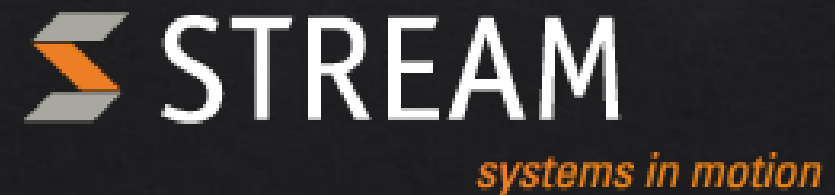


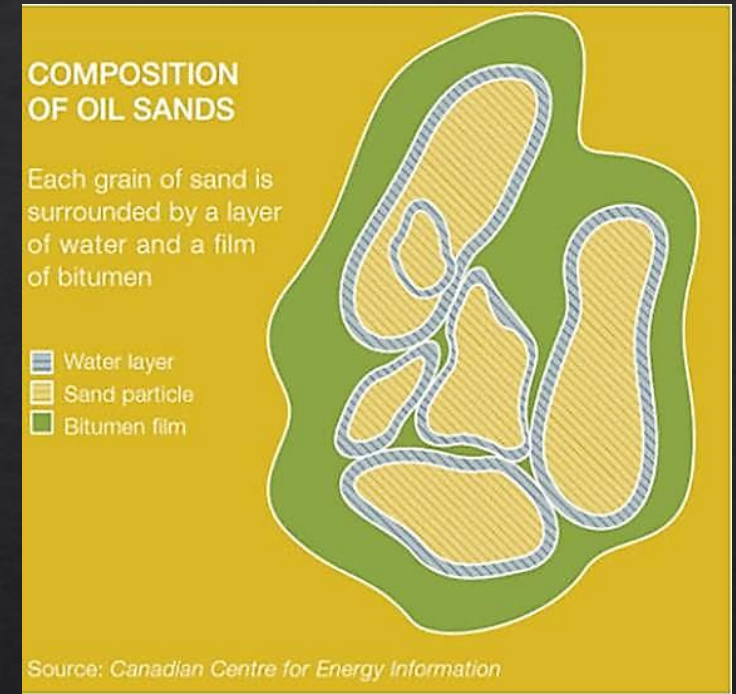
# Modeling and Optimization of Wells Scheduling for In-Situ Oil Production

Stream Systems Ltd  
AnyLogic Conference 2015

Philadelphia, PA



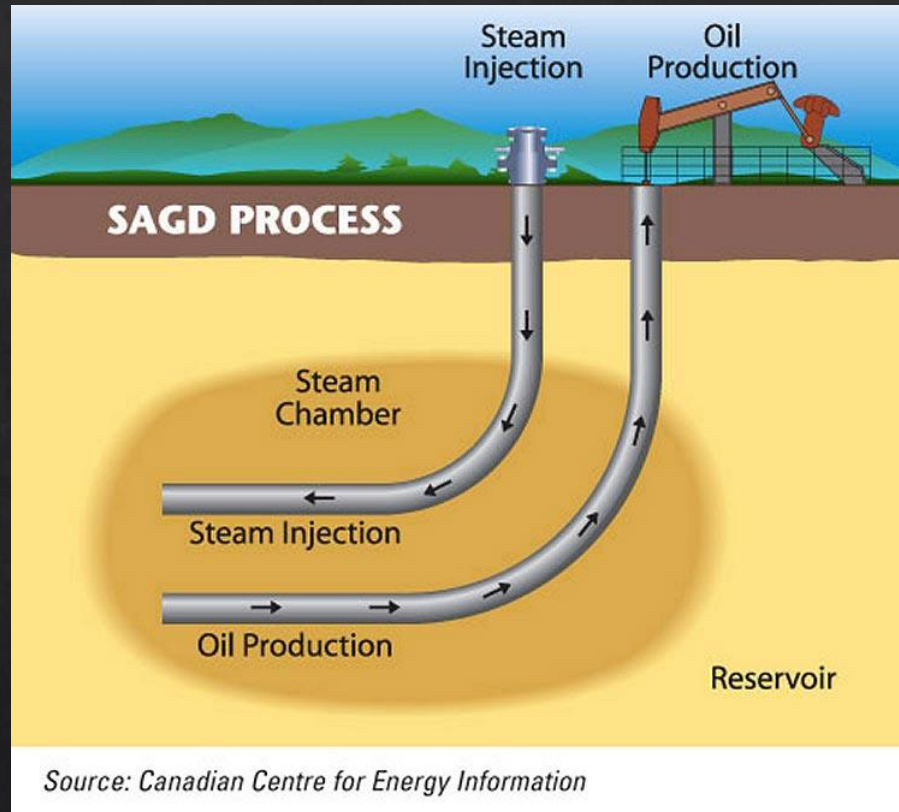
- **Oil Sands:** Natural mixture of sand + oil + water + others
- **3 main** countries
- **In-Situ**
- Capex: **34 billion CAD in 2014**
- High operational cost
- In-Situ production > **1.3m bpd**



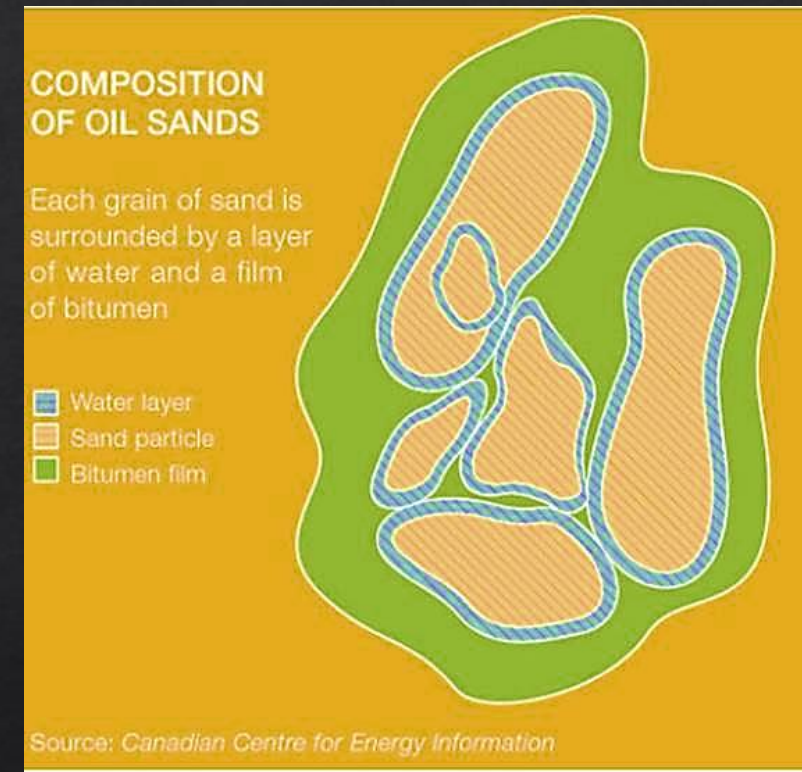
Oil price



## Steam-Assisted Gravity Drainage (SAGD)

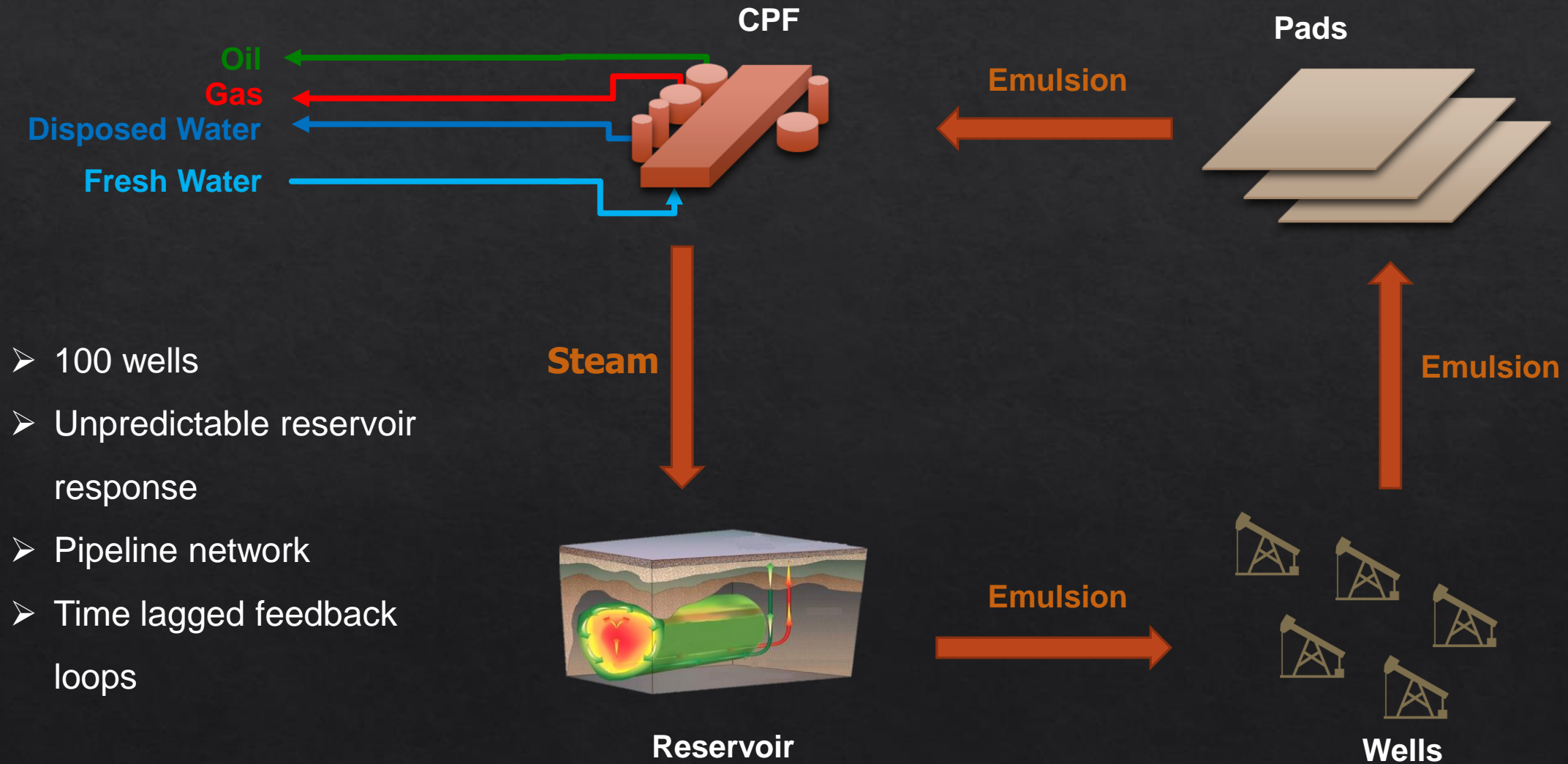


## Oil Sands Reservoir



- Applying heat (steam) to oil reservoirs beneath the earth's surface to warm the bitumen so it can be pumped to the surface through recovery wells.
- Two common types of in-situ petroleum production: SAGD & CSS





- 100 wells
- Unpredictable reservoir response
- Pipeline network
- Time lagged feedback loops

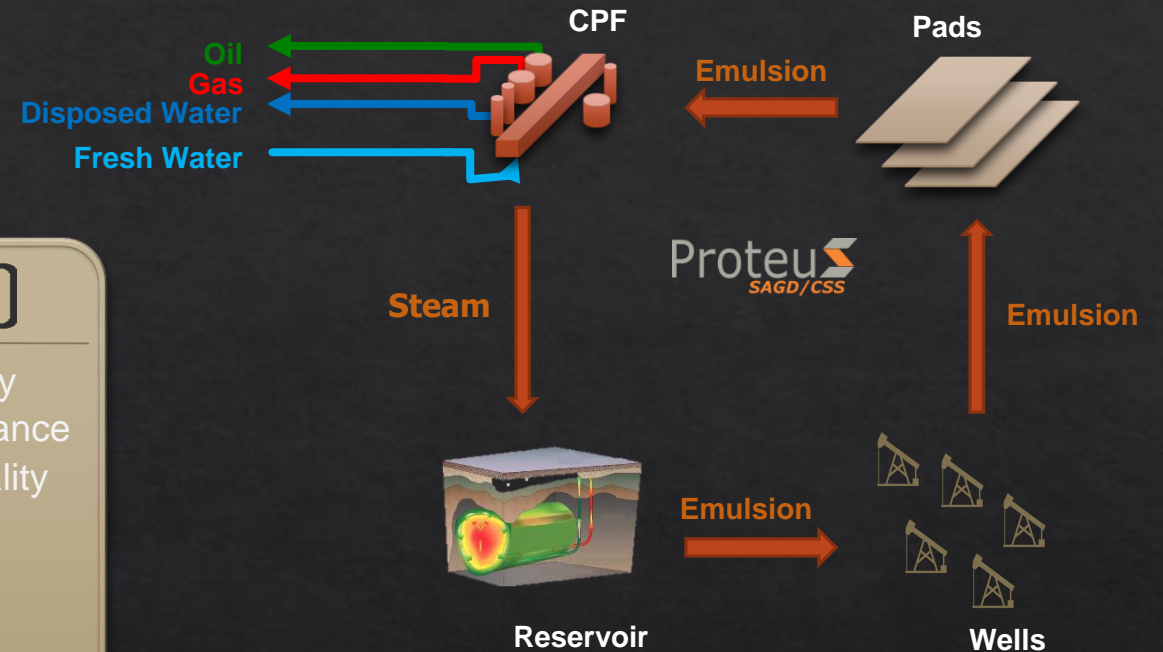
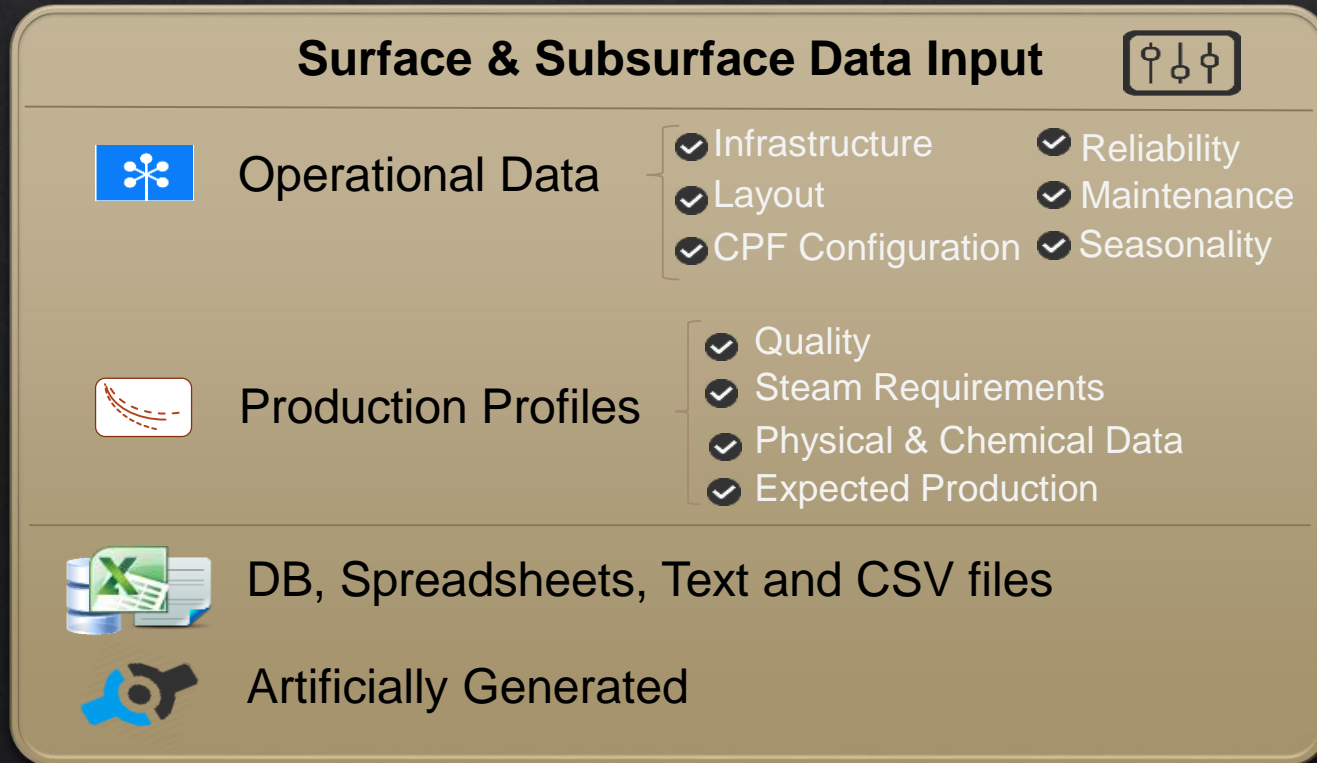
- ◇ Surface & Subsurface data/models separately
- ◇ Methodological approach
  - ◇ No integrated approach
  - ◇ Spreadsheets, lots of it!
  - ◇ No variability/scenario analysis



**High  
Complexity!**

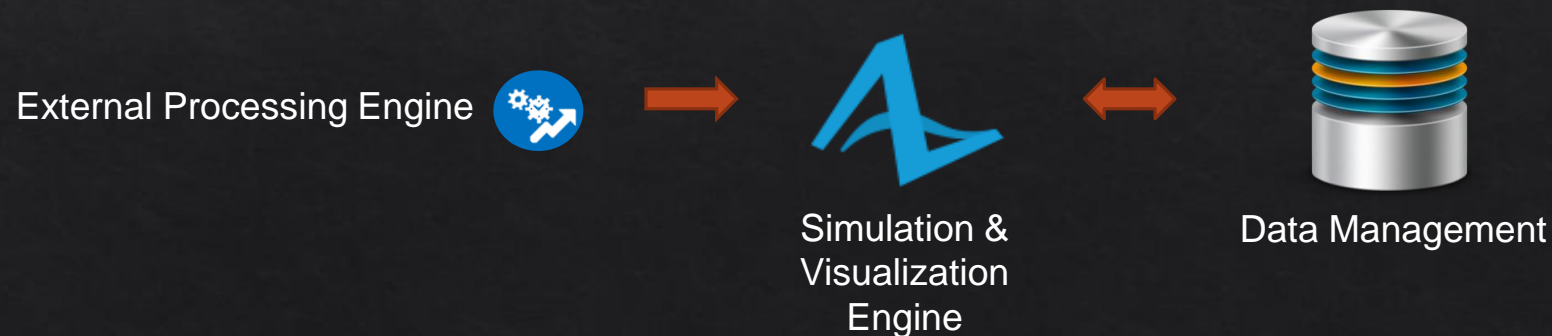
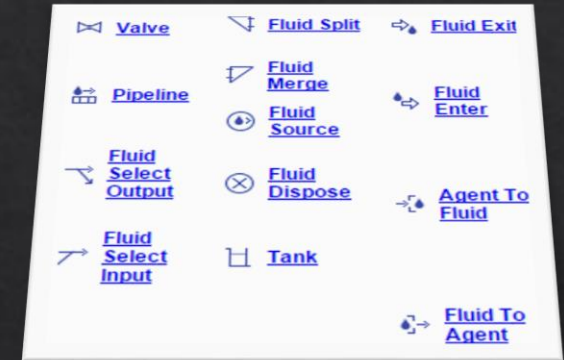
# Modeling Approach

# Close the Loops Above to Below Ground and Back





- ◇ Agent-Based and Discrete Event Approach
- ◇ Fluids Library
- ◇ Easy to integrate with external data sources
- ◇ High Performance
- ◇ External Java libraries to manage additional calculations





120

WELLS

6

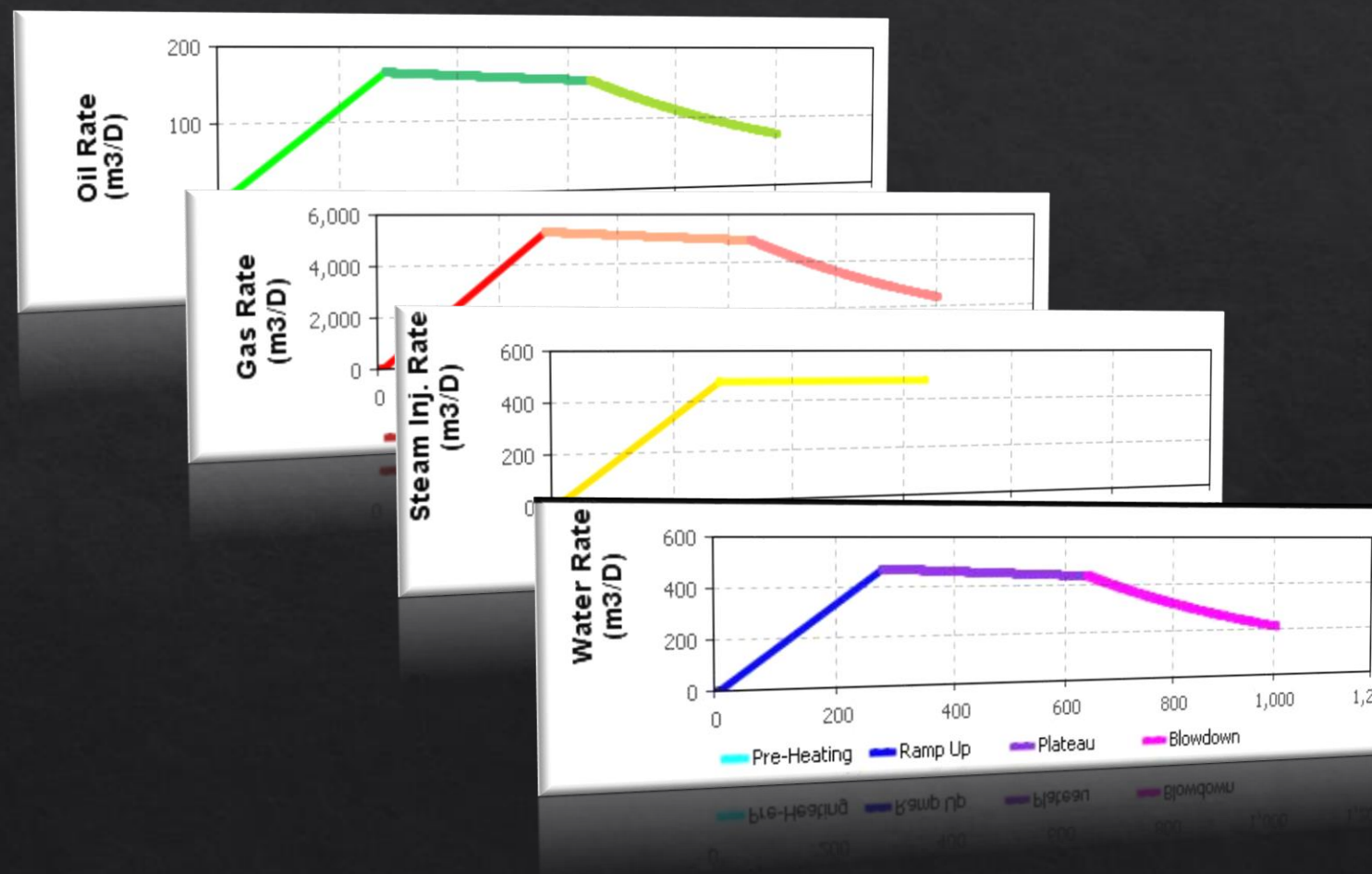
CURVES

70

PARAMETERS

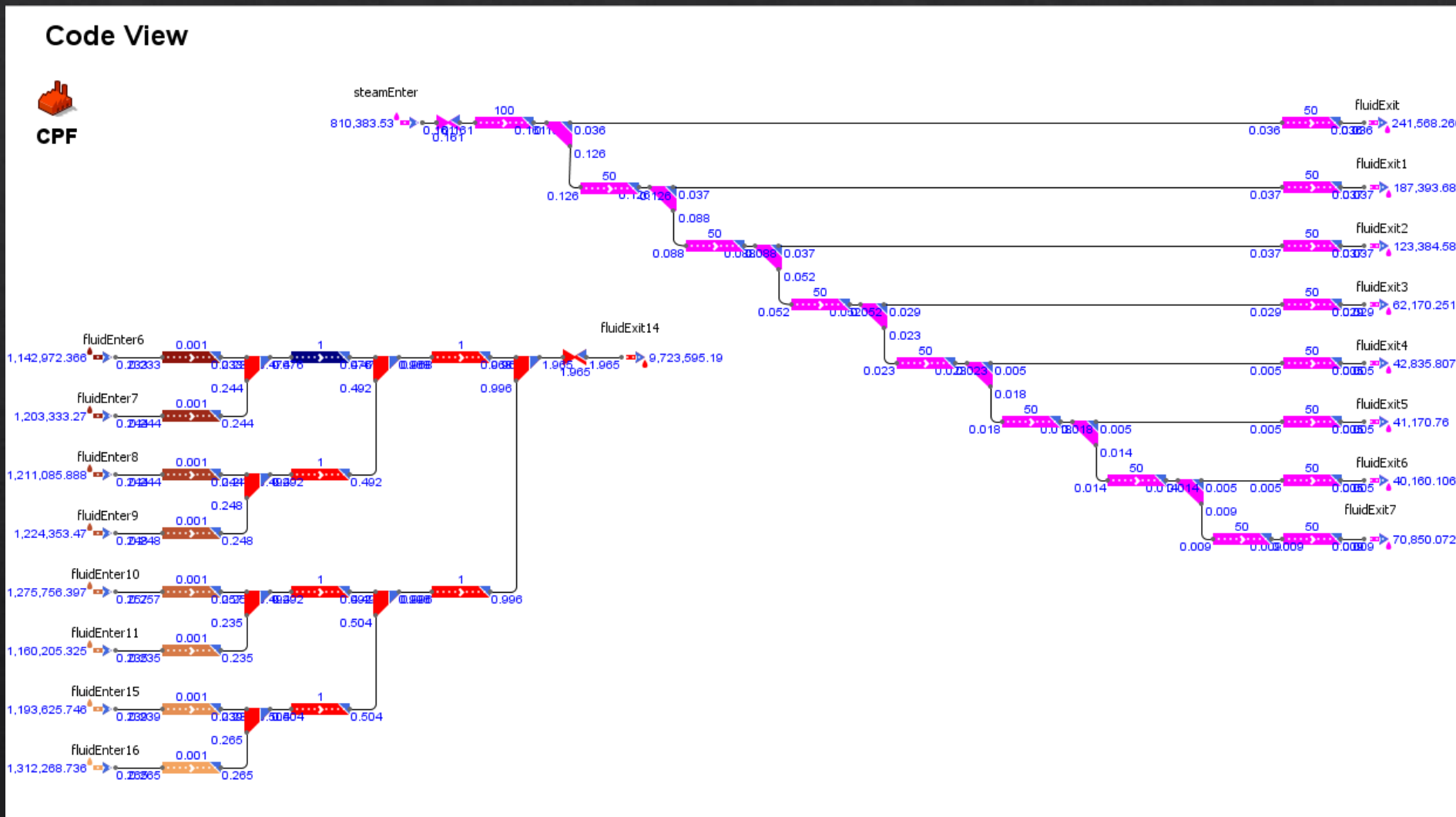
14

VARIABLES



260  
OTHER COMPONENTS

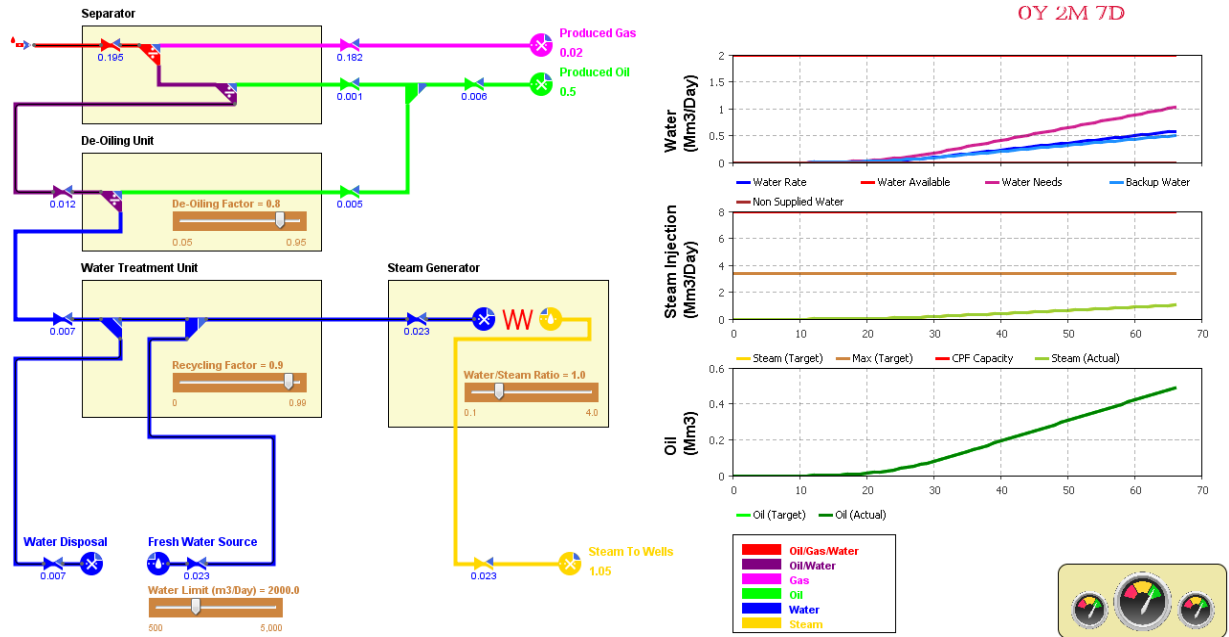
24  
HOURS



## SAGD Dashboard



## Central Processing Facility



## Statistics : CPF

Rate	Ratio	Cumulative	Quality	Report
------	-------	------------	---------	--------

### Production Summary

	Parameter	Actual	Target	Difference
Oil	Cum. (M m3)	62.04	62.04	0 0%
	Rate (M m3/Day)	0.62	0.62	0 0%
Water	Cum. (M m3)	79.77	79.77	0 0%
	Rate (M m3/Day)	0.78	0.78	0 0%
Gas	Cum. (MM m3)	1.88	1.88	0 0%
	Rate (MM m3/Day)	0.02	0.02	0 0%

Water Limit (M m3/day)	2
Steam to Water Ratio	1
Recycling Factor	0.9
CPF Steam capacity (M m3/Day)	8
Number of Wells per Pad	5
Number of Pads	6

Project Name:

Company Name:

Reported By:

Date:

yyyy mm dd

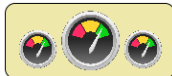
Print Report

### CPF Summary

	Rate (M m3/Day)	Cum (M m3)
Steam	1.49	155.26
Water from Wells	0.78	79.77
Required Water	1.49	155.26
Makeup Water	0.79	26.99
Non-Supplied Water	0	0

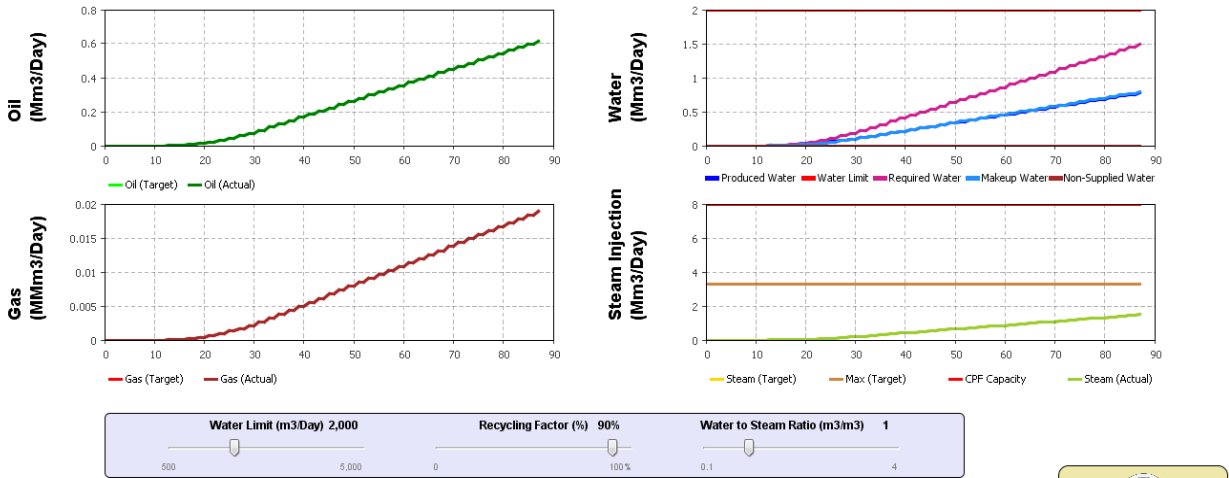
### Quality Index (ppm)

	Actual	Target	Difference
TDS	1,530	1,530	0 0%
TOC	242	242	0 0%
Hardness	639	639	0 0%
Silica	982	982	0 0%
Alkalinity	150	150	0 0%
H2S	16	16	0 0%



## Statistics : CPF

Rate	Ratio	Cumulative	Quality	Report
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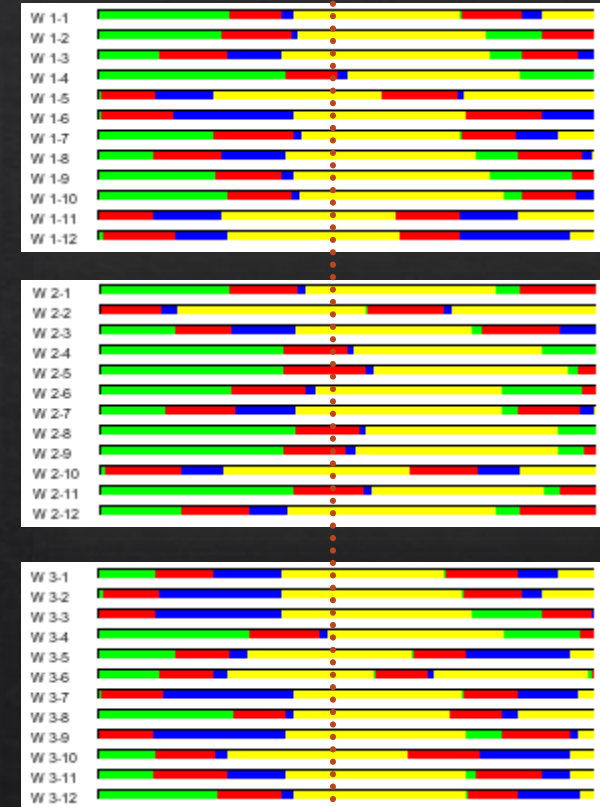




# Advantages of the Approach

- ◆ Dynamic populations
- ◆ Fluid modeling
- ◆ Tracking of all batches in the model
- ◆ Quality calculations
- ◆ Advanced decision algorithms
  - ◆ Scheduling
  - ◆ Backward calculations
  - ◆ Reliability
- ◆ Multiple scenario analysis

Optimization



- ◆ Systemic Approach
- ◆ Deal with Complexity
- ◆ Ripple and Timing Effects
- ◆ Experimentation Platform

- ◆ Manoochehr Akhlaghnia, PhD.
- ◆ Alistair Wright, PhD.
- ◆ Dumitru Cernelev, P.Eng, MBA.
- ◆ Birgit Juergensen, Dipl.Ing.Oec
- ◆ Alvaro Gil, M.Sc.
- ◆ Industrial Partners



# Q&A Session

Thanks for your attention