An Australian first initiative to re-develop the first commercial onshore oilfield into a CO_2 miscible-EOR project.

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Bridgeport Energy
Stephanie Barakat, Bob Cook, Karine D'Amore

Rock Flow Dynamics
Alberto Diaz, Andres Bracho

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Overview of Presentation

- Moonie background, location and production history
- Analogue pre-screening
- Reservoir model
- CO_2-EOR Pilot Project concept
- Pilot simulation results
- Sensitivity & uncertainty analysis
- Sourcing CO_2
- Conclusion and the future CO_2– EOR projects

Background

Moonie Oil Field

- discovered in December 1961 by Union Oil Co.
- commenced production in 1964 as the first commercial oil field in Australia PL1(1) at a peak production rate of 8,500bopd
- production principally from the Precipice formation (approx. 1,480 mSS)
- production from the tighter Evergreen formation directly overlying the Precipice
- produces a sweet light (35°API gravity) crude
- unsaturated crude at reservoir conditions with a bubble point of 1467 psig and GOR of 253 SCF/bbl
- strong water drive effectively providing secondary recovery
  - little decline from the original reservoir pressure of 2,520 psig
- currently producing approximately 135 BOPD with average water > 99%
- acquired by Bridgeport (BEL) in 2016 from Santos

BEL is planning towards a tertiary recovery production phase

Location

Located 170km west of Toowoomba

Precipice format is at 1,750mRT

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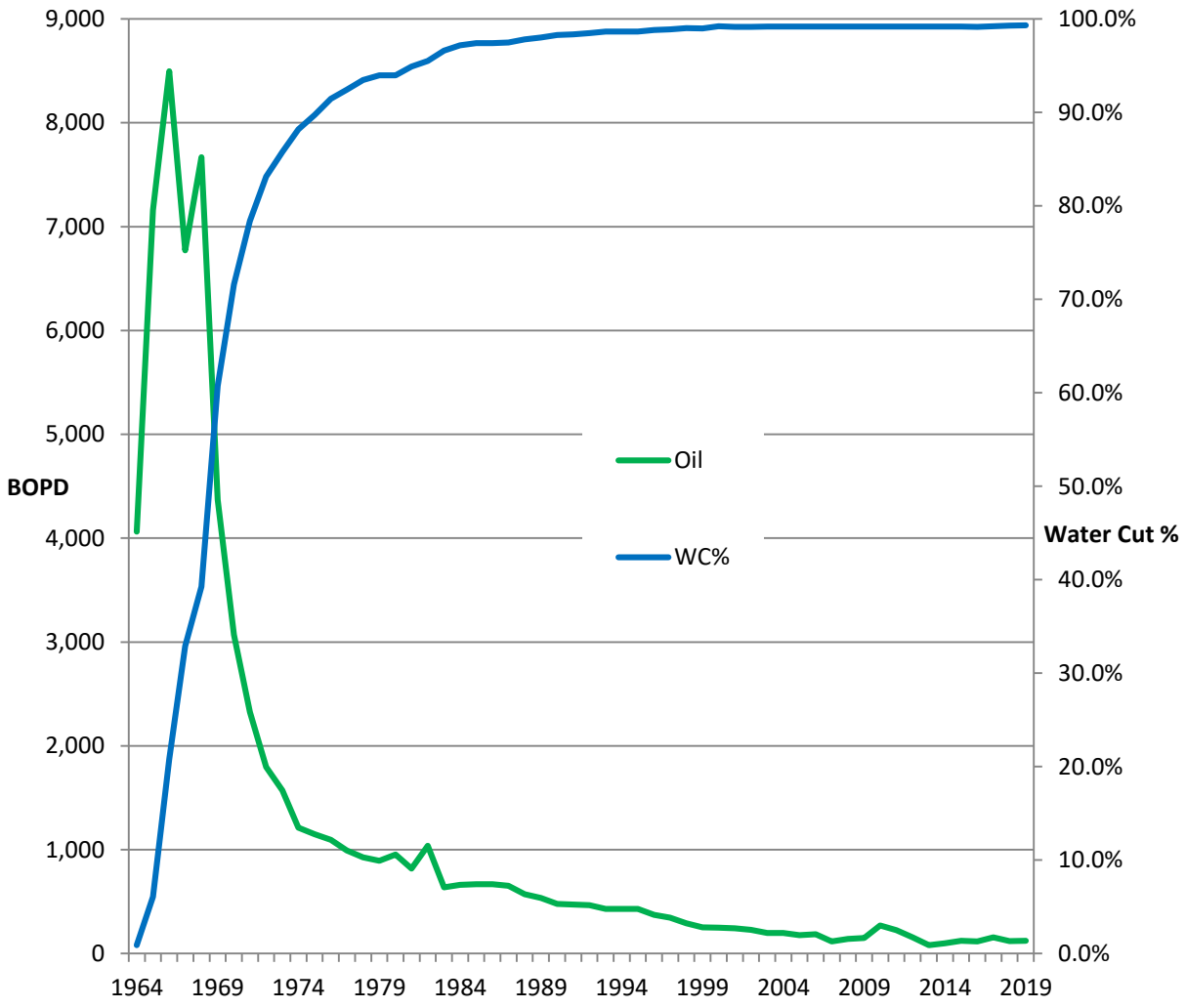
Production History

Moonie:

- 25 MMbbls production to date
- Reservoir pressure supported by a strong water drive
- 46 wells drilled to date, last 2 in 2018
- 13 wells on-line with a further 17 available

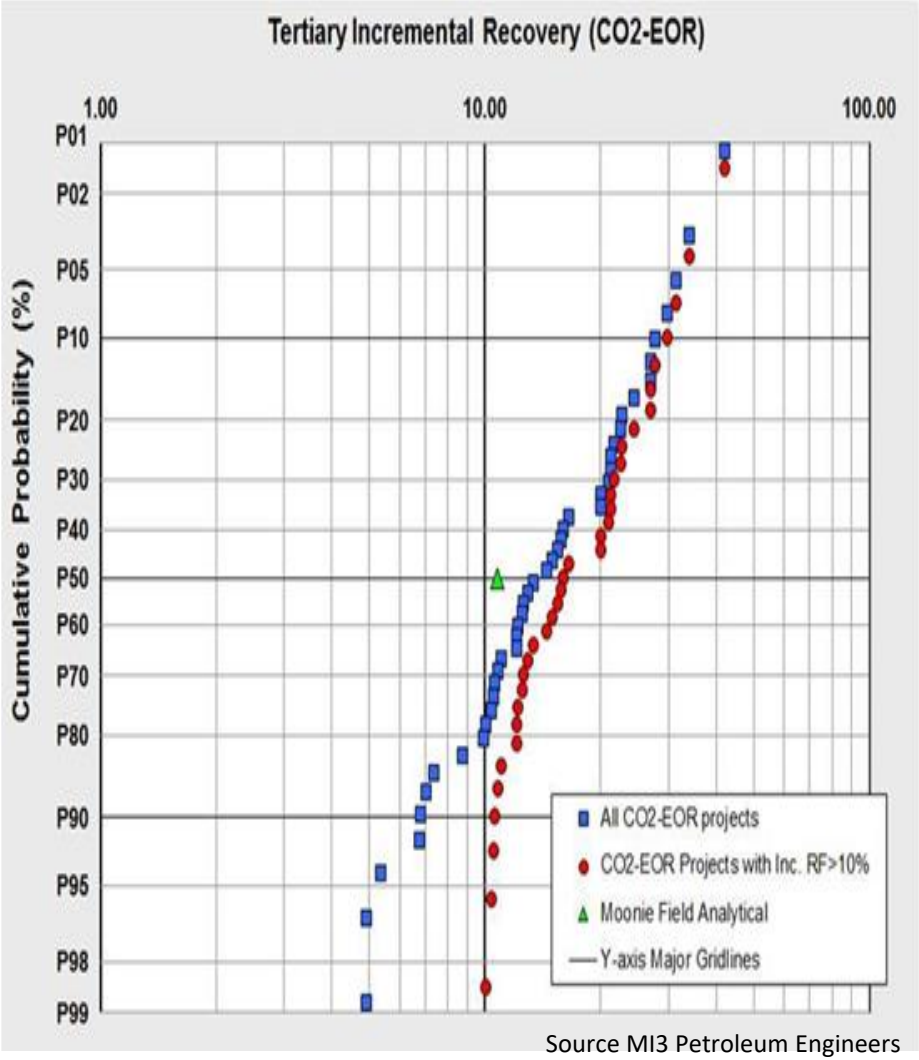


EOR Pre-Screening

- MI3 Petroleum Engineers engaged for initial EOR appraisal.
- Moonie geological and fluid properties were used to compare EOR options and analogues.
- CO_2-EOR analogues in MI3's data base are presented to the right.
- First pass recovery estimate was 10.7% (of OOIP) from a CO_2 flood.

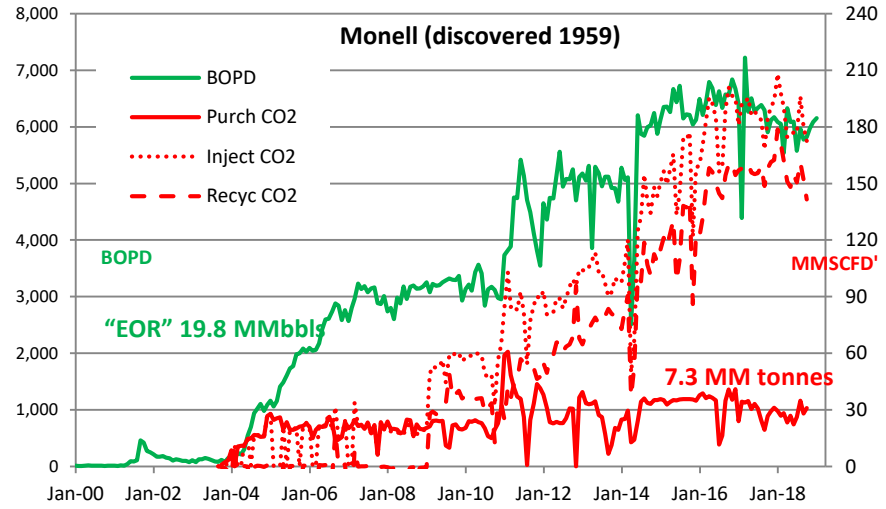
This helped support BEL's decision to

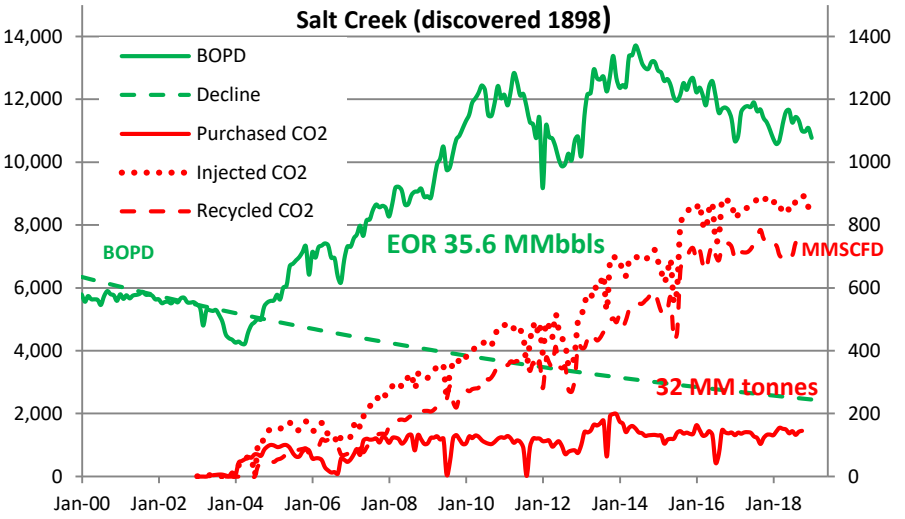
- Construct a reservoir model
- Undertake further laboratory work
- Commence search for CO_2 sources

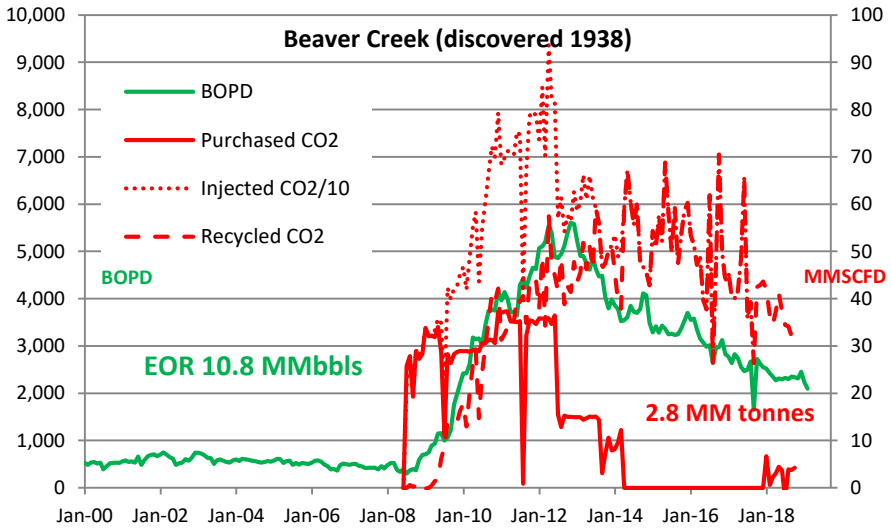


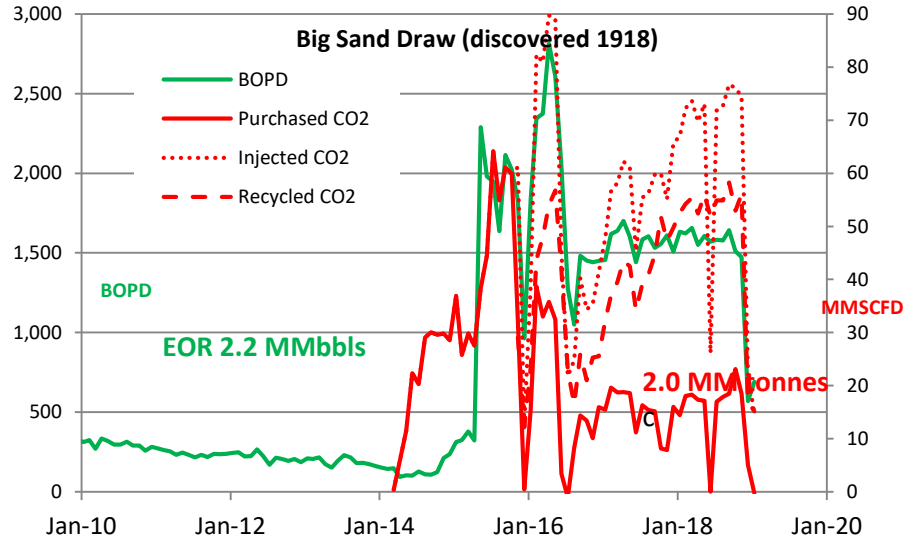
Source MI3 Petroleum Engineers

Some Wyoming Analogues









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Reservoir Model

Prior to acquiring the Moonie oilfield it was operated on care-maintenance. Bridgeport has been reworking the field to identify remaining oil including the construction of a static and dynamic reservoir model:

Key model specifications:

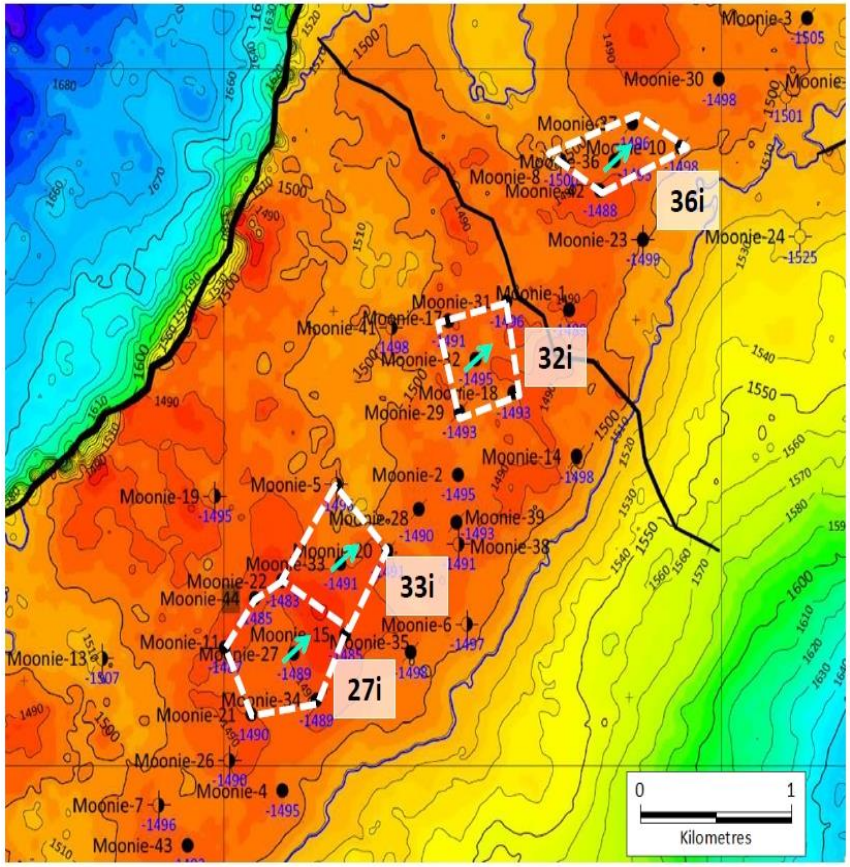
- Petrel static geo-cellular model
- Grid geometry 50 x 50 x 1 (m) for net reservoir zones
- Isopach maps were imported for six reservoir levels: two in the Evergreen and four in the Precipice
- PVT data from analyses fresh recombined crude and gas samples
- An OOIP mid-case estimate of 64 MMbbls was used for history matching
- Black oil eclipse model for history match and Compositional for prediction
- Production supported by a strong water drive
- The residual oil saturation was calculated to be 20%

Reservoir Model (cont.)

The next step was to evaluate the impact of the CO_2 flood in several sectors of the reservoir

- Partly because of a limited supply of CO_2 currently available and,
- As a first step to proving the field concept

4 injector-producer spot patterns were identified as potential pilot areas



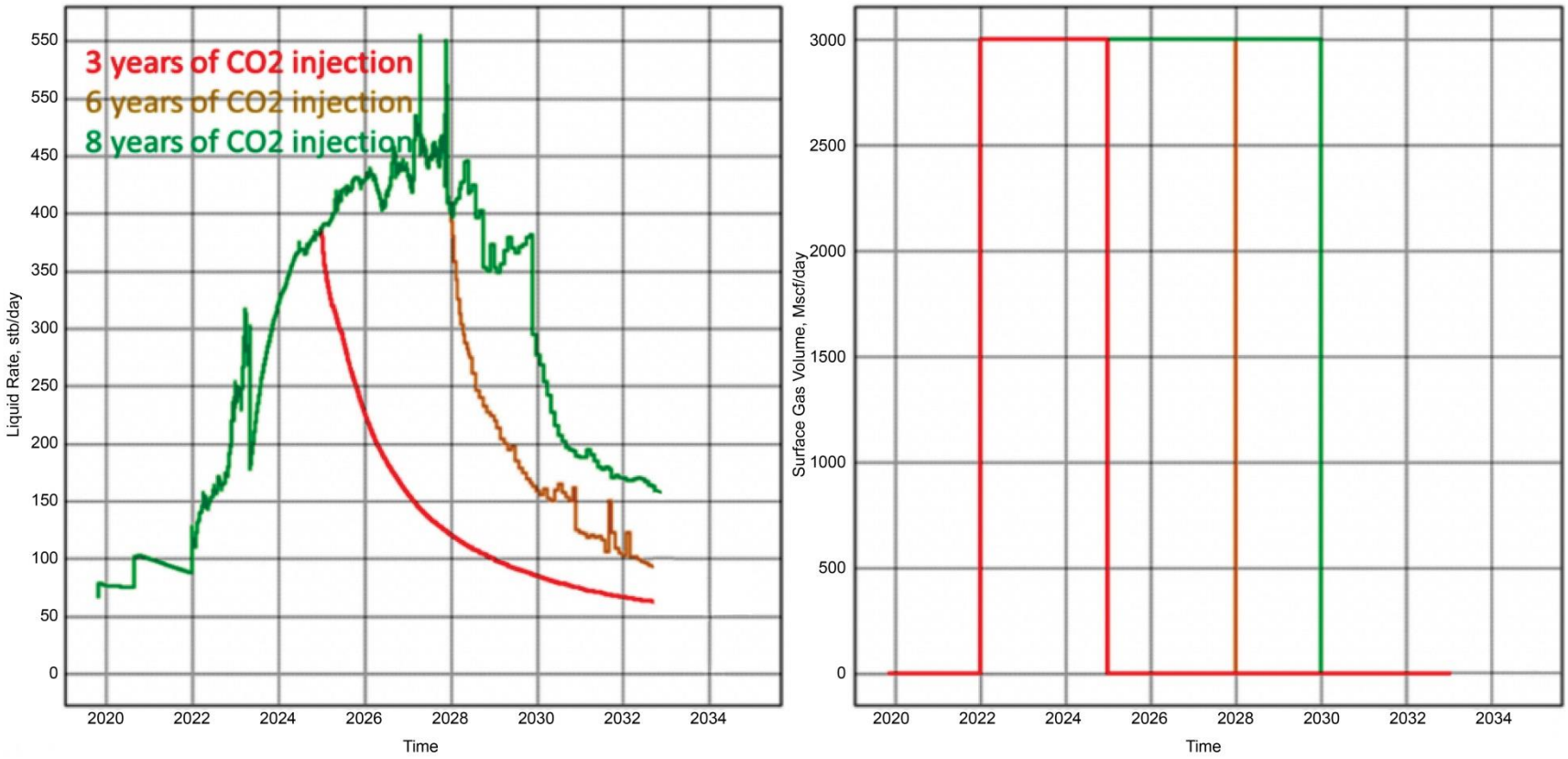
Patterns	
Injector (Conversion)	Producers
36i	8, 10, 37 & 42
32i	17, 18, 29 & 31
33i	5, 15, 20 & 22
27i	11, 15, 21, 22, 34 & 44

Reservoir Model (cont.)

Injection of CO_2 at Moonie #27 with production at Moonie #11, #15, #21, #22, #34 and #44 during the pilot phase proved to be the most attractive outcome for three technical and practical reasons:

- Generated the best recovery within the modelled sectors
- Most number of wells were available without major workovers required
- The sector is closest to the current infrastructure/facilities and has easy access for CO_2 trucking requirements

#27 Pilot Prodn. & Injectn. Rates



- The 6 MMSCFD injection rate achieved a peak rate of ~ 800 BOPD

#27 Pilot Production Simulations

Sensitivity of production (and sequestration) to varying

- Injection Rate → 3 & 6 MMSCFD
- Injection time → 3, 6, & 8 years

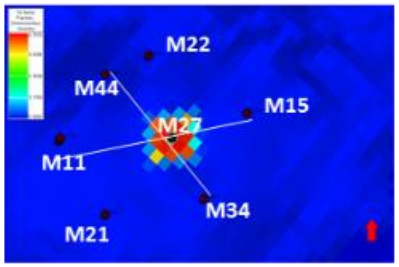
Produced the following results:

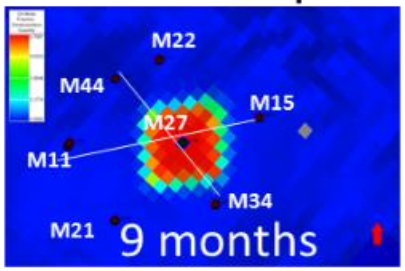
CO_2 Rate	Period	Production	CO_2 Sequestered
3 MMSCFD	3 years	0.70 MMbbls	96%
3 MMSCFD	6 years	1.13 MMbbls	92%
3 MMSCFD	8 years	1.34 MMbbls	92%
6 MMSCFD	3 years	1.13 MMbbls	93%

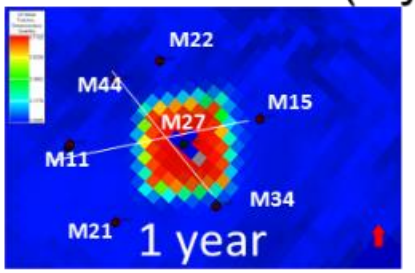
- Economics require 4-5 years before NPV10 return
- 8 year injection case also yields a reasonable economic outcome

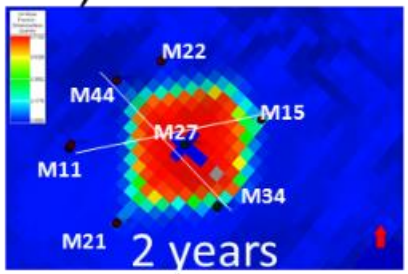
Simulation of #27 CO_2 Injection

- CO2 flow between M-27 and all producers - Areal view (layer 51)

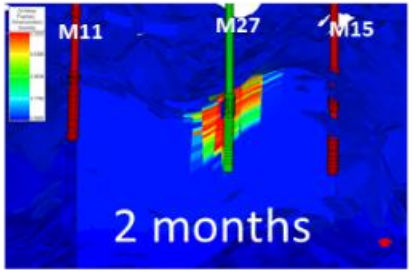


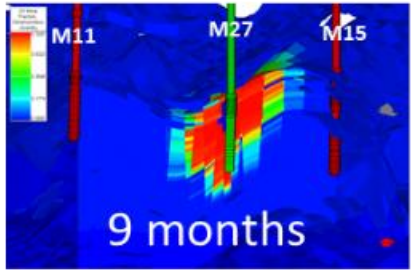


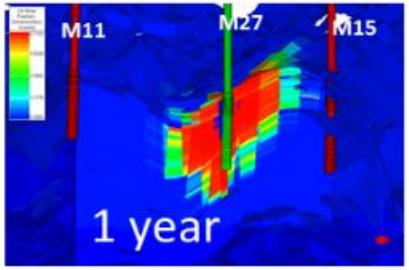


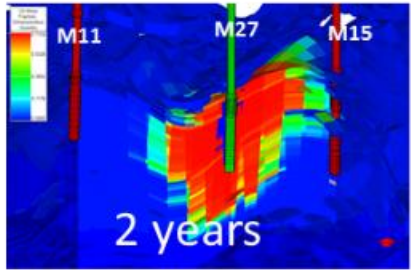


- CO2 flow between M-27 injector and producers (M-11 and M-15)-X section

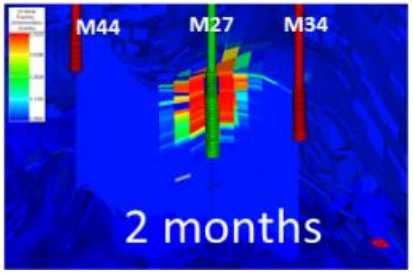


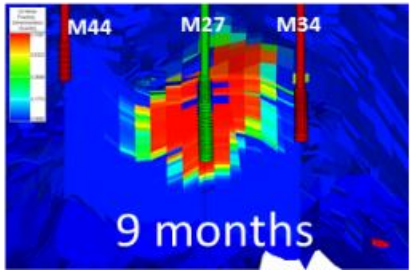


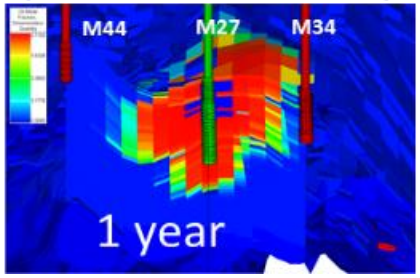


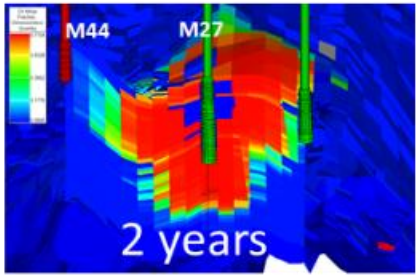


- CO2 flow between M-27 and producers (M-44 and M-34)- X section

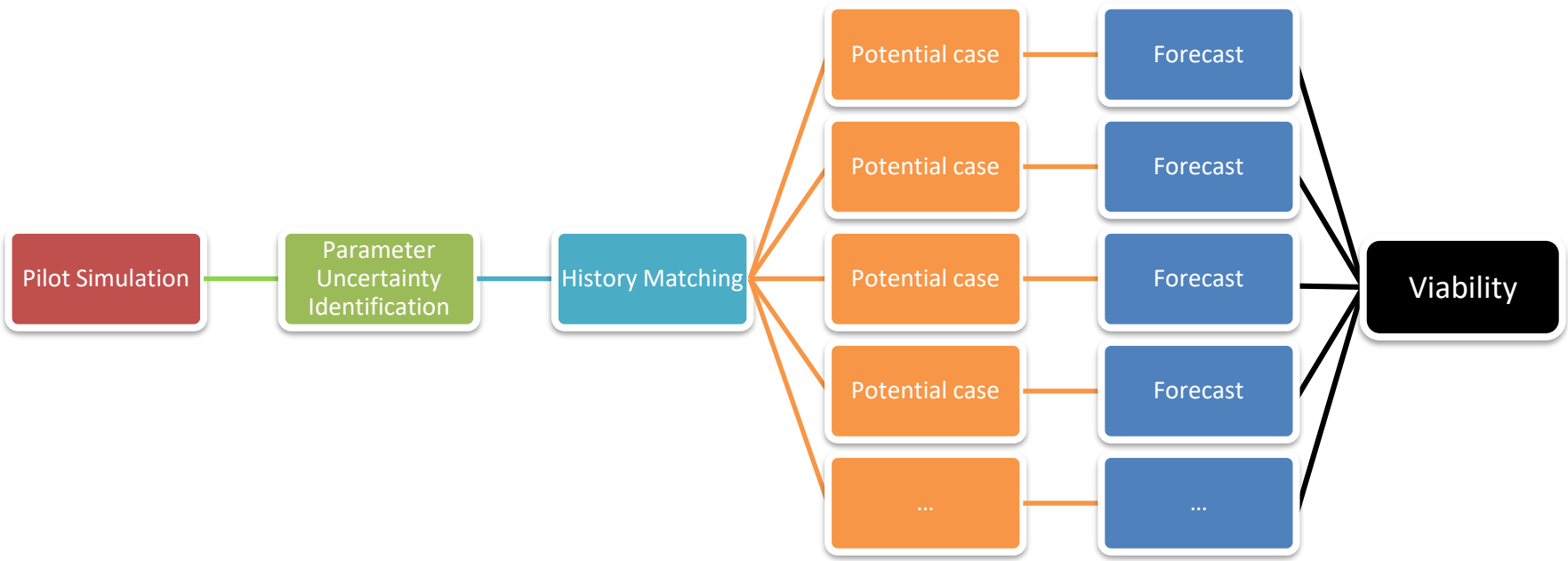








t-Navigator Uncertainty Workflow



Uncertainty Analysis

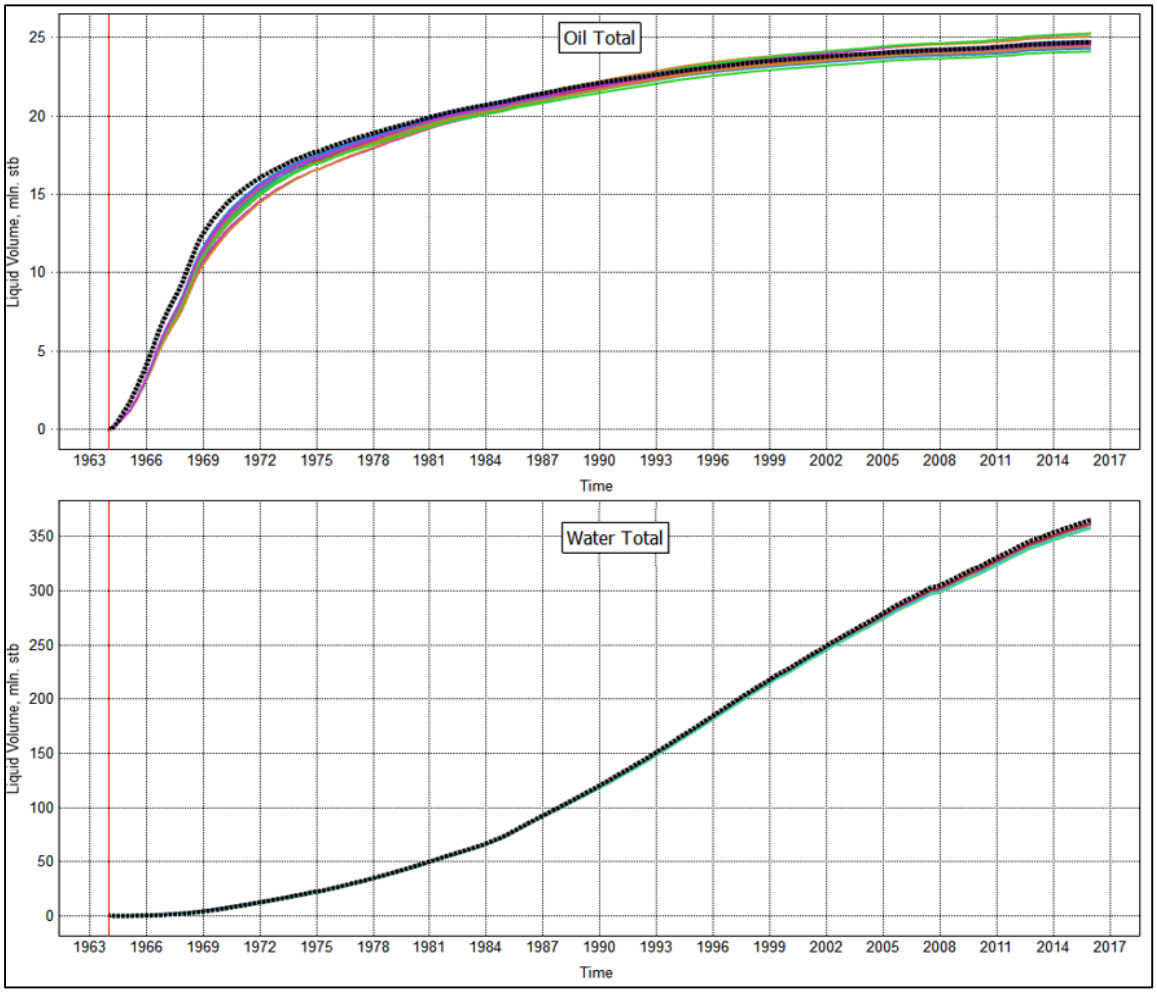
- Take uncertainty into consideration to assess project viability
- Main uncertain parameters and ranges identified by BEL

Reservoir Parameters	Maximum	Base Case	Minimum
Porosity Multiplier	1.2	1	0.8
Permeability Multiplier	1.2	1	0.8
Aquifer Permeability (mD)	800	200	0
Oil Water Contact (ft)	4,975	4,970	4,968
Critical Oil Saturation	0.35	0.25	0.2
Relative Permeability	LET correlation		
Initial Water Saturation	Two water saturation distributions		

- Oil and water total used as main criteria for history matching
- Latin hypercube experimental design used to generate 500+ realizations
- Tolerance ranges for key history matching parameters were used

Uncertainty Analysis - History Match

- 15 cases were considered satisfactory
- **Oil and water total** used as main criteria
- **Multidimensional scaling** used to narrow the cases down to 10 substantially unique models



Uncertainty - Forecast Results

- Injection periods determined during pilot phase used for forecasts
- Simulation results indicate:
  - Incremental oil in the range of 320 to 730 Mbbls
  - CO_2 sequestration fraction ranging from 90-97%
  - Maximum Cumulative CO_2 injected of 3.28 BCF (at rate of 60,000 tonnes per annum)
  - Incremental oil very sensitive to sequestration potential

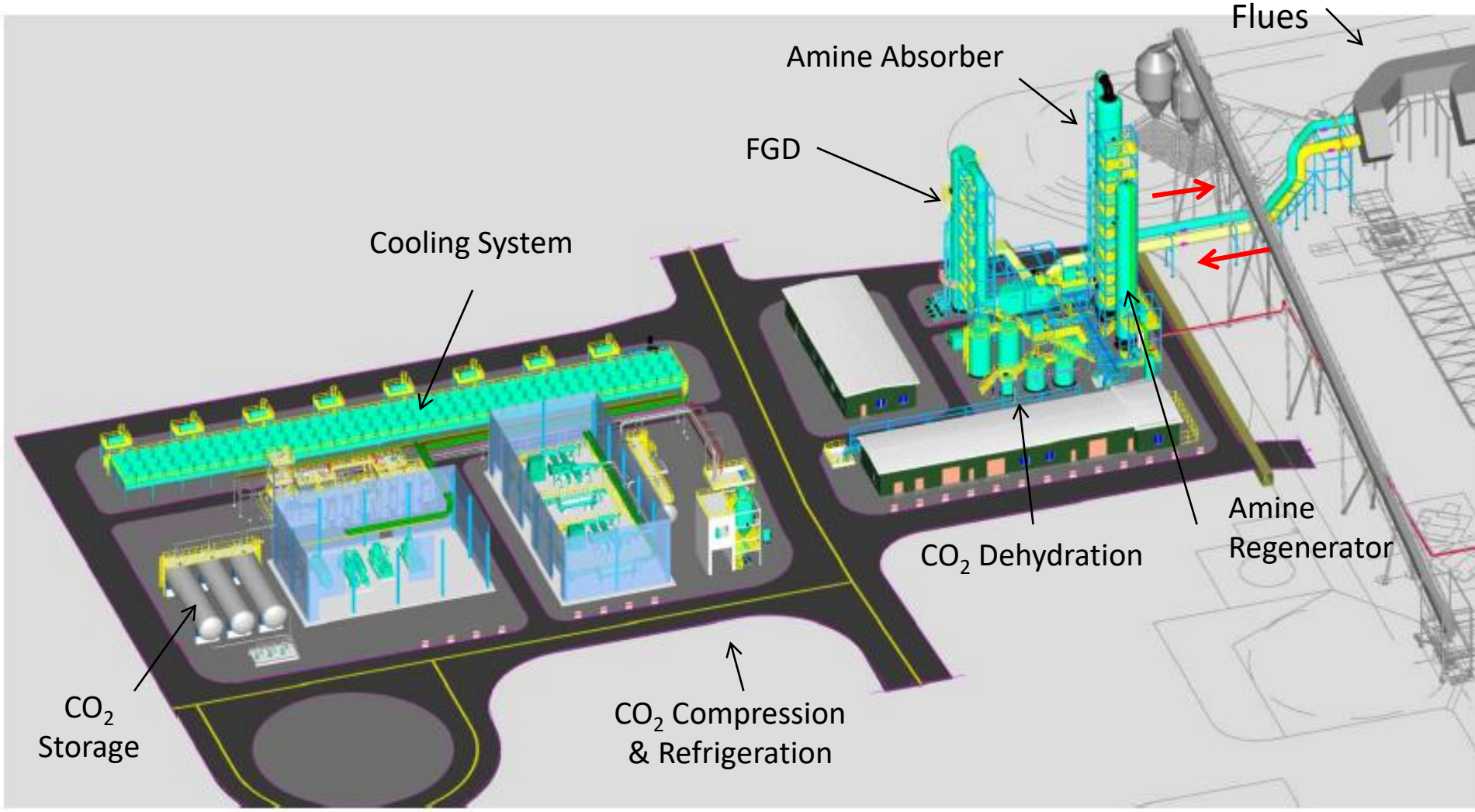
	Case	Units	Minimum	Mean	Maximum
Cumulative CO_2 injected	Production Forecast	BCF	3.27	3.28	3.28
CO_2 sequestered	Production Forecast	(%)	90%	95%	97%
Incremental oil	Difference	MMbbls	0.32	0.58	0.73

Potential Sources of CO_2

Potential Sources of CO_2

- Initial target was Carbon Energy's underground coal gasification
  - Capable of supplying CO_2 for the requirements of full field development
- Next option was the ethanol plant at Dalby used to frame the 3 MMSCFD for the pilot/sector model
- Consideration was given to several other industrial supply options including from fertiliser and explosives manufacturers
- Current target is CO_2 from post combustion capture (PCC) at a south east Queensland power station
  - FEED for PCC of 120,000 tonnes/year (6 MMSCFD) has been completed
  - Has support of coal industry via COAL21 (low emission thermal coal generator options)
  - CO_2 from PCC is to be used in part for CCS research designed to lead to full scale CCS
  - PCC expected to be operational by Q1, 2022 assuming FID Q4, 2019
  - CO_2 for the pilot will be trucked to Moonie

Typical PCC Facilities



Conclusions

- Establishment of a source of CO_2 is expected to trigger the Moonie CO_2-EOR pilot project
- A PCC plant at a thermal power plant appears to provide initial and ultimate source of CO_2
- Preliminary modelling of a full field development with no attempt at an optimum EOR design suggests at least 6 MMbbls recovery
- EOR project could sequester 8 MM tonnes of CO_2
- Precipice and Evergreen structures could store additional CO2 post-EOR, possibly as a first step in the proposed Surat Basin Hub CO_2 gathering & sequestering project
- t-Navigator's software and efficient hardware utilization proved invaluable in testing the large number of project uncertainty outcomes
- CO_2-EOR (known as carbon capture utilisation and storage (CCUS)) is the only current economic carbon capture scheme worldwide capturing industrial CO_2 and using it for additional oil recovery
- To encourage more carbon capture, Australia needs a USA "45Q" type tax concession that will stimulate investment around thermal coal fired power plant capture processes

The Future

- New wells in 2018 on Moonie structure -> revising the static and dynamic model and considering residual oil zone (ROZ) opportunities
- Moonie could be the “pilot” for other Australian CCUS opportunities

Field Area	~Production to date (Bn bbls)	Est additional oil CCUS project	CO2 availability (MMTPA) *	Sequester Potential (MMtonnes)
Bass Strait	4	1.5	44	475
Barrow Island et al	0.6	0.2	4	63

*** Bass Strait CO_2 sources Longford plant and Latrobe valley, Barrow Island source Gorgon field associated CO_2**

- The largest benefit of CCUS projects is the minimal capex to progress because most wells are available and additional infrastructure is incremental to existing facilities
- Implementation of a CCUS tax concession would focus attention on these offshore production and sequestration opportunities