Oil Production Greenhouse Gas Emissions Estimator (OPGEE)
Version 1.1 draft A
Model updates & changes

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Overview

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3. Changes from OPGEE v1.0
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1. Introduction

Overview of OPGEE

- *Oil Production Greenhouse Gas Emissions Estimator - Draft version A* 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
September 17th 2012	Release OPGEE v1.0 for public review and commenting
March 5th 2013	Public workshop to discuss changes to OPGEE v1.0 (release of OPGEE v1.1 Draft A)

OPGEE version 1.1 – Goals and motivation

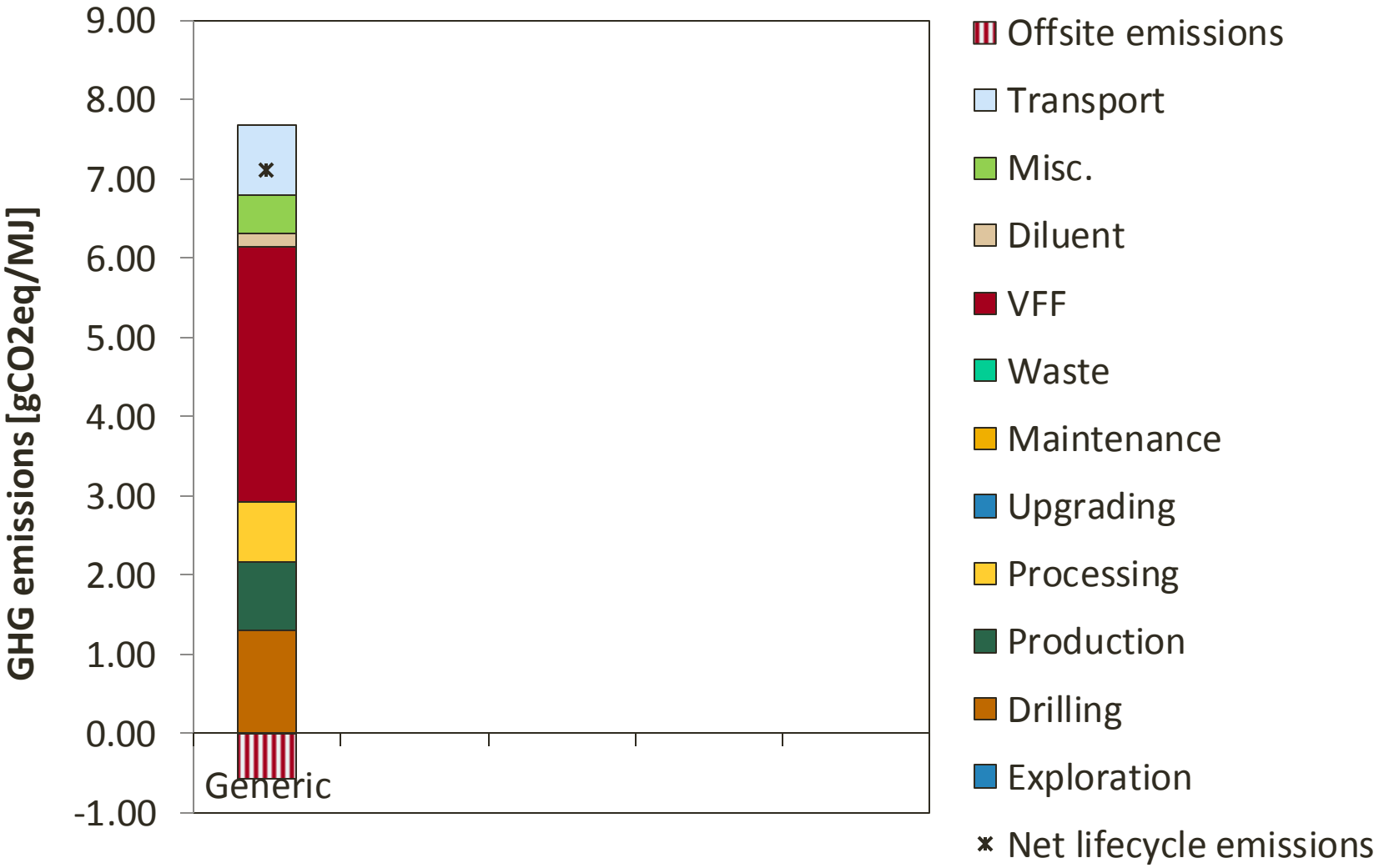
- OPGEE Version 1.1 was developed for multiple reasons
  - Improve usability of tool with bulk assessment
  - Add functionality and more accurate modeling of various production options
  - Clarify and model in detail important sources treated simply before (e.g., associated gas flaring)
  - Correct errors reported after last public comment period

3. Changes from OPGEE v1.0

User inputs & results worksheet

- Organized user inputs worksheet for the implementation of new macro for the bulk assessment
- Improved the flexibility of modeling by adding features to User inputs & results sheet
  - Allowed removal of gas processing units
  - Added ocean tanker size
  - Added volume fraction of diluent
- Changed the accounting of emissions
  - Removed the allocation of off-site GHG emissions (credits/debts)
  - Added a separate emissions category for total off-site GHG emissions
  - Added a separate emissions category for diluent life cycle emissions

Results graph changes

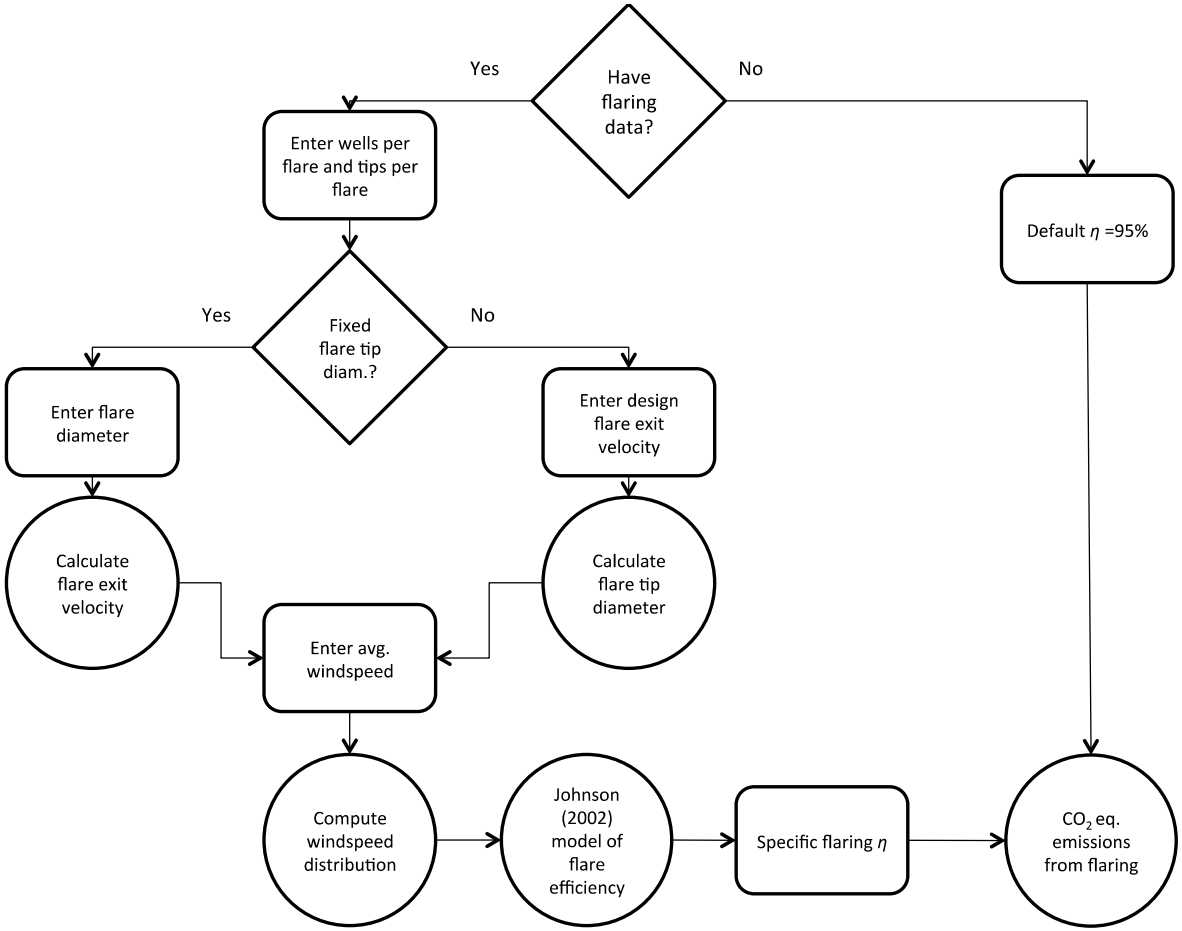


Data and input parameters

- Modified land use change emissions factors to account for 30 year analysis period
  - Desired consistency with other CARB fuel pathways (e.g., biofuels) with 30 year lifetime
  - Original study first author S. Yeh (UC Davis) modified model for emissions from land use change to account for 30 year lifetime
  - Many land use emissions estimates go up: project life is ~30 years, so no regrowth occurs
  - 150 year lifetime remains in model as option
- Added petroleum coke life cycle energy consumption and GHG emissions
  - GREET data basis

New model functionality – Flaring efficiency

- Old flaring model assumes static flaring eff. (95%)
- New model has two options:

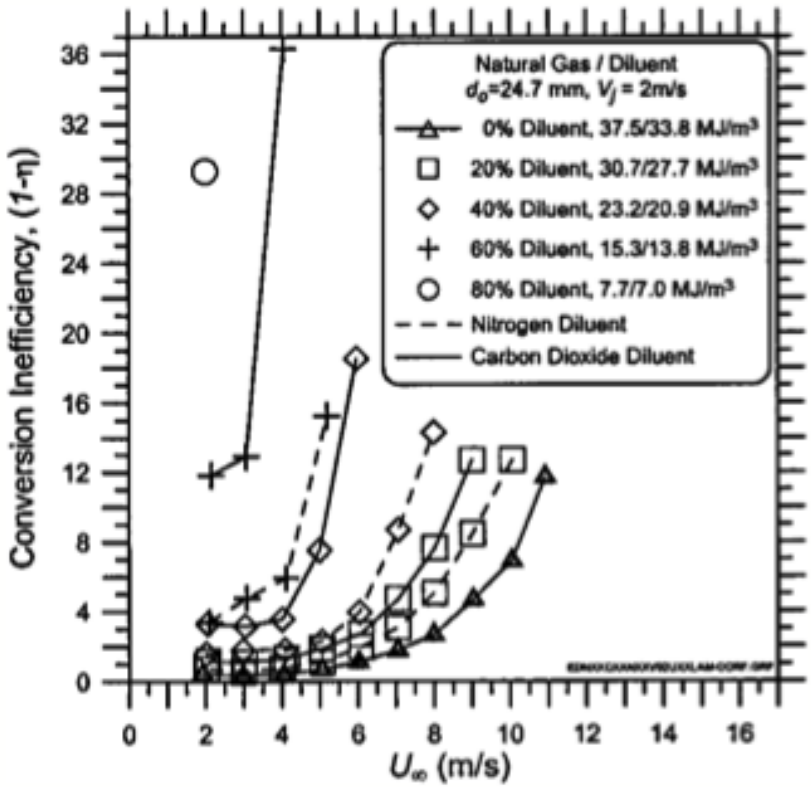


Flaring efficiency

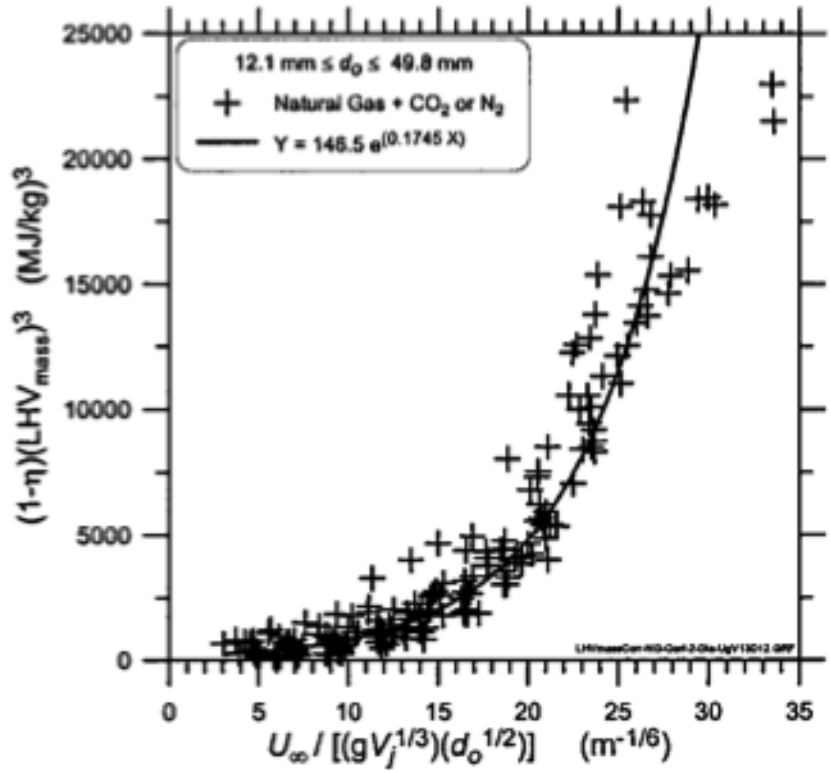
Parametric model of Johnson et al. 2002:

$$\eta_F = 1 - \frac{A \exp\left[\frac{BU_\infty}{(gVd)^{\frac{1}{3}}}\right]}{LHV^3}$$

Constant diameter
and exit speed
- Vary diluent

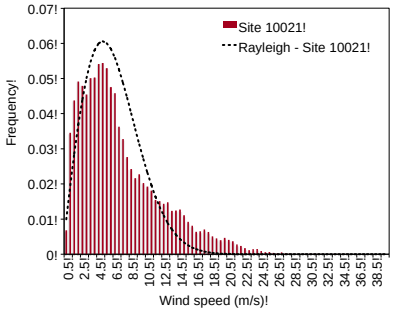


All data with
varying diameters
and exit speeds

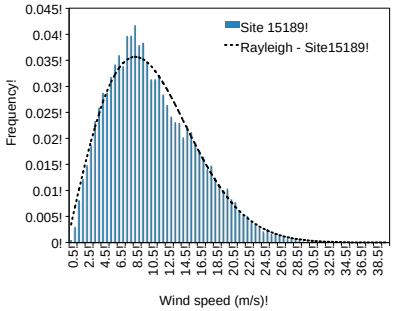


Importance of wind speed

- Cross wind speed matters. Flares are generally efficient **if**:
  - Large scale flare and cross wind velocities are not high
- We include a Rayleigh distribution to estimate wind speed distributions

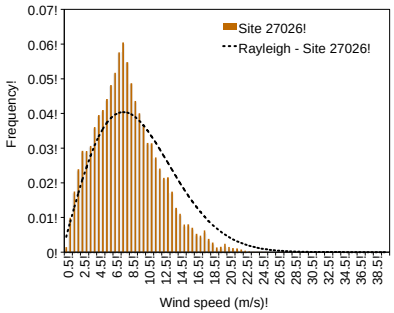


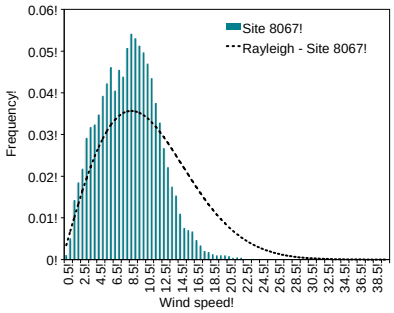
(a)



(b)

$$m_U = \frac{\mu_U}{\sqrt{\frac{\pi}{2}}}$$





$$p(U) = \frac{U}{m_U} \exp\left[-\frac{1}{2}\left(\frac{U^2}{m_U^2}\right)\right]$$

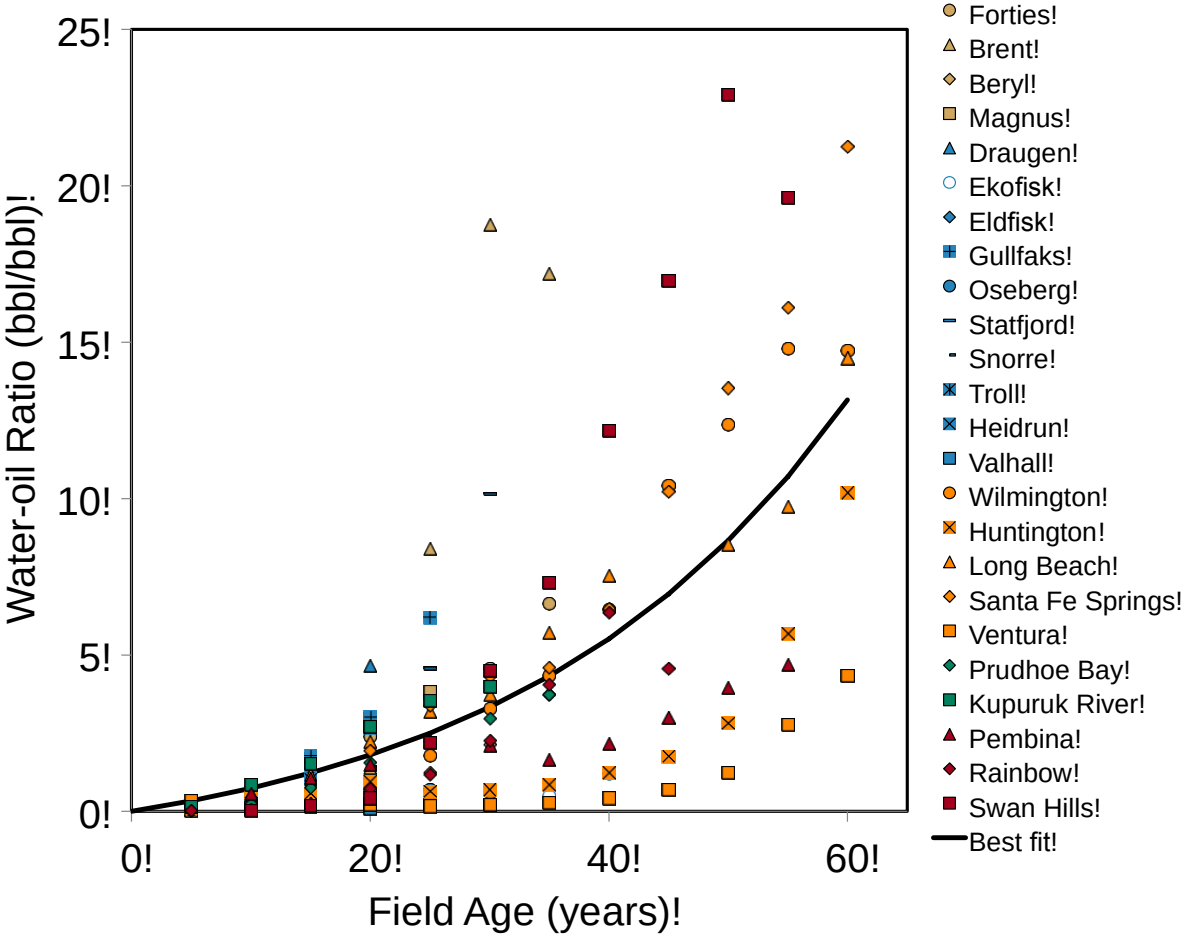
Source: Rayleigh model - Da Rosa (2012), Wind data from NREL Western Wind dataset

Requirements for running wind model

- Strong data requirements for running wind model
  - If not all data are available, must use default
- Required data
  - Number of flare tips (or flares/well and tips/flare)
  - The flare exit velocity if a fixed velocity (variable orifice) tip is used
  - The flare diameter if a fixed diameter tip is used
  - The average local wind speed (lookup available in USA)

Water-oil ratio smart default improved

$$WOR(t) = a_{WOR}\exp[b_{WOR}(t - t_0)] - a_{WOR} \quad \left[\frac{\text{bbl water}}{\text{bbl oil}}\right]$$



Improved geographical coverage
- UK North Sea
- Norway North Sea
- California
- Alaska
- Alberta

Only largest fields are included
- >= 100 M m^3 (630 M bbl)
- These types of fields are likely to export internationally

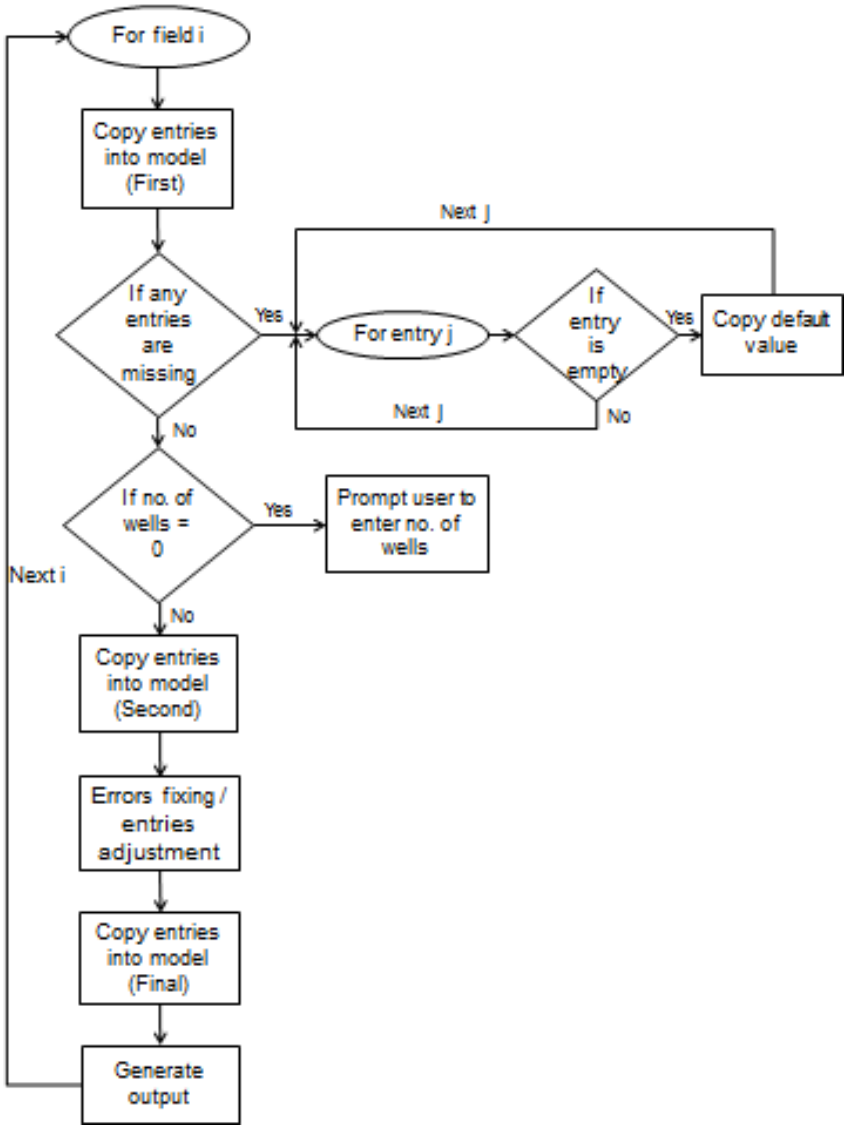
Long tail effects eliminated
- Data from old California fields is excluded
- Behavior can be driven by old-age behavior which may not be representative (only CA data past 60 years)

New model functionality

- More detailed demethanizer model now includes energy consumed by demethanizer
  - Energy for compression applies to all input feed
  - Energy for refrigeration work applies to condensed feed
  - Heat recovery assumed to supply heat to reboiler
- Developed the option of diluent blending after production
  - Accounts for indirect GHG emissions associated with importing NGL for use as diluent
- Add non-integrated upgrader option for heavy oil (non-bitumen pathways)
  - Uses upgrading data from bitumen worksheet
- Allowed processing configuration flexibility
  - Switch ON/OFF dehydrator, AGR unit and/or demethanizer

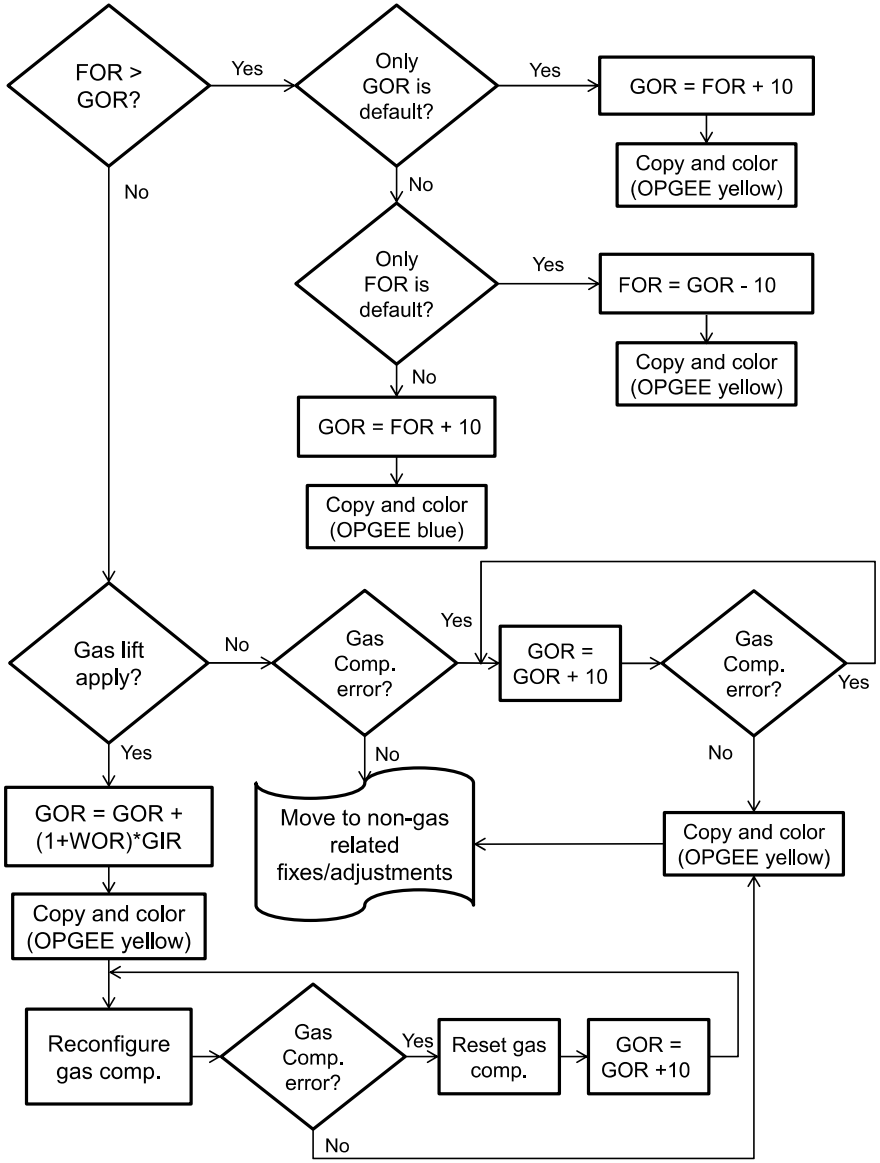
Bulk assessment macro changes

- New macro runs the bulk assessment for unlimited number of fields
- Macro has built-in logic for error fixing and populating model with defaults
- Bulk assessment features:
  - Works with limited datasets, fills in defaults or smart defaults where applicable
  - Resolves errors by changing consistently the well diameter, productivity index, GOR etc
  - Uses colors to highlight where the macro fills in or alters data



Bulk assessment: Error fixing and adjustment

- Errors that are addressed in the macro:
  - Discrepancies between country-average default flaring rate and entered GOR
  - Discrepancies between default fugitive emissions of gaseous components and gas available from production
  - Requirement to iteratively solve for the gas composition in the wellbore in the case of gas lift
  - Error with productivity index resulting in negative bottomhole pressures
  - Error resulting from very large frictional lifting penalties due to too small assumed wellbore
  - Requirement to iteratively solve for gas reinjected to result in 0 gas export



Complete set of logic flow diagrams and description is found in the model documentation

Conventional oil model corrections and improvements

- Changed heater/treater calculations
  - Default oil emulsion (14% emulsified water) gives fraction of emulsified water irrespective of WOR
- Improved compressor model
  - Compressor now varies between 1 and 5 stages
  - Conversations and data from Statoil suggested need for compressors with more stages
- Corrections and clarifications
  - Corrected the AGR unit venting emissions calculation (eliminated double counting of non-CO_2 emissions)
  - Corrected two typos in bulk assessment worksheet
  - Corrected flaring emissions calculations (use preprocessing gas composition)

Bitumen sheet

- Error correction and model clarifications
  - Heating value basis in '*Bitumen Extraction & Upgrading*' worksheet is changed from HHV basis to LHV basis
  - Improved treatment of imported vs. on site energy at bitumen production facilities and clarified use of fuel cycle emissions for imported fuels
  - Diluted bitumen pathways now exhibit sensitivity in flaring and fugitive emissions computations to level of diluent blending.

Small changes

- Error checks
  - Corrected the *'Gas Balance'* gas composition overall error check
  - Added error check to ensure that downhole pump and gas lift do not co-exist (results in miscalculation of required lifting work)
  - Added error check to ensure that user input for volume fraction of diluent is not less than the volume fraction of NGL produced onsite as crude oil blend (this is part of adding the capability of diluent blending with low grade conventional crude oil)
- Added worksheet to track model changes
- Changed color themes to OPGEE color themes

4. Moving forward

Feedback on model v1.1

- Feedback appreciated on OPGEE v1.1 DRAFT A
- Feedback will be incorporated in OPGEE v1.1 final
- Welcome feedback
  - Errors or omissions
  - Thoughts on modeling options
  - Major gaps or needs for future research
  - Data or detailed information on any modules

Thank you