Life Cycle of Oil/Gas Projects

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Course Name & Code: Introduction to Petroleum Engineering I (PTR 217)

3rd Semester (2nd Grade Fall Semester)

Week #2/Lecture #2

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Previous Lecture

- What is Petroleum?
- Petroleum System Elements
- What is Petroleum Engineering?
- What is Oil and Gas Supply Chain?
- Offshore and Onshore
- Petroleum Engineering Career Paths.

Content

- Resources and Reserves
- Petroleum Field/Reservoir Lifecycle

1. Exploration and Discovery
2. Appraisal and Delineation
3. Development
4. Production
5. Abandonment

Lecture Learning Outcomes

By the end of this lecture, you will be able to:

- Identify the concept of Resources and Reserves.
- List and comprehend the petroleum reservoir life cycle stages from exploration up to abandonment.

Resources and Reserves

Resources:

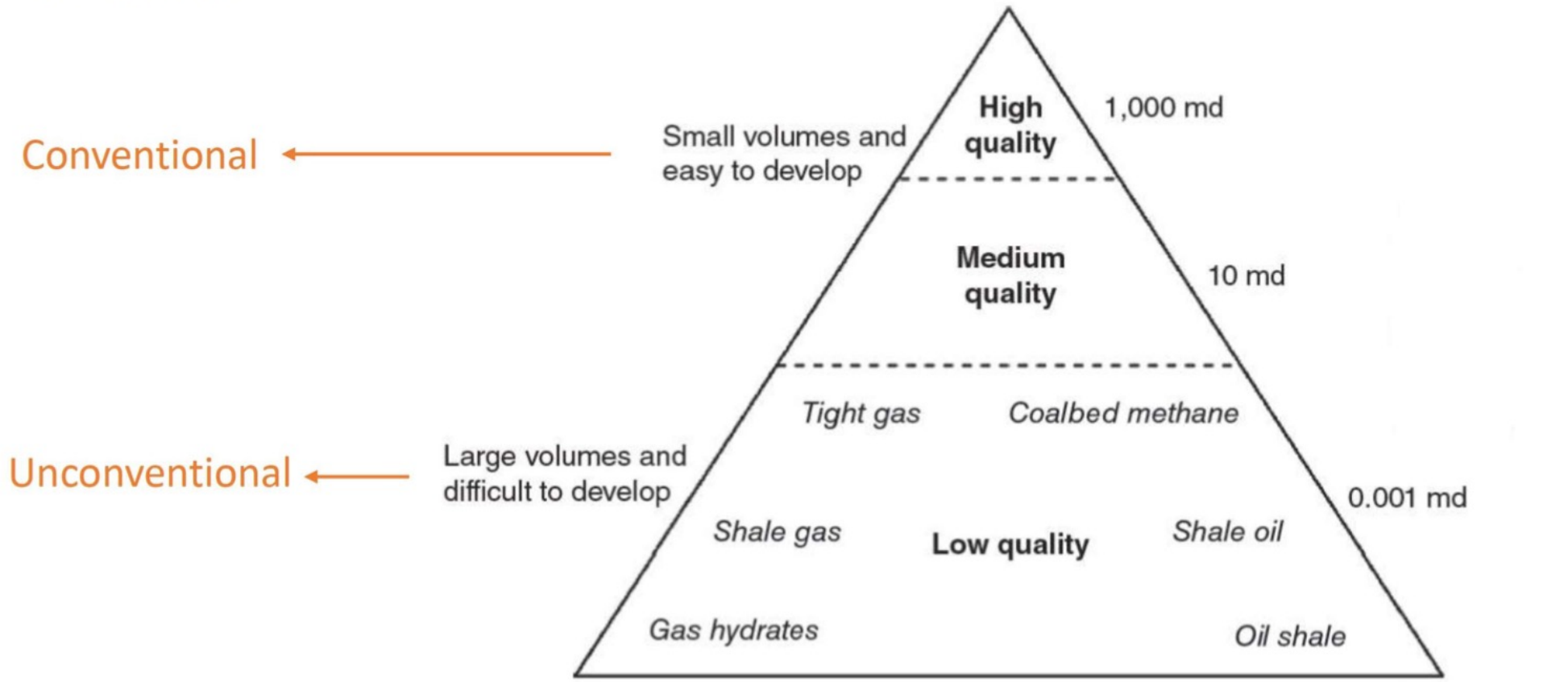
- Oil and gas resources may be characterized as conventional and unconventional resources:

➢ **Conventional** oil and Gas resources refer to formations that can be produced at economic flow rates or that produce economic volumes of oil and gas without stimulation treatments or special recovery processes and technologies.

➢ **Unconventional** oil and gas resources refer to formations that cannot be produced at economic flow rates or do not produce economic voulmes of oil and gas without stimulation treatments or special recovery processes and technologies.

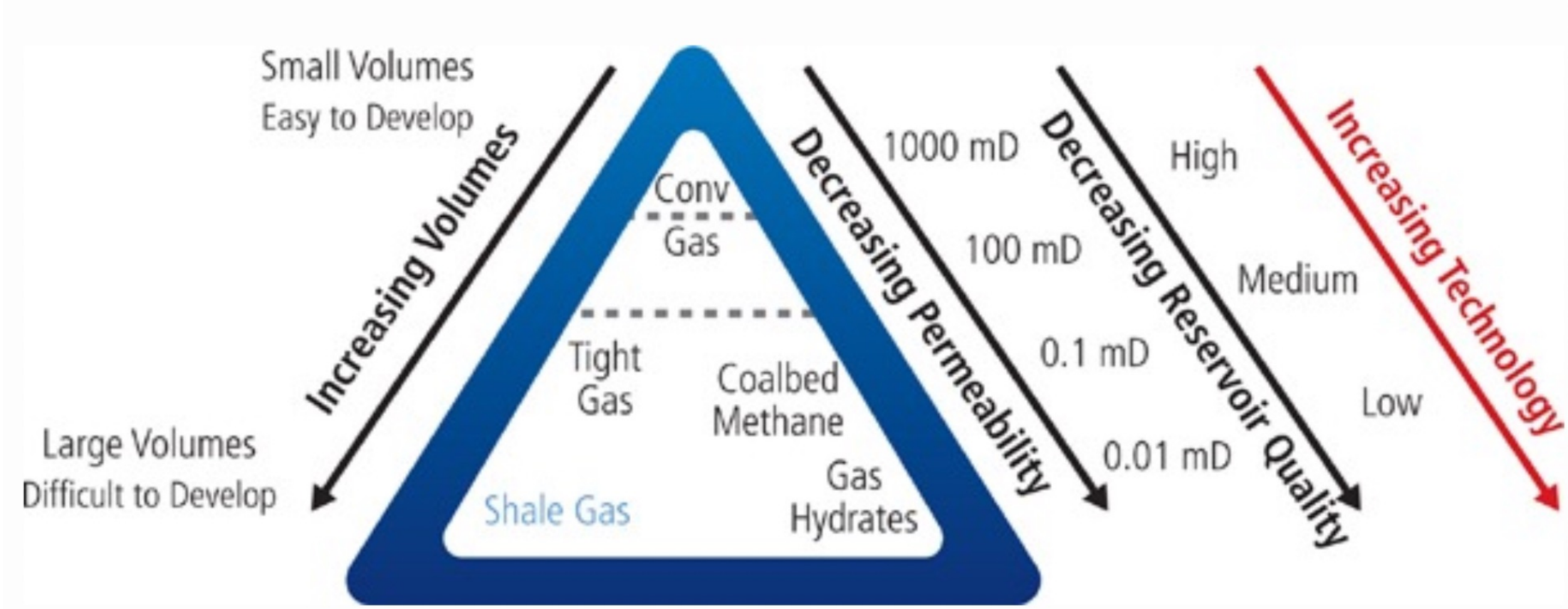
Resources and Reserves

Resources:



Resource triangle (modified from Holditch & Ayers, 2009; Masters, 1979; Gray, 1977).

Resources and Reserves



The Unconventional Resource Triangle: The concept of the resource triangle applies to every hydrocarbon-producing basin in the world. (Holditch 2006 after Masters 1979 and Gray 1977.)

Reserves:

- **Reserves** are defined as those quantities of petroleum which are anticipated to be commercially recovered from known accumations from a given date forward.

- Reserves can be classified as:

1. **Proved Reserves:** Those quantities of petroleum which by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially recoverable, from a given date forward, from known resevoirs, and under defined economic conditions, operating methods and government regulations.

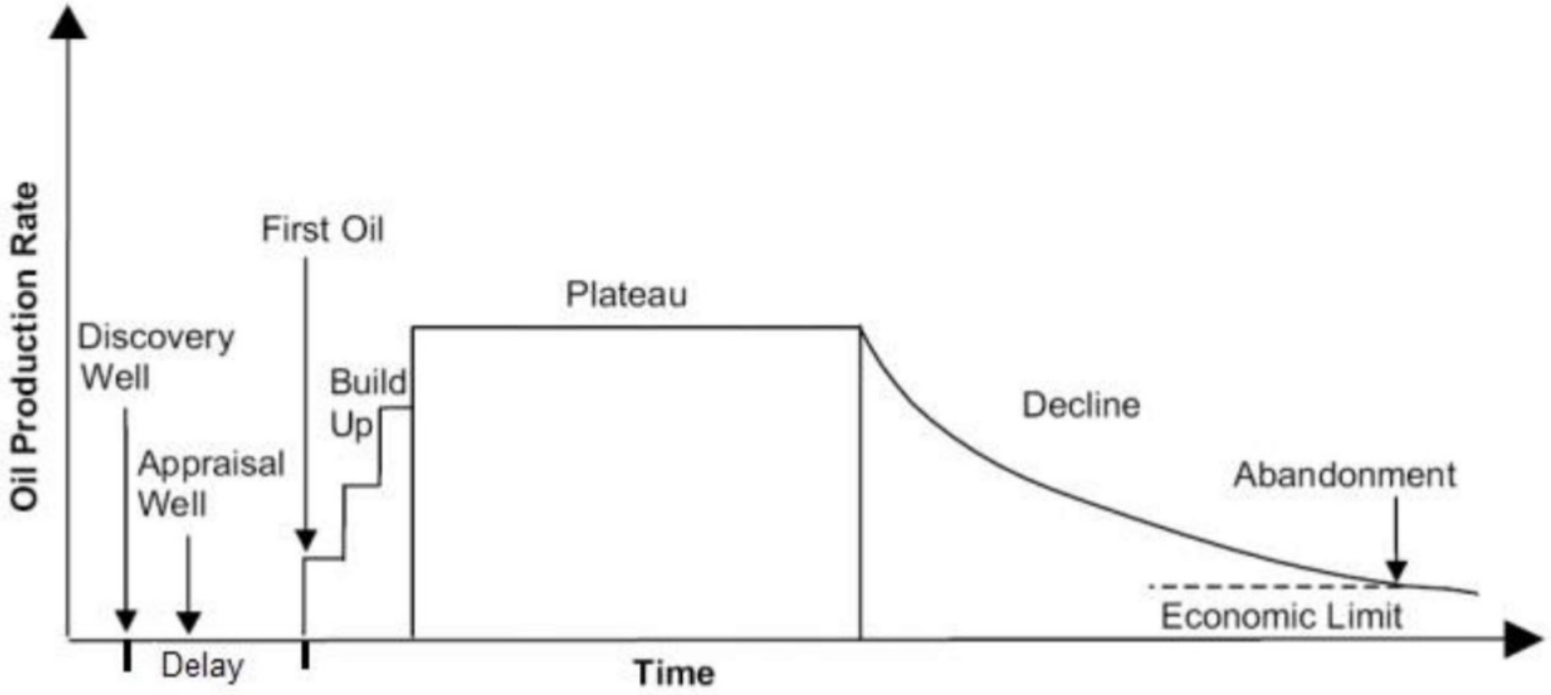
Resources and Reserves:

2. Probable Reserves: Those additional reserves which analysis of geoscience and engineering data indicate are less likely to be recovered than proved reserves but more certain to be recevered than possible reserves.

3. Possible Reserves: Those additional reserves which analysis of geoscience and engineering data suggest are less likely to be recoverable than probable reserves.

Petroleum Reservoir Lifecycle

This figure illustrates a typical production profile for an oil field beginning with the discovery well and proceeding to abandonment. Production can begin immediately after the discovery well is drilled or several years later after appraisal and delineation wells have been drilled.



Theoretical production profile of an oilfield, describing various stages of development in an idealized case (Höök, M. *et al.*, 2009)

Petroleum Reservoir Lifecycle

Appraisal wells are used to provide more information about reservoir properties and fluid flow.
Delineation wells better define reservoir boundaries. In some cases, delineation wells are converted to development wells.
Development wells are drilled in the known extent of the field and are used to optimize resource recovery.
A **build-up period** ensues after first oil until a production plateau is reached. The production plateau is usually a consequence of facility limitations such as pipeline capacity.
A production decline will eventually occur. Production continues until an economic limit is reached and the field is abandoned.

Petroleum Reservoir Lifecycle

The five distinct phases in reservoir lifecycle are:

1. Exploration and Discovery
2. Appraisal and Delineation
3. Development
4. Production
5. Abdandonment

Petroleum Reservoir Lifecycle

1. **Exploration and Discovery:**

❖ Begins when resources are allocated to identify and assess a prospect for possible development. This stage requires the acquisition and analysis of more data before an exploration well is drilled.

❖ Exploratory wells are also referred to as wildcats. They can be used to:

- To test a trap that has never produced
- To test a new reservoir in a known field.
- To extend the known limits of a producing reservoir

❖ Discovery occurs when an exploration well is drilled and hydrocarbons are encountered.

Petroleum Reservoir Lifecycle

2. Appraisal and Delineation:

- One or more appraisal wells are drilled to evaluate the reservoir size and quality.
- In this phase, wells are drilled to identify the extent of the reservoir.
- Delineation wells are originally drilled to define the size of the reservoir, but they can also be used for production or injection later in the life of the reservoir

Petroleum Reservoir Lifecycle

3. Development:

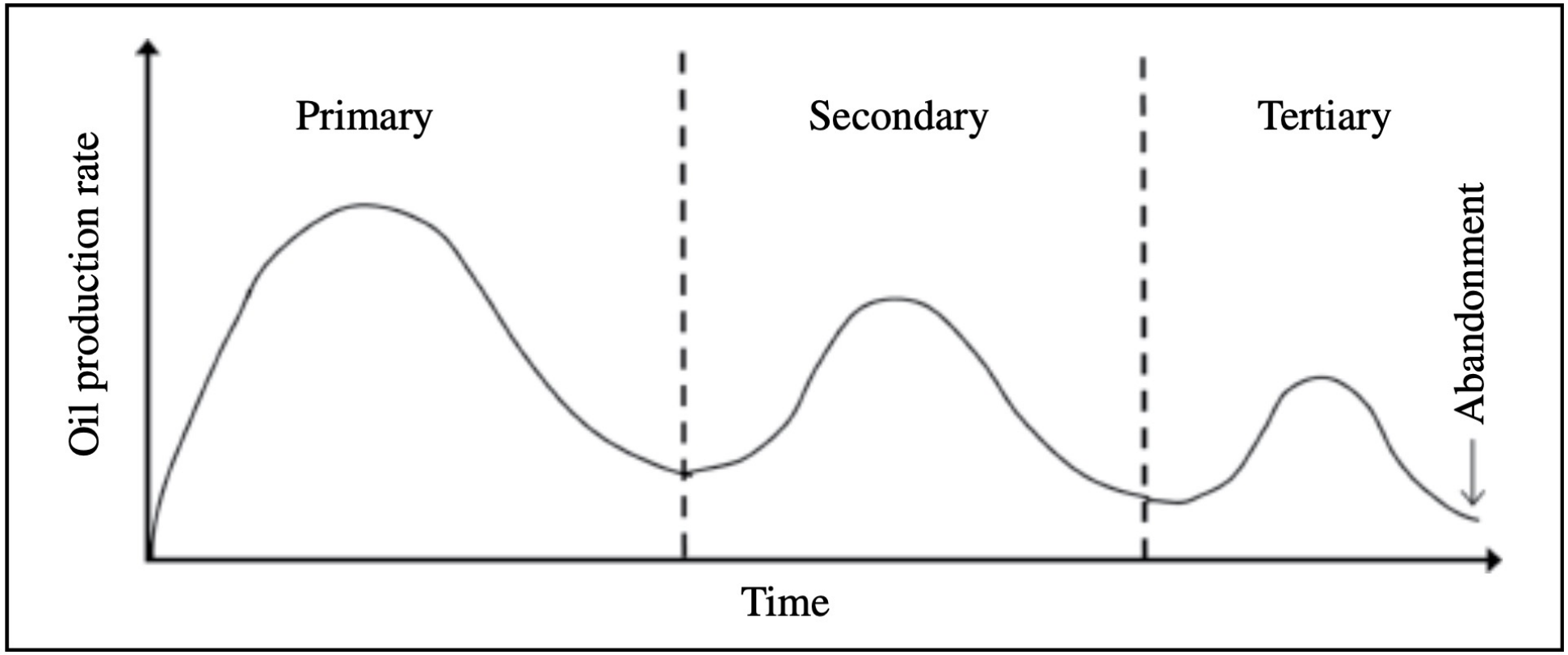
- Appraisal of reservoirs is followed by development.
- During this phase, oil and gas wells are drilled to produce the reservoir optimally.
- The location, placement, and design of wells are decided by conducting reservoir simulation studies and reviewing from what-if scenarios.

Petroleum Reservoir Lifecycle

4. Production:

- The production phase of the reservoir brings the fuits of the efforts of all earlier phases.
- The reservoir is initially produced by primary drive mechanisms. The primary drive to produce oil and gas is based on the natural energy stored in the reservoir.
- Secondary recovery efforts are mostly centered on waterflood operations or gas injection, or both.
- Once secondary recovery operations are not sufficient, EOR effort are initiated to recover further amounts of oil.

Petroleum Reservoir Lifecycle



Sketch of production stages (Fanchi, J.R. and Christiansen, R.L., 2016.)

Petroleum Reservoir Lifecycle

- **Primary Production** is the first stage of production and relies entirely on natural energy sources to drive reservoir fluids to the production well. The reduction of pressure during primary production is often referred to as *primary depletion*.

- Oil recovery can be increased in many cases by showing the decline in pressure. This can be achieved by supplementing natural energy. The injection of water or natural gas may be referred to as *pressure maintenance* or **secondary recovery**.

- **Enhanced Oil Recovery (EOR)** processes include chemical, thermal, and microbial processes. EOR processes are originally implemented as a third, or *tertiary production* stage that followed secondary production.

Petroleum Reservoir Lifecycle

5. Abandonment:

A reservoir approaches the final phase, abandonment, when the declining production or certain operational issues lead to a production level that is no longer economical.

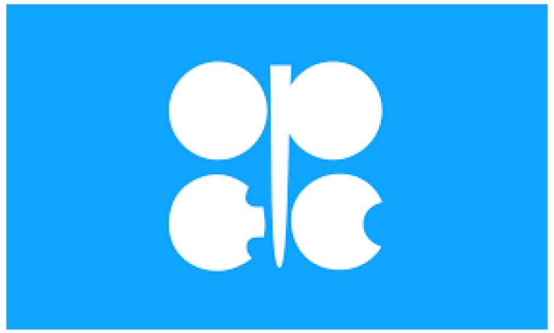
The most common causes of abandonment are:

I. Declining well rate
II. Excessive water production
III. High gas-oil ratio
IV. Frequent workover of wells, which are cost intensive.

Petroleum Reservoir Lifecycle

OPEC

The **O**rganization of the **P**etroleum **E**xporting **C**ountries **(OPEC)** is an intergovernmental organization of 14 nations, founded in 1960 in Baghdad by the first five members (Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela), and headquartered in Vienna, Austria since 1965.



OPEC

Country	Region	Membership years[2][3]	Population (2018 est.)[123][124]	Area (km^2)[125]	Oil production (bbl/day, 2016)[A][120]	Proven reserves (bbl, 2016)[A][126]
Algeria	North Africa	1969–	42,228,408	2,381,740	1,348,361	12,200,000,000
Angola	Southern Africa	2007–	30,809,787	1,246,700	1,769,615	8,423,000,000
Equatorial Guinea	Central Africa	2017–	1,308,975	28,050	...	...
Gabon	Central Africa	1975–1995, 2016–	2,119,275	267,667	210,820	2,000,000,000
Iran	Middle East	1960[B]–	81,800,188	1,648,000	3,990,956	157,530,000,000
Iraq	Middle East	1960[B]–	38,433,600	437,072	4,451,516	143,069,000,000
Kuwait	Middle East	1960[B]–	4,137,312	17,820	2,923,825	101,500,000,000
Libya	North Africa	1962–	6,678,559	1,759,540	384,686	48,363,000,000
Nigeria	West Africa	1971–	195,874,685	923,768	1,999,885	37,070,000,000
Republic of the Congo	Central Africa	2018[127]–	5,125,821	342,000	260,000	1,600,000,000
Saudi Arabia	Middle East	1960[B]–	33,702,756	2,149,690	10,460,710	266,578,000,000
United Arab Emirates	Middle East	1967[C]–	9,630,959	83,600	3,106,077	97,800,000,000
Venezuela	South America	1960[B]–	28,887,118	912,050	2,276,967	299,953,000,000
OPEC total			**483,630,000**	**12,492,695**	**35,481,740**	**1,210,703,000,000**
World total			**7,903,809,000**	**510,072,000**	**80,622,287**[128]	**1,650,585,000,000**
OPEC percent			**6.3%**	**2.4%**	**44%**	**73%**

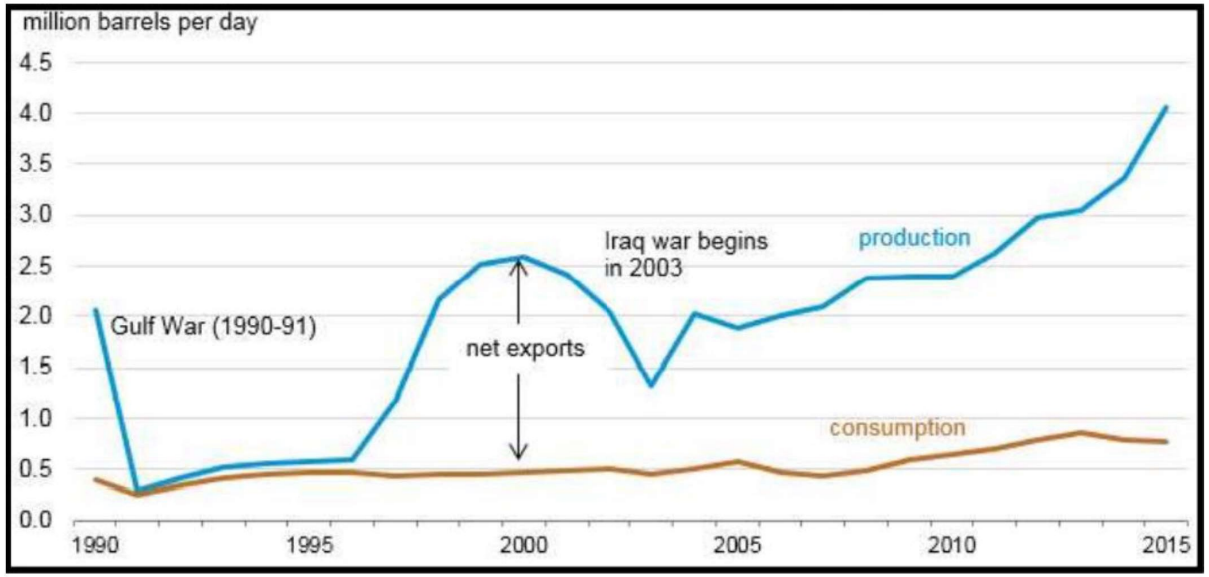
Oil Consumption by Countries

Rank	Country/Region	Oil consumption (bbl/day)	Year
-	World (incl biofuels)	100,100,000[4]	2019
1	United States	19,400,000	2019
-	European Union	15,000,000[5]	2017
2	China	14,225,000	2020
-	ASEAN	6,226,000	2019
3	India	5,271,000	2019
4	Japan	3,812,000	2019
5	Saudi Arabia	3,788,000	2019
6	Russia	3,317,000	2019
7	South Korea	2,760,000	2019
8	Canada	2,403,000	2019
9	Brazil	2,398,000	2019
10	Germany	2,281,000	2019

Oil Consumption Iraq

11	Iran	2,018,000	2019
12	Mexico	1,733,000	2019
13	Indonesia	1,628,000	2015
14	France	1,530,000	2019
15	Thailand	1,344,100	2015
16	Singapore	1,339,000	2015
17	Italy	1,262,000	2015
18	Spain	1,226,000	2015
19	United Kingdom	1,118,000	2019
20	Australia	1,046,000	2019
21	United Arab Emirates	1,042,000	2019
22	Taiwan	1,031,100	2015
23	Netherlands	835,000	2015
24	Turkey	835,000	2015
25	Malaysia	831,000	2015
26	Egypt	743,000	2019
27	Iraq	716,000	2019
28	Belgium	683,000	2019
29	Poland	670,000	2019
30	Argentina	599,000	2019

Oil Consumption & Production-Iraq



Next Lecture

Next week on Thursday October 19th, 2022 at 12:00, in class L.104, we will have the following topics:

- Hydrocarbon Exploration
- Geophysics
- What is Geophysical Exploration?
- Geophysical Methods
- Seismic Geophysical Surveys