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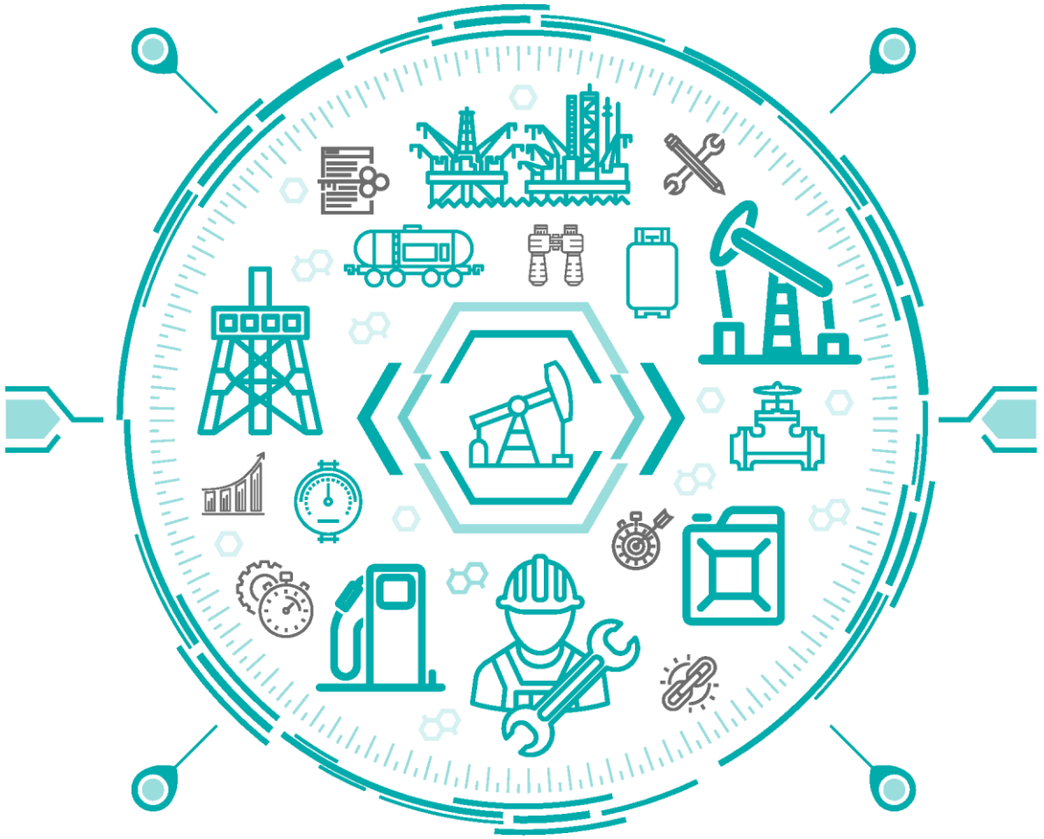


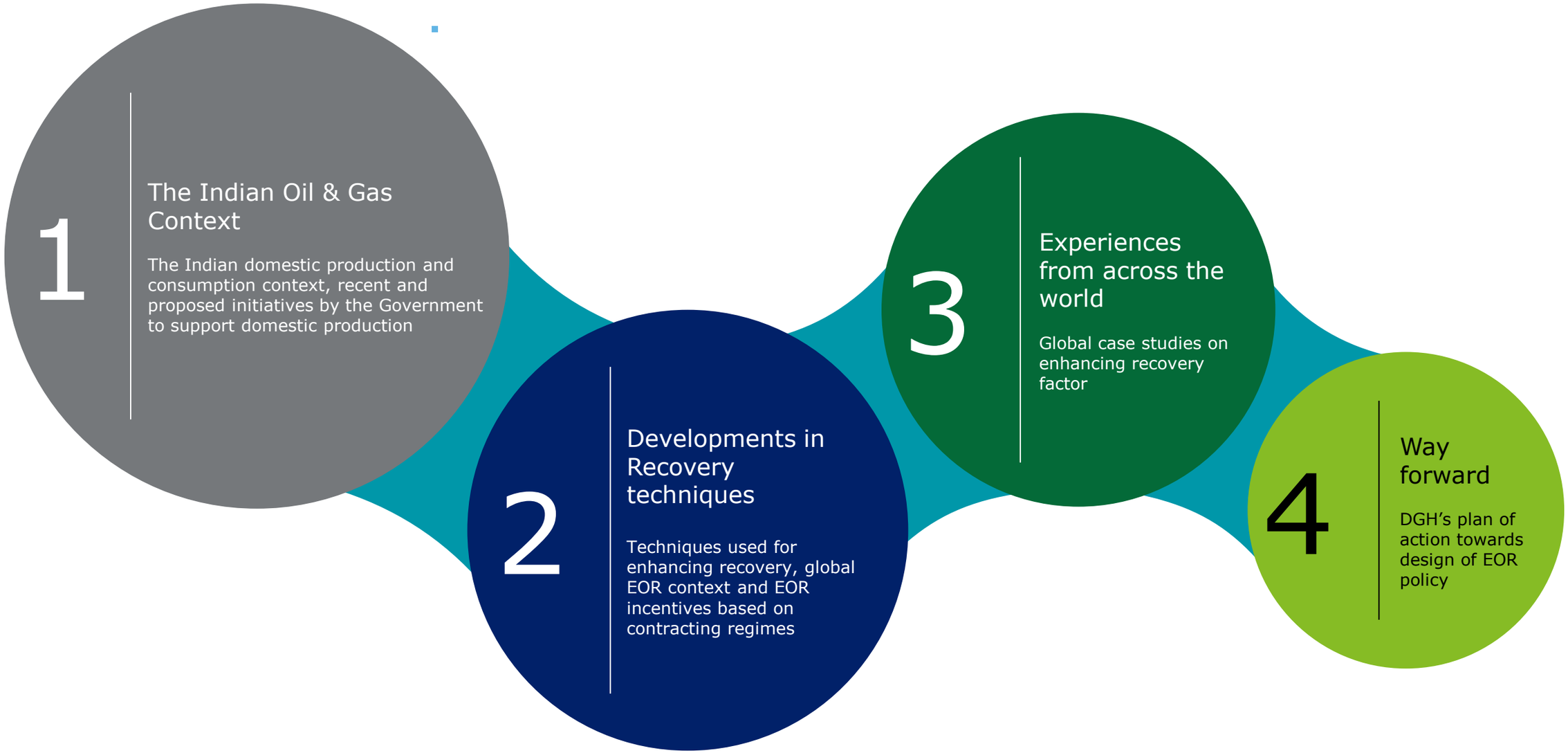
Enhancing Recovery in the Indian E&P Sector

Background note

June 20, 2017

Contents

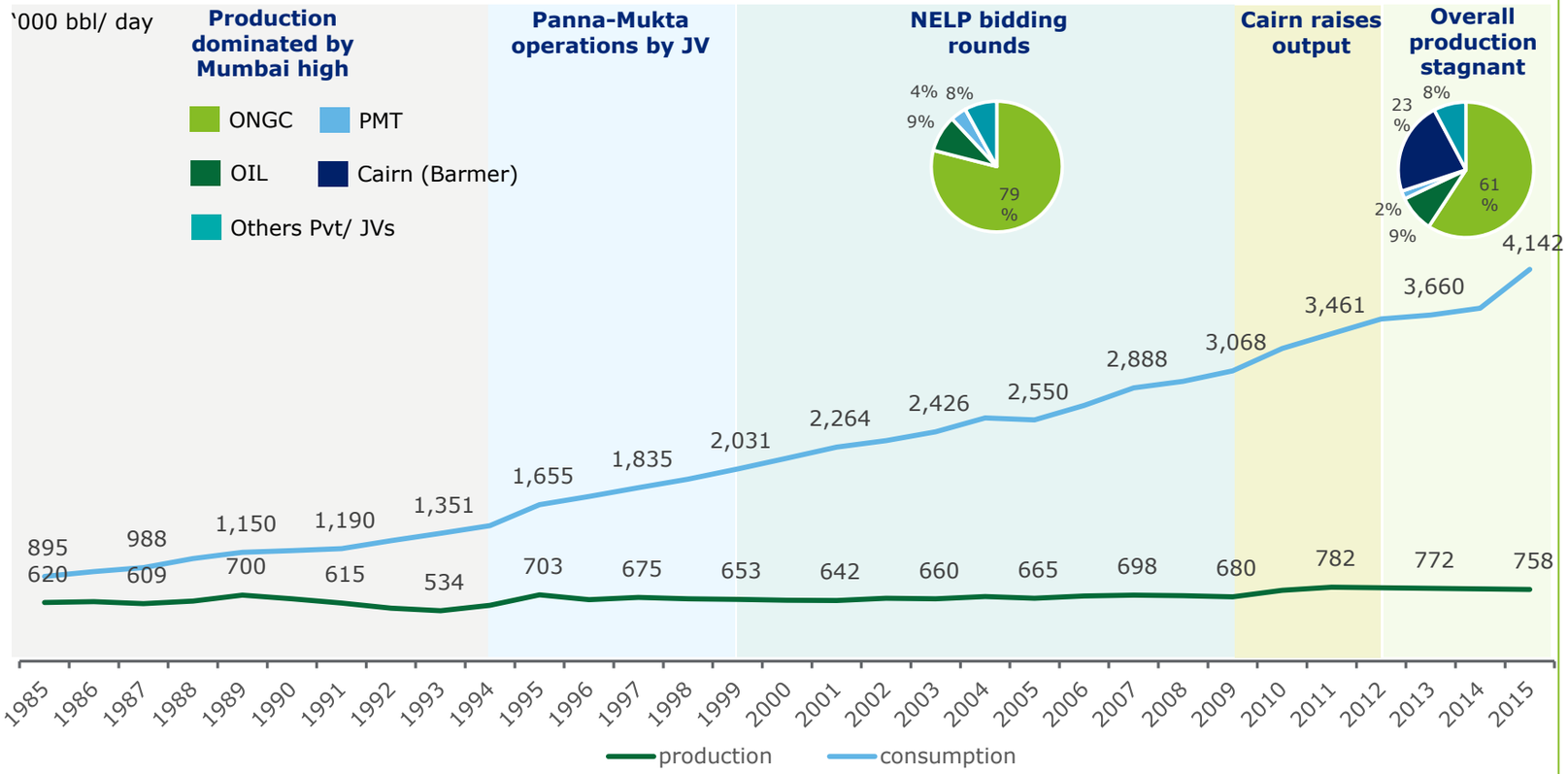
Towards design of a policy to promote Enhanced Recovery in Indian Oil & Gas Industry



India domestic production

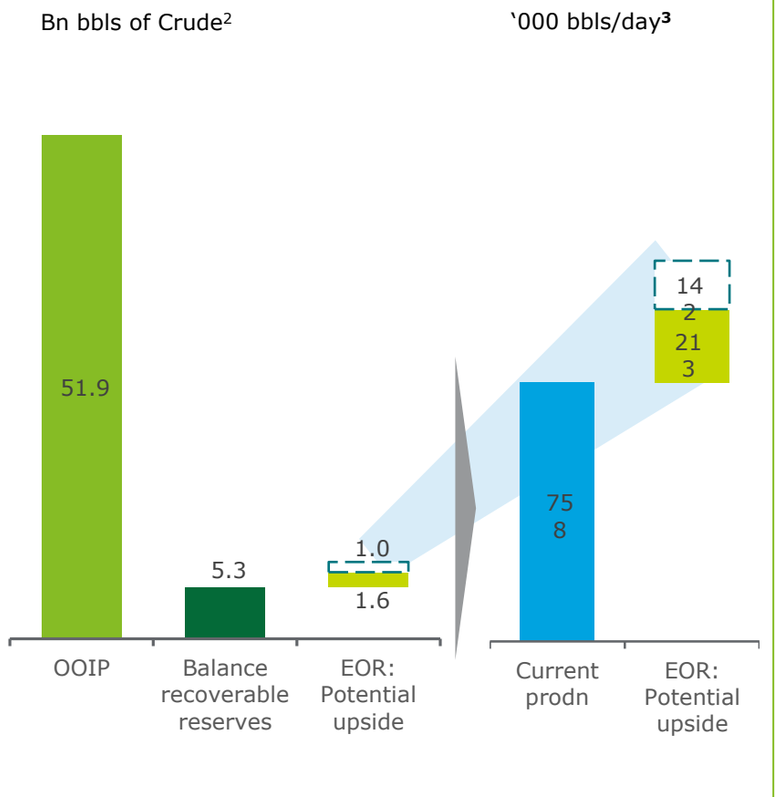
Indian crude production has lagged behind the growth in demand, EOR may present an opportunity

India - Crude Oil Production and consumption profile[1]



- Demand for oil is expected to grow at a CAGR of ~ 4% from 2015-2035
- Domestic crude production as a percentage of consumption has reduced from ~ 69% in 1985 to ~ 18% in 2015. Major production fields of ONGC, OIL ONGC, PMT etc. have matured
- Since Cairn (almost a decade ago), no major discoveries have been made

Excess production potential from EoR



Use of Enhanced Oil Recovery (EoR) techniques could potentially increase output by 45%

Sources: MoPNG, EIA, DGH, Indian Bureau of Mines, BP Energy Outlook 2017, Annual corporate filings of RIL, Cairn India etc.
Notes: 1) Pie-charts for share of production have been provided for FY2003 and FY2016 for representation; 2) OOIP recovery upside is assumed as 3% (conservative case) and 5% (optimistic case); 3) Assumes an average lifespan of 20 years for oil-fields;

Focus areas

The Government and DGH have undertaken numerous measures to improve hydrocarbon production

1 Uniform licensing

India is now among the few countries that allow conventional and unconventional activity with a single license. **Company free to explore all avenues for production**

2 Pricing and marketing freedom

Implementation of marketing and pricing freedom, in line with changes earlier introduced for deepwater and HPHT[1] fields, **will reinvigorate the ailing upstream natural gas industry**.

3 Successful Bidding for DSF Round

The recently concluded Discovered Small Fields bid round was a success and drew >140 bids for 34 contract areas. These are expected to produce >50,000 bpd of Crude Oil & 25,500 boepd of Natural Gas over the next 15 years

4 Open acreage licensing (OALP)

Companies can directly approach the government to prospect currently unlicensed territory. This **eliminates the need to wait for bid rounds**, and is expected to generate interest in prospecting activities in available areas and drive exploration.

5 Resource sharing model

The newly introduced Hydrocarbon Exploration & Licensing Policy (HELP) has, amongst other initiatives, installed **a revenue sharing model** in place of the production sharing system of the past. This will **curtail cost recovery disputes** of the past.

Government has announced its intention to develop a plan to leverage technologies to improve hydrocarbon output

Sources: Wood Mackenzie, news articles, Government announcements

Notes: 1. High Temperature, High Pressure

Engagement objectives

DGH intends to create an EOR/IOR policy for India

Objectives

Objectives

- Growth of domestic crude oil production to reduce import dependency (and enhance energy security)

Key scope elements

- Review of global policies for Enhanced Oil Recovery (EOR) and Improved Oil Recovery (IOR)
- Benchmark the leading practices for EOR/ IOR processes across the world
- Develop a policy framework for adoption of EOR/ IOR in India

Key questions

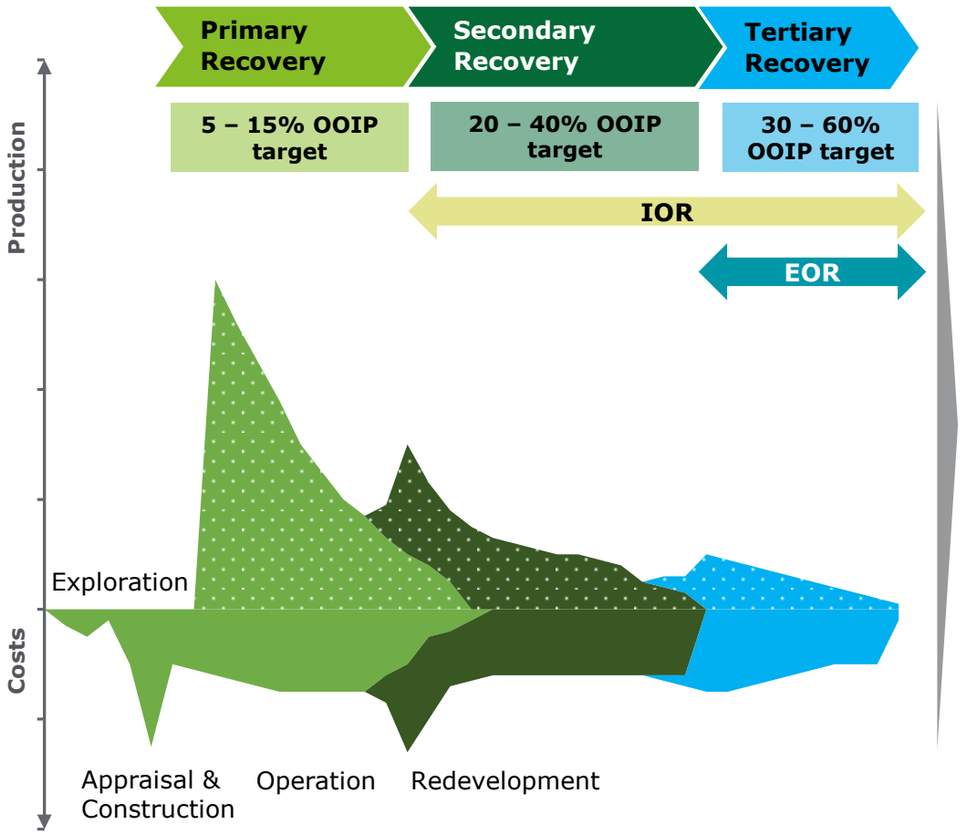
Understanding leading practices in adoption of EOR

- *Is a separate policy necessary to enhance production?*
- *Should the policy consider investment, operating cost or output?*
- *Should there be any differentiation based on technology being adopted?*
- *Should there be any differentiation based on type of reserves viz. onshore, offshore or based on size?*
- *How should fields be identified for EOR / IOR projects? Should there be an additional approval process?*
- *How can the administration of policy be made simpler?*
- *How will the policy impact the overall production trends?*

Enhancing recoveries

Secondary and tertiary recovery methods are important for extracting maximum value of a reservoir

Lifecycle of a petroleum reservoir



- **Primary Recovery**
  - Natural flow
  - Artificial Lift (Pumps etc.)
- **Secondary Recovery**
  - Water flooding
  - (Immiscible) Gas flooding
    - Gas injection
    - HC gas flooding
- **Tertiary Recovery**
  - Thermal Flooding
    - Cyclic steam (CSS)
    - Steam flooding
    - In-situ combustion
  - Chemical flooding
    - Polymer flooding
    - Alkali flooding
    - Surfactants
    - Alkali-Polymer (A+P) flooding
  - Miscible (gas) flooding
    - CO_2 flooding
    - N_2 flooding
    - HC flooding
  - Others
    - Simultaneous WAG[1]
    - Foam assisted WAG
    - Microbial

Improved Oil Recovery and Enhanced Oil Recovery are capital investments done to recover additional oil from the reservoirs

Sources: EIA

Notes: 1) Water alternating gas

Legend Technologies which have been primarily used in India

Global EOR

EOR contributes ~3% of world crude oil production; Investments into EOR compete against other non-conventional investments

	Extraction Cost (US$ / bbl)	Lead Time to Production (# Years)	Risk Profile	
Onshore Conventional	• MENA: ~5 to 18 • Russia: ~35 to 60 • RoW: ~24 to 60	3 – 5 years	• Exploration risk is ***medium-to-high*** • Technology is widely available	Conventional extraction has a weighted average cost of ~US$15/ bbl in MENA, ~US$51/ bbl in Russia, and ~US$44/ bbl in the Rest of the World
Offshore	• Shallow: ~15 to 43 • Deep: ~25 to 53	> 9 years	• Exploration risk is ***medium-to-high*** • Technology is available with experienced operators	Shallow water and deep-water projects have a weighed average cost of ~US$32/ bbl, ~US$38/ bbl respectively
Shale/ Tight Oil	• USA: ~28 to 58	< 1 year	• Exploration risk is ***Low,*** as shale-rich US basins are well-mapped • Technology is available with experienced operators	Extraction costs have declined sharply for USA Shale - from weighted averaged cost US$60-84/ bbl in 2014 to US$ 31-37 in 2016, leading to continued investments
Enhanced Oil Recovery (EOR)	• CO2 EOR: ~20 to 70 • Other EORs: ~30 to 80	5 – 8 years	• Exploration risk is ***Low*** as EOR is implemented on existing wells • Technology is evolving and available with experienced operators	Economic returns limited as projects have an higher ongoing operating expenditure and also the volumes upside is lower

In a low oil price environment, Capital follows options based on economic potential

Sources: IEA, Wood Mackenzie, Rystad, Columbia Energy Institute, Oil and Gas Journal, News Articles

Petroleum regimes across the world and potential EOR incentives

Major regimes are concessions, product sharing contracts and service contracts

Regime

Factors for consideration

	Concessions		Production sharing contract		
	Concessions – Royalty and tax regime	Concessions – Pure tax regime	Royalty and Production sharing contract regime	Pure Production Sharing Contract regime	Service Contracts regime
Risk Sharing	Oil company takes all the risk. Payments to have to pay royalty and tax. Taxes could be both Income tax and/or special oil tax.	Oil company takes all the risk. Taxes could be both Income tax and/or special oil tax	Oil company takes exploration risk. Oil company and government share risk of development and production costs. Risk higher as royalty is also paid	Oil company takes exploration risk. Oil company and government share risk of development and production costs	Government takes complete risk as oil companies get full compensation of costs and guaranteed margins. No upside available to Operators.
Example countries[1]	US, Colombia	UK, Norway	India[2], Angola	Indonesia, Egypt, Malaysia[3]	Iran, Philippines
Potential EoR / IoR Incentive Mechanisms	Reduces royalty and /or tax rates	Reduce tax rate	Reduce royalty rates, allow capital cost recovery for EOR investments	Allow capital cost recovery for EOR investments	Government decides if EOR to be undertaken. Offer additional compensation

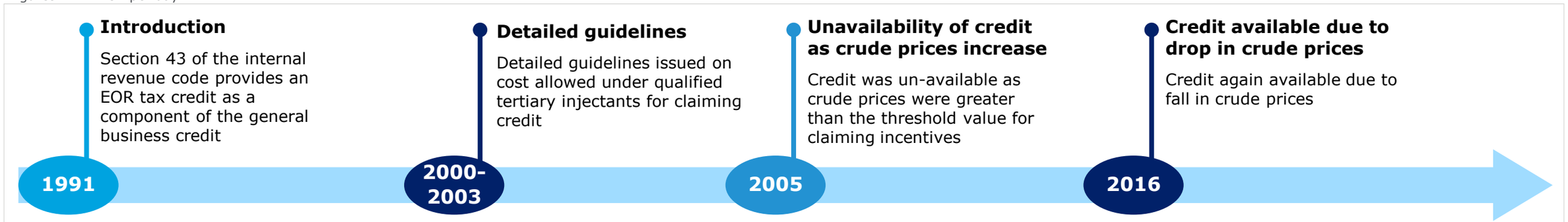
Notes: 1) Some of the other countries have a mix and match of these regimes; 2) India, along with royalty and production sharing contract, recently introduced revenue sharing contract regime; 3) Malaysia also has a service contract regime for marginal fields

Case study 1: USA

Market forces drive the concession based US market, which requires EOR to compete with unconventional sources

Total oil demand	Total oil production	Unconventional oil production	Primary contract type
15.8	13.9	4.9	Concession with Royalty Payments

Figures in MMBOE per day



- *The US EOR production has declined from 0.76 to 0.72 Mn BBL during the period 1992 – 2014. Number of active projects have also declined from 273 to 218 during the same period.*
- *Tax credit linked to crude oil prices made the policy unavailable for almost 10 years from 2005 to 2015*

Incentive mechanism	Incentive process	Investor/Stakeholder views	Latest developments	Pros	Cons
• Federal credit at 15% of qualified EOR cost and state specific tax exemptions/ concessions are available. • Incentives are available if commodity price as notified by IRS for the year is below a defined threshold. This threshold is adjusted annually for inflation. • Credits earned may be carried back (1 year) or carried forward (20 years). • The qualifying project has to be completed within defined period, use specified recovery technology and meet well output restrictions	• EOR to commence after December 1990 • Applicable to both oil and gas fields • A qualified engineer is required to certify eligibility of a project, technology used and eligible production to claim benefits	• The scheme is viewed by O&G companies as a valuable scheme in the current low price environment to manage their tax burden and improve cash flow. • However following concerns are raised ▪ No differentiation between onshore & offshore fields ▪ Only specific technologies are covered	• Carbon dioxide (CO2) enhanced oil recovery (EOR) has received increased attention and US has laid large infrastructure to support transport of CO2 from source to fields	• Cost based incentive based on audited numbers • Simple to administer • Applicability notified by IRS leaving little scope for disputes • No delays in incentive realization	• Only specified technologies allowed for EOR • No differentiation for onshore/ offshore

Case study 2: Alberta, Canada

Alberta in the recent policy has allowed enhanced recovery incentives for all hydrocarbons, thus EOR would need to compete with enhanced recovery measures for other hydrocarbons

Total oil demand	Total oil production	Unconventional oil production	Primary contract type
1.87	4.05	2.47	Concession with Royalty Payments

Figures in MMBOE/day

2011 – Conduct study

Alberta Energy Regulator (AER) determined the Enhanced Oil Recovery potential in Alberta

2014 – Introduced policy

Government introduced the Enhanced Oil Recovery Program ("EORP") for **tertiary EOR techniques** with royalty rate **floored at 5%.** The policy was applicable to **Oil fields only**.`

2017 – Revised policy launched

Government replaced existing EORP with Enhanced Hydrocarbon Recovery Program which allowed even **secondary EOR technique** with royalty rate of **flat 5%.** The new program is applicable **for crude oil, natural gas, gas product or oil sand.**

The new policy has reduced royalty rate to flat 5% for EOR project whereas average royalty rate has been in the range of 15% to 20% for oil.

Incentive mechanism

- Alberta Government provides royalty rate reduction to incentivize EOR
- The term is predetermined and dependent on the percentage of incremental crude oil recoverable from pool through tertiary methods
- For secondary EOR techniques, the term is determined on case to case basis

Incentive process

- The new program is applicable for crude oil, natural gas, gas product or oil sand.
- Every applicant has to submit supporting technical and financial information along with expected additional production to claim the EOR incentives

Investor/ Stakeholder views

- Petroleum producers welcomed the policy as it recognized the higher risks and greater project costs of drilling and implementing secondary recovery schemes

Latest developments

- In 2017, to support oil production, the country also allowed incentives for secondary EOR techniques

Pros

- Secondary EOR techniques are also eligible for incentives
- Applicable to all fossil fuels

Cons

- Benefits like additional production has to be quantified with a field development report
- Case to case basis analysis requires a strong regulator
- Same incentive for all fields & techniques

Sources: Alberta Energy website, Park land institute, EIA, EIU

Case study 3: Malaysia

The Government is using the existing production sharing regime to promote EOR activities by signing EOR specific PSC with large companies

Total oil demand	Total oil production	Unconventional oil production	Primary contract type
0.69	0.72	NA	Production Sharing

Figures in MMBOE/day

2008 – PSC for EOR

Exxon and Petronas entered into a PSC for development of 7 Oil fields through EOR activities

2010 – Incentive scheme launched

Government rolls out incentive mechanism for promotion of EOR activities and is applicable even for existing fields

2011 – PSCs signed for 2 large projects

Shell & Petronas enter into two 30 years PSC Contracts for Chemical EOR projects – Sabah and Baram Delta fields. Expected increase in recovery factor from 36% to 50%

2014 – PSC expanded to include gas

Commencement of operations from the Exxon-Petronas Tapis EOR project

Expanded BaramDelta PSC with Shell to include Natural gas production

2016 – Large # projects undertaken

24 IOR / EOR / IGR production enhancements projects under way

Production Sharing Model with project specific approval allowance has no bearing on crude prices and recovered for the life for the project

As per Petronas estimate 1 billion barrel plus of oil from 14 fields have been identified for EOR projects

Incentive mechanism

- Investment allowance equal to 60% of the capital expenditure to be deducted against statutory income.
- Maximum 70% of statutory income can be deducted in a year
- Investment Allowance can be recovered during the life of the project until it has been fully recovered

Incentive process

- EOR applicable for tertiary methods
- The incentive provided is technology agnostic and the same for all the tertiary methods
- Separate PSCs are signed for EOR projects

Investor/Stakeholder views

- "EOR activities could boost oil production from Tapis by up to 35,000 barrels per day (bpd) from the present 3,000 to 4,000 bpd, increase the economic value of the field by more than 25 years" Director – Petronas
- "Malaysian Government has given tax incentives to encourage more EOR projects and PETRONAS has provided a lot of facilitation for PS contractors and new PSC arrangements to make it attractive" - Head of Technology – Petronas

Latest developments

- Tapis field has become the largest South East Asia's largest EOR project
- Petronas has become the largest operator of EOR techniques in offshore fields

Pros

- Capital expenditure based incentive de-risking operators
- PSC signed considers actual field conditions on case to case basis

Cons

- Needs a strong regulator to appreciate EOR techniques being used and accordingly modify PSC
- Largely off-shore fields which makes EOR costly and difficult

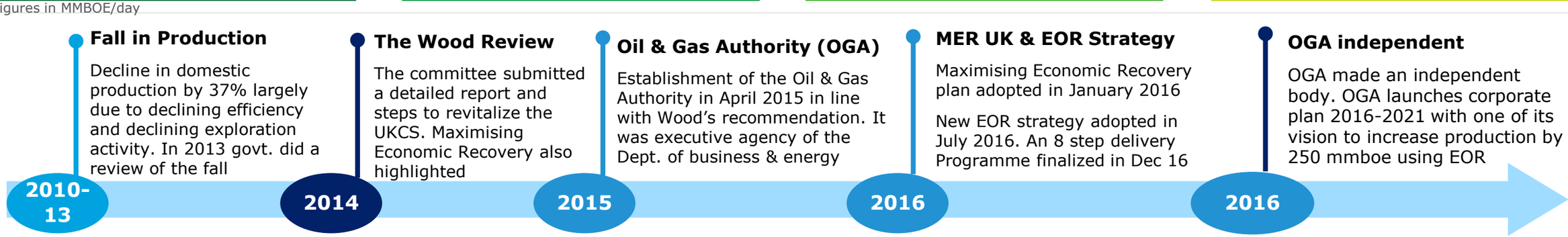
Sources: Petronas; Shell; Exxon Mobil; Newspaper articles; Petroleum Regulations 2013; Oil and Gas Overview by Malaysia International Chamber of Commerce and Industry; EIA, EIU

Case study 4: UK

With most large fields reaching maturity and not much large discoveries happening the Government has created a detailed plan to increase the recovery from the existing fields

Total oil demand	Total oil production	Unconventional oil production	Primary contract type
1.6	1.01	NA	Concession – Pure tax regime

Figures in MMBOE/day



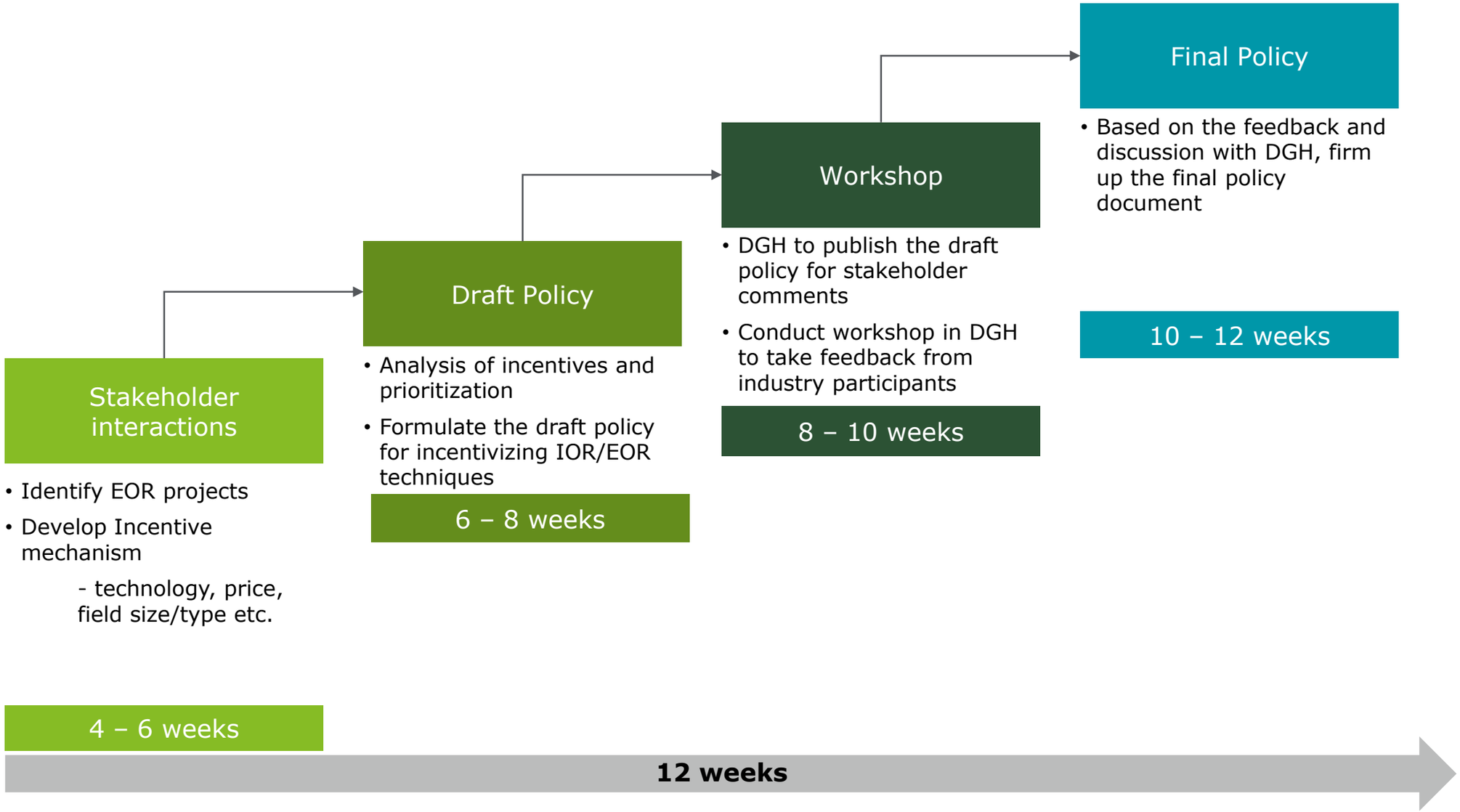
Currently no incentive to promote EOR activity; In Dec 2016 Govt. launched an 8 step process to increase EOR production which is under implementation.

Incentive mechanism	Incentive process	Investor/Stakeholder views	Latest developments	Pros	Cons
• Currently no incentive mechanism which has been defined by the Govt. • By Q4 2017, as part of the 8 step program OGA plans to outline a business case for EOR activities in the UKCS.	• To be decided once the incentive processes are finalized	• "Companies stated that not only is EOR prohibitively expensive to provide an economically viable solution in the UKCS but there is also no supply chain to offer these techniques at competitive price. Thus, organizations call for fiscal incentives targeted at encouraging companies to take up and develop technologies pertinent to EOR to meet MER UK plans" - Summary of interview of various oil & gas executives	• Captain polymer EOR project to start production by Q3 2017 • Clair ridge low sanity EOR scheme start-up by Q3 2017	• Strong collaboration between the industry, operators and oil & gas authority • An 8 step plan clearly charted out with defined timelines	• Slow progress of recommendations of the Wood committee • Lack of fiscal incentives to promote areas like EOR

Sources: Oil & Gas Authority; newspaper articles; BP energy outlook 2017

Way Forward

Formulate the policy based on study and feedback from the stakeholders



DGH would be engaging with all relevant stakeholders to develop a policy that would lead to increase in production

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