Reducing the environmental footprint of NatureWorks® Polymer

NatureWorks LLC

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- Introduction to NatureWorks LLC
- Our Environmental Objectives
- The two tracks we follow reducing the environmental impact
- The impact on fossil energy use and climate change
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- How to deal with new materials in LCA

About NatureWorks LLC

- Stand alone company wholly owned by Cargill Inc.
- Has created a platform of sustainable polymers with a competitive technical and cost performance and entirely made from renewable resources.
- Manufacturing facility in Nebraska, USA
- Headquartered in Minnetonka, MN, USA
- Offices in The Netherlands, Japan and China
- More than 200 employees world-wide
- Unique and extensive patent position

PLA Manufacturing Overview

Corn Starch

Sugar Production

Unrefined Dextrose

Fermentation

Lactic Acid

Monomer Production

Lactide

Polymer Production

PLA

NatureWorks® Polymer

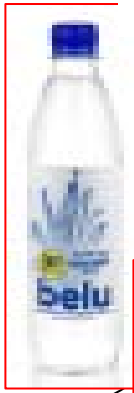
Future ?

Opportunities for NatureWorks® Polymer and Ingeo™ Fibers

Durables

Semi-durables

Disposables



NatureWorks Environmental Objectives

- Source raw materials from annually renewable feedstock.
- Reduce non-renewable energy consumption through the use of wind power and new technologies.
- Eliminate greenhouse gases emissions from our business system to the lowest level.
- Minimize water use and eliminate waste and co-product production.
- In a vision to zero waste, provide the greatest number of disposal options:
  - Chemical and mechanical recycling, industrial compostability, clean incineration

NatureWorks Environmental Objectives for "More Sustainable" Products

How bringing them into practice?

- Past - We created an entirely new production system for polymers based on annually renewable resources (PLA5). PLA5 represents the 2005 cradle-to-pellet PLA production system (= the benchmark).
- Today (2006) - Replaced our electricity use by wind energy via purchasing RECs (PLA6). PLA6 represents the 2006-2008 cradle-to-pellet PLA production system.
- Near future - By implementation of new process technology and the use of green power for our electricity needs (PLA/NG). PLA/NG represents this Next Generation, cradle-to-pellet PLA production system.
- Long term - By using new carbohydrate feedstock (corn residue-biomass). The biomass is also used as energy source for steam and heat. Green Power is used for electricity needs.

NatureWorks Life Cycle Initiatives

- New Publication:
  - "The eco-profiles for current and near future NatureWorks® polylactide (PLA) production."

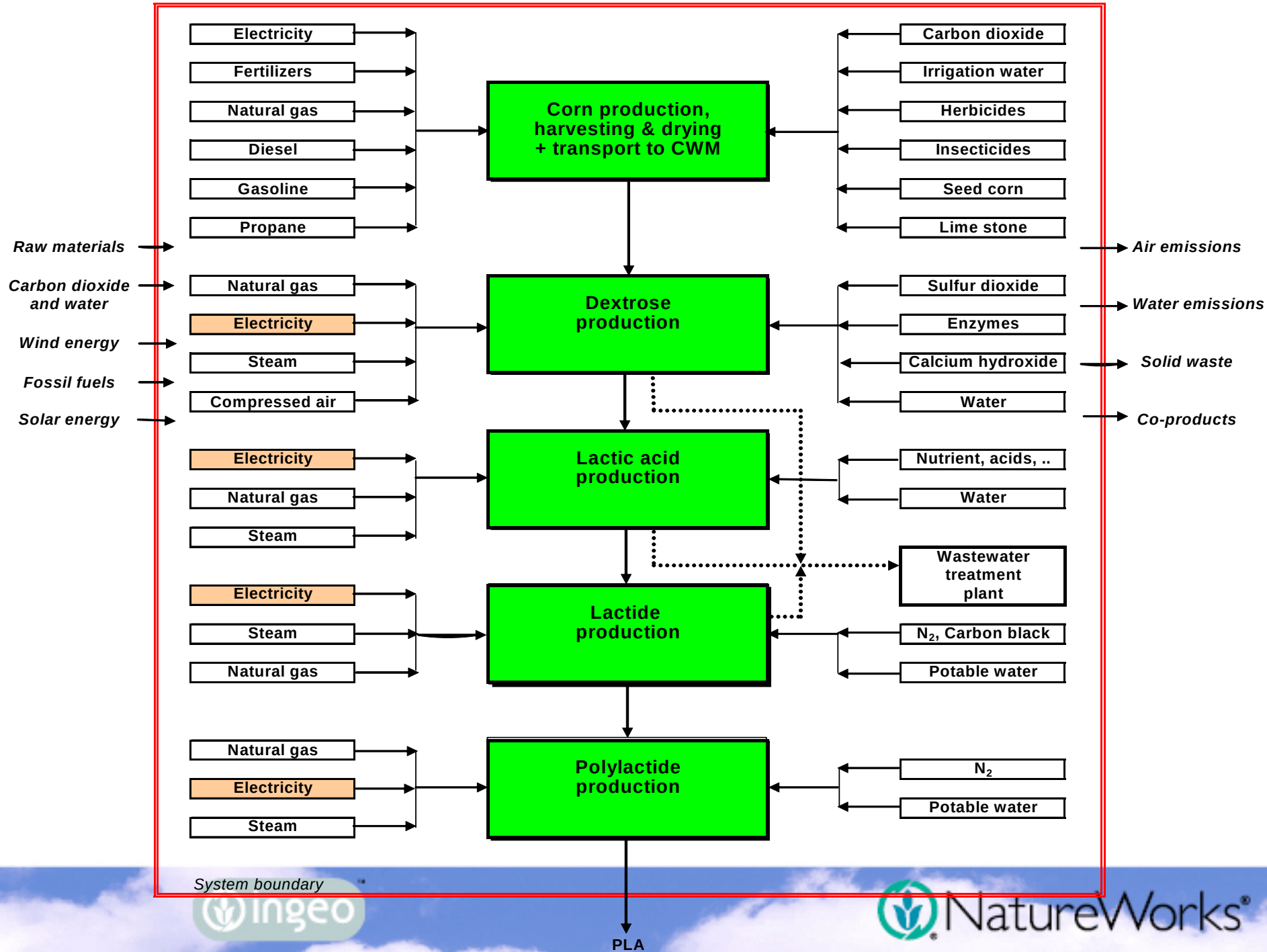
Erwin T.H. Vink, David A. Glassner, Jeffrey J. Kolstad, Bob Wooley, Ryan P. O'Connor, Industrial Biotechnology, March 2007

e-copy: www.natureworkspla.com

hard copies: NatureWorks Communications

Competitive polymers vs NatureWorks® Polymer

Competitive polymers	NatureWorks® Polymer
Plastics*Europe**/Boustead *methodology*	= Plastics*Europe*/Boustead *methodology*
Boustead *Software*	= Boustead *Software*
Boustead *Core database*	= Boustead *Core database (detail+accuracy)*
Calculated by Boustead	= *Reviewed by Boustead*
Boustead data format	= *Same format*
	= ***STARTING AT THE SAME BASELINE***


Electricity
Fertilizers
Natural gas
Diesel
Gasoline
Propane
Carbon dioxide
Irrigation water
Herbicides
Insecticides
Seed corn
Lime stone
Corn production, harvesting & drying + transport to CWM
Raw materials
Carbon dioxide and water
Wind energy
Fossil fuels
Solar energy
Air emissions
Water emissions
Solid waste
Co-products
Natural gas
Electricity
Steam
Compressed air
Sulfur dioxide
Enzymes
Calcium hydroxide
Water
Dextrose production
Electricity
Natural gas
Steam
Nutrient, acids, ..
Water
Lactic acid production
Wastewater treatment plant
Electricity
Steam
Natural gas
Lactide production
N_2, Carbon black
Potable water
Natural gas
Electricity
Steam
Polylactide production
N_2
Potable water
System boundary
PLA

GHG emission sources mapped according to "The Greenhouse Gas Protocol", a reporting tool of the WRI & WBCSD

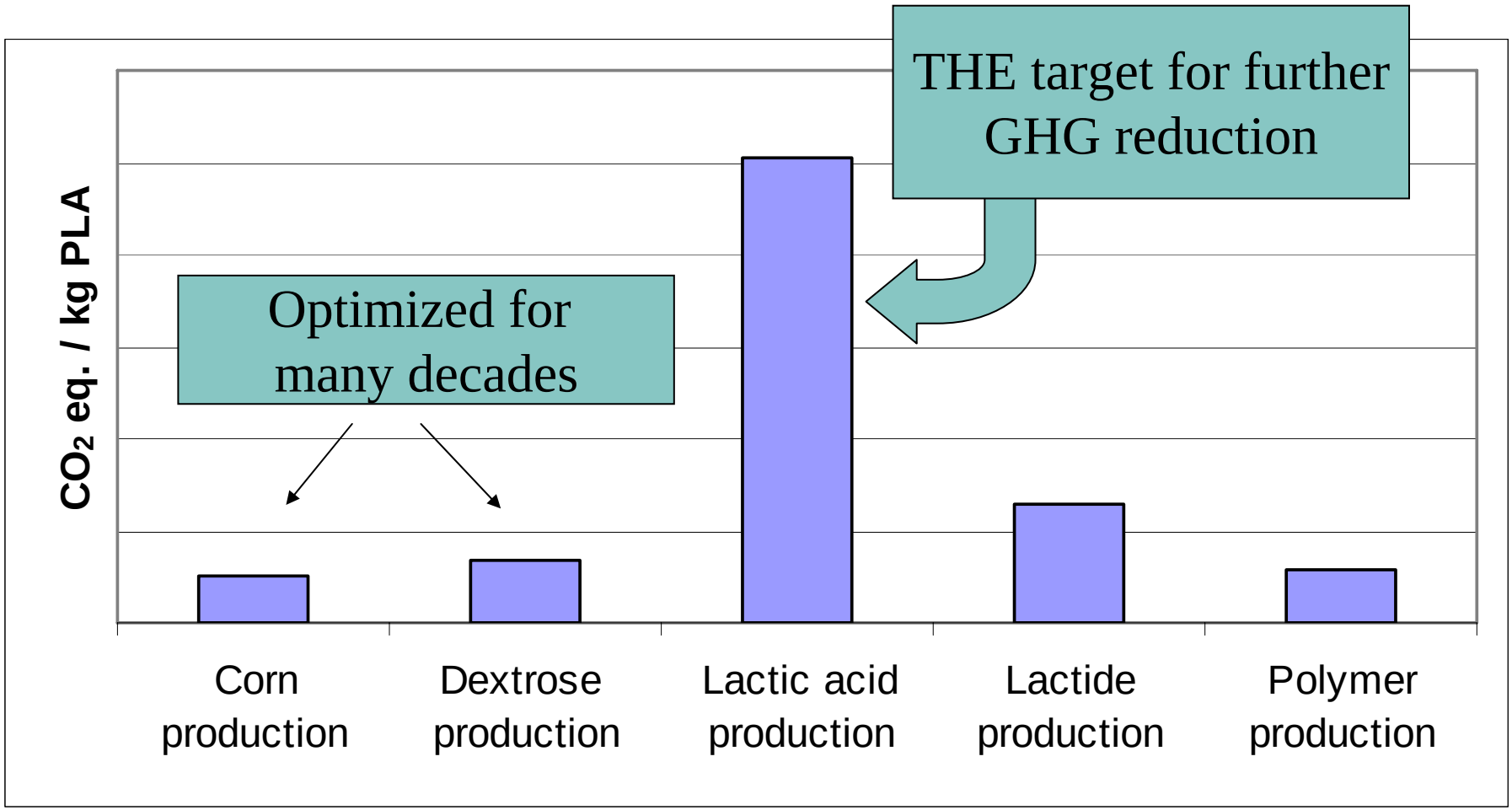
		Cargill/NatureWorks Case
Scope 1	Accounts for *direct* GHG from sources controlled by reporting company	CWM, Lactic acid, lactide, polymer, steam, heating oil, air, WWTP
Scope 2	Includes the *indirect* GHG associated with purchase of electricity, heat, or steam generated by an *outside* party.	externally produced electricity used in Scope 1 processes
Scope 3	Includes *indirect* GHG that are a consequence of the activities of the reporting company, but occur from sources owned or controlled by another company	the production and delivery of operating supplies (H_2O, N_2, acids and bases), Corn, Fuels, EOL operation (process waste) outsourced activities (e.g. recycling)

Outcome of GHG mapping process - 1

Scope	Emission sources	CO_2 eq. (kg/kg PLA5)
1	NatureWorks/Cargill site, direct emissions	1.038
2	Indirect emissions from electricity production	1.561
3	Fuel, material, corn production, reclamation	1.244
	Corn feedstock - CO_2 uptake	-1.820
	Total:	2.023

Look for an alternative source for fossil based electricity production.

Outcome of GHG mapping process - 2



Look for GHG reductions in Lactic acid production process.

Two tracks for GHG reductions:

1. Optimization of Lactic acid Process Technology
   - Improvements in current technology used: more energy efficient equipment.
   - Changes in raw materials
   - Changes in energy carriers: electricity>steam>heat oil>direct natural gas
   - Change of basic technology (PLA/NG)
   - Look for on/off-site waste heat stream

2. Optimization of Electricity Production
   - On-site renewable generation: solar voltaic systems, wind mills, bio fueled Heat/Power installation
   - Green power: purchasing both electricity + environmental attributes from local supplier (1/3 of today's volume)
   - Renewable energy certificates (implemented since January 2006)

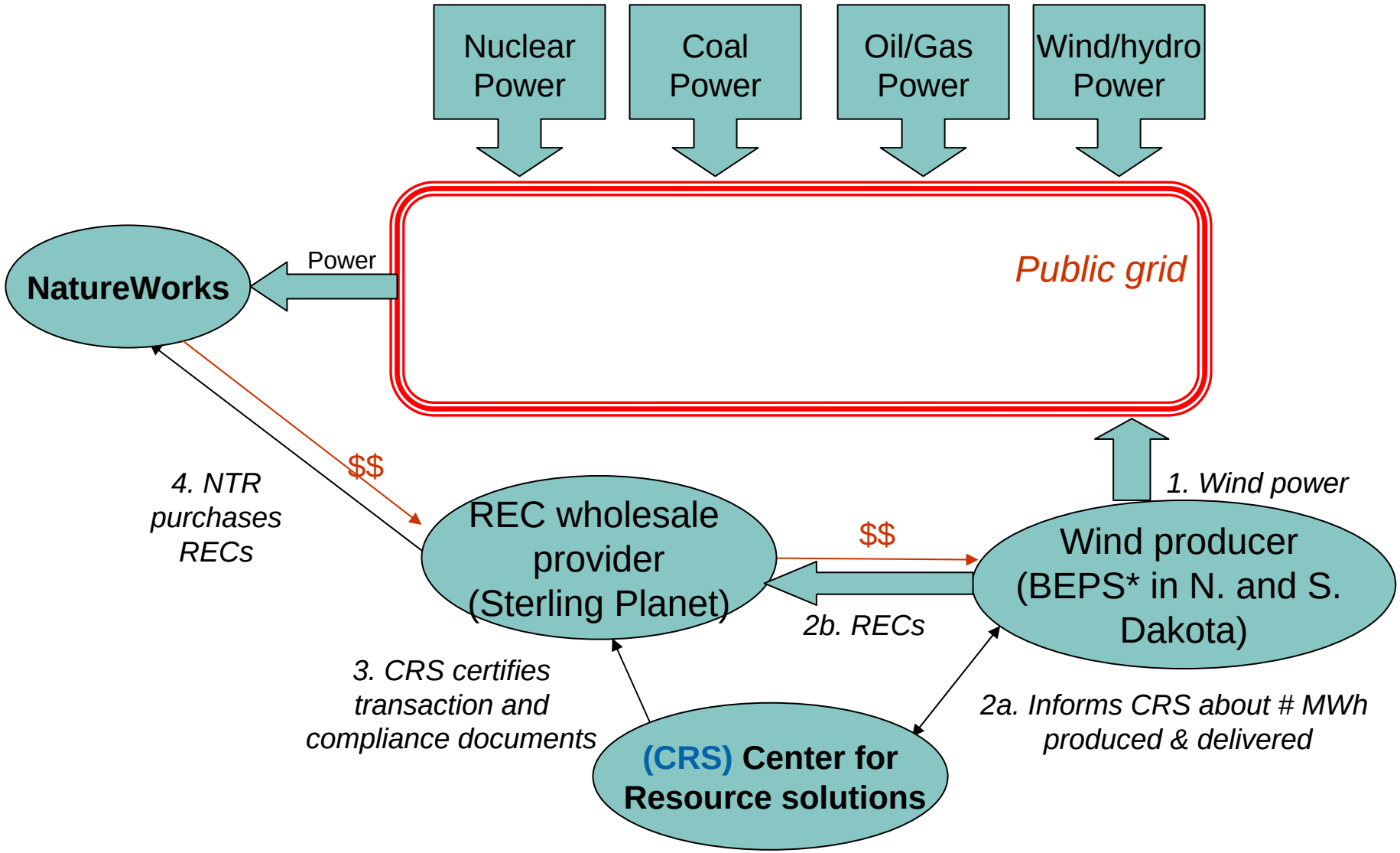
Wind Energy Based RECs

- A REC represents the environmental attributes – for example the avoided CO_2 emissions – that are created when electricity is generated using renewable resources instead of using fossil fuel sources.
  - A REC assure that the wind energy is being produced and delivered, and that the attributes are being claimed only once.
- NatureWorks purchases Green-e® certified RECs. The Centre for Resource Solutions operates this certification and auditing program. (www.green-e.org)
  - Green-e® certified RECs assures that they are from qualifying "new facilities" (up to several years), not facilities running for "years and years".
- For 2006 NatureWorks purchased RECs and also for 2007 and 2008 contracts are in place.
- The wind energy is being generated by wind farms located within the MAPP region (= the power pool region where our facilities are located).
  - Today already 1/3 of the require wind power is purchased from our direct energy provider.
  - RECs are only applicable on *additional* wind power initiatives, not on mandatory wind energy.
- With the purchase of REC NatureWorks is supporting the growth of renewable energy in the US.

Corporate Guide to Green Power Markets of the World Resource Institute

www.thegreenpowergroup.org

How do RECs work?



*BEPS: Basin Electric Power Cooperative

Certification & Auditing

REC are widely accepted*: they provide a means to drive the adoption of more renewable energy.

The Green Power Market Development Group, collaboration of companies with the World Resource Institute, are promoting the development of cost effective green power.

USA:

- Alcoa
- Dow
- DuPont
- FedEx
- GM
- Georgia Pacific
- Google
- IBM
- Interface
- J&J
- NatureWorks
- Pitney Bowes
- Staples
- Starbucks

Europe:

- British Telecom
- Dow
- DuPont
- GM
- Holcim
- IKEA
- Interface
- J&J
- Nike
- Staples
- TetraPak

Ref: GPMDG, press release November 30, 2005

***US EPA, several NGO's and many companies**

NatureWorks LLC ranks No. 24 on the EPA Top 25 list of largest United States green power purchasers – As of July 9 2007

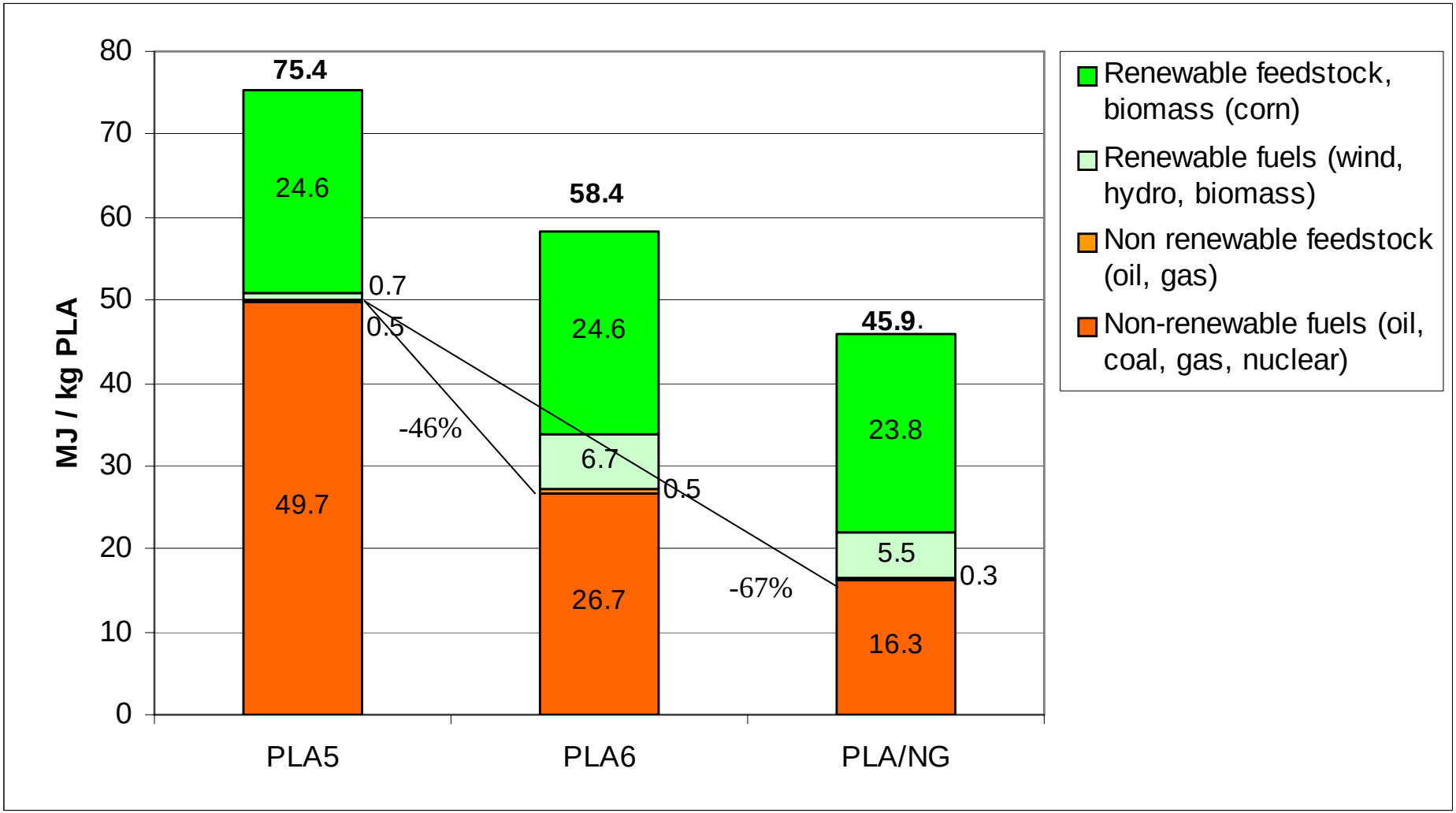
- Combined, the Top 25 purchases amount to nearly 6.2 billion kWh of green power annually.
- The top 25 takes 60% of the green power commitments made by all EPA Green Power Partners

1. PepsiCo	1,105,045
2. Wells Fargo & Company	550,000
3. Whole Foods Market	509,105
4. The Pepsi Bottling Group	457,851
5. U.S. Air Force	457,500
6. Johnson & Johnson	400,703
7. US Environmental Protection	329,880
8. Kohl's Department Stores	201,396
9. LA County Sanitation Districts	196,003
10. Starbucks	185,000
11. DuPont Company	180,000
12. US Department of Energy	157,964
13. Pepsi Americas. Inc	157,063
14. Vail Resorts	152,000
15. Cisco Systems Inc.	128,204
16. HSBC North America	124,544
17. Staples	121,800
18. New York University	118,616
19 The World Bank Group	114,735
20. University of Pennsylvania	112,000
21. IBM Corporation	110,103
22. Mohawk Fine Papers	100,200
23. U.S. Department of Veterans	90,000
24. NatureWorks LLC	**89,000**
25. Sprint Nextel	87,600

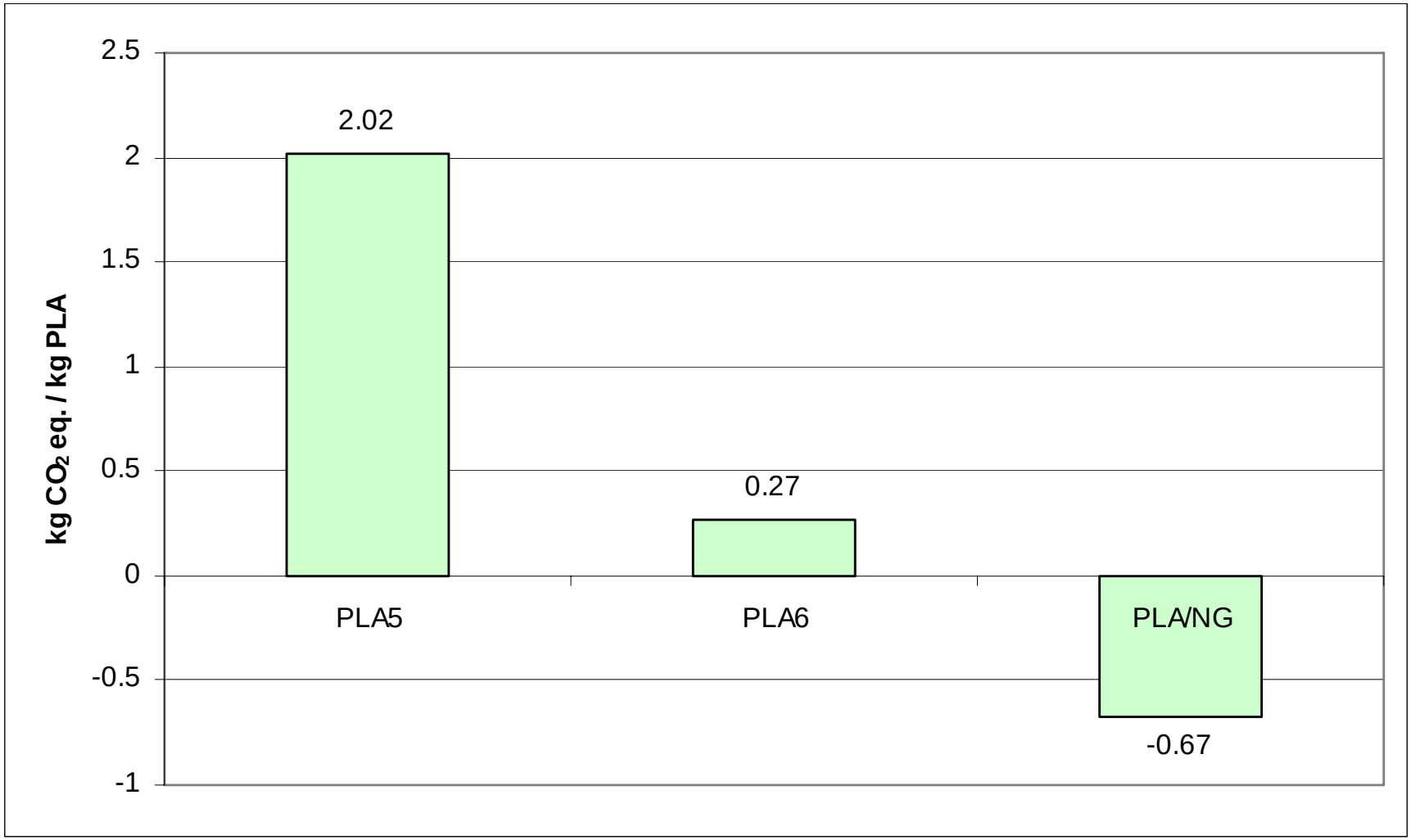
http://epa.gov/greenpower/partners/top25.htm

Corporate purchases are voluntary; governmental agencies are under a directive.

Results of the utilization of wind energy and new technology on Fossil Energy Use.



Results of the utilization of wind energy and new technology on GHG emissions.



Conclusions

- **NatureWorks LLC has been showing the world, for the first time, that a competitive bio-based polymer can be produced commercially with less environmental foot-print today and a potential of much less foot-print in near future.**

- **RECs/Wind Power are a perfect fit. NatureWorks actively sought out renewable energy solutions to marry with its renewable based feedstock.**

How to deal with innovative, new materials in LCA?

- Quite often new materials,
  - which are in their early stage of development,
  - which are produced in small scale or singular facilities,
  - and which conversion and final disposal are not optimize are directly, on a 1:1 basis, compared with

  mature materials of which the life cycle has been optimized for several decades.
- This is often leading to a biased comparison.
- Therefore LCA practitioners should always include possible optimization steps. By not including, the tool of LCA kills innovation at its early stage, which was never the intention.
- This is a key responsibility of the LCA practitioner.

NatureWorks LLC

Thank you

Visit NatureWorks LCA website on:
www.natureworksllc.com for the latest publications and LCA studies