections

The Internet and social media in Kenya, which played a central role in this year's elections by allowing Kenyans to question candidates, took on a new function Tuesday—spreading messages of peace to avert new bloodshed.

► Five Stocks Handled the Heavy Lifting

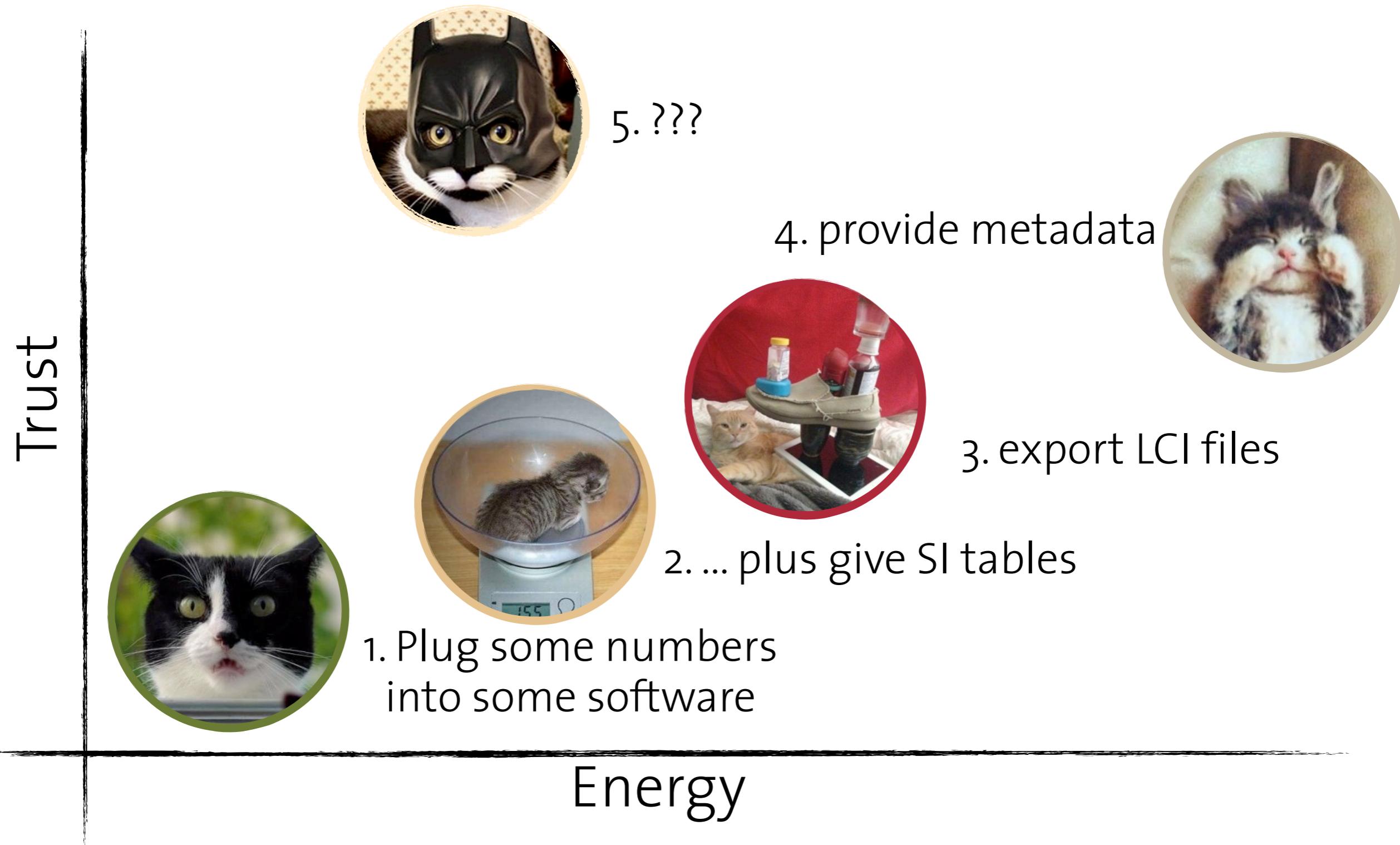
Five blue-chip stocks accounted for about 40% of the rally in the Dow since the financial crisis.

► Beijing, U.S. New Korean Sanctions

The U.S. and China are facing a new round of sanctions against North Korea. United Nations that they said would significantly affect the development of Pyongyang's nuclear and missile programs, in to its test last month of an atomic bomb.

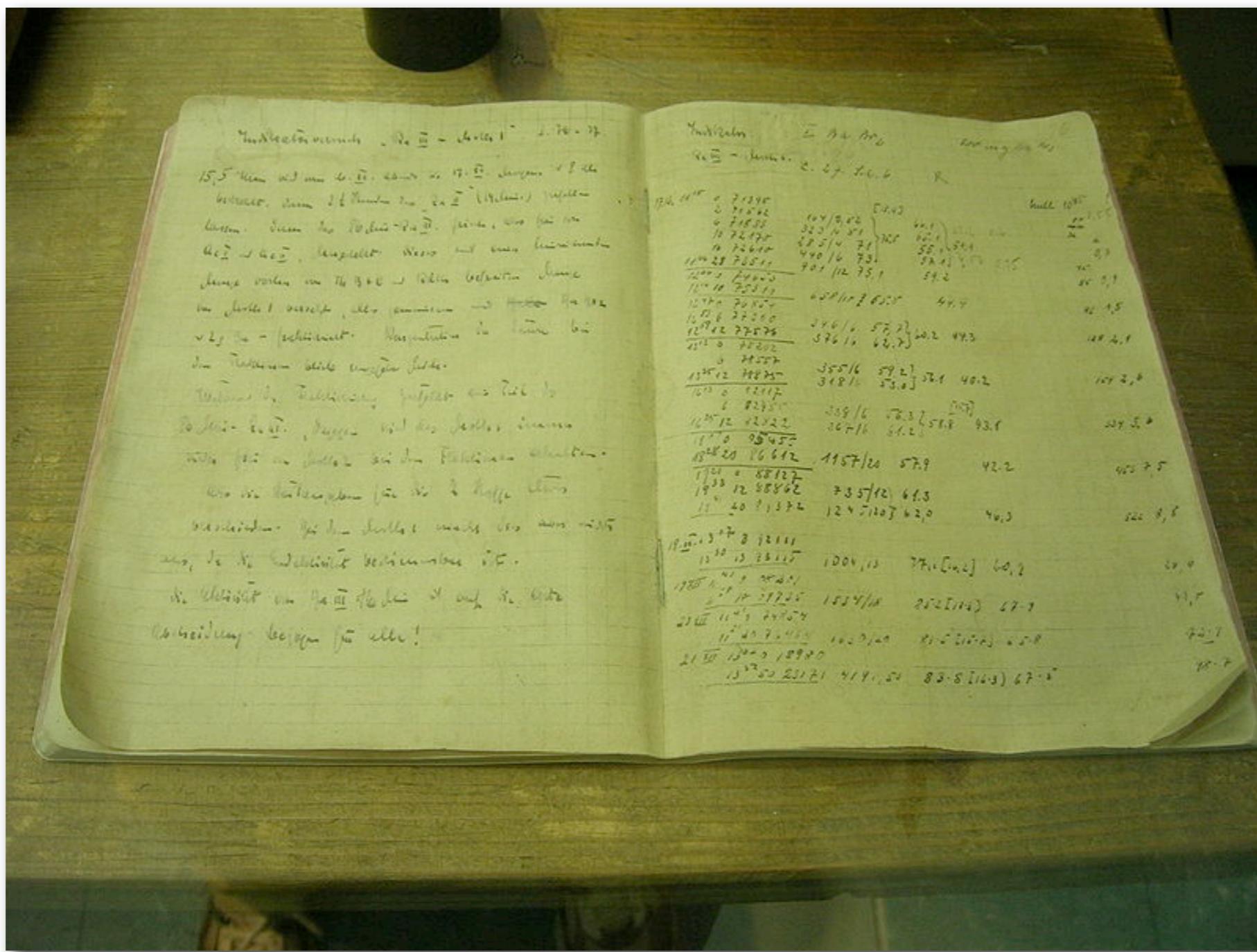
Don't Miss

# Resource conflicts



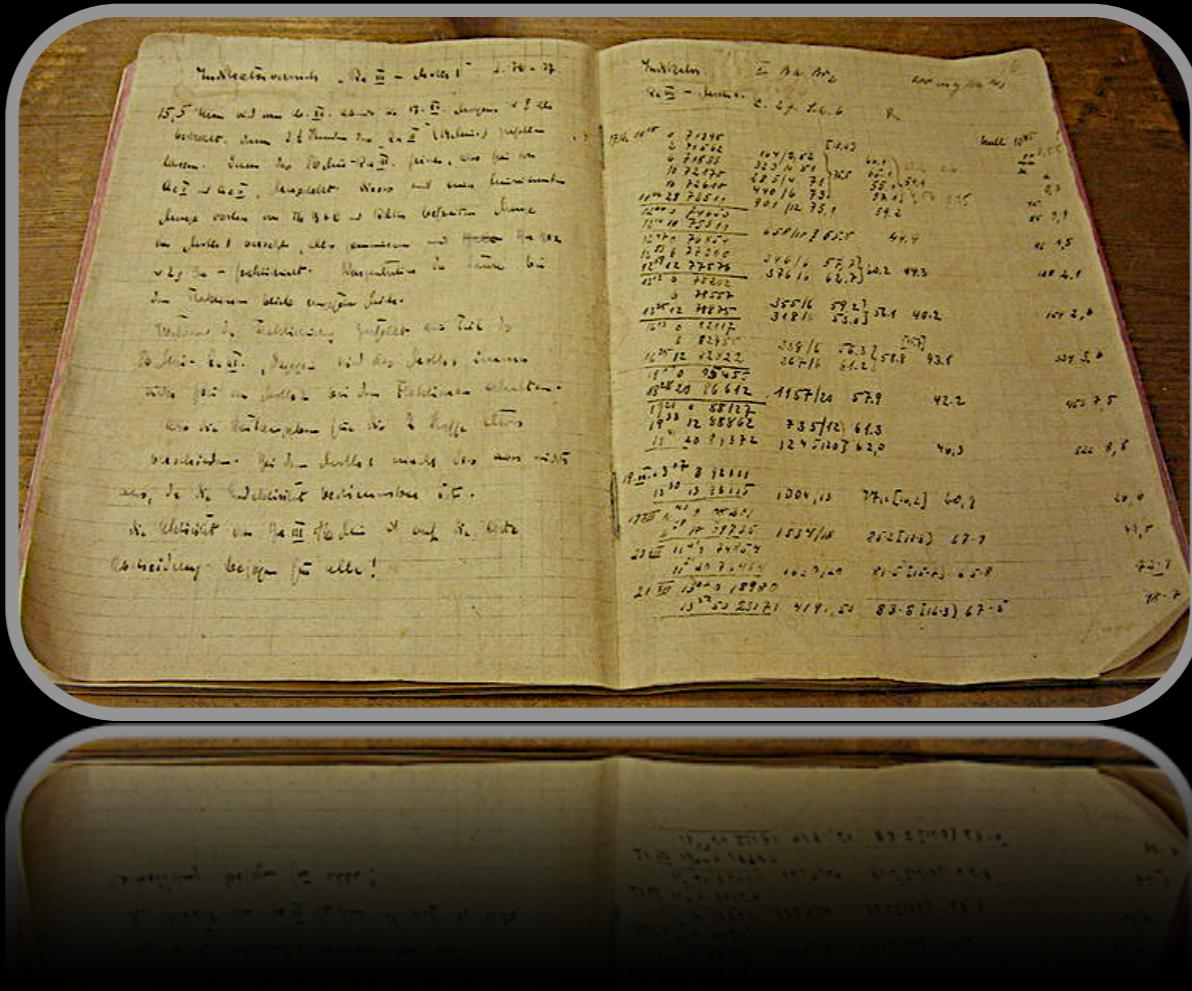
There are various ways of providing data to make reproducible or open LCA science. Is there a “batcat” option, which is more reproducible, or has higher trust, but requires less work?

# Lab notebook



The classic way to record your work is a scientific lab notebook.

# iLab notebook 2.0



- Combine notes and work
- Copy and paste links, pictures, video
- Copy and modify work, & redo calculations
- Access by teams (web)

An updated scientific lab notebook would include a record of work, but add significant value with additional features.

# Brightway2

## Brightway2

A new [open source](#) framework for [advanced](#) life cycle assessment calculations.  
It is designed to be [easy](#) to use, while still being [powerful](#).

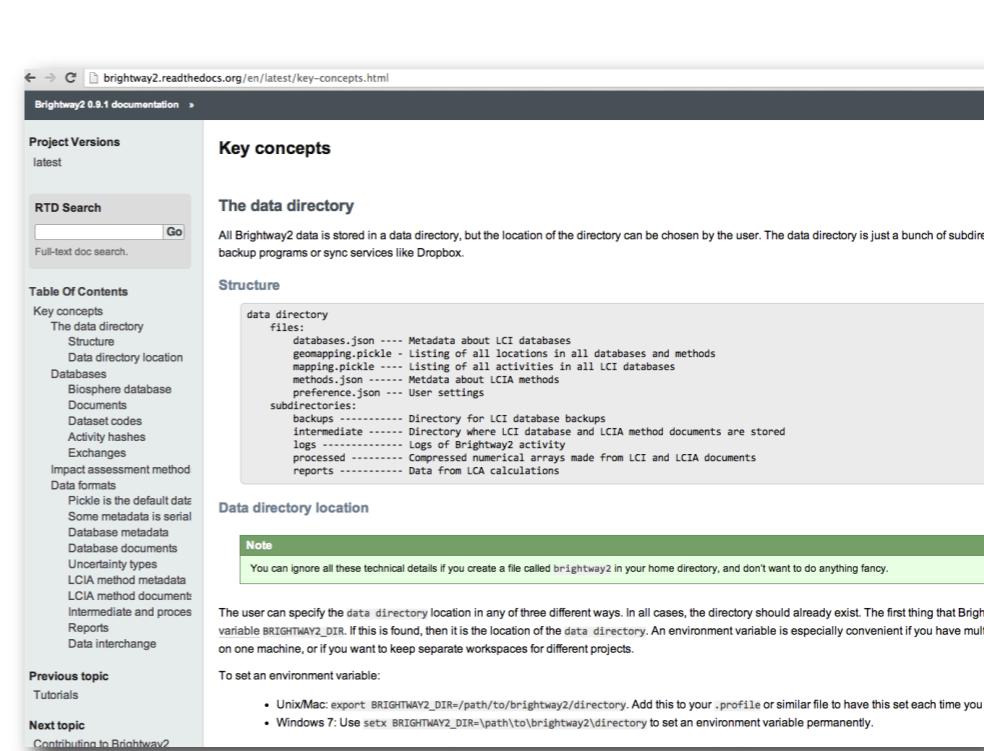
[Introduction](#) | [Motivation](#) | [Principles](#) | [Technology](#) | [Contributing](#) | [Credits](#)

### Introduction

Brightway2 is a completely new program for calculating life cycle assessments (LCA). Its core principles are simplicity, innovation, and power. It can be installed on Windows, OS X, and Linux, and has a web interface.

- [Documentation & Quickstart guide](#)
- [An example LCA report](#)
- [Getting started with Brightway2](#)
- [A simple LCA calculation](#)
- [Example: LCIA method independence](#)

### Motivation



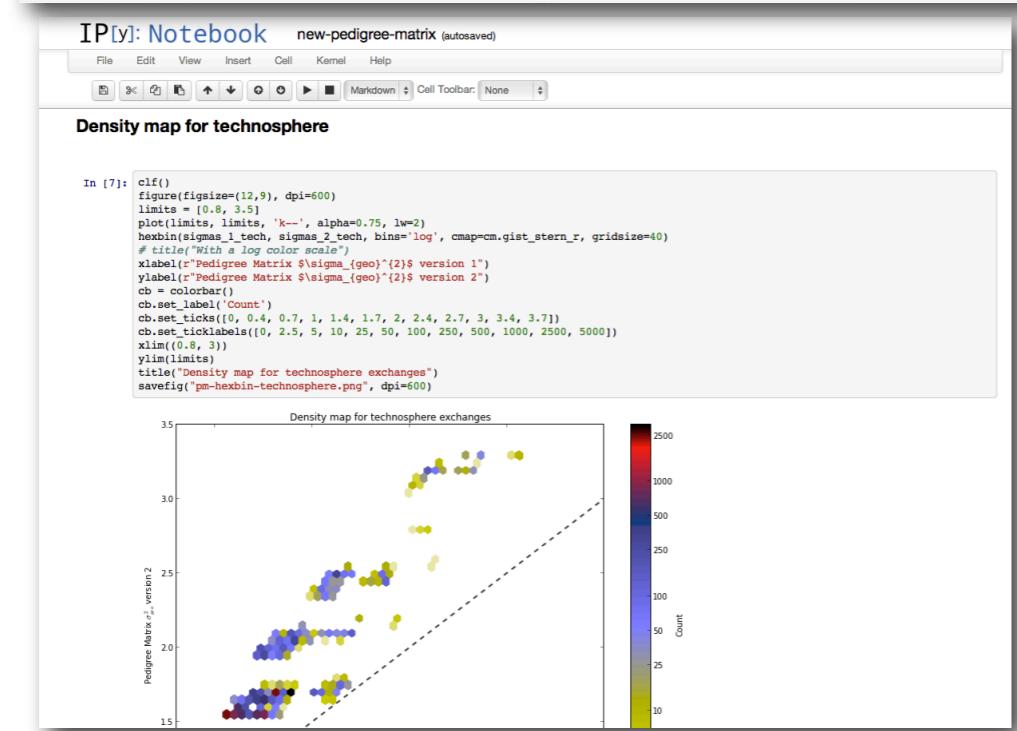
The data directory  
All Brightway2 data is stored in a data directory, but the location of the directory can be chosen by the user. The data directory is just a bunch of subdirectories, backup programs or sync services like Dropbox.

Structure  
data directory  
files:  
databases.json .... Metadata about LCI databases  
geomapping.pickle - Listing of all locations in all databases and methods  
mapping.pickle .... Listing of all activities in all LCI databases  
methods.json .... Metadata about LCIA Methods  
preference.json .... User settings  
subdirectories:  
backups ..... Directory for LCI database backups  
intermediate ..... Directory where LCI database and LCIA method documents are stored  
logs ..... Logs of Brightway2 activity  
processed ..... Compressed numerical arrays made from LCI and LCIA documents  
reports ..... Data from LCA calculations

Data directory location  
**Note**  
You can ignore all these technical details if you create a file called brightway2 in your home directory, and don't want to do anything fancy.

The user can specify the data directory location in any of three different ways. In all cases, the directory should already exist. The first thing that Brightway2 does is to check for the environment variable BRIGHTWAY2\_DIR. If this is found, then it is the location of the data directory. An environment variable is especially convenient if you have multiple workspaces on one machine, or if you want to keep separate workspaces for different projects.

To set an environment variable:  
• Unix/Mac: export BRIGHTWAY2\_DIR=/path/to/brightway2/directory. Add this to your .profile or similar file to have this set each time you open a terminal window.  
• Windows 7: Use setx BRIGHTWAY2\_DIR=\path\to\brightway2\directory to set an environment variable permanently.



Density map for technosphere

```
In [7]: clt()
figure(figsize=(12,9), dpi=600)
limits = [0.8, 3.5]
plot(xlimits, ylims, 'k--', alpha=0.75, lw=2)
hexbin(xlimits[1].tech, ylimits[1].tech, sigmas=2, bins='log', cmap=cm.gist_stern_r, gridsize=40)
# title('With a log color scale')
xlabel(r'Pedigree Matrix $\Sigma \sigma_{geo}^{(2)}$ version 1')
ylabel(r'Pedigree Matrix $\Sigma \sigma_{geo}^{(2)}$ version 2')
cb = colorbar()
cb.set_label('Count')
cb.set_ticks([0, 0.4, 0.7, 1, 1.4, 1.7, 2, 2.4, 2.7, 3, 3.4, 3.7])
cb.set_ticklabels([0, 2.5, 5, 10, 25, 50, 100, 250, 500, 1000, 2500, 5000])
xlim([0.8, 3))
ylim([0.8, 3))
title("Density map for technosphere exchanges")
savefig('pm-hexbin-technosphere.png', dpi=600)
```

Density map for technosphere exchanges

### Brightway2 web

Functional unit:  
• light clay brick, at plant: 1 kilogram  
• corrugated board, recycling fibre, single wall, at plant: 1 kilogram  
• chromium steel 18/8, at plant: 1 kilogram  
• soya oil, at plant: 1 kilogram

Impact assessment method:  
CML 2001: photochemical oxidation (summer smog): EBIR

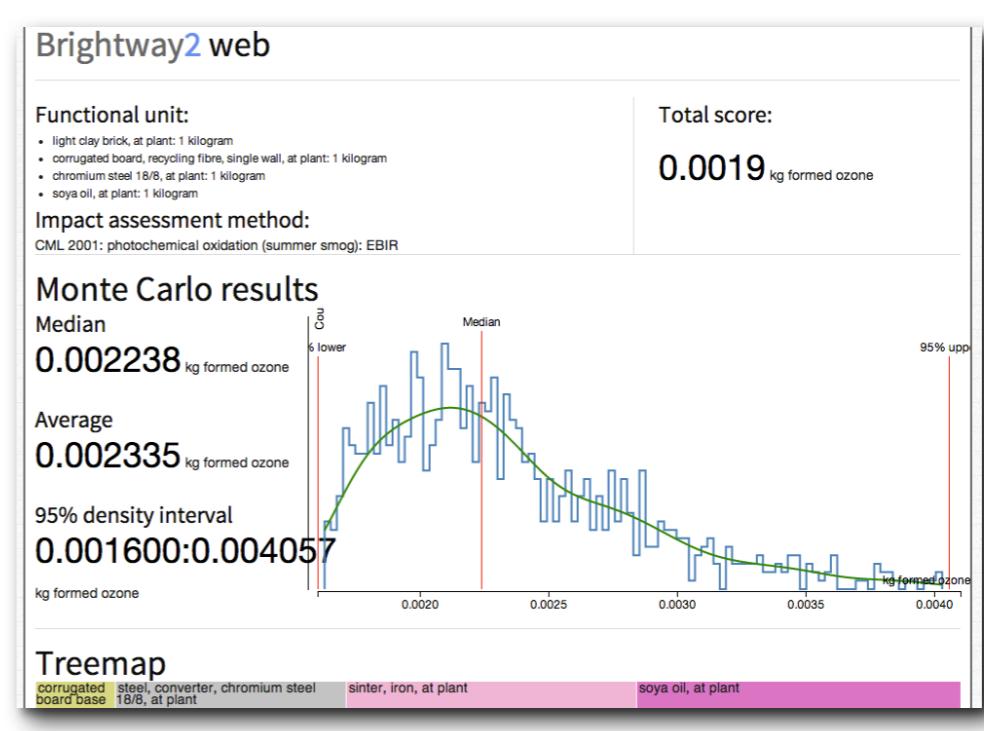
Total score:  
**0.0019 kg formed ozone**

Monte Carlo results

Median  
**0.002238 kg formed ozone**

Average  
**0.002335 kg formed ozone**

95% density interval  
**0.001600:0.004057 kg formed ozone**



Treemap

corrugated board base	steel, converter, chromium steel	sinter, iron, at plant	soya oil, at plant
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[Brightway2 \(<http://brightwaylca.org/>\)](http://brightwaylca.org/) is one possible LCA software which can be used interactively, and is therefore well suited for use in online scientific notebooks.

# Demonstration

[http://brightwaylca.org/examples/  
demo-notebook-lca-orlando.html](http://brightwaylca.org/examples/demo-notebook-lca-orlando.html)

The demo online notebook is static, not interactive, but can show the general idea of what an online lab notebook can look like.

# Conclusions

- Notebooks not specific to IPython
  - e.g. Sage, Rstudio
- Notebooks are a journey, not a destination
  - Still need to do & document your work
- Reproducibility and openness good for LCA used in democratic decision making