

Life Cycle Assessment with focus on the automotive industry

Prof. Dr. Matthias Finkbeiner

GIZ Lecture Series: LCA in the Automotive Industry
Shanghai * Hefei * Beijing - September 2013



Technische Universität Berlin
Department of Environmental Technology
Chair of Sustainable Engineering

Agenda



- Introduction to Life Cycle Assessment
 - Motivation
 - Method
 - Application
- Life Cycle Assessment in the automotive industry
 - State-of the art and application
 - Challenges
 - E-Mobility
- Perspectives for cooperation
 - Chair of Sustainable Engineering at the Technische Universität TU Berlin
 - Cooperation options



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Towards the fundamental question...



- We all agree that we want to protect the environment!
- We all agree that sustainable development is the way to go!

"Our world has enough for each person's need, but not for his greed."

Mahatma Gandhi



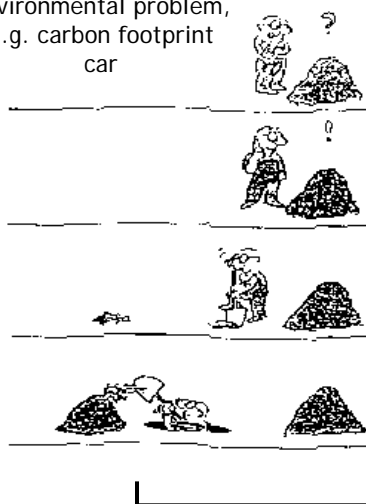
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It ain't easy being green....



environmental problem,
e.g. carbon footprint
car



environmental problem,
e.g. water footprint of biofuel



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The fundamental questions



- How can we measure what is green (environmentally preferable)?
- How can we measure what is blue (more sustainable)?

- for products
- for processes
- for organisations
- for nations

- If we know the green and blue, how can we make it happen?



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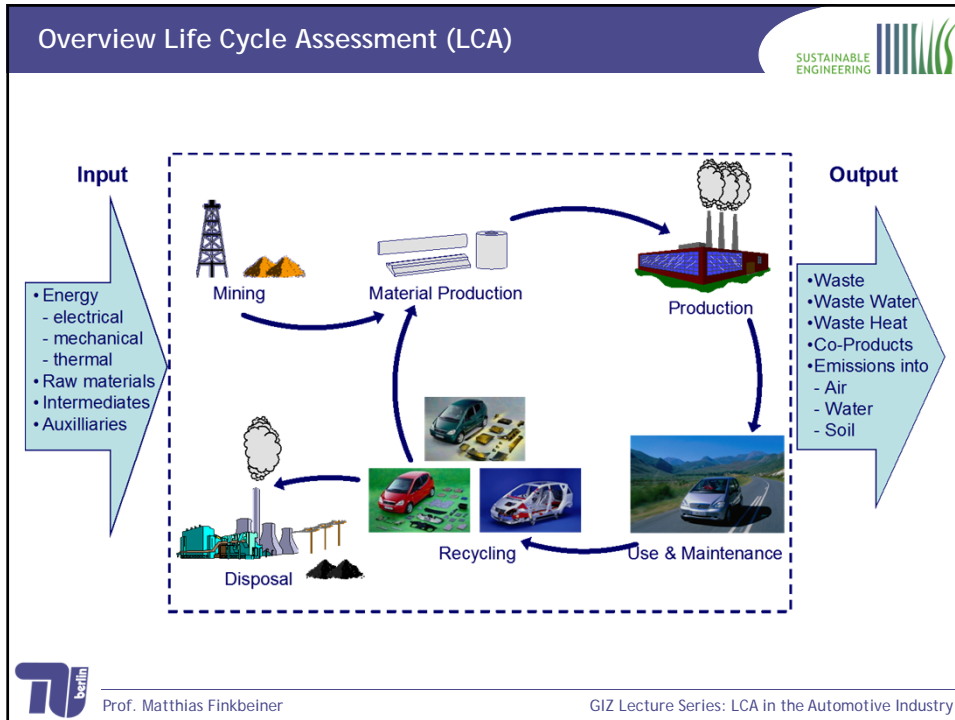


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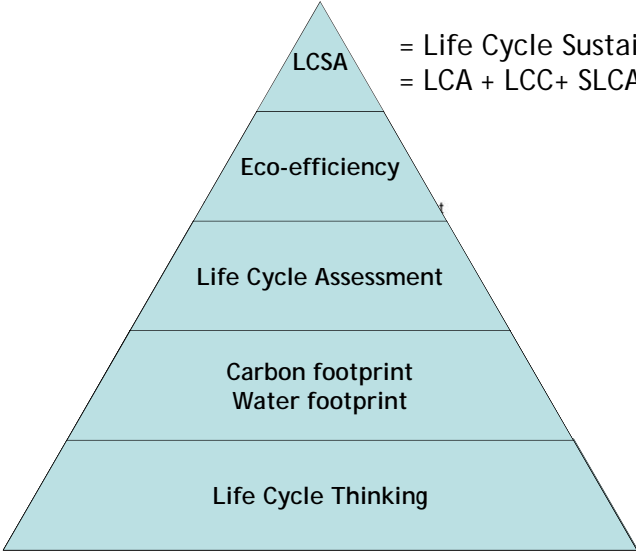


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Consistent Roadmap: Maslow's Pyramid adapted to environmental and sustainability assessment



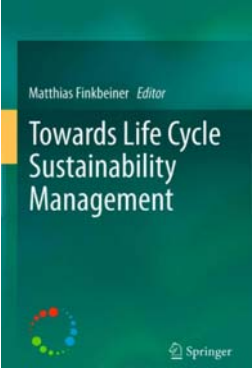
LCSA = Life Cycle Sustainability Assessment
= LCA + LCC + SLCA

Eco-efficiency


Life Cycle Assessment

Carbon footprint
Water footprint

Life Cycle Thinking




Matthias Finkbeiner Editor
Towards Life Cycle Sustainability Management
Springer
Springer Publishers, 2011
ISBN: 978-94-007-1898-2


 Prof. Dr. Matthias Finkbeiner Worldautosteel Meeting Berlin 2012

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Applications of LCA



- products
- technical processes
- organizations


Product(s) Process(es)	existing	new
one	hot spot analysis (optimisation)	design optimisation
more than one with the same function	choice optimisation	design optimisation choice



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Lesson learnt: there is no one size fits all LCA




In the past:

- „Whatever the problem is, LCA is gonna fix it.“
- One big, costly LCA to be used for everything, i.e. comparison, optimisation, communication, etc.
- Often no clear result and disappointment, „it depends“

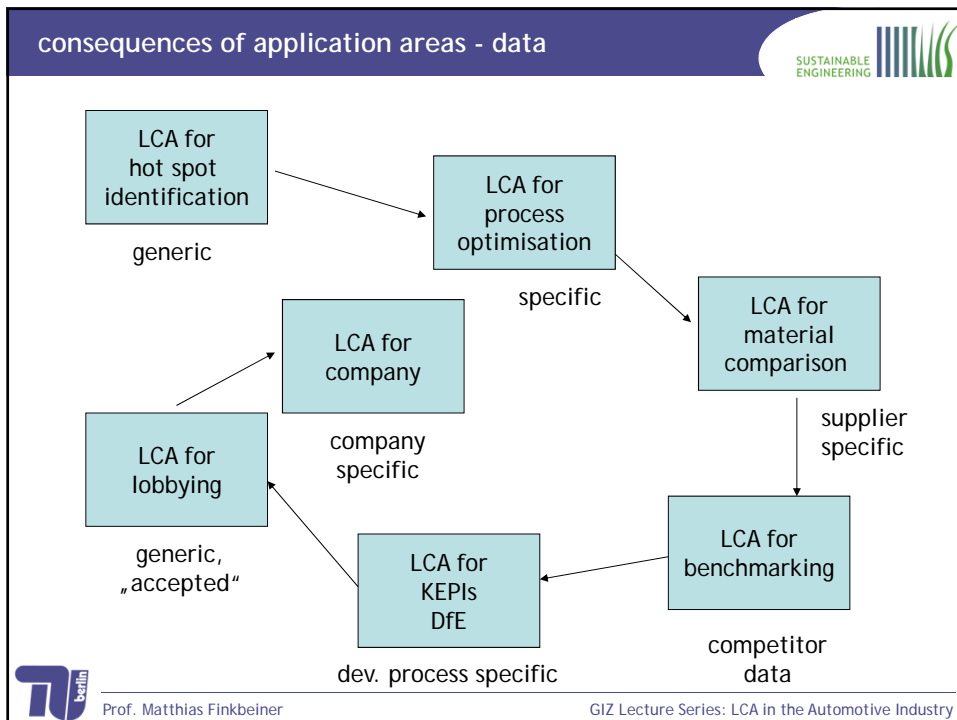
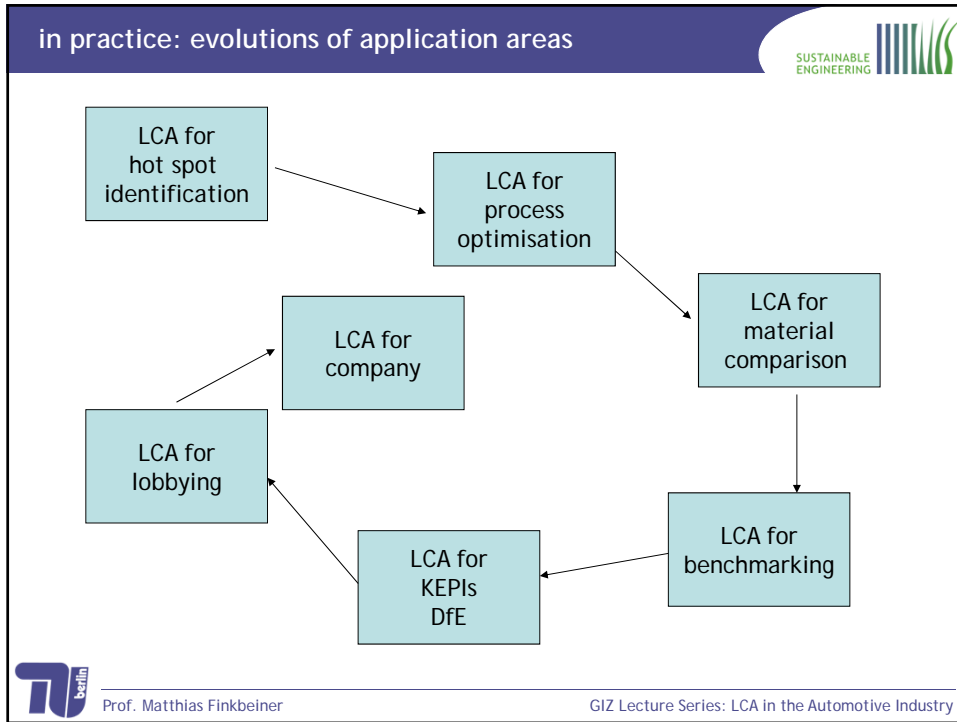
Today:

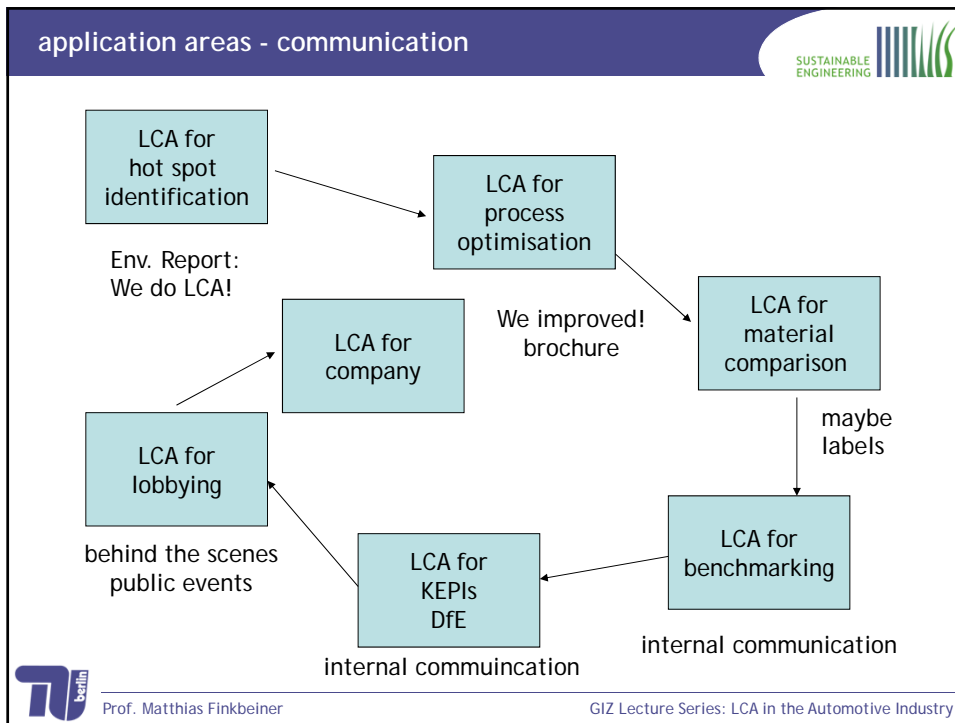
- Goal and application dependant LCAs
- The better defined the question to answer is, the better the LCA result.
- LCA is not a „religion“ (good or bad?), it is a tool (useful or not useful?).



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Recent trend: policy relevance of LCA in the EU

„LCAs provide the best framework for assessing the potential environmental impacts of products currently available.“

EU-Commission - Integrated Product Policy - COM/2003/0302 final

Development of a European methodology for the calculation of products and companies Environmental Footprint

Michele Galatola, policy officer
DG Environment, C1

European Commission

ENVIRONMENT

European Commission > Environment > Industry > Integrated Product Policy

Home | Who's who | Policies | Integration | Funding | Law | Resources

European Platform on Life Cycle Assessment (LCA)

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LCA-based legislation: example RED - Directive (I)



DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 23 April 2009
on the promotion of the use of energy from renewable sources and amending and subsequently
repealing Directives 2001/77/EC and 2003/30/EC

Article 17

Sustainability criteria for biofuels and bioliquids

2. The greenhouse gas emission saving from the use of biofuels and bioliquids taken into account for the purposes referred to in points (a), (b) and (c) of paragraph 1 shall be at least 35 %.

With effect from 1 January 2017, the greenhouse gas emission saving from the use of biofuels and bioliquids taken into account for the purposes referred to in points (a), (b) and (c) of paragraph 1 shall be at least 50 %. From 1 January 2018 that greenhouse gas emission saving shall be at least 60 % for biofuels and bioliquids produced in installations in which production started on or after 1 January 2017.

Article 19

Calculation of the greenhouse gas impact of biofuels and bioliquids



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LCA-based legislation: example RED - Directive (II)



C. Methodology

- Greenhouse gas emissions from the production and use of transport fuels, biofuels and bioliquids shall be calculated as:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee}$$

where


- E = total emissions from the use of the fuel;
- e_{ec} = emissions from the extraction or cultivation of raw materials;
- e_l = annualised emissions from carbon stock changes caused by land-use change;
- e_p = emissions from processing;
- e_{td} = emissions from transport and distribution;
- e_u = emissions from the fuel in use;
- e_{sca} = emission saving from soil carbon accumulation via improved agricultural management;
- e_{ccs} = emission saving from carbon capture and geological storage;
- e_{ccr} = emission saving from carbon capture and replacement; and
- e_{ee} = emission saving from excess electricity from cogeneration.




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LCA at Volkswagen



VOLKSWAGEN
ARTIKELLESENART

Environmental Protection over the entire Life Cycle

VOLKSWAGEN

Volkswagen Group
Environmental Principles Products

The Volkswagen Group Environmental Principles serve as a guideline for all the Group's divisions and regions. Within the scope of the "Environmental Principles" we aim to be responsible for the people, products and the planet. We have made the continuous improvement of the Group's products a matter of our strategic importance, and we are committed to the highest standards of our products. Our activities and products are always in line with the highest standards of environmental protection.


In line with this approach, we have defined the following objectives:

1. **Climate protection**
 - reduce greenhouse gas emissions
 - reduce fuel consumption in the driving cycle and over the vehicle's entire life cycle
 - reduce CO₂ emissions (scope 1 & 2)
2. **Resource conservation**
 - reduce resource efficiency
 - reduce energy consumption by taking account of renewable energy sources
 - reduce CO₂ emissions
 - reduce water and electricity consumption
 - reduce and reuse auxiliary substances (paints, adhesives, etc.)
 - reduce and reuse auxiliary substances (paints, adhesives, etc.)
 - reduce and reuse auxiliary substances (paints, adhesives, etc.)
3. **Recycling**
 - reduce the use of hazardous and non-hazardous substances
 - reduce the use of hazardous and non-hazardous substances
 - reduce the use of hazardous and non-hazardous substances
 - reduce the use of hazardous and non-hazardous substances

We believe we will continue to meet these objectives in the future. In the future, it remains our responsibility to continue to improve our products. As we do so, we will make sure that our products are always in line with the highest standards of environmental protection.

In this process, the Volkswagen Group will take particular account of the changes in the market and environmental requirements. The Environmental Principles will be updated as necessary. The Environmental Principles will be updated as necessary. The Environmental Principles will be updated as necessary.

Prof. Dr. Martin Winterkorn
Chairman of the Board of Management of Volkswagen AG
01.12.2009




Volkswagen is the high-volume brand that stands for innovation and engineering excellence.

Dr. Martin Winterkorn, Chairman of the Board of Management of Volkswagen AG

In future, we will develop each model in such a way that, in its entirety, it presents better environmental properties than its predecessor. As we do so, we will make sure that improvements are attained over the entire product life cycle.

Page 5

Dr. S. Krinke (K-EPUP)



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Dr. Stephan Krinke: Environmentally friendly vehicles and environmental strategy of the brand Volkswagen, 19.11.2009

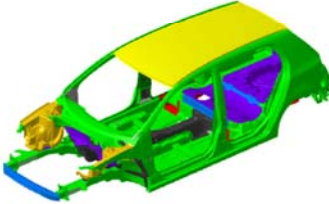
LCA at Volkswagen

SUSTAINABLE ENGINEERING


VOLKSWAGEN
HERZGEBIET

Applications of Life Cycle Assessment

Product development



Communication & Customer information



Dr. Stephan Krinke: Environmentally friendly vehicles and environmental strategy of the brand Volkswagen, 19.11.2009

Group Research Environmental Affairs Product Page 17

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Followers catching up....

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- LCA teams are growing
- management attention is growing
- decision relevance is growing
- relevant topics are growing (e-mobility, CFRP, ...)
- supplier involvement is growing

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LCA at Volkswagen

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ENGINEERING

VOLKSWAGEN
AGTIENGESELLSCHAFT

Time and resource demand for LCA of cars
Starting position in 2000

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LCA at Volkswagen

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Time and resource demand for LCA of cars
Situation today

~ 1 day ~ 1-30 days ~ 0-2 days

transfer file other internal data sources mapping file

interface 1 complete transfer file interface 2

internal data sources technical drawings product model

IMDS IMDS

specify vehicle • close data gaps
• check weights
• check materials map material/
process information
to available data
sets in database

data base manual processing predefined process electronic data


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Dr. Stephan Krinke: Environmentally friendly vehicles and environmental strategy of the brand Volkswagen, 19.11.2009


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LCA of a car




- > 40.000 unit processes
- > 2000 inputs and outputs
- customized software and databases
- Finkbeiner et al. (2003) : "Data Collection Format for Life Cycle Assessment of the German Association of the Automotive Industry"; Int. J. of Life Cycle Assessment (6) 379 - 381



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Example LCA of a car



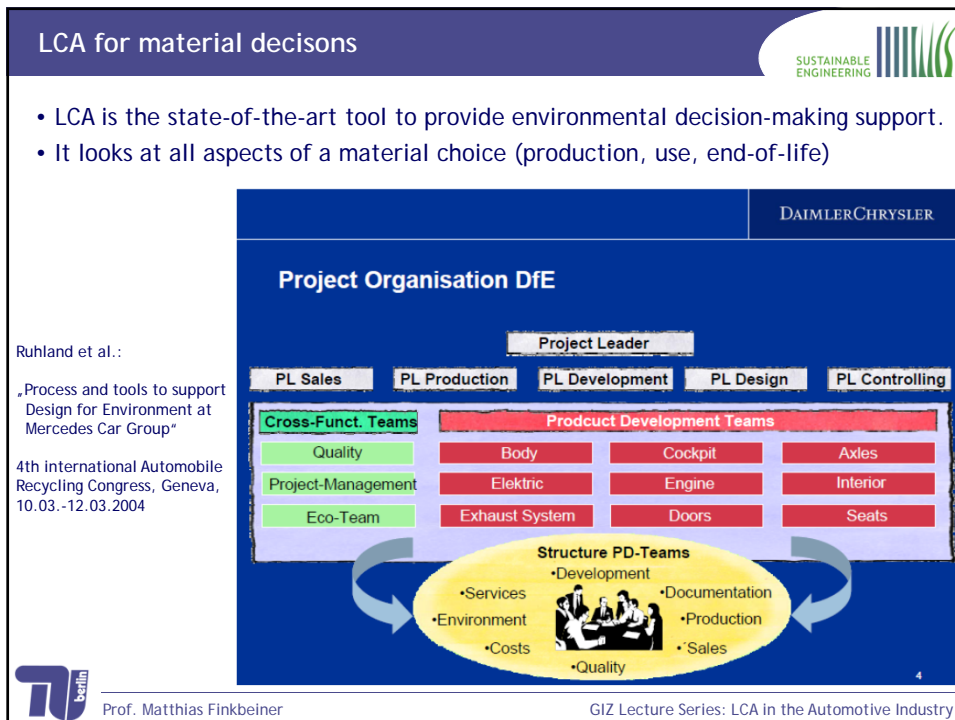
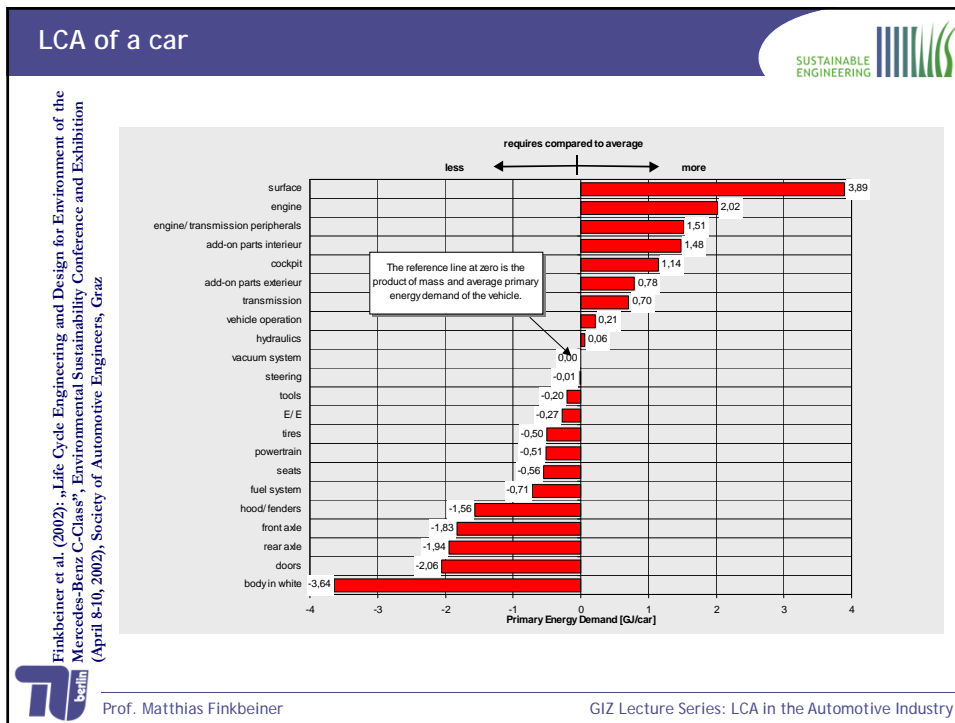
■	Production Phase	■	Use Phase - Fuel Production
■	Use Phase - Tailpipe and Maintenance	■	End - of - Life - Phase

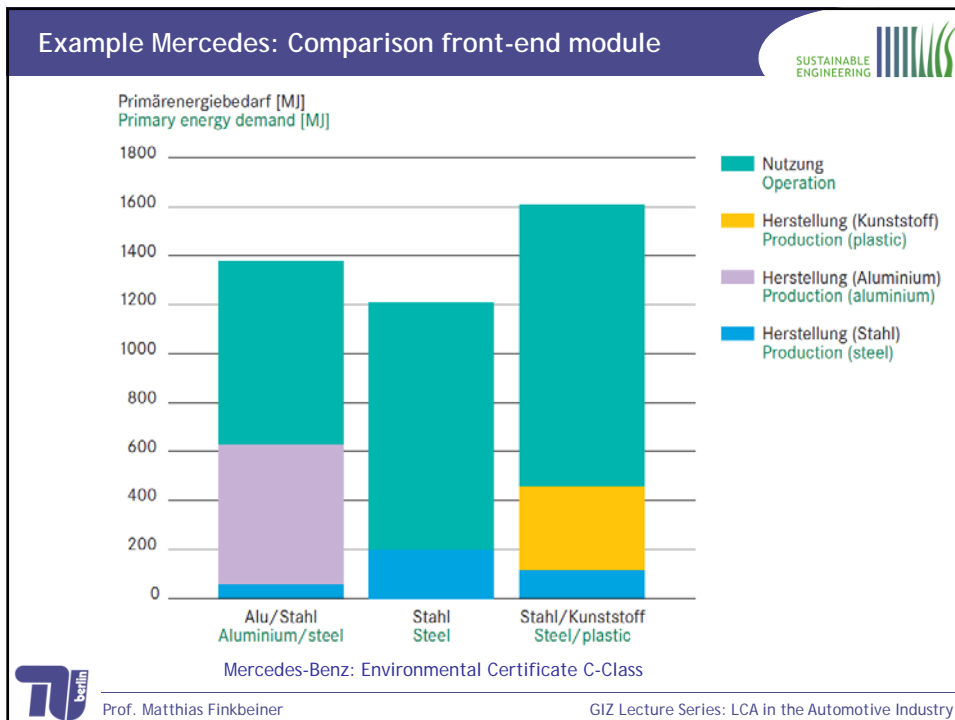
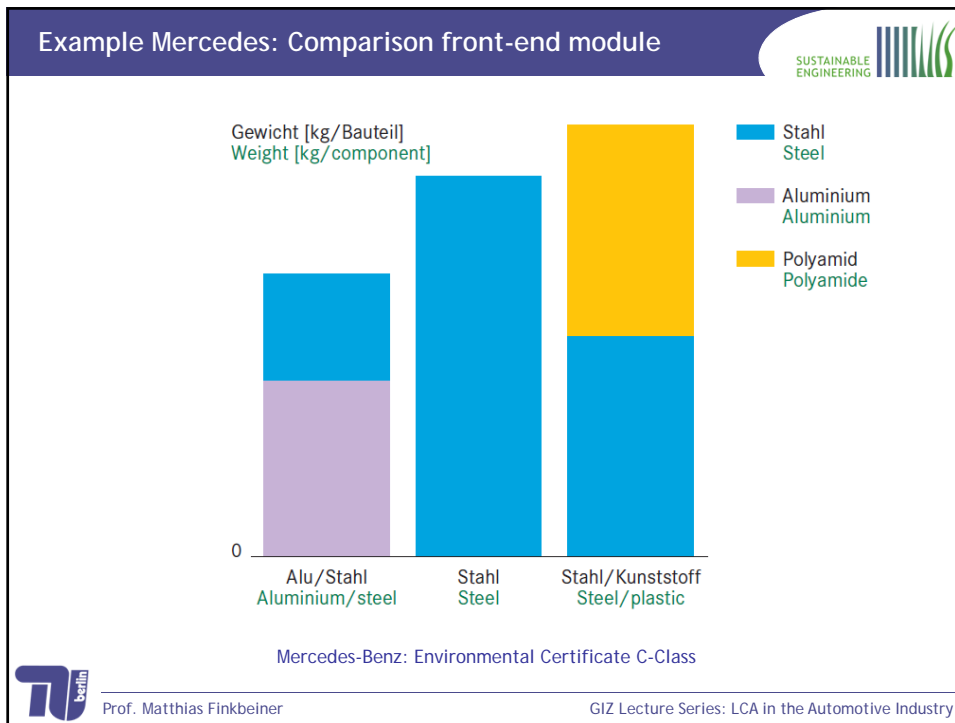
Indicator	Production Phase (%)	Use Phase - Fuel Production (%)	Use Phase - Tailpipe and Maintenance (%)	End - of - Life - Phase (%)
Primary Energy Demand	15	15	70	0
CO2	15	15	70	0
CO	45	20	35	0
NOx	25	55	15	5
NMVOC	5	85	10	0
CH4	25	75	0	0
SO2 (50 ppm S-Gehalt; ab 11.2001)	60	35	5	0
Water Demand	80	15	5	0
Deposits	75	25	0	0
Global Warming Potential (GWP 100 years)	15	15	70	0
Eutrophication Potential (EP)	25	55	15	5
Photochemical Oxidant Creation Potential (POCP)	5	85	10	0
Acidification Potential (AP)	45	40	10	5

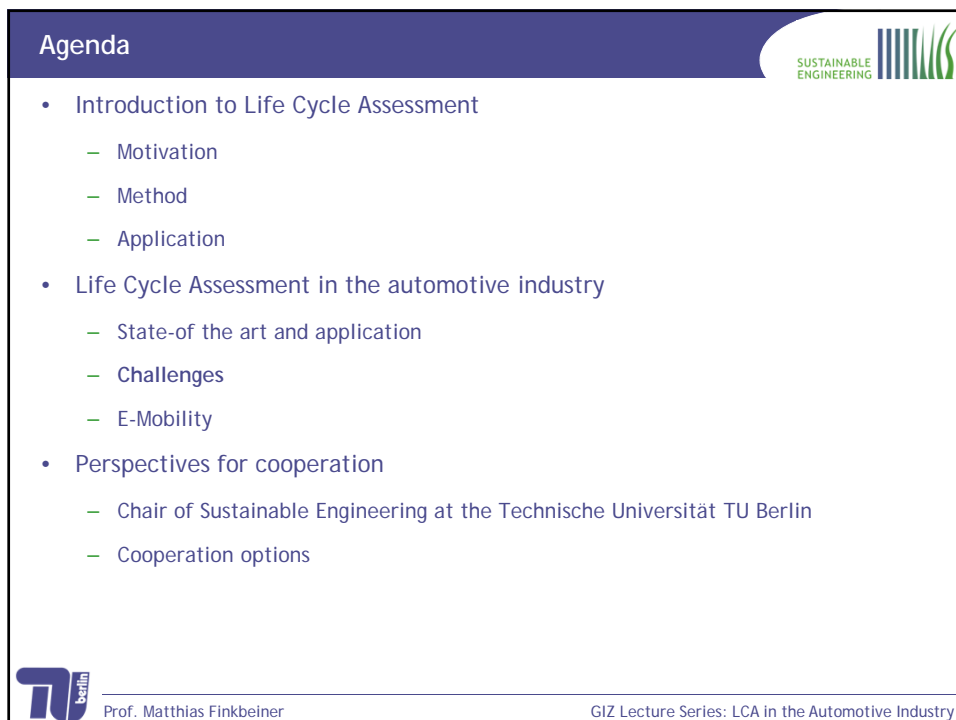
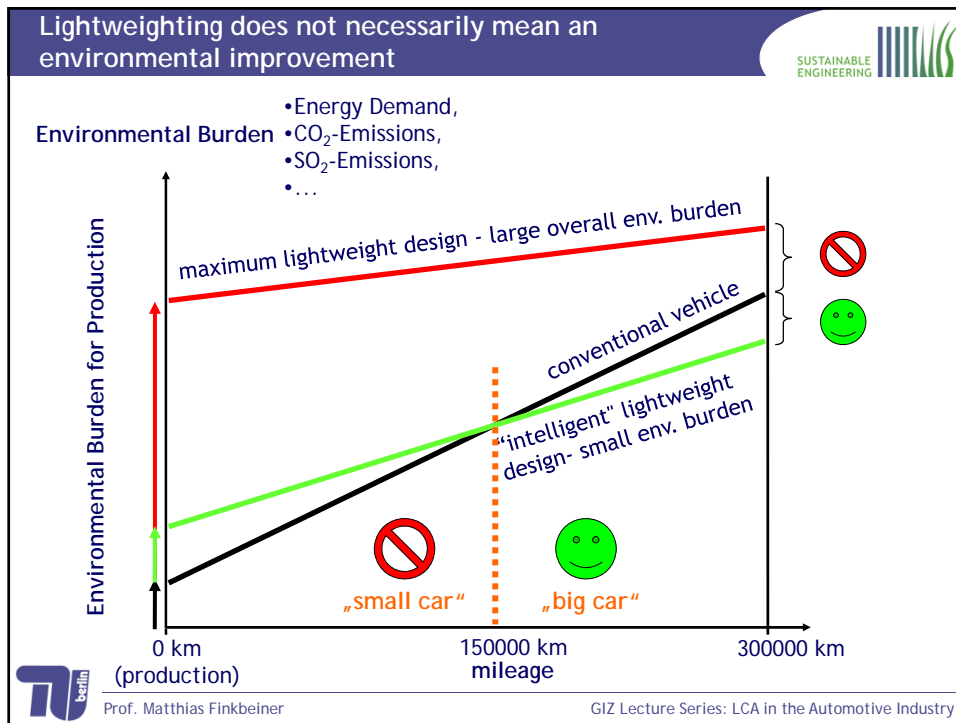


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Sophistication and method refinement in classical areas of automotive parts LCAs...

- How to model EoL-phase ?
(recycled content vs. EoL-recycling or new approaches)
- How to model use phase?
 - FRVs?
 - non-fuel derived emissions?
- How to model energy supply?
 - renewables?
 - production or consumption mix?
- Data issues
 - e-mobility
 - CFRP
 - other specialties

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New challenge: Water Footprint

Stand-alone methods

Virtual Water

Water Footprint according to WFN

Global Water Tool

Corporate Water Gauge

LCA methods

Water inventories

↓

Impact assessment methods for Human health Ecosystems Resources

Bayart et al. (2010)

Boulay et al. (2011a)

Ecoinvent (2011)

PE International (2011)

Quantis (2012)

Hauschild and Wenzel (1998)

Brent (2004)

Bösch et al. (2007)

Mila i Canals et al. (2008)

Frischknecht et al. (2009)

Bayart et al. (2009)

Pfister et al. (2009)

Boulay et al. (2011b)

Veolia (2011)

Motoshita et al. (2008)

Pfister et al. (2009)

Maendly & Humbert (2011)

Motoshita et al. (2011)

van Zelm et al. (2011)



Boulay et al. (2011b)

} Midpoint

} Endpoint

**ISO 14046
(working draft)**

Berger, M. & Finkbeiner, M.
Water Footprinting: How to address water use in LCA? *Sustainability* 2010, 2(4)
<http://www.mdpi.com/2071-1050/2/4/919/>

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Case study just published in ES&T*

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- Water footprinting in the automotive industry
 - How much water is consumed in a car's life cycle?
 - What is the impact of this water consumption?
- Procedure
 - Determine water consumption on an inventory level by means of LCA software and Volkswagen's LCI data bases
 - Geographical differentiation of water consumption according to Import mixes, location of production sites, etc.
 - Selection of methods for impact assessment & determination of regional characterization factors
 - Impact assessment
 - Interpretation

**M. Berger, J. Warsen, S. Krinke, V. Bach, M. Finkbeiner (2012): Water footprint of European cars: potential impacts of water consumption along automobile life cycles Environmental Science and Technology, DOI: 10.1021/es2040043*

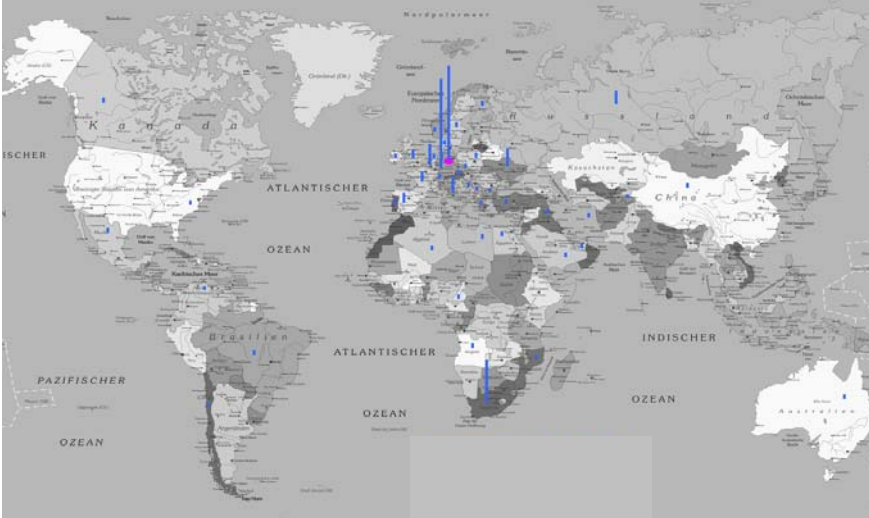
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Case Study

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- LCI: ~ 80 m³ fresh water



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OEM publications: Daimler - smart

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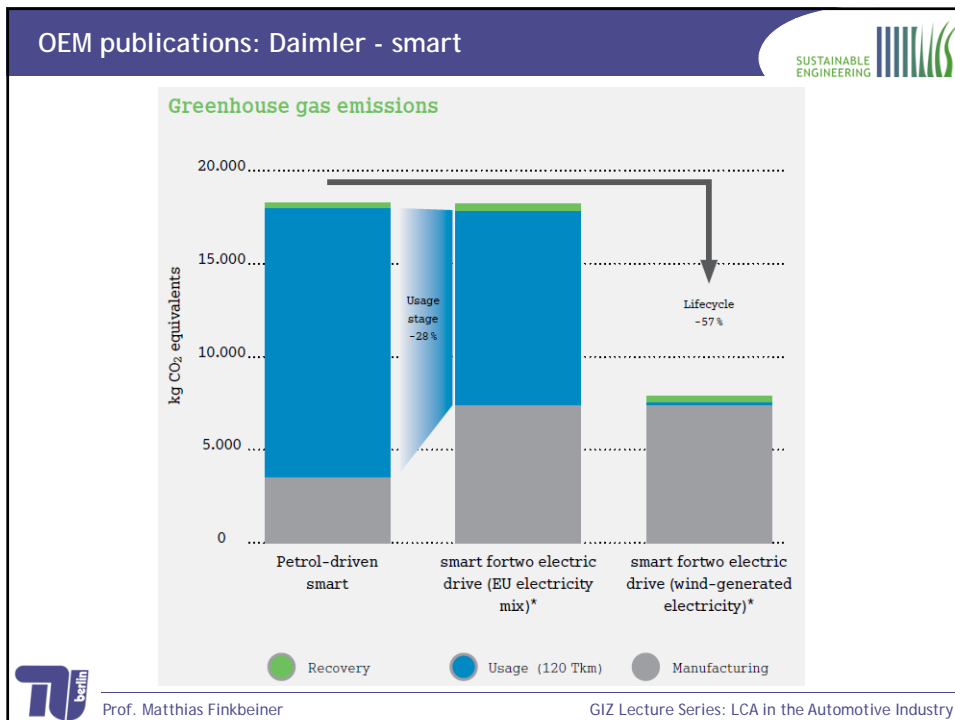


smart
open your mind.

>> Environmental brochure.
smart fortwo electric drive.

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OEM publications: Renault

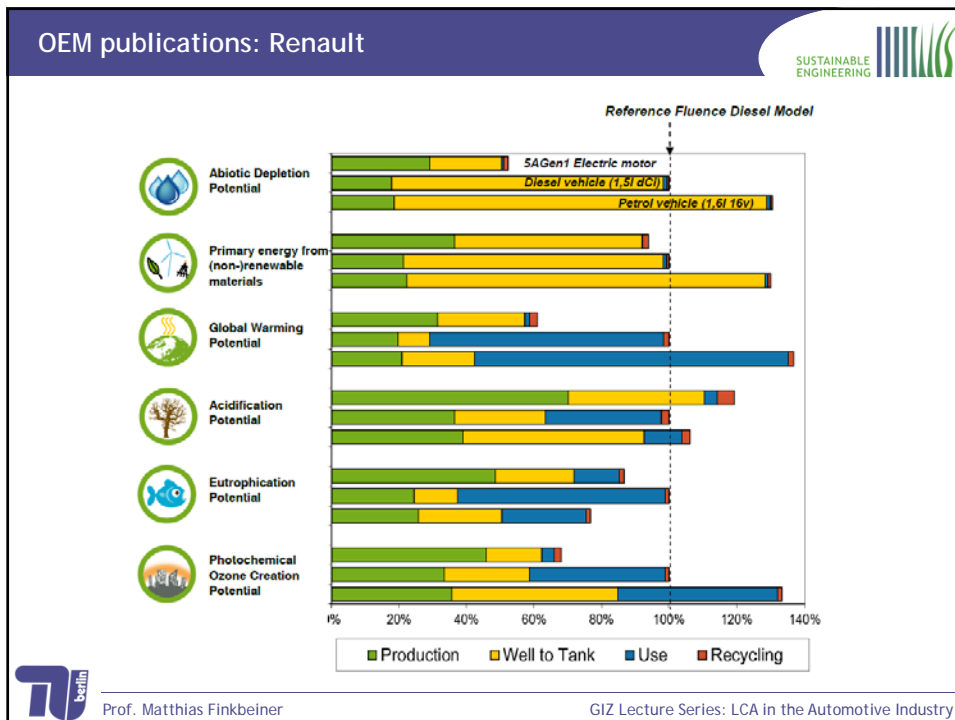
SUSTAINABLE ENGINEERING

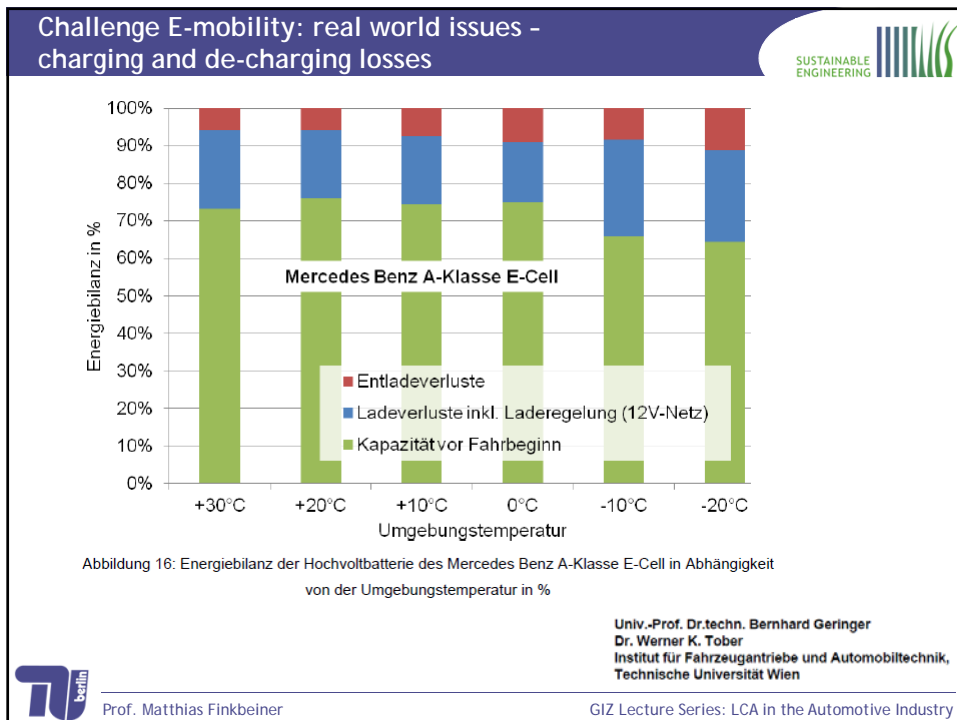
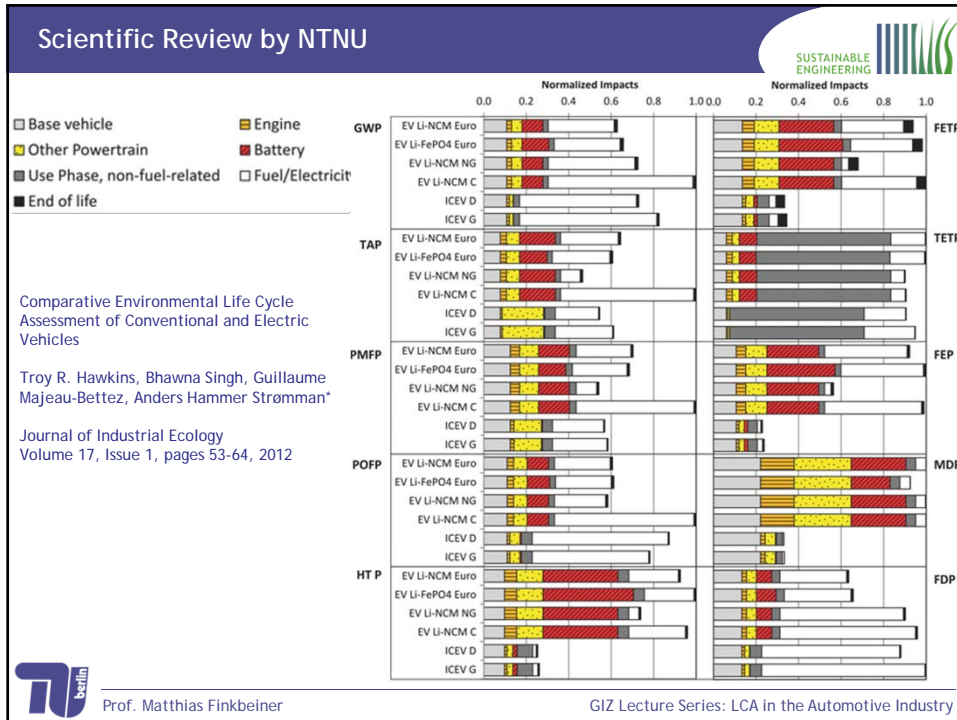
DRIVE THE CHANGE

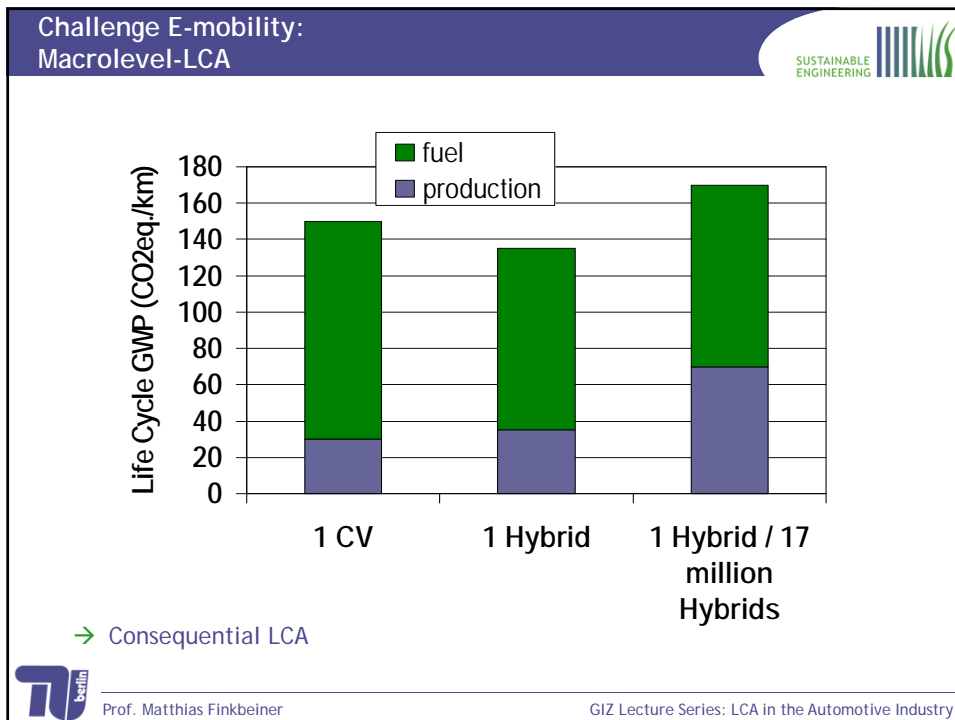
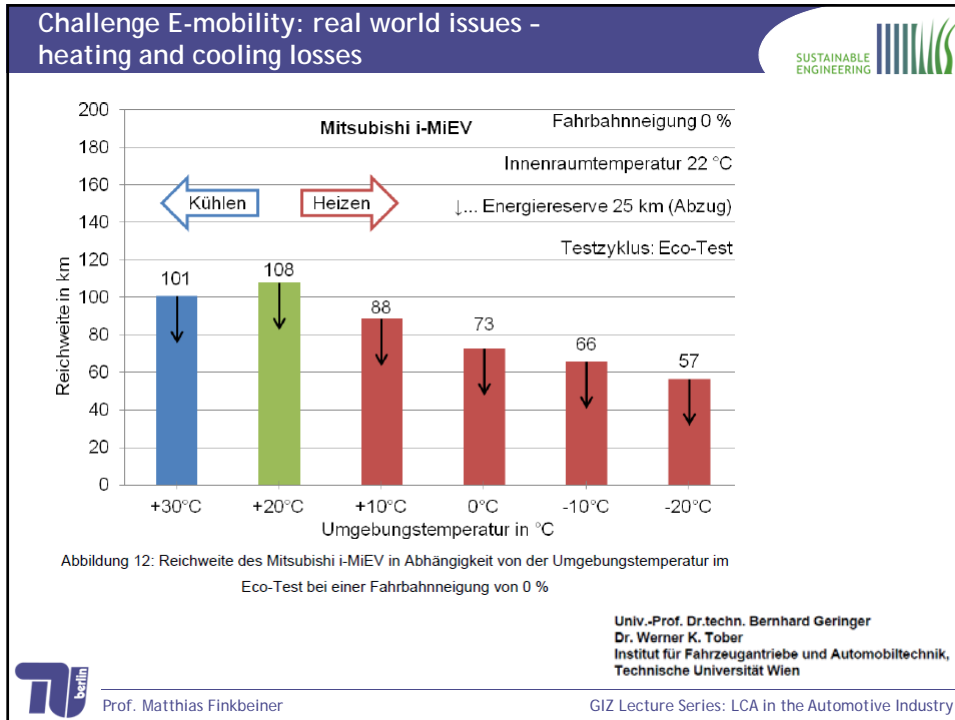
RENAULT

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Technische Universität Berlin





Technische Universität Berlin



- 27.049 students, 5.603 from foreign countries
- 4.500 employees, 319 Professors
- 90 study courses
- 7 faculties
- > 140 million € third party funds







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Chair of Sustainable Engineering



- Technische Universität Berlin
 - Faculty III - Process Sciences
 - Department of Environmental Technology
 - Chair of Sustainable Engineering



- Target:
 - Promote a sustainable way of engineering
 - Implement principles of sustainability into daily engineering practice
 - Support the development of sustainable products and processes
 - Provide tools that enable the “measurement” sustainability aspects
 - Teaching of students in sustainability topics




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Key facts




- experience of >>100 LCA case studies in a variety of sectors, e.g. Mobility, Building, Food, Energy, Investment goods, Consumer Goods, Services
- Carbon footprint studies for both organisations (scope 3) and products
- Water footprint studies for several industrial products
- Social LCA for several industrial products
- Resource efficiency and availability studies for several companies and industry associations.
- Third party funds about 60% from companies and industry associations and 40% public research grants
- Growth of the group from 4 members in 2008 to more than 20 today.
- interdisciplinary team with >50% female and >30% international members.




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**SUSTAINABLE
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ISO TC207 Life Cycle Assessment



INTERNATIONAL
ORGANIZATION FOR
STANDARDIZATION


Subject: Appointment as ISO/TC 207 Subcommittee 5 Chair

Dear Dr. Finkbeiner:


On behalf of the Chair, member bodies and expert participants of ISO/TC 207 on Environmental Management, I congratulate you on your recent appointment as Chair of ISO/TC 207 Subcommittee 5 on Life Cycle Assessment. The work of Subcommittee 5 has helped build the international reputation and credibility of the ISO 14000 family of standards and is critical to our continued success. As you know, the analytical tools of life cycle assessment are being increasingly used by governments and industry as a decision support in a variety of applications, including resource efficiency, environmental labeling or carbon footprinting initiatives.

Thanks again for your leadership and support. I look forward to working with you over upcoming years to ensure ISO's 14000 series standards remain rigorous, relevant and timely.

Sincerely,



ISO Chairman TC207/SC5 Life Cycle Assessment
Chairman Advisory Committee TC207 seit Juni 2008 in Bogota




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**SUSTAINABLE
ENGINEERING** 

UNEP Project Leader Carbon Footprinting

United Nations Environment Programme

برنامج الأمم المتحدة للبيئة · 联合国环境规划署
PROGRAMME DES NATIONS UNIES POUR L'ENVIRONNEMENT · PROGRAMA DE LAS NACIONES UNIDAS PARA EL MEDIO AMBIENTE
ПРОГРАММА ОРГАНИЗАЦИИ ОБЪЕДИНЕННЫХ НАЦИЙ ПО ОКРУЖАЮЩЕЙ СРЕДЕ

Mr. Mathias Finkbeiner,

The UNEP/SETAC Life Cycle Initiative (<http://lcinitiative.unep.fr>) is a global Initiative which aims "to bring science based life cycle approaches into practice worldwide". Since 2002 the world has experienced a positive evolution regarding the internalization of Life Cycle Thinking in policy making and business. Today key players in sustainable decision making issues see the Initiative as a one-stop-shop for approaches and knowledge. One important achievement is the set up of an international Life Cycle Community with more than 1000 members, 40% of which come from developing countries and economies in transition.

We would like to confirm our acknowledgment of your in kind contribution to the activities of the UNEP/SETAC Life Cycle Initiative in special of the areas to "Life Cycle GreenHouseGas Protocol and Carbonfootprint", which you are leading.

We will be very grateful to continue receiving your support.

Sincerely yours,



Mr Arab Hoballah
Chief, Sustainable Consumption and Production
Branch
UNEP-DTIE



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UNEP Member of International LC Panel SUSTAINABLE ENGINEERING

ILCP seit Dezember 2008

Secretariat

Life Cycle Inventory

- LCI Database Registry
- LCI Database Characteristics and Quality
- LCI Methodological Consistency
- LCA Case study library for meta-analyses

Life Cycle Impact Assessment



- LCA information system
- Natural resources and land use
- Toxicity impacts
- Transboundary impacts

Life Cycle Management



- LCM Handbook
- Life cycle based product development
- Communication of life cycle information
- Management along the life cycle

Cross-Cutting Activities

- Simplified LCA
- Integrated Resource and Waste Management
- Integration of social aspects into LCA





ICMM International Council on Mining & Metals

Canada  

RioTintoAlcan **RONA** **VEOLIA** **TOTAL** **AMERICAN CHEMISTRY COUNCIL** **PlasticsEurope**

GIGA **ESG** **EPA VICTORIA** **ArcelorMittal** **Cascades** **Desjardins** **CIRAIG** **eeq** **EDF**

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WBCSD/WRI Steering Committee GHG SUSTAINABLE ENGINEERING



World Business Council for Sustainable Development



WORLD RESOURCES INSTITUTE

Dear Matthias,

As you may know, the WRI/WBCSD GHG Protocol is launching a new initiative to develop guidelines for product and supply chain greenhouse gas accounting and reporting. We would like to invite you to be a member of the Steering Committee for this important new initiative.

We hope you will consider this invitation, and we would be very grateful to have your input and leadership in this venture.



Margaret Flaherty
Senior Managing Director
World Business Council for Sustainable Development



Manish Bapna
Executive Vice President & Managing Director
World Resources Institute

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„Blue Angel“ Jury

 Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, 11055 Berlin

Herrn
Prof. Dr. rer. nat. Matthias Finkbeiner
Technische Universität Berlin Institut für Technischen Umweltschutz
Fachgebiet Sustainable Engineering
Straße des 17. Juni 135
10623 Berlin

Peter Altmaier
Bundesminister
Mitglied des Deutschen Bundestages

TEL +49 3018 305-2000
FAX +49 3018 305-2046
makingang@bmu.bund.de
www.bmu.de

Berlin, 13. März 2013

Sehr geehrter Herr Professor Finkbeiner,

ich danke Ihnen für Ihre Bereitschaft, sich für die Mitarbeit in der Jury Umweltzeichen zur Verfügung zu stellen, und berufe Sie hiermit für die aktuelle Berufungsperiode 2013 bis 2015 zum Jurymitglied.

Für Ihre Tätigkeit in der Jury wünsche ich Ihnen viel Erfolg.

Mit freundlichen Grüßen



 Prof. Matthias Finkbeiner







GIZ Lecture Series: LCA in the Automotive Industry

Collaborative Research Center (CRC) 1026


CRCs in general

- ▶ The DFG (German Research Foundation) is the self-governing organisation for excellent science and research in Germany.
- ▶ Collaborative Research Centers are high-profile institutions established at universities for up to 12 years that enable researchers to pursue an outstanding research programme, crossing the boundaries of disciplines, institutes and faculties.

CRC 1026 Sustainable Manufacturing

- ▶ 22 Chairs
- ▶ 17 subprojects
- ▶ close to 11,000,000€ funding for the first 4 years
- ▶ plus Integrated Research Training group incl. 35 one year doctoral scholarships

Laboratory for Sustainable Manufacturing



Source: TUB

Sustainable MANUFACTURING

Business solution → Solution ready for use

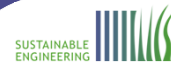
Project Area A
Strategy Development
Opening solution space

Project Area B
Product Technology Solutions
Creating potentials

Project Area C
Principles, Methods and Tools for Qualification
Enabling for sustainable value creation

Sustainable MANUFACTURING

Agenda



- Introduction to Life Cycle Assessment
 - Motivation
 - Method
 - Application
- Life Cycle Assessment in the automotive industry
 - State-of the art and application
 - Challenges
 - E-Mobility
- Perspectives for cooperation
 - Chair of Sustainable Engineering at the Technische Universität TU Berlin
 - Cooperation options

Integrated Research Training Group

Technische Universität Berlin  **IWF** **DFG** Deutsche Forschungsgemeinschaft

Doctoral Scholarships

Reference Number: SFB-1026-MGK-12-1
Topic: Short term doctoral scholarships in the Integrated Research Training Group of the Collaborative Research Centre CRC 1026

Motivation:
 Three one year doctoral scholarships (Euro 1,362.00 per month) will be awarded in April and October 2012.
 The scholarships are granted for the participation in the German Science Foundation (DFG) funded Integrated Research Training Group "Sustainable Manufacturing – Shaping Global Value Creation" at the Technische Universität Berlin. The challenge in creating products and technologies which promote social, economical and ecological sustainable production.


DFG-Graduiertenkolleg 1026
 „Sustainable Manufacturing“ Univ.-
 Prof. Dr.-Ing.
 Günther Seliger

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- ▶ 5 scholarships per year from 2013
- ▶ after one year: potentially get researcher position in the CRC or go back to "home university".
- ▶ <http://www.mf.tu-berlin.de/fileadmin/fq267/stellenausschreibungen/SFB-1026-MGK-12-1.pdf>

 Sustainable MANUFACTURING

Cooperation options

 SUSTAINABLE ENGINEERING

- informal
 - always welcome
 - limited resources and sustainability
- formal
 - cooperation agreements
 - joint research projects
 - advisory or guest professorship

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Chair of Sustainable Engineering

Prof. Dr. Matthias Finkbeiner



Technische Universität Berlin
Department of Environmental Technology
Chair of Sustainable Engineering