IOR TECHNOLOGY: ENHANCING PRODUCTION
WHAT IS IMPROVED OIL RECOVERY?

Any of various methods, chiefly reservoir drive mechanisms and enhanced recovery techniques, designed to improve the flow of hydrocarbons from the reservoir to the wellbore to increase oil recovery beyond that achieved with primary production alone.

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<th>HOW?</th>
<th>GOAL?</th>
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<td>- Miscible gas is injected into a well to begin the Huff n’ Puff (HnP) process. The gas is absorbed into the oil causing it to swell, reducing the viscosity and increasing the mobility of the oil.</td>
<td>- Re-pressurize the reservoir and energize the physical properties of the oil. Increased oil mobility and reservoir energy will allow recovery of more of the oil in place.</td>
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<td>- Increased oil mobility and reservoir pressure allows the oil to move through the rock and gives the reservoir the energy needed to push the oil to the surface.</td>
<td>- IOR can result in extended economic well life, recovery of more oil and accelerated primary production.</td>
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Huff n’ Puff (HnP) miscible gas injection is the optimal IOR method for the Eagle Ford reservoir and has been demonstrated as technically feasible through projects already in place.

(1) Gas Purchase Pipeline will be used for start up and to augment recycled gas as necessary.
WHERE HAS IOR BEEN IMPLEMENTED?

- Five operators have Huff n’ Puff operations on approximately 200 wells within the Eagle Ford.
WHAT ARE THE BENEFITS OF IOR?

- IOR adds energy to the reservoir, which increases the amount of oil that will ultimately be recovered from a well and accelerates the production that would have occurred later in the well’s life.

- IOR increases the Estimated Ultimate Recovery (EUR) of a well by 30 – 70% compared to primary recovery alone.

- Primary recovery alone recovers only 5 – 10% of the Original Oil in Place (OOIP); IOR increases that recovery to 7 – 17% of OOIP, which is a dramatic increase.

- IOR attains results without drilling or completing additional wells and without requiring additional local resources such as sand and water.

Result is a well that has an extended economic life and an acceleration in the rate of production.
WHAT IS THE IOR INVESTMENT TIMELINE?

- A timely decision to implement IOR is required during the later stages of the primary development phase of a play.

- Eagle Ford IOR projects have demonstrated technical success after 2 – 6 years of primary production.

- Approximately one year of design and geologic and petroleum system evaluation is required to assess the viability of IOR in a given area.

- Another year is required to construct, pilot test and optimize IOR.

- Where utilized, IOR adds incremental production and extends a well’s economic life; however, significant up front investment is required to reduce operator risk.

Chesapeake makes a substantial investment in science and engineering to determine project viability and justify IOR expense.
The IOR process does not typically involve drilling new wells. Rather existing wells are utilized in one of three ways outlined below.

- **Huff n’ Puff well (HnP)**
  A well that will be both an active injection and production well. This well will be on a varying cycle of injection (huff), soak and puff (production).

- **Containment well**
  A well that limits the movement of gas beyond the immediate IOR injection areas. Well will be equipped with gas lift production equipment. This well acts as a boundary to the IOR project.

- **Monitor well**
  A well that will be used to monitor nearby HnP wells. Well will be shut in during pilot for scientific purposes. This well will later be converted to containment or HnP based on results.

**IOR generic pilot scope and well layout**

- HnP wells will see cyclic injection, soak and flowback
  - Gas is recycled back to IOR compression station
  - Liquids are sent to existing production facilities
- Centralized compression to minimize IOR surface impact
- Actual wellfield design will vary from area to area
During primary development, wells experience natural decline in production and reservoir pressure. (see oil production line in figure)

Gas injection during IOR will re-pressurize the reservoir to above the bubble point, resulting in increased oil mobility and increased oil recovery.

More gas is required to re-pressurize reservoirs that have produced more primary fluids by producing longer. (see red bars in figure)

Economics of HnP are dependent on commodity prices (i.e. gas price, oil price). Low gas prices and high oil prices are beneficial for HnP.
WHAT DOES A TYPICAL IOR PROJECT LOOK LIKE?

- IOR build out is executed in three phases:
  - Phase 1: Pilot
  - Phase 2: Expansion
  - Phase 3: Full-Field

- Existing wells, facilities and right of ways are leveraged
- Project is scaled with minimal additional infrastructure
WHAT DOES A TYPICAL IOR PROJECT LOOK LIKE ON THE SURFACE?

### Key Operational Difference Between Primary and IOR Unconventional Development

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<th>Primary Development</th>
<th>IOR Development</th>
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<td>Drilling and Completion of Wells</td>
<td>Injection Into Existing Wells</td>
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<tr>
<td>Hydraulic Fracturing to Access Reserves</td>
<td>Gas Injection to Swell/Mobilize Existing Resources</td>
</tr>
<tr>
<td>Artificial Lift for Pumping Wells</td>
<td>Injection Energy Used to Lift Wells</td>
</tr>
<tr>
<td>Buildout of Well Pads and Production Gathering</td>
<td>Existing Infrastructure Plus Parallel Injection System</td>
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IOR projects take longer to develop than primary drilling

Approximately two years to begin gas injection and another six months for pilot testing. Timely communication and execution of unit agreement and infrastructure approvals influence schedule.

- **Early Work and Design** – prospect evaluation, conceptual engineering, landowner approval, and JV partner approval
- **Procurement, Construction and Commissioning** – detailed engineering, procure compression and other long lead equipment, construct facilities, and construct gas supply line
- **Testing and Optimization** – operate the facilities to complete multiple HnP cycles; evaluate data and optimize operations
- **Execution** – maximize production during project life and expand IOR to other parts of the field

IOR Development Schedule

- Early Work and Design: 12 months
- Procurement, Construction and Commissioning: 15 months
- Testing and Optimization: 6 months
- Execution: 4 – 8 years
IOR has lower capital costs (capex), but requires two years to design and implement compared to a mobilization of months for drilling and completing new wells (primary development). Early investments in IOR capex are not offset by revenues for two to three years.

IOR has higher operating costs (opex) due to operating compression and purchase of working gas; impacts revenue to recoup capex. (longer time to breakeven)

Economics are sensitive to opex, which can be impacted by the volume and price of working and fuel gas.
In order to conduct an IOR project, it will be necessary to amend the underlying lease(s) to effectively:

- Recognize IOR project operations as “operations” that perpetuate the lease(s) even if there may be periods of cessation of production or other operations that exceed 90 days.
- Address the accounting for and payment of royalties on gas to allow Lessee to produce, use, recycle and sell “Working Gas” without the obligation to pay royalties thereon.
  - Oil royalties will be based on the amount actually produced and sold.
- Address the unitization and allocation of production from wells within the applicable IOR Project Area to the pooled units or tracts in which the lease(s) have been included.

The estimates included in the foregoing slides are for demonstrative purposes only and are not representations or guarantees regarding future production or performance. Although Chesapeake believes the estimates to be reasonable, they are subject to change and actual results may vary significantly. These slides are meant to demonstrate the potential related to the IOR Project but are not to be relied upon as a prediction of actual future performance.