Wisconsin Energy Institute
UNIVERSITY OF WISCONSIN-MADISON

Biomass in a Sustainable Land Use/Agro/Energy System

Gary Radloff
Director of Midwest Energy Policy Analysis
University of Wisconsin-Madison
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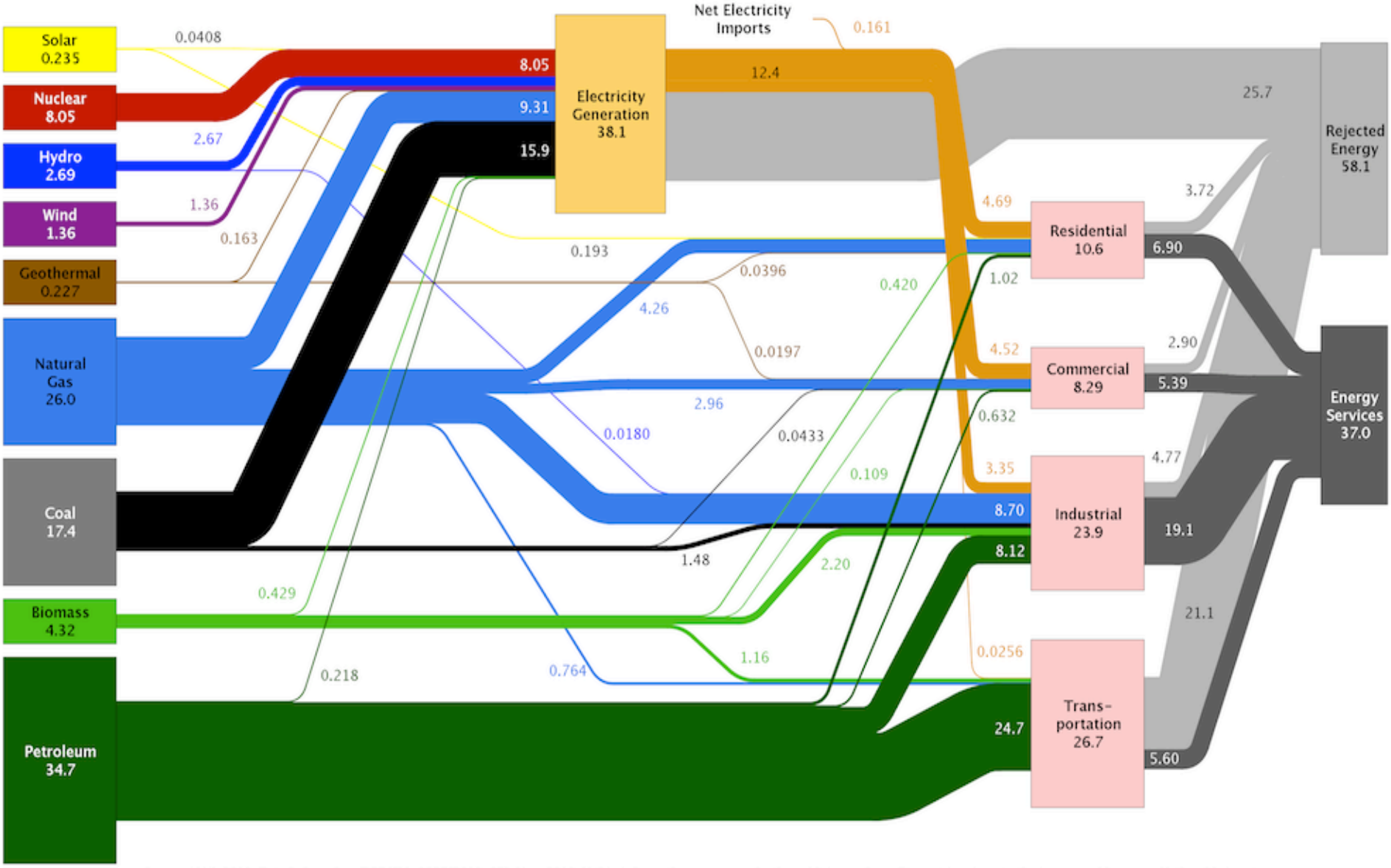
Theme and Topics

- Planning a transition to new energy economy
- To achieve the new energy economy will require steady steps of innovation. Focus must be on systems solutions and sustainability.
- Biomass is already WI leading renewable energy source. Have abundant supply for the future
- Biogas leading opportunity: On-Farm AD, Wastewater Treatment Plants AD, and Food waste Diversions, CHP combinations & thermal
- New Advanced Agro/Energy Systems.

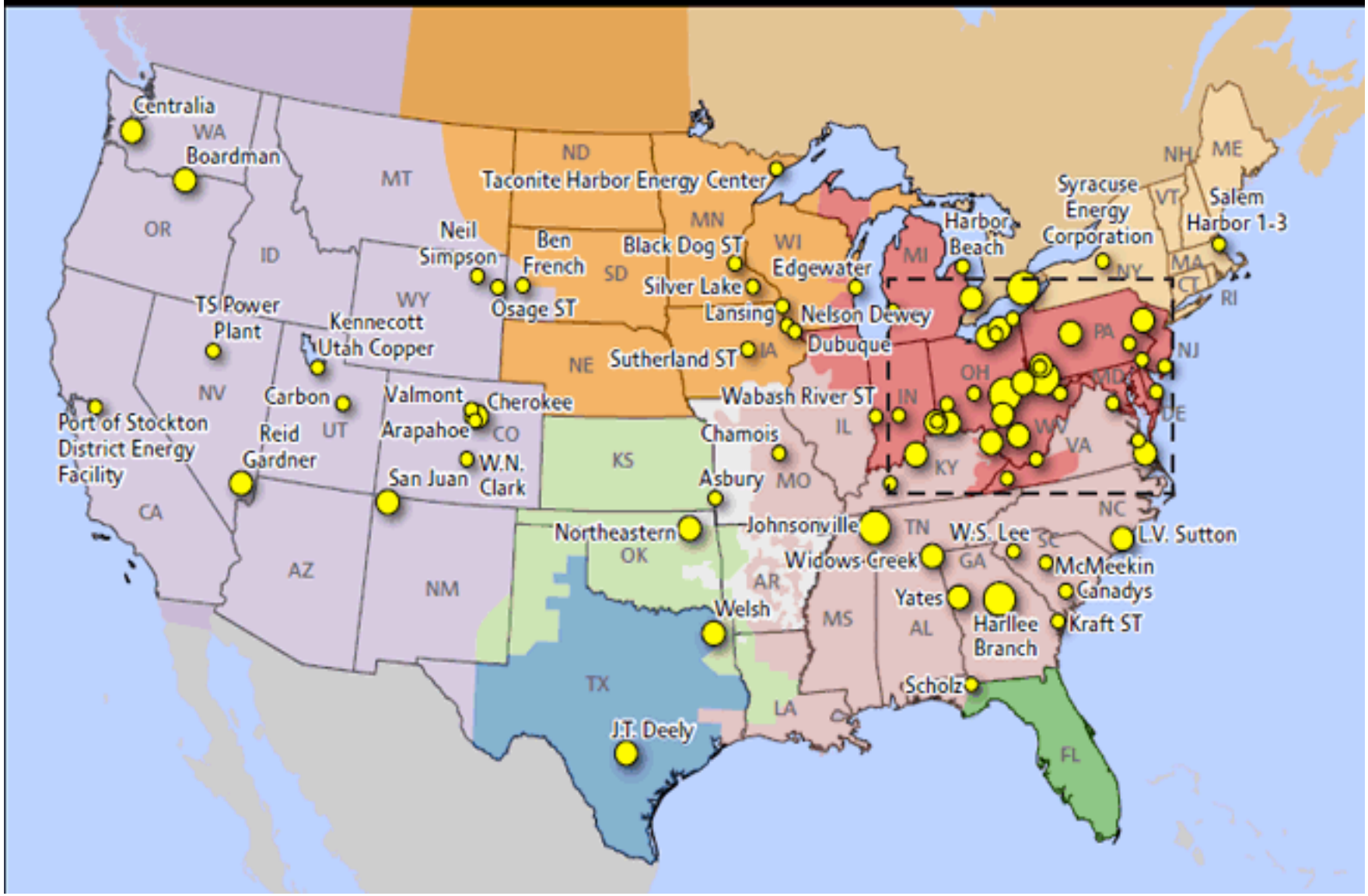
Estimated U.S. Energy Use in 2012: ~95.1 Quads

Lawrence Livermore National Laboratory

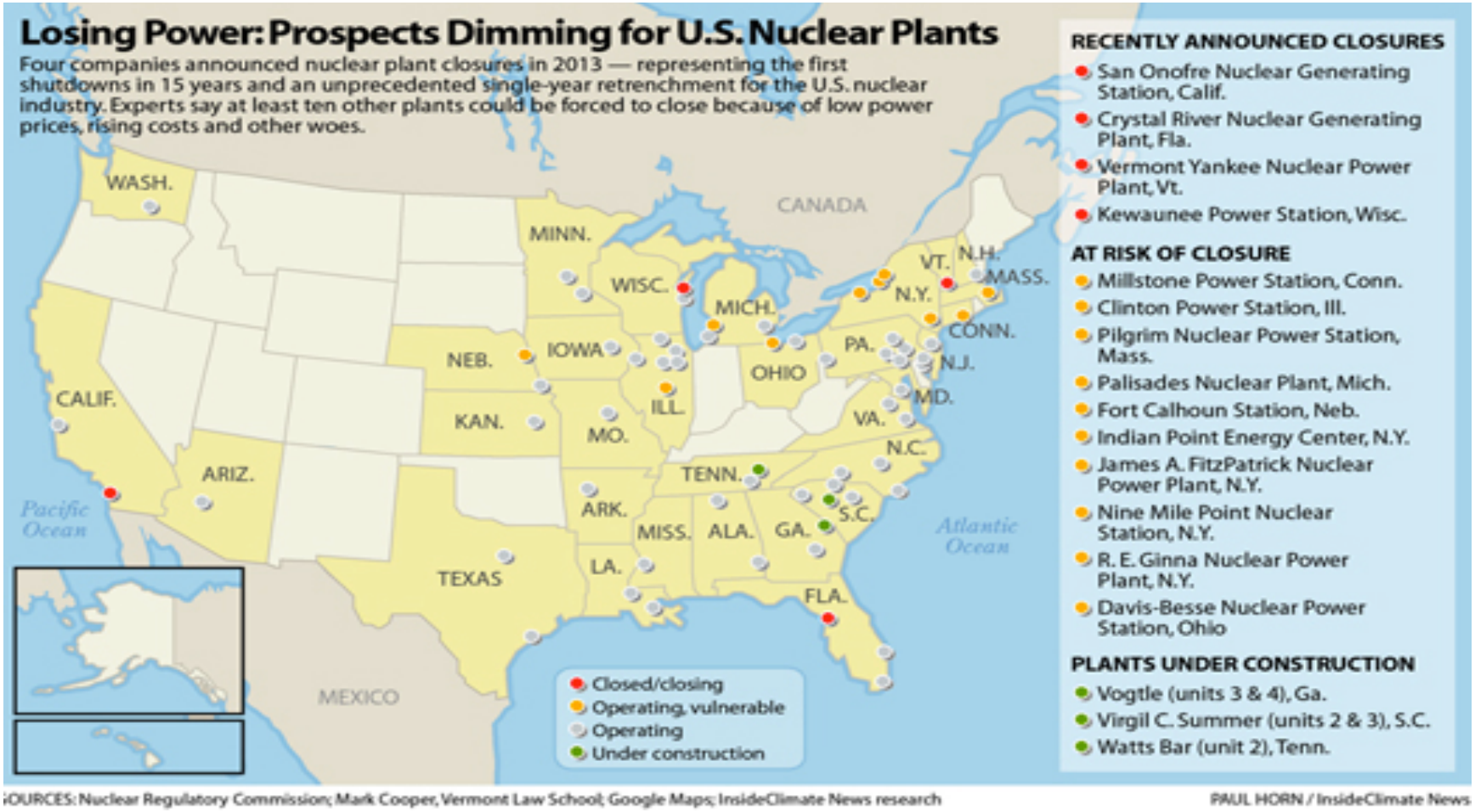


Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

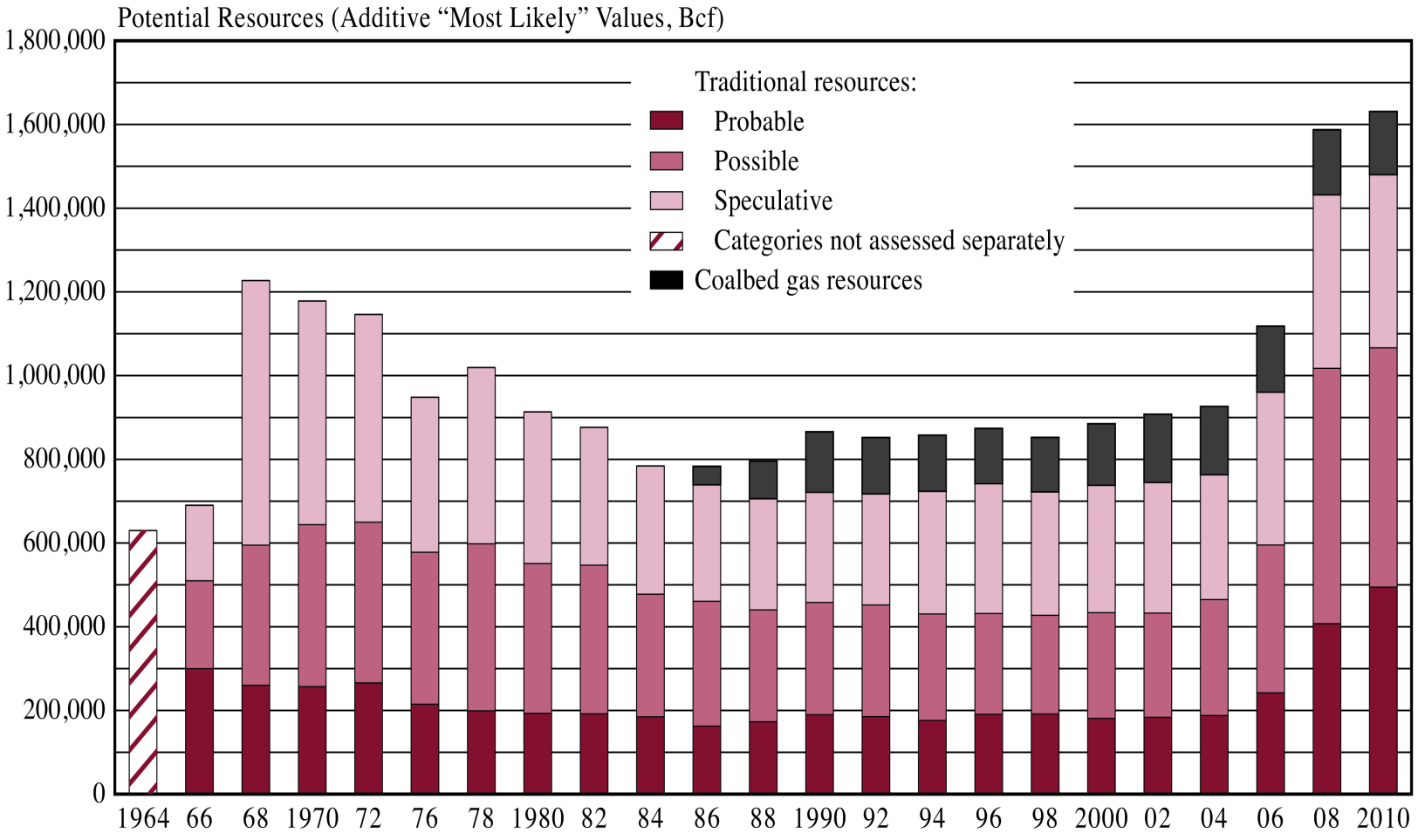
Planned coal capacity retirements 2013-2022



Nuclear Plant Closures

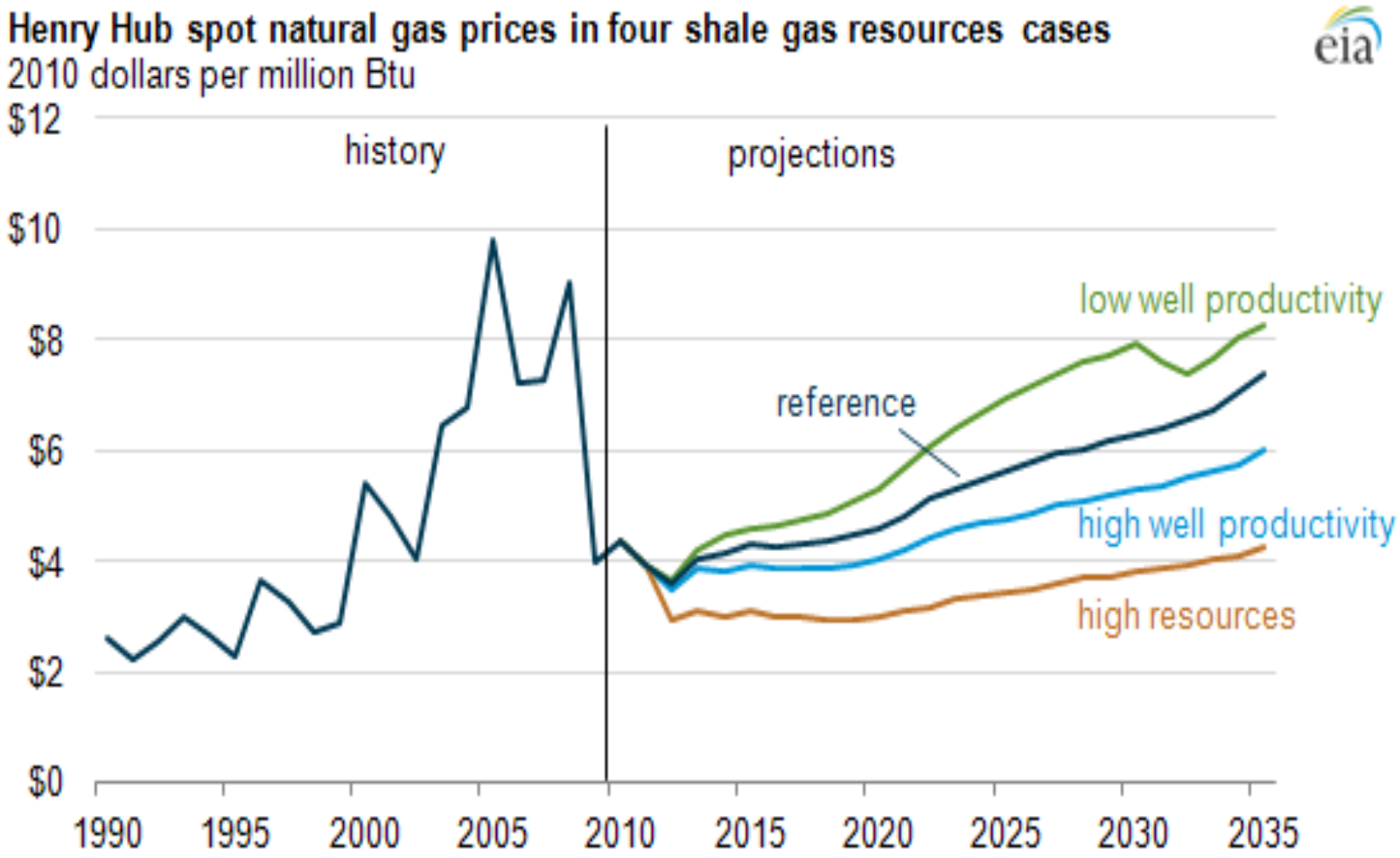


Natural Gas: How much really?



Source: Potential Gas Committee (2011)

We Don't Know the Future Costs?



Natural Gas is a Volatile Commodity

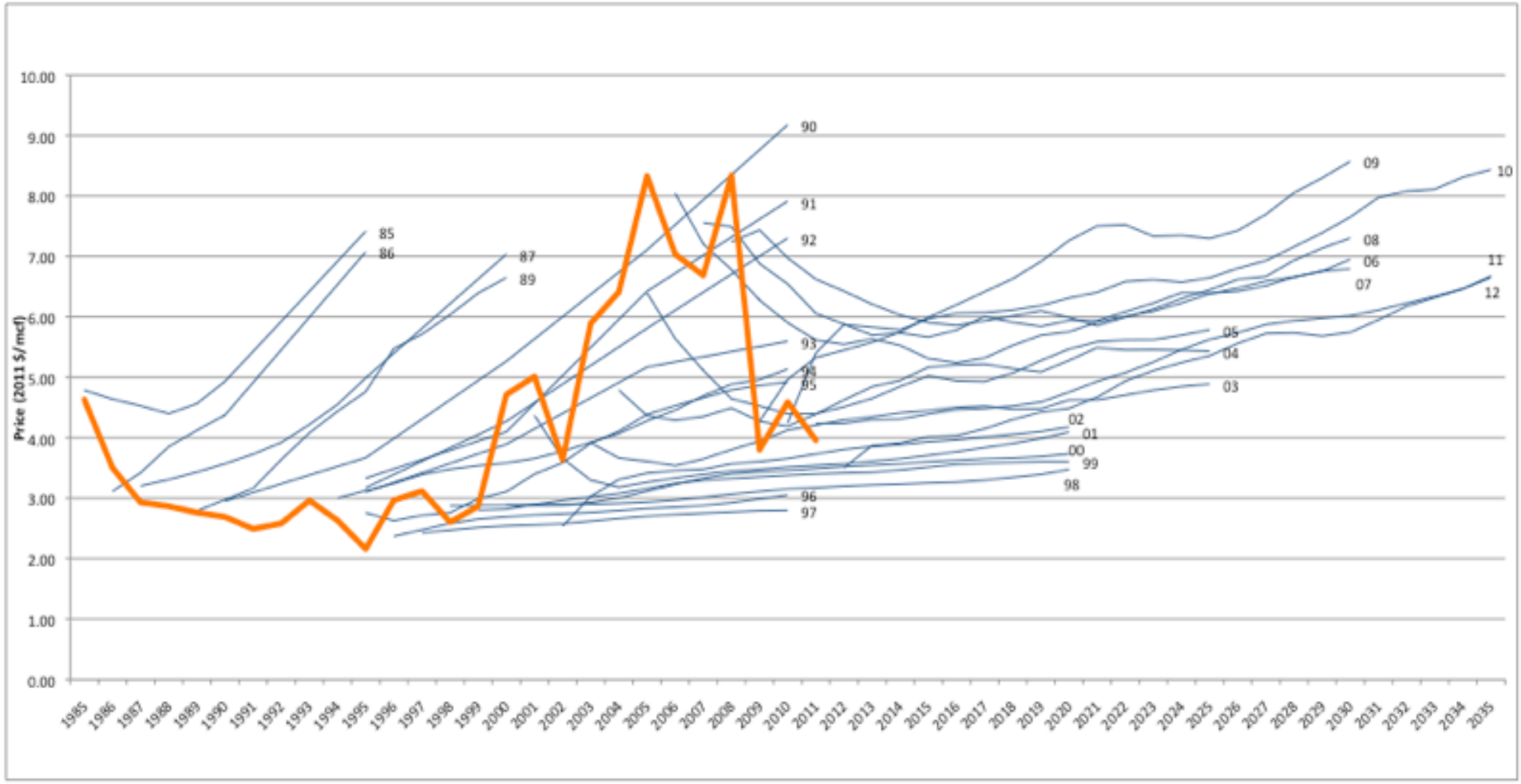
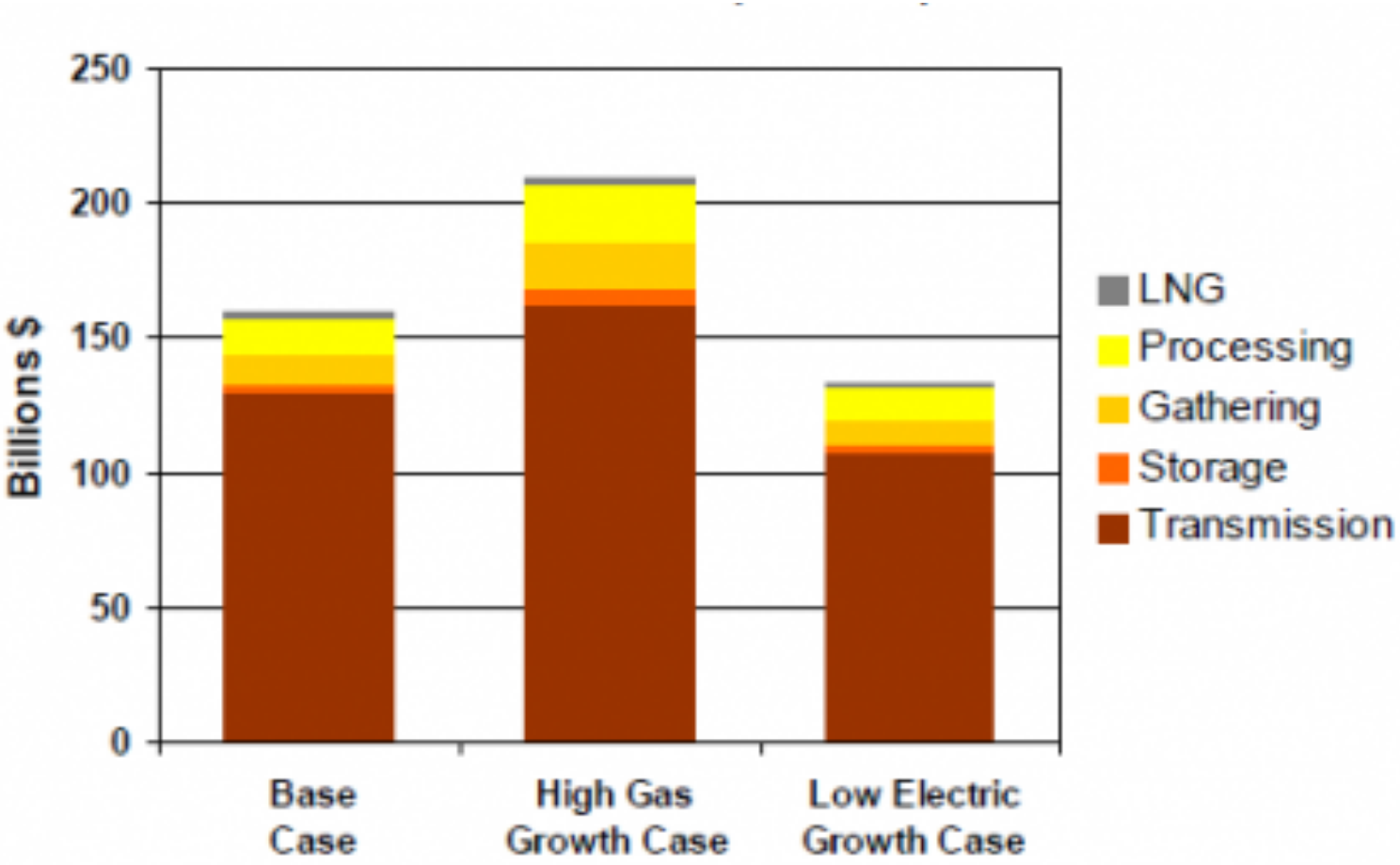


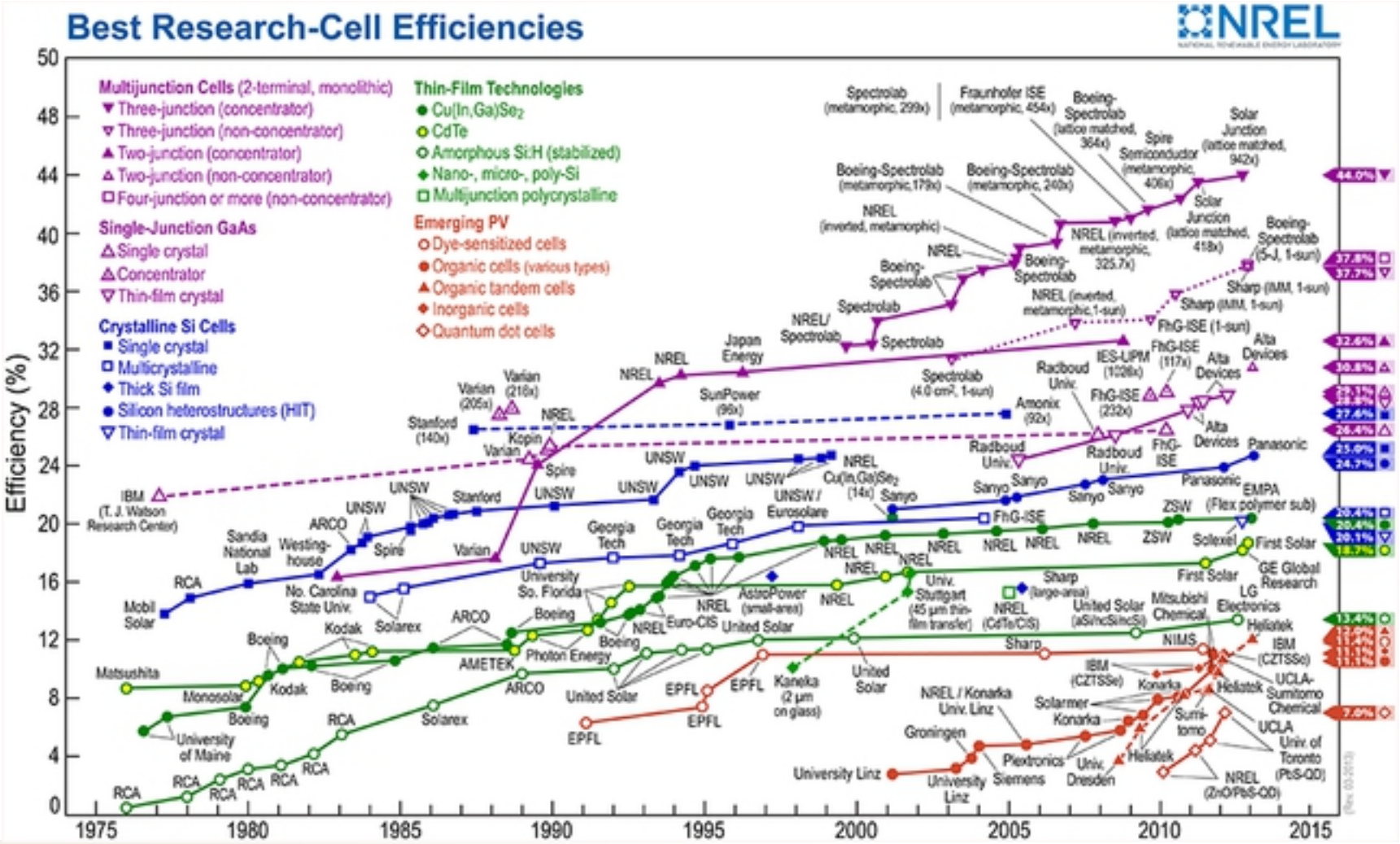
Figure: U.S. Energy Information Administration forecasts of U.S. wellhead natural gas prices, adjusted for inflation, in various years (blue lines) compared with actual prices (orange line).

$130 B to $ 210 B Infrastructure Needs

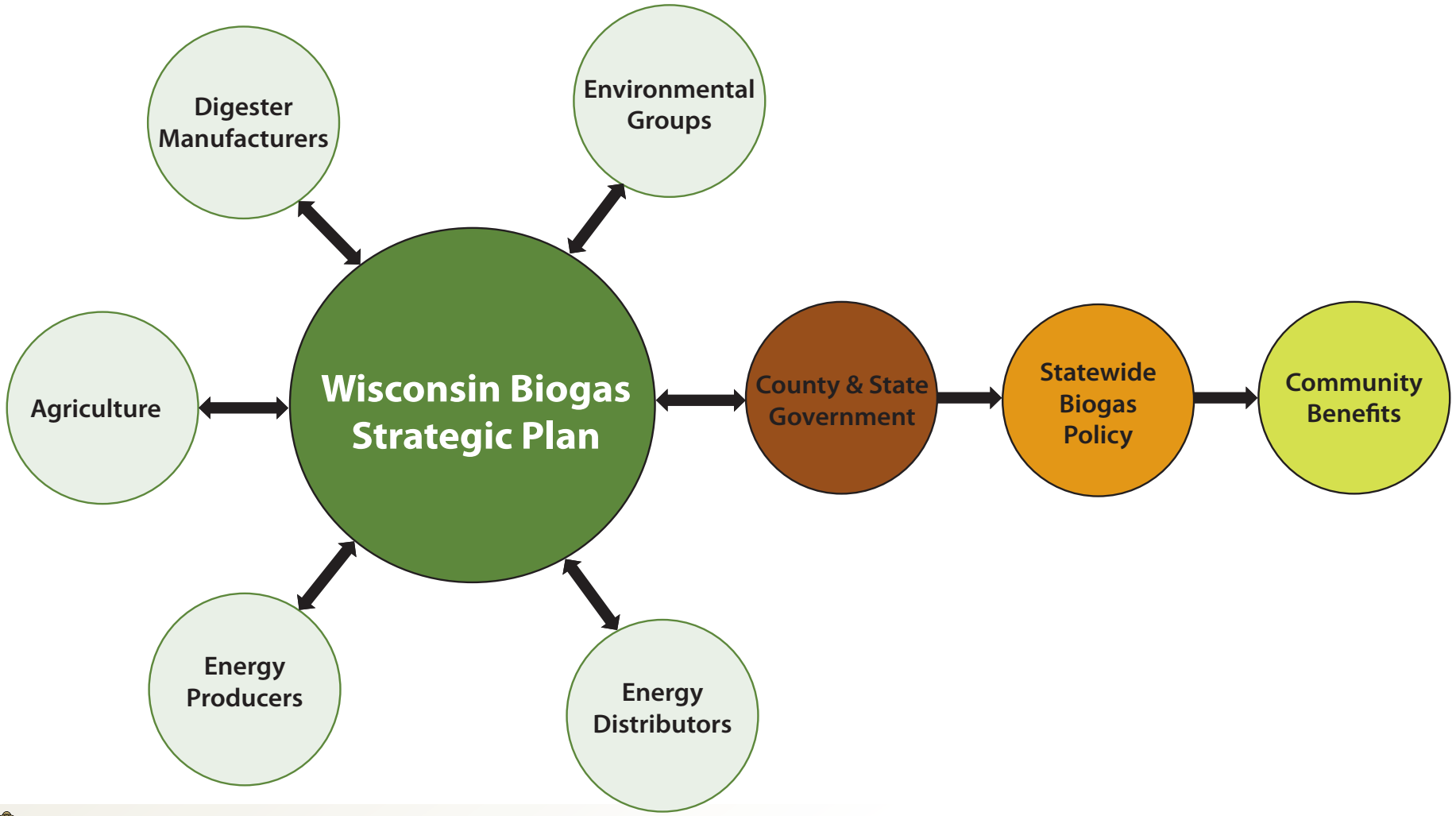
Source Interstate Natural Gas Association of America



Solar Technology Innovation (NREL)



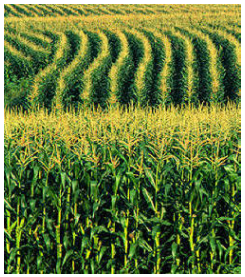
Wisconsin Biogas Stakeholder Communities



What is Biogas? – Inputs

Inputs → Biological Activity → Outputs

Manure



Substrates
- Corn Silage
- Wheat
- Grass

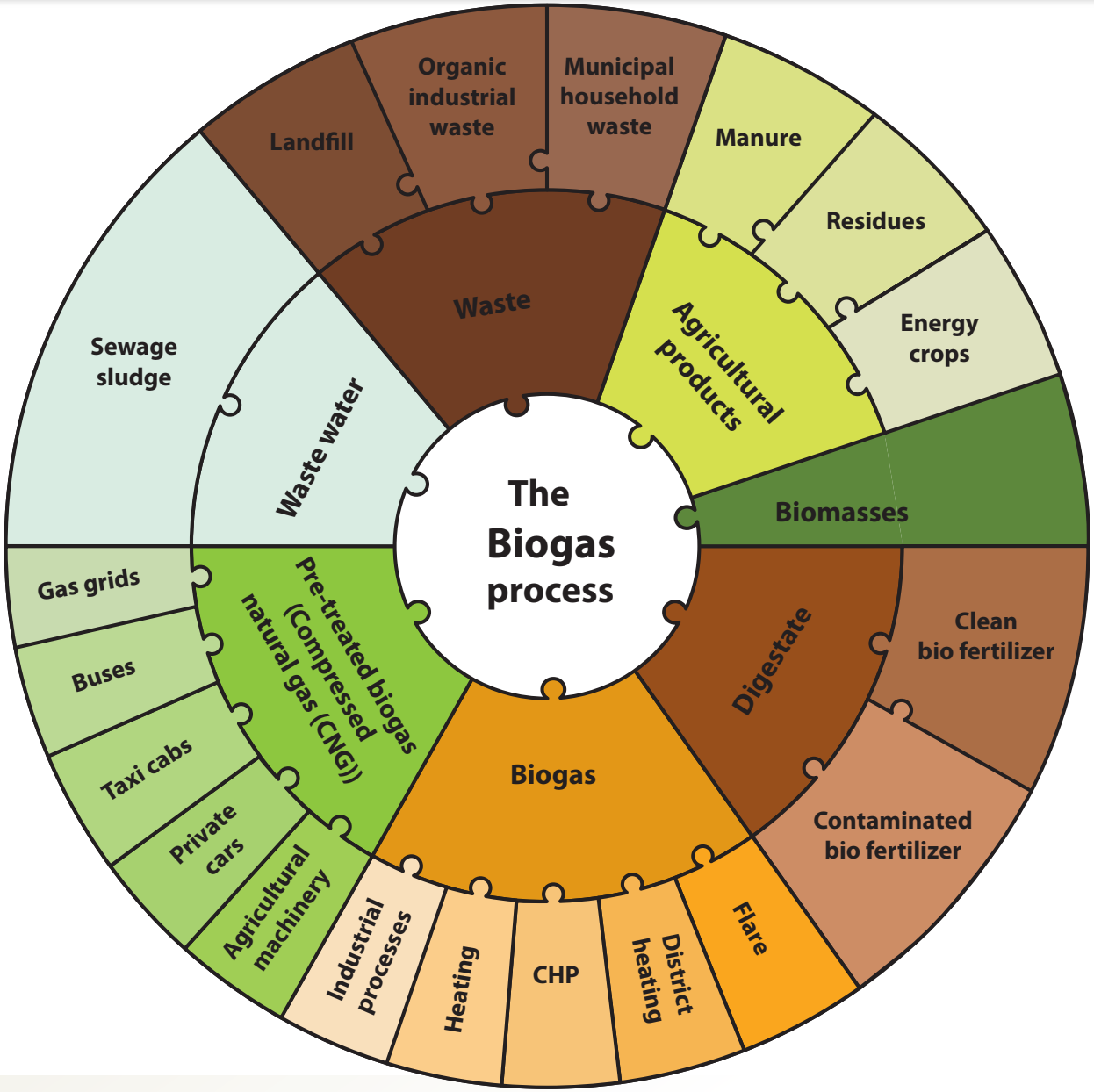
- Others

Anaerobic Digester

- *Microbes*
- *Heat*
- *No oxygen*

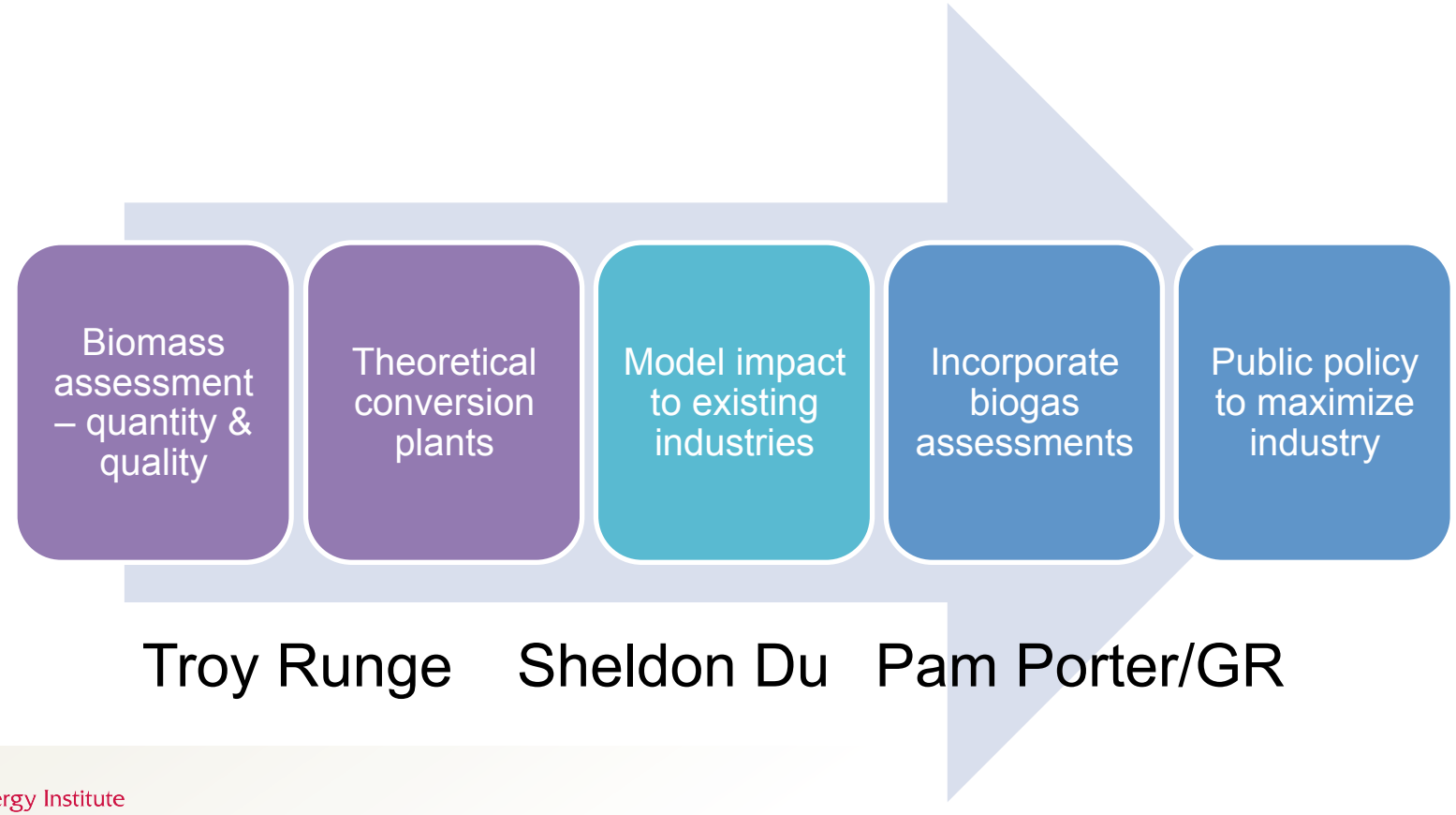
Digested Solids

Biogas (50-75% Methane)

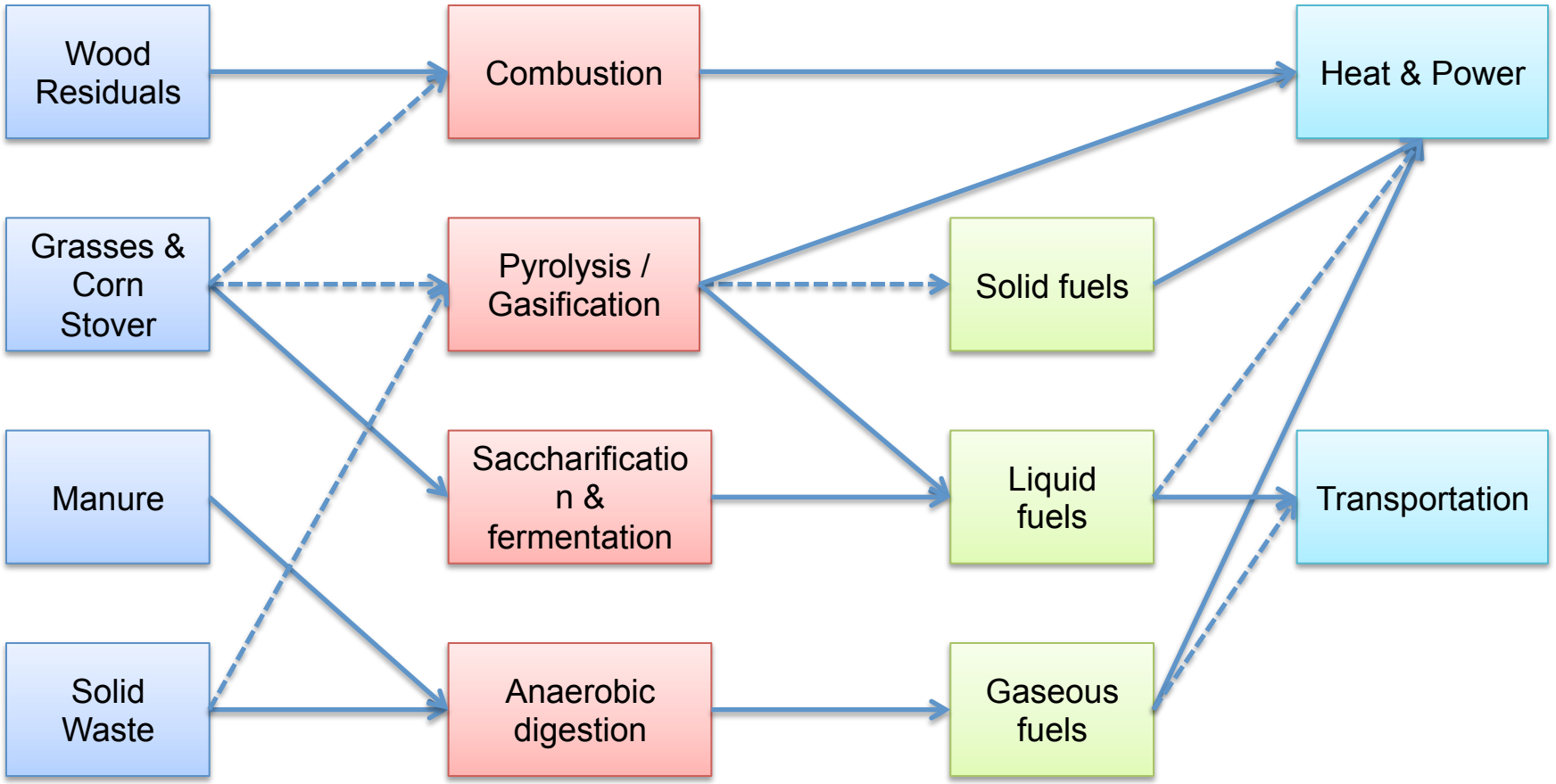

The Biogas process
Waste
Landfill
Organic industrial waste
Municipal household waste
Waste water
Sewage sludge
Biomasses
Agricultural products
Manure
Residues
Energy crops
Pre-treated biogas (Compressed natural gas (CNG))
Gas grids
Buses
Taxi cabs
Private cars
Agricultural machinery
Biogas
Industrial processes
Heating
CHP
District heating
Flare
Digestate
Clean bio fertilizer
Contaminated bio fertilizer

Biomass Assessment Methodology

- Understand linkage between feedstock and market opportunity



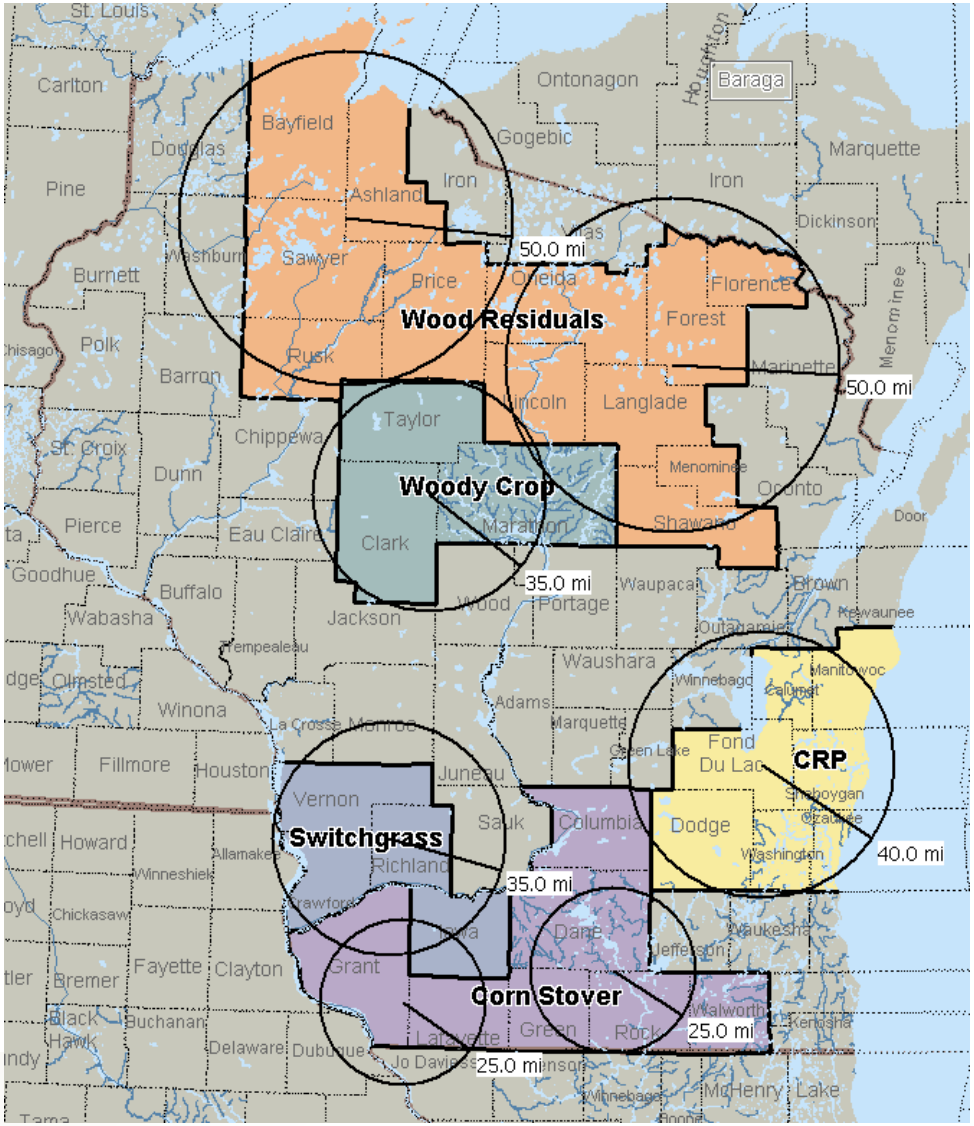
Simplified Conversion Pathways
Biomass to Energy/Fuels



Primary Secondary

Biomass Opportunities

- Identified top counties with biomass densities
- Looked for natural groupings
- Used circles to identify processing sites >200,000 tons/year



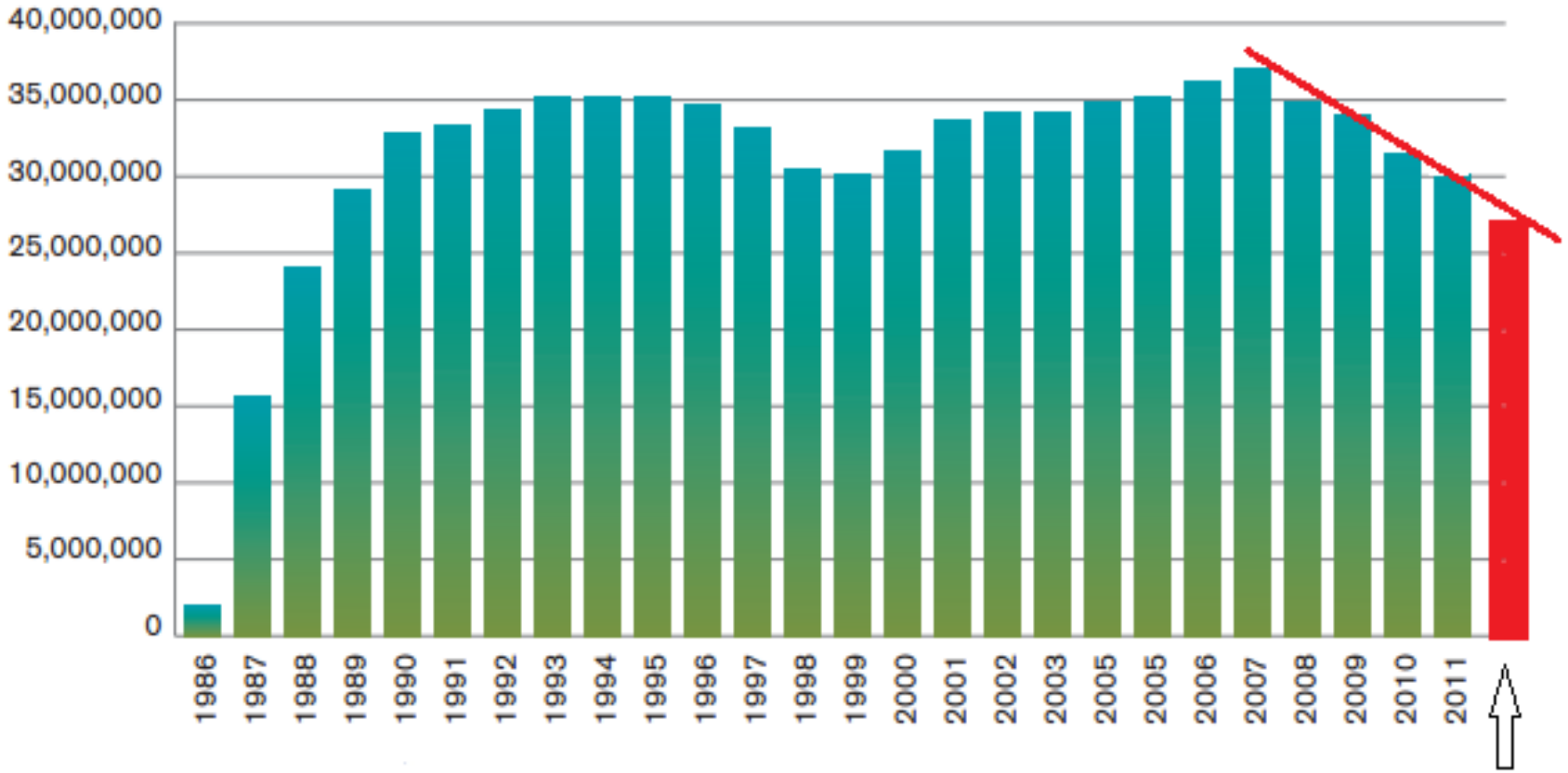
Adding it up

Biomass Type -	Mass (MM Dry Tons/yr)	Energy (MMBtu/yr)
Wood harvest residuals	1.46	1.90×10^7
Unused processing residuals	0.03	3.90×10^5
Corn stover	2.81	3.65×10^7
Dairy manure	4.77	2.39×10^7
Wood energy crops	2.29	2.98×10^7
Additional wood harvest	1.40	1.82×10^7
Perennial grasses from marginal land	3.14	4.08×10^7
Total	15.9	[a] 1.69×10^8
Wisconsin Consumption		1.68×10^9

[a] Could offset 10 million tons of PRB coal and 18 million tons of CO_2 emissions

Total Acres Enrolled in CRP 1986 - 2012

CRP acres have fallen 26%, or 9.7 million acres in 5 years Since Ethanol Mandate

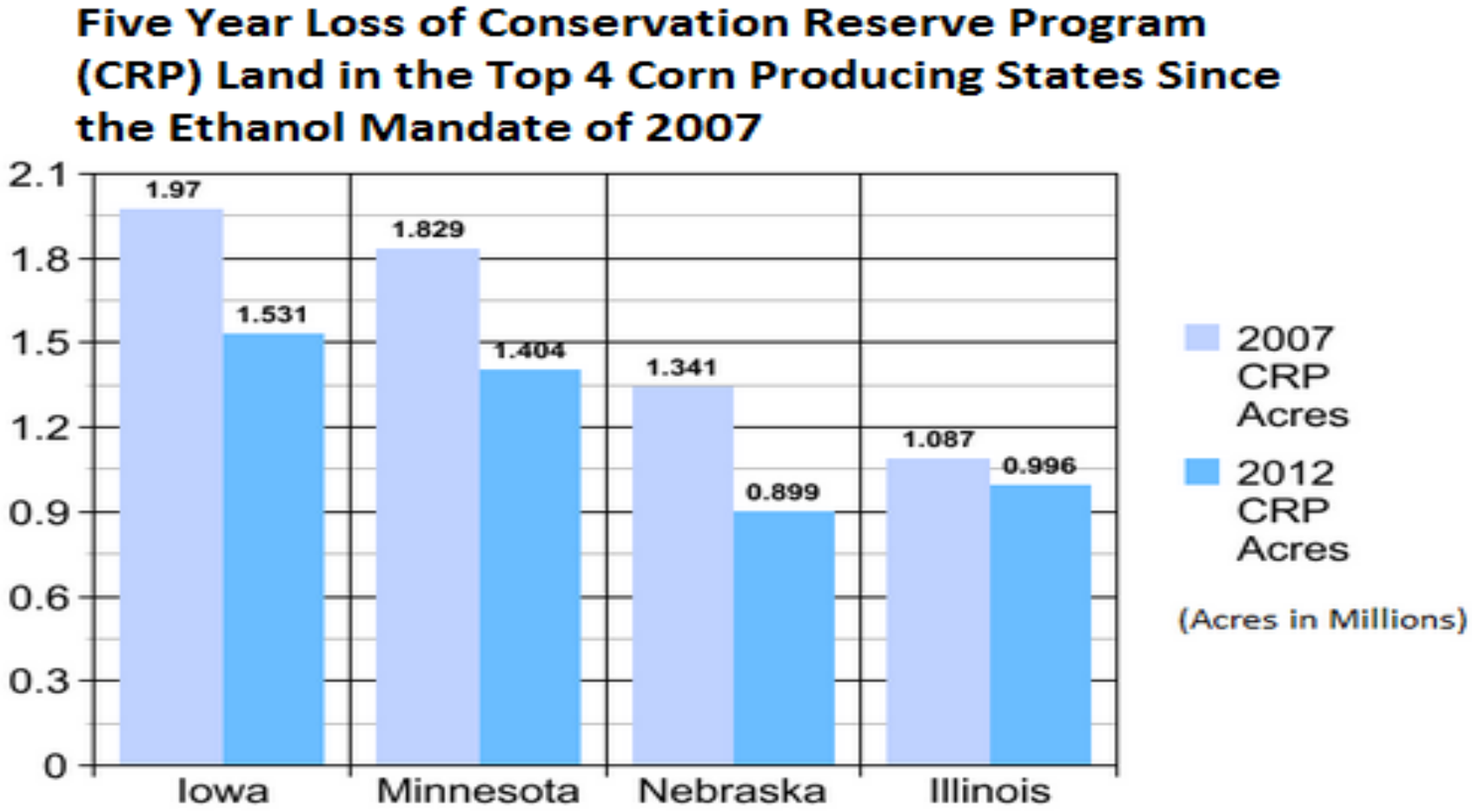


Note that 2007 was the year of passage of the "Energy Independence and Security Act of 2007" which set the renewable fuel standard mandating the use of corn ethanol to a level which now uses more than 40 percent of the corn crop produced in the U.S.

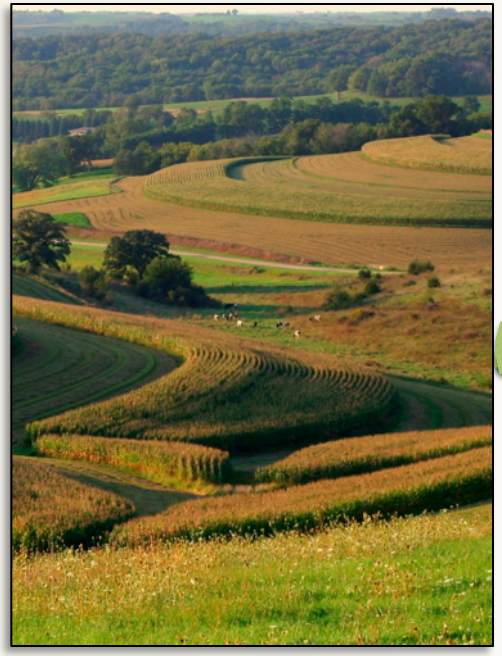
Source: USDA Data.

CRP Land Loss Since 2007

(Source USDA)



Landscape “services”



- Energy and Economy

- Air Quality

- Water Quality

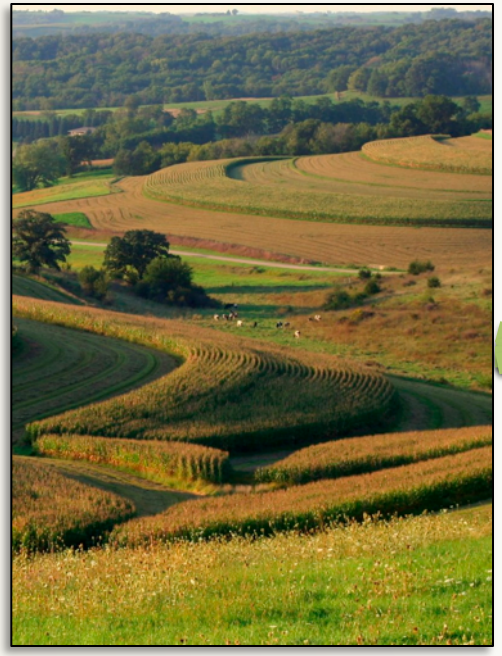
- Soils

- Food

- Human Communities

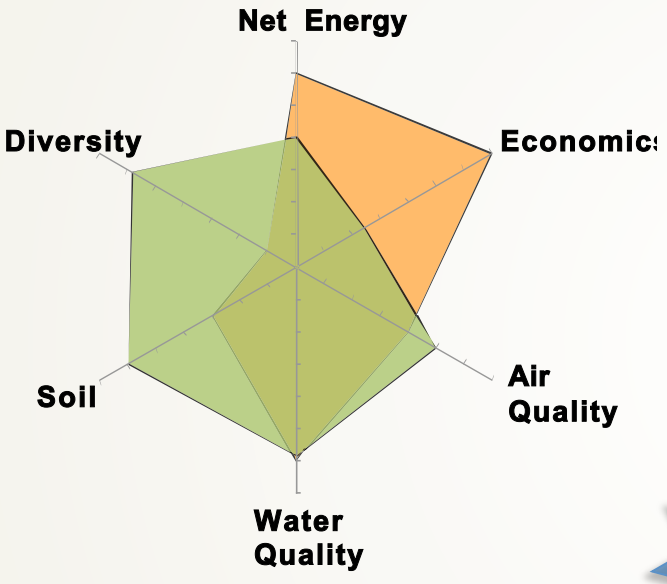
- Natural Communities

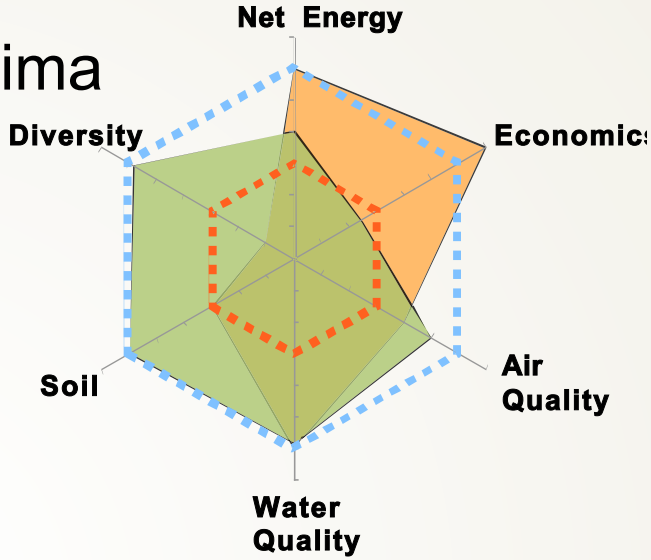
Landscape “services”



Provisioned by Landscape	Metric	Model
Energy and economy		
Biomass production	crop yield	EPIC
Income generation	crop yield and crop price	EPIC
Carbon credit income	carbon sequestration	EPIC
Non-renewable resource use	fossil fuel, phosphate	LCA
Air Quality		
greenhouse gas balance	CO2, CH4, N2O flux	EPIC
particulate production	particulate pollution rates	
pesticide inhalation	pesticide amount x EIQ	
Water Quality		
Crop water use efficiency	yield per unit ET	EPIC
Nutrient leaching	NO3, PO4 leaching	EPIC
Nutrient runoff	NO3, PO4 runoff	
Pesticide hazards - leaching	pesticide amount x EIQ	
Pesticide hazards - runoff	pesticide amount x EIQ	
Soils		
erosion potential	erosion rate	InVEST
soil organic matter	soil organic matter	EPIC
pesticide residues	pesticide amount x EIQ	
healthy soil structure	soil compaction	
Food		
Pollination potential	pollination services	GIS
Pest control potential	biocontrol services	GIS
Human communities		
Recreational resources	area of recreational habitat	GIS
Aesthetic beauty		
Educational and inspirational resources	area of natural habitat	GIS
Generational replacement		
Natural communities		
Alpha biodiversity	plant diversity, insect diversity, bird diversity, microbes	GIS
Beta biodiversity	landscape diversity	GIS
Rare species habitat	rare species life history	GIS

- Establish minima or ideals





- Sustainability Index

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Many Collaborators & Advisors to Thank

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Contact Information

Gary Radloff
Wisconsin Energy Institute
University of Wisconsin-Madison
gradloff@energy.wisc.edu
608-890-3449
http://energy.wisc.edu/about/people/radloff