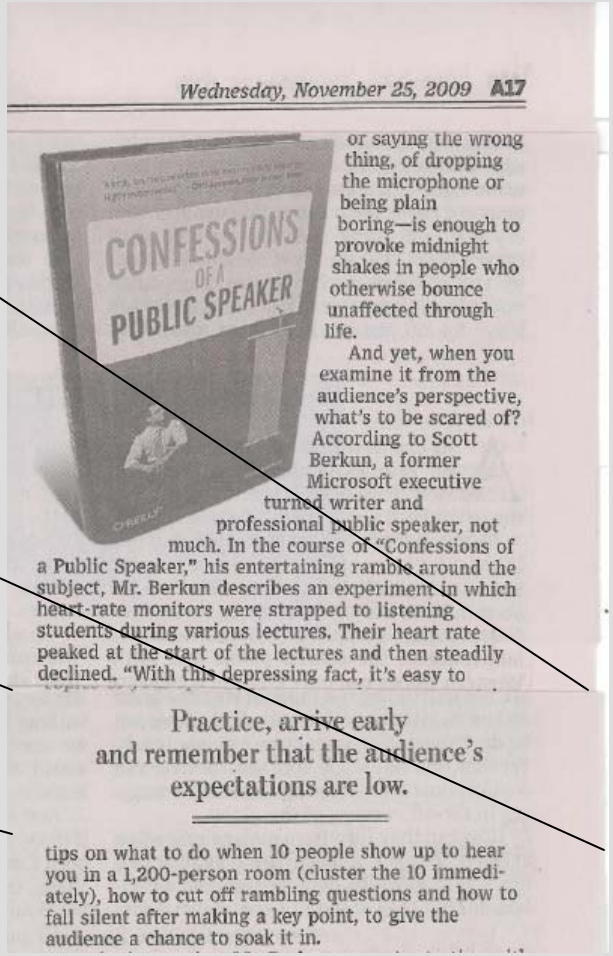
CO_2 EOR Carbon Balance

Charles E. Fox

Kinder Morgan CO_2 Company, LP

Tip

Practice, arrive early
and remember that the audience's
expectations are low.



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or saying the wrong thing, of dropping the microphone or being plain boring—is enough to provoke midnight shakes in people who otherwise bounce unaffected through life.

And yet, when you examine it from the audience's perspective, what's to be scared of? According to Scott Berkun, a former Microsoft executive turned writer and professional public speaker, not much. In the course of "Confessions of a Public Speaker," his entertaining ramble around the subject, Mr. Berkun describes an experiment in which heart-rate monitors were strapped to listening students during various lectures. Their heart rate peaked at the start of the lectures and then steadily declined. "With this depressing fact, it's easy to

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tips on what to do when 10 people show up to hear you in a 1,200-person room (cluster the 10 immediately), how to cut off rambling questions and how to fall silent after making a key point, to give the audience a chance to soak it in.

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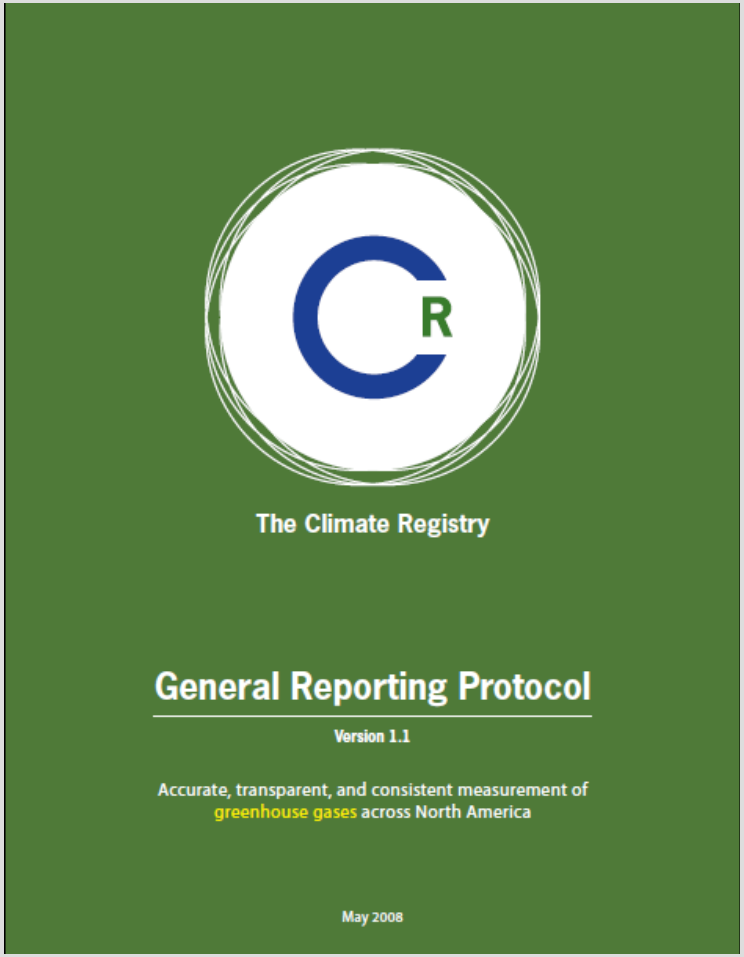
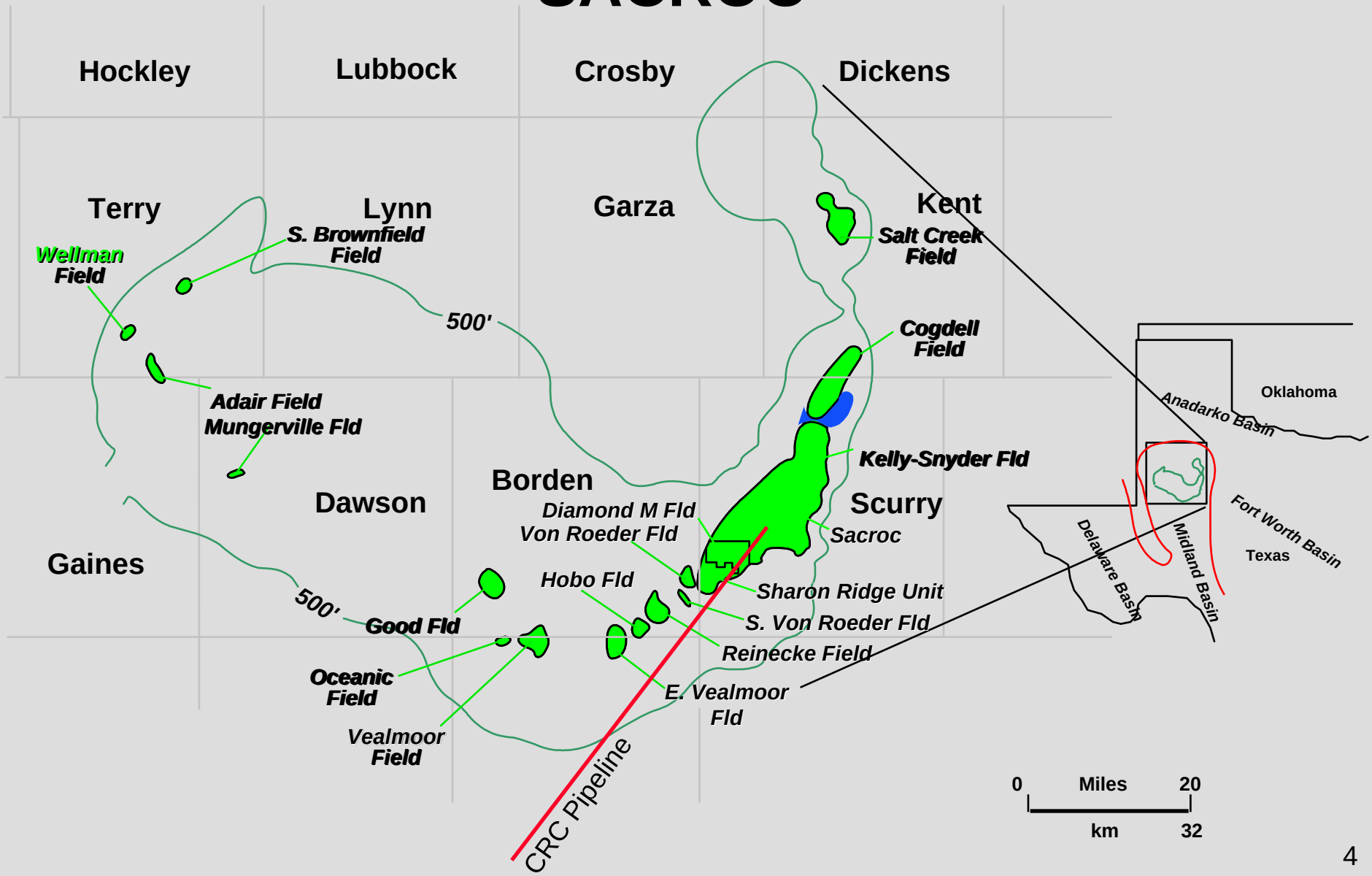
EOR Carbon Balance

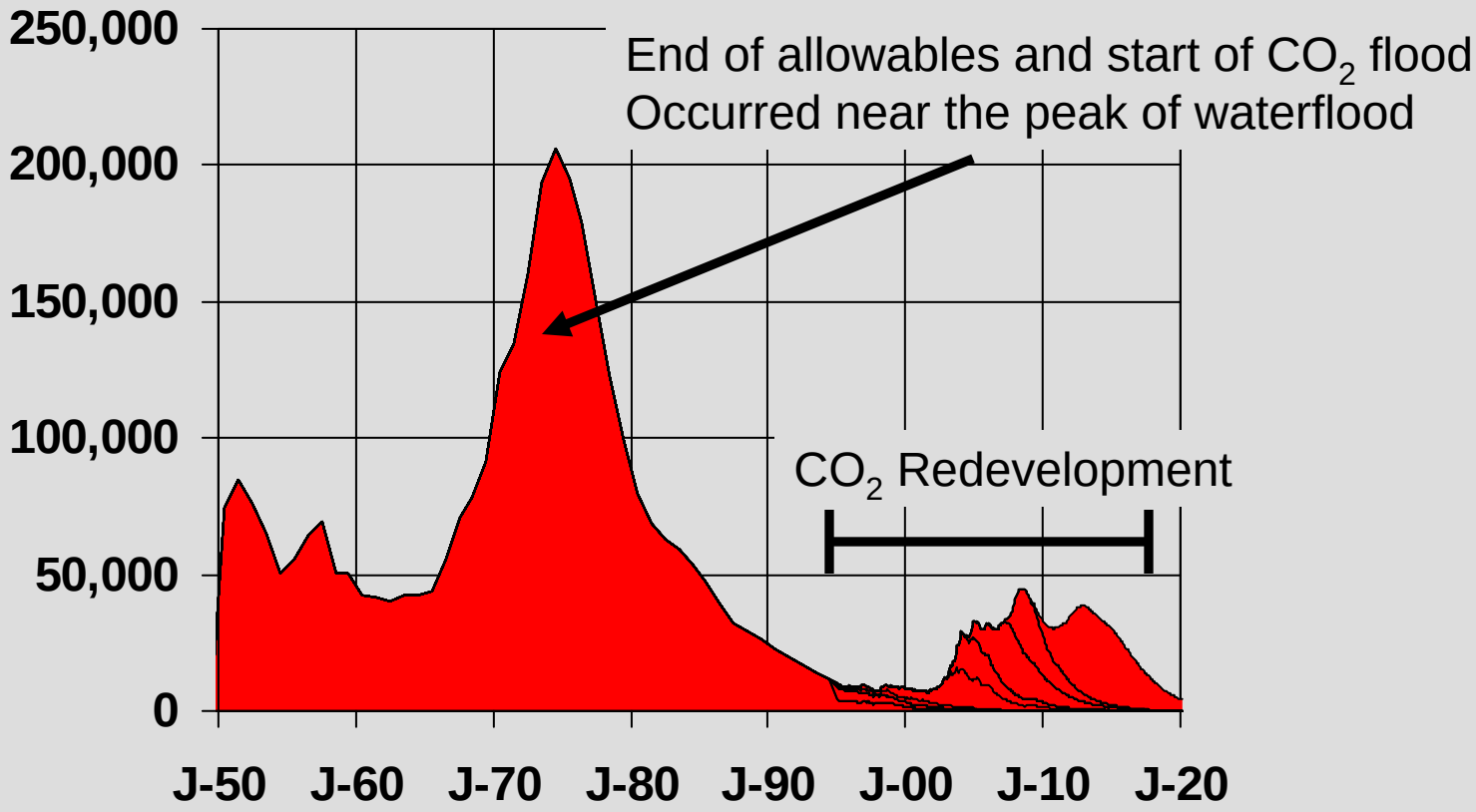
- Calculate carbon emissions for SACROC in 2007 using CA Registry methods (mostly)
- Compare various emission sources
- Comment on how you can make your calculations
- Look at short term and long term carbon balance calculations for the SACROC oil field



SACROC


Hockley
Lubbock
Crosby
Dickens
Terry
Lynn
Garza
Kent
Wellman Field
S. Brownfield Field
Salt Creek Field
500'
Cogdell Field
Adair Field
Mungerville Fld
Kelly-Snyder Fld
Borden
Dawson
Scurry
Diamond M Fld
Von Roeder Fld
Sacroc
Gaines
Hobo Fld
Sharon Ridge Unit
500'
Good Fld
S. Von Roeder Fld
Reinecke Field
Oceanic Field
E. Vealmoor Fld
Vealmoor Field
CRC Pipeline
Oklahoma
Anadarko Basin
Fort Worth Basin
Texas
Delaware Basin
Midland Basin
0
Miles
20
km
32

Oil Production (BOPD)



Basis - SACROC Complex 2007

- Production
  - 27,635 BOPD
  - 624,000 BWPD
  - 75,000 MCFD HC Gas
  - 637,000 MCFD CO2
- Injection
  - 582,000 BWPD into reservoir
  - 892,000 MCFD (CO2 + HC)
  - 212,000 MCFD Purch

- 835 Wells
- 57 Compressors & Pumps >1000 HP
- 225,500 HP in 2007
  - Added five 5000 hp compressors later
- Handles 120 MMCFD for 3rd Parties (16 MW)
- Snyder Gas Plant
  - 15,000 BBL NGL/Day
  - 20 MMCFD HC gas

2007 Emissions

- Approximately 1 million tonnes CO_2e
- Primarily energy use – metered
  - Direct
  - Indirect
- Calculations based on
  - Metered volumes
  - Estimated factors
- California Registry Methodology
  - Except for indirect emissions

Gas Fired Power Plant

397,500 tonnes in 2007

- 103 MW (net) Combined Cycle Plant
- Two LM6000 turbines
  - 45 MW each
- One HRSG
  - Heat Recovery Steam Generator
  - 18 MW
- Burns 19.8 MMCFD (20,300 MMBTU/day)
- Heat Rate – 8000 kW/MMBTU
- 0.44 tonnes/MW-hr

Purchased Power (Indirect)

409,600 tonnes in 2007
336,900 tonnes in 2007*
***No 3rd party gas processing**

- Purchase 107 MW
- Total power needs = 210 MW
  - 30% Wells/ESP
  - 20% Water General
  - 14% Inlet Compression
  - 34% Recompression
  - 1% CO_2 Recovery
  - 1% CO_2 Pumps

Reciprocating Engines

89,000 tonnes in 2007

- Cooper Bessemer
- Caterpillar
- White Superior
- Dresser Rand

- 2 stroke, lean burn
- 4 stroke lean burn

- Purpose
  - Sales
  - Gas gathering
  - Third party gas return

- Metered

Flares

61,400 tonnes in 2007

- CO_2 Membrane Facility
- CO_2 Membrane Topping Unit
- Snyder Gas Plant

- Two metered sources:
  - "Flared" CO_2
  - Gas burned

Heaters & Boilers

54,100 tonnes in 2007

- NGL treating and gas conditioning for CO_2 separation
- MDEA
- MEA
- CO_2 Recovery
- Metered gas usage

Vented Emissions

34,500 tonnes in 2007

- Compressors
- Heaters
- Reciprocating Engines
- Turbines

- Based on maintenance factors

Fugitive Emissions

1200 tonnes in 2007

- **SGP (non refrigerant)**
  - **343 tonnes**
- **Compressor area**
  - **178 tonnes**
- **Process area**
  - **132 tonnes**
- **Refrigerants (vehicles/offices)**
  - **87 tonnes**
- **Power Plant**
  - **39 tonnes**
- **Misc.**
  - **390 tonnes**

Factors

Mobile Emissions

500 tonnes in 2007

- Heavy duty vehicles
- Light trucks
- Passenger cars
- Fork lifts
- Lawn mowers

- Gasoline and diesel usage

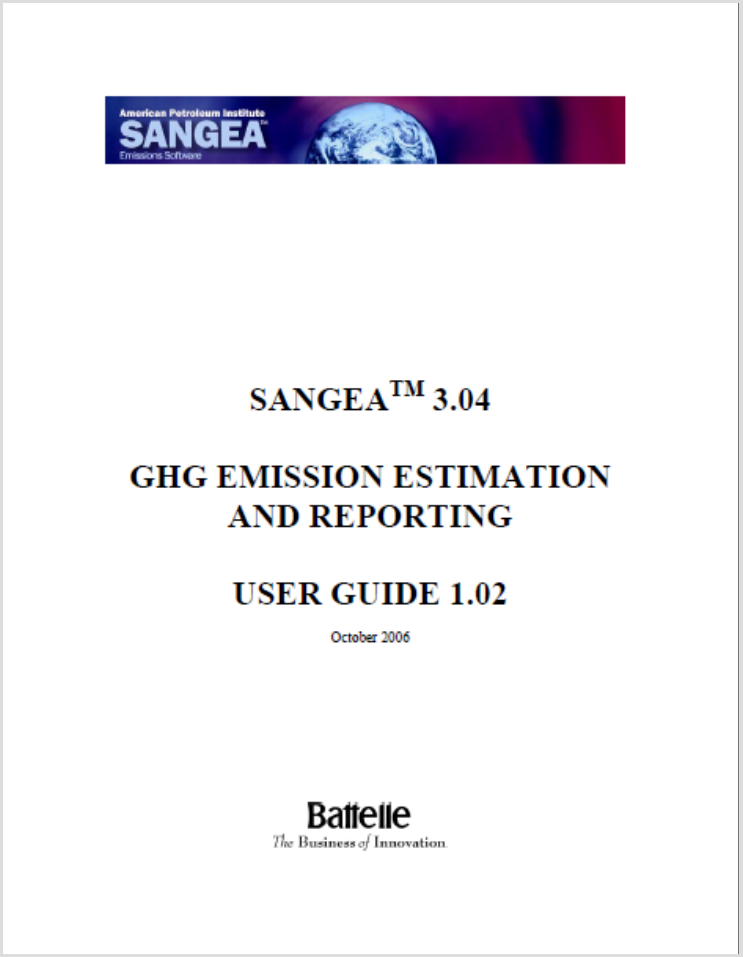
How did we get those numbers?

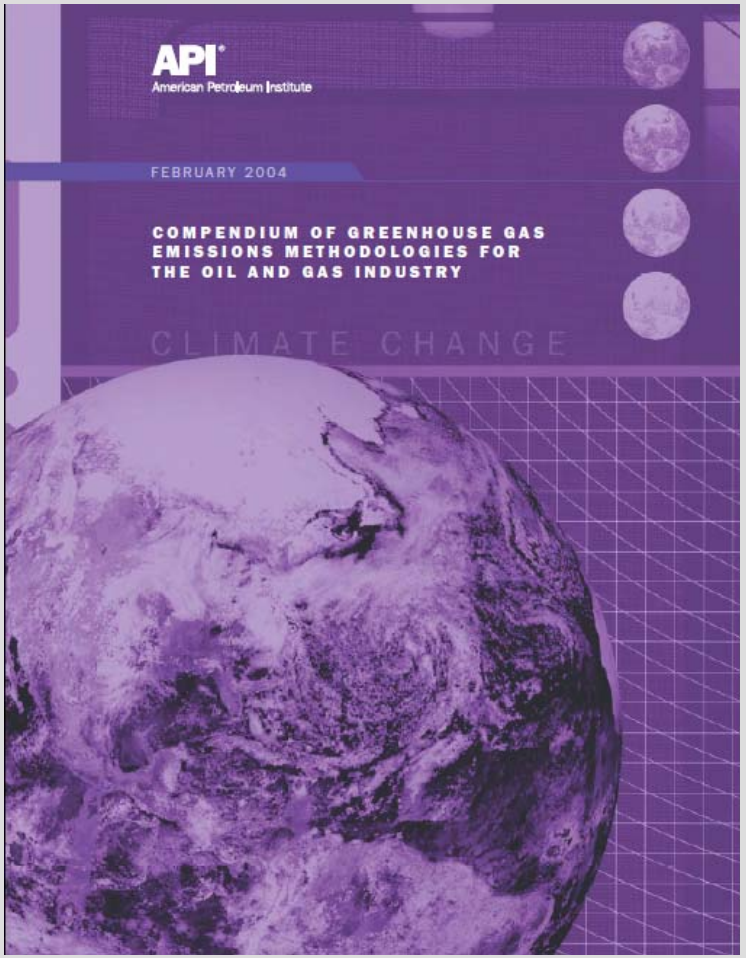
Combustion Emissions from a Stationary Flare

Specie	HC Gas Burned MMBTU	Emission t/MMBTU	Emission t	t CO2e/ t emitted specie	t CO2e
CO_2	525.6	0.05306	27.88834	1	27.88834
N_2O	525.6	9 E-7	0.000473	310	0.14664
Methane	525.6	9 E-7	0.000473	21	0.00993

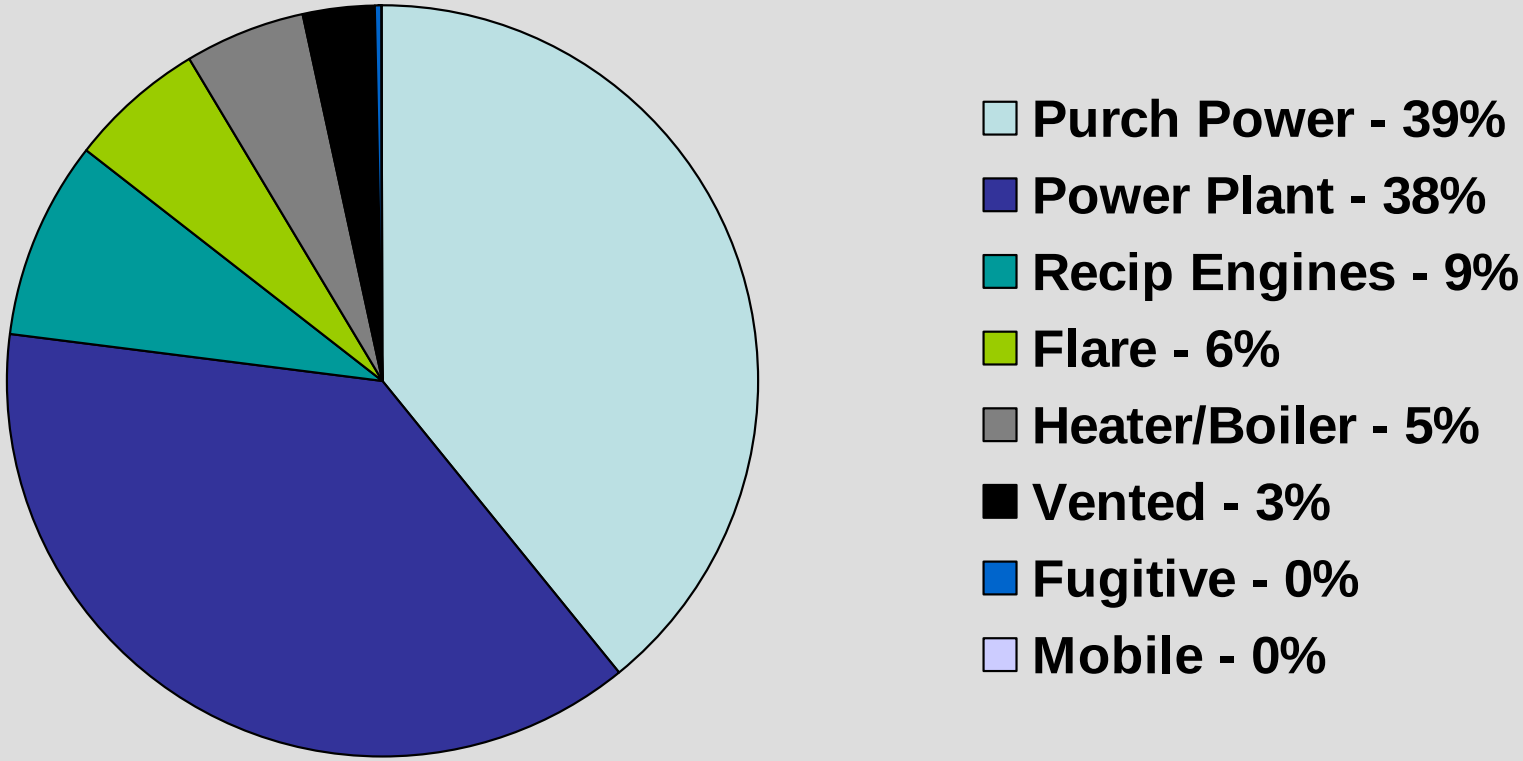
Based on fuel usage

Where can I go for more pain?





SACROC Complex GHG Emissions
2007 Estimate



1,046,000 Tonnes Total Complex
972,800 Tonnes CO_2 Flood

Smyth Study

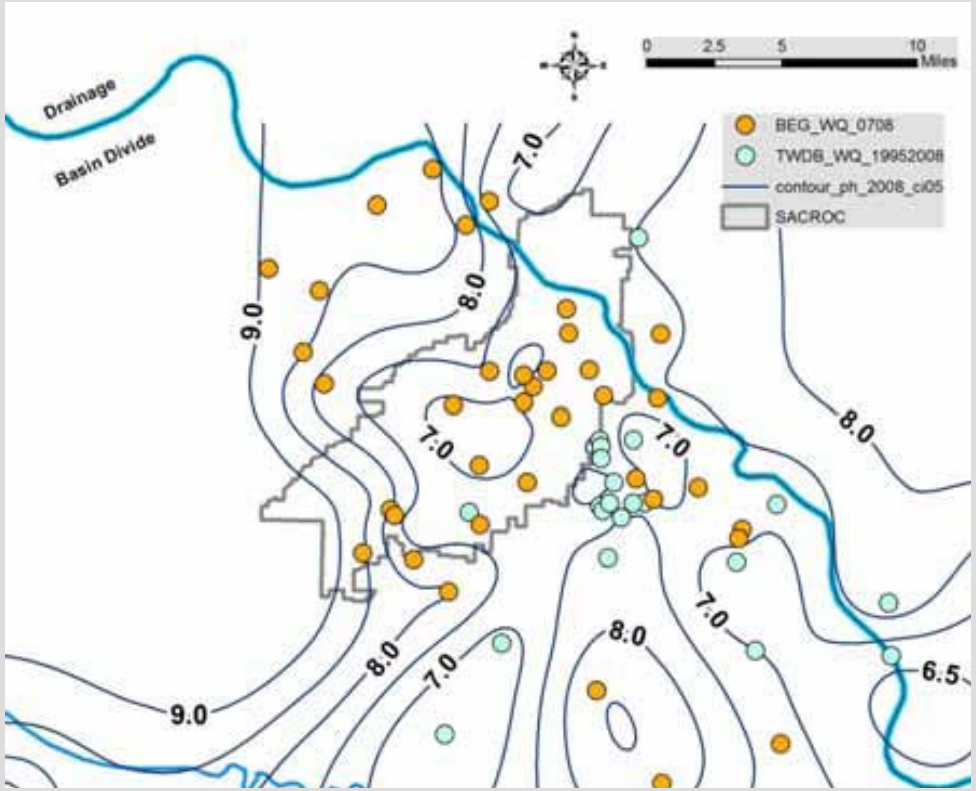


Figure 7. Contours of pH measured by BEG and TWDB in Scurry County between 1995 and 2008. Contour interval = 0.5 pH units.

Retention

- Federal Register/Vol 75/No 68/Apr 10, 2009/P. 16584 :

  "There are several EOR operations in the Permian Basin of Texas. One study showed that retention rates (for CO_2) for 8 reservoirs ranged from 38% to 100% and averaged 71%, but many of these projects are not mature enough to predict final retention."

- **Implication: If it is not retained, it is emitted – NOT SO!**

- Retention is a term of art
- From Practical Aspects of CO_2 Flooding (SPE Monograph 22)

  "Retention: the amount of CO_2 remaining in the reservoir at any given time, which equals the amount of CO_2 injected less the amount of CO_2 produced. This normally is expressed as a percentage."

- Retention = Net Utilization/Gross Utilization

Carbon Balance 2007

• Purchased	4.08 Mt
• Direct/Indirect Emissions	- 0.97 Mt
• Total Sequestered	3.11 Mt

• Oil Production	10.1 MMBO
• CO2e Emitted/BO	0.1 t/BO
•	1.8 Mcf/BO

Mt = million metric tons

Field Life Carbon Balance

- EOR Production* 185 million BO

- Purchased 260.0 Mt
- Direct/Indirect Emissions** -18.5 Mt
- Total Sequestered 241.5 Mt

- *10% of 1.85 billion bbl OOIP
- **CO2e emitted 0.1 t/BO

Sequestering 93% of purchased injection

Capital Carbon Emissions (Embedded Carbon)

- Emissions created by creating and installing the capital stock
  - Drilling and completing wells
  - Installing compression
  - Laying flowlines
- Hard to calculate
- 530 tonnes/$1 million GDP*
- SACROC CO_2 flood capital – approx $3.5 billion
- Approx 2 million tonnes

***2007 Data**

Hot Job: Calculating Products' Pollution

BY ANA CAMPOY

Until a few years ago, Nuno da Silva's arcane occupation—professional pollution calculator—was of little utility to the corporate world.

But in these days of global-warming worries and greener-than-thou marketing, companies suddenly can't get enough of his services. Revenue at the division he manages exploded 150% in 2008 and continues to expand this year, despite the recession. Since the beginning of 2008, he has added 13 people to his staff, bringing the number of employees to 16.

"We used to be the environmental geeks," said Mr. da Silva, who oversees the U.S. division of a German environmental consulting company, **PE International**. "Now we're mainstream."

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Field Life Carbon Balance With "Capital Emissions"

• Purchased	260.0 Mt
• Direct/Indirect Emissions	- 18.5 Mt
• Capital Emissions	- 2.0 Mt
• Total Sequestered	239.5 Mt

Sequestering 92% of purchased injection

Additionality

- Some say one must include the emissions from the oil production. This only makes sense if you don't assume that oil wouldn't be produced elsewhere, nevertheless:

- 0.43 tonnes/BO – EPA
- 134 lb/mcf or 0.06 tonnes/mcf - EIA

Field Life Carbon Balance With "Capital Emissions" and Additionality

• Purchased	260.0 Mt
• Direct/Indirect Emissions	- 18.5 Mt
• Capital Emissions	- 2.0 Mt
• Oil/Gas Product Emissions	- 97.0 Mt
• Total Sequestered	124.5 Mt

Sequestering 48% of purchased injection

Conclusion

- GHG emissions at EOR fields are tied almost exclusively to energy consumption
  - electric power
  - gas fired reciprocating engines
  - heat
- GHG emission calculations are tedious
- EOR can sequester CO_2