

CO₂ Sources for Enhanced Oil Recovery

Presented at the CO₂ EOR Conference, Midland Texas

Presented by Phil DiPietro

December 7, 2011

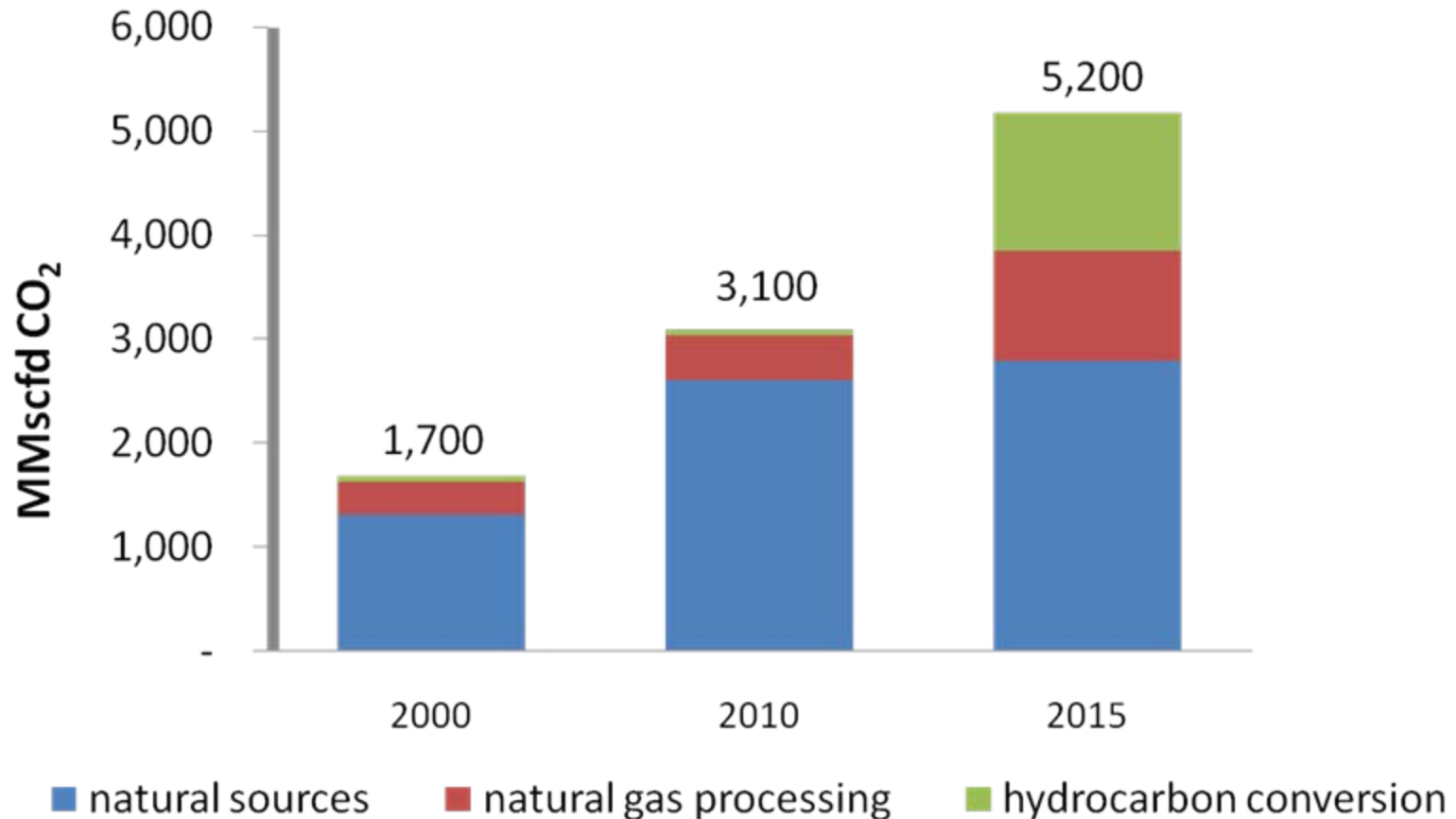
Sources of CO₂

Compile information on sources of CO₂ for enhanced oil recovery projects in the United States

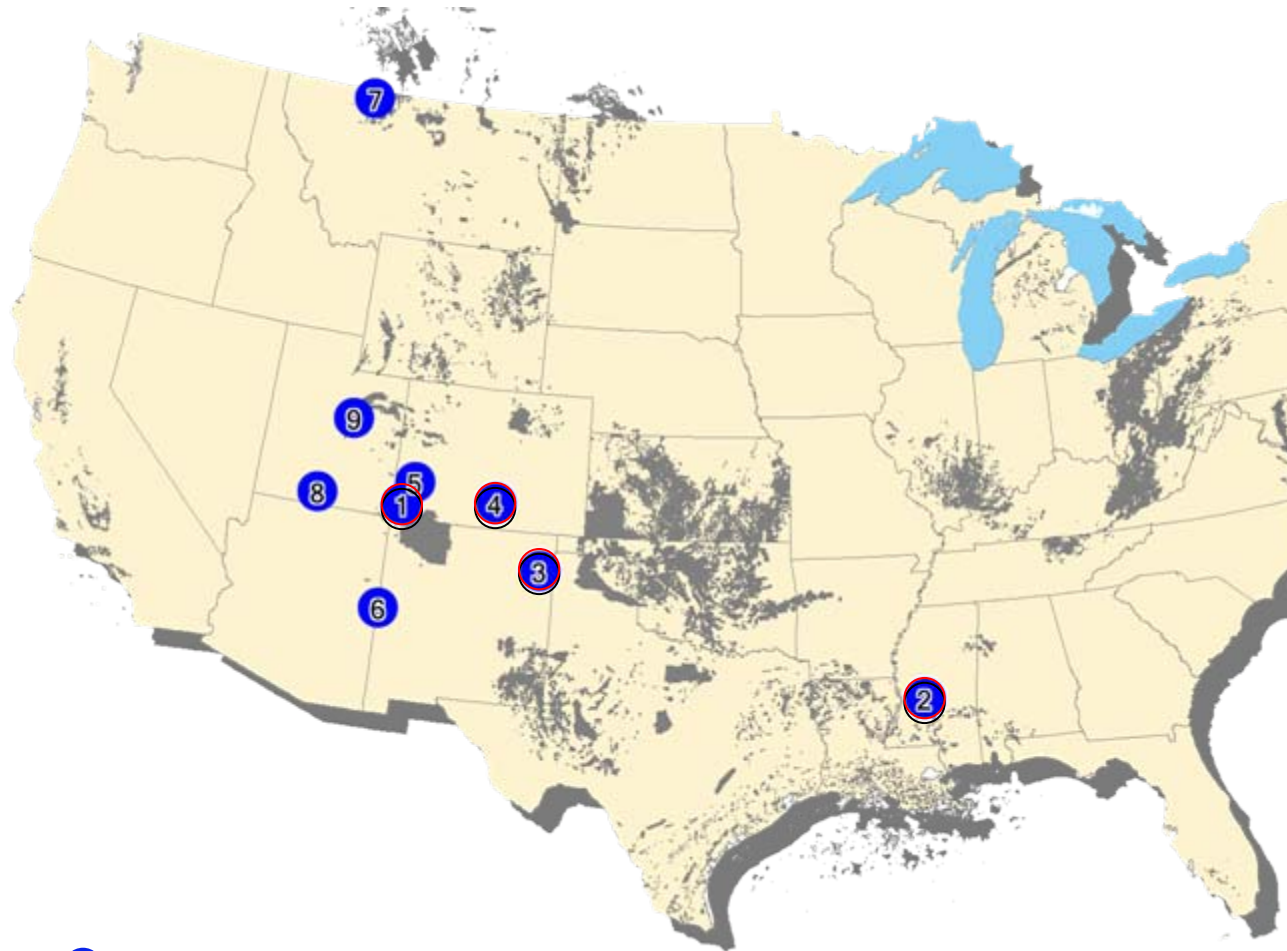
Use publically-available information: company financial reports, technical journals, newspaper articles, etc.

Objective: (1) inform policymakers, others and (2) understand a market that is of strategic interest to DOE

Sources of CO₂ Supply for Enhanced Recovery Operations in the United States



Natural CO₂ Resources in the United States



● Natural Sources
 ■ Oil & Gas Fields*

Unconventional Accumulations			
	Reserve TCF	2010 Prodn, MMscf/d	
1	McElmo	10	1,150
2	Jackson	10	930
3	Bravo	8.0	290
4	Sheep		35
5	DOE Canyon	0.8	100
6	St. John's	8.2	100
7	Kevin	0.7	0
8	Escalante	1.5	0
9	Gordon Creek	1.0	0
Total		40	2,600



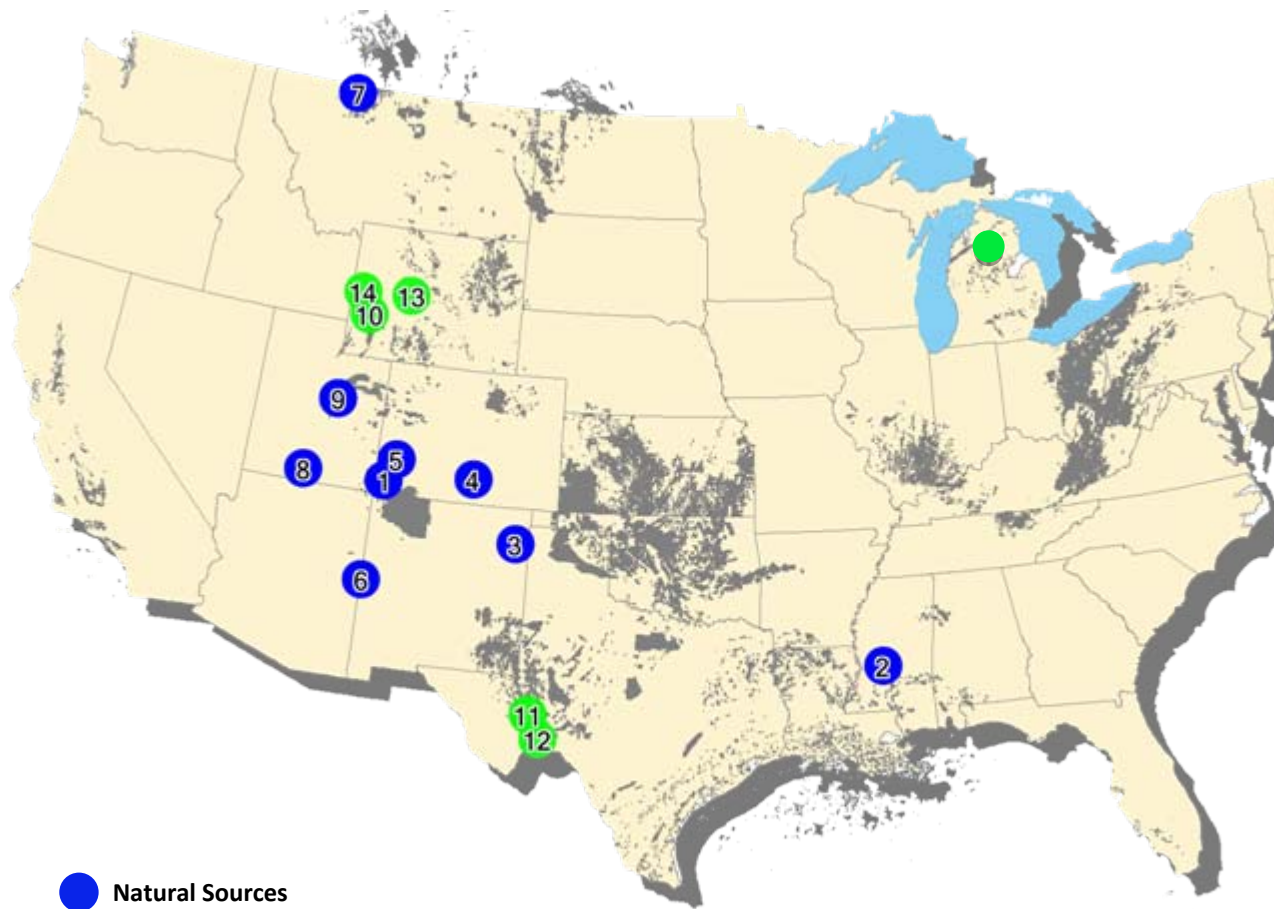
Natural Sources of CO₂ in the United States

	Formation name	Operator	Current CO ₂ Reserves (TCF)	Production Rate, MMscfD		2010 Production, % of Reserves
				2000	2010	
In Production	McElmo Dome	KM/ ExxonMobil	10	840	1,150	4.2%
	Jackson Dome	Denbury	10	55	930	3.4%
	Bravo Dome	KM/Oxy/Hess	8	350	290	1.3%
	Sheep	Oxy	Nearly depleted	70	35	
Under Development	Doe Canyon Deep	KM	0.75	0	100	
	St. John's	KM	8.2	0	100	
	Kevin Dome	Vecta	0.7	0	0	
	Escalante Anticline		1.5	0	0	
	Gordon Creek	Thunderbird	1.0	0	0	
Total			40	1,300	2,600	2.4%

Divide MMscfd by 51.69 to get MMmtCO₂/yr; Multiply TCF by 53 to get MMmtCO₂



Underground CO₂ Resources in the United States



- Natural Sources
- Natural Gas Processing
- Oil & Gas Fields*

Unmixed Accumulations			
		Reserve TCF	2010 Prodn, MMscf/d
1	McElmo	10	1,150
2	Jackson	10	930
	Pravo	8.0	290
	Sheep		35
	DOE Canyon	0.8	100
6	St. John's	8.2	100
7	Kevin	0.7	0
8	Escalante	1.5	0
9	Gordon Creek	1.0	0
Subtotal		40	2,605
Natural Gas Processing			
10	LaBarge	55	300
11	Century		0
12	TGRMP		75
13	Lost Cabin		50
14	Riley Ridge	2.4	0
Subtotal		57.4	425
Total		97.4	3,030

Natural Gas Processing Facilities with CO₂ Capture

Facility name (owner)	Owner	Year online	CO ₂ conc. in source gas	CO ₂ reserve estimate, TCF	Production rate, MMscfd	
					2010	2015
LaBarge	Exxon Mobil	1963	65%	55	300	360
Century Plant	Oxy/ Sandridge	2011	65%		0	450
Terrell, Grey Ranch, Mitchell, and Puckett	Sandridge Energy Inc.	1998			75	75
Lost Cabin	Conoco Phillips				50	50
Riley Ridge	Denbury	2012	65%	2.4	130	130
Total				57.4	425	1,065

Produced gas contains Helium

Revenues for Natural Gas Processing with CO₂ Capture

Produced gas component	Concentration	Market Price (plant gate)	Revenues, \$/Mscf produced gas
Natural gas	29%	4 \$/mmbtu	1.2
Helium	0.6%	150 \$/Mscf	0.9
CO ₂	65%	10 \$/mtCO ₂	0.34
Other	5%	-	-

Information Sources : EIA well head price for Natural Gas, USGS helium commodities report, average produced gas composition from Labarge and Century

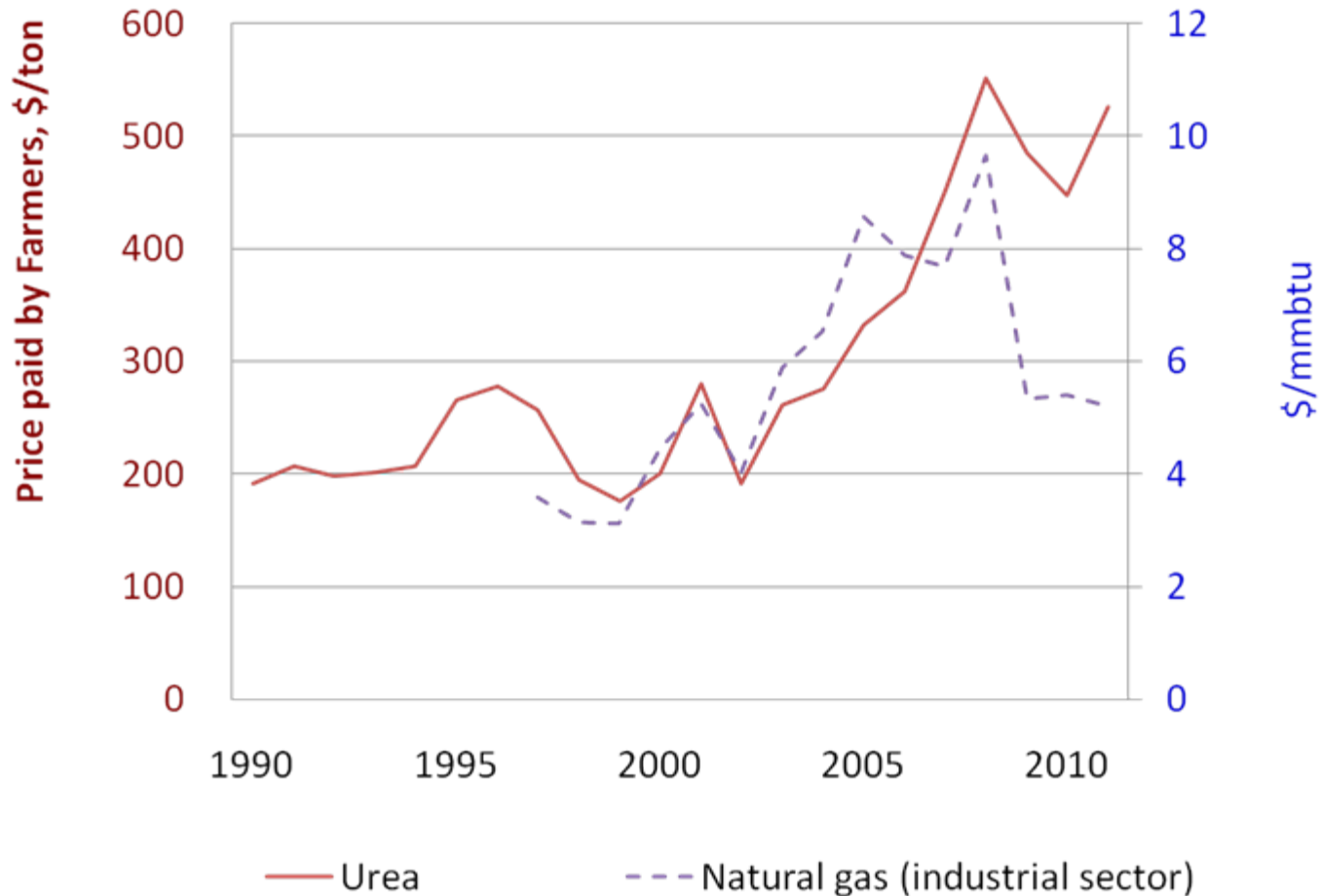
Industrial Processes w/ CO₂ Capture in the United States

Owner (location)	Product	online year	CO2 Supply	Total
Agrium (TX)	Ammonia/Urea	1980	0.5	1.2
Koch Nitrogen (OK)	Ammonia/Urea		0.7	
Green Rock Energy (LA)	Ammonia/Urea	2011	4.0	8.2
Bonanza Energy (KS)	Ethanol		0.2	
ZEEP/Eastman (TX)	Hydrogen		4.0	
CVR Energy (KS)	Ammonia/Urea	2013	0.8	1.8
Air Products (TX)**	Hydrogen		1.0	
Summit (TX)	Power/Urea	2014	2.4	5.1
Mississippi Power (MS)**	Power		2.7	
NRG (TX)	Power	2015	1.4	9.3
Leucadia (LA)	Methanol		4.0	
DKRW (WY)	FT Liquids		3.9	
SCS Energy/HECA (CA)	Power/Urea	2017	2.3	2.3
			Total	28

Projects in blue are receiving DOE cost share funding for the capture portion

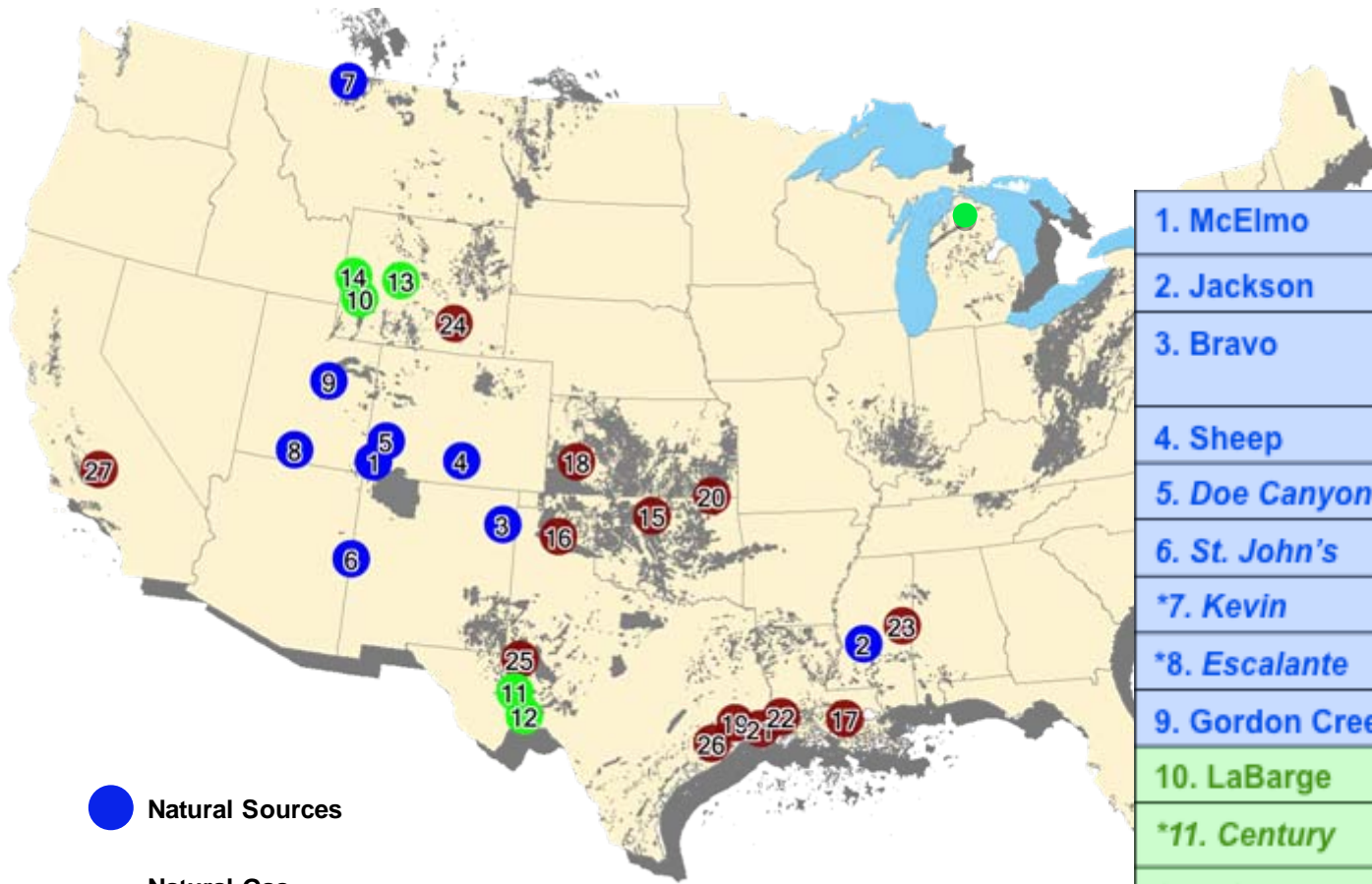
** under construction

Prices for Fertilizer, Power, and Natural Gas



Source: US Department of Agriculture, Economic Research Service, <http://www.ers.usda.gov/Data/FertilizerUse/> U.S. Department of Energy, Energy Information Administration, Electricity and natural gas prices to ultimate customers, industrial sector. Divide by 2.93 to convert power price to cents/kWh.

Sources of CO₂ for Domestic EOR Floods



● Natural Sources

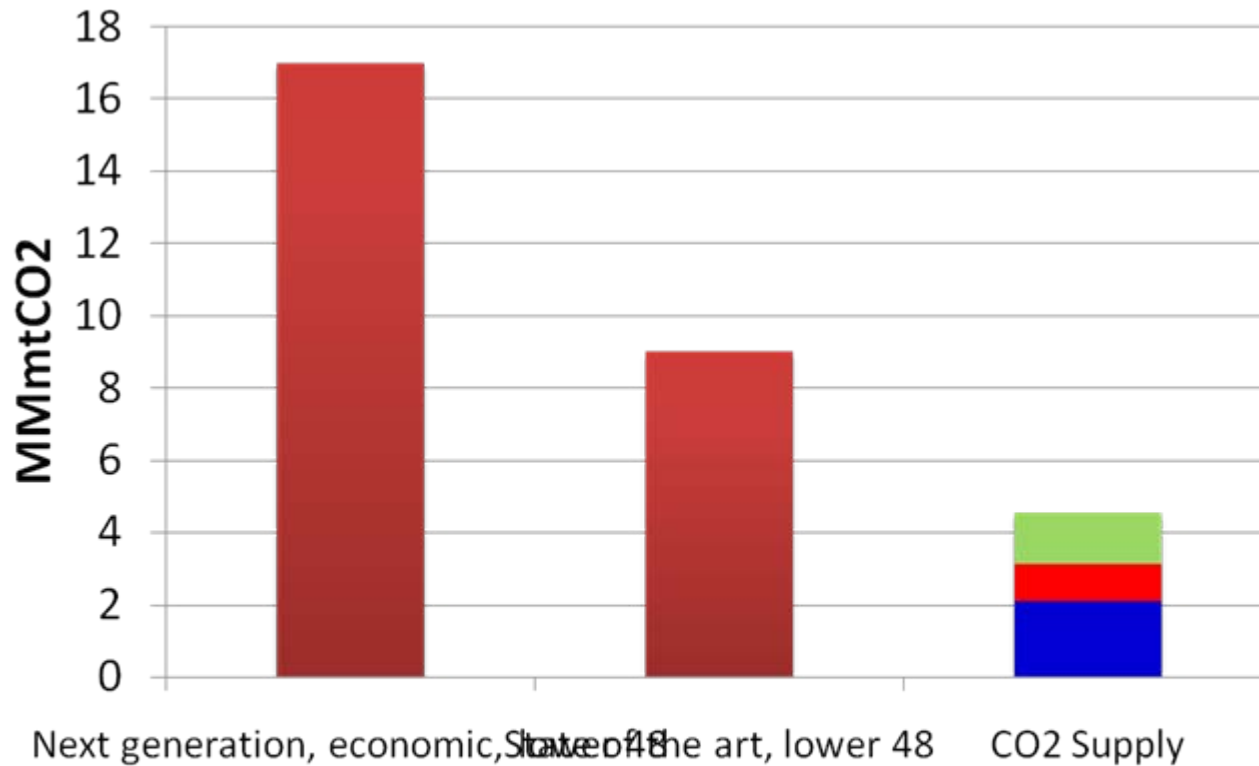
● Natural Gas Processing

● Hydrocarbon Conversion

■ Oil & Gas Fields*

1. McElmo	15. Koch Nitrogen
2. Jackson	16. Agrium, Inc.
3. Bravo	*17. Green Rock Energy
4. Sheep	*18. Bonanza Energy
5. Doe Canyon	*19. ZEEP/Eastman
6. St. John's	*20. CVR Energy
*7. Kevin	*21. Air Products
*8. Escalante	*22. Leucadia Energy
9. Gordon Creek	*23. Mississippi Power
10. LaBarge	*24. DKRW
*11. Century	*25. Summit Texas
12. TGRMP	*26. NRG
13. Lost Cabin	*27. HECA
14. Riley Ridge	

CO₂ Supply and Demand



Actions Going Forward

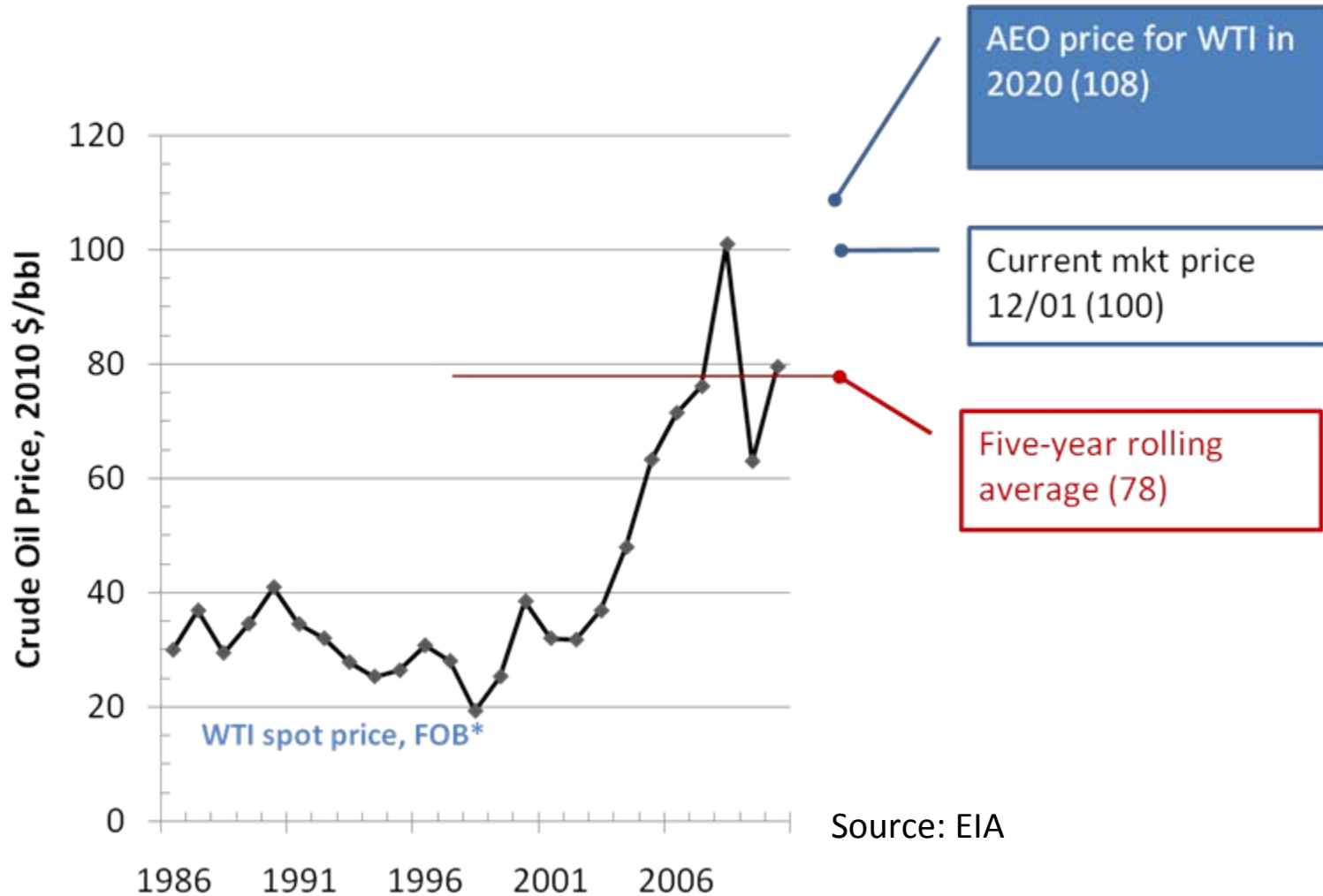
- Consistency of data
 - Reserve estimates for natural sources
 - Progress toward deployment for industrial sources
- Expand scope to include North America
- Continually update and revise, move to internet application with two way information flow

Thank you!

Sources of CO₂

- 1. Natural sources** – naturally-occurring underground accumulations where the produced gas is primarily CO₂ (90% or higher).
- 2. Natural gas processing** – naturally-occurring underground accumulations where the produced gas contains significant amounts of methane.
- 3. Hydrocarbon conversion** – industrial processes in which a hydrocarbon feedstock (coal, crude oil) is converted into a higher value product or slate of products and exhaust CO₂ is captured.

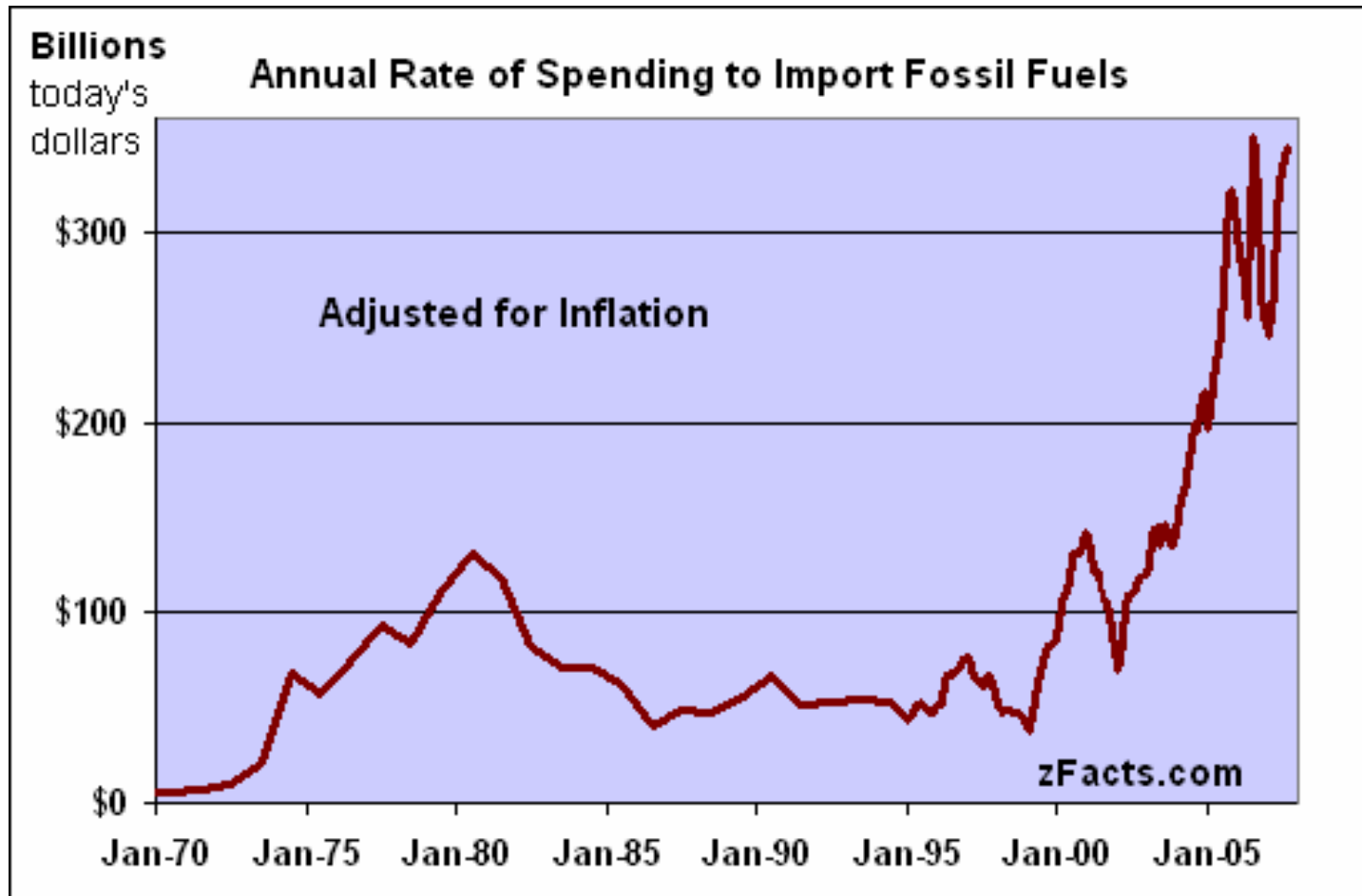
Crude Oil Price Trend



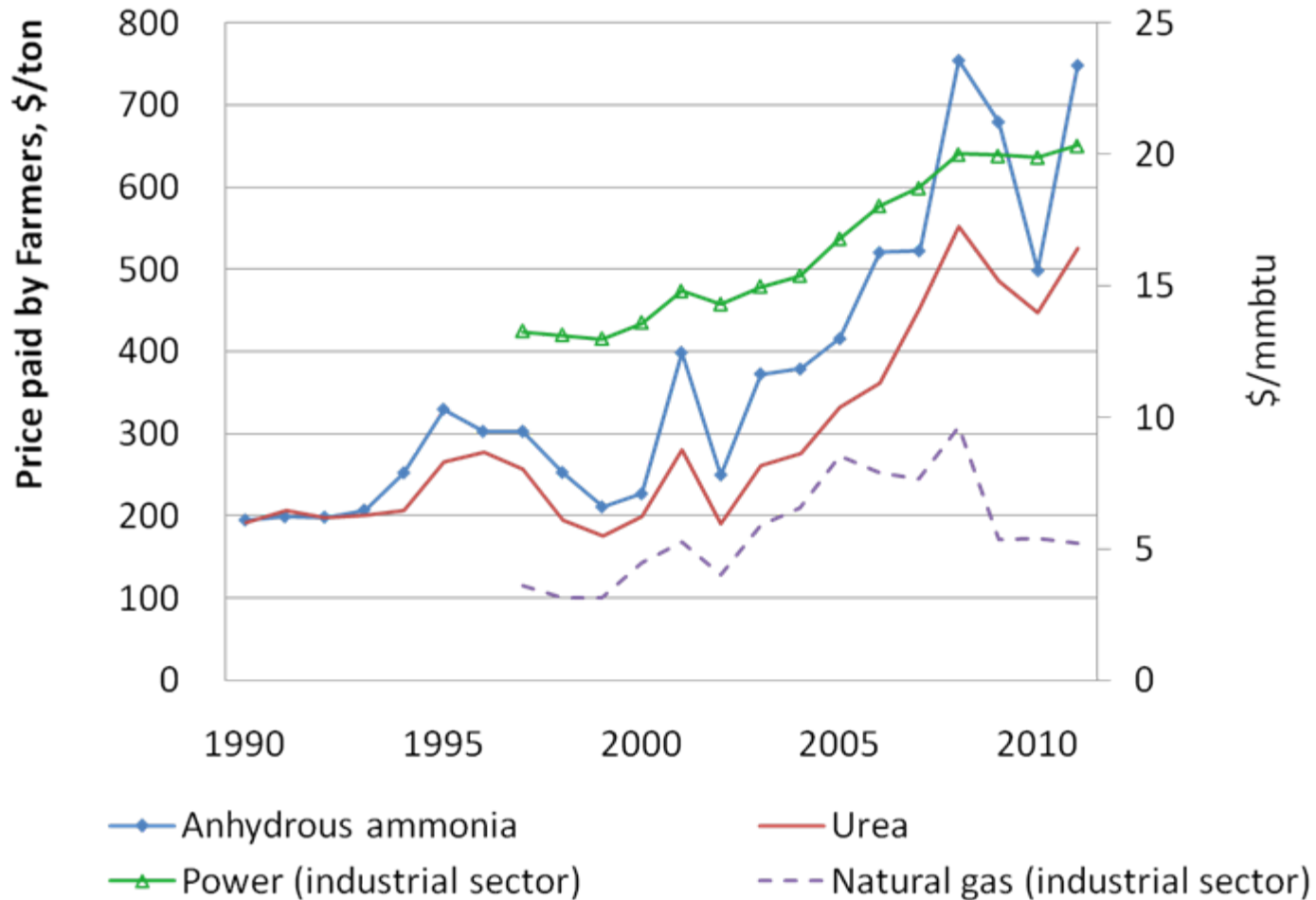


Oil Dependency is a Drain on our Economy

from Secretary Chu's Keynote Address, 2009 EIA Energy Conference April 7, 2009

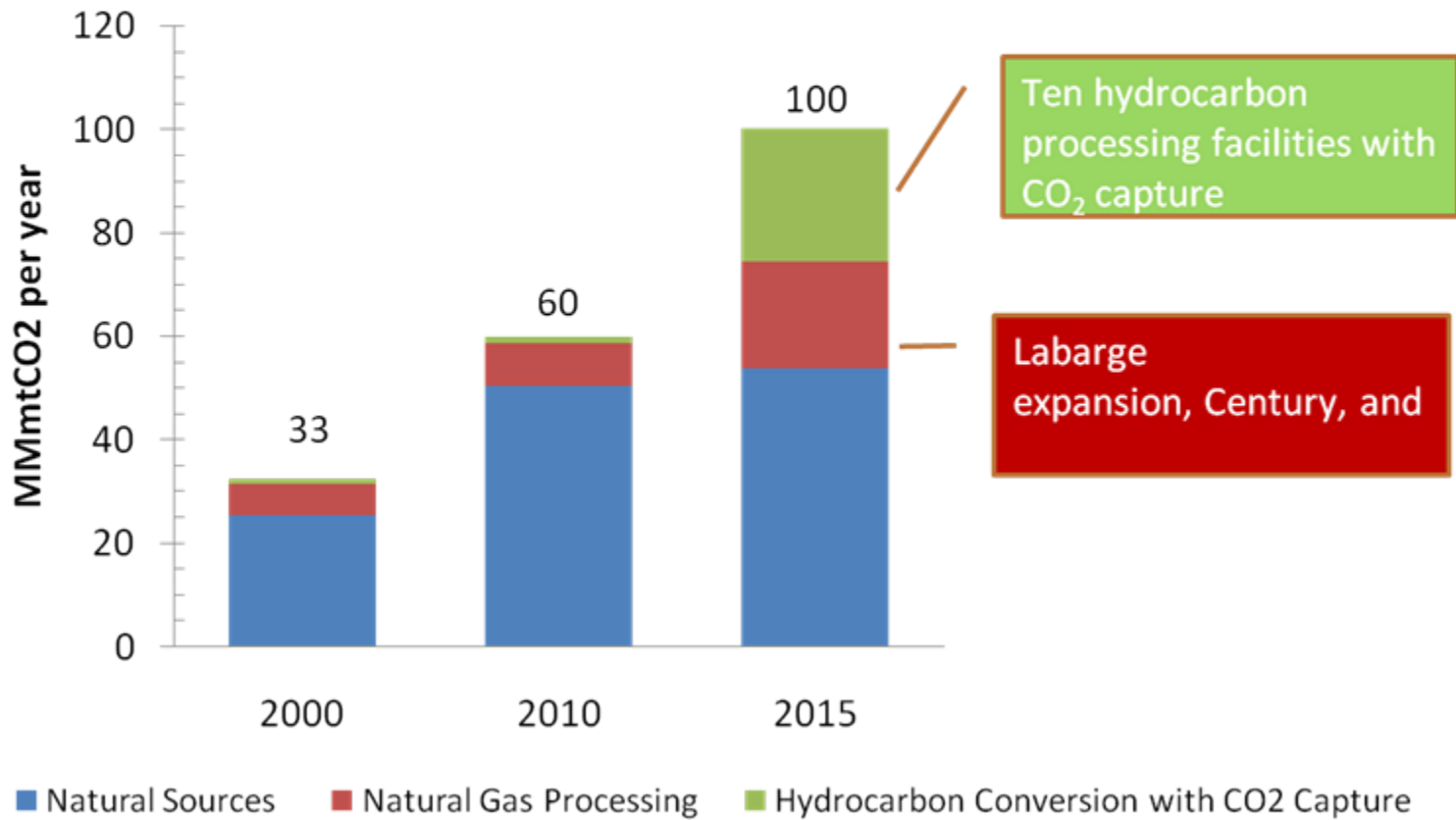


Prices for Fertilizer, Power, and Natural Gas

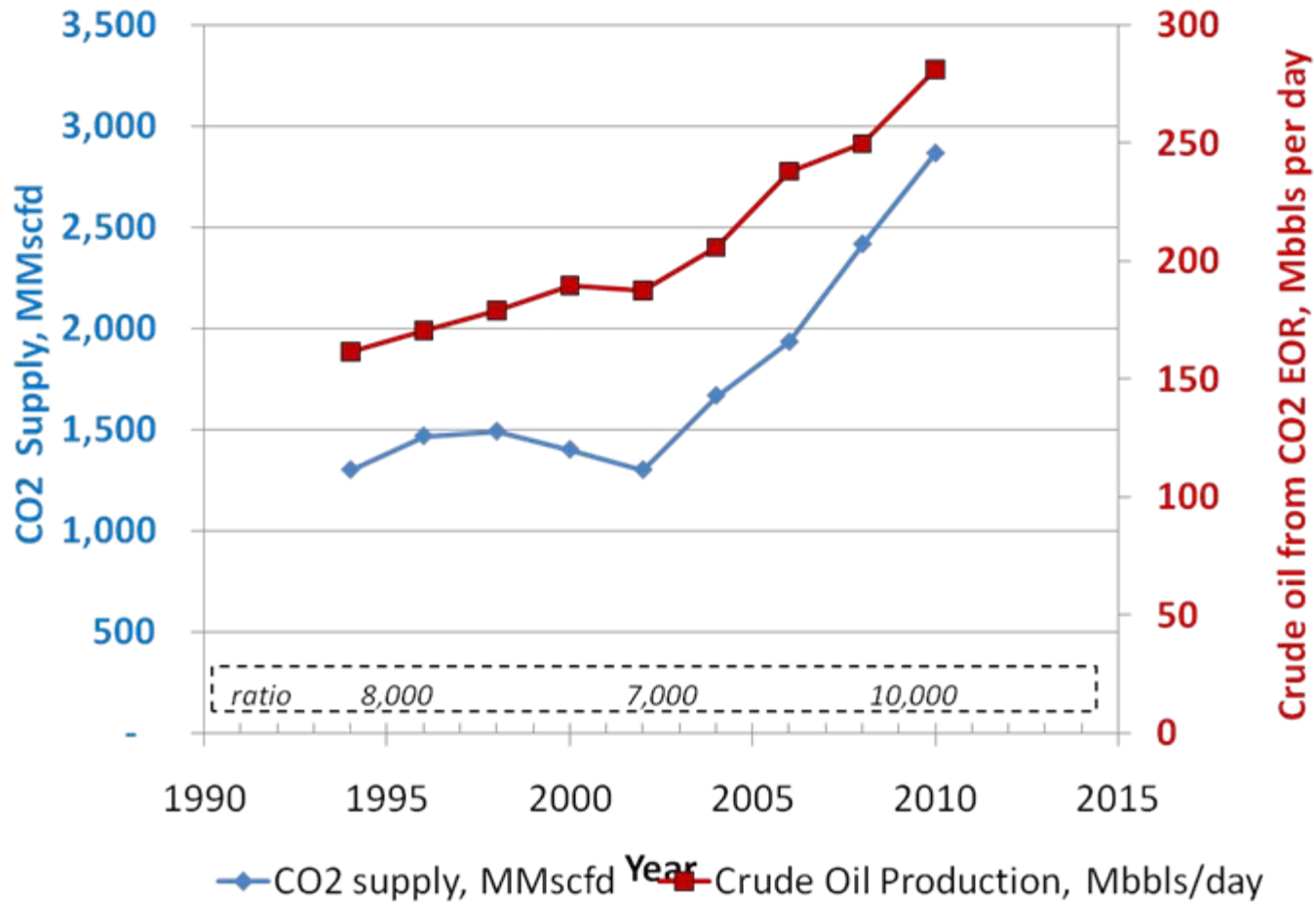


Source: US Department of Agriculture, Economic Research Service, <http://www.ers.usda.gov/Data/FertilizerUse/> U.S. Department of Energy, Energy Information Administration, Electricity and natural gas prices to ultimate customers, industrial sector. Divide by 2.93 to convert power price to cents/kWh.

CO₂ Supply for Enhanced Recovery Operations in the United States doubled between 2000 and 2010, on track to increase another 70% by 2015

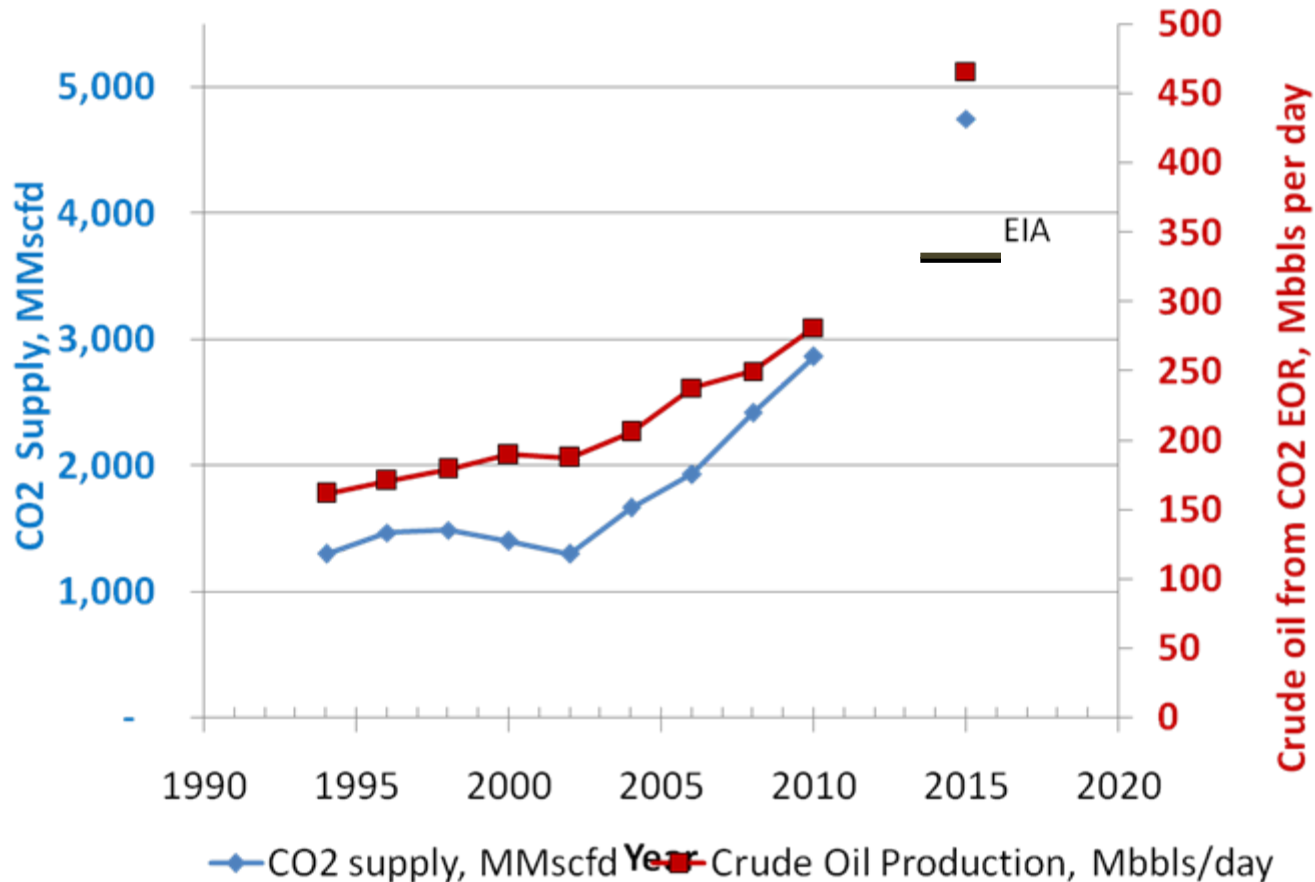


CO₂ Supply and CO₂ EOR Production



Information Sources: Oil&Gas Journal, CO₂ EOR oil prodn through 2010; Kinder Morgan, CO₂ supply through 2010

CO₂ Supply as a Leading Indicator



Information Sources: Oil&Gas Journal, CO₂ EOR oil prodn through 2010; Kinder Morgan, CO₂ supply through 2010