



**MINISTRY OF ENERGY AND ENERGY INDUSTRIES  
REPUBLIC OF TRINIDAD AND TOBAGO**

**GUIDELINES TO OPERATORS FOR THE APPROVAL OF A  
WATERFLOOD AND WATER ALTERNATING GAS (WAG) PROJECTS  
BY THE RESOURCE MANAGEMENT DIVISION**

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**GOVERNMENT OF THE REPUBLIC OF TRINIDAD AND TOBAGO**  
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## **1. Introduction**

This guidance document is a subset of the legal framework governing the approval of a waterflood project both onshore and offshore by the Resource Management Division of the Ministry of Energy and Energy Industries (MEEI).

Waterflooding is a type of Improved Oil Recovery (IOR) method. It can be implemented to boost oil production in Trinidad and Tobago's mature fields after the primary production phase. Therefore, it is important that the MEEI plays its part in assisting and encouraging operators to carry out waterflooding projects. In saying this, it is imperative that the MEEI be kept abreast with the actions of the operators to ensure that the projects are successful and beneficial to all parties.

## **2. Objectives**

Before granting approval for a waterflood project, the MEEI must be provided with relevant documentation to demonstrate that the operator has:

- i. a suitable rationale for the waterflood project
- ii. the required facilities and infrastructure,
- iii. technical knowledge
- iv. financial support
- v. adequate environmental protection considerations in place.

## **3. Authority**

These Guidelines are established pursuant to the authority prescribed in the Petroleum Act Chapter 62:01 of 1969 and in the Petroleum Regulations 1970 and specifically with reference to Clause 43 (h) of the Act, which states: "*the licensee shall exert his utmost efforts to develop any discovered fields to the maximum extent consistent with good petroleum industry practice and in particular observe sound technical and engineering principles regulating the conservation of the deposits of hydrocarbons, in preventing damage to adjoining petroleum bearing strata, in controlling the flow, in preventing the escape or waste of petroleum discovered, in preventing the entrance of fluids through wells into petroleum bearing strata except in **approved fluid injection operations** and in protecting water bearing strata encountered in the course of drilling;*".

#### **4. Applicability**

Waterflood is a method of secondary recovery in which water is injected into the reservoir formation to displace residual oil. The water from injection wells physically sweeps the displaced oil to adjacent production wells (Schlumberger Oilfield Glossary). It usually occurs after the economic limit of primary production has been reached.

Water alternating gas (WAG) injection is a process whereby water injection and gas injection are carried out alternately for periods of time to provide better sweep efficiency and reduce gas channelling from injector to producer.

This guidance document applies to any waterflood injection and water alternating gas project.

#### **5. Guidelines to operators on the approval process for waterflood projects by the Resource Management Division**

There are 2 phases of guidelines which are to be followed: Pre-approval phase and Post approval phase.

##### **Pre- Approval Phase**

- 1) Company / Operator who is interested in conducting a waterflood should present a Waterflood Project Presentation in a meeting to MEEI officials. Subsequently, company / operators should officially submit a Waterflood Study Proposal to MEEI in the form of two (2) hard copies and one (1) soft copy. This Study Proposal should be submitted at least 3 months prior to desired project approval date. During this period, a project site visit is required.
- 2) The Waterflood Study Proposal should include but is not limited to:

##### **Project Background and Description**

- Project scope, project phases and objectives.
- State the anticipated oil production increase and incremental recovery by well.
- State type of injection pattern for example line drive, 5-spot, inverted 5-spot, etc.
- List active and inactive wells in waterflood project
- Identify and map water floodable reservoirs showing the area / field of the waterflood zone.
- State sands / reservoirs / formation for waterflood study and state reason for choosing these.

## **Reservoir Description**

- Provide geologic and stratigraphic description of reservoir.
- Provide well correlation over the project area. Include digital LAS files for correlated wells.
- Show georeferenced net pay, net sand and structure maps of the formation of interest with project boundaries, faults, lease or licence boundaries highlighted. Supply any reservoir simulation model of the area of interest (Petrel RE, CMG, etc).
- Show a georeferenced base/ surface map for the project area highlighting the location of proposed:
  - conversion injectors
  - new drill injectors
  - existing producers
  - new drill producers
  - observation wells.
- Give reservoir parameters and fluid properties of the project study area. (i.e porosity, permeability, saturations, bulk rock volume, current bottomhole pressure, Original Oil In Place (OOIP), Gas to Oil ratio (GOR), mobility ratio, API gravity, specific gravity etc.). Identify for each parameter/property its source as well as the date it was measured or calculated.
- Provide historical production data and cumulative production. Provide written narrative on production history.
- State sweep efficiency.
- State Primary Production Mechanism.

## **Water Injection and Production Parameters/Criteria**

- Identify the injection water source and state type of water that would be used for injection.
- State volume of water required to carry out waterflood and state whether company / operator has adequate supply of water to carry out waterflood. State also, volume of water required per day to carry out waterflood activities. State how the volume of water and production rates would be determined.
- State the depth to which the water would be injected.
- State well spacing and depth of all wells being used in the waterflood.
- Provide a listing of producer well names, injector well names and observation well names.
- Provide complete wellbore diagrams for all injector and producer wells
- State what parameters would be recorded from observation wells.

- Provide coordinates of all injectors, producers and observation wells under the waterflood study. For onshore wells these should be in Naparima 1955 datum and for offshore wells these should be in WGS1984 datum.
- Provide Injectivity test results.
- State voidage of target area and fill up time and show calculation inputs and processes.
- State the amount of water production from the field both historically as well as a forecasted value for the project.
- State what would be done with the produced water and how the Company / operator intends to dispose of it.
- Show that the injection water is compatible with the reservoir / receiving formation. The operator / company shall inform MEEI of plans for treatment in any instance where the produced water to be injected is sourced from a different formation. State how the compatibility of injection water with the reservoir was determined. Show what compatibility tests would be carried out, as well as the water compatibility test results.
- State the plans for water treatment.

### **Surface Equipment**

- Show schematic of surface equipment for example: water treatment equipment, well pads, well heads, drilling/workover rigs, rod pumps, injection pumps, compressors, pressure gauges, valves, water supply trucks, water supply tanks, battery tanks, gathering stations, pipelines, roads, fencing, gas detecting equipment and workman sheds.
- State condition of all equipment / materials being used and provide details on the status and condition of the injection stations.
- Ensure that all storage tanks are up to international standard.
- Provide operational parameters for example: total pump flow rate, maximum allowable operating pressure for pump/compressor, normal operating pressure for pump/compressor, fluid temperature etc.

### **Drilling and Production considerations**

- State procedures involved in wellbore integrity testing and state integrity of wells being used in waterflood. Ensure that all injectors, producers and observation wells being used are in proper workable conditions.
- Show historical and planned workover work and status of wells involved in the waterflood. The operator / company should implement an inspection and maintenance program to ensure the internal and external integrity of all injection wells. This programme should include, but not be limited to, ensuring the absence

of leakage in the casing, tubing or packer of the injection wells. These records of such inspections and maintenance should be made available to MEEI upon request. Refer to the 'Disposal and Injection Well Technical Guidance' document.

- State intervals in wells that should be abandoned in accordance with Ministry of Energy and Energy Industries 'Procedures for the Plugging and Abandonment of Oil and Gas Wells' if any, to isolate sands under study from others to prevent any cross-flow of fluids if applicable.
- The company / operator should ensure that the injection pressure does not exceed the fracture pressure of the formation and state the method of determination of fracture pressure. The company / operator should monitor and record the injection pressure, injection depth and fracture pressure for each injection well which should be provided to MEEI.
- If the company / operator observes any significant changes in the relationship between injection pressure and injection flow rate, immediate measures should be taken to correct the problem and the company / operator should inform MEEI within 24 hours of detecting such change. Subsequently, a report should be submitted to MEEI within seven (7) days of detecting significant changes in the relationship between injection pressure and injection flow rate. The report should include:
  - The cause of change in the relationship between the injection pressure and injection flow rate.
  - Measures implemented to correct the problem.
  - A statement of the time taken for the situation to return to normal.
  - A discussion of the environmental impacts likely to result from the change.

### **Environmental Considerations**

- State precautionary measures that will be used to ensure that the fresh water aquifers / water tables are not contaminated by either hydrocarbons or saline water. Ensure that there is no pollution to the environment or contamination of the aquifer, rivers, lakes, water wells and earth's surface.
- A georeferenced map showing the location of the surface water sources, aquifer systems and private or Water and Sewerage Authority (WASA) wells that are located in the specific area / block being considered for CO<sub>2</sub> injection. State the number and depth of WASA water wells in the area / block.
- The company / operator should apply for a Certificate of Environmental Clearance (CEC) from the Environmental Management Authority (EMA). A copy of the Certificate of Environmental Clearance (CEC) should be provided to MEEI. Otherwise, it should be provided after Resource Management approval, which will be conditional upon CEC delivery.

- Give proof that the environment would not be affected in a negative way while undertaking waterflood operations. Ensure that Corporate Social Responsibility is maintained for the environment. Precautionary measures should be met with relevant supporting documents to ensure that the operation of the proposed waterflood would be taken in a safe manner with minimal harm to the environment upon approval.

### **Project Economics and Timelines**

- Show project cash flow tables with inputs such as: operating expenditure, capital expenditure, discount rate, oil price assumption, royalties and taxes as well as determinants of profitability like: NPV, payout and IRR.
- State Peak Oil Rate, production decline rate and recovery.
- State risked forecasted incremental waterflood production for each block / area being injected into.
- State work activities for the waterflood or WAG and the timeframes for completion & procedures involved in conducting the waterflood or WAG.

### **Miscellaneous**

- Provide any contracts / agreements between licensee and sub-licensee if any.
- Provide any service contracts/ agreements between operator and service companies.
- State any concerns / risks and uncertainties that may affect the project.

### **Post Approval Phase**

#### **Waterflood Data Monitoring**

- Submission of Production and Injection data as well as quality of injection data.

#### **Quarterly Reports**

- Submission of quarterly reports that should contain:
  - Integrity of wells used
  - Pressure data and flow level test data from well observation
  - Production profiles for each sand
  - Condition of equipment/ materials used



## **Annual Report**

- Highlight performance of the project
- Major issues and key learnings of the project

## **Project Implementation Report**

- Implementation report must be based on:
  - Completion of injectivity test for all wells under study area
  - Major changes of any proposed producers, injectors and observation wells
  - Provide a Forward Drilling Plan if new wells are being drilled in the waterflood area.
  - CEC issues
  - Procedures used in the water filtration system
  - Status and condition of the injection stations and equipment used for the project

## **Monitoring Discussions and Site Visits**

- Routine site visits and/or meetings with Ministry of Energy and Energy Industries officials as necessary.
- Recommendations should be made throughout the life of the project depending on economic factors, environmental concerns incremental oil etc.

## **6. References**

- i. Petrowiki. (2018, January 15). *Waterflooding*. Retrieved from Petrowiki: <https://petrowiki.org/Waterflooding>
- ii. Schlumberger Oilfield Glossary Definitions for *Water Alternating Gas, Waterflood* <https://www.glossary.oilfield.slb.com/>

## 7. Queries

Queries on this guidance document can be forwarded to Christian Welsh, Senior Petroleum Engineer (Ag), Resource Management Division of the Ministry of Energy and Energy Industries.

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