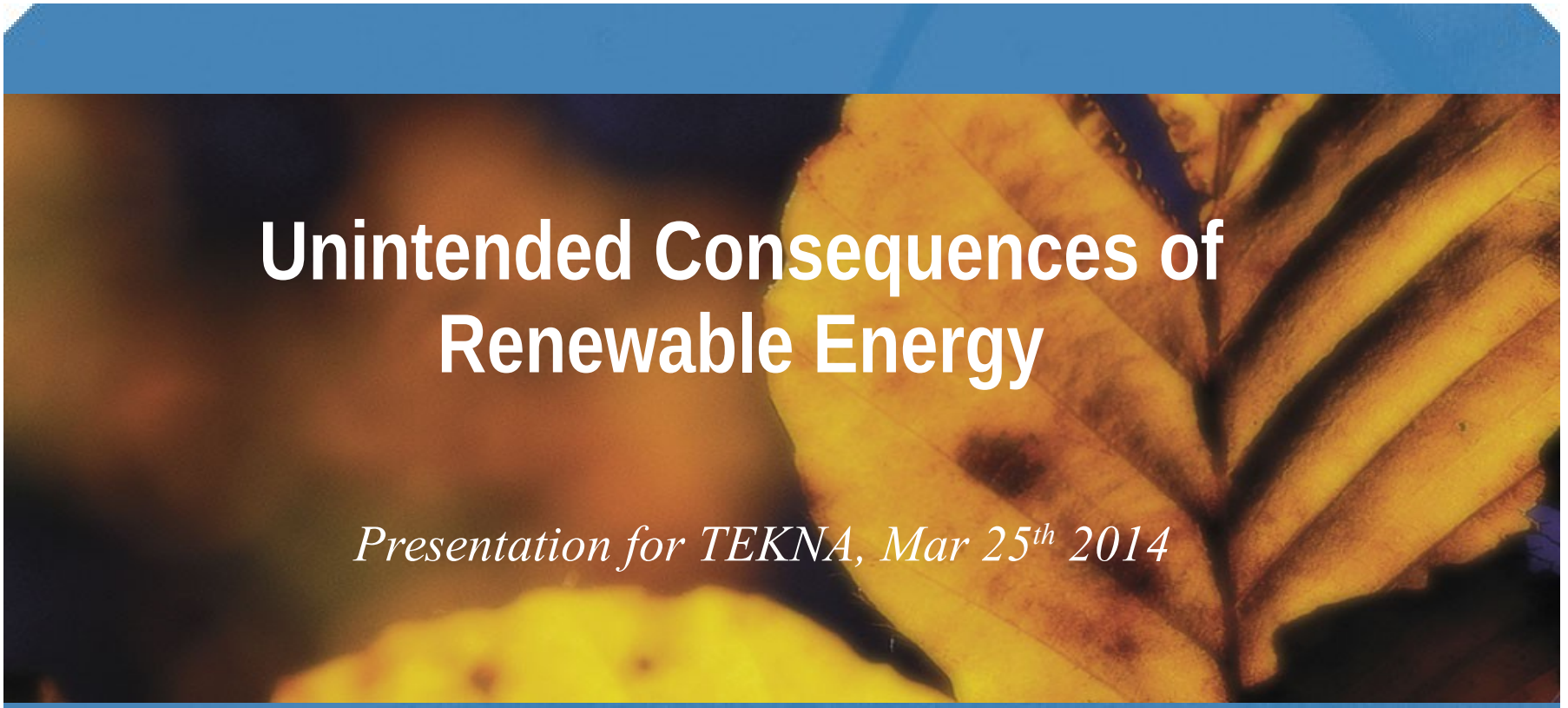

Unintended Consequences of Renewable Energy

Presentation for TEKNA, Mar 25th 2014

Otto Andersen, Stiftinga Vestlandsforsking / Western Norway Research Institute

WESTERN NORWAY RESEARCH INSTITUTE
VESTLANDSFORSKING
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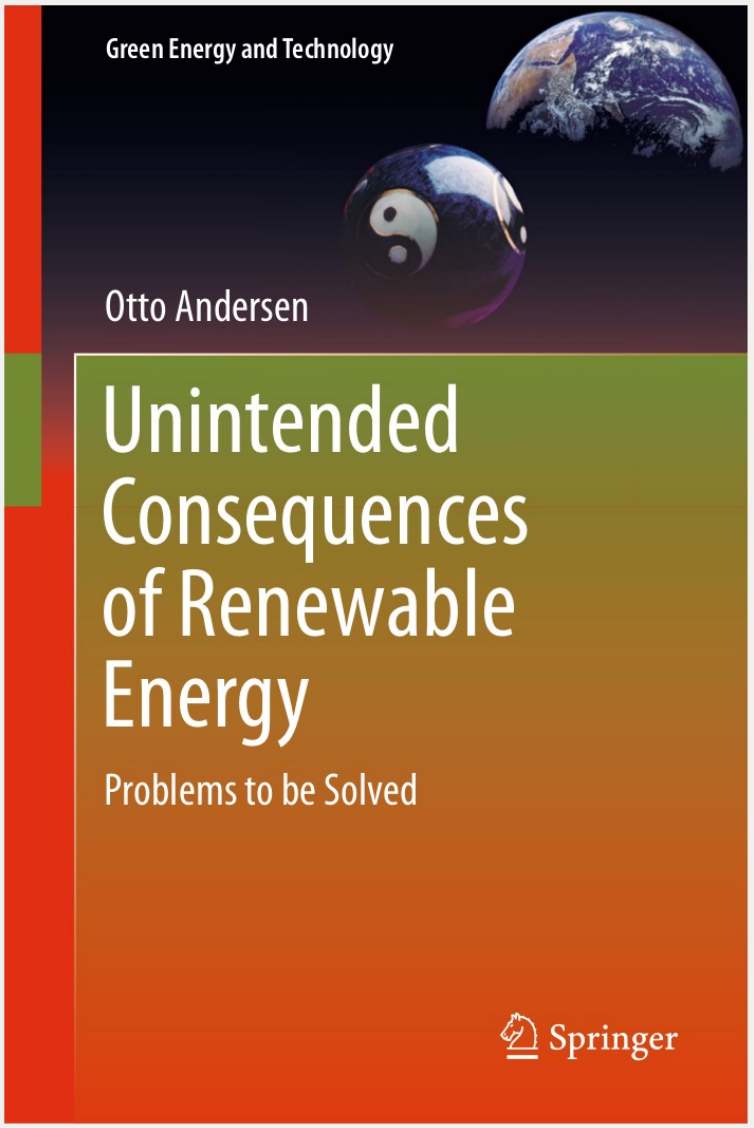
Basis (1)


Green Energy and Technology
Otto Andersen
Unintended Consequences of Renewable Energy
Problems to be Solved
Springer

Basis (2)

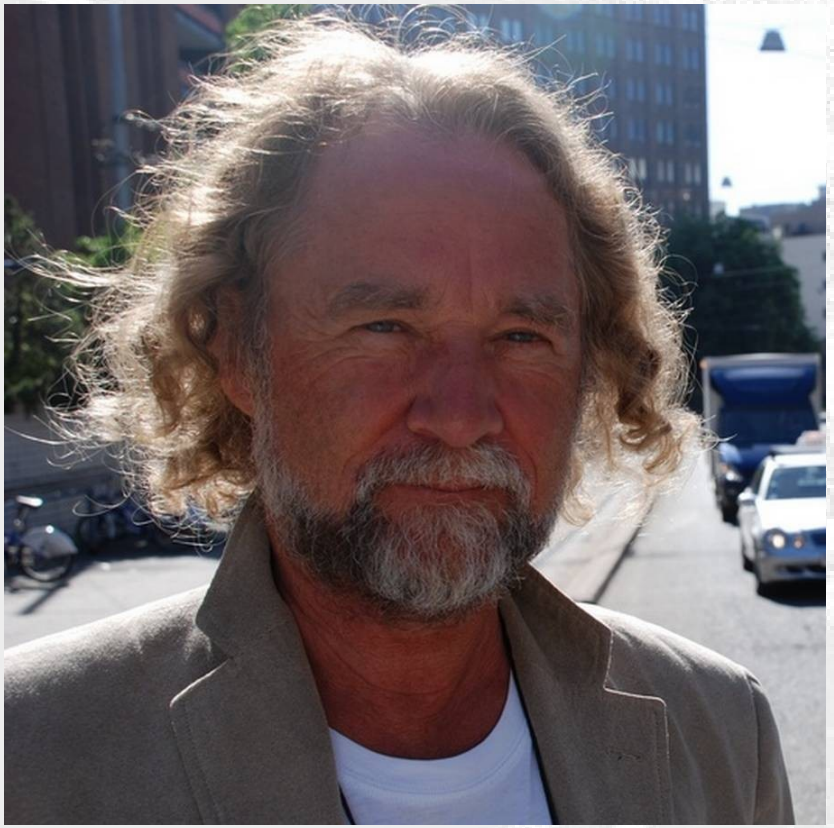


Foto: Jannicke Nilsen

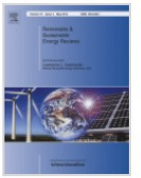
Karl Georg Høyer

1946 – 2012

Basis (3)

Renewable and Sustainable Energy Reviews

Volume 16, Issue 4, May 2012, Pages 2102–2110



Toxicological aspects of nanomaterials used in energy harvesting consumer electronics ☆

Sergio Manzetti[a, b], Otto Andersen[a]

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http://dx.doi.org/10.1016/j.rser.2012.01.037

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Abstract

Sustainable energy harvesting, such as solar energy, depends increasingly on nanotechnology components. This article will look briefly at the principles of photovoltaic units and elucidate the toxicological aspects of its principal components, namely fullerenes and carbon nanotubes. Through this approach, we address the rebound effect related to health adverse and environmental aspects which is a key issue to be solved when innovating in energy harvesting. The understanding of sustainability in this context is that the technology provides lasting improvement by bringing environmental compatibility along with technological agility, providing major reductions in both material and energy resource use and avoid negative impacts on our environment and health. With the *rebound effect* we understand the unintended emergence of negative environmental impacts resulting from intentions of improving environmental issues.

Biodiesel and its Blending into Fossil Diesel

Biodiesel and its Blending into Fossil Diesel (1)

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Kronikk

Biodiesel i autodiesel - "kvikk-fiks" på miljøproblem?

Produksjon av biodrivstoff er blitt kritisert for å konkurrere med matproduksjon og redusere biologisk mangfold. Men bruken av disse drivstoffene kan også være problematisk, skriver forskere fra Vestlandsforskning i denne kronikken.

Otto Andersen
forsker, Vestlandsforsking
Sergio Manzetti
forsker, Vestlandsforsking

Onsdag 18. august 2010
kl. 05:00

(Foto: Morten Stene)

Tema
- Alternativ energi
- Bil og trafikk

Se også

Tjærestoffer kan ha hormonell effekt

Det har lenge vært fokus på tjærestoffer og kreftrisiko. Men det er nødvendig å undersøke om de også kan bidra til redusert fruktbarhet hos menn, skriver Sergio Manzetti i denne kronikken.

- Bra med hogst på kort sikt
- Skittent biodrivstoff
- Flyr på kyllingfett
- Biodiesel kan skade DNA
- Setter fart i biodrivstoff

Se også kortnytt

Svevestøv er farligere enn antatt

Relaterte saker
- Bygger hybrid fiskebåt
- Vannkraften gjør Norge helgrønt
- Vil bremse orkaner med vindmøller
- Bilene er på full fart inn India og Vietnam
- Kan bake mat på solstrålar
- Produksjon av solceller er fortsatt ikke optimal
- Hver tredje vei og bane er skredutsatt
- Du grønne, glitrende bulk, goddag
- Oppdrettsproblem kan bli landbruksressurs
- Får mer ut av vindmøllene

På forsiden nå
- Oljeutslipp gir fisken hjerteanfall
- En tvilling på bakken og en i rommet
- Får brakkesyke på asylmottak
- Kalsium i kosten forebygger fedme
- Vi trenger mer enn bare eneboliger i distriktene

Biodiesel and its Blending into Fossil Diesel (2)

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Kronikk

Biodiesel kan skade DNA

Nanopartikler fra biodiesel kan inneholde giftig tjærestoff som øker eksosen sin evne til å skade DNA, skriver Otto Andersen i denne kronikken.

Otto Andersen
forsker, Vestlandsforsking

Torsdag 13. januar 2011
kl. 05:00

(Foto: Colourbox)

Nanopartikler er små partikler som finnes i eksos fra biler. De har en diameter på mindre enn 100 nanometer. I eksos fra diesel er det flere nanopartikler enn i eksos fra bensin.

Blanding av biodiesel inn i vanlig (fossil) diesel er vanlig tiltak for å øke bruk av biodrivstoff i Europa og USA. I Norge blandes det inn 3,5 prosent biodiesel i den totale mengden diesel som selges. Dette skal økes til 5 prosent i løpet av året.

Nanopartikler kan være giftige, og inneholder mange forskjellige kjemiske forbindelser, som blant annet kommer fra ufullstendig forbrenning av drivstoffet.

Mulig kreftfare

Studier har vist at eksos fra biler som går på biodiesel inneholder flere nanopartikler enn eksos fra biler som går på fossil diesel. Det har også blitt vist at innblanding av biodiesel øker mutagenisiteten av eksosen. Dette er et signal om mulig økt kreftfare.

Kunnskapen om sammenheng mellom biodieselinnblanding og helseffekter er fortsatt begrenset, men på konferansen EURO OIL &

Tema
- Bil og trafikk
- Forurensning
- Nanoteknologi

Se også

Bioenergi kan gi klimagevinst raskt

Vi mangler god nok kunnskap om klimagasseffekten av økt hogst til bioenergiformål. Det er langt enklere å beregne effekten av hogstavfall til energiformål. Dette gir raskt en positiv og betydelig effekt, skriver Per Kristian Rørstad i denne kronikken.

- Bioenergi er naturfiendtlig
- Biodiesel i autodiesel - "kvikk-fiks" på miljøproblem?
- Lønnsomme bioraffineri
- Bønder mot bioetanol
- "Den store biodrivstoff-svindelen"
- Tråkker i so

Relaterte saker
- Oljeutslipp gir fisken hjerteanfall
- Bygger hybrid fiskebåt
- Fire ukjente menneskeskapte gasser funnet i atmosfæren
- Muslingenes årringer forteller om klima
- Nanosølv kan forandre cellene våre
- - Kjemikalier gir barn hjerneskader
- Ustabilt hav kan gi bråere klimaendring
- Små mengder olje kan ødelegge næringskjeden i Arktis
- Cocktail av plantevernmidler gir økt miljørisiko
- Miljøgifter i mors mage gir overvektige døtre

På forsiden nå
- Oljeutslipp gir fisken hjerteanfall
- En tvilling på bakken og en i rommet
- Får brakkesyke på asylmottak
- Kalsium i kosten

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Biodiesel and its Blending into Fossil Diesel (3)

TU BYGG INDUSTRI IT KARRIERE KLIMA KRAFT PETROLEUM SAMFERDSEL FORSKNING

Norsk forskning viser at biodrivstoff kan være helseskadelig. Foto: Scanpix

– Biodrivstoff kan øke kreftfaren

Biodrivstoff på tanken kan utgjøre økt helsefare, advarer norske forskere. – Myndighetene har ikke brukt føre-var-prinsippet når de introduserer biodrivstoff, advarer Otto Andersen.

Av Jannicke Nilsen

Publisert: 4. november 2010 kl. 07:23

TU Stilling

Profilerte stillinger:

Biodiesel and its Blending into Fossil Diesel (4)

HELSEFARLIG? Forskere fra Vestlandsforskning mener nå å ha funnet indikasjoner på at bilfører og omgivelsene også blir utsatt for nye, hittil ukjente giftstoffer, når man kjører med en blanding av fossil diesel og biodiesel på tanken. Foto: Jannicke Nilsen

Folkehelseinstituttet: – Dette må forskes videre på

– Dette visste vi ikke. Hvis det er riktig at det kommer nye utslipp ut i luften, er dette virkelig nytt. Myndighetene er nødt til å sørge for at det forskes videre på dette, sier avdelingsdirektør Per Swarze ved Folkehelseinstituttet.

Av Jannicke Nilsen

Publisert: 4. november 2010 kl. 07:21

Biodiesel and its Blending into Fossil Diesel (5)

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BYGG INDUSTRI IT KARRIERE KLIMA KRAFT PETROLEUM SAMFERDSEL FORSKNING

Flom Karbonfangst Forsknin

ETTERLYSER BRED DEBATT: - Innføringen av biodrivstoff har vært drevet av den grønne bølgen, og man har antatt at alt som har med biodrivstoff å gjøre har vært bra. Dessverre er det ikke alltid sånn, sier DNA-professor Hans Krokan ved NTNU. Foto: Erle Kyllingmark

Advarer mot biodiesel i fossil diesel: – Svært mange kan bli syke

Selv om det bare skulle være en liten økning i risikoen for å få helseproblemer fra biodiesel, kan svært mange mennesker bli syke, advarer DNA-professor Hans Krokan ved NTNU.

Av Jannicke Nilsen

Publisert: 9. desember 2010 kl. 07:31

TU Stilling

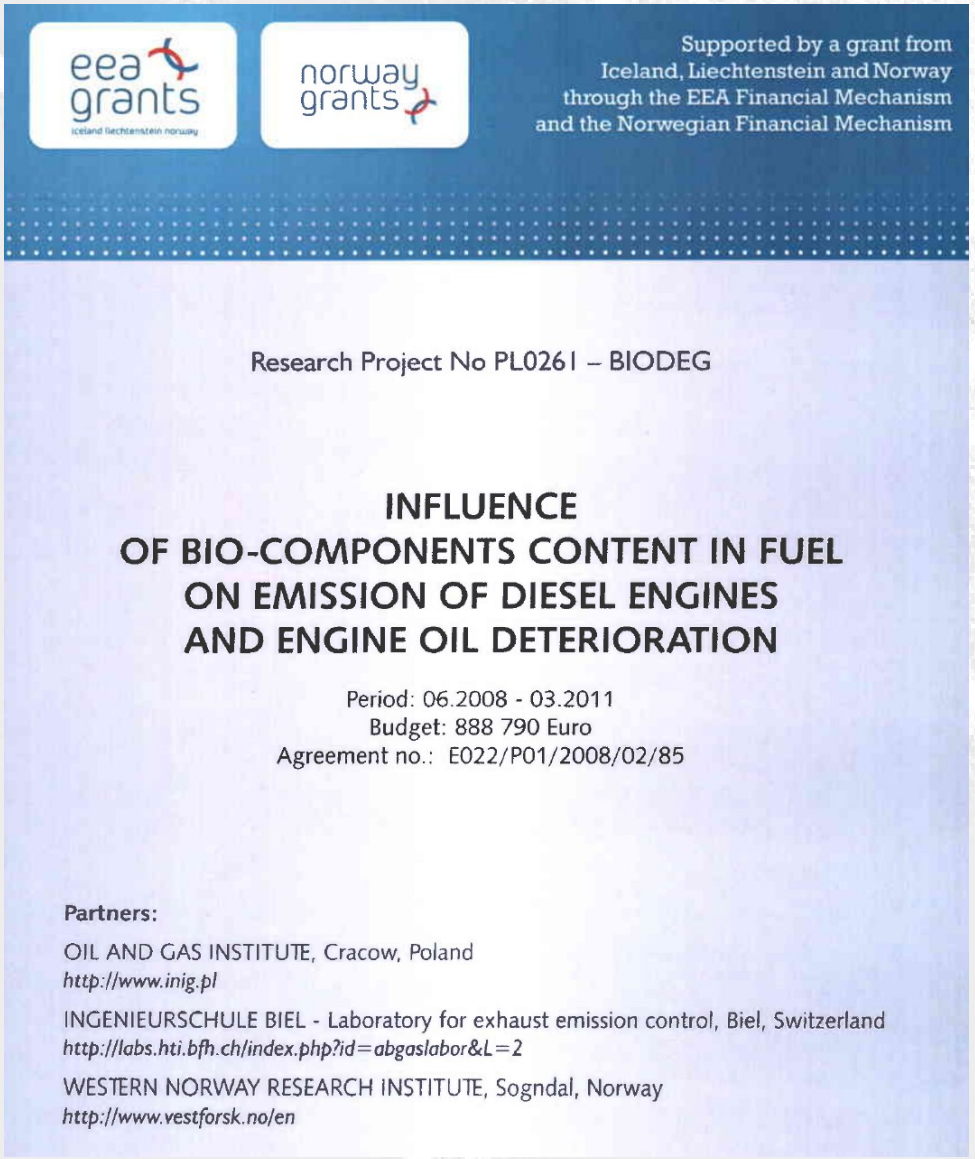
Profilerte stillinger:

Biodiesel and its Blending into Fossil Diesel (6)

Schrödingers katt 02.12.2010

Kan man få kreft av å kjøre dieselbil? Etter at det ble påbudt med et par prosent biodiesel tilsatt til all vanlig diesel, er forskere bekymret. De frykter at miljøtiltaket kan være helsefarlig.

Biodiesel and its Blending into Fossil Diesel (7)



eea grants
Iceland Liechtenstein Norway

norway grants

Supported by a grant from
Iceland, Liechtenstein and Norway
through the EEA Financial Mechanism
and the Norwegian Financial Mechanism

Research Project No PL0261 – BIODEG

**INFLUENCE
OF BIO-COMPONENTS CONTENT IN FUEL
ON EMISSION OF DIESEL ENGINES
AND ENGINE OIL DETERIORATION**

Period: 06.2008 - 03.2011
Budget: 888 790 Euro
Agreement no.: E022/P01/2008/02/85

Partners:

OIL AND GAS INSTITUTE, Cracow, Poland
http://www.inig.pl

INGENIEURSCHULE BIEL - Laboratory for exhaust emission control, Biel, Switzerland
http://labs.hti.bfh.ch/index.php?id=abgaslabor&L=2

WESTERN NORWAY RESEARCH INSTITUTE, Sogndal, Norway
http://www.vestforsk.no/en

Biodiesel and its Blending into Fossil Diesel (8)

Vestlandsforsking
Boks 163, 6851 Sogndal
Tlf. 57 67 61 50
Internett: www.vestforsk.no

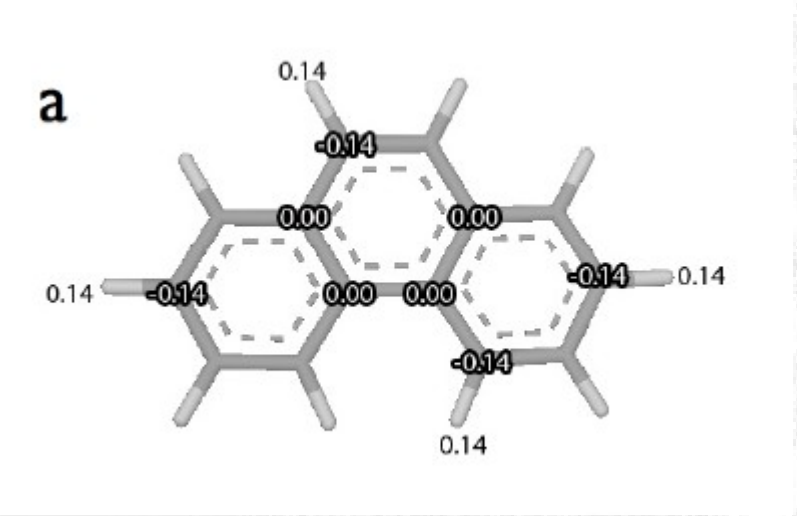
VF-rapport nr. 18/1998

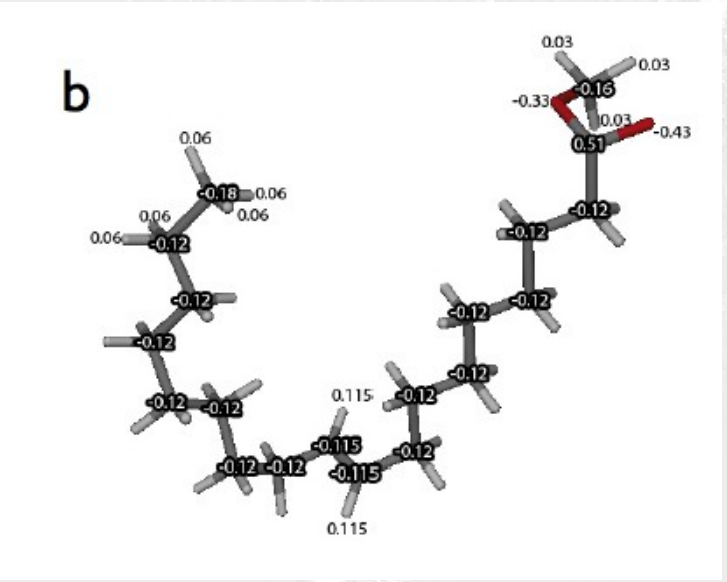
"Biodiesel in heavy-duty vehicles in Norway – Strategic plan and vehicle fleet experiments"

Final report from European Commission
ALTENER-project XVII/4.1030/Z/209/96/NOR

By
Otto Andersen, Hans Einar Lundli, Eivind Brendehaug and Morten Simonsen

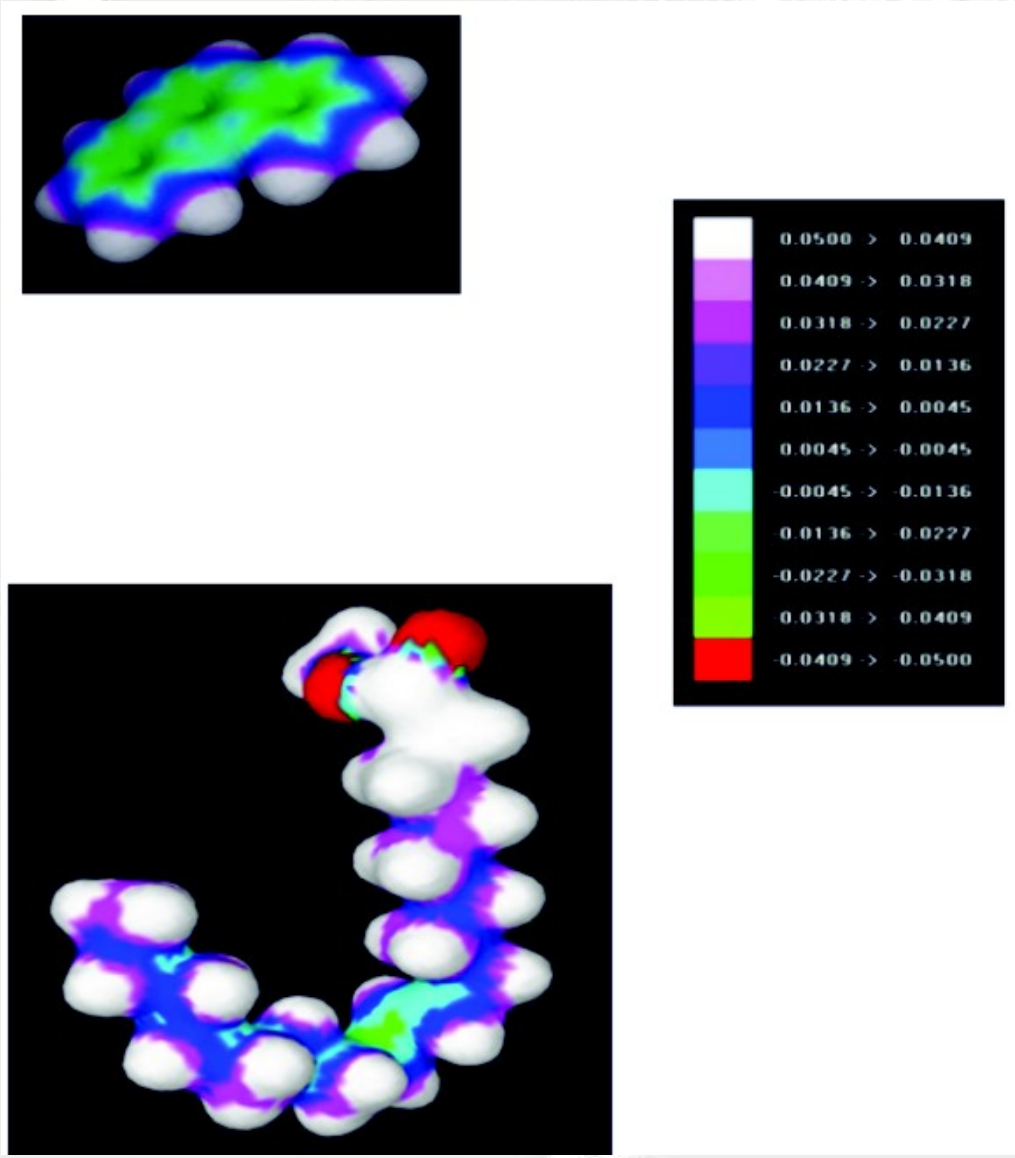
Biodiesel and its Blending into Fossil Diesel (9)



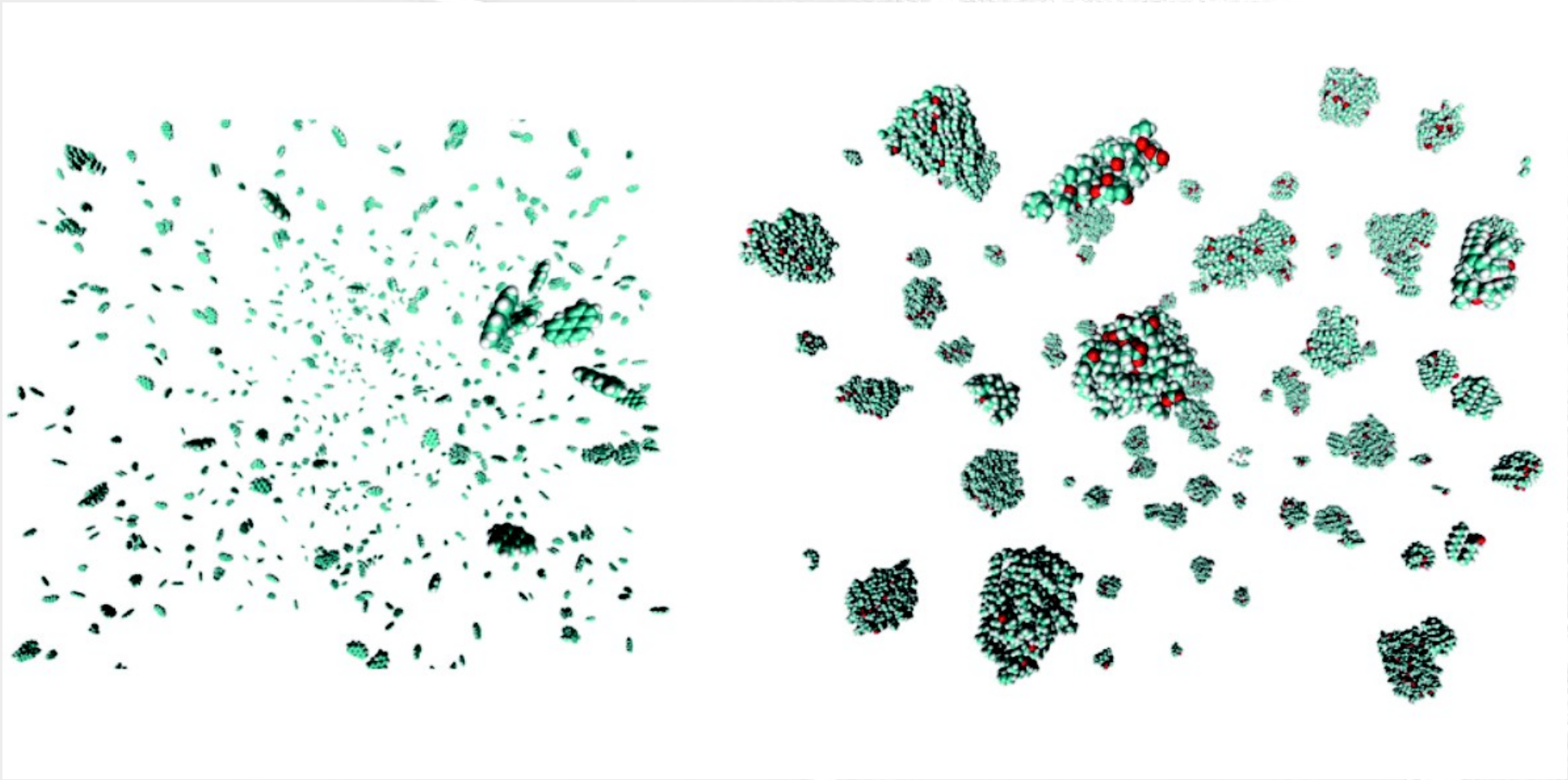


a Phenanthrene, b OME

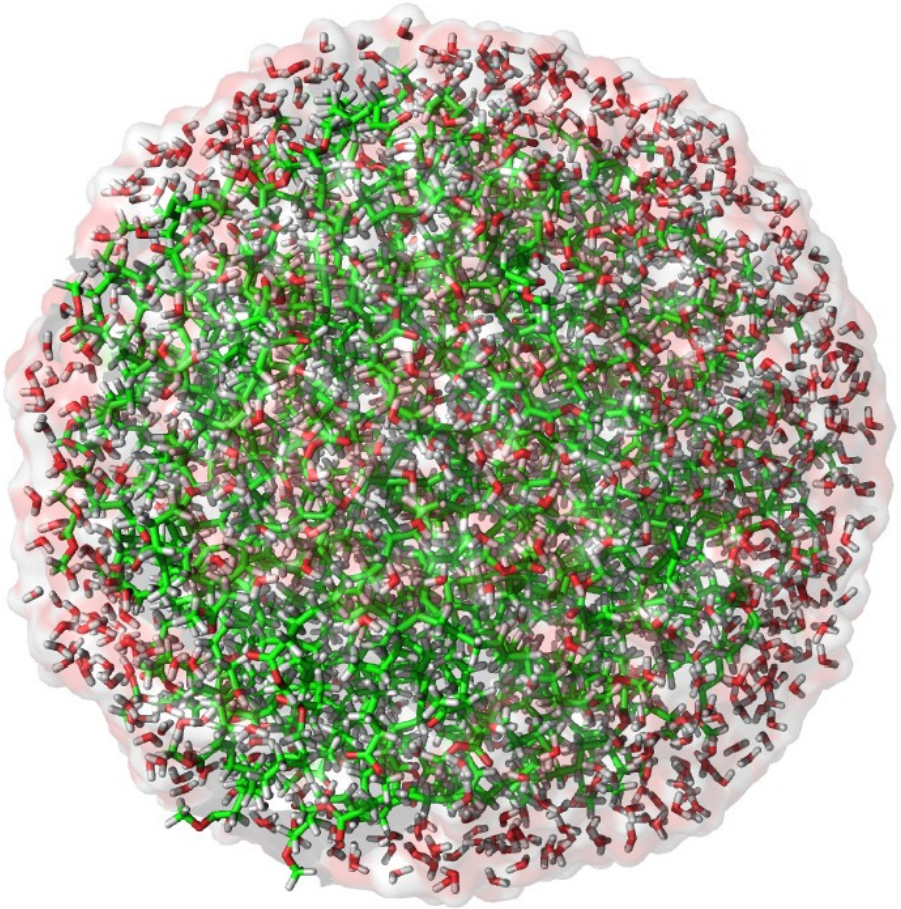
Biodiesel and its Blending into Fossil Diesel (10)

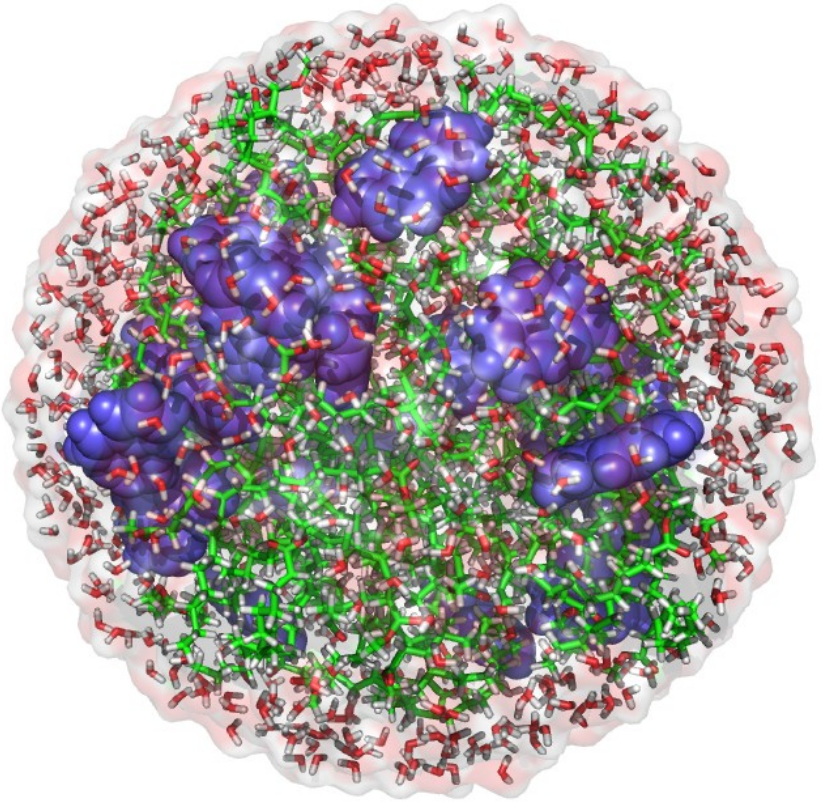


Biodiesel and its Blending into Fossil Diesel (11)

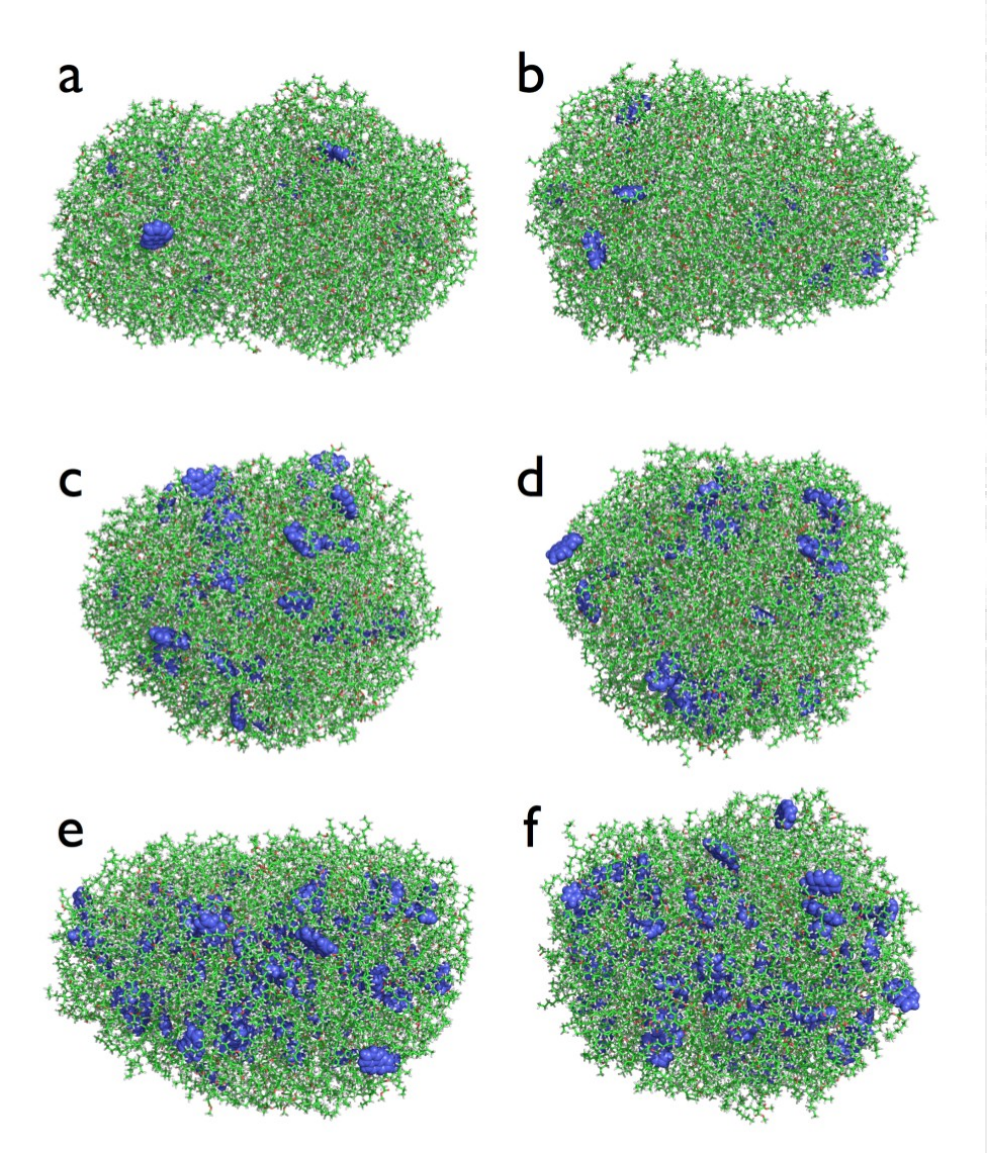


Biodiesel and its Blending into Fossil Diesel (13)





Biodiesel and its Blending into Fossil Diesel (14)



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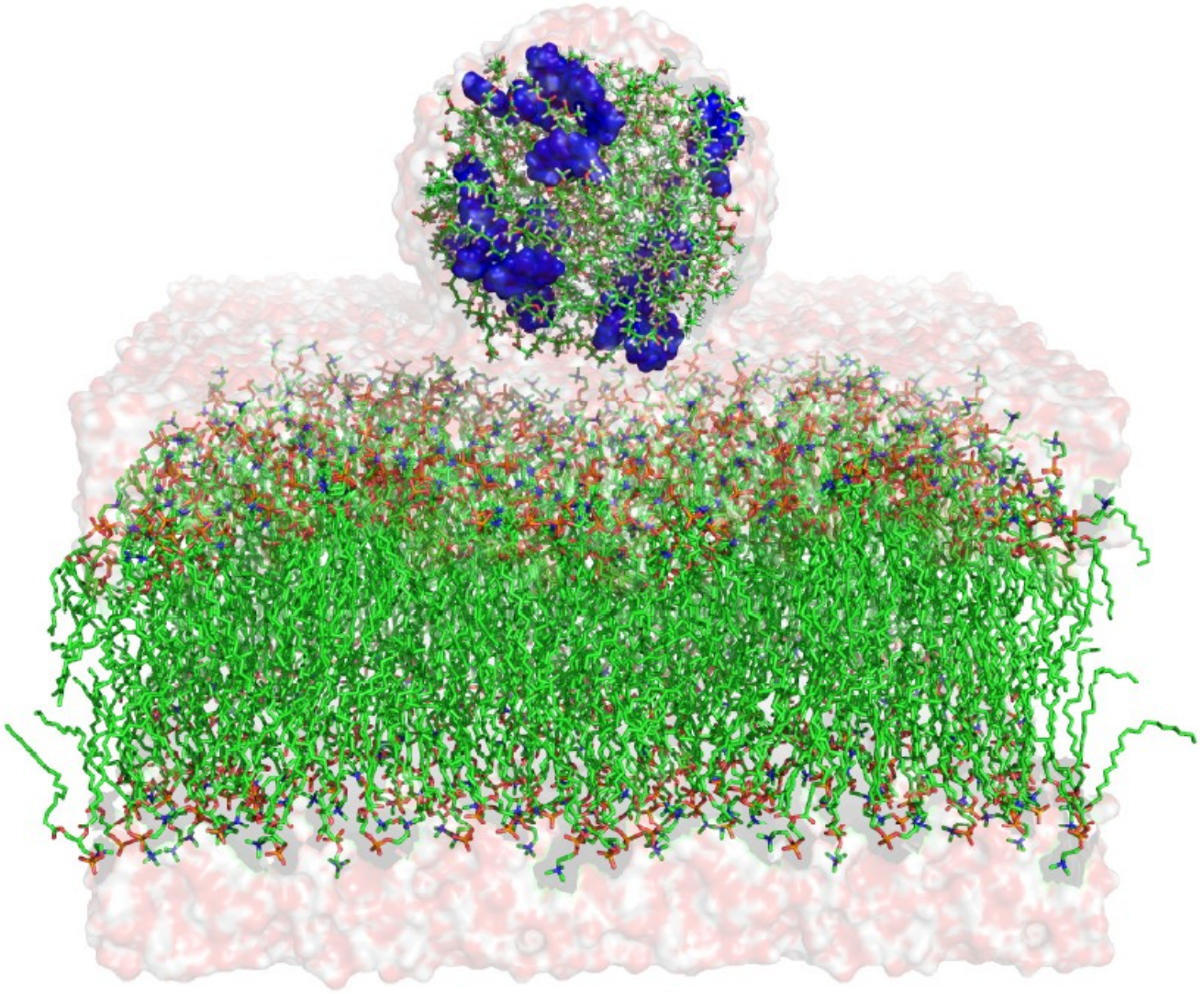
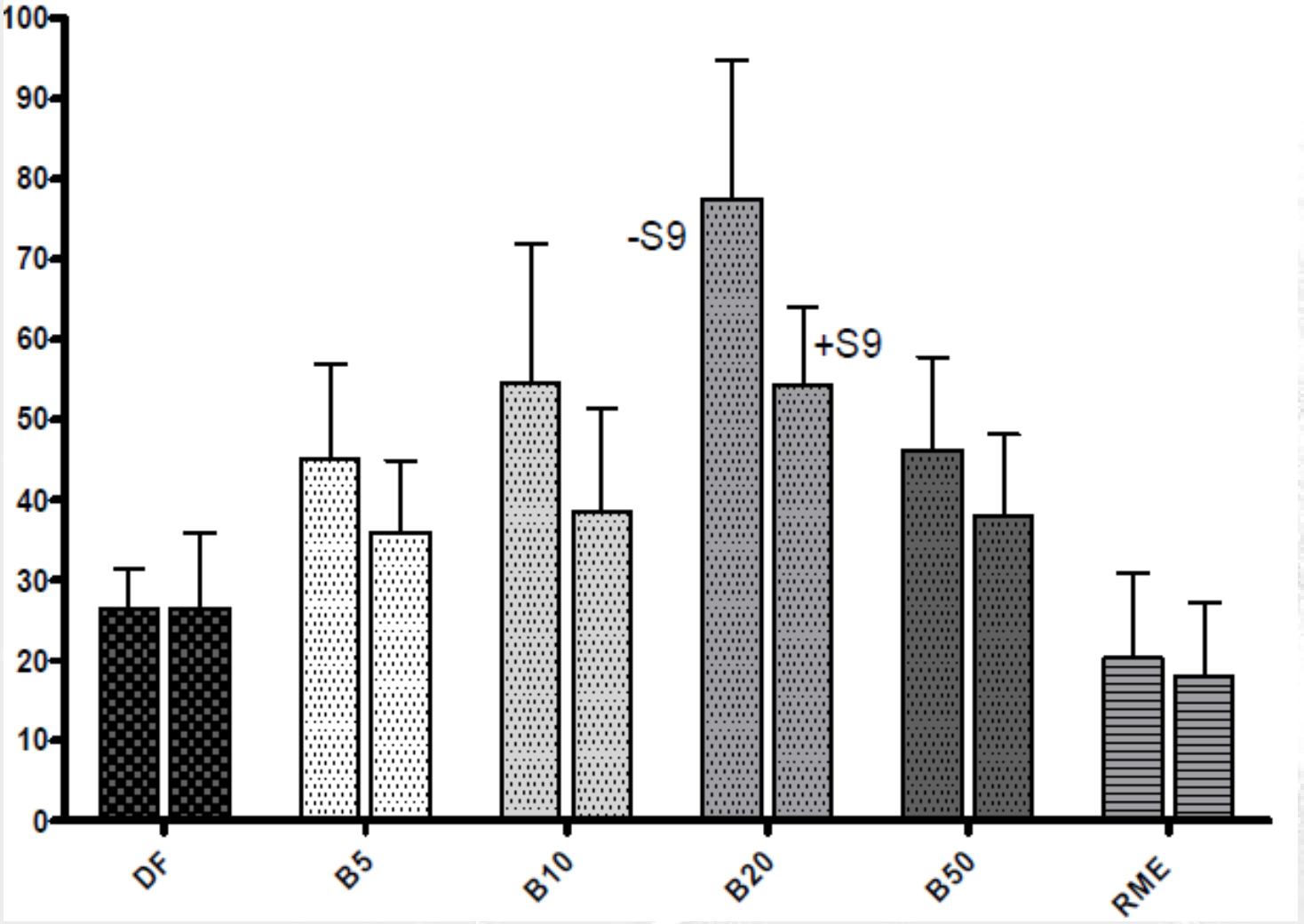


Biodiesel and its Blending into Fossil Diesel (16)



Munack A, Krahl J, Bünger J, Ruschel Y , Scröder O (2008) Exhaust gas emissions and mutagenic effects of modern diesel fuels, GTL, biodiesel, and biodiesel blends. Paper presented at the IGR — International conference of agricultural engineering XXXVII Congresso Brasileiro de Engenharia Agrícola Brazil, Aug 31 to Sept 4, 2008.

Peak Phosphate

Peak Phosphate (1)

- Phosphate is used by plants to form the cell walls and membranes through phospholipids

- Phosphate is key parts of DNA

- There is no substitute for phosphorus in food production

- It is estimated that by 2025-2030 the world will reach **peak phosphate**, with a flattening out of fertilizer production

- 85 % of the global reserves of high grade phosphate is in Western Sahara

- Western Sahara has been occupied by Morocco since the Spanish colonialists left in 1976

- Many neighboring states reject the Moroccan administration of Western Sahara, and several states have established diplomatic relations to the ‘‘Sahrawi Arab Democratic Republic’’ represented by the Polisario Front. This movement is operating in exile in Algeria, and UN recognizes it as the rightful representative of the territory. It is believed that the phosphate deposits were the major reason that Morocco took an interest in the Western Sahara.

- The Polisario Front would like to have it back

Peak Phosphate (2)

The Bou Craa mine in the Western Sahara sends phosphate down a 150-kilometer-long conveyor belt to the port of El Ayoun

Pearce F (2011) Phosphate: A Critical Resource Misused and Now Running Low. Yale University, New Haven, CT

Towards the Use of Electric Cars

Towards the Use of Electric Cars(1)

Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles

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

Keywords:

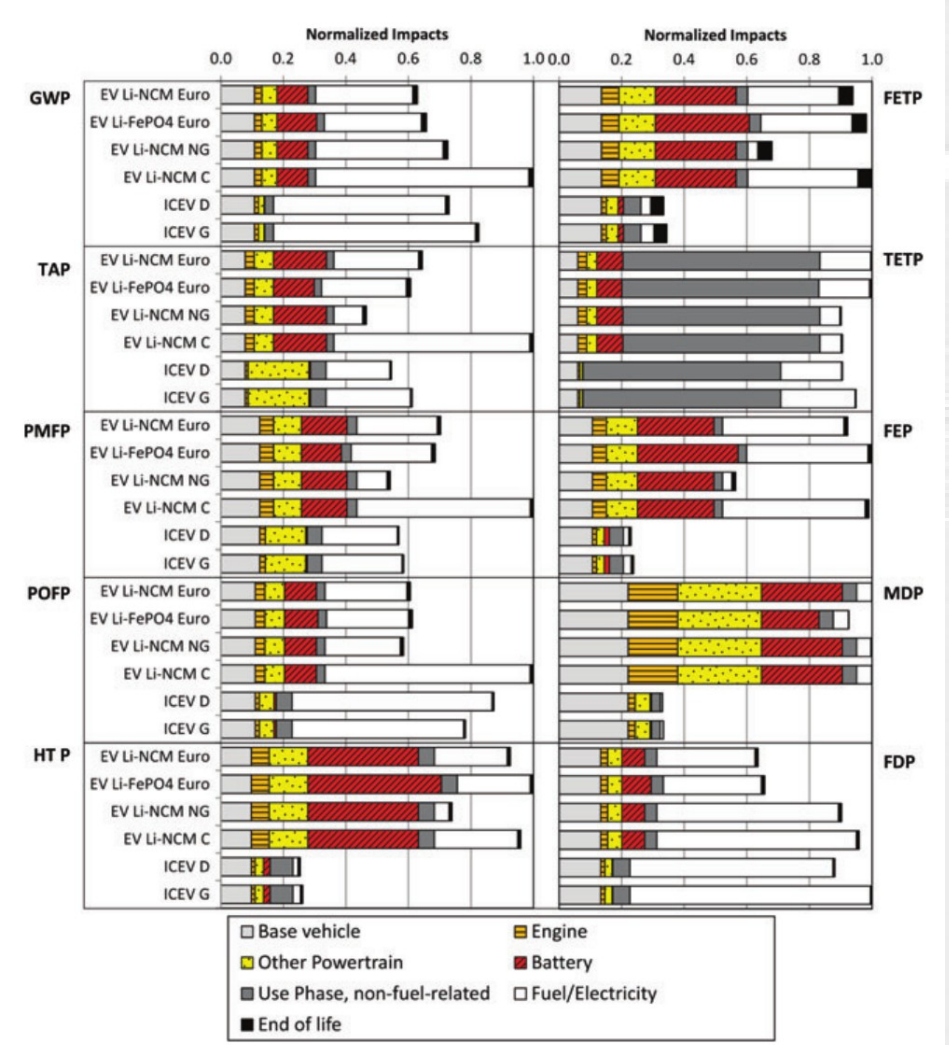
batteries
electricity mix
global warming
industrial ecology
life cycle inventory (LCI)
transportation

Supporting information is available on the *JIE* Web site

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 of a diesel vehicle. Improving the environmental profile of EVs requires engagement around reducing vehicle production supply chain impacts and promoting clean electricity sources in decision making regarding electricity infrastructure.

Towards the Use of Electric Cars(2)



Normalized impacts of vehicle production. Results for each impact category have been normalized to the largest total impact.

Impact categories:

GWP	Global Warming Potential
TAP	Terrestrial Acidification Potential
PMFP	Particulate Matter Formation Potential
POFP	Photochemical Oxidation Formation Potential
HTP	Human Toxicity Potential
FETP	Freshwater Eco-Toxicity Potential
TETP	Terrestrial Eco-Toxicity Potential
FEP	Freshwater Eutrophication Potential
MDP	Mineral Depletion Potential
FDP	Fossil Depletion Potential

Batteries:

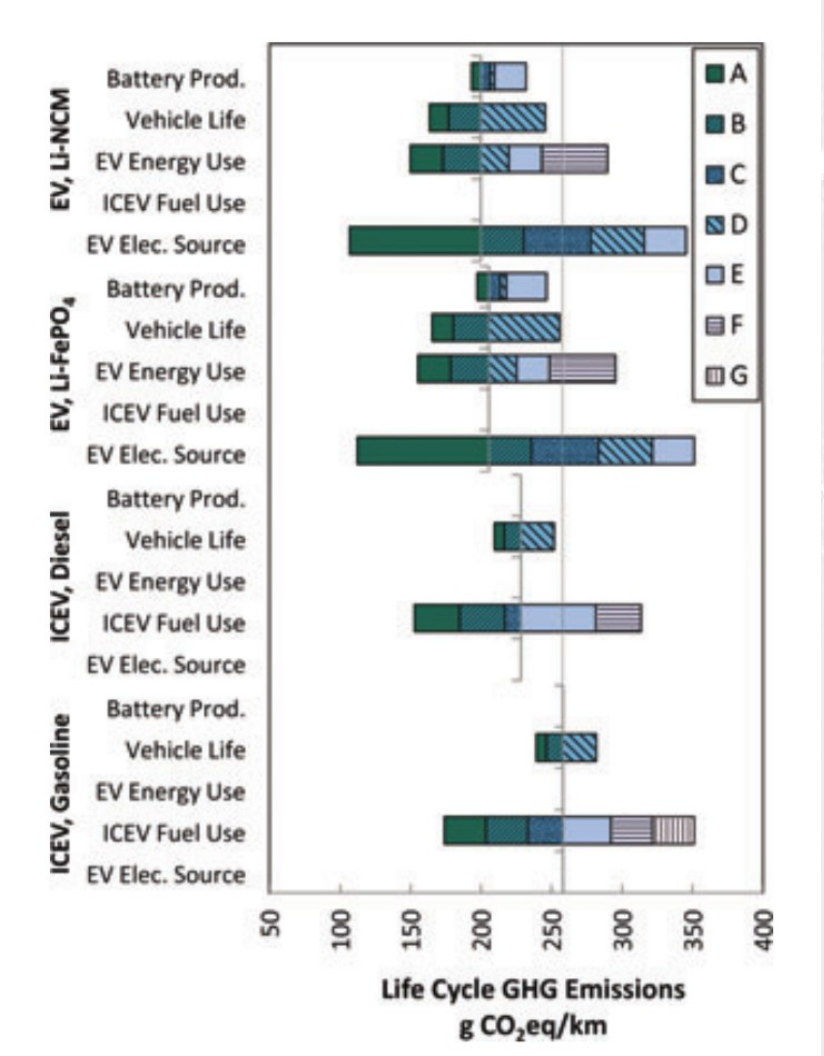
$LiFePO_4$	Lithium Iron Phosphate
LiNCM	Lithium Nickel Cobalt Manganese

Electricity sources:

C	Coal
NG	Natural Gas
Euro	European Electricity Mix

Hawkins T, Singh B, Majeau-Bettez B, Strømman A (2013) Comparative Environmental Life Cycle Assessment of Conventional and Electrical Vehicles. Int J Ind Ecol 17(1):53–64.

Towards the Use of Electric Cars(3)



Battery prod (mass of battery required, normalized to base case):
0.8 (A), 1.0 (B), 1.2 (C), 1.3 (D), 2 (E)

Vehicle lifetime (km):
250 000 (A), 200 000 (B), 150 000 (C), 100 000 (D)

EV energy use (MJ/km):
0.3 (A), 0.45 (B), 0.6 (C), 0.75 (D), 0.9 (E), 1.2 (F)

ICEV diesel use (L/km):
0.03 (A), 0.04 (B), 0.05 (C), 0.06 (D), 0.07 (E), 0.08 (F)

ICEV gasoline use (L/km):
0.04 (A), 0.05 (B), 0.06 (C), 0.07 (D), 0.08 (E), 0.09 (F), 0.1 (G)

EV Elec. Source:
wind (A), natural gas (B), oil (C), coal (D), lignite (E)

$LiFePO_4$ Lithium Iron Phosphate
LiNCM Lithium Nickel Cobalt Manganese

Hawkins T, Singh B, Majeau-Bettez B, Strømman A (2013) Comparative Environmental Life Cycle Assessment of Conventional and Electrical Vehicles. Int J Ind Ecol 17(1):53–64.

Towards the Use of Electric Cars(4)

- Electric vehicles have **only marginally lower life-cycle GWPs** than gasoline and diesel vehicles (10-24% with present European electricity mix)

- It is counterproductive to promote EVs in regions where electricity is produced from oil, coal, and lignite combustion

- With a massive increase to be expected in the future number of electric vehicles, there is potential for serious unexpected consequences in terms of significant **increased:**
    - **human toxicity (180-290%), freshwater eco-toxicity, freshwater eutrophication**
    - **metal depletion (200-300%**

- In particular, the production of electronic equipment necessary for an electrical vehicle requires a variety of **metals**, which poses a **challenge for recycling** and raises serious **toxicity** concerns

- This stems, to a large degree, from the **high use of copper wires** in electrical vehicles, and the use of **nickel** in cars with lithium-nickel cobalt-manganese batteries

- Problem shifting:
    - from **GWP** to **toxicity** and **mineral** resource depletion
    - moving emissions away from the road **rather than reducing them globally**

- Hawkins T, Singh B, Majeau-Bettez B, Strømman A (2013) Comparative Environmental Life Cycle Assessment of Conventional and Electrical Vehicles. Int J Ind Ecol 17(1):53–64.
- Johnson J, Harper E, Lifset R, Graedel T (2007) Dining at the periodic table: metals concentrations as they relate to recycling. Environ Sci Technol 41(5):1759–1765
- Gaines L, Nelson P (2009) Lithium-ion batteries: possible materials issues. Argonne National Laboratory, Argonne
- Gaines L, Nelson P (2010) Lithium-ion batteries: examining material demand and recycling issues. Argonne National Laboratory, Argonne

Towards the Use of Electric Cars(5)

Kennecott Copper Mine in Bingham Valley, Utah

Anaconda copper Mine in Butte, Montana

Nickel runoff, Sudbury, Ontario

Source: Sociological Images (2014), W.W. Norton Company Inc.

Implementation of Hydrogen Gas as a Transport Fuel

Implementation of Hydrogen Gas as a Transport Fuel (1)

Potential Environmental Impact of a Hydrogen Economy on the Stratosphere

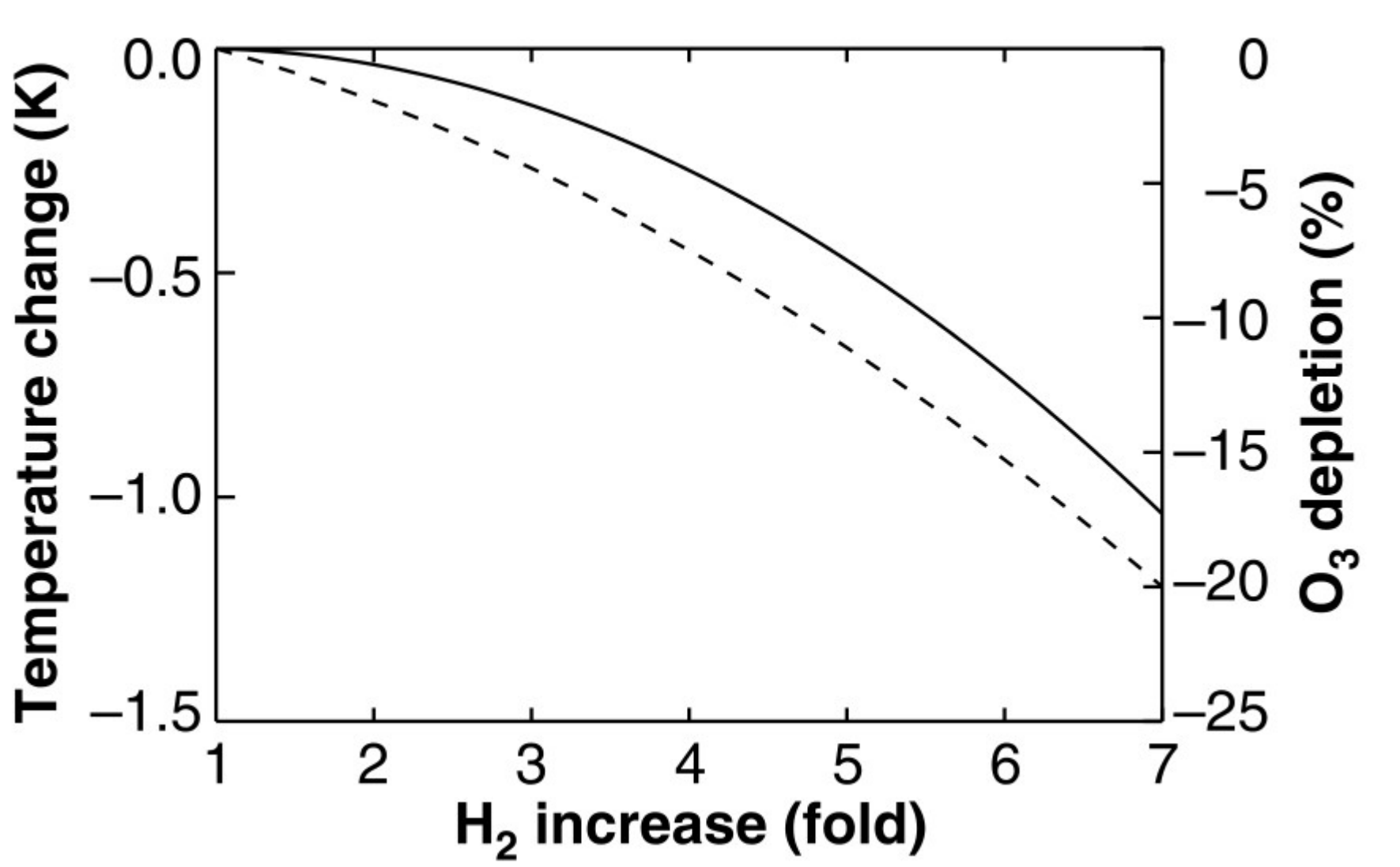
- Stratospheric Ozone-depletion

- Unintended emission of molecular hydrogen (H_2) from future widespread use of hydrogen as fuel

- Leakage of H_2 from infrastructure and operations connected to the production, distribution, and use of the hydrogen fuel

- Increase the abundance of water vapor in the stratosphere. The water increase, plausibly as much as 1 part per million (ppm), would cause stratospheric cooling, enhancement of the heterogeneous chemistry that destroys ozone

Implementation of Hydrogen Gas as a Transport Fuel (2)



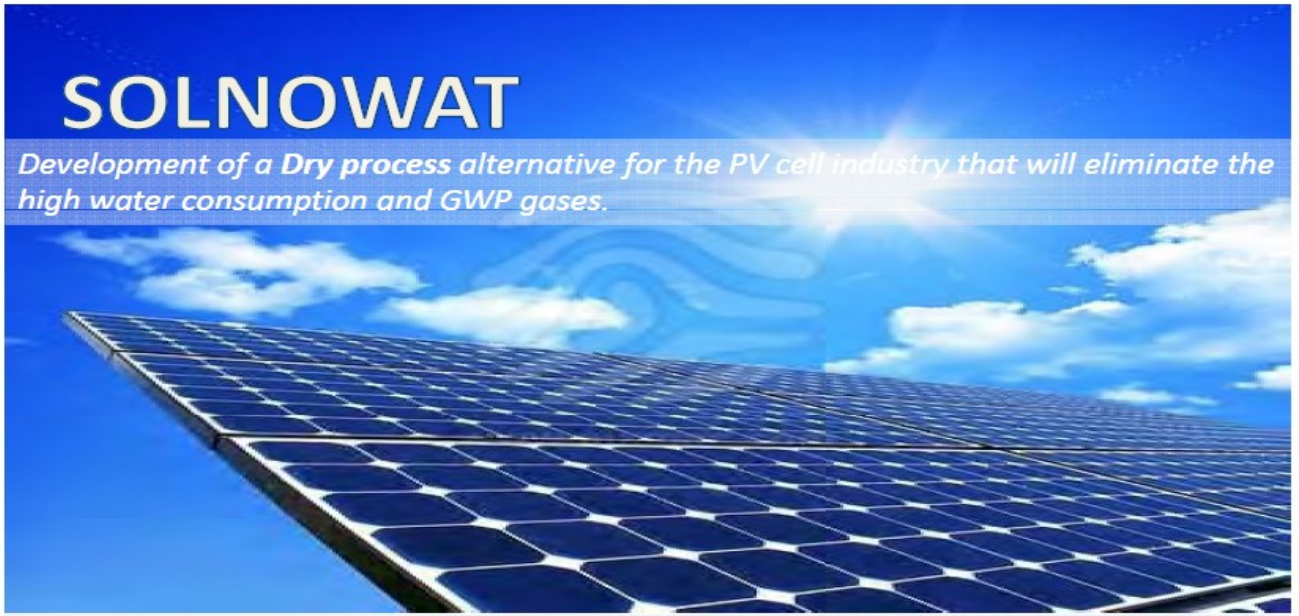
Tromp T, Shia R-L, Allen M, et al. (2003) Potential environmental impact of a hydrogen economy on the stratosphere. Science 300(5626):1740–1742.

Solar Cell Production

Solar Cell Production (1)

- Wet chemical **etching** of crystalline silicon photovoltaic wafers
  - High **water consumption** from rinsing between successive chemical baths
  - Emission of high-GWP gases

- New etching process needed (dry etching)

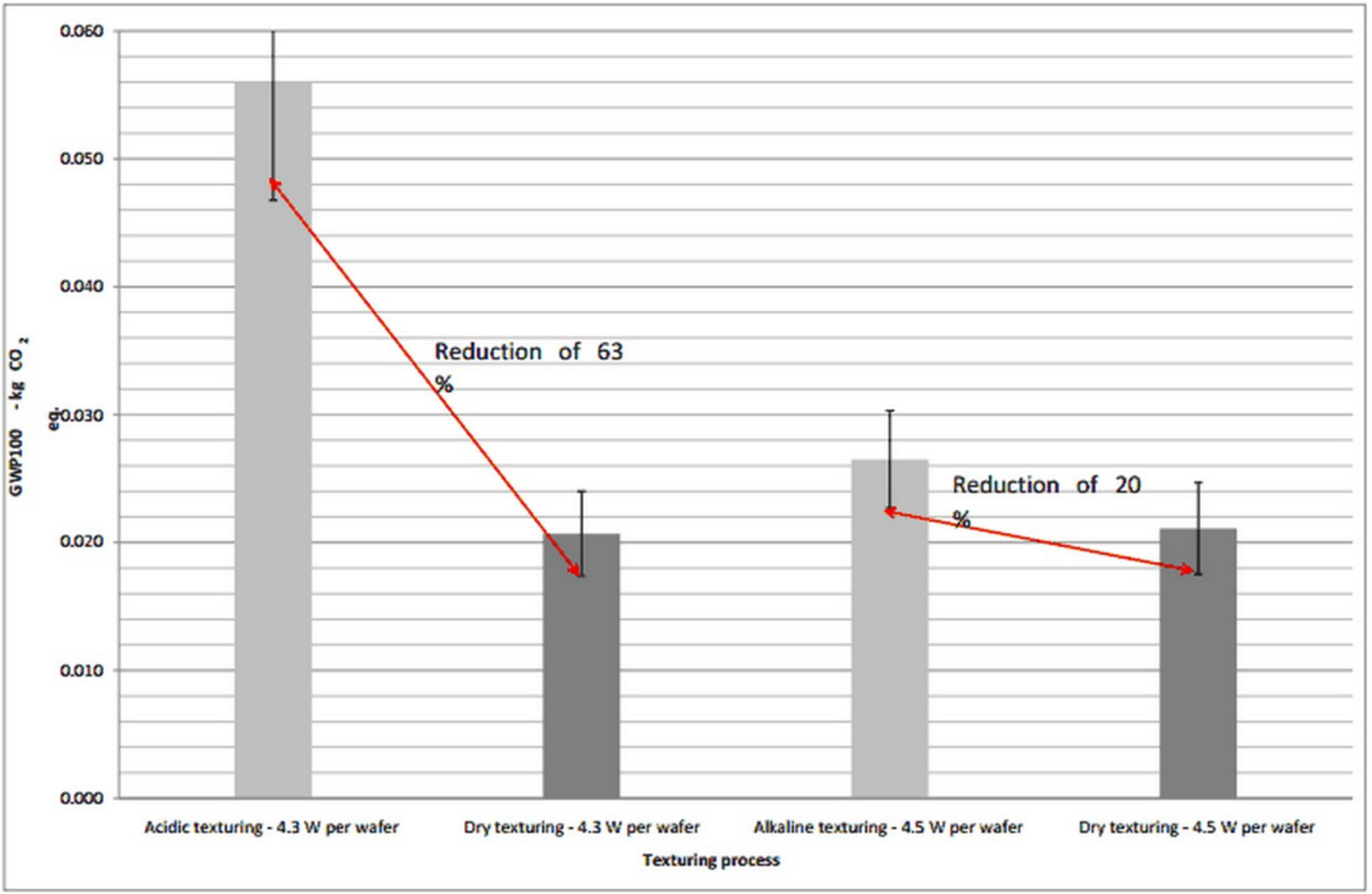


Solar Cell Production (2)

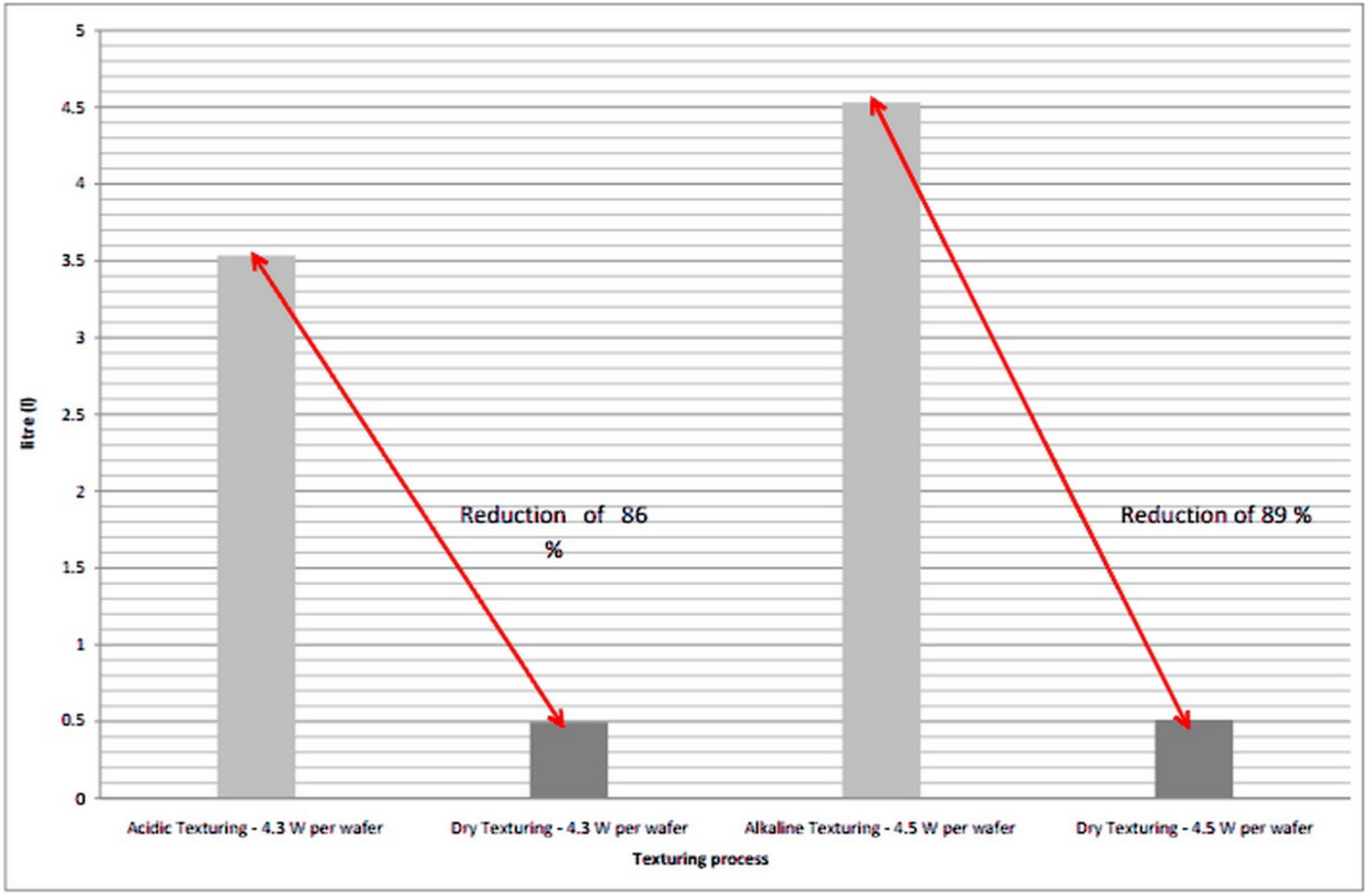
➔ CONSORTIUM:

Type of participant	Participant organisation name	Contact name	Country
SMEP	Ultra High Vacuum Solutions ltd T/A Nines Engineering	Laurent Clochard Edward Duffy	Ireland
SMEP	Alyxan	Michel Heninger	France
SMEP	Solartech S.R.O.	Ales Poruba	Czech Rep
SMEP	Zimmermann & Schilp Handhabungstechnik GmbH	Michael Schilp	Germany
RTD	Fraunhofer ISE and IWS	ISE: Johannes Seiffe IWS : Gerrit Madder	Germany
RTD	Vestlandsforsking	Otto Anderson	Norway

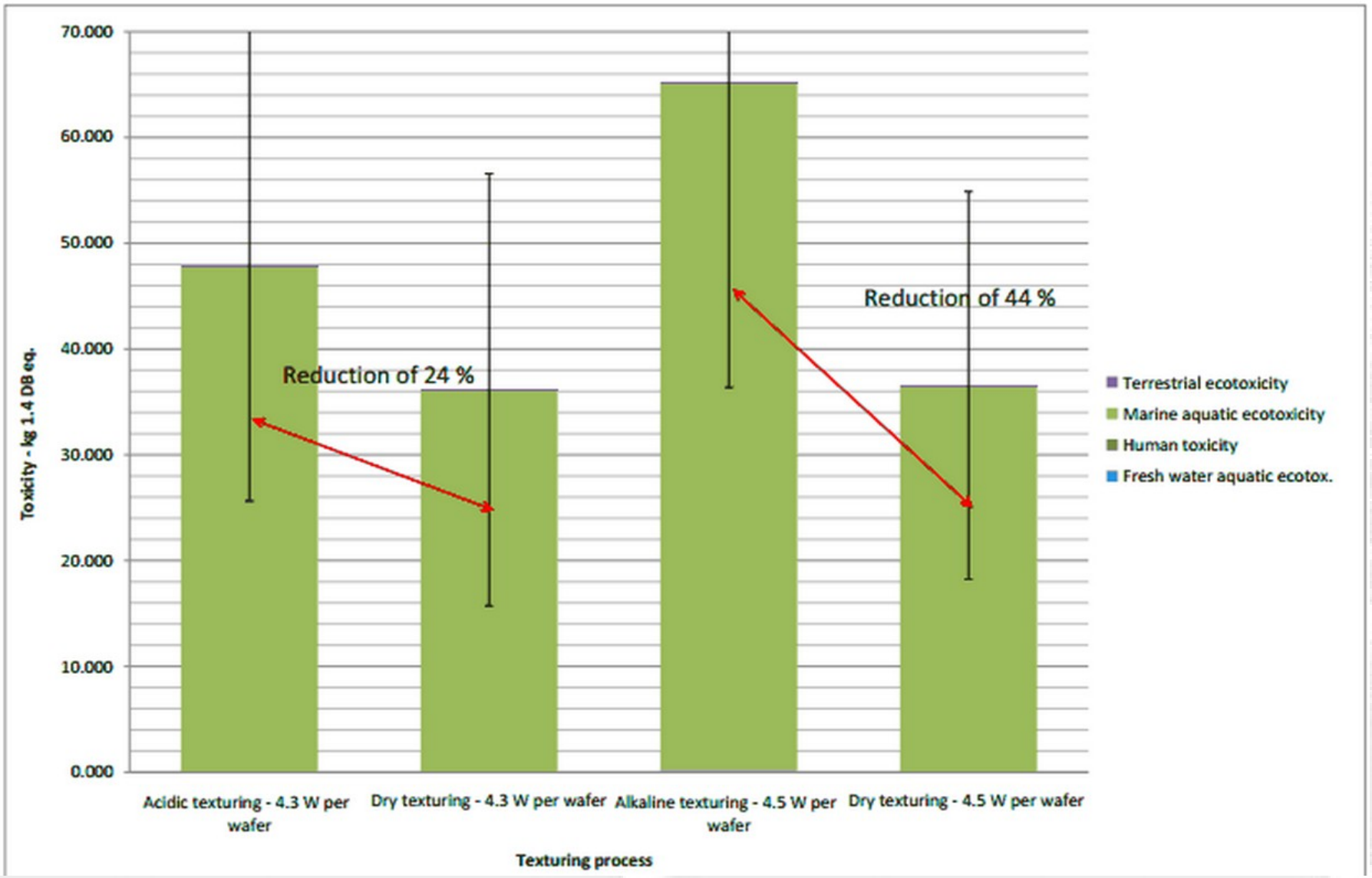
Solar Cell Production (3)
GWP comparison



Solar Cell Production (4)
Water consumption comparison



Solar Cell Production (5)
Toxicity comparison



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