Sustainable Manufacturing Seminar

"Designing to Sustain the Economy, Environment and Society"

Sustainable Product Standards (case-study)

The Eco-efficiency Evaluation of BASF's Greenville Thermal Oxidizer

150 years

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We create chemistry

Bruce Uhlman
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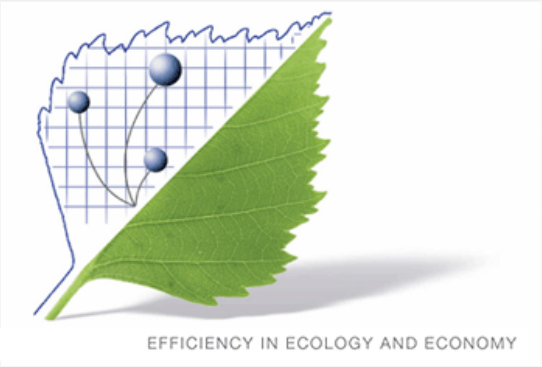
September 22, 2015



Sustainability Evaluation
My Role

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Sustainability:
One Word – Many Meanings

Volatility
Biodegradable
Climate change
Non-toxic
Environment
Growth
Urbanization
Measure impact of activities
Durability
Generations
Ecosystem
Eco-friendly
Alternatives
Profit
Responsibility
Pollution
Balanced
People
Go green
Safety
CSR
Partnership
Solar
Global warming
Recycle
Non-Renewable
Waste
Renewable
Environmental education
Economy
Emissions
Ozone layer
Social responsibility
Ecological footprint
Energy efficiency
Fair Trade
Innovation
Eco-efficient
Biocapacity
Eco-consumer
Ethical
Organic
Resource efficiency
Sourcing
Life cycle thinking
Future
Green building
Reuse
Wind power
GMO
Responsible Care
New technologies
Economic
Population Growth
Green washing
Buying local
Green
Reusable
Commitment
Carbon off-setting
Clean
Cradle to cradle
Emerging markets
Climate
People planet profit
Aging Population
Greenhouse gas
Overconsumption
Water scarcity
Globalization
Lohas
Green chemistry
Carbon footprint
Impact
Responsible sourcing
Repurpose
Intelligent
Bio-mass
Human rights
Fuel efficiency
Lightweighting

Our **stakeholders** what to now more about what BASF is doing around sustainability as a manufacturer / supplier and what are the environmental impacts / sustainability benefits of our operations and products

Applied Sustainability:
Supporting Innovation, Business growth & Market differentiation

Identifying industry & value chain specific levers for sustainable development

Develop business & innovation opportunities to address levers using our SD strategy tools

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Applied Sustainability Tool Box
Sustainability Evaluation

- BASF has a robust, science based tool box for helping us evaluate the relative sustainability of products and processes over their life cycle
- Clearly and easily depicts the environmental, social, and economic values and trade-offs between different products
- Over 600 studies completed globally for diverse products and market applications
- Methodologies 3rd party validated by TÜV, DNV and NSF. Externally communicated studies verified by NSF in North America

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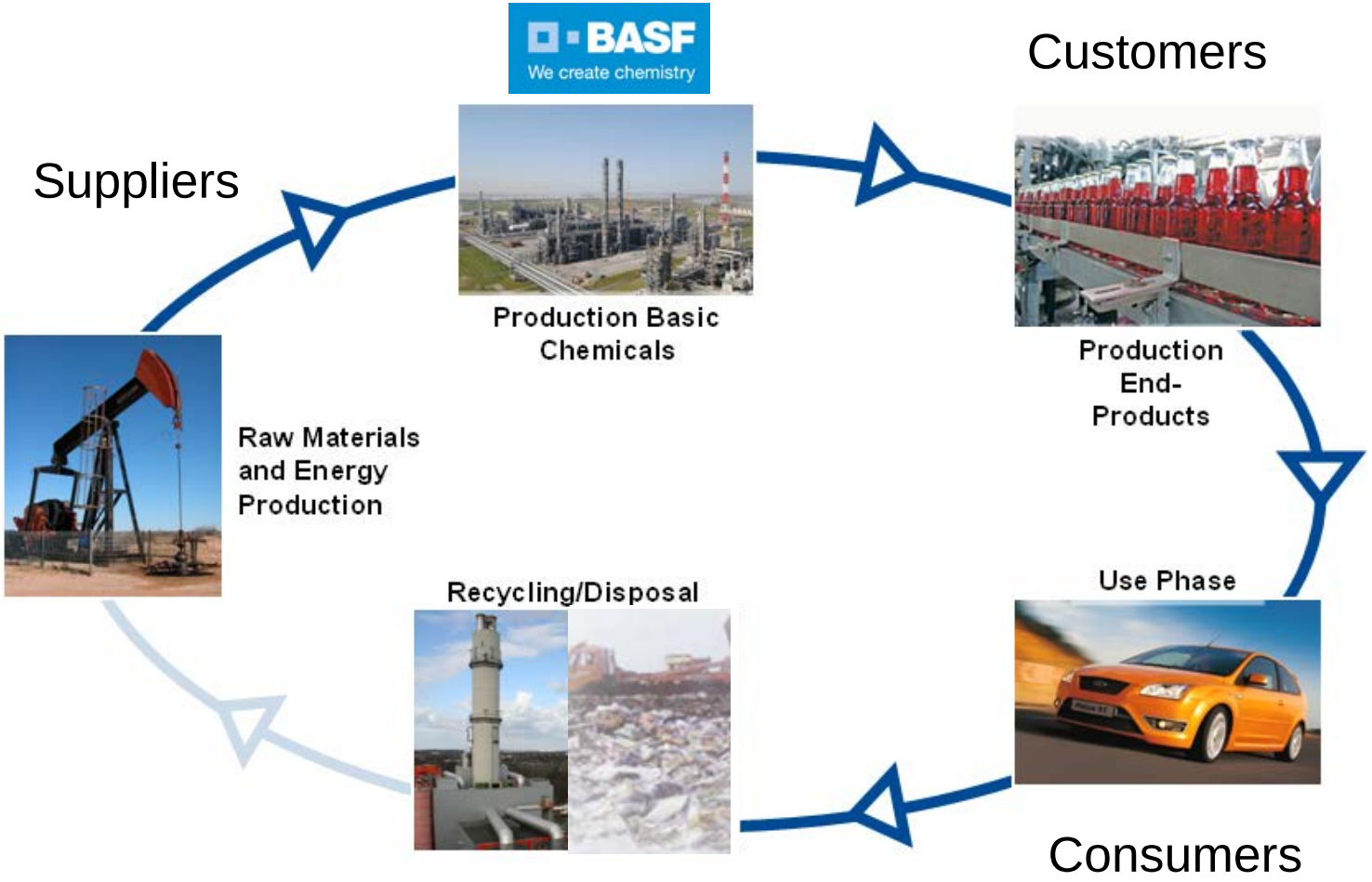
Sustainability Evaluation
A life cycle approach



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Applied Sustainability Tool Box
Eco-efficiency Analysis

ISO[1] conforming, science based and holistic life cycle assessment tool which measures a rigorous list of environmental impacts balanced against life cycle economic impacts

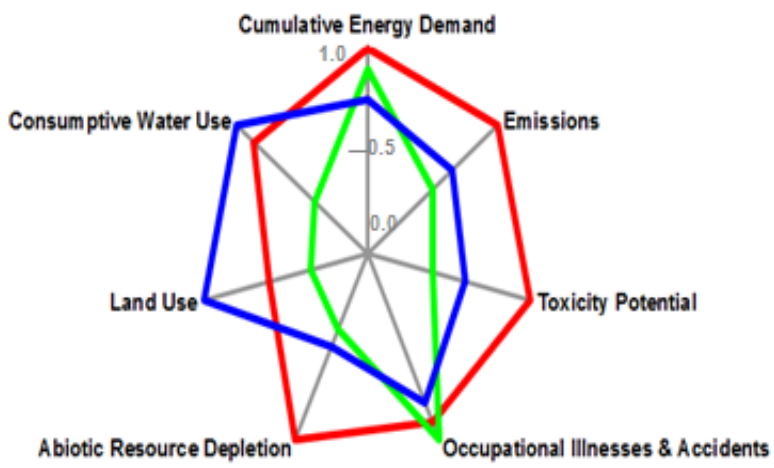
Over 600 studies completed since 1996 for a wide range of products and processes

3rd party validated life cycle assessment methodology

[1] International Organization for Standardization

Applied Sustainability Tool Box
Eco-efficiency Analysis

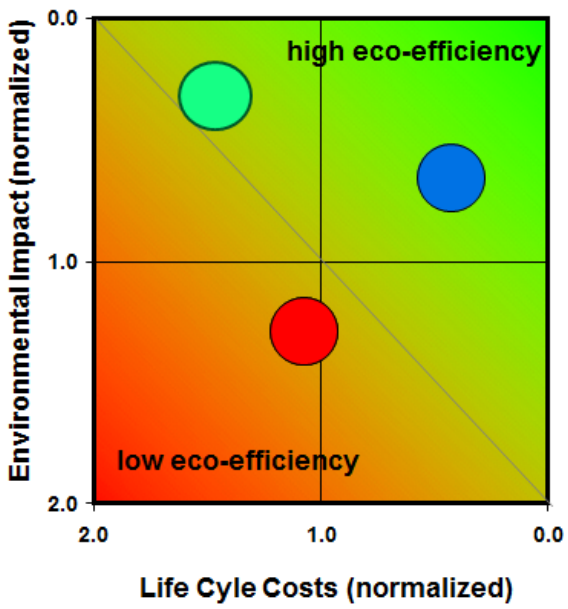
Environmental Fingerprint



1.0 = greatest environmental burden
0.0 = least environmental burden

Life cycle data is gathered in seven environmental categories for each alternative and depicted on an environmental fingerprint. The data are then weighted, aggregated and normalized to obtain an overall environmental impact.

Eco-efficiency Portfolio



Eco-efficiency portfolio balances life cycle environmental impacts with life cycle cost data. It reflects a comparative assessment of the relative eco-efficiencies of various alternatives.

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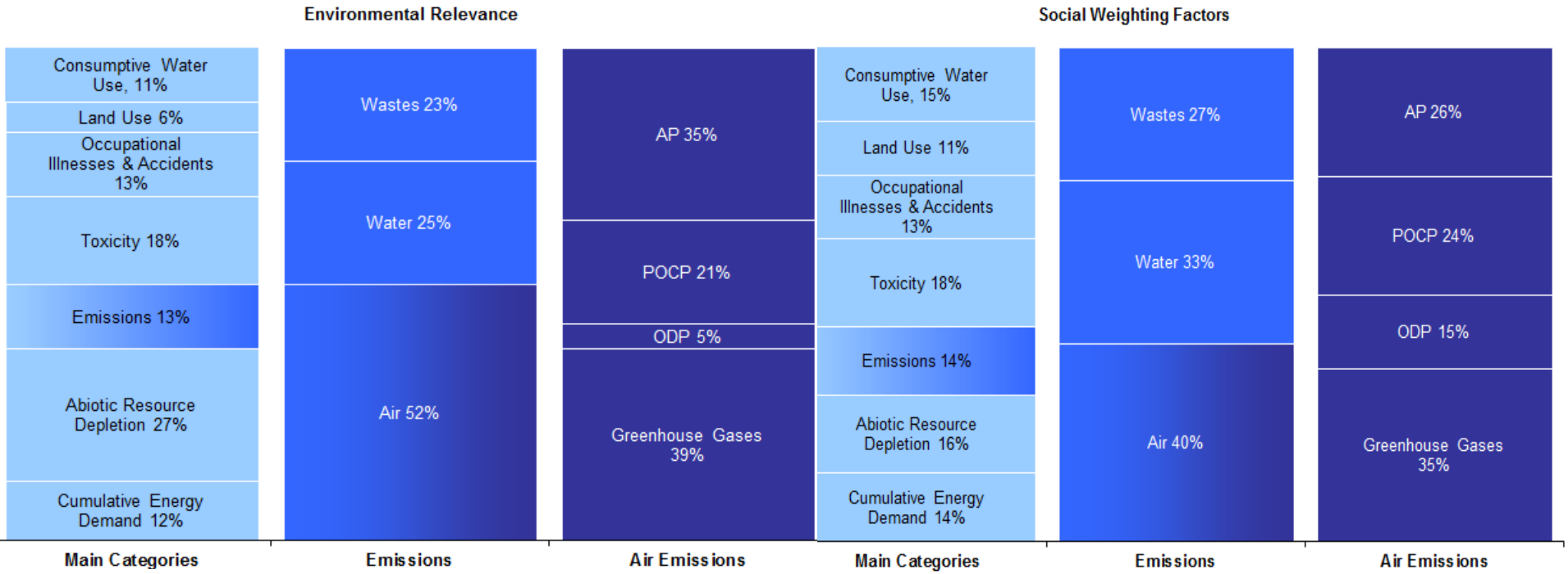
Eco-Efficiency Methodology
Weighting Factors



What does the emission (or energy consumption) contribute to the total emissions (or energy consumption) in the region considered ?

What value does society in a specific region attach to the reduction of the individual potentials?

Greenville Thermal Oxidizer Project

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Scope of Evaluation

- While still remaining within permit limits, it was proposed to reduce the operating temperature of the Greenville thermal oxidizer (TOU) in order to save natural gas usage (leading to lower operating costs).
- The trade-off of the reduced temperature was a reduction in destruction efficiency (of various VOCs) from 99.96% to 98.63%.

Higher VOC emissions

Less consumption of fossil fuels and lower GWP

Was operating at a lower temperature more sustainable ???

Study Assumptions

- This evaluation will utilize BASF's eco-efficiency methodology:
  - to evaluate the eco-efficiency performance of the TOU under the two different operating temperatures
  - compare the environmental trade-offs of lower natural gas usage/combustion vs. higher VOC emissions
    - Energy, Resource and GWP vs POCP trade-off
  - compare overall environmental impact of TOU vs. the economic savings realized through lower NG usage
- Natural gas usage was reduced from 7,630 scfh to 6,601 scfh
  - March 2014 avg. gas cost for Ohio of $5.97/mscf (http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SOH_m.htm)
- Natural gas usage profile for ECAR (East Central Reliability Coordination Agreement) was utilized.
  - NG profile considers pre-chain impacts (e.g. exploration, distribution, etc.)

Study Assumptions

- TOU operates 24 hrs/day for 345 days/year
- VOCs in process fumes to the TOU were modeled as an equal % of MIBK, Toluene and Xylene. Overall concentration was 17,422 ppm
  - Each chemical contributes towards POCP (summer smog)
  - Relative POCP values for emissions were taken from widely accepted LCA guidelines (CML Heijungs, Environmental Life Cycle Assessment of Products, Guide-1992 and for MIBK the 1998 IVL POCP for individual VOCs report)
- POCP values used: (kg ethylene equivalents/kg)
  - CH_4 = 0.007; Toluene: 0.563; o-Xylene: 0.666; MIBK: 0.84
- GWP values from 2007 IPCC (Intergovernmental Panel on Climate Change) 4th Assessment
- Process fumes were close to ambient conditions at inlet to TOU

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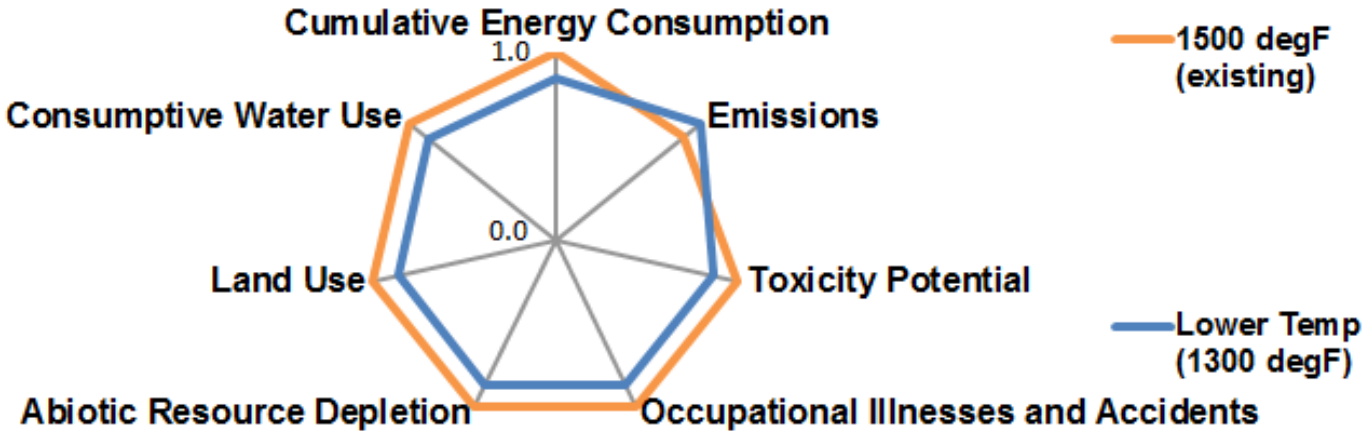
Key Air Emission Results

Emission	Current Operation	Proposed Operation	Difference	units
CO_2	4,067	3,520	547	mtons/year
total GHGs	5,311,000	4,597,000	714,000	kg CO_2 eq./year
total GHGs	5,311	4,597	714	mtons CO_2 eq./year
VOCs (total)	70	2,393	-2,323	kg/year
MIBK	23.3	798	-774	kg/year
Toluene	23.3	798	-774	kg/year
Xylene	23.3	798	-774	kg/year
total POCP	399	1,958	-1,559	kg ethylene eq./year
total AP	5,784	5,004	780	kg SO_2 eq./year

Eco-Efficiency Results
Environmental Fingerprint

- Environmental Fingerprint



- The new operating conditions lead to reductions in 6 of the 7 environmental impact categories. However, the emissions category was higher, namely due to the significant increase in VOC emissions.
- Note: as per our eco-efficiency methodology not all environmental impact categories are weighted equally (have the same relevance/importance).

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Eco-Efficiency Results
What matters most ? Weighting factors

Relevance factors

RANK	Environmental impact	Relevance factors
1	Greenhouse Gases	36.76%
2	Energy	33.42%
3	POCP	13.75%
4	AP	9.99%
5	Resources	6.08%
6	Solid Wastes	0.01%
7	Water Emissions	0.000716%
8	Consumptive Water Use	0.000001%
9	ODP	0.00000003%
10	Land Use	0.0000000006%
	SUM	100.00%

high relevance:	>10%
medium relevance:	5-10%
low relevance:	<5%

Relevance factors

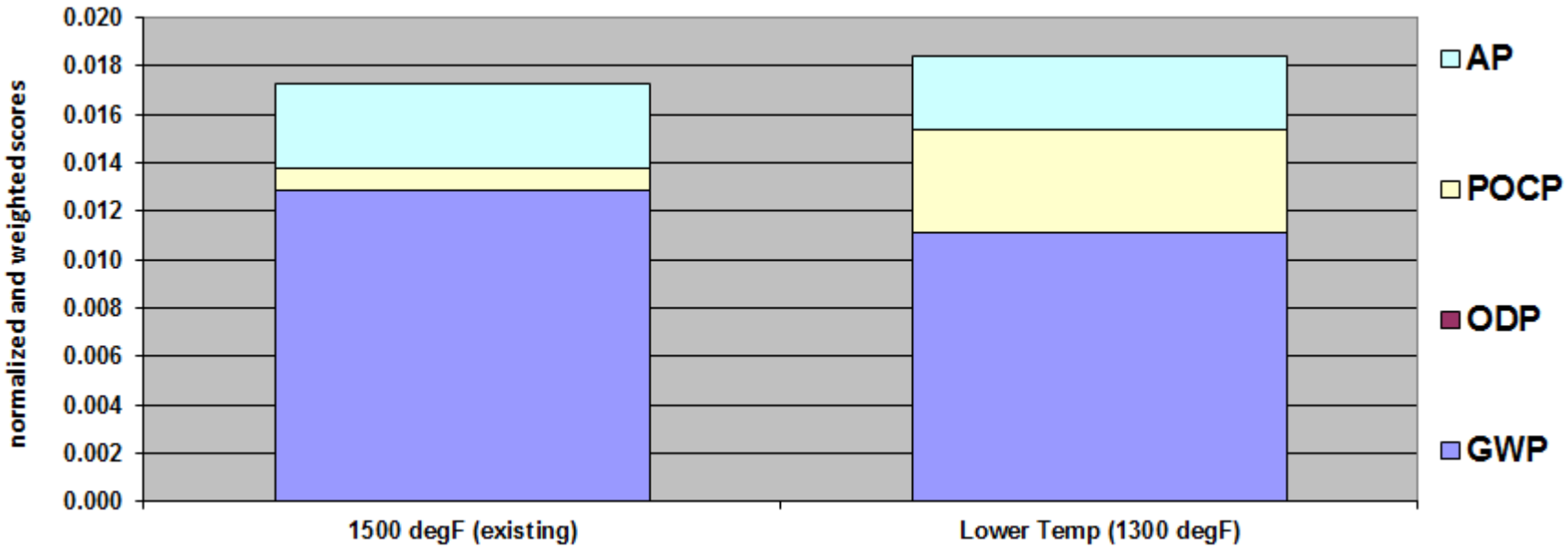
Relevance factors indicate how important the individual environmental compartment is for a particular Eco-Efficiency Analysis. The purpose is to define the 'scientific weighting factors'. The greater, for example, the contribution of an emission to the total emission of the field investigated, the higher the scientific weighting factor.

This stops very small emissions that are immaterial to the total emission situation in the United States, for example, from being overvalued and other, larger and decisive emissions from being undervalued.

The relevance factors automatically determine the main influences during the calculation. The larger these factors, the greater the importance of this environmental impact for the product or process under consideration. This information can also be used for critically querying the base values and models used and for determining the main influences of the system. As a result, the system will picture the circumstances in different analyses correctly in each case. When comparing different water treatment plant designs, for example, emissions to water are given distinctly higher weighting than energy consumption. Optimization of the treatment performance is therefore to be preferred to energy optimization. If, however, different coating concepts with and without solvent are compared, for example, the POCP can be the dominant factor and have a corresponding influence on the overall result.

Eco-Efficiency Results
Air Emissions

- Composite Graph of individual Air Emissions



- Though the use of less natural gas led to significant reductions in GHG emissions and emissions leading to AP (Acidification Potential), they could not off-set the increase in POCP emissions (Photochemical Ozone Creation Potential)
- Overall air emissions increased by about 7%

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Eco-Efficiency Analysis
Results Overview

- The new operating conditions led to reductions in 6 of the 7 environmental impact categories. Specifically, the conditions lead to the following improvements:

An almost 14% reduction in overall energy consumption. Saving almost 10 million MJs of energy/year.

Overall reduction in toxicity and Risk potential.

Better natural resource efficiency, saving almost 14% in fossil fuel consumption (non-renewable resource).

Increase VOC emissions by over 2.3 mtons/year

Reduced GHG emissions by over 714 tons of CO_2 equivalents.

Significant reductions in other emissions such as reduced AP and reductions in emissions to water and land.

Eco-Efficiency Analysis
Results Overview

- From the Environmental Relevance factors calculated for this analysis the most influential impact categories are GHG emissions, energy consumption and POCP.
- In determining the overall environmental impact the previous (regionally and project specific) relevance factors are combined with social weighting factors to determine a final environmental score.
- The alternative reflected by the lower operating temperature had an overall reduction in environmental impacts of over 8 %.
- When combined with an economic savings of around 13% the alternative with the lower operating temperature was the more eco-efficient process (an improvement of over 10%)

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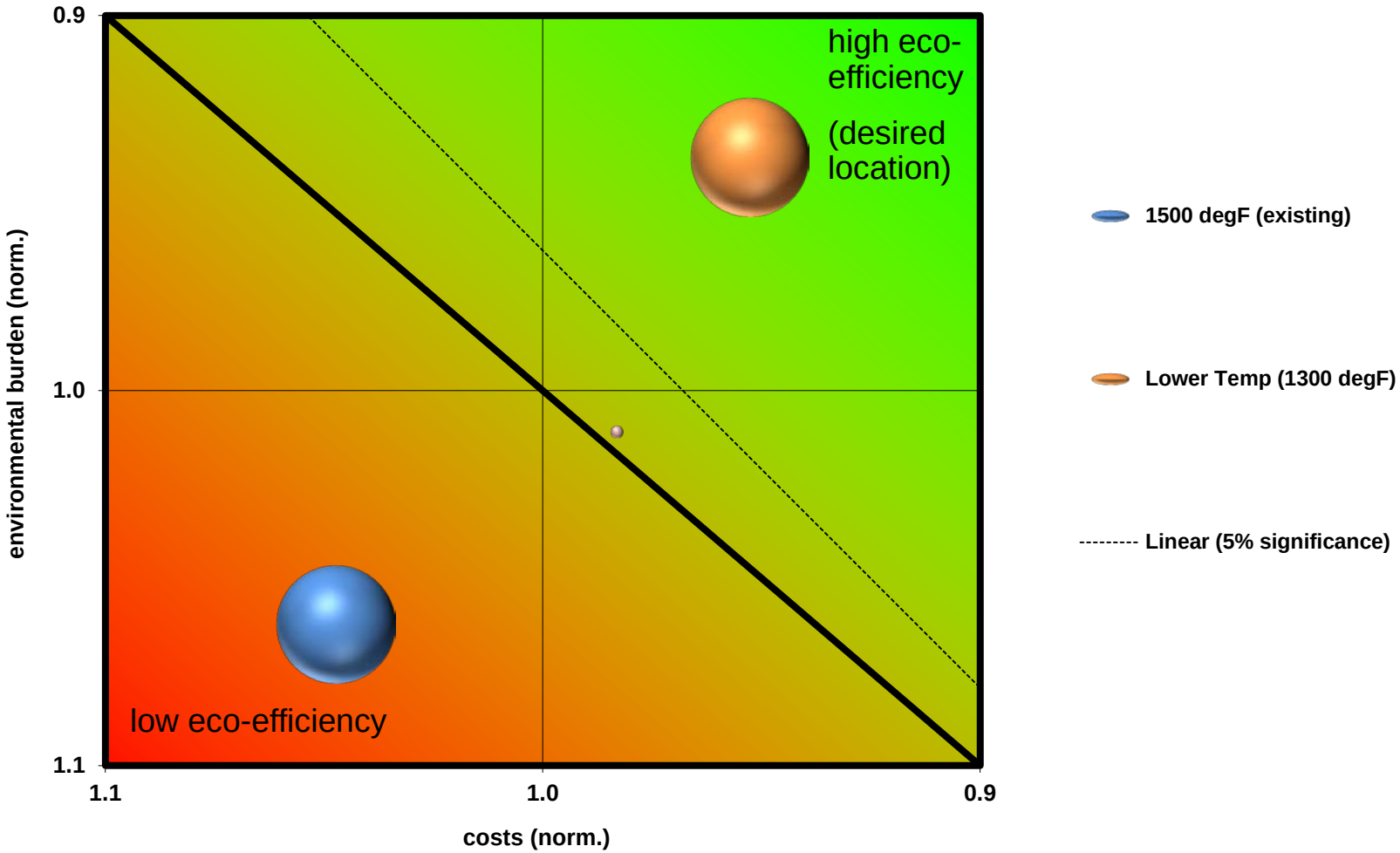
Eco-Efficiency Analysis
Balancing Economics and Ecology



Results Communication
Environmental Equivalencies

The savings of 714 tons CO_2 equivalents is equivalent to:

Annual greenhouse gas emissions from

150

Passenger vehicles

1,700,000

Miles/year driven by an average passenger vehicle

Note: The increased VOC emissions which led to an increase in POCP (summer smog) was equivalent to the emissions from approximately 97 additional vehicles.

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Results Communication
Environmental Equivalencies

The savings of over 714 tons CO_2 equivalents is equivalent to:

CO_2 emissions from

80,342
gallons of gasoline consumed

766,917
Pounds of coal burned

9.5
tanker trucks' worth of gasoline

Carbon sequestered by

18,308
tree seedlings grown for 10 years

585
acres of U.S. forests in one year

5.5
acres of U.S. forests preserved from conversion to cropland in one year

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Results Communication - Energy
Environmental Equivalencies

Savings equivalent to the total energy consumed by 104* residential US homes in a year

*Source: 2009 EIA US Residential Energy Summary (94,500 MJ/US Residential Home)

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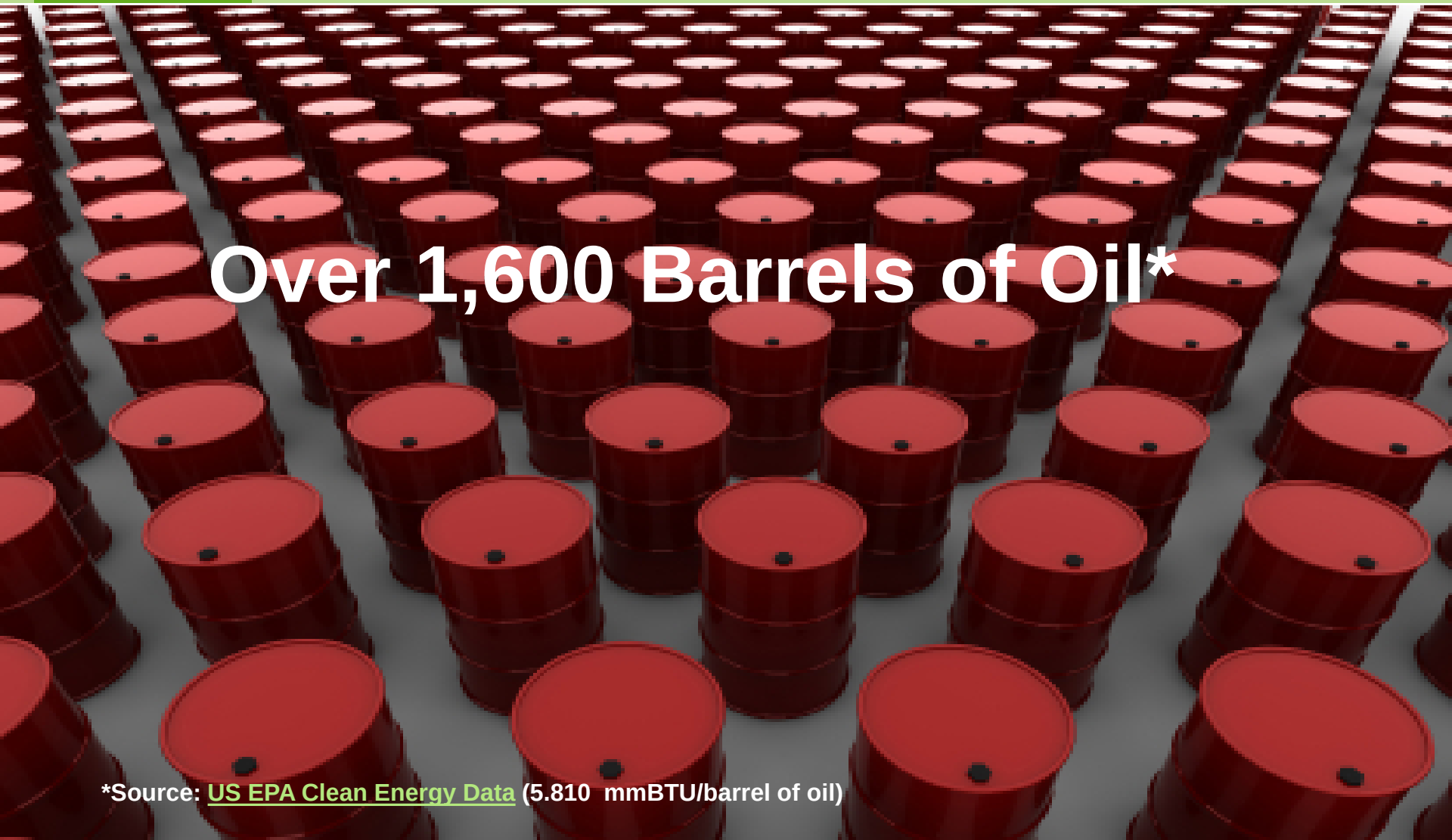
Results Communication - Energy
Environmental Equivalencies



Over 1,600 Barrels of Oil*

*Source: US EPA Clean Energy Data (5.810 mmBTU/barrel of oil)

Questions / Discussion

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For More Information:

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