COSIA CHALLENGE

Mobilizing the world's minds and resources to improve environmental performance.

High Temperature Membrane Demineralization of Recovered Water

SOLUTION DESCRIPTION:

Membrane demineralization technologies operating above 85^{0}C to replace part of or the entire Steam Assisted Gravity Drainage (SAGD) of Cyclical Steam Stimulation (CSS) water treatment train

CREATED: March 31, 2014

All projects are evaluated and actioned as they are received.

CHALLENGE SPONSOR:

COSIA's **Water EPA** is sponsoring this challenge.

The Water EPA is seeking solutions which **reduce water use and increase water recycling rates at oil sands mining and in situ (in place) operations without causing negative environmental impacts in other areas.**

COSIA has four Environmental Priority Areas (EPAs): Water, Land, Tailings, and Greenhouse Gases (GHGs).

For more information on this COSIA Challenge please visit **www.cosia.ca**

Canada's Oil Sands Innovation Alliance (COSIA) accelerates the pace of environmental performance improvement in Canada's oil sands through collaborative action and innovation. COSIA Members represent more than 90 per cent of oil sands production. We bring together innovators and leading thinkers from industry, government, academia and the wider public to identify and advance new transformative technologies. Challenges are one way we articulate an actionable innovation need, bringing global innovation capacity to bear on global environmental challenges.

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WHAT TO SUBMIT TO COSIA

COSIA requires sufficient non-confidential, non-proprietary information to properly evaluate the technology.

Some items that will be especially important to present in your submission are:

- Concept and basic unit operations
- Technical justification for the approach (e.g. laboratory batch or continuous experiments; pilot or demo plants; process modeling; literature precedent)
- Describe quantities and qualities of utilities and consumables that are required
- Energy inputs – quantity and type(s)
- Capital and operating cost estimates if available based on described capacity targets
- 3rd party verification of your proposed technology. 3rd party verifiers should be reputable, independent engineering companies if possible
- Basis of cost estimation, including estimation scope, contingency, etc.
- IP status of your proposed technology
- What operating environment restrictions might your technology face:
  - Explosive atmospheres
  - Severe weather
  - Power fluctuations

FUNDING, FINANCIALS, AND INTELLECTUAL PROPERTY

COSIA Members are committed to identifying emerging technologies and funding the development of the technologies to the point of commercialization, while protecting the Intellectual Property (IP) rights of the owner of the technology.

Successful proposals can receive funding from COSIA members to develop and demonstrate the technology in an oil sands application. Multiple technologies may be funded, at the discretion of the Members.

HOW TO SUBMIT TO COSIA

Submit a summary of your solution using COSIA's Environmental Technology Assessment Portal (E-TAP) Process, available at: **http://www.cosia.ca/initiatives/etap/idea-submission-form**

Please note: ETAP is a staged submission process. The initial submission requires only a brief description and limited technical information. Upon review by COSIA, additional information may be requested. Instructions for submission are provided on the ETAP site.

All information provided is non-confidential. COSIA will respond to all submissions.

DETAILED SOLUTION DESCRIPTION

The Water Environmental Priority Area Steering Committee invites proposals for membrane demineralization technologies operating above 85^{0}C to replace part of or the entire SAGD water treatment train. Two applications, possibly sequential are seen; feed water for once-thru-steam generators (lower quality), and feed water for drum boilers (higher quality).

The successful technology will:

Meet one or both applications for water quality specifications below:

- Application 1 – OTSG Feed
  - TDS 500-8,000 mg/L, SiO2 < 50 mg/L (minimum, < 25 mg/L desired), Ca/Mg <0.5mg/L, >25 mg/L TOC

Or

- Application 2 – Drum Boiler Feed
  - TDS < 20 mg/L, SiO2 < 10 mg/L, Ca/Mg <0.1mg/L, TOC <10 mg/L
  - Recover >80% of feed water
  - Use less than 5 kWh/m3
  - Scale to 15,000-30,000 m3/day

BACKGROUND

The most common recovery processes employed for producing oil from deep oil sands reservoirs (geological formations), are SAGD and CSS. In these processes, steam is generated at a Central Processing Facility (CPF), transported to well pads, and injected into a horizontal well bore within the formation. The heat supplied by the steam warms the heavy oil in the reservoir, allowing it to flow via gravity into a second well (SAGD), or the injecting well bore (CSS) which captures the oil water mixture and produces it to the surface with the hydrocarbon at temperatures of over 180°C, and high levels of impurities, including salts, metals, silica and organic compounds, and needs to be treated before being fed to the steam generators.

If most of the hardness and silica can be removed the produced water can be fed to a Once Through Steam Generator (OTSG) (Application 1), or if almost all the dissolved solids can be removed it can be fed to a high quality drum boiler, recycling more of the water (Application 2). OTSGs tolerate lower quality water because 15-25% of the water is discharged to waste, while the yield of steam from a drum boiler is near 100%, but the drum boiler requires near pure water to avoid rapid fouling.

Currently produced water treatment is done using lime softening or evaporation. Oil sands companies believe that there are opportunities to improve environmental and economic produced water recycle performance using emerging membrane technologies, and are interested in a high flux, low energy process to remove impurities from heavy industrial process water, either membranes which:

- Can produce drum boiler quality (Application 1)water in
  - a single step (silica & hardness)
  - two steps (replacing the WLS, which removes silica, and the WAC polishers, which remove hardness in separate steps)
- Can produce OTSG quality(Application 2) water in a single step

Produced (inlet) Water Characteristics

- Water temperatures of 85°C (minimum) to 165°C
- TDS 500-10,000 mg/L
- pH 6-11
- SiO2 100-350 mg/L, Ca 5-150 mg/L, Mg 5-75 mg/L, TOC 200-600 mg/L, TIC <100 mg/L
- Free and emulsified oil <10 mg/L

APPROACHES WHICH HAVE BEEN OF INTEREST

The following approaches have/are being investigated by COSIA members:

- New and novel ceramic, polymer, hybrid and graphene membranes
- Membrane treatments which improve performance including fouling resistance

APPROACHES NOT OF INTEREST

The following approaches are not of interest:

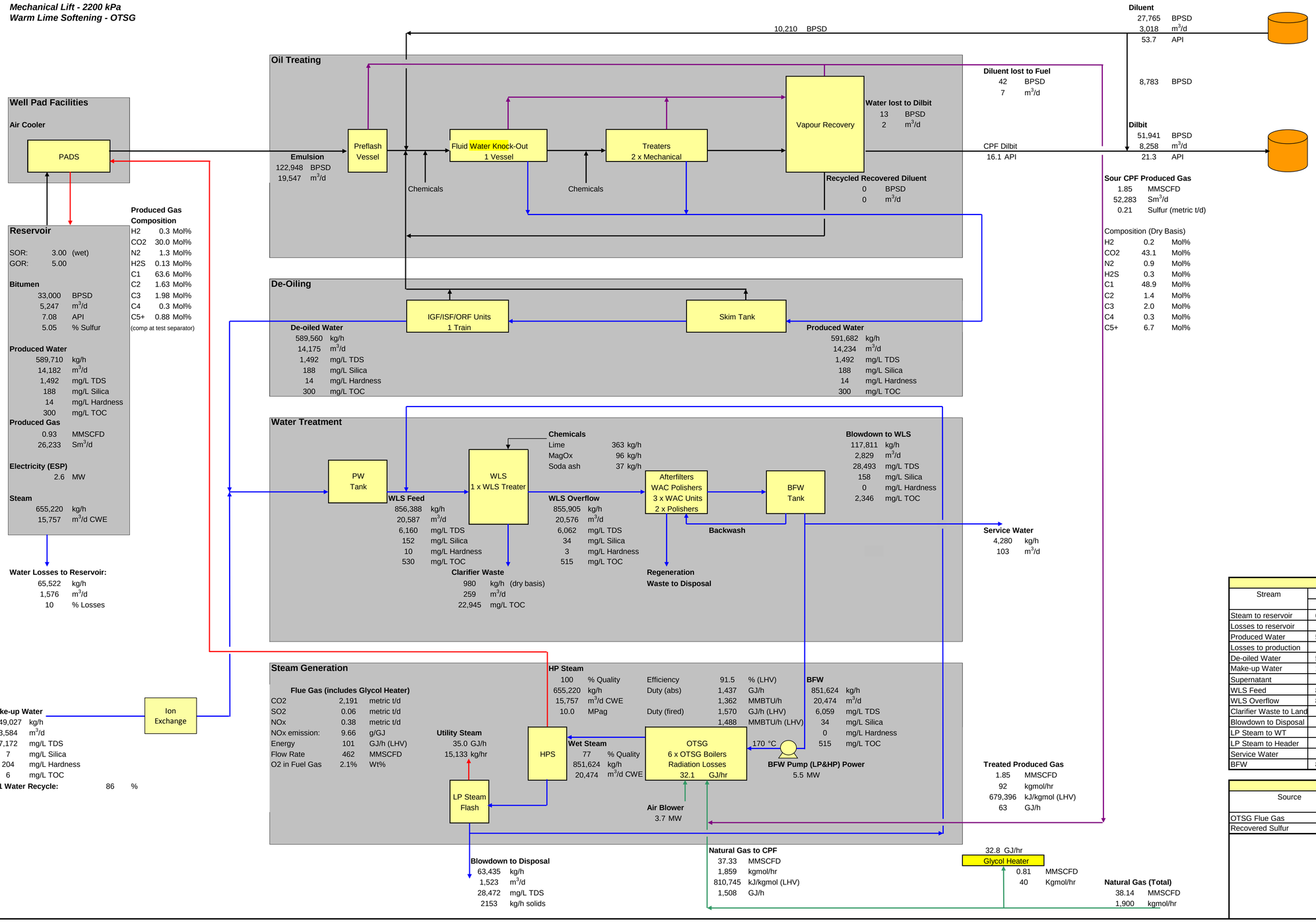
- Solutions which are currently commercial, COSIA members have investigated these existing solutions thoroughly
- Approaches requiring the use of chemical pretreatment
- Approaches not operating above 85 ^{0}C
- Packed bed systems
- Solutions which add complexity to the overall operation for a slight increase in boiler feed water quality

ADDITIONAL INFORMATION

Supplemental Information – Typical SAGD Energy and Material Balance

COSIA SAGD TEMPLATE

Base Case
Mechanical Lift - 2200 kPa
Warm Lime Softening - OTSG



Summary Table	
MU TDS (ppm)	7,172
PW TDS (ppm)	1,492
PW TOC (ppm)	300
LP Flash BD (%)	8%
BD Recycle (%)	60%
TDS to Boiler (ppm)	6,059
Boiler TOC (ppm)	515
MU Flowrate (kg/h)	149,027
WLS Sludge (kg/d)	23,530
Disposal Type (L,S)	L
Disposal Rate (kg/h)	63,435
Disposal Solids (kg/d)	51,662

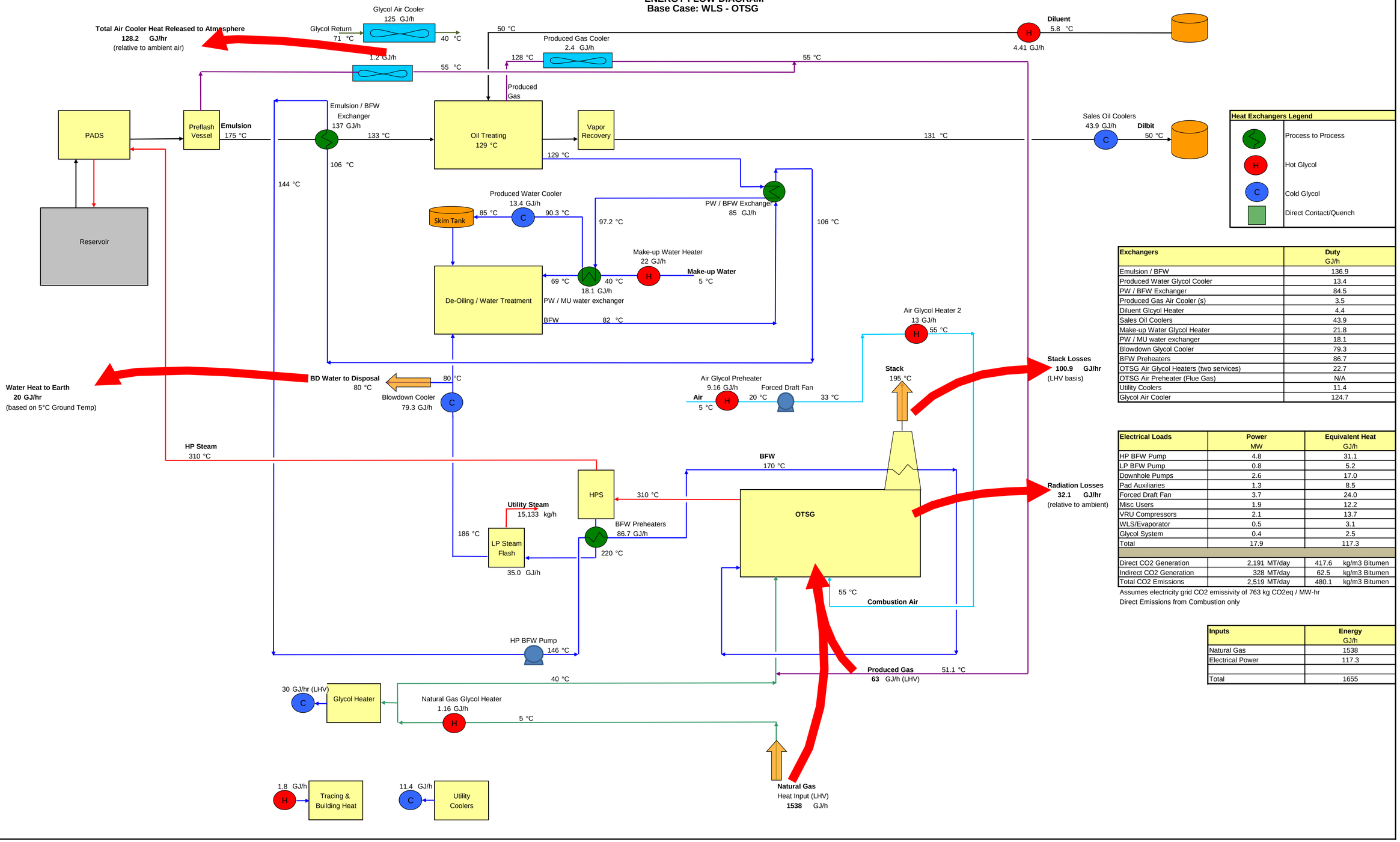
Water Balance

Stream	Flow kg/h	Flow m3/d	TDS ppm	Silica ppm	Hardness ppm
Steam to reservoir	655,220	15,757	-	-	-
Losses to reservoir	65,522	1,576	-	-	-
Produced Water	591,682	14,234	1,492	188	14
Losses to production	85	2	-	-	-
De-oiled Water	589,560	14,175	1,492	188	14
Make-up Water	149,027	3,584	7,172	7	204
Supernatant					
WLS Feed	856,388	20,587	6,160	152	10
WLS Overflow	855,905	20,576	6,062	34	3
Clarifier Waste to Land	980	259			
Blowdown to Disposal	63,435	1,523	28,472	158	0
LP Steam to WT	0	0	0	0	0
LP Steam to Header	15,133	363,198	0	0	0
Service Water	4,280	103	6,059	34	0
BFW	851,624	20,474	6,059	34	0

Emissions Summary

Source	SO2 metric t/d	S metric t/d	CO2 metric t/d	NOx metric t/d
OTSG Flue Gas	0.06	0.03	2191	0.38
Recovered Sulfur	-	0.00	-	-

ENERGY FLOW DIAGRAM
Base Case: WLS - OTSG



Heat Exchangers Legend

	Process to Process
H	Hot Glycol
C	Cold Glycol
	Direct Contact/Quench

Exchangers	Duty GJ/h
Emulsion / BFW	136.9
Produced Water Glycol Cooler	13.4
PW / BFW Exchanger	84.5
Produced Gas Air Cooler (s)	3.5
Diluent Glcyol Heater	4.4
Sales Oil Coolers	43.9
Make-up Water Glycol Heater	21.8
PW / MU water exchanger	18.1
Blowdown Glycol Cooler	79.3
BFW Preheaters	86.7
OTSG Air Glycol Heaters (two services)	22.7
OTSG Air Preheater (Flue Gas)	N/A
Utility Coolers	11.4
Glycol Air Cooler	124.7

Electrical Loads	Power MW	Equivalent Heat GJ/h
HP BFW Pump	4.8	31.1
LP BFW Pump	0.8	5.2
Downhole Pumps	2.6	17.0
Pad Auxiliaries	1.3	8.5
Forced Draft Fan	3.7	24.0
Misc Users	1.9	12.2
VRU Compressors	2.1	13.7
WLS/Evaporator	0.5	3.1
Glycol System	0.4	2.5
Total	17.9	117.3
Direct CO2 Generation	2,191 MT/day	417.6 kg/m3 Bitumen
Indirect CO2 Generation	328 MT/day	62.5 kg/m3 Bitumen
Total CO2 Emissions	2,519 MT/day	480.1 kg/m3 Bitumen

Assumes electricity grid CO2 emissivity of 763 kg CO2eq / MW-hr
Direct Emissions from Combustion only

Inputs	Energy GJ/h
Natural Gas	1538
Electrical Power	117.3
Total	1655