Oil Production Greenhouse Gas Emissions Estimator (OPGEE): Model updates & changes

Hassan M. El-Houjeiri
Adam R. Brandt
Department of Energy Resources Engineering
Stanford University

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Overview

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2. Work to date
3. Defaults
4. Review & changes
5. Documentation
6. Moving forward

1. Introduction

Overview of OPGEE

- *Oil Production Greenhouse Gas Emissions Estimator - Draft version A* (OPGEE v1.0a) released for comments
- An open-source, fully public LCA tool for the estimation of GHG emissions from oil production operations
- Engineering-based bottom-up modeling of production, processing, storage and transport

OPGEE modeling goals

Improve crude oil GHG modeling in 5 ways:

1. Build a rigorous, engineering-based model of GHG emissions from oil production operations
2. Use disaggregated data for accuracy and flexibility
3. Use public data where possible
4. Document sources for all equations, parameters, assumptions
5. Maintain model as free to access, use, and modify by any interested party

2. Work to date

OPGEE timeline

November 15th 2011	Scoping plan released
March 16th 2012	OPGEE beta version released
March 19th 2012	Public workshop
July 3rd 2012	OPGEE Draft version 1.0a released
July 10th 2012	Draft CI summary tables and input data released
July 12th 2012	Public workshop

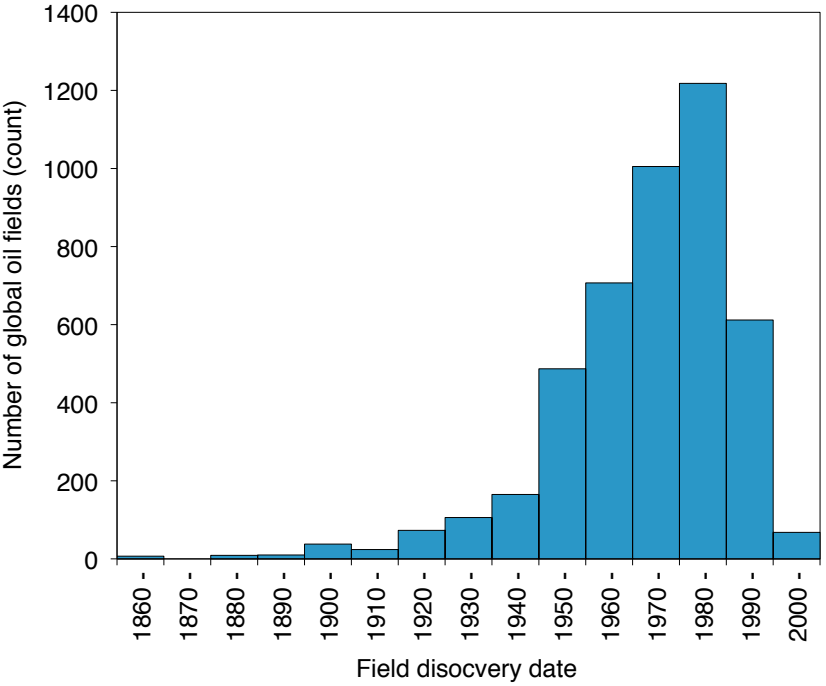
Work since March 19th workshop

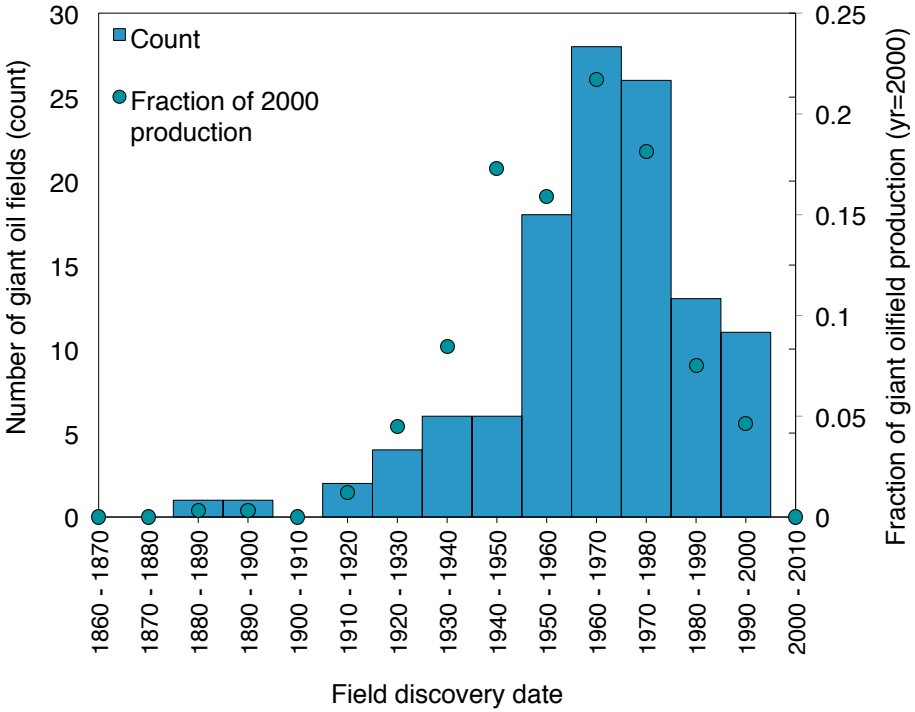
- Defaults
  - Use global averages where possible
  - Smart defaults that interact with user inputs
- Response to internal and external review
  - Updates to model
  - Debugging of model
  - Improve user controls (avoid inconsistent inputs)
- Generation of OPGEE Pro v1.0
  - More comprehensive front sheet
  - Bulk assessment capability: running the model on > 50 fields at a time and documenting inputs/ results
- Writing of OPGEE documentation

3. Defaults

Default - field age (Documentation, p. 45)

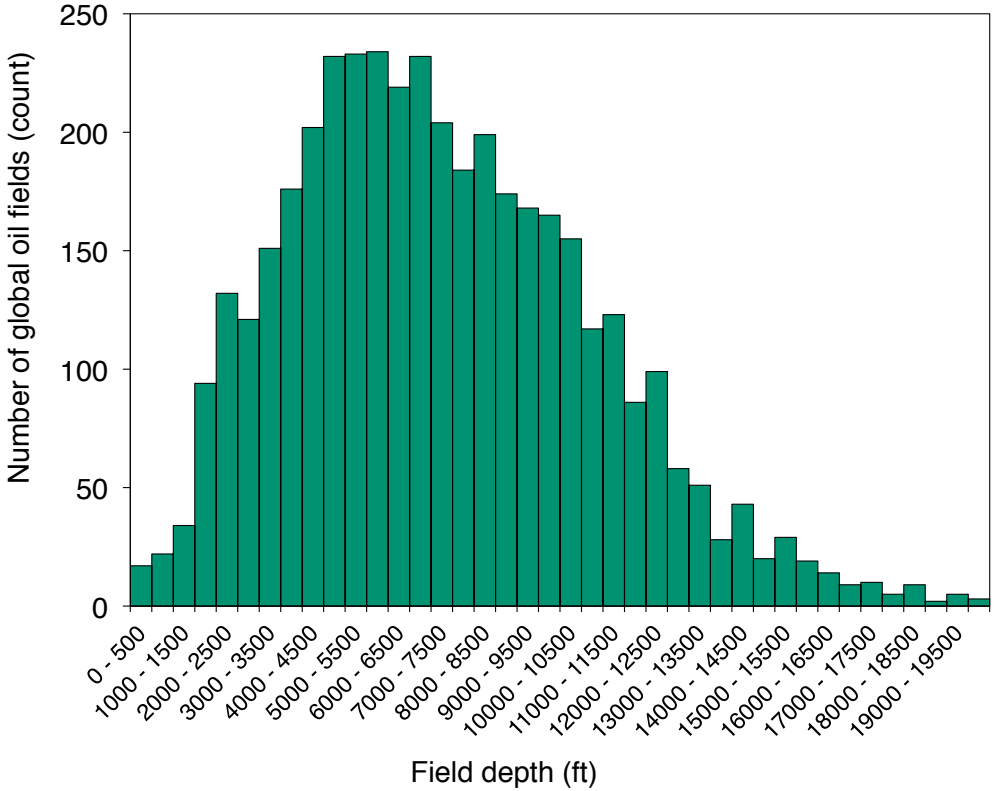
- Data for 6502 global oil fields collected from Oil & Gas Journal *2010 Worldwide Oil Field Production Survey*
- 4837 fields reported discovery dates
- Global average field age (by count) is approx. 35 years (assuming 3 years development timeline)
- Giant fields over 100 kbbl/d in 2000 (116 fields) have older age of ~40 years (production-weighted average)





Default - field depth

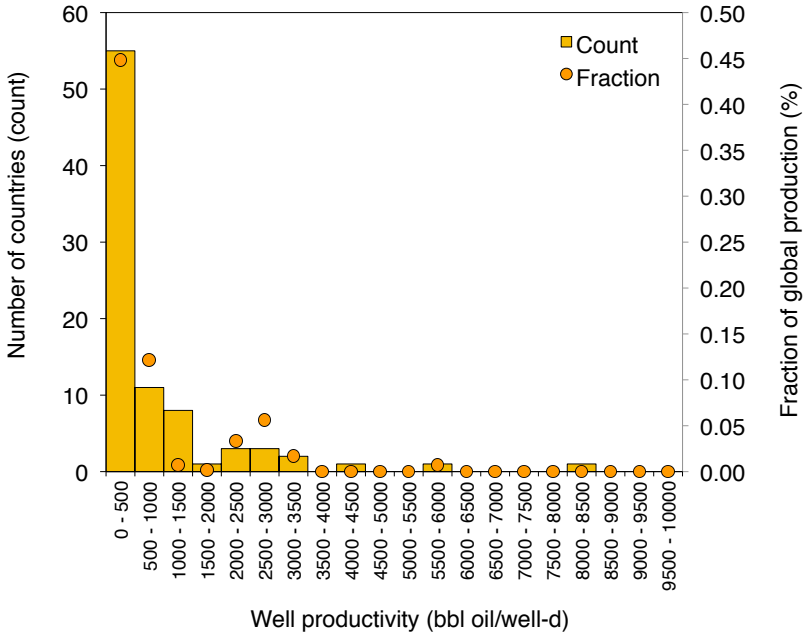
- Data from Oil & Gas Journal *2010 Worldwide Oil Field Production Survey*
- 4489 fields with depth data
- Mean depth is 7240 ft (by count)
- The distribution is not normal. The median is shallower than the mean (6800 ft)



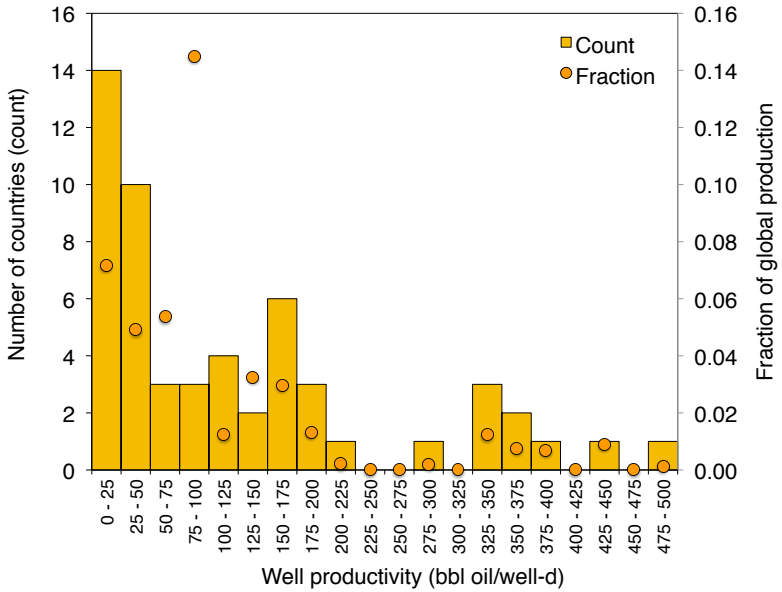
Default - production per well

- Data for production and producing wells from 107 countries (O&GJ *2010 Worldwide Oil Field Production Survey*)
- Majority of countries produced less than 500 bbl/well-d
- Global average productivity is 82 bbl/well-d
- US stripper wells reduce average significantly
- Non-US per-well productivity = 183 bbl/well-d (OPGEE default)

a) All producing countries



b) Countries producing less than 500 bbl/well-d



Default - WOR (smart)

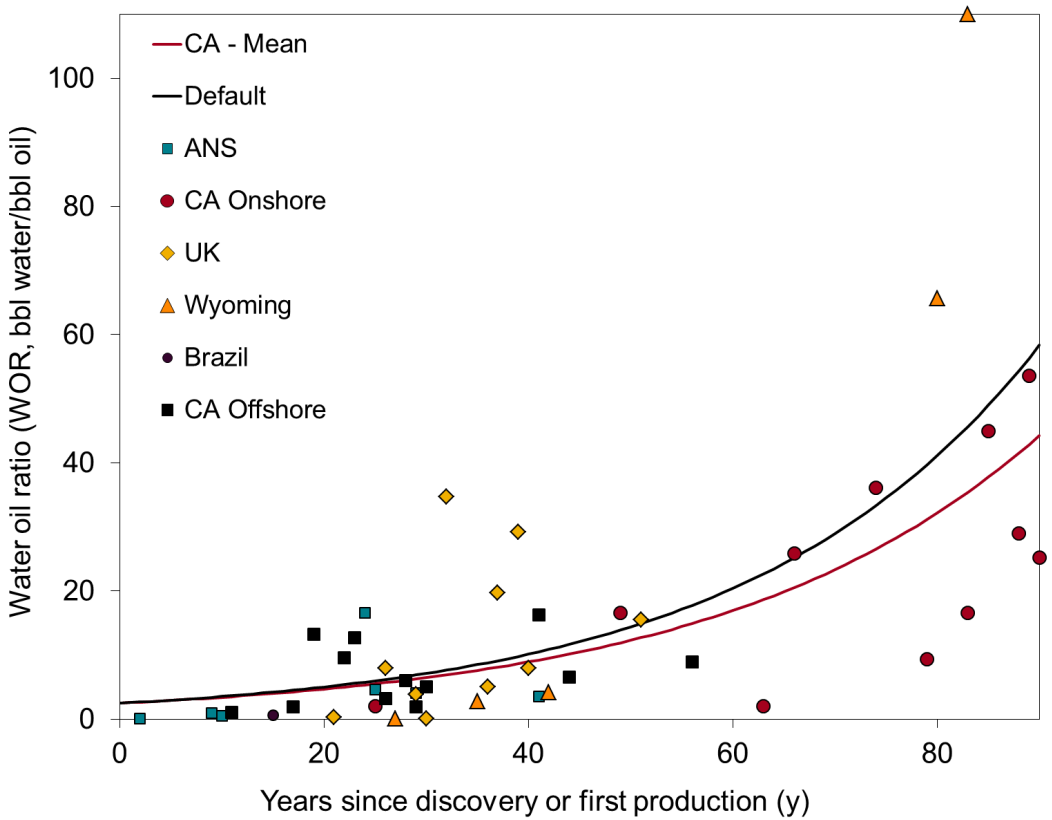
- A smart default for WOR as a function of field age was generated using data from California and other regions (100s of fields)
- WOR modeled using exponential function
- Default case is a moderate case slightly higher than CA average
- Appendix D of documentation shows analysis in detail

$$WOR(t)=a \cdot \exp[b(t - t_0)]$$

a = Initial WOR

b = WOR growth rate

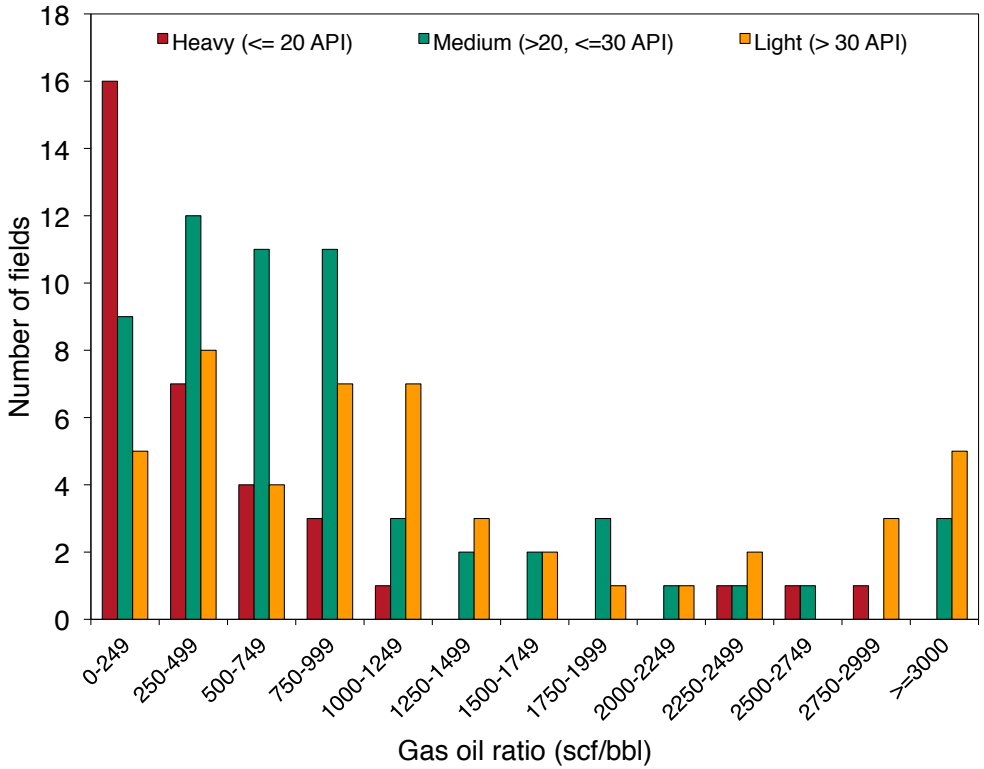
Note: WOR relationship is changed from documentation due to removal of pool-level WOR data from Alberta



Default - GOR (smart)

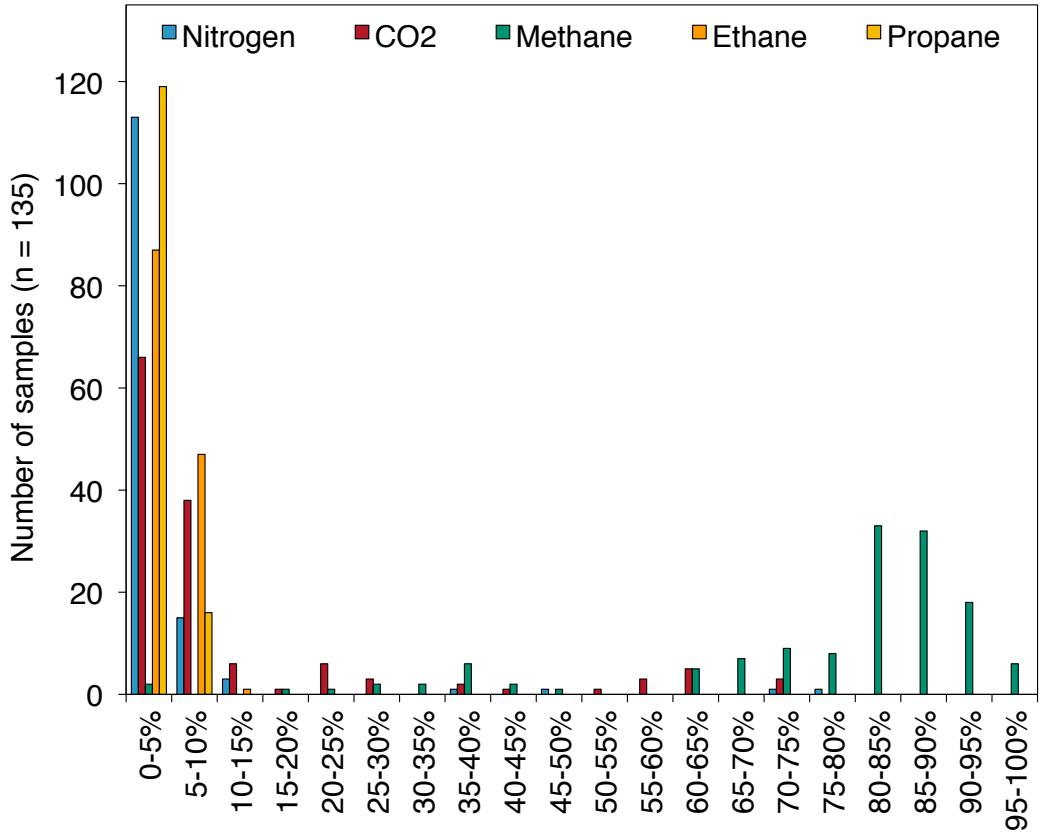
- GOR depends on API gravity, gas gravity, and temperature and pressure of crude oil
- As reservoir pressure drops, results in higher producing GOR over time. Lighter crude oil tends to have higher GOR
- Crude oil are binned by API gravity into three categories: heavy (< 20 API), medium (>=20, ,30 API), and light crude (>= 30 API)
- GOR for 169 California oil fields compiled for 2010 (binned by API gravity).

Mean GORs are used to assign a smart default for each bin



Default - gas composition

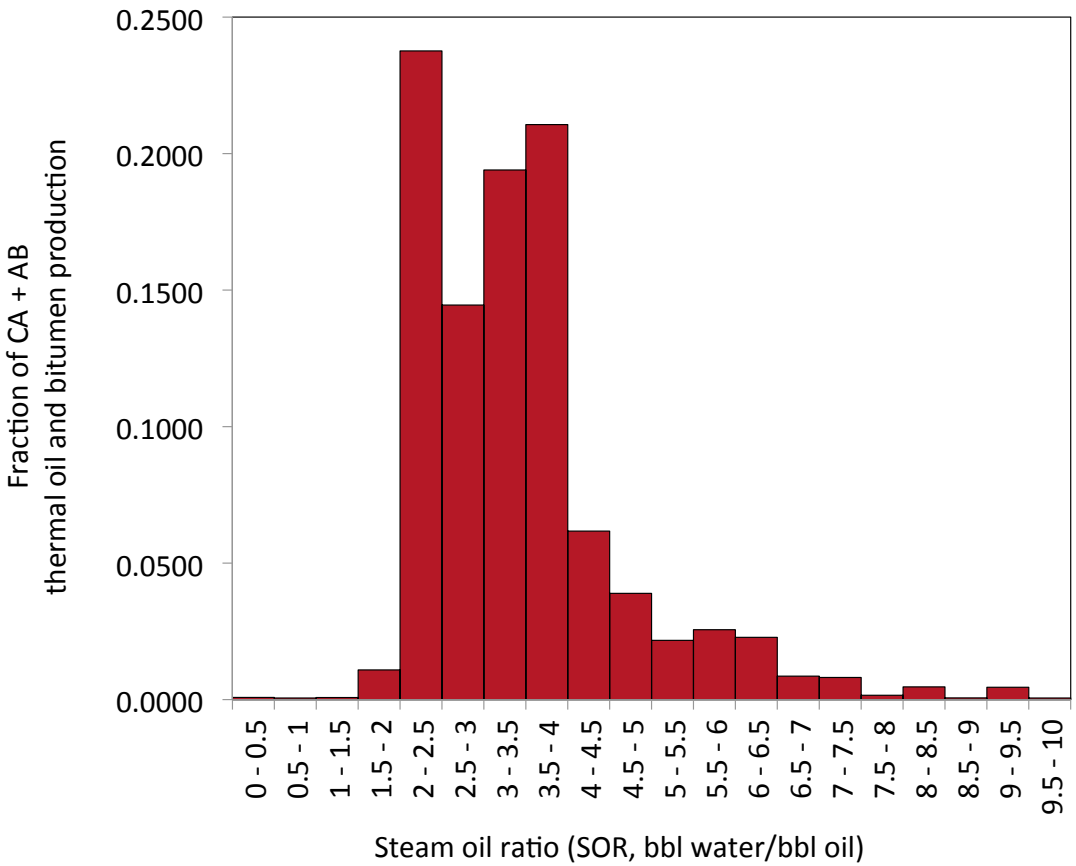
- Default gas composition for associated gas is derived from gas composition data from 135 California oil fields
  - 17 data points of methane <50 % removed
- The mean compositions were rounded and used in OPGEE for default gas composition



Default - SOR

- Average steam oil ratios computed for California and Alberta thermal recovery projects (2009 and 2010 data)
- Steam oil ratios binned by SOR and weighted by relative production volume

- Mean SOR:
  - CA: 3.3-3.4
  - AB: 3.3-3.6
- Default = 3 bbl/bbl



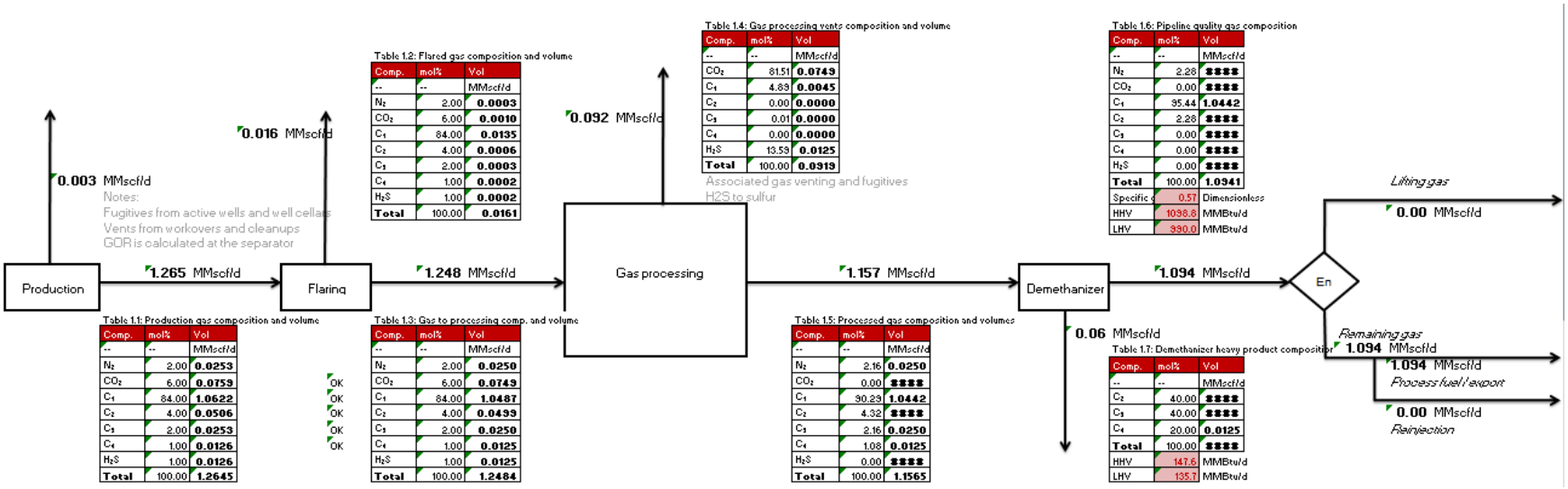
4. Review & changes

Review and testing

- Thorough review of model
  - Detailed review by ARB staff (J. Duffy)
  - Review by ICCT (Galarza and Malins)
  - Review by Energy-Redefined LLC (Howarth)
- Model debugging and testing
  - Functionality testing of model during generation of CA baseline
  - Model run on >300 fields of widely varying characteristics
  - Allows us to understand power and limitations of model

Updates & corrections: Gas balance

- Associated gas balance changed to properly account for venting, fugitives and flaring
- Gas is now balanced by component
- User guidance ensures gas composition is consistent with gas loss
- Flaring is assumed occurring before processing (allowing early field production or production in locations where there is no gas market)



Updates & corrections: VFF emissions

- Flaring data table (Table 1) includes all oil producing countries [NOAA, 2010; EIA, 2010]
- Estimating venting of CO_2 from AGR unit by assuming venting of all CO_2 remaining in the gas stream after other venting and fugitives
- Estimating methane emissions from AGR unit on volume basis rather than on unit basis using data from EPA on methane emissions from AGR unit [EPA, 1996]
- Gas recovered is properly accounted for, re-enters gas balance

EPA. Methane Emissions from the NG Industry. Technical Report, Environmental Protection Agency, 1996

Updates & corrections: production energy consumption

- Corrected gas compressor work equation (found by both internal and external review).
- Lifting pressure calculations adjusted account for the pressure drawdown between the reservoir and the bottomhole.
- Added optional methane flooding to account for cases when the gas injected is more than the amount of gas produced (found by both internal and external review).

Updates & corrections: surface processing and water treatment

- Corrected calculation of electricity for makeup water treatment
- Recalculated amine circulation rate based on the changes to the gas balance (CO_2 venting from AGR unit and flaring before gas processing)
- Added NGL options
  - Percentage of ethane, butane and propane condensed in the demethanizer
  - End use disposition of NGL (blend or export)
- Adjustments to defaults and user controls

Restructuring of gathering sheets

- Changed front sheet calculations for readability.
- Complete GHG emissions breakdown by component and type of direct emission
- Calculation of indirect emissions by fuel type (Table 1 & 2 of *'GHG Emissions'* gathering sheet)

Table 1: GHG emissions panel

GHG emissions panel							
	Combustion	Land use	VFF				
			Venting	Flaring	Fugitives		
	Value	Value	Value	Value	Value	Unit	Notes:
Exploration	**0**	**0**	**0**	**0**	**0**	gCO2eq/d	
Drilling & Development	**655,539**	**4,086,198**	**0**	**0**	**0**	gCO2eq/d	
Production & Extraction	**30,630,297**	**0**	**0**	**0**	**1,218,822**	gCO2eq/d	
Downhole pump	19,672,726	0	NA	NA	NA	gCO2eq/d	
Water re-injection pump	10,957,572	0	NA	NA	NA	gCO2eq/d	
Gas re-injection compressor	0	0	NA	NA	NA	gCO2eq/d	
Water flooding injection pump	0	0	NA	NA	NA	gCO2eq/d	
Gas lifting compressor	0	0	NA	NA	NA	gCO2eq/d	
Air separation unit	0	0	NA	NA	NA	gCO2eq/d	All fuel used in a cryogenic ai
Gas flooding injection compressor	0	0	NA	NA	NA	gCO2eq/d	
Steam injection	0	0	NA	NA	NA	gCO2eq/d	Natural gas fired
Oil Field Processing	**5,857,720**	**0**	**4,669,805**	**1,321,327**	**1,294,431**	gCO2eq/d	
Crude oil processing	3,466,699	0	NA	NA	NA	gCO2eq/d	
Dehydration heater	0	0	NA	NA	NA	gCO2eq/d	Either natural gas fired or elec
Stabilizer column	3,466,699	0	NA	NA	NA	gCO2eq/d	Either natural gas fired or elec
Gas processing	2,391,021	0	NA	NA	NA	gCO2eq/d	
Amine treater	2,380,292	0	NA	NA	NA	gCO2eq/d	
Pumps	0	0	NA	NA	NA	gCO2eq/d	Pumps in amine treater are ele
Air coolers	0	0	NA	NA	NA	gCO2eq/d	Air coolers in amine treater us
Reboiler	2,380,292	0	NA	NA	NA	gCO2eq/d	Glycol reboiler is natural gas f
Glycol dehydrator	10,729	0	NA	NA	NA	gCO2eq/d	

Updates & corrections: steam injection

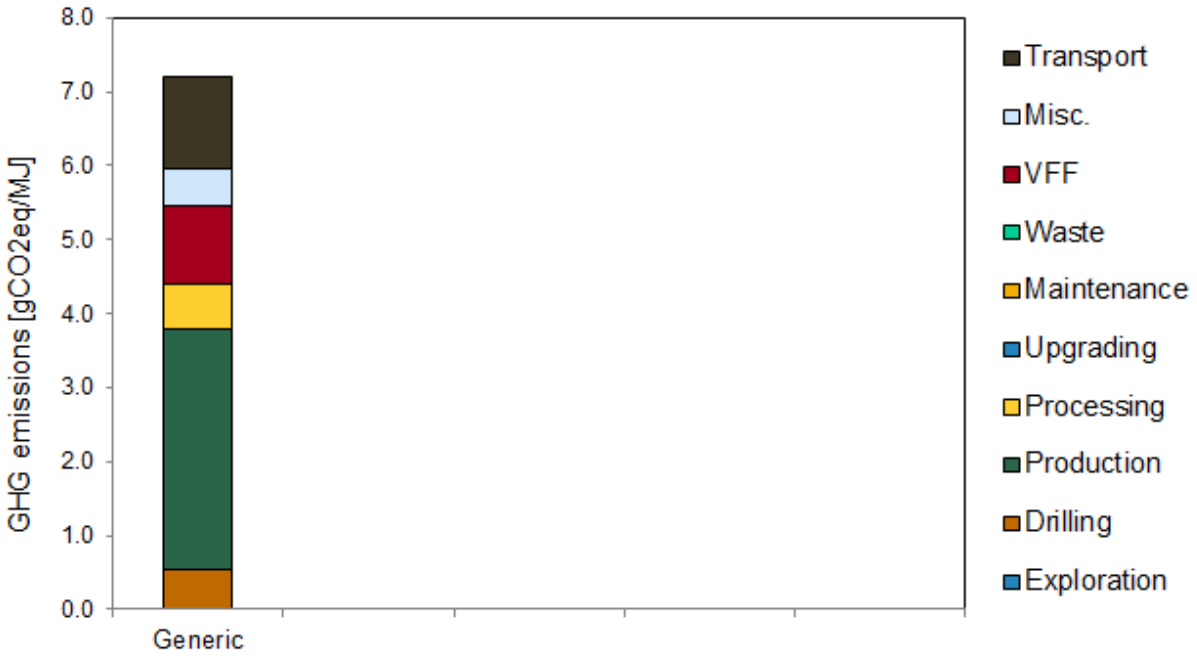
- Steam injection fueled with produced crude added as option
- Gas turbine calculations performed using more rigorous methods
- Small errors and bugs fixed to ensure energy balance

Addition: Bitumen extraction and upgrading

- Bitumen extraction and upgrading added from GHGenius model
  - Integrated & non-integrated mining & upgrading
  - In situ to diluted bitumen
- Primary inputs from GHGenius extracted
  - Energy inputs by pathway
  - Energy types breakdown
- Integrated with OPGEE emissions system
  - Consistent fuel characteristics ensures alignment with rest of OPGEE results
  - Slight differences between OPGEE and GHGenius results for same pathway

Updates & Changes: User interaction sheet

- Input parameters changed to ratios (e.g. gas flooding injection volume to injection ratio)
- Added bitumen emissions and changed graphical output to show bitumen emissions breakdown
- Added 0.5 g of CO_2 emissions for miscellaneous emissions

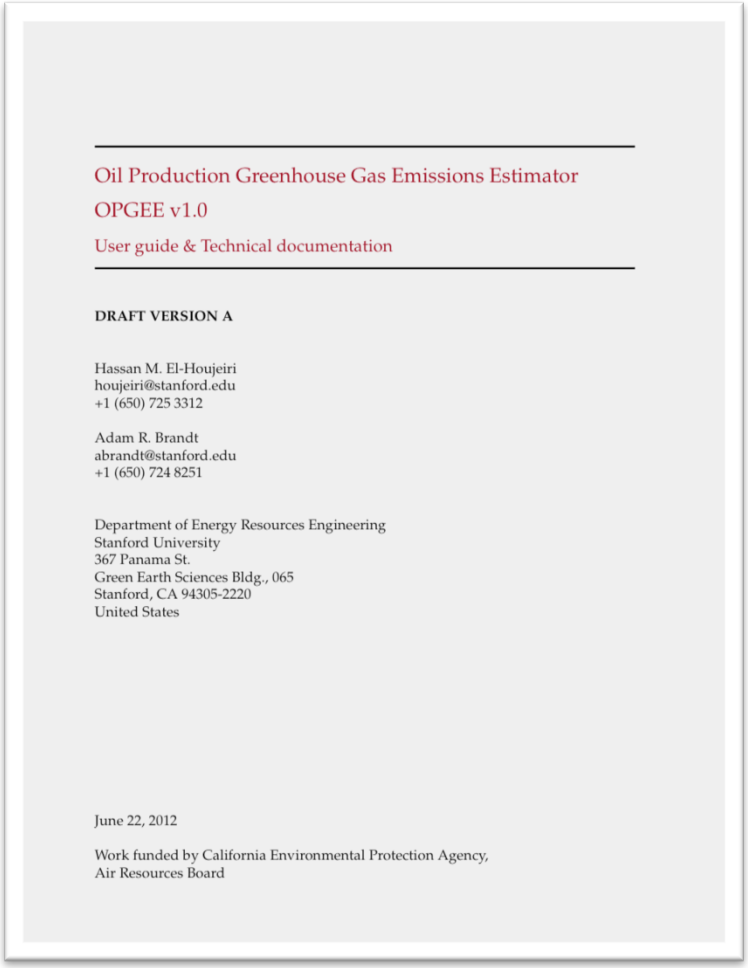


5. Documentation

Documentation

- Explains model calculations and assumptions
- Provides information on model data sources and calculations of defaults
- Designed to integrate well with model

1. Goals and motivation for OPGEE are described
2. Structure and usage of OPGEE is introduced
3. Production stages are explained in detail, outlining the calculation methods and assumptions
4. Supplemental calculation sheets are explained in detail (e.g. steam injection, VFF, etc.)
5. Gathering sheets are explained



Oil Production Greenhouse Gas Emissions Estimator

OPGEE v1.0

User guide & Technical documentation

DRAFT VERSION A

Hassan M. El-Houjeiri
houjeiri@stanford.edu
+1 (650) 725 3312

Adam R. Brandt
abrandt@stanford.edu
+1 (650) 724 8251

Department of Energy Resources Engineering
Stanford University
367 Panama St.
Green Earth Sciences Bldg., 065
Stanford, CA 94305-2220
United States

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6. Moving forward

Moving forward

- Modeling is generally complete
- Minor changes before next comment period
  - Tank emissions currently not included, will be included after revising tank calculations
  - Integrate field-level flaring results from UC Davis/ NOAA

Thank you