Arcadia
BIOSCIENCES

Sharing technologies that benefit the environment and human health, with growers in the developing world

October 16, 2008

CREATE-IGERT Symposium

Arcadia Corporate Background

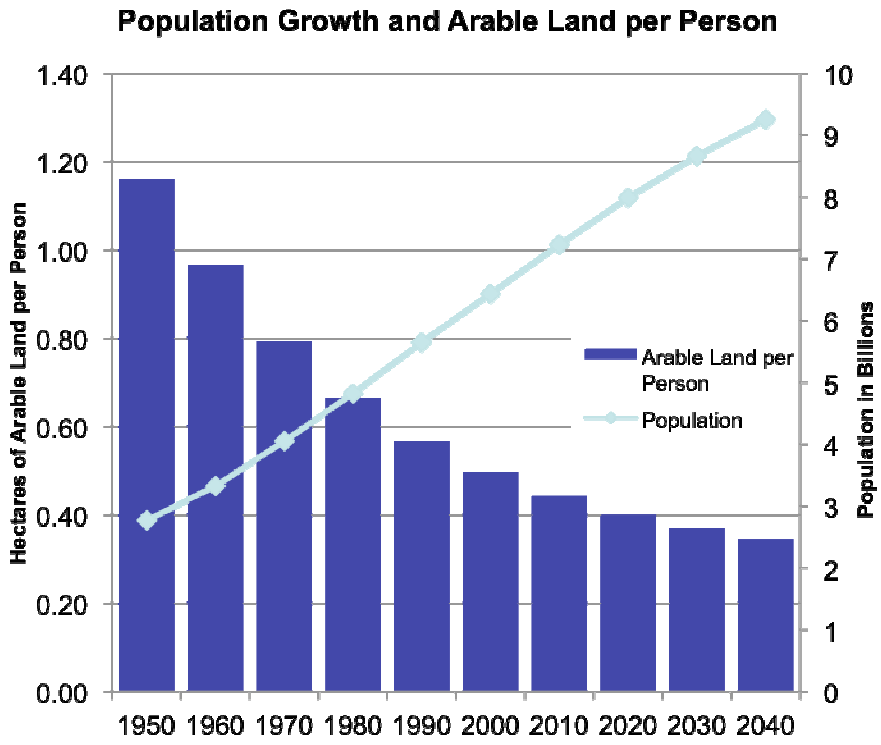
Mission: Arcadia develops plants that improve the environment and human health

- Founded in 2003
- Privately Owned
  - Exeter Life Sciences (majority)
  - CMEA Ventures
  - BASF Ventures
  - Saints Capital
- Headquarters & main R&D facilities in Davis, California
- Additional facilities in Seattle, WA (TILLING research) and Phoenix, AZ (accounting)
- Total staff 80; R&D staff 60

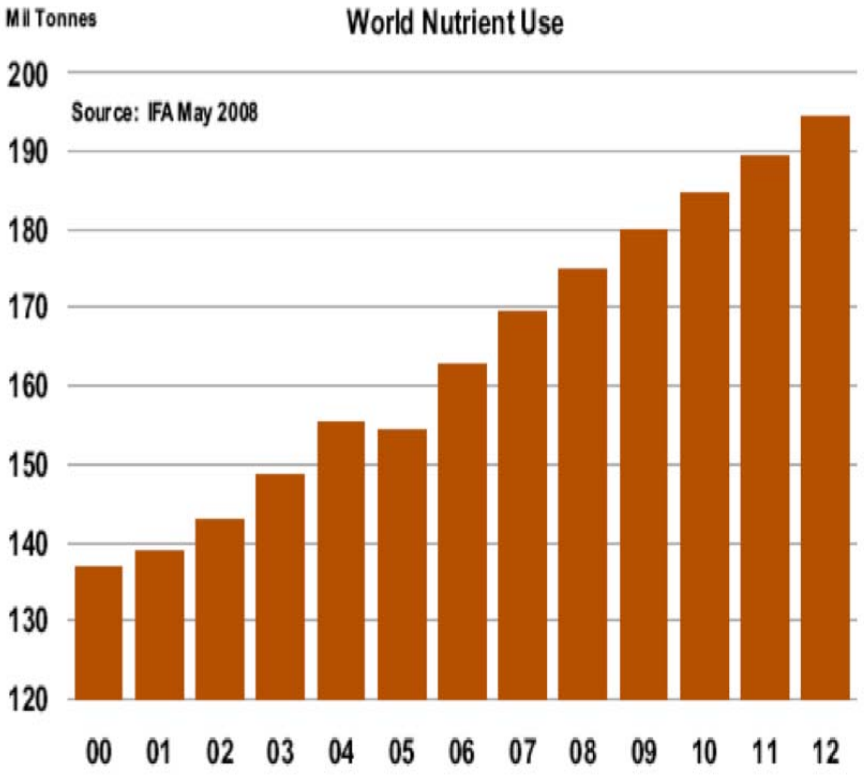
Agriculture and the Environment

Fertilizer is the “Fuel” of Agriculture

Hectares per person decreasing…



…yield maintained with nutrient (NPK) usage.



Source: US Census World Population and IFA

Nitrogen and Agriculture

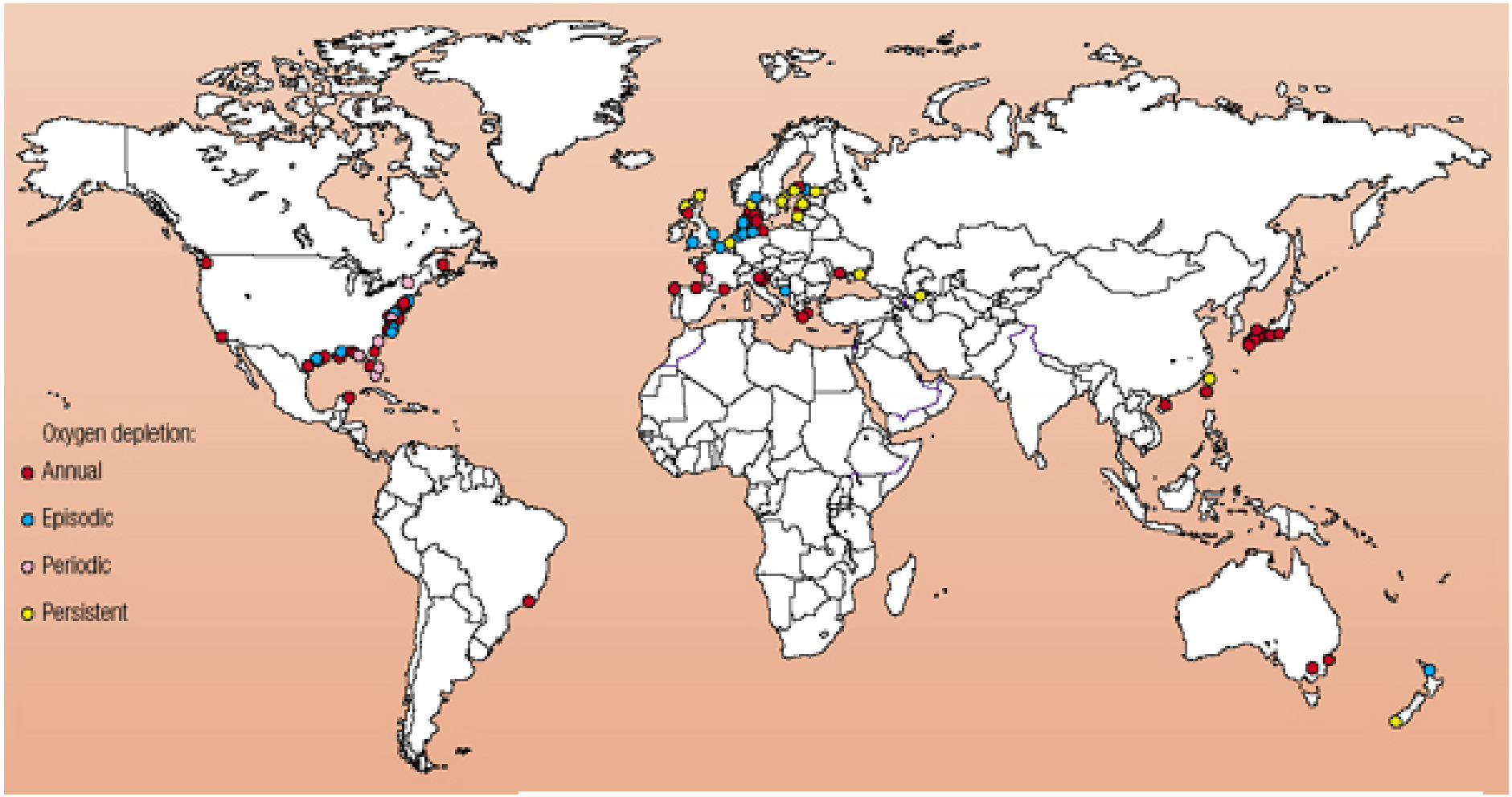
- Nitrogen in fertilizer is *the* key input to global agriculture
  - Annual value > $60 billion; natural gas driver
- Less than 50% of nitrogen is absorbed by plants
  - Economic inefficiency for farmers
- Unabsorbed nitrogen damages the environment
  - Eutrophication of marine environments
  - Ground water pollution
  - Air pollution (Greenhouse Gas Emissions)

Eutrophication through over-fertilization of N

Spreading menace: nitrogen-based fertilizers enter rivers and cause them to become choked by algae.

Source: Nature 2005

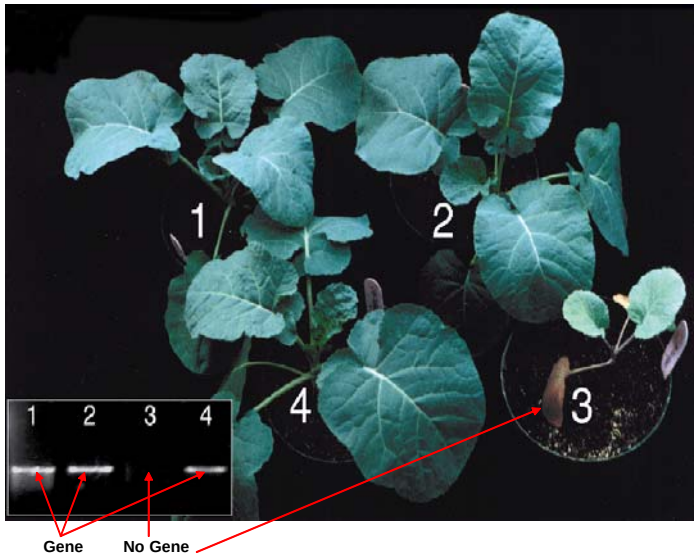
Ocean eutrophic zones (Dead Zones) are a global issue

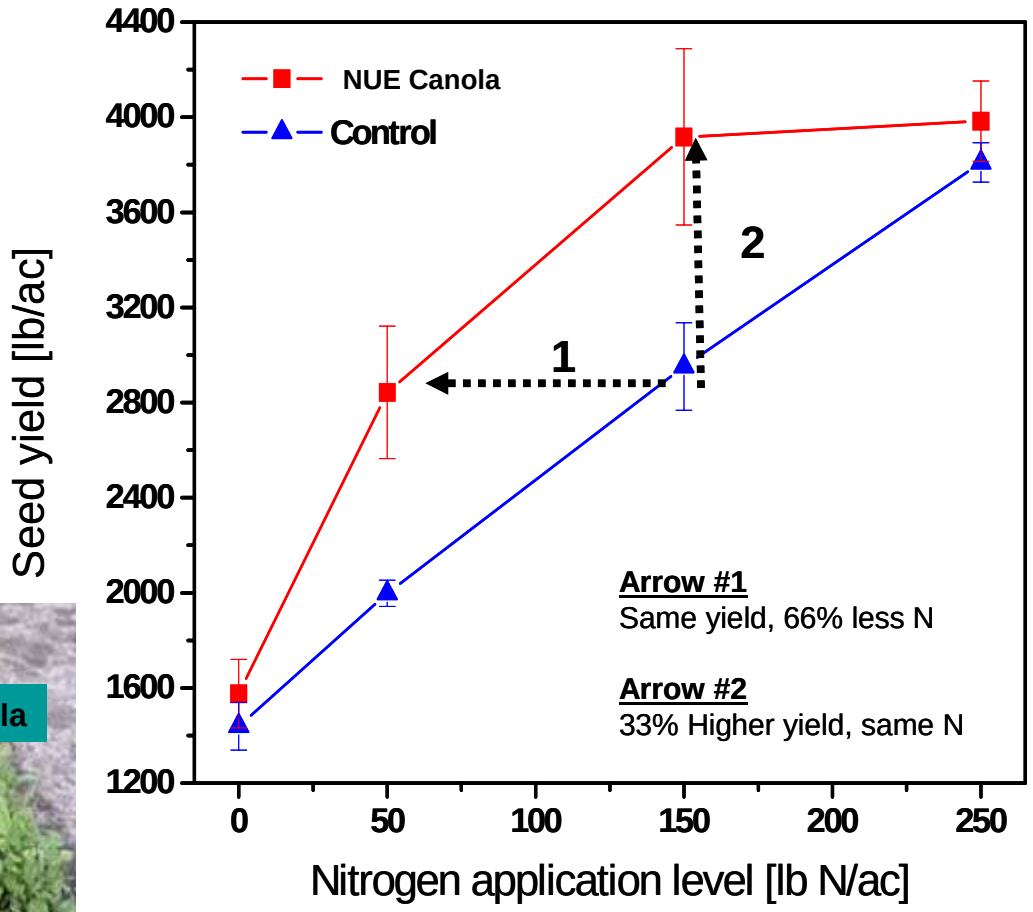


Source: United Nations Environment Programme, **GEO Yearbook 2003** (Nairobi: 2004), compiled from Boesch 2002, Caddy 2000, Diaz et al. (in press), Green and Short 2003, Rabalais 2002

Nitrogen Use Efficiency (NUE) Program

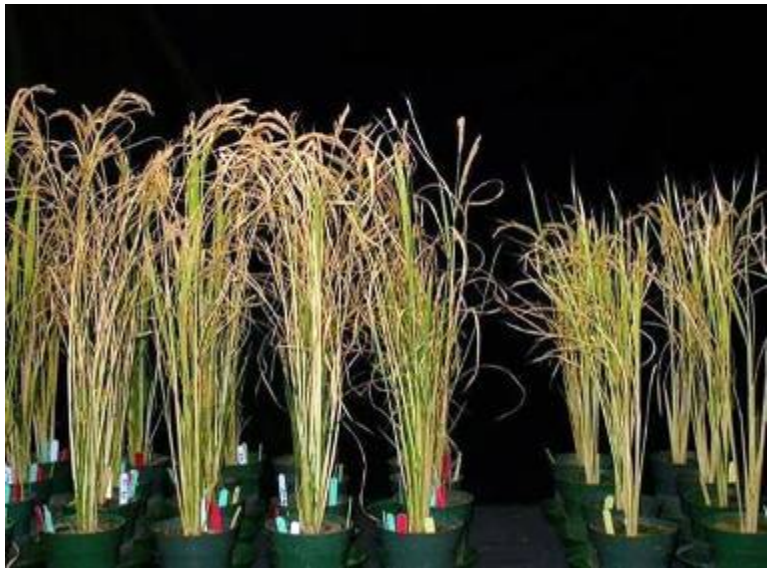
Nitrogen Use Efficiency (NUE) in Canola



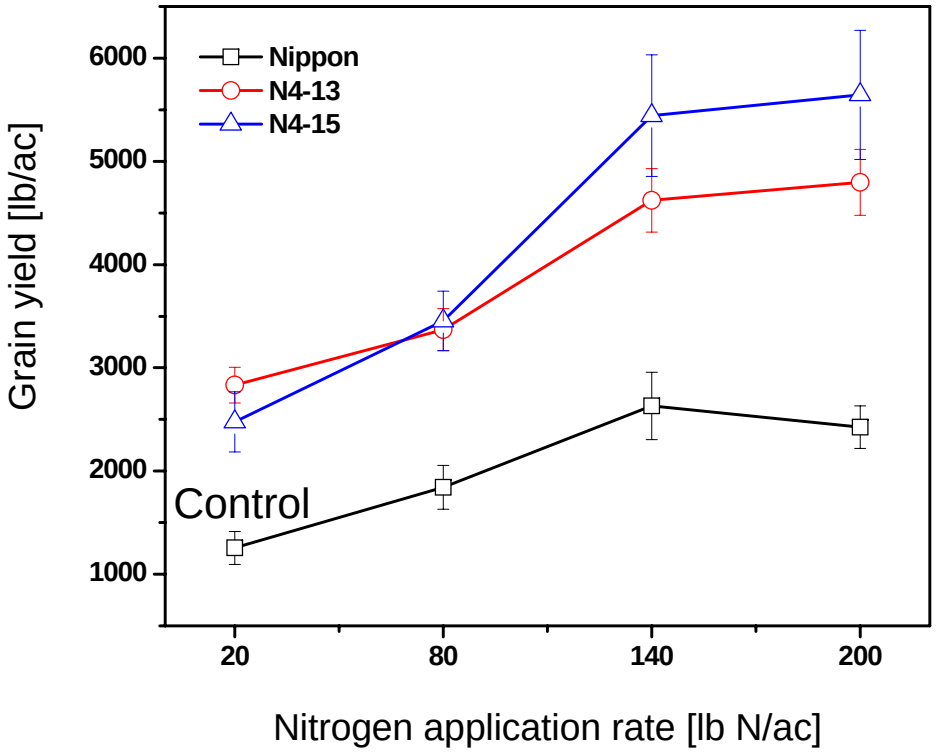


NUE Technology in Rice

Ripening Stage



NUE Rice **Control**

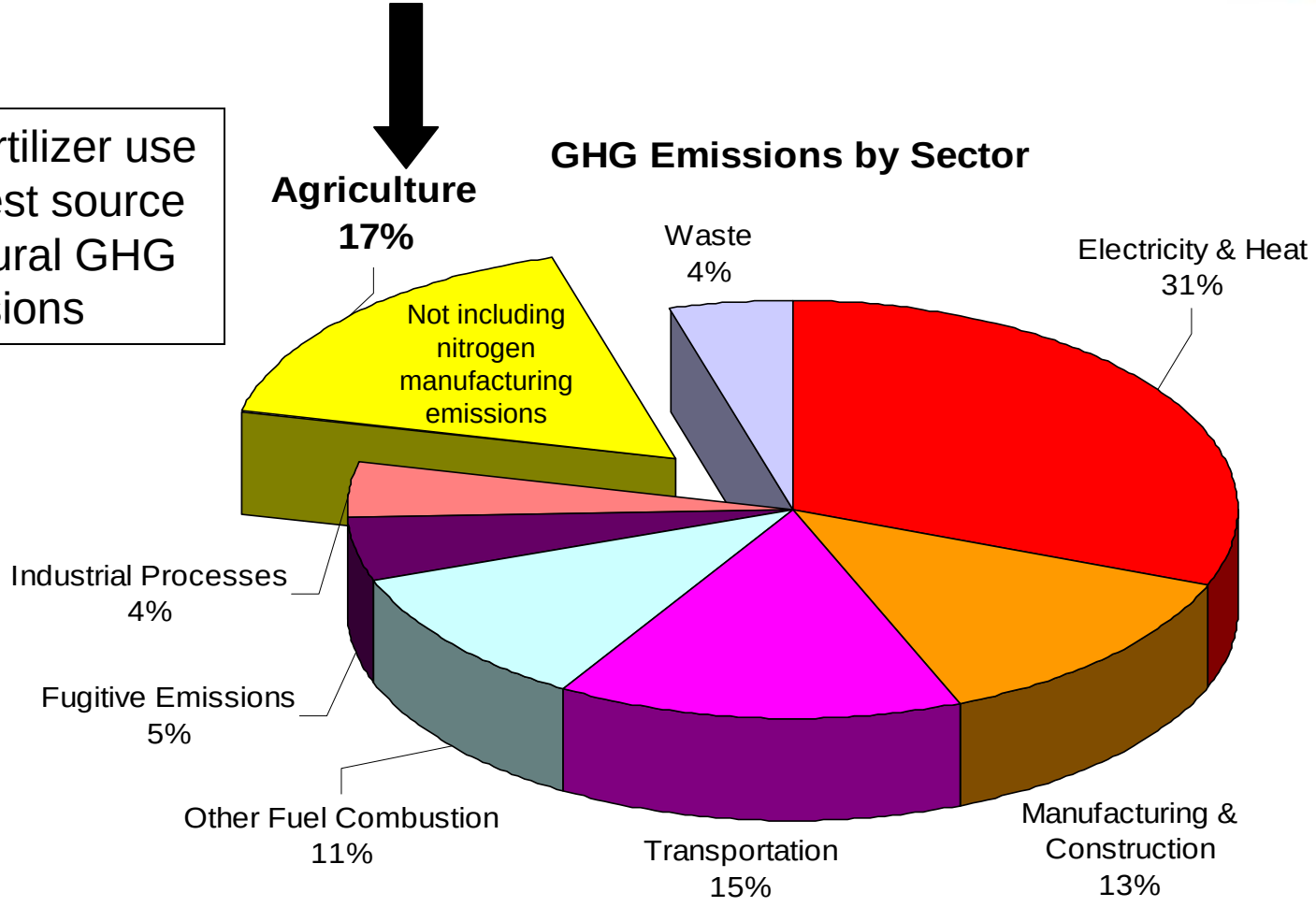


NUE Technology Licenses

- Canola: Monsanto (US), global
- Corn: Pioneer (US), global
- Turf: Scotts Company (US), global
- Sugar Beets: SES Vanderhave (BE), global
- Wheat & Barley: CSIRO/ACPFG (AU), Australia
- Wheat: Mahyco, India
- Sugarcane: Mahyco, India
- Rice: Mahyco, India
- Rice: Africa, AATF, no-cost technology donation

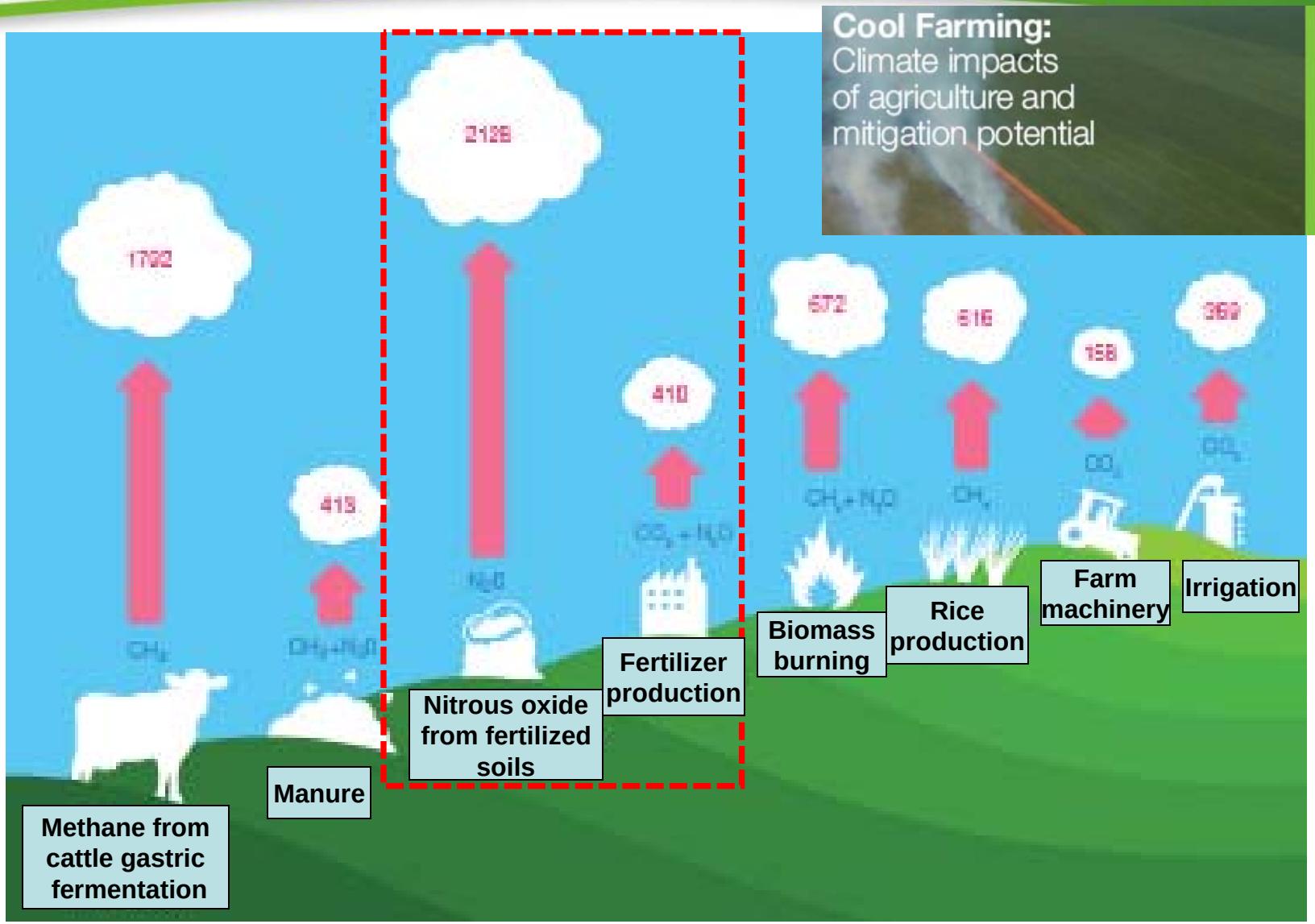
Agriculture is the #2 Industrial Source of Global Greenhouse Gas

Nitrogen fertilizer use is the largest source of agricultural GHG emissions



Climate Analysis Indicators Tool (CAIT) Version 4.0. (Washington, DC: World Resources Institute, 2006).

Greenpeace Agrees



Nitrous Oxide is a Potent Greenhouse Gas

Nitrous Oxide has 300 times the global warming potential of CO_2.

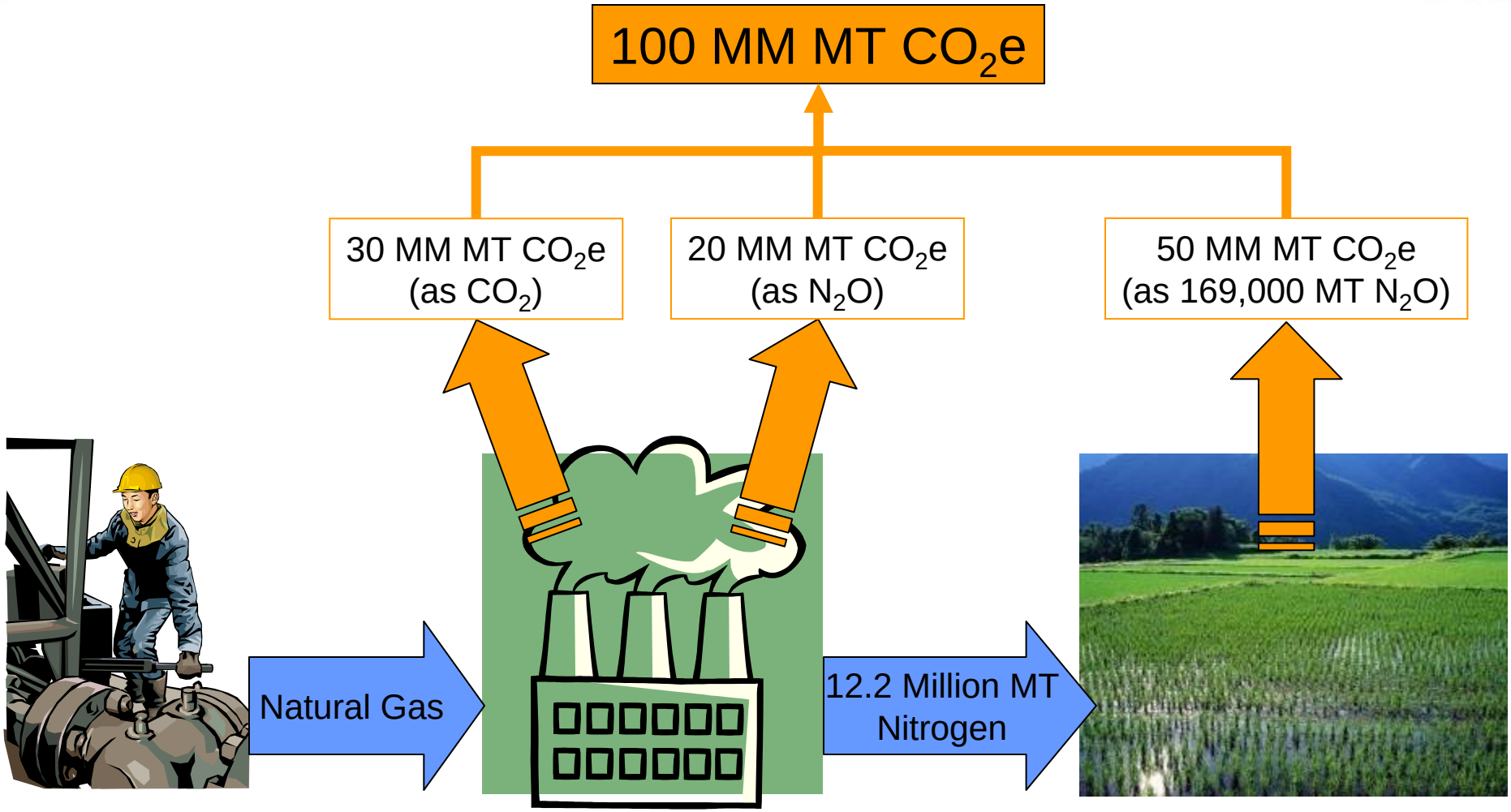
Table 8.1 Characteristics of Kyoto Greenhouse Gases

Despite the higher GWP of other greenhouse gases over a 100-year time horizon, carbon dioxide constitutes around three-quarters of the total GWP of emissions. This is because the vast majority of emissions, by weight, are carbon dioxide. HFCs and PFCs include many individual gases; the data shown are approximate ranges across these gases.

	Lifetime in the atmosphere (years)	100-year Global Warming Potential (GWP)	Percentage of 2000 emissions in CO_2e
Carbon dioxide	5-200	1	77%
Methane	10	23	14%
Nitrous Oxide	115	296	8%
Hydrofluorocarbons (HFCs)	1 – 250	10 – 12,000	0.5%
Perfluorocarbons (PFCs)	>2500	>5,500	0.2%
Sulphur Hexafluoride (SF_6)	3,200	22,200	1%

Source: Ramaswamy et al. (2001)[8] and emissions data from the WRI CAIT database[9].

Example: Global Rice Production and Greenhouse Gas Emissions



Ningxia Hui (Islamic) Autonomous Region

Overall Goals of Rice Carbon Project

Establish basis of methodology to capture nitrous oxide (N_2O) emissions from agricultural field of crops such as rice

Development of New Methodology

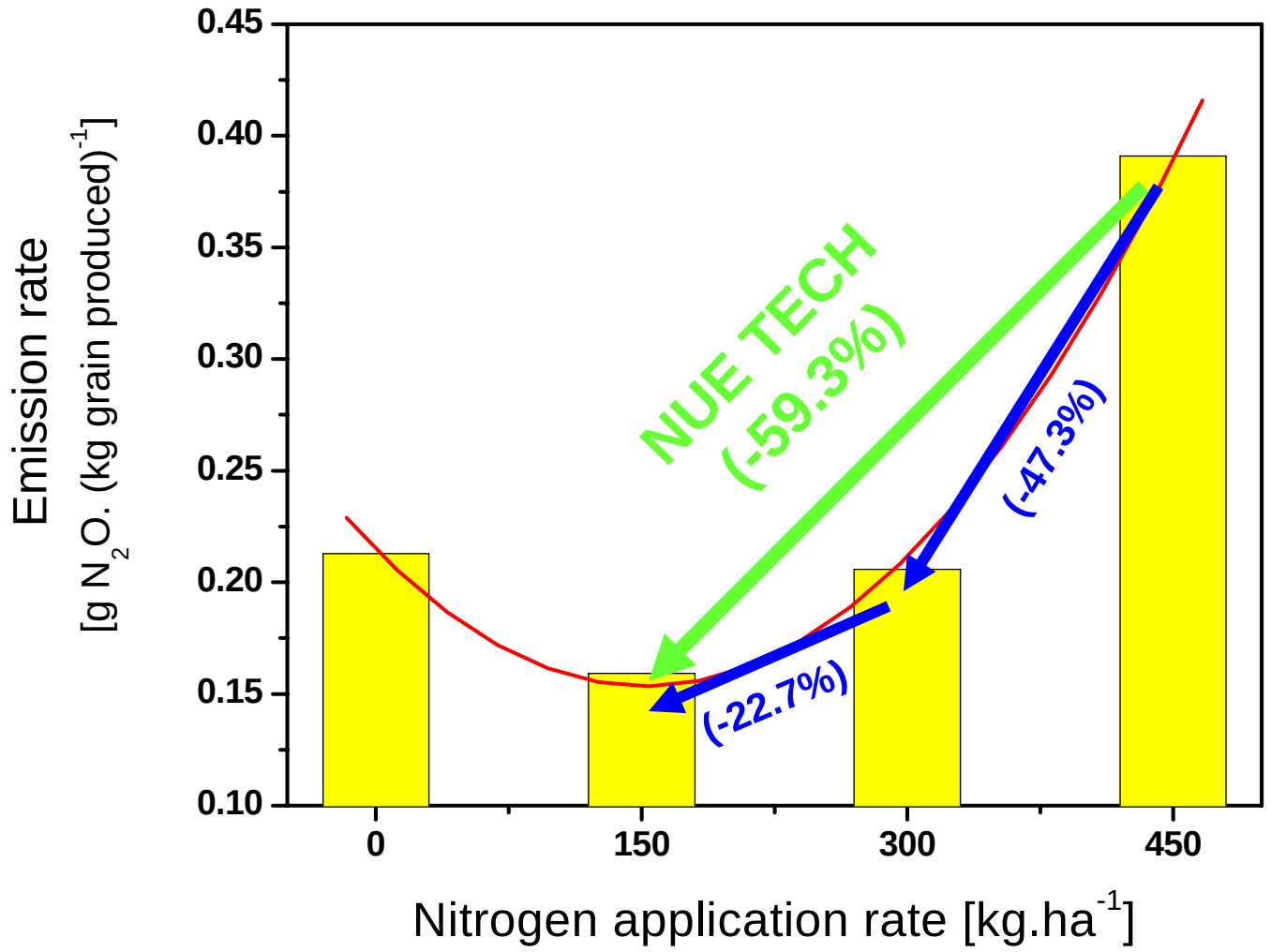
- Field data collection by Arcadia and the Ningxia Academy of Agriculture and Forestry Sciences (NAAFS),
- Develop documents necessary for submission of a new methodology to the UNFCCC/CDM Executive Board,
- Working with relevant CDM authorities and/or other experts within and outside China to achieve approval by Executive Board.

Establishment of Agricultural Carbon Credit and Trading System.

- The NAAFS coordinates with the appropriate authorities in Ningxia to establish an agricultural carbon credit and trading system within Ningxia,
- System is based upon methodologies approved by the UNFCCC/CDM Executive Board and conform to international standards.

Gas Sampling Throughout the Rice Crop Cycle

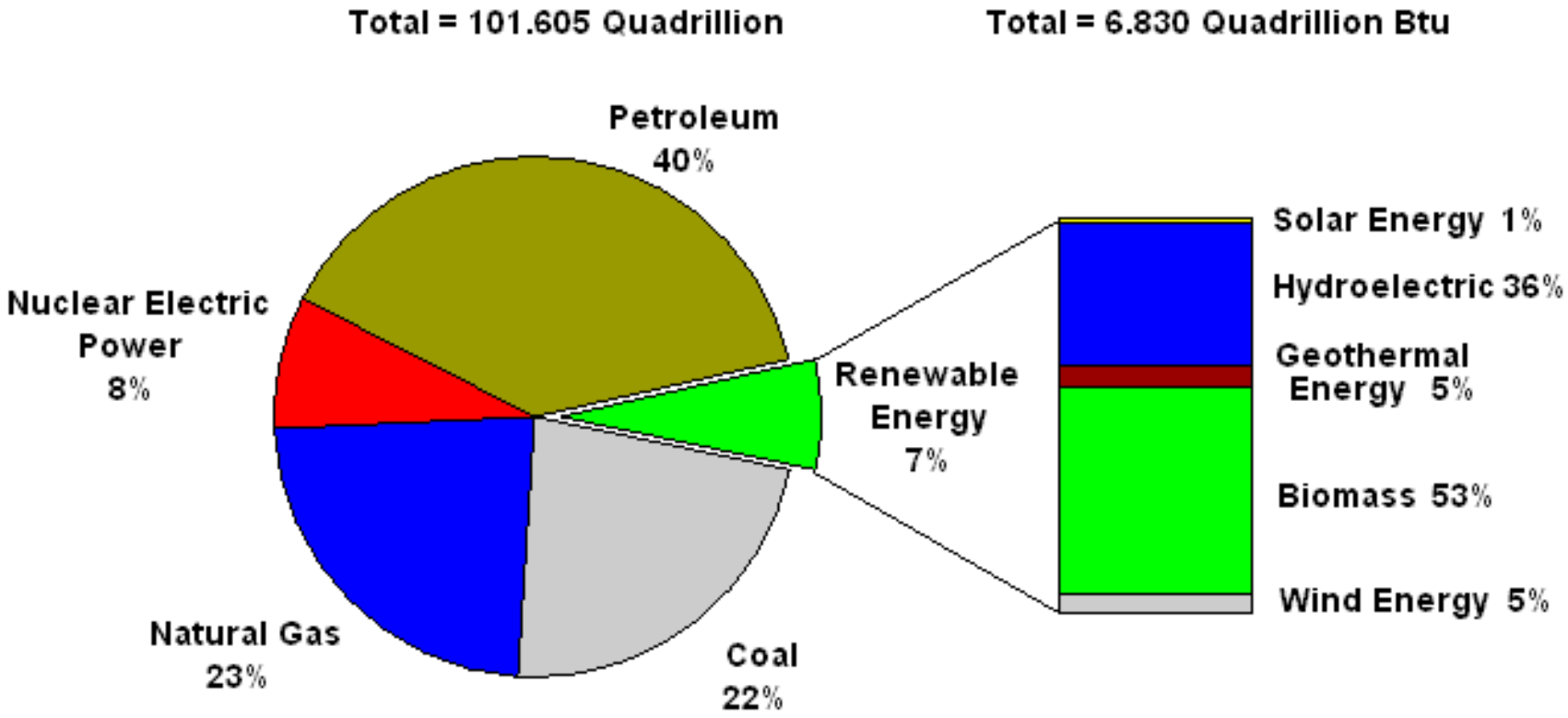
China Rice GHG Emissions Data



Agricultural GHG Reduction Opportunity

- A carbon credit/offset system can be applied to agriculture, as for other industries
- A 50% reduction in GHG emissions in global rice production = 25 million MT CO_2 = $750 million on current European carbon credit market
- A 50% reduction of nitrogen use in agricultural crops would generate $30-40 billion per year in potential carbon credits for farmers
- A 50% reduction of nitrogen use in the top 6 crops would have the equivalent impact of eliminating all of the automobiles in the US, UK, and Germany

U.S. Energy Consumption 2007



Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels
http://www.eia.doe.gov/cneaf/alternate/page/renew_energy_consump/figure1.html

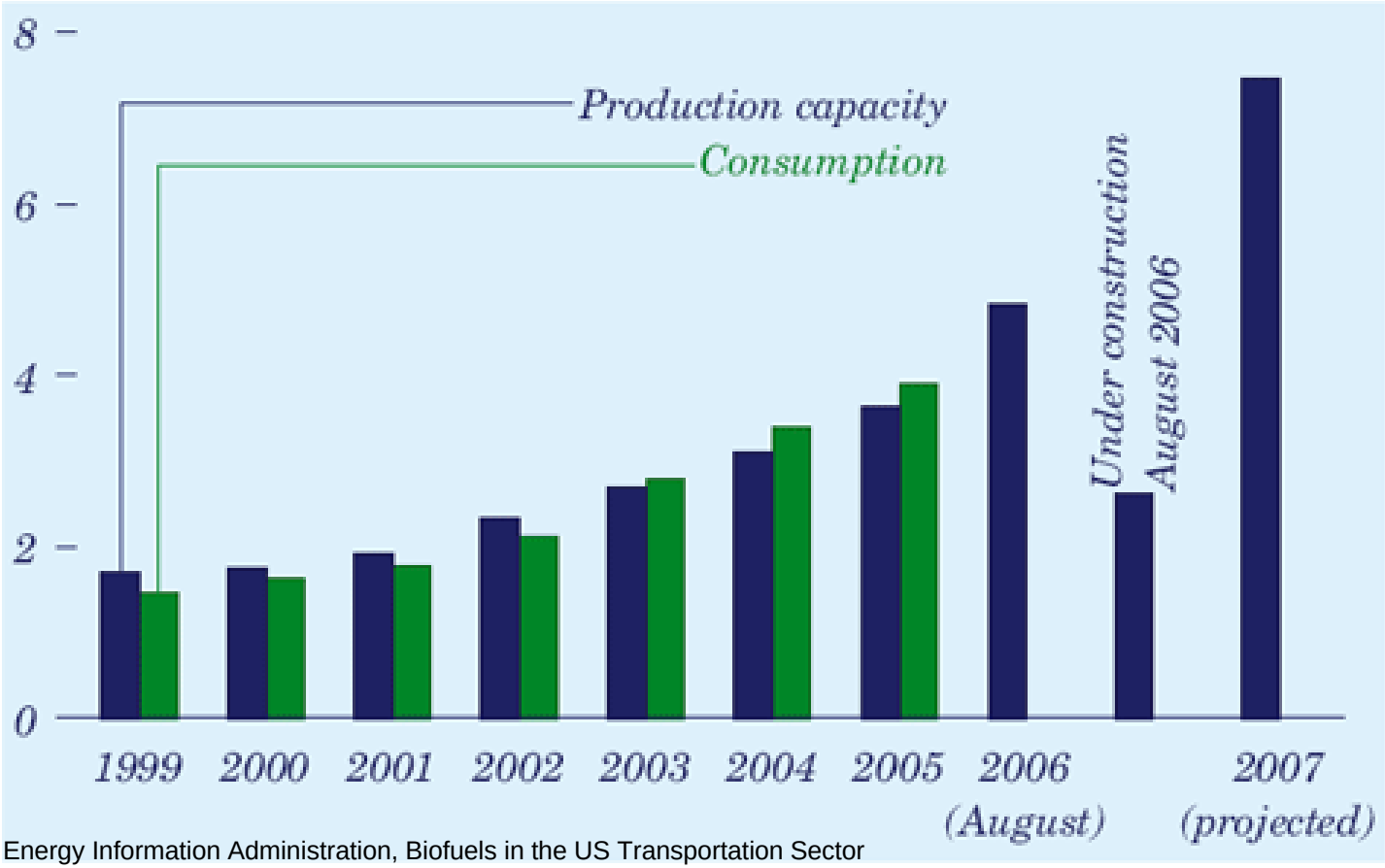
What is Biofuel?

- 1st Generation biofuel
  - Biodiesel
    - Animal fats
    - Vegetable oil – soy, canola, sunflower, palm, hemp
  - Ethanol
    - Sugar fermentation – wheat, corn, sugar beets, sugar cane, sweet sorghum, potato, fruit waste (any thing that alcoholic beverages can be made from)
  - Biogas
    - Landfill
    - Ag waste (manure)
- 2nd Generation biofuel
  - Cellulose fermentation tech
  - Biobutanol – less corrosive than ethanol
- 3rd Generation biofuel
  - Energy crops
    - Perennial grasses, fast growing trees and algae

http://www1.eere.energy.gov/biomass/pdfs/nbap.pdf

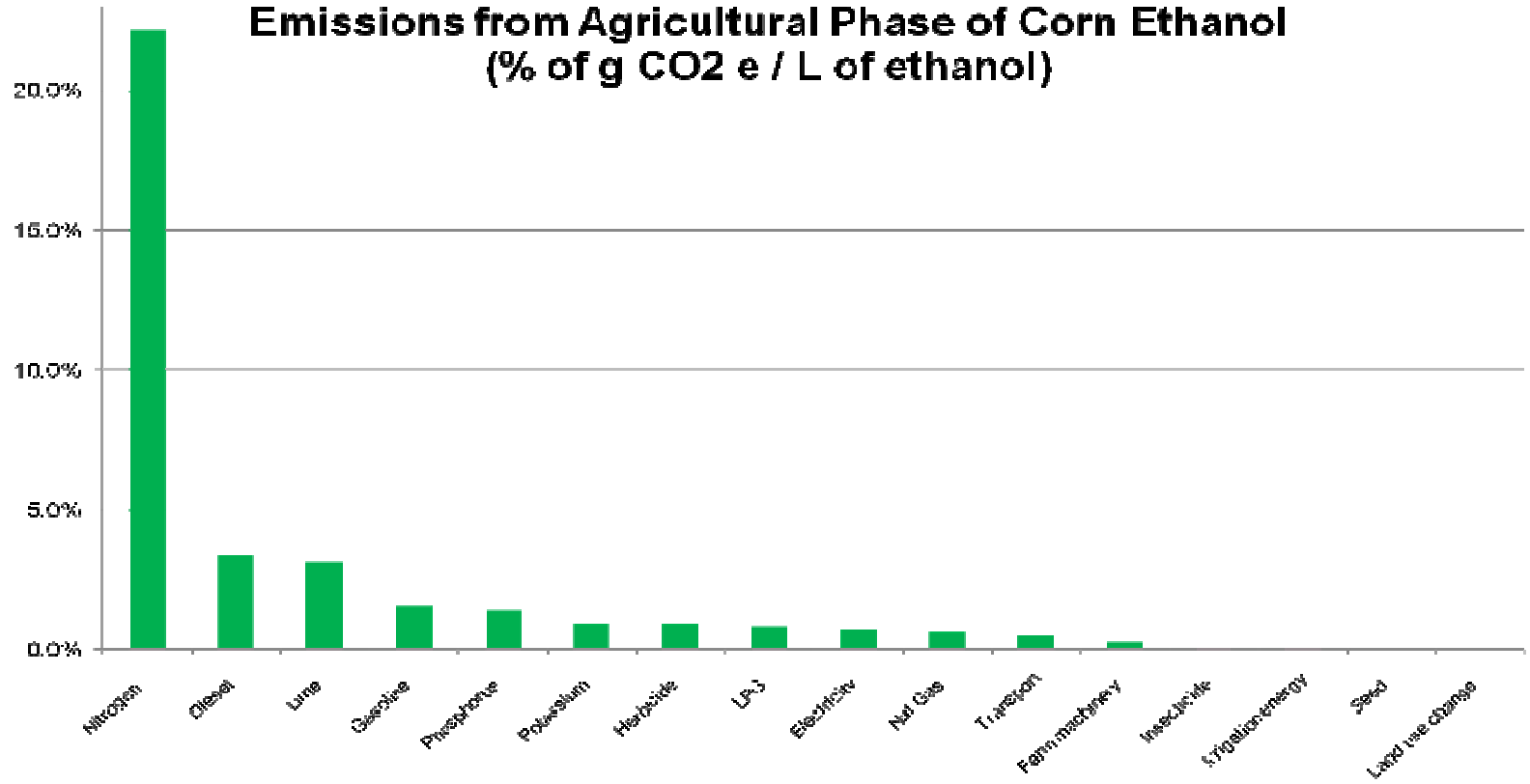
Current Biofuel Consumption > Production

Figure 22. U.S. ethanol production and production capacity, 1999-2007 (billion gallons)

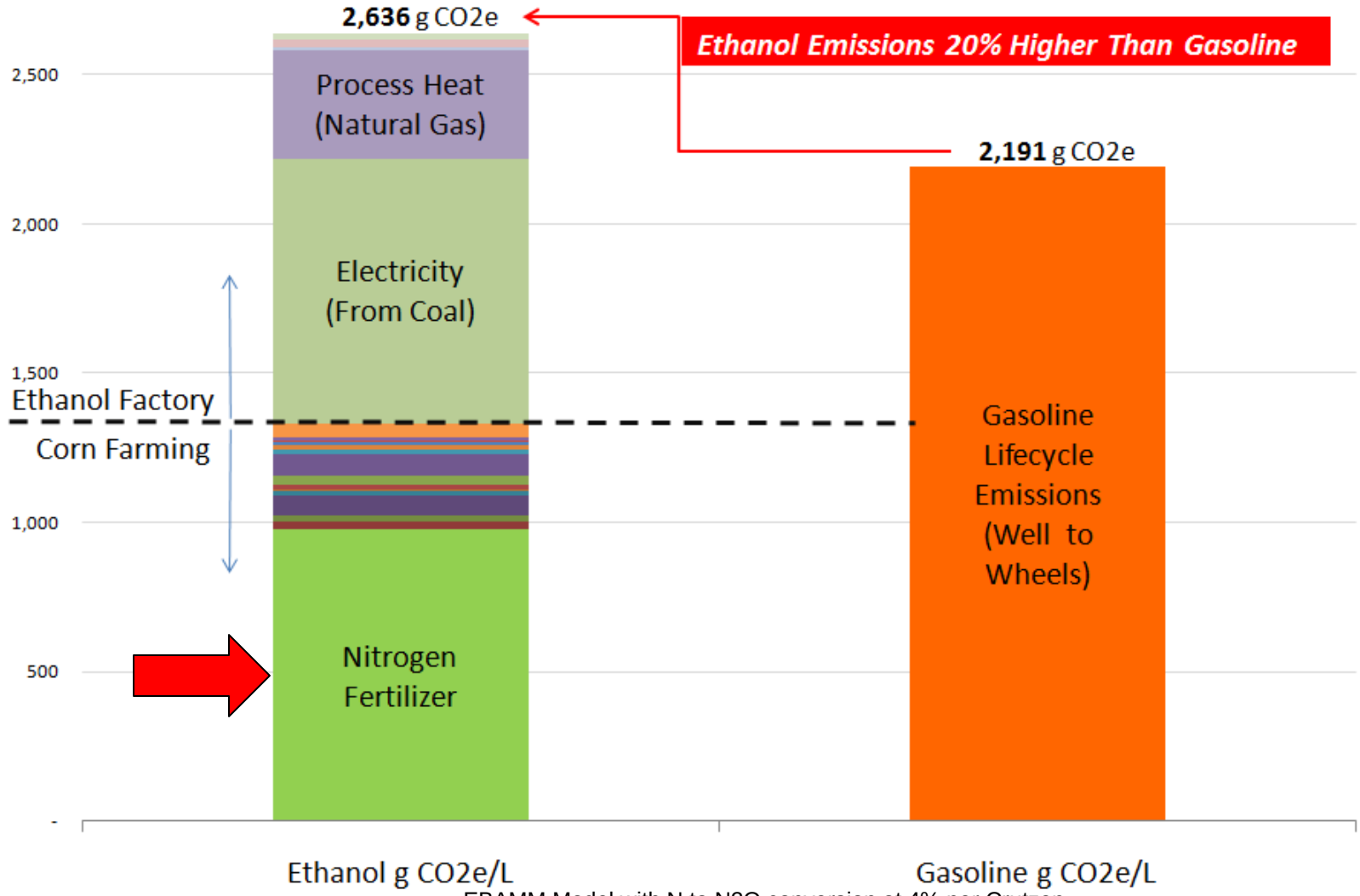


Source: Energy Information Administration, Biofuels in the US Transportation Sector
http://www.eia.doe.gov/oiaf/analysispaper/biomass.html

GHG emissions in Ag Phase

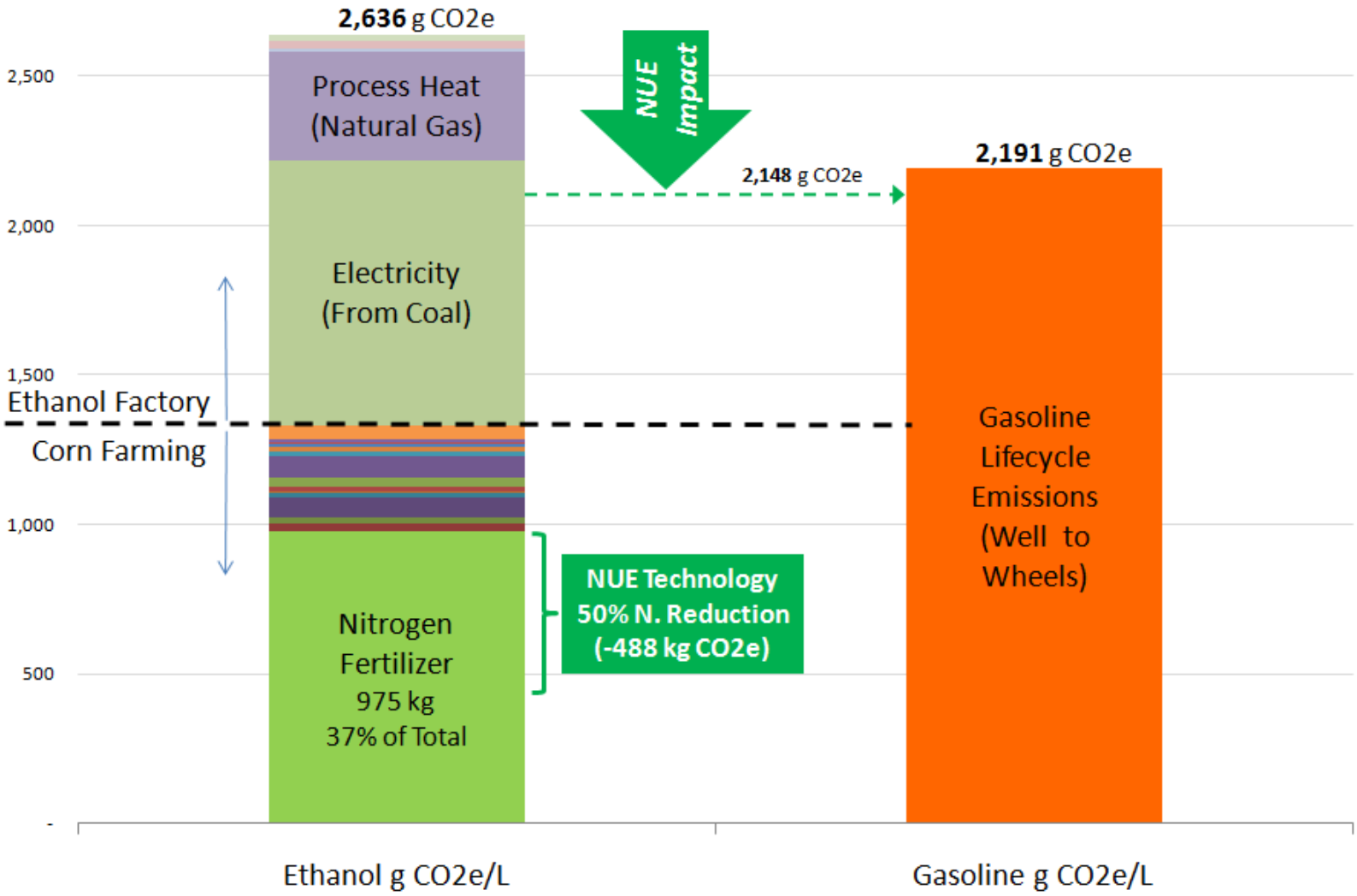


Corn Ethanol GHG Emissions Exceed Gasoline Emissions

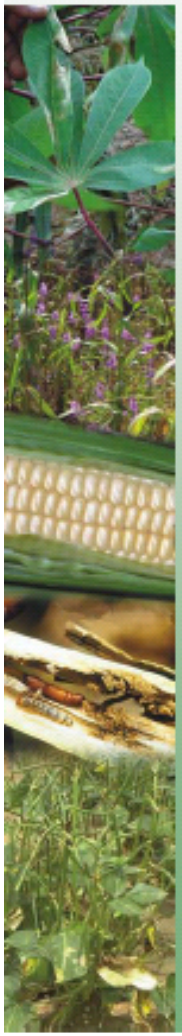


EBAMM Model with N to N2O conversion at 4% per Crutzen.
Values normalized to energy equivalent basis.

NUE Technology Can Improve Biofuel GHG Emissions



Values normalized to energy equivalent basis.



Adding Value to Rice Productivity through Nitrogen-Use Efficiency and Salinity Tolerance Traits

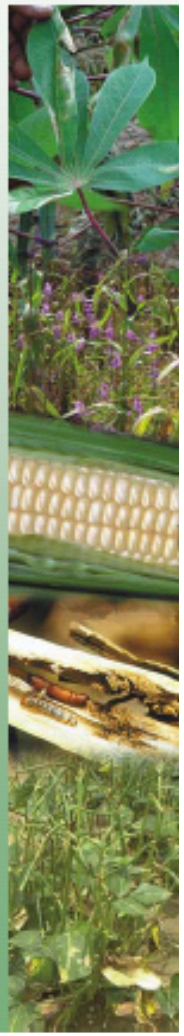
Jacob Mignouna, PhD

Technical Operations Manager

African Agricultural Technology Foundation

27 March 2006

WARDA, Cotonou, Benin



Goal and objectives

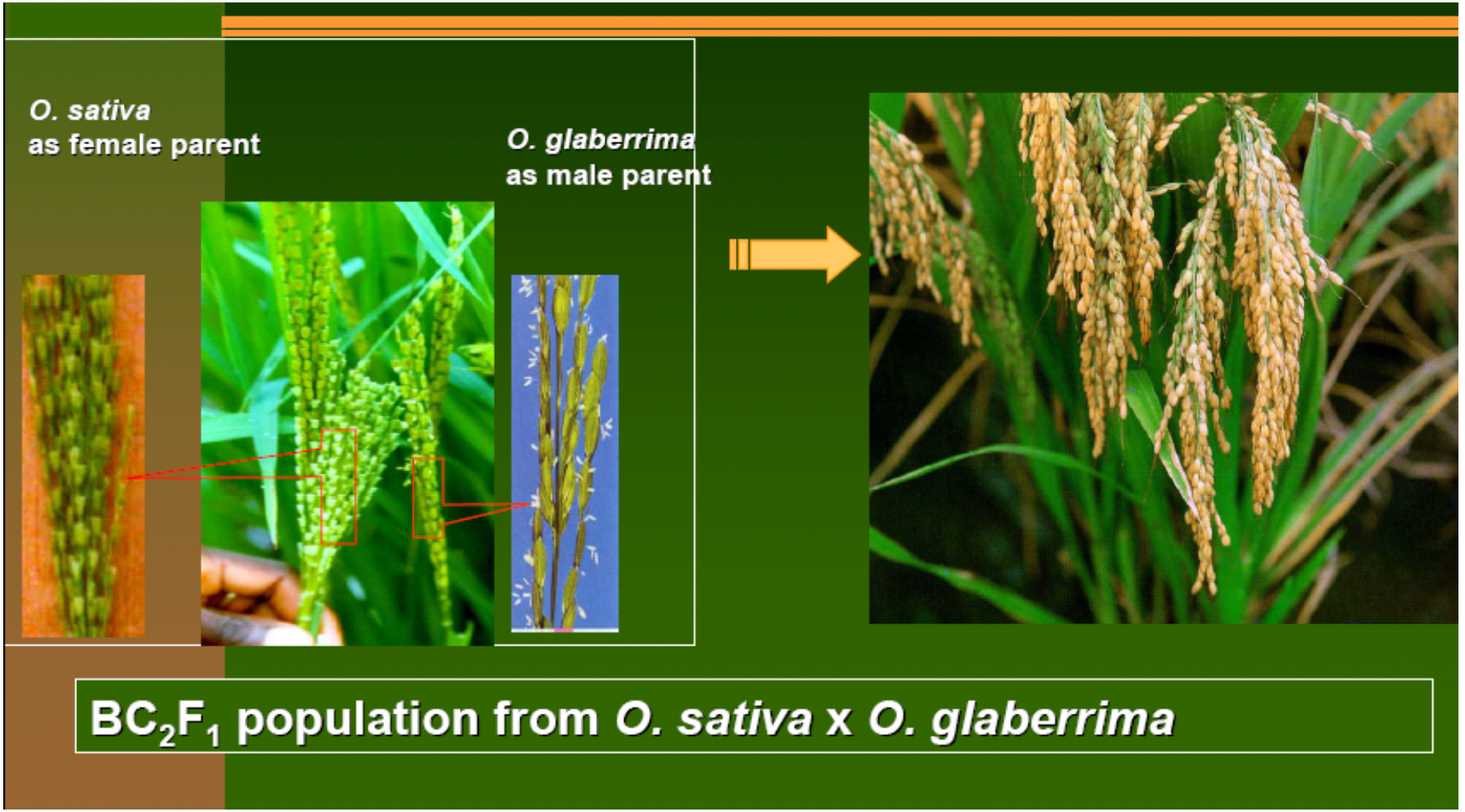
Goal

To set in motion the process of access, adaptation and delivery of technologies to raise the productivity of rice in Africa

Specific Focus

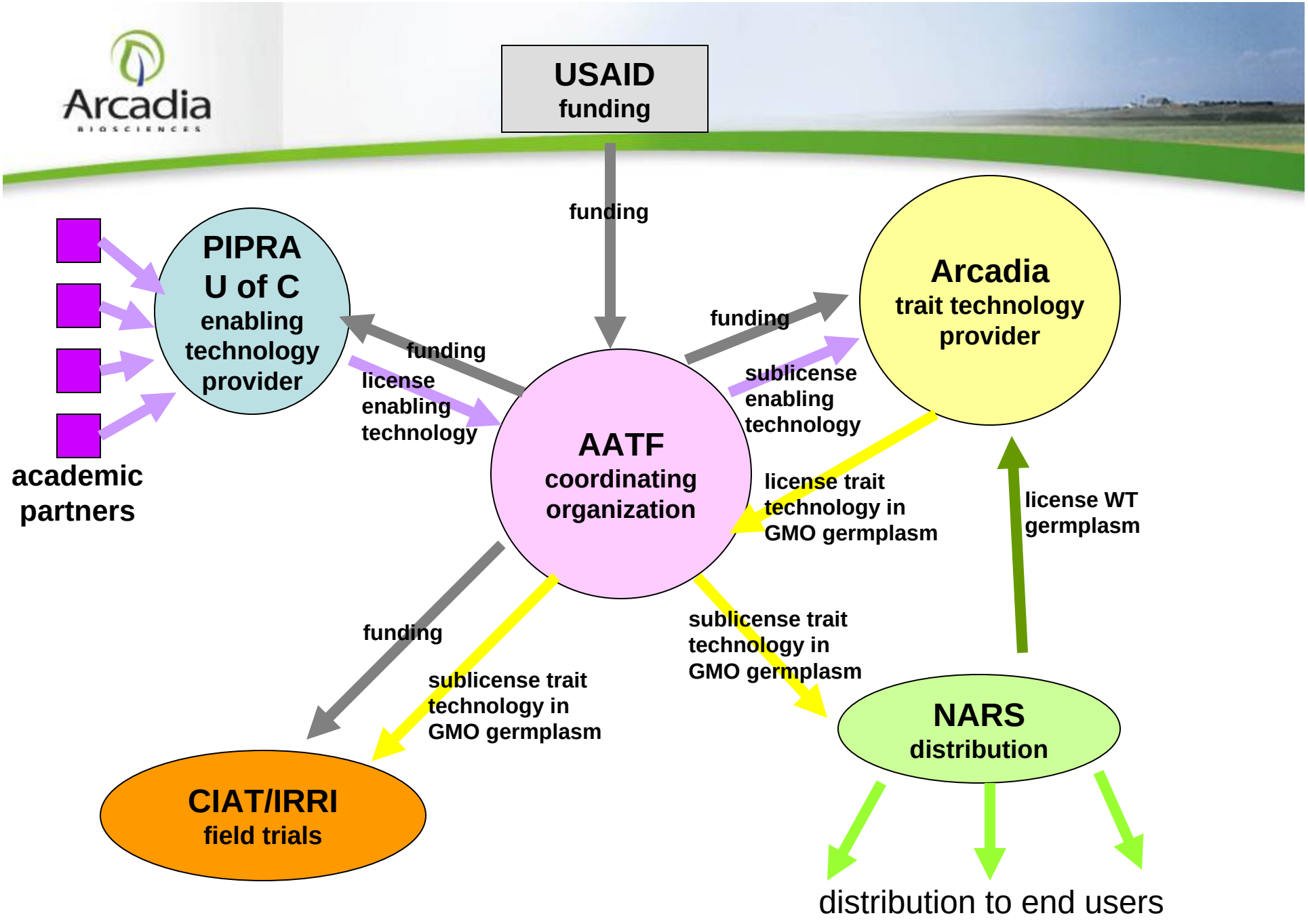
1. Adding value to Rice: NUE and Salinity tolerance
2. Technology Access strategy
3. IP and regulatory issues
4. Foster Partnerships
5. Institutional role for project implementation
6. Proposal development

Crossing African rice with Asian rice = NERICA



Upland NERICA development

NERICA in Davis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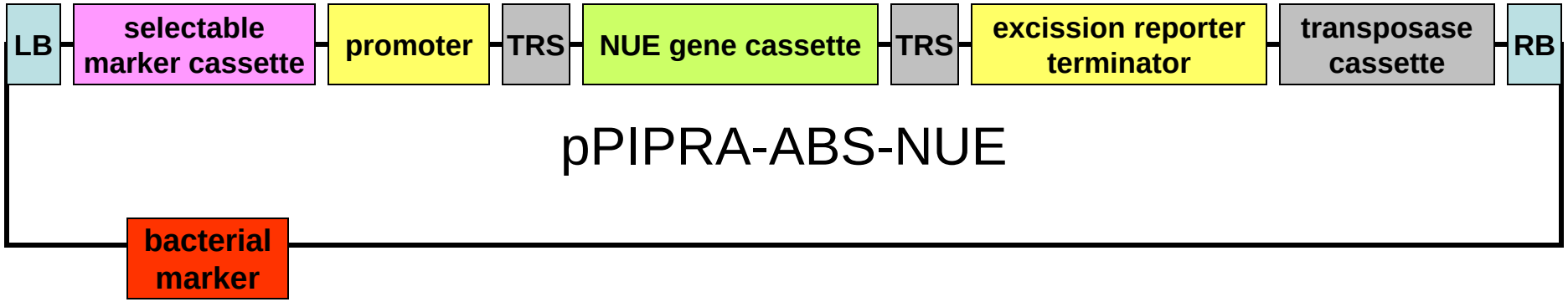
technology in
GMO germplasm
NARS
distribution
CIAT/IRRI
field trials
distribution to end users

AATF Project

Agrobacterium-mediated transformation of embryogenic Nerica calli



Summary

Nitrogen Use Efficient crops addressing large and diverse agricultural and human health markets:

- Technology proven in field trials
- Reducing water pollution and oceanic dead zones
- Reducing greenhouse gas emissions
- Boosting ‘greener” biofuel production
- Linking to an agricultural carbon credit and trading system
- Linking increased farm opportunities to environmental opportunities
- Collaborations with industry leaders
- Collaborations for non-profit spreading of technology for humanitarian purposes

Acknowledgements

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NAAFS (NingXia, China)

Greenhouse and growth chamber staff
Kendra Williams

Poster: **Nitrogen Use Efficiency in Canola and Arabidopsis**