Produced Water Management & Treatment

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Outline

- Introduction
- Produced Water Treatment
- Produced Water Management
- Greening the Desert Initiative at Petroleum Development Oman
- Outcome of Desktop Study on Potential
- What are the Produced Water Management challenges?
Produced Water (PW) Definition

- Water trapped in reservoir (or below Oil zone) and brought to surface along with oil & gas production
- It usually contains oil (dispersed & dissolved), metals, (heavy metals), NORM, Salt, Chemical additives used during drilling, Suspended Solids….etc
- Quantities of Produced Water increase as Oil producing field matures
- Treatment of produced water is a major cost component of Oil production
Oil Production Growth

Oil, Condensate & Gas Production

Excludes Associated Gas Production
Oil Water Production Forecast

Wells in 1994: 2340
Wells in 2011: 5088
Wells in 2020: ~7700

Water & Oil Production (kb/d)

Water in the GCC...Towards Efficient Management
Worldwide Quantities of PW

- In the US, average water-to-oil ratio is 10 (2010)*

- Kuwait Oil Company produces 500,000 bbl/day of water Compared to 2.5 million bbl of oil

- ARAMCO produces approximately 5 Mbbl/day in comparison to 12 million bbl of Oil

- Oman (PDO) produces 5 Mbbl/day of water versus 550,000 bbl/day Oil
Oman: Largest Produced Water Quantities in Shell

The highest water producer within Shell is Oman (PDO).

Water in the GCC...Towards Efficient Management
Oman Highest Water Producer

- Oman Oil fields reached maturity
- Oman has started exploring and implementing new technologies to extract difficult Oil
- Produced Water treatment and management are the major challenges in Enhanced Oil Recovery
  - Polymer Injection
  - Steam Injection
- Oman with all their experience and challenges faced, is an excellent candidate for Center of Excellence on Produced Water treatment & management
Fate of Produced Water (Petroleum Development Oman)

- One bbl of oil => 10 bbl produced water
  - 4.5 bbl Water Injection, Enhanced Oil Recovery to produce more Oil
  - 5.5 bbl Deep Water Disposal, Energy Intensive Operation up to 3 km deep into ground at 120-170 bar pressure - wasted energy & resource

- Nimr Water Treatment Plant (Reed Beds) is handling~100,000m3/d

- Alternatives are investigated for efficient utilisation of produced water - Aquifer Recharge, Bio-saline Agriculture, Trans-Oman Water line....
Produced Water Treatment Challenges in the Oil Industry

Water in the GCC...Towards Efficient Management
Produced Water Treatment Stages

- Water quality varies from one field to the other across Oman
- In past most Oil fields used Skim or settling tanks and CPIs for bulk water treatment
- Currently; water flood projects & Enhanced Oil Recovery projects require stringent water specifications and hence more complex water treatment equipment

**Primary**
- Corrugated Plate Interceptors (CPIs)
- Tilted Plate Interceptors (TPIs)
- Skim Tanks

**Secondary**
- Hydro cyclones
- Gas Flotation Tank (GFT)
- Induced Gas Flotation (IGF)
- Centrifuges

**Polishing/Tertiary**
- Nutshell Filters
- Ceramic Membranes
- Ion Exchange
- Double Pass RO

EOR/ Polymer Injection/Steam Injection
Water Treatment Challenges

- Improving Primary Separation
  - Performance of secondary and tertiary WT equipment depends on design and operation of primary separation
  - Increasing residence time improves primary separation and reduces cost of water treatment

- Troubleshooting of New Water Treatment Equipment
  - Some new technologies are being implemented for the first time e.g. GFT, Electro-coagulation and electro-floculation
  - This requires advanced expertise on Engineering, Maintenance & Operation

- Vendor Experience and Contracting Strategy
  - Vendor experience and references are of most importance
  - Investigating possibility of DBO&T, DBOO for water treatment
Water Treatment Facts

- Water treatment is crucial for Oil production
- Major cost of Oil production is attributed to water treatment and management
- Oil operators are developing more focused approach towards selecting appropriate water treatment technologies
- There is a clear gap between the demand in the Oil industry and what the market and water experts are providing
- Oil industry has the ability to move fast in developing new technologies simply because cost effective & continuous energy production is of highest importance
Produced Water Management (Utilisation)

Drivers

- Objective: Offset Deep Water Disposal high energy demand operation - **Cost**
- Relatively Good Water Quality in South Oman - low salinity (5000ppm) and increasing water rates
- An excellent Sustainable Development initiative & strategic move towards turning PW from a liability into an Opportunity
  - New business Opportunity for Oil companies by diversifying core activities; bio-fuels, carbon sinks, bio-saline forestry, water based industries, biomass production, aquifer recharge - **Game Changer**
a. Greening the Desert Initiative

b. Desk Top Investigation of Potential Low Salinity Systems
Nimr Reed Bed Pilot-2000

C-Train

B-TRAIN
- B1
- B2
- B3
- B4

A-TRAIN
- A1
- A2
- A3
- A4

EVAPORATION POND A

TOTAL AREA = 61.4 HA

Water in the GCC...Towards Efficient Management
Pilot Performance Since 2002

- Avoid direct food chain
- Fodder- Racing Horses
- Timber for wood production
- Halophytes for landscaping
- Plants for CO2 sequestration

Water in the GCC...Towards Efficient Management
Status of Nimr Reed Bed Pilot 2013

Atriplex sp.  Sesuvium sp.  Conocarpus lancifolius

Acacia ampliceps  Salvadoria persica

Water in the GCC...Towards Efficient Management
Nimr Water Treatment Plant

- Oil-Water Separation
- Reed Bed
- Sodiumchloride precipitation area
- Summer/winter Buffer Area
- Evaporation Salt Fields
- Residual Storage area
Nimr Water Treatment Plant

- Offset energy used for DWD (10MW pumps)
- Biomass or Bio-fuel Production potential
- Salt Production - base case scenario
- Currently 110,000 m³/d capacity
Produced Water Management at Petroleum Development Oman (PDO)

a. Greening the Desert Initiative

b. Desk Top Investigation of Potential Low Salinity Systems
Potential Utilisation Options for Produced Water

- Excess treated Produced Water can be used for;
  - Agriculture
    - Bio-Saline such as Jatropha, Cotton and halophytes or forages
    - Spec B (Cereals, seed crops & fodder)
  - Aquifer recharge
  - Solar desalination
    - Fresh Water
    - Salt
  - Water Based Industries
    - CO2 sequestration
    - Pulp industry
    - Duqum area development (Industrial Use)
- Water Quality in terms of salinity, heavy metals & Boron
- End Use/Product
- Treatment Requirements & Cost Benefit analysis
- Contracting Strategies (DBOO & DBOT)
- Vision 2020, 2030 (National SD Plans)
Produced Water Management Challenges

- Treating produced water as liability rather than resource
- Lack of recognition from water experts and Decision makers in order to develop & accelerate the process of PW utilization
- Full solutions are required from source (produced water) to sink (value product) to sustain Oil production
- Stakeholder serious commitment (Ministry of Water resources, Ministry of Environment, Ministry of Agriculture, Ministry of Commerce, Regulatory & International bodies to certify the Water Quality, …etc)
- Contracting Strategies a sub company of Oil operator, or different players ?!!
- Oil price fluctuations and National SD plans
- The legacy of time consuming R&D still prevailing despite the advances made worldwide
- Too many initiatives/pilots and lack of follow up
- Availability and reliability
- Ease of technology installation, operation & maintenance
- Continuous monitoring, evaluation and follow up
Way Forward

- An independent specialized **Produced Water Center of Excellence** has to be established that includes:
  - Water technologists/Experts
  - Government Representatives who are decision makers and able to influence the National Sustainable Development Plans
  - Industrialists who can manufacture & develop water treatment technologies – “In Country Value” Initiative
  - Experts that do base line assessment, define, select and assist in implementation of produced water utilisation options
  - Define & Certify water qualities per end use requirements
  - Guard the intellectual property of these technologies and initiatives in order to develop into new business portfolio for the country/company

- A center that is moving fast with technology taking into account the national and regional SD needs/plans
Close Out

- Oman is the lead in PW utilization field regionally and this in itself is a new business potential
- The produced water treatment and utilisation should involve other decision makers on National level
- There is a strong link between Water industry & Oil Industry
- Oil industry is willing to spend money on research and technology advancement however they need serious commitment & assurance from other key players
- Need for proper utilisation of Produced Water has to come from decision makers in the country and not as a courtesy from Oil industry