Oil Production GHG Emissions Estimator (OPGEE): Introduction and motivation

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March 19th, 2012

Overview

1. Introduction to OPGEE
2. Previous work and need for improvement
3. OPGEE structure, system boundaries, significance cutoffs
4. General overview of stages
5. Data inputs

1. Introduction to OPGEE

Overview of OPGEE

- Oil production greenhouse gas emissions estimator (OPGEE) beta version released today for technical comment
- 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

Our modeling goals

Improve the state of the art in crude oil GHG modeling in 5 ways:

1. Build a rigorous, engineering-based model of GHG emissions from oil production operations
2. Build a model with disaggregated data to provide maximum accuracy and flexibility
3. Build the model using public data where possible
4. Build a model that documents sources for every equation, parameter, and input assumption
5. Build a model that is (and will remain) free to access, use, and modify by any interested party

Modeling team

- Adam Brandt (Assistant Professor, Stanford)
  - Leading effort and overseeing components of work
- Hassan El-Houjeiri (Post-doc, Stanford)
  - Funded with ARB grant (2011-2012)
  - Building modeling tool, focus on primary, secondary, tertiary recovery
- Jacob Englander (Graduate student, Stanford)
  - Working on oil sands (future versions of model)
- Sebastian Galarza (ICCT)
  - Assisting with data analysis and EU context

2. Previous studies

Previous studies

- Previous LCA models generally treat oil simply
  - GREET models oil production very simply, oil sands are modeled using two broad categories
  - GHGenius includes somewhat more detail, especially on oil sands, lacks ability to differentiate carbon intensity of different crudes

- More recent studies have looked at emissions as a function of crude oil properties
  - Consultants: Jacobs, TIAX, Energy Redefined
  - Government: NETL

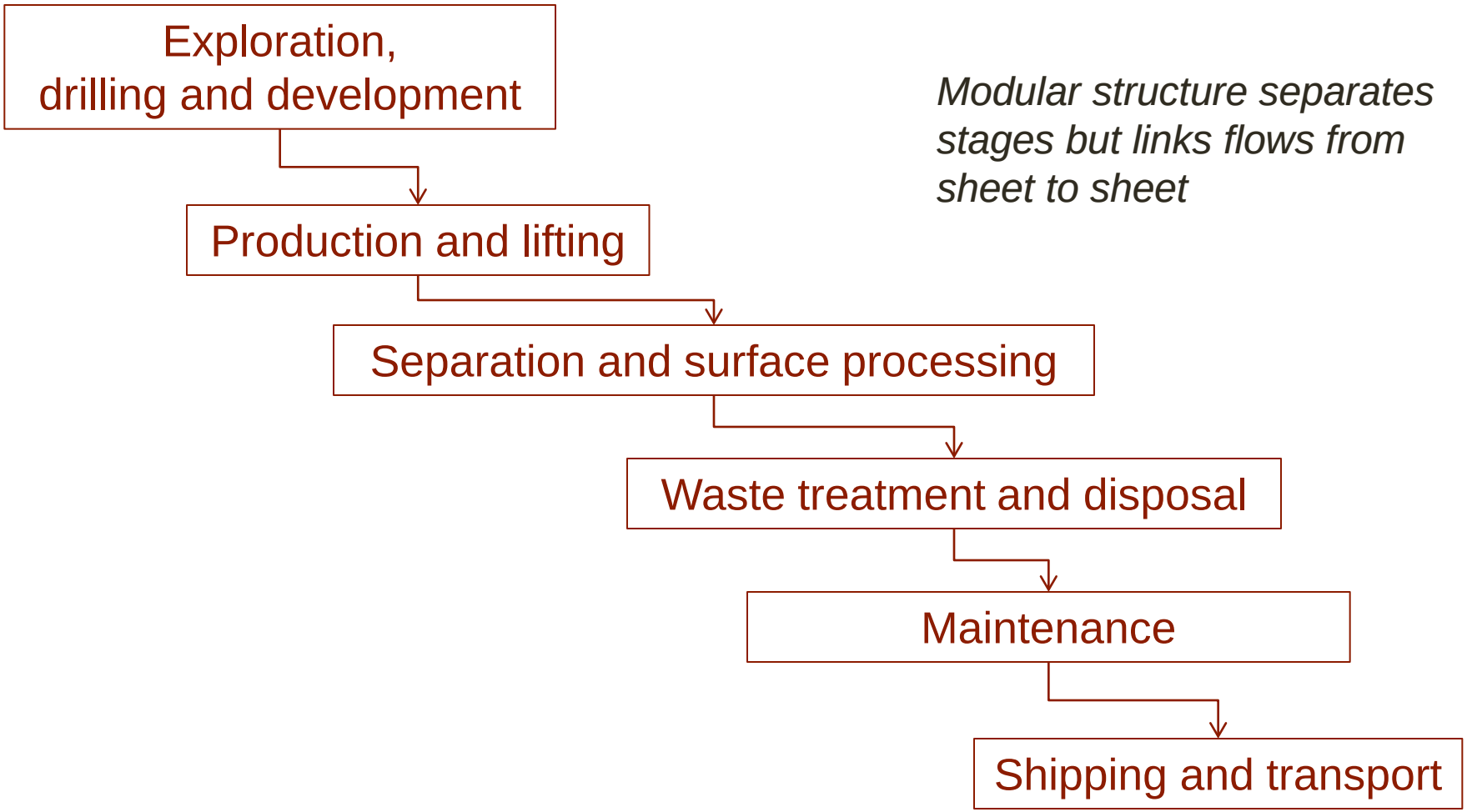
The need for a new model

- For regulatory purposes, a new model is desired
  - More transparency is needed compared to previous private models
  - More rigor is needed compared to previous public models
- Aim is to generate reliable estimates using a relatively small number of data inputs
  - Lessen effort required while still providing accurate measurement

3. OPGEE structure, system boundaries, significance cutoffs

Current model structure

- Includes all oil operations upstream of refinery gate



Modular structure separates stages but links flows from sheet to sheet

Specificity and simplicity

- Tradeoffs between amount of detail included and complexity of model
- We have taken a “two tier” approach
  - Simpler front-end with small number of data inputs
  - More detailed calculations in supporting sheets

What does an “estimator” mean?

- We are purposely calling OPGEE an “estimator”

- The question OPGEE aims to answer:

<u>Given all available information, what is a best estimate of GHG emissions from a given oil and gas project?</u>

What does an “estimator” mean?

- How does OPGEE make an estimate?
- Two-tiered approach
  - Plug data into summary sheet – OPGEE assumes a default, common production method
  - Make changes to back sheets – OPGEE allows more customization
- Goal of OPGEE is to model GHG emissions from common practices

System boundaries: What is included?

- Overview sheet gives clear view of what is included and excluded in any given model version
  - Includes all known emissions sources, regardless of size or magnitude

- Allows for clear setting of significance boundaries
  - *Model will not cover all emissions sources, but will be very clear about what is and is not covered*
  - “Future proof” the model – Structure allows new emissions sources

Model codes and classifications

- Combustion: Direct combustion products and associated fugitive emissions
- Electricity: Direct electricity use leading to upstream emissions
- Venting: Emissions of hydrocarbons including venting, leaks, process blowdown, other fugitive sources
- Embodied: Emissions embodied in materials used in production
- Land use: Emissions due to land use changes (soil and plant carbon release)

Combustion	c
Electricity	e
Venting	v
Embodied	m
Land use	l

Significance cutoffs

- All LCA models require a significance cutoff
  - Every model does this (implicitly or explicitly)
- If we can think of an emissions source, it is given a rating
  - Initial rating based on our judgment, feedback
- Careful about not dividing efforts among too many sources

Importance	Estimated size		Degree of treatment
*	0.01	g/MJ	Excluded
**	0.1	g/MJ	Included with defaults or excluded
***	1	g/MJ	Included with ease of customization
****	10	g/MJ	Included with significant treatment and uncertainty analysis

4. General overview of stages

Basic model structure

- Overview sheet controls the model
  - Major data inputs put into front sheet
  - Graphical output graphs emissions sources by stage
  - Allows comparison of a number of cases at once
- Each major process stage has its own sheet
- Cross-cutting or important sources have their own specialized sheet

Exploration and development

- Exploration below significance cutoff
  - Exploration has a minor impact on the total GHG emissions and is moved to second priority
- Field development includes land use and drilling energy
  - Land use impacts from Yeh et al. (lookup table)
  - Drilling energy from Brandt (2011)
- Could add other impacts in future versions
  - Hydraulic fracturing and flow-back methane
  - Fugitives release during development

Fluid lifting and production

- OPGEE runs any combination of 5 main production techniques:
  - Downhole pump (sucker-rod, electric submersible)
  - Water flooding
  - Nitrogen flooding
  - Gas lifting
  - Steam flooding (TEOR)
- OPGEE currently does not include oil sands extraction
  - Considering use of GHGenius data until oil sands module is developed

Separations & surface processing

- Current OPGEE version includes key surface operations
  - Separation and processing of oil, gas and water
  - Heater/treater
  - Gas dehydration
  - Gas treatment
  - Crude stabilization
  - Multi-stage water treatment
- Water treatment includes treatment of produced water and treatment of water for injection (if needed)

Waste disposal and maintenance

- Waste disposal below significance cutoff
  - Will have a minor impact on the total GHG emissions
  - Possible exceptions – Disposal of fracturing fluids and fracturing flow-back water
- Maintenance-related VFF emissions included
  - VFFs from compressor blowdowns, well workovers and cleanups, separators cleaning and repair, pipeline gathering maintenance and pigging
  - Other maintenance emissions excluded

Crude transport

- Transport module in OPGEE derived from GREET
  - GREET model contains sufficient detail
- Can change transport distances and modes

5. Data inputs

Data sources and scientific basis

- Use scientific and engineering basis
- Rigorous core model will allow significant future work to add details and run additional cases
- Being clear about data sources helps make assumptions clear and transparent

References and data sources

- Goal: rely on publically available but technically competent data sources

- The challenge of accessibility vs. quality
  - Web sources, public domain data
  - Journal articles
  - Textbooks and industry references
  - Proprietary datasets (IHS etc.)

- Less accessible
- More detailed
- More accurate

- Will use mostly industry references + journal articles, avoid proprietary datasets

Key reference texts used

- Lake, L. *Petroleum Engineering Handbook: Volume I-VI*
- Takacs, G. *Modern Sucker-Rod Pumping*
- Takacs, G. *Sucker-Rod Pumping Manual*
- Takacs, G. *Gas lift manual*
- *Waterflooding*. SPE reprint series no. 56
- Green, D., Willhite, G. *Enhanced Oil Recovery*
- Jarrell, P. Fox, C., Stein, M., Webb, S. *Practical Aspects of CO2 flooding*
- Chilingarian, G., Robertson, J, Kumar, S. *Surface operation in petroleum production, I & II*
- Manning, F., Thompson, R. *Oilfield Processing of Petroleum. Volume 1: Natural Gas*
- Manning, F., Thompson, R. *Oil Field Processing. Volume 2: Crude Oil*
- Szilas, A. *Production and transport of oil and gas. Part B: Gathering and transport*
- McAllister, E.W., Pipeline Rules of Thumb: Handbook
- Miesner, T., Leffler, W. *Oil and Gas Pipelines in Nontechnical Language*
- *Schmidt. Fuel Oil Manual*
- API Std 2000/ISO 28300 - Venting Atmospheric and Low-pressure Storage Tanks
- API Publ 306 - An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks
- API Publ 334 - A Guide to Leak Detection for Aboveground Storage Tanks
- API DR 141- Global Emissions of Carbon Dioxide from Petroleum Sources

Various other data sources

- GREET
  - Emissions factors: boilers/heaters, turbines, reciprocating engines, and flaring with 0.2% non-combustion
  - Fuel cycles and displaced systems: natural gas
  - ocean tanker / pipeline transport
  - Fuel specs (liquid fuel heating values)
- Caterpillar
  - Technical sheets for oil and gas engines
- General electric (GE)
  - Technical sheets for motors
- NOAA and EIA
  - Country-specific flaring volumes
  - Country-specific crude oil production

How are sources and equations documented?

- Some documentation in place
  - Visual distraction minimized by placing at side in light font
  - Includes reference, author, page number
- Equations for key model components in place
  - Allows easier reading of model equations than Excel formulas
- Documentation writing underway
  - Hassan El-Houjeiri is lead documentation author

5. Work in progress and next steps

In progress: Parameterization and defaults

- Eventual goal for model: improve data basis for model by defining “smart defaults” and default relationships
- Example: what is the default water-oil ratio?
  - Could use global average WOR
  - Could use relationship between field age and water-oil ratio

In progress: Comparison cases

- A goal: build comparison cases to test OPGEE accuracy and flexiblity
  - Compare to previous studies such as Jacobs, TIAX, NETL, etc.
  - Compare to reported emissions in some jurisdictions (e.g., California)
- Comparisons may be difficult due to lack of data transparency

In progress: Documentation

- Full documentation of model in progress
  - Easier to understand than spreadsheet-only
  - More detailed explanation of sources
  - Explanation of supplementary datasets
- Documentation writing will occur in parallel with initial review
  - Documentation released with first version of model in Summer 2012

Timeline

- April: Initial outside expert review of model
- May: Address comments with changes to model and update documentation
- March-June: First draft of documentation and updates to documentation based on comments
- Early summer: OPGEE v. 1.0 Model and documentation release