

EORgui Help

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EORgui

Graphical User Interface for the United States of America, Department of Energy, Publicly Available EOR Software.

by Petroleum Solutions Ltd

EORgui Help

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Printed: May 2010

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EORgui

Graphical User Interface for the United States of America, Department of Energy, Publicly Available EOR Software.



1 Welcome to EORgui

1.1 Introduction

	EORgui - Enhanced Oil Recovery Screening Software	
<u> </u>		S About @
Applications « Quick Screen Quick Screen EORgui Help	EOR Methods Quick Screening [Slaughter Example.EOR] Recent Files Portal Sughter DOE Example API Gravity 32 Formation Sandatone Oli viscosity (61 2 Thickness < 20 ft Oli Saturation, fraction 0.5 Composition High % C1-C7 Sammary Screening Detail	Abod Abod
	Steam Carbon Dioxide Polymer Polymer, ASP, alkaline	Enhanced VidetriGooding Method Criteris Fil Polymer 50% (4) SP / ASP 57% (3) (Thermal - Mechanical Methods) Criteris Fit Steam 42% (7) Combustion 43% (6)
CO2 Miscible Flood		
Polymer		Calculate
Chemical Flood		
In-Situ Combustion		
Steamflood		
Infill Drilling		PetroleumSolutions.co.uk
<mark>0 1</mark> 4		

EORgui is a Graphical User Interface for the United States of America, Department of Energy, National Energy Technology Laboratory, Publicly Available EOR Software.

Through the use of this application, the user can quickly screen oil fields and quantify incremental production for potentially applicable EOR techniques.

This graphical user interface (GUI) application :

- Quickly screen and rank appropriate EOR methods for a given set of summary reservoir and fluid properties.
- Prepares the input files required for the technical analysis portions of the publicly available fortran applications. Namely, the GUI does not prepare the input required to calculate the economic analysis that is also available within these publicly available software.
- The GUI runs the fortran applications and imports the results back into the application.
- The results are input into convenient data tables for export into other applications (eg. Microsoft Excel), and also plotted in high output quality charts for use with other applications (eg. Microsoft Powerpoint).

License.dat File

The "License.dat" file is located in the Application Startup folder (eg C:\Program Files\Petroleum Solutions\Waterdrive\)

The contents of this ASCII license file needs to contain the following license information.

[License Settings] LicensedTO = Company = ProductID = LicenseID =

If any of the above License key information is incorrect or absent, or if the License.dat file is missing then the application will fail to startup.

.NET Framework

The Profile application requires the presence or installation of Microsoft .Net Framework version 2.

.NET Framework version 2 is a component of the Microsoft Windows® operating system used to build and run Windows-based applications.

Should .NET Framework version 2 not be installed on the destination PC then a link is provided below to download this system software. The user should download and install .NET Framework version 2 before attempting to install Waterdrive.

Inttp://www.petroleumsolutions.co.uk/downloads.html

The installation of .Net Framework also requires a minimum software and hardware requirement. Details of which are shown below. Specifically, note that you cannot install the .NET Framework on a computer running the Microsoft Windows 95 operating system.

Minimum requirements

To install .NET Framework [Dotnetfx2.exe], you must have one of the following operating systems, with Microsoft Internet Explorer 5.01 or later installed on your computer:

- Microsoft® Windows® 98
- Microsoft® Windows® 98 Second Edition
- Microsoft® Windows® Millennium Edition (Windows Me)
- Microsoft® Windows NT® 4 (Workstation or Server) with Service Pack 6a
- Microsoft® Windows® 2000 (Professional, Server, or Advanced Server) with the latest Windows service pack and critical updates available from the Microsoft Security Web site (www.microsoft. com/security).
- Microsoft® Windows® XP (Home or Professional)

Recommended hardware

CPU Recommended	RAM Recommended
Pentium 90 MHz or faster	96 MB or higher

EORgui

Graphical User Interface for the United States of America, Department of Energy, Publicly Available EOR Software.



2 EORgui Sections

2.1 Quick Screening

This routine is based on the 1996 Society of Petroleum Engineers Paper entitled "*EOR Screening Criteria Revisited*" by Taber, Martin, and Seright. Contained within this paper are concise screening guidelines for various EOR techniques, all of which are listed in the table provided in the *Detail* tab, as shown in the third figure below.

O EOR Methods Quick Screening [[Slaughter Example.EOR]		- • -
🔁 Recent Files 👻 🗁 🔚 🗎	9		
Title	Slaughter DOE Example		
API Gravity	32 Formation	Sandstone 💌	Depth [feet] 5000
Oil viscosity [cP]	2 Thickness	< 20 ft 💌	Temperature [deg F] 105
Oil Saturation, fraction	0.5 Composition	High % C1-C7	Permeability [mD] 6
Summary Screening Detail			
			Gas Injection Methods
	Nitrogen		Criteria Fit
			Nitrogen
Combustion		Hydrocarbon	Hydrocarbon
			Carbon Dioxide
			Immiscible
			Enhanced Waterflooding Methods
Steam	¥	Carbon Dioxide	Criteria Fit
		/	Polymer
		/	SP / ASP
		/	Thermal - Mechanical Methods
Polymer		Immiscible	Criteria Fit
			Steam
	Micellar / polymer, ASP, alkaline		Combustion
			Calculate Close

Once the user has input all the necessary data, then press the *Calculate* button to calculate the relative Criteria fit to the input data.

O EOR Methods Quick Screening	[Slaughter Example.EOR]			- • •			
🛃 Recent Files 👻 🗁 🛃 🗎	9						
Title	Slaughter DOE Example						
API Gravity	32 Formation	Sandstone 💌	Depth [feet]	5000			
Oil viscosity [cP]	2 Thickness	< 20 ft	Temperature [deg F]	105			
Oil Saturation, fraction	0.5 Composition	High % C1-C7	Permeability [mD]	6			
Summary Screening Detail							
			Gas Injectio	n Methods			
	Nitrogen			Criteria Fit			
			Nitrogen	40% [8]			
Combustion 80- Hydrocarbon 60- Carbon Dioxide 44% [5]							
Combustion 80 60 60 40 60 40 81 Hydrocarbon 60% [2] Carbon Dioxide 44% [5] Immiscible 83% [1]							
	40-		Immiscible	83% [1]			
	20-		Enhanced Waterfl	ooding Methods			
40- 20- Steam () () () () () () () () () (
	$\mathbb{N} \setminus \mathbb{N} \neq \mathbb{N} \setminus \mathbb{N}$		Polymer	50% [4]			
			SP / ASP	57% [3]			
			Thermal - Mecha	nical Methods			
Polyme				Criteria Fit			
			Steam	42% [7]			
	Micellar / polymer, ASP, alkaline		Combustion	43% [6]			
			Calculate	Close			

The results are shown in both summary chart and a colour coded results table.

Recent Files 👻 🗁	screening (slaugi		4					
	Title Slaugh	ter DOE Example						
Al	PI Gravity 32		Formation	Sandstone	-	Depth [f	eet] 5000	
Oilvise	cosity [cP] 2		Thickness	< 20 ft		Temperature [deg	g F] 105	
Oil Saturatio	n, fraction 0.5		Composition	High % C1-C7	-	Permeability [r	mD] 6	
Summary Screening	Detail							
Properties 🖌	Nitrogen and flue gas	Hydrocarbon	Carbon Dioxide	Immiscible Gases	Miscellar/polymer, ASP, and alkaline flooding	Polymer flooding	Combustion	Steam
Oil API Gravity	> 35 Average 48	> 23 Average 41	> 22 Average 36	> 12	> 20 Average 35	> 15, < 40	> 10 Average 16	> 8 to 13.5 Average 13.5
Oil Viscosity (cp)	< 0.4 Average 0.2	< 3 Average 0.5	< 10 Average 1.5	< 600	< 35 Average 13	>10, <150	< 5,000 Average 1200	< 200,000 Average 4,700
Composition	High % C1-C7	High % C2-C7	High % C5-C12	Not critical	Light, intermediate. Some organic acids for alkaline floods	Not critical	Some asphaltic components	Not critical
Oil Saturation (%PV)	> 40 Average 75	> 30 Average 80	> 20 Average 55	> 35 Average 70	> 35 Average 53	> 70 Average 80	> 50 Average 72	> 40 Average 66
Formation Type	Sandstone or Carbonate	Sandstone or Carbonate	Sandstone or Carbonate	Not critical	Sandstone preferred	Sandstone preferred	High porosity sandstone	High porosity sandstone
Net Thickness (ft)	Thin unless dipping	Thin unless dipping	Wide range	Not critical if dipping	Not critical	Not critical	> 10 feet	> 20 feet
Average Permeability (md)	Not critical	Not critical	Not critical	Not critical	> 10 md Average 450 md	> 10 md Average 800 md	> 50 md	> 200 md
Depth (ft)	> 6000	> 4000	> 2500	> 1800	< 9000 Average 3250	< 9000	< 11500 Average 3500	< 4500
Temperature (deg F)	Not critical	Not critical	Not critical	Not critical	< 200	< 200	> 100	Not critical
Calculate Close								

In the example provided above, the most appropriate EOR methods appear to be immiscible gas injection, followed by perhaps CO2 injection.

The colouring scheme is simply based on the degree in which the criteria is met or not. Namely, if a cell is coloured red then this criteria is not met, whereas if a cell is coloured light green then the criteria is just met, whereas if the cell is coloured dark green then the criteria is well met.

References:

Taber, J., Martin, D., Seright, R.," EOR Screening Criteria Revisited", SPE 35385, 1996.

Taber, J., Martin, D., Seright, R.,"*EOR Screening Criteria Revisited - Part 2: Applications and Impact of Oil Prices*", SPE 39234, 1997.

2.2 CO2 Miscible Flooding Predictive Model

The CO2 flooding process consists of injecting large quantities of CO2 into the reservoir. Although CO2, is not first-contact miscible with the crude oil, the CO2 extracts the light-to-intermediate components from the oil, and, if the pressure is high enough, develops miscibility to displace the crude oil from the reservoir. Immiscible displacements are less effective, but they recover oil better than waterflooding.

CO2 recovers oil by swelling the crude oil, lowering the viscosity of the oil and lowering the interfacial tension between the oil and the CO2 phase in the near miscible region.

The following description is taken from the US Department of Energy CO2 Predictive Model (CO2PM) documentation.

"The CO2PM is a three-dimensional (layered, five-spot), two-phase (aqueous and oleic), three component (oil, water, and CO2) model. It computes oil and CO2 break through and recovery from fractional theory modified for the effects of viscous fingering, areal sweep, vertical heterogeneity and gravity segregation. One-dimensional fractional flow theory is applied to first-contact miscible displacements in the presence of a second immiscible phase. The theory is based on a specialized version of the method of characteristics known as coherence or simple wave theory. The theory incorporates the Koval (1963) factor method to account for unstable miscible displacements (fingering). An extension of the Koval approach is used to model the influence of gravity segregation. Reservoir heterogeneity is accounted for by allowing up to five layers in the model, with permeabilities computed from a user-specified Dykstra-Parsons (1950) coefficient. The fractional flow theory with gravity and heterogeneity dependence is corrected for areal sweep with a generalization of Claridge's (1972) procedure to first-contact miscible floods of arbitrary WAG ratios and arbitrary initial conditions."

- 2 - 2	EORgui - Enhanced Oil Recovery Screening Software	
		😡 About 🔞
Applications «	O CO2 Miscible Flood Predictive Model [US DOE CO2 Example SLAUGHTER.CO2]	
Quick Screen	🛛 Recent Files 🔻 😂 📊 🚔 🎯	
CO2 Miscible Flood		
CO2 Miscible Flood		
Help Documentation	l ype of Hecovery Calculation (3-D Calculations (2-D + gravity, recommended for screening)	
http bocamentation	Reservoir Calculations Output (-D summary and 3-D (or 2-D) pattern production and injection schedule for total layers	
	Solubility of CO214 Water CO22 Solubility in Water Not accounted for	
	Required Data Optional Data	
	Reservoir Depth [ft] 5000 Reservoir Pressure [psia] 2000	
	Pattern Area 40 Acres Reservoir Temperature (deg F) 105	
	Porosity (fraction) 0.113 Number of Layers 3	
	Permeability [mD] 6 Dykstra-Parsons Within Layers 0.48	
	Net Pay Thickness [ft] 77.5 Koval Factor within Layers 0	
	kv/kh Ratio 0.01 Gas Gravity 0.8	
	Dykstra-Parsons Coefficient 0.48 Solution GOR (scf/stb) 600	
	Oil API Gravity 32 Oil FVF. Bo (rb/stb) 1.22	
	Endpoint kro at Swc 1 CO2 FVF [rb/Mscf] 0	
	Endpoint krw at Sor 0.34 Viater FVF, Bw (rb/stb) 1	
	Corey Exponent for Oil 2.55 Water Salinity [ppm] 50000	
	Corey Exponent for Water 1.78 Oil viscosity [cP] 2 Clear All	
	Swc, fraction 0.08 CO2 viscosity [cP] 0.074 Calculate	
	Sor, fraction 0.31 Water viscosity [cP] 0.8 Optional Data	
	Calculate Close	
Polymer		
In-Situ Combustion		
Steamflood		()
Infill Drilling	PetroleumSolutions.co.uk	
0 14		

CO2 Miscible Flood Predictive M	/lodel [US DOE CO2 Examp	le SLAUGHTER.CO2]			
🛽 Recent Files 👻 🗁 🛃 📄	9				
Title SLAUGHTER					
Type of Recovery Calculation	3-D calculations (2-D + grav	vity, recommended for se	creening)		-
Reservoir Calculations Output	1-D summary and 3-D(or 2-	D) pattern production ar	d injection schedul	e for total layers	•
Solubility of CO2 in Water	CO2 solubility in water not a	accounted for			-
Reservoir and Fluid Data Injection	on and Production Controls	Results			
	Pr	ediction Timeframe			
Start Date Ja	in 2008 🚔 🔹	Reporting Freque	ncy Monthly	-	
	Initial oil cut at the start of	CO2 flooding [fraction]	0.13 Raw Calculate	/ ed Data	
	Time increment for recov	very calculations [year]	0.5		
Concentration incr	rement used for fractional flow	v calculations [fraction]	0.001		
	Total flui	d injection rate [rb/day]	390	Calculate Default	
	WAG	ratio for CO2 injection	1.00 🚖		
Total hydrocarbon po	ore volumes of CO2 and wate	er injected during WAG	1.5		
Т	Fotal pore volumes of wag an	d chase water injected	4		
					Clear All
				Re	eset Defaults
			C	alculate	Close

Once the user has pressed the Calculate button, the results data will be re-imported back into the application and displayed as shown in the following three screen captures below.



The user can copy the data from the data tables to the Windows clipboard for use with other applications, such as Microsoft Excel. To display the context menu shown below, simply single right-mouse-click while over the data table.

т	itle SLAUGHTER						
Type of R	ecovery Calculation 3-	D calculations ((2-D + gravity, reco	ommended for sc	reening)		
Papapuair	Calculations Output 1	D summany and	3-D(or 2-D) patte	rn production and	diniection schedu	le for total lavere	
neservoir	Calculations Output	o summary and	13-D(012-D) patte	in production and	a injection schedu	lie for total layers	
Solubi	ility of CO2 in Water C	O2 solubility in	water not accounte	ed for			
Reservoir and	d Fluid Data Injection a	nd Production C	ontrols Results				
Main Results	Profiles Charts						
Date	Dimensionless Time [Pore Volume]	Oil Rate [bbl/d]	Water Rate [bbl/d]	Gas Rate [Mscf/d]	CO2 Rate [Mscf/d]	Cumulative Oil [Mbbl]	Cumulative Water [Mbbl]
Jan-2008	0.00	44.8	335.4	26.9	0.0	1.39	10.4(
Feb-2008	0.01	44.8	335.4	26.9	0.0	2.69	20.12
Mar-2008	0.01	44.8	335.4	26.9	0.0	4.08	30.52
Apr-2008	0.02	44.8	335.4	26.9	0.0	5.42	40.58
May-2008	Copy P	rofiles Table	335.4	26.9	0.0	6.81	50.98
Jun-2008	0.03	44.65	335.4	26.9	0.0	8.15	61.04
Jul-2008	0.03	44.8	335.4	26.9	0.0	9.54	71.44
Aug-2008	0.03	44.8	335.4	26.9	0.0	10.93	81.84
Sep-2008	0.04	44.8	335.4	26.9	0.0	12.28	91.9(
Oct-2008	0.04	44.8	335.4	26.9	0.0	13.66	102.3(
Nov-2008	0.05	44.8	335.4	26.9	0.0	15.01	112.3
Dec-2008	0.05	44.8	335.4	26.9	0.0	16.40	122.7(
Jan-2009	0.06	44.8	335.4	26.9	0.0	17.79	133.1!
Feb-2009	0.06	44.8	335.4	26.9	0.0	19.04	142.5
Mar-2009	0.06	44.8	335.4	26.9	0.0	20.43	152.94
Apr-2009	0.07	44.8	335.4	26.9	0.0	21.77	163.0(
May-2009	0.07	44.8	335.4	26.9	0.0	23.16	173.4(
Jun-2009	0.08	44.8	335.4	26.9	0.0	24.51	183.4(
Jul-2009	0.08	44.8	335.4	26.9	0.0	25.89	193.8
Aug_2009	80.0	<u>8 NN</u>	225.4	26.9	0.0	27.28	204.21

The user can also copy the active chart to the Windows clipboard for use with other applications, such as Microsoft Powerpoint.



2.3 Chemical Flood Predictive Model

All chemical flooding methods recover oil by lowering the interfacial tension between the oil and water, solubization of oil in some micellar systems and mobility enhancement.

Limitations

- An areal sweep of more than 50% on waterflood is desired.
- Relatively homogeneous formation is preferred.
- High amounts of anhydrite, gypsum, or clays are undesirable.
- Available systems provide optimum behavior over a narrow set of conditions.
- With commercially available surfactants, formation water chlorides should be <20,000 pprn and divalent ions (Ca⁺⁺ and Mg⁺⁺) <500 ppm.

Problems

- Complex and expensive systems.
- Possibility of chromatographic separation of chemicals in reservoir.
- High adsorption of surfactant.
- Interactions between surfactant and polymer.
- Degradation of chemicals at high temperature.

The following description is taken from the US Department of Energy Chemical Flooding Predictive Model (CFPM) documentation.

"The CFPM models micellar (surfactant)-polymer (MP) floods in reservoirs which have been previously waterflooded to residual oil saturation. Thus, only true tertiary floods are considered. An option is available in the model which allows a rough estimate of oil recovery by caustic (alkaline) or caustic-polymer processes.

The CFPM uses theory and the results of numerical simulation to predict MP oil recovery in five-spot patterns. Oil-bank and surfactant breakthrough and project life are determined from fractional flow theory. A Koval-type factor, based on the Dykstra-Parsons (1950) coefficient, is used to account for the effects of reservoir heterogeneity on surfactant and oil bank velocities. The overall oil recovery efficiency is the product of the efficiencies for 1-D displacement, vertical sweep of surfactant, and polymer sweep. The displacement efficiency is determined from the capillary number, which is in turn a function of permeability, depth and well spacing. Correlations derived from the results of numerical simulation are used to express vertical sweep efficiency as a function of surfactant slug size, surfactant adsorption and reservoir heterogeneity. The polymer sweep efficiency is an empirical factor developed from numerical simulation and is a function of the polymer slug size and the vertical sweep efficiency. The overall recovery efficiency is corrected for the effects of crossflow by a formula, again developed from the results of numerical simulation, which depends on the ratio of vertical to horizontal permeability."

O Chemical Flood Predictive Model [DOE Example CMFL.c	ml]	_ 0 🔀
🛃 Recent Files 👻 🔂 📑 📮	. 0		
Title DOE BASE CASE C	FPM		
Type of Chemical Flood Mi	cellar-Polymer		
NPC Modifications Switch Or	iginal Model - Recomm	ended For High-Water-Content And	I Low Viscosity Soluble-Oil Slugs
Lithology Sa	ndstone		•
Reservoir and Fluid Data Field and I	njection Data Results		
Required Data)	Op	otional Data
Reservoir Depth [ft]	2900	Reservoir Pressure [psia]	1270.7
Pattern Area 20	Acres 💌	Reservoir Temperature [deg F]	122
API Gravity	39	Gas Gravity	0.8
Porosity [fraction]	0.16	Solution GOR [scf/stb]	399
Permeability [mD]	75	Initial Oil FVF, Boi [rb/stb]	1.2
Net Pay Thickness [ft]	59	Final Oil FVF, Bo [rb/stb]	1.05
kv/kh Ratio	0.1	Final Water FVF, Bw [rb/stb]	1
Dykstra-Parsons Coefficient	0.68	Oil viscosity [cP]	3
Endpoint kro at Swc	0.8	Water viscosity [cP]	0.6
Endpoint krw at Sor	0.2	Water Salinity [ppm]	80000
Corey Exponent for Oil	2		
Corey Exponent for Water	2		Clear All
Swc, fraction	0.29		Calculate
Sor, fraction	0.38		Optional Data
			Calculate Close

O Chemical Flood Predictive Mod	el [DOE Example CMF	E.cml]	
Recent Files 👻 🔀 📄	9		
Title DOE BASE CAS	E CFPM		
Type of Chemical Flood	Micellar-Polymer		•
NPC Modifications Switch	Original Model - Reco	mmended For High-Water-Content And Lo	ow Viscosity Soluble-Oil Slugs 🔹
Lithology	Sandstone		•
Reservoir and Fluid Data Field a	nd Injection Data Resu	llts	
		Prediction Timeframe	
Start Date Ja	n 2008 🚔 🔹	Reporting Frequency Monthl	
Required Da STOOIP [MMstb Cumulative Oil [MMstb Bottom Water [fraction Gas Cap [fraction	a 795.191 279.5 0 0 0	Semi-J Annua User Surfactant Retent. Weight Fraction Cla Rock Grain Density [g/m] Surfactant Slug Density [g/m] Surfactant Concentration [fraction Surfactant Slug Size	Annually ly alculated Data y 0.1 1 2.68 1 1 0.05 e 1.3
		Polymer PV Injected (fraction User Displacement Efficienc Steady State Pattern Rate (rb/d Injectivity Coefficient, psi/	1] 0.65 9'
			Calculate Close

Once the user has pressed the Calculate button, the results data will be re-imported back into the application and displayed as shown in the following three screen captures below.



The user can copy the data from the data tables to the Windows clipboard for use with other applications, such as Microsoft Excel. To display the context menu shown below, simply single right-mouse-click while over the data table.

Chemical Flo	ood Predictive N	Nodel [DOE Exa	mple CMFL.cml]					
Recent File	s 🕶 🗁 🔚	i 💆 🔘						
т	itle DOE BASE	CASE CFPM						
Type	e of Chemical Flo	ood Micellar-Po	lvmer					
		0.1.1.11	, 		C			
NPC M	Indifications Swi	tch Uriginal Mo	del - Recommende	ed For High-water-	Content And Low V	iscosity Soluble-C	/II Slugs	
	Lithold	ogy Sandstone						
Reservoir and	Fluid Data Fiel	d and Injection D	lata Results					
Main Results	Profiles Charts							
Date	Oil Rate [bbl/d]	Gas Rate [Mscf/d]	Water Rate [bbl/d]	Cumulative Oil [Mbbl]	Cumulative Gas [MMscf]	Cumulative Water [Mbbl]	WOR	Wa
Jan-2008	0.0	0.0	180.0	0.00	0.00	5.58		
Feb-2008		0.0	360.0	0.00	0.00	16.02		1
Mar-2008		0.0	540.0	0.00	0.00	32.76		
Apr-2008	Сору	Profiles Table	530.6	0.27	0.11	48.68	59.40	
May-2008	17.9	\$7.1	521.3	0.82	0.33	64.84	29.18	
Jun-2008	26.8	10.7	511.9	1.63	0.65	80.20	19.10	
Jul-2008	45.2	18.1	492.5	3.03	1.21	95.46	10.89	
Aug-2008	63.7	25.4	473.2	5.00	2.00	110.13	7.43	
Sep-2008	82.1	32.8	453.8	7.46	2.98	123.75	5.53	
Oct-2008	96.3	38.4	438.9	10.45	4.17	137.35	4.56	
Nov-2008	110.4	44.1	424.1	13.76	5.50	150.07	3.84	
Dec-2008	124.6	49.7	409.2	17.62	7.04	162.76	3.28	
Jan-2009	122.7	49.0	411.2	21.43	8.55	175.51	3.35	
Feb-2009	120.9	48.2	413.1	24.81	9.90	187.07	3.42	
Mar-2009	119.0	47.5	415.1	28.50	11.38	199.94	3.49	
Apr-2009	117.1	46.7	417.1	32.02	12.78	212.46	3.56	
May-2009	115.2	46.0	419.1	35.59	14.20	225.45	3.64	
Jun-2009	113.3	45.2	421.1	38.99	15.56	238.08	3.72	
Jul-2009	111.4	44.5	423.1	42.44	16.94	251.20	3.80	
Aug-2009	109.6	43.7	425.0	45.84	18.29	264.37	3.88	
₹	107.7	10.0	0.70	10.07	10 50	10 575	2.00	•
						Calculate	Clo	se

The user can also copy the active chart to the Windows clipboard for use with other applications, such as Microsoft Powerpoint.



2.4 Polymer Predictive Model

The intent with polymer flooding is to provide better displacement and volumetric sweep efficiencies during a waterflood. This process improves recovery by increasing the viscosity of water, decreasing the mobility of water and contacting a larger volume of the reservoir.

The following description is taken from the US Department of Energy Polymer Flooding Predictive Model (PFPM) documentation.

"The PFPM is switch-selectable for either polymer or water-flooding, and an option in the model allows the calculation of the incremental oil recovery and economics of polymer relative to waterflooding. The PFPM is a three-dimensional (stratified, five-spot), two-phase (water and oil) model which computes water front break through and oil recovery using fractional flow theory, and models areal and vertical sweeps using a streamtube approach. A correlation based on numerical simulation results is used to model the polymer slug size effect. The physical properties of polymer fluids, such as adsorption, permeability reduction, and non-Newtonian effects, are included in the model. Pressure drop between the injector and producer is kept constant, and the injectivity at each time step is calculated based on the mobility in each streamtube. Heterogeneity is accounted for by either entering detailed layer data or using the Dykstra-Parsons coefficient for a reservoir with a log-normal permeability distribution."

O Polymer Predictive Model [Poly	/mer DOE Example.pfm]]		- • •
🛃 Recent Files 👻 🔂 📑	9			
Tit. DOE Polymor Ev	vamala			
Type of Recovery Calculation	Polymer Flood Less Wat	terflood = Incremental		
Reservoir Calculations Output	Output Formation and FI	luid Properties, and Pattern Inj/Prod I	Reports	•
Areal Sweep Calculation	Eight Streamtubes used	in each Layer		-
Lithology	Sandstone			•
Reservoir and Fluid Data Polyme	er and Layer Data Result	ts		
Required D	Data	Op	otional Data	
Reservoir Depth	[ft] 2500	Reservoir Pressure [psia]	1000	
Pattern Area 20	Acres 🗸	Reservoir Temperature [deg F]	125	
API Grav	vity 25	Gas Gravity	0.7	
Endpoint kro at S	э́мс 0.8	Solution GOR [scf/stb]	175	
Endpoint krw at	Sor 0.2	Oil FVF, Bo [rb/stb]	1.104	
Corey Exponent for	Oil 2	Water FVF, Bw [rb/stb]	1.008	
Corey Exponent for Wa	ater 2	Oil viscosity [cP]	5	
Swc, fract	tion 0.3	Water viscosity [cP]	0.6	
Sor, fract	tion 0.25	Injectivity Coefficient, psi/ft		Clear All
Wellbore Radius	s, ft 0.5			Calculate
Injection Rate Override, rb/	day			Optional Data
			Calculate	Close
			Calculate	s

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Title DOE Polymer E	xample			
Type of Recovery Calculation	Polymer Flood Less Wa	terflood = Incremental		
Reservoir Calculations Output	Output Formation and F	luid Properties, and Pattern Inj/Prod	Reports	
Areal Sweep Calculation	Eight Streamtubes used	in each Layer		
Lithology	Sandstone			
Reservoir and Fluid Data Polym	ner and Layer Data Resul	ts		
Required	Data	Or	tional Data	
Reservoir Dept	h [ft] 2500	Reservoir Pressure [psia]	1000	
Pattern Area 20	Acres 💌	Reservoir Temperature [deg F]	125	
API Gra	vity 25	Gas Gravity	0.7	
Endpoint kro at	Swc 0.8	Solution GOR [scf/stb]	175	
Endpoint krw at	Sor 0.2	Oil FVF, Bo [rb/stb]	1.104	
Corey Exponent for	r Oil 2	Water FVF, Bw [rb/stb]	1.008	
Corey Exponent for W	ater 2	Oil viscosity [cP]	5	
Swe frac	tion 0.3	Water viscosity [cP]	0.6	
So Sw	c, fraction	Injectivity Coefficient, psi/ft		Clear All
Wellbore	onnate water saturation			Calculate
Injection Rate Override, rb	/day			Optional Data
)	(
			Calculate	Close

Tooltips, as shown above, are provided to help define some of the input data requirements. To display these tooltips simply hover the mouse over the label box describing the input data.

O Polymer Predictive Model [Poly	mer DOE Example.pfr	n]				
🔁 Recent Files 👻 🗁 🛃 📄	9					
Title DOE Polymer Ex	ample					
Type of Recovery Calculation	Polymer Flood Less W	/aterflood = Incr	emental			•
Reservoir Calculations Output	Output Formation and	Fluid Properties	s, and Pattern Inj/I	Prod Reports		•
Areal Sweep Calculation	Eight Streamtubes use	ed in each Laye	r			•
Lithology	Sandstone					-
Reservoir and Fluid Data Polyme	r and Layer Data Resu	ults				
		Prediction Ti	meframe			
Start Date Jan	n 2008 🗘 🗸	Rep	orting Frequency	Semi-Annually Monthly		
Polymer Concentration, pp	m 900	Layer Ca	Iculation Options	Annually Raw Calculated	d Data lity Thic	kness 💌
Polymer Viscosity, o	p 10.9	Dykstra-Pa	rsons Coefficient	0.6		
Resistance Facto	or 12	N	lumber of Layers	10 🔽		
Polymer Adsorption, Ib/ac-	ft 100	Layer	Thickness	Porosity	Permeability	Sw at
Residual Resistance Fact	or 1.101	Number	[ft]	[fraction]	[mD]	[fraction
Polymer Slug Size, P	V 0.3	1	50	0.3	200	
Max PVs To Be Injected, P	V 3					
Polymer Viscosity Power	-Law Factors					
Power Law Coefficie	nt 4					
Power Law Exponent,	N 0.6					
	Reset Defaults					
				Ca	lculate	Close

Once the user has pressed the Calculate button, the results data will be re-imported back into the application and displayed as shown in the following three screen captures below.



The user can copy the data from the data tables to the Windows clipboard for use with other applications, such as Microsoft Excel. To display the context menu shown below, simply single right-mouse-click while over the data table.

Polymer Pre	edictive Model [Poly	/mer DOE Exam	nple.pfm]				
Recent File	es 🕶 🔁 🔚 🗎	9					
	The DOE Polymor F	vamala					
	Title DOE Polymer E	kampie					
Type of R	Recovery Calculation	Polymer Flood	Less Waterflood	d = Incremental			
Reservoir	r Calculations Output	Output Format	ion and Fluid Pro	operties, and Patte	rn Inj/Prod Reports	3	
Area	al Sween Calculation	Fight Streamtu	bes used in eacl	h Laver			
Area	a Sweep Calculation	Eight of containing	bes used in each	il Edyor			
	Lithology	Sandstone					
Reservoir an	nd Fluid Data Polyme	r and Layer Dat	a Results				
Main Results	s Profiles Charts						
Date	Total Pore Volume [Fraction]	Oil Rate [bbl/d]	Gas Rate [Mscf/d]	Water Rate [bbl/d]	Cumulative Oil [Mbbl]	Cumulative Gas [MMscf]	Cumulative Water [Mbbl]
Jan-2008	0.00	1.0	-0.3	-17.0	-0.34	-0.06	-3.10
Jul-2008	Copy Pro	ofiles Table	-10.2	-321.7	-11.13	-1.94	-62.29
Jan-2009	0.12	L297.4	-17.1	-664.5	-28.76	-5.03	-182.55
Jul-2009	0.16	-69.0	-12.1	-884.4	-41.46	-7.26	-345.29
Jan-2010	0.19	-46.9	-8.3	-1043.4	-49.94	-8.75	-534.14
Jul-2010	0.22	-29.6	-5.2	-1169.7	-55.38	-9.71	-749.38
Jan-2011	0.24	-19.5	-3.4	-1257.2	-58.92	-10.33	-976.93
Jul-2011	0.27	-12.2	-2.1	-1332.4	-61.16	-10.72	-1222.10
Jan-2012	0.30	-7.9	-1.3	-1395.2	-62.61	-10.97	-1476.03
Jul-2012	0.32	-4.4	-0.7	-1449.5	-63.41	-11.10	-1742.73
Jan-2013	0.35	-1.4	-0.2	-1496.9	-63.66	-11.14	-2013.66
Jul-2013	0.39	19.0	3.3	-1494.9	-60.16	-10.52	-2288.71
Jan-2014	0.42	45.3	7.9	-1472.4	-51.96	-9.08	-2555.22
Jul-2014	0.46	53.3	9.3	-1484.6	-42.16	-7.37	-2828.39
Jan-2015	0.51	54.0	9.4	-1454.6	-32.37	-5.66	-3091.67
Jul-2015	0.55	52.4	9.1	-1444.5	-22.73	-3.98	-3357.46
Jan-2016	0.60	49.1	8.5	-1444.4	-13.79	-2.42	-3620.33
Jul-2016	0.64	43.7	7.6	-1440.0	-5.76	-1.02	-3885.30
•							4

The user can also copy the active chart to the Windows clipboard for use with other applications, such as Microsoft Powerpoint. Data tooltips can also be displayed within the chart area by hovering the mouse over a series datapoint, as shown below.



2.5 In-situ Combustion Predictive Model

In-situ combustion involves starting a fire in the reservoir and injecting air to sustain the burning of some of the crude oil. This process recovers oil by the application of heat to lower the oil viscosity, upgrading the crude through thermal cracking, and the pressure supplied to the reservoir by the injected air.

Limitations

- If sufficient coke is not deposited from the oil being burned, the combustion process will not be sustained. This prevents the application for high-gravity, paraffinic oils.
- If excessive coke is deposited, the rate of advance of the combustion zone will be slow, and the quantity of air required to sustain combustion will be high.
- Oil saturation and porosity must be high to minimize heat loss to rock,
- Process tends to sweep through upper part of reservoir so that sweep efficiency is poor in thick formation.

Problems

- Adverse mobility ratio.
- Complex process, requiring large capital investment, is difficult to control.
- Produced flue gases can present environmental problems.
- Operational problems such as severe corrosion caused by low pH hot water, serious oil-water emulsions, increased sand production, deposition of carbon or wax, and pipe failures in the producing wells as a result of the very high temperatures.

The following description is taken from the US Department of Energy Insitu Combustion Predictive Model (ICPM) documentation.

"The ICPM oil recovery algorithm is based on the work of Brigham, et al (1980), who correlated the major variables in the combustion process to the results of 12 field pilot tests. Their correlation relates oil burned and oil produced to the amount of air injected and the reservoir volume, and is for dry combustion only. A method to predict wet combustion performance was added by NPC based on laboratory data (Garon and Wygal, 1974; Prats, 1982)."

🕐 Insitu Combustion Predictive Model [US DOE 🔹 Recent Files 👻 🗁 🚂 📄 🖳 🥝	Example - Insitu Co	omł	bustion.icm]	
Title US DOE Example - BASE CASE	MODEL			
Start Date Jan 2008	Prediction	n Tii	ting Frequency Monthly]
Input Data Results				
Required Data			Optional Data	
Total Developed Area 600	Acres 💌		Reservoir Pressure [psia]	500
Reservoir Depth [ft]	3000		Reservoir Temperature [deg F]	138
Porosity [fraction]	0.25		Oil FVF, Bo [rb/stb]	1.1
Permeability [mD]	500		Water FVF, Bw [rb/stb]	
Net Pay Thickness [ft]	150		Dead Oil viscosity [cP]	
API Gravity	25		Air Injection Rate [mscf/day]	
Current Oil Saturation [fraction]	0.5		Water/Air Ratio [stb/mscf]	-1
Current Water Saturation [fraction]	0.5		Maximum Volume Swept [fraction]	
Current Gas Saturation [fraction]				
Number of Producing Wells	80			Clear All
Maximum Thickness per Burn Zone [ft]	1			Reset Defaults
		J		
			Calculate	Close

Once the user has pressed the Calculate button, the results data will be re-imported back into the application and displayed as shown in the following three screen captures below.

💽 Insitu Combustion Predictive Model [US DOE Example - Ins	itu C	ombustion.icm]		- • •
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Title US DOE Example - BASE CASE MODEL				
Pre	dictio	Timeframe		
	uicito			
Start Date Jan 2008	Re	porting Frequency Mor	nthly 🔽	
Input Data Results				
Main Results Profiles Charts				
1				*
INPUT DECK ECHO				
1 US DOE Example - BASE CASE MODEL				=
2 0, 0, 1, 0 3 3000 500 138				
4 150, 500, 0.25				
5 0.5, 0, 0.5				
6 25, 0, 1.1, 0				
7 600, 80, 0, -1, 0.4, 1				
1				
• •				
* NATIONAL PETROLEUM COUNCIL *				
* INSITU COMBUSTION PREDICTIVE MODEL *				
* (ADDIT, 1985) *				
US DOE Example - BASE CASE MODEL				
CASE CONTROLS				
RECOVERY PREDICTION METHOD	0	IRES		
PATTERN CONTROL	0	IPAT		
ECONOMIC ANALYSIS CONTROL	0	IECON		-
r				Class
			Calculate	Close

The user can copy the data from the data tables to the Windows clipboard for use with other applications, such as Microsoft Excel. To display the context menu shown below, simply single right-mouse-click while over the data table.

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٦	itle US DOE Ex	ample - BASE CA	SE MODEL					
			Pred	iction Timeframe				
	Start Date 🗸	an 2008	•••	Reporting Freque	ency Monthly	•		
Input Data R	esults							
Main Results	Profiles Charts							
Date	Oil Rate [bbl/d]	Waste Gas Rate [Mscf/d]	Water Rate [bbl/d]	Liquid Rate [bbl/d]	Cumulative Oil [Mbbl]	Cumulative Waste Gas [MMscf]	Cumulative Water [Mbbl]	
Jan-2008	0.0	0.0	0.0	0.0	0.00	0.00	0.00	1
Feb-2008	83.3	434.7	39.3	122.6	2.41	12.61	1.14	
Mar-2008	124.9	652.1	59.0	183.9	6.29	32.82	2.97	
Apr-2008	142.3	869.5	78.6	220.9	10.55	58.91	5.33	
May-2008	159.6	1086.8	98.3	257.9	15.50	92.60	8.37	
Jun-2008	177.0	Copy Pro	ofiles Table	294.9	20.81	131.72	11.91	
Jul-2008	192.5	1321.3	8 137.0	330.1	26.78	178.89	16.18	
Aug-2008	208.1	1738.9	Copy Profile	e Table to Clipboar	d 33.23	232.80	21.05	
Sep-2008	223.6	1956.2	176.9	400.5	39.94	291.48	26.36	
Oct-2008	237.0	2173.6	196.6	433.5	47.29	358.86	32.45	
Nov-2008	250.3	2390.9	216.2	466.6	54.80	430.59	38.94	
Dec-2008	263.7	2608.3	235.9	499.6	62.97	511.45	46.25	
Jan-2009	258.7	2608.3	235.9	494.6	70.99	592.31	53.56	
Feb-2009	253.6	2608.3	235.9	489.5	78.09	665.34	60.17	
Mar-2009	248.6	2608.3	235.9	484.5	85.80	746.20	67.48	
Apr-2009	243.6	2608.3	235.9	479.5	93.10	824.44	74.56	
May-2009	238.5	2608.3	235.9	474.4	100.50	905.30	81.87	
Jun-2009	233.5	2608.3	235.9	469.4	107.50	983.55	88.95	
Jul-2009	229.5	2608.3	235.9	465.4	114.62	1064.41	96.26	
Aug-2009	225.5	2608.3	235.9	461.4	121.61	1145.27	103.57	
₹	201.0	0000.0	005.0	100 0	100.00	1000 51	440.05	
						Calaulata	Class	5

The user can also copy the active chart to the Windows clipboard for use with other applications, such as Microsoft Powerpoint. Data tooltips can also be displayed within the chart area by hovering the mouse over a series datapoint, as shown below.



2.6 Steamflood Predictive Model

The steamdrive process or steamflooding involves the continuous injection of steam to displace oil towards the producing wells. This process recovers oil by heating the oil and reducing it's viscosity, supplying pressure to drive oil to the producing wells and steam distillation, especially in light crude oils.

Limitations

- Oil saturations must be quite high and the pay zone should be more than 20 feet thick to minimize heat losses to adjacent formations.
- Lighter, less viscous crude oils can be steamflooded but normally will not be if the reservoir will respond to an ordinary waterflood.
- Steamflooding is primarily applicable to viscous oils in massive, high-permeability sandstones or unconsolidated sands.
- Because of excess heat losses in the wellbore, steamflooded reservoirs should be as shallow as possible as long as pressure for sufficient injection rates can be maintained.
- Steamflooding is not normally used in carbonate reservoirs.
- Since about one-third of the additional oil recovered is consumed to generate the required steam, the cost per incremental barrel of oil is high.
- A low percentage of water-sensitive clays is desired for good injectivity.

The following description is taken from the US Department of Energy Steamflood Predictive Model

(SFPM) documentation.

"The SFPM is applicable to the steam drive process, but not to cyclic steam injection (steam soak) processes. There are four separate oil recovery predictive algorithms in the SFPM: the Williams et al (1980) model, also known as the Stanford University Petroleum Research Institute (SUPRI) model, the Jones (1981) model, the Gomaa (1980) model, and the Intercomp model (Aydelotte and Pope, 1983). All of the predictive algorithms in the SFPM make use of calculations for heat losses in surface pipe and in the wellbore, as originally presented by Williams et al (1980)."

💽 Steam Flood Predictive Model [US	DOE Steamflood Example.sfm]	
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Title	US DOE Example - MCKITTRICK F AREA	
Heat Production Calculation	Produced Heat not accounted for	-
Reservoir Calculations Output	Output only Final Results	-
Steam Table Options	Use Internal Steam Tables	-
Surface Line Heat Loss Method	Adiabatic (No Heat Loss)	-
Reservoir Performance Method	Gomaa Method	-
Reservoir Data Fluid and Saturation	Data Surface and Wellbore Data Time Step Data Results	
Required Data	Optional Data	
Reservoir Depth [ft]	2250 Reservoir Pressure [psia] 150	
Pattern Area 10	Acres Reservoir Temperature [deg F] 120	
Net Pay Thickness [ft]	120 Gross Thickness [ft] 150	
Porosity [fraction]	0.35 Rock Density [lb/ft ³]	
Permeability [mD]	1500 Rock Heat Capacity [BTU/Ib]	
Reservoir Dip, degrees	15 Rock Thermal Diffusivity [ft²/hr] Clea	r All
Area heated at heat breakthrough [fraction]	Initial Injectivity Index [bpd/psi]	0.11-1
broakarougn[huoaon]	Steam temperature increase applied to hot zone [fraction]	Ita
	Calculate	Close

Tooltips, as shown below, are provided to help define some of the input data requirements. To display these tooltips simply hover the mouse over the label box describing the input data.

Steam Flood Predictive Model [US	DOE Steamflood Example.sfm]	
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Title	US DOE Example - MCKITTRICK F AREA	
Heat Production Calculation	Produced Heat not accounted for	•
Reservoir Calculations Output	Output only Final Results	
Steam Table Options	Use Internal Steam Tables	•
Surface Line Heat Loss Method	Adiabatic (No Heat Loss)	•
Reservoir Performance Method	Gomaa Method	•
Reservoir Data Fluid and Saturation	Data Surface and Wellbore Data Time Step Data Results	
	Prediction Timeframe	
Start Date Jar	2008 Reporting Frequency Semi-Annually	
Clear All Reset Defaults	Heat produced per Net Pay ft [MMBTU/ft] Estimated efficiency at end project [fraction of area heated] Estimated efficiency at end project [fraction of area Estimated efficiency at end of project [Fraction Of [must be between 0.4 and 0.9] Multiplier of calculated steam overlay angle [fraction] Number Of Time Steps 60 Size Of Time Step 121.75 Steam injection rate for time step [bbl/day] 1800 Maximum generator pressure for time step [psia] 250 Steam quality for time step [mass fraction at sandface]	a heated] Area Heated]
	Calculate	Close

Once the user has pressed the Calculate button, the results data will be re-imported back into the application and displayed as shown in the following three screen captures below.

🚯 Steam Flood Predictive Model [US D	OE Steamflood Example.sfm]
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Reservoir Data Fluid and Saturation Da Main Results Profiles Charts	ta Surface and Wellbore Data Time Step Data Results
1 INPUT DECK ECHO 	TTRICK F AREA 0 120
STEAM FLOOD PREDICTIV (SFPM - RELEASE 3. (NUCHET 1995)	E MODEL 4
*	• Close

The user can copy the data from the data tables to the Windows clipboard for use with other applications, such as Microsoft Excel. To display the context menu shown below, simply single right-mouse-click while over the data table.

Title US DOE Example - MCKITTRICK F AREA Heat Production Calculation Produced Heat not accounted for Reservoir Calculations Output Output only Final Results Steam Table Options Surface Line Heat Loss Method Reservoir Performance Method Cumulative Cumulative Cumulative Cumulative (Method Reservoir Data Fluid and Saturation Data Surface and Wellbore Data Time Step Data Results Mater Results (Macrid) Mater Results (Macrid) Output Options Table Tites 5 Date Oil Rate (Macrid) Output Table Tites 5 1800.0 1800.0 0.0 0.0 327.60 Ui-2008 0.0 0.0 1800.0 1800.0 0.0 327.60 Ui-2009 Gas Copy Profile Table to Clipboard 1800.0 103.13 1.45 121.67 an-2010 Gas Copy Profile Table to Clipboard 1800.0 307.39 <td< th=""><th>Recent File</th><th>es 🔹 🔁 📮</th><th></th><th>amflood Exampl</th><th>e.stmj</th><th></th><th></th><th></th><th></th></td<>	Recent File	es 🔹 🔁 📮		amflood Exampl	e.stmj					
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Adlabatic (No Real Loss) Reservoir Performance Method Goma Method Reservoir Data Fluid and Saturation Data Surface and Wellbore Data Time Step Data Results Date Oil Rate [Ibbl/d] Gas Rate [Ibbl/d] Cumulative Oil [Ibbl/d] Cumulative Oil [Ibbl/d] Cumulative Gas [IMMscr] Cumulative Water [IMbbl] Cumulative Oil [Ibbl/d] Cumulative [Ibbl/d] Cumulative Oil [Ibbl/d] Cumulative Oil [Ibbl/d] <th col<="" td=""><td></td><td></td><td></td><td>- (No Lloot Looo)</td><td>-</td><td></td><td></td><td></td><td></td></th>	<td></td> <td></td> <td></td> <td>- (No Lloot Looo)</td> <td>-</td> <td></td> <td></td> <td></td> <td></td>				- (No Lloot Looo)	-				
Reservoir Performance Method Gomaa Method Reservoir Data Fluid and Saturation Data Surface and Wellbore Data Time Step Data Results Date Oil Rate [bbl/d] Gas Rate [Mscfid] Water Rate [bbl/d] Steam Rate [BCWE/d] Cumulative Oil [Mbbl] Cumulative Gas [MMscf] Cumulative Water [Mbbl] Cumulative Gas [Mmscf] Cumulative Gas [Mmscf] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Gas [Mmscf] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Gas [Mmscf] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] <t< td=""><td>Surrace</td><td>Line Heat Loss</td><td>Method Adiabat</td><td>ic (NO Heat LOSS)</td><td></td><td></td><td></td><td></td><td></td></t<>	Surrace	Line Heat Loss	Method Adiabat	ic (NO Heat LOSS)						
Reservoir Data Fluid and Saturation Data Surface and Wellbore Data Time Step Data Results Date Oil Rate [bbl/d] Gas Rate [Mscf/d] Water Rate [bbl/d] Steam Rate [BC/VE/d] Cumulative Oil [Mbbl] Cumulative Gas [MMscf] Cumulative Water [Mbbl] Cumulative Mater [Mbbl] Cumulati	Reservo	ir Performance	Method Gomaa	Method						
Main Results Profiles Charts Date Oil Rate [bbl/d] Gas Rate [Mscf/d] Water Rate [bbl/d] Steam Rate [BCWE/d] Cumulative Oil [Mbbl] Cumulative Gas [MMscf] Cumulative Water [Mbbl] Cumulative Mater [Mbbl] Cumulative Mater [Mbbl] <tht< td=""><td>Reservoir Da</td><td>ta Fluid and Sa</td><td>turation Data Su</td><td>rface and Wellbor</td><td>e Data Time Step D</td><td>Data Results</td><td></td><td></td><td></td></tht<>	Reservoir Da	ta Fluid and Sa	turation Data Su	rface and Wellbor	e Data Time Step D	Data Results				
Date Oil Rate [Ibbl/d] Gas Rate [Ibbl/d] Water Rate [Ibbl/d] Steam Rate [IBCWE/d] Cumulative Oil [Mbbl] Cumulative Gas [Mbbl] Cumulative Water [Mbbl] Cumulative Wate	Main Results	Profiles Chart	ts							
an-2008 0.0 0.0 1800.0 1800.0 0.00 0.00 327.60 ul-2008 Copy Profile Table 1785.9 1800.0 2.59 0.04 656.21 an-2009 363.6 Copy Profile Table 1614.2 1800.0 36.23 0.50 948.37 ul-2009 363.6 Copy Profile Table to Clipboard 1800.0 103.13 1.45 1212.67 an-2010 513.1 7.2 1286.9 1800.0 307.39 4.32 1665.41 an-2011 573.5 8.1 1226.5 1800.0 307.39 4.32 1665.41 an-2011 487.6 6.8 1312.4 1800.0 500.91 7.04 2128.89 an-2012 398.7 5.6 1401.3 1800.0 533.2 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 762.59 10.71	Date	Oil Rate [bbl/d]	Gas Rate [Mscf/d]	Water Rate [bbl/d]	Steam Rate [BCWE/d]	Cumulative Oil [Mbbl]	Cumulative Gas [MMscf]	Cumulative Water [Mbbl]	Cumu Ste [MBC	
Ul-2008 an-2009 1785.9 1800.0 2.59 0.04 656.21 ul-2009 363.6 Copy Profile Table to Clipboard 1800.0 36.23 0.50 948.37 ul-2009 363.6 Copy Profile Table to Clipboard 1800.0 103.13 1.45 1212.67 an-2010 513.1 7.2 1286.9 1800.0 307.33 4.32 1665.41 an-2011 573.5 8.1 1226.5 1800.0 411.20 5.78 1887.40 ul-2011 487.6 6.8 1312.4 1800.0 500.91 7.04 2128.89 an-2012 398.7 5.6 1401.3 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 762.59 10.71 3508.81 ul-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 <	lan-2008	0.0	0.0	1800.0	1800.0	0.00	0.00	327.60		
Interpretation 1614.2 1800.0 36.23 0.50 948.37 ul-2009 363.6 Copy Profile Table to Clipboard 1800.0 103.13 1.45 1212.67 lan-2010 513.1 7.2 1286.9 1800.0 196.00 2.76 1445.60 ul-2010 605.4 8.5 1194.6 1800.0 307.39 4.32 1665.41 an-2011 573.5 8.1 122.65 1800.0 500.91 7.04 2128.89 an-2012 398.7 5.6 1401.3 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 <t< td=""><td>Jul-2008</td><td>Con</td><td>v Profiles Table</td><td>1785.9</td><td>1800.0</td><td>2.59</td><td>0.04</td><td>656.21</td><td></td></t<>	Jul-2008	Con	v Profiles Table	1785.9	1800.0	2.59	0.04	656.21		
Ul-2009 363.6 Copy Profile Table to Clipboard 1800.0 103.13 1.45 1212.67 Ian-2010 513.1 7.2 1286.9 1800.0 196.00 2.76 1445.60 Ul-2010 605.4 8.5 1194.6 1800.0 307.39 4.32 1665.41 Ian-2011 573.5 8.1 1226.5 1800.0 411.20 5.78 1887.40 ul-2011 487.6 6.8 1312.4 1800.0 500.91 7.04 2128.89 an-2012 398.7 5.6 1401.3 1800.0 573.47 8.05 2383.93 ul-2012 309.0 4.3 1491.0 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11	lan-2009			1614.2	1800.0	36.23	0.50	948.37	=	
an-2010 513.1 7.2 1286.9 1800.0 196.00 2.76 1445.60 ul-2010 605.4 8.5 1194.6 1800.0 307.39 4.32 1665.41 lan-2011 573.5 8.1 1226.5 1800.0 411.20 5.78 1887.40 ul-2011 487.6 6.8 1312.4 1800.0 500.91 7.04 2128.89 an-2012 398.7 5.6 1401.3 1800.0 573.47 8.05 2383.93 ul-2012 309.0 4.3 1491.0 1800.0 680.80 9.56 2933.60 ul-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2013 278.9 3.9 1521.1 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0	lul-2009	363.6	Copy F	Profile Table to Cli	pboard 1800.0	103.13	1.45	1212.67		
ul-2010 605.4 8.5 1194.6 1800.0 307.39 4.32 1665.41 an-2011 573.5 8.1 1226.5 1800.0 411.20 5.78 1887.40 ul-2011 487.6 6.8 1312.4 1800.0 500.91 7.04 2128.89 an-2012 398.7 5.6 1401.3 1800.0 573.47 8.05 2383.93 ul-2012 309.0 4.3 1491.0 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2013 242.5 3.4 1557.5 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2015 114.4 1.6 1685.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0	lan-2010	513.1	7.2	1286.9	1800.0	196.00	2.76	1445.60		
Ian-2011 573.5 8.1 1226.5 1800.0 411.20 5.78 1887.40 Iul-2011 487.6 6.8 1312.4 1800.0 500.91 7.04 2128.89 Ian-2012 398.7 5.6 1401.3 1800.0 573.47 8.05 2383.93 ul-2012 309.0 4.3 1491.0 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2013 242.5 3.4 1557.5 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0	Jul-2010	605.4	8.5	1194.6	1800.0	307.39	4.32	1665.41		
ul-2011 487.6 6.8 1312.4 1800.0 500.91 7.04 2128.89 an-2012 398.7 5.6 1401.3 1800.0 573.47 8.05 2383.93 ul-2012 309.0 4.3 1491.0 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2013 242.5 3.4 1557.5 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	an-2011	573.5	8.1	1226.5	1800.0	411.20	5.78	1887.40	_	
an-2012 398.7 5.6 1401.3 1800.0 573.47 8.05 2383.93 ul-2012 309.0 4.3 1491.0 1800.0 630.32 8.85 2658.28 an-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2013 242.5 3.4 1557.5 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	ul-2011	487.6	6.8	1312.4	1800.0	500.91	7.04	2128.89		
jul-2012 309.0 4.3 1491.0 1800.0 630.32 8.85 2658.28 jan-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2013 242.5 3.4 1557.5 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	an-2012	398.7	5.6	1401.3	1800.0	573.47	8.05	2383.93		
an-2013 278.9 3.9 1521.1 1800.0 680.80 9.56 2933.60 ul-2013 242.5 3.4 1557.5 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	ul-2012	309.0	4.3	1491.0	1800.0	630.32	8.85	2658.28		
ul-2013 242.5 3.4 1557.5 1800.0 725.41 10.18 3220.19 an-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	an-2013	278.9	3.9	1521.1	1800.0	680.80	9.56	2933.60		
Ian-2014 205.4 2.9 1594.6 1800.0 762.59 10.71 3508.81 Iul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 Ian-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 Ian-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	ul-2013	242.5	3.4	1557.5	1800.0	725.41	10.18	3220.19		
ul-2014 156.4 2.2 1643.6 1800.0 791.37 11.11 3811.23 an-2015 114.4 1.6 1685.6 1800.0 812.08 11.39 4116.32 ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	lan-2014	205.4	2.9	1594.6	1800.0	762.59	10.71	3508.81		
Image: Second	lul-2014	156.4	2.2	1643.6	1800.0	791.37	11.11	3811.23		
ul-2015 90.1 1.3 1709.9 1800.0 828.66 11.62 4430.94 an-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	lan-2015	114.4	1.6	1685.6	1800.0	812.08	11.39	4116.32		
lan-2016 54.8 0.8 1745.2 1800.0 838.63 11.76 4748.57	lul-2015	90.1	1.3	1709.9	1800.0	828.66	11.62	4430.94		
	Jan-2016	54.8	0.8	1745.2	1800.0	838.63	11.76	4748.57		
	(7 00		1770.0	1000.0	011 10	11.07	F074 00	Þ	
	-									

The user can also copy the active chart to the Windows clipboard for use with other applications, such as Microsoft Powerpoint.



2.7 Infill Drilling Predictive Model

The following description is taken from the US Department of Energy Infill Drilling Predictive Model (IDPM) documentation.

"The IDPM is a three-dimensional (stratified, five-spot), two-phase (oil and water) model which uses a minimal amount of reservoir and geologic data to generate production and recovery forecasts for ongoing waterflood and infill drilling projects. The model computes water-oil displacement and oil recovery using finite difference solutions within streamtubes. It calculates the streamtube geometries and uses a two-dimensional reservoir simulation to track fluid movement in each streamtube slice."

Recent Files V 🗁 🛃 🗎) ()	impleaning		
Title US DOE Example - N	North Riley U	nit Base Case		
Output simulator arrays Do	not output si	mulator grid array	vs with timestep data	
Output streamtube calculations Do	not output st	reamtube calcula	tions	
Reservoir and Fluid Data Layer Data	Results			
		Reg	uired Data	
Reservo	oir Depth [ft]	6300	API Gravity	32
		Opti	ional Data	
Reservoir Pres	ssure [psia]	2750	Water density at standard conditions	64
Reservoir Temperat	ture [deg F]	107	Oil compressibility at reservoir conditions	7.35E-06
Pressure for Porosity and Density	/ data [psia]	3000	Water compressibility at reservoir conditions	3E-06
Pore volume compressi	ibility [1/psi]	3E-06	Endpoint kro at Swc	0.752
G	Gas Gravity	0.8	Endpoint krw at Sor	0.4
Solution GC	OR [scf/stb]	330	Corey Exponent for Oil	2
Oil FVF,	Bo [rb/stb]	1.28	Corey Exponent for Water	2
Water FVF,	Bw [rb/stb]		Swc [fraction]	0.32
Oil vi	iscosity [cP]	1.7	Sor [fraction]	0.25
Water vis	scosity [cP]	0.6	Initial oil saturation override [fraction]	
Reset Defaults Clear A	All			
\				
			Calculate	Close

Tooltips, as shown below, are provided to help define some of the input data requirements. To display these tooltips simply hover the mouse over the label box describing the input data.

Infill Predictive Model [US DOE]	Infill Drilling Example.ifr	n]				- • ×
Recent Files 👻 🗁 🔚 📄	9					
Title US DOE Examp	le - North Riley Unit Base (Case				
Output simulator arrays	Output simulator arrays Do not output simulator grid arrays with timestep data					
Output streamtube calculations	Output streamtube calculations					
Reservoir and Fluid Data Layer D	Data Results					
		Predic	tion Timeframe			
Start Date Ja	n 2008 🚑 🗸		Reporting Freq	uency Annually		•
Infill plug-back control Do not	t plug back	•	Water	cut at which infill	is to occur 0.7	5
Number of streamtub	es per layer 12		F	inal abandonmen	t water cut 0.9	5
Number of grid cells per	streamtube 15			Maximum run f	time [days]	
Ratio	of KY to KX 1		Layer Calcul	lation Options In	iput VDP - Equal	Thickness 🖃
Ratio of KV to	o KX [kv/kh] 0.1		I	Dykstra-Parsons	Coefficient 0.8	3
Infill pattern type 5-spot	to 5-spot	-		Numbe	r of Layers 11	•
Infill Pattern Area 40	Acres	-	Layer	Thickness	Porosity	Permeability
Infill Distance betwe	en Wells [ft]		Number 1	נתן 400	[iraction] 0.08	[mb] 10
Reservoir connectivity f	for Infill Area 0.55					
Distance for 100% c	optinuity [ft] 300					
Non infill injection rate into patte	Distance for 100% co	ntinuity	/[ft]			
Infill injection rate into patte	The distance between at which continuity is	1 wells 1.0	(in feet)			
Reset Defaults Clear	r All					
					Calculate	Close

Once the user has pressed the Calculate button, the results data will be re-imported back into the application and displayed as shown in the following three screen captures below.



The user can copy the data from the data tables to the Windows clipboard for use with other applications, such as Microsoft Excel. To display the context menu shown below, simply single right-mouse-click while over the data table.

	Title US DOE	Example - North R	iley Unit Base Case	•				
0	utput simulator a	arrays Do not out	put simulator grid	arrays with timeste	ep data			
				1.0				
Outputstr	eamtube calcul	ations Do not out	put streamtube cal	culations				
Reservoira	nd Fluid Data	ayer Data Result	s					
Main Resul	te Profiles Ch	arte						
Date	Oil Rate [bbl/d]	Water Rate [bbl/d]	Cumulative Oil [Mbbl]	Cumulative Water [Mbbl]	Pore Volumes Injected	Oil RF [Fraction of OIP at Start]	WOR	٧
2008	19.9	0.0	7.27	0.00	0.01	1.0987	0.00	
2009	19.5	0.0	14.38	0.00	0.01	2.1765	0.00	
2010	1		11.45	0.05	0.02	3.2452	0.01	
2011	1	Copy Profiles	Table 7.81	0.99	0.03	4.2051	0.15	
2012	15.6	Conv Profile Ta	able to Clipboard	2.82	0.04	5.0664	0.32	
2013	14.1	7.0	38.65	5.35	0.04	5.8412	0.49	
2014	12.5	9.0	43.21	8.64	0.05	6.5287	0.72	
2015	11.3	10.5	47.33	12.49	0.06	7.1501	0.93	
2016	10.3	11.9	51.08	16.83	0.07	7.7166	1.16	
2017	9.4	12.9	54.52	21.56	0.07	8.2358	1.37	
2018	8.7	13.9	57.69	26.62	0.08	8.7159	1.59	
2019	8.1	14.6	60.65	31.96	0.09	9.1619	1.81	
2020	7.6	15.3	63.42	37.57	0.10	9.5813	2.02	
2021	7.1	15.9	66.01	43.37	0.10	9.9737	2.24	
2022	6.7	16.4	68.47	49.36	0.11	10.3447	2.44	
2023	6.4	16.8	70.79	55.51	0.12	10.6963	2.64	
2024	6.1	17.2	73.02	61.82	0.13	11.0323	2.84	
2025	5.8	17.6	75.13	68.23	0.13	11.3530	3.03	
2026	5.6	17.9	77.16	74.76	0.14	11.6601	3.21	
2027	5.3	18.2	79.11	81.39	0.15	11.9560	3.40	
2028	5.1	18.4	80.99	88.13	0.15	12.2404	3.58	
•	III							Þ.

The user can also copy the active chart to the Windows clipboard for use with other applications, such as Microsoft Powerpoint.



2.8 Example Data Files

Contained within the installation process are example data files for each of the application modules.

These files can be found in a sub-folder of the Application installation folder, and is typically called :

C:\Program Files\Petroleum Solutions\EORgui\Examples\

Computer > Local Disk (C:) > Program Files > Petroleum Solutions > EORgui > Examples

The user can browse to this folder within the application to see how input is formatted and to trial the functionality of the various modules.

An example screen capture of one one these files is shown below.

<polymerflood data=""></polymerflood>
<title>DOE Polymer Example</title>
<iopt>2</iopt>
<iaropt>2</iaropt>
<ilit>0</ilit>
<bo>1.104</bo>
<bw>1.008</bw>
<viso>5</viso>
<visw>0.6</visw>
<api>25</api>
<temp>125</temp>
<gor>175</gor>
<sgg>0.7</sgg>
<pform>1000</pform>
<lyropt>2</lyropt>
<vdp>0.6</vdp>
<nlayer>10</nlayer>
<thicknessstring>50.0.0.0.0.0.0.0.0.0.0</thicknessstring>
<pre><porostring>0.3,0,0,0,0,0,0,0,0,0</porostring></pre>
<permstring>200,0,0,0,0,0,0,0,0,0</permstring>
<swcstring>0.5,0,0,0,0,0,0,0,0,0</swcstring>
<concp>900</concp>
<visp>10.9</visp>
<rf>12</rf>
<dspaf>100</dspaf>
<rrf>1.101</rrf>
<vpmb>0.3</vpmb>
<vimax>3</vimax>
<xkpl>4</xkpl>
<xnpl>0.6</xnpl>
<swc>0.3</swc>
<sorw>0.25</sorw>
<xkroe>0.8</xkroe>
<xkrwe>0.2</xkrwe>
<xno>2</xno>
<xnw>2</xnw>
<depth>2500</depth>
<area/> 2U
<areaunits>U</areaunits>
< <u>RW</u> >U.5< <u>RW</u> >
<cp>U</cp>
<qres>U</qres>
<pre><startdate>U1/U1/2008_00:00:00</startdate></pre>
<pre></pre>

