Downhole Steam Generation

Created: **October 8, 2014** **Expiry: March 31, 2015**
(High potential projects will be actioned when received)

Types of Solutions Needed
Existing Technology

Financials
Projects of interest to members will be funded as COSIA Joint Industry Projects by COSIA members.

COSIA Sponsor:
COSIA GHG Environmental Priority Area Steering Committee.

COSIA's Greenhouse Gas Environment Priority Area (EPA) is looking for innovative and sustainable solutions to significantly reduce GHGs at oil sands mining and InSitu (in place) operations without environmental burden shifting (causing negative environmental impacts in other areas).

Our aspiration is to "Produce our oil with lower GHG emissions than other sources of oil"

Canada's Oil Sands Innovation Alliance (COSIA) is an alliance of oil sands producers focused on accelerating the pace of improvement in environmental performance in Canada's oil sands through collaborative action and innovation. We bring together leading thinkers from industry, government, academia and the wider public to improve measurement, accountability and environmental performance in the oil sands in four priority areas. These four Environmental Priority Areas (EPAs) are tailings, water, land and greenhouse gases. This is one of multiple COSIA Challenges that are released on an on-going basis, all of which will range in priority and potential level of environmental benefit.

Technology Need Description

The COSIA Greenhouse Gas Environmental Priority Area Steering Committee has identified **Downhole Steam Generation** as a technology which could improve the environmental performance of the oil sands. This could apply to both Steam Assisted Gravity Drainage (SAGD) or Cyclic Steam Stimulation (CSS) processes. New technology is sought which could replace conventional surface based steam generators ("boilers") in either new or existing thermal InSitu operations. The GHG EPA is interested in new technologies for generation of steam down hole, either at the interface between the well(s) and the reservoir or in the well bore itself.

The successful technology will:

- Significantly reduce or eliminate heat losses to the atmosphere. Current steam generators lose 15-20% of the fired duty to the atmosphere in the form of hot flue gas and radiate heat.
- Significantly reduce or eliminate heat losses throughout the steam delivery infrastructure, including the well bore, resulting in higher quality steam to reaching the reservoir. This will improve well productivity and reduce water production and treating costs.
- Be able to reliably produce steam closer to reservoir pressure range (1.5 to 5 MPa) when the reservoir is already heated, but higher pressures (10-15 MPa) when the reservoir is cold.
- Produce steam at 75% quality or higher.

- Be capable of utilizing treated produced water from a typical thermal insitu operation.
- Be economically deployable at a well and/or pad level.

BACKGROUND

A number of enhanced hydrocarbon recovery processes inject steam into the reservoir in order to raise the temperature and reduce viscosity of the oil in place. This in turn mobilizes the oil, which can then be pumped to the surface together with water from the condensing steam.

Typical steam requirements in these types of process range from 2 to 5 barrels or more of water per barrel of oil produced. Most of the steam is returned to the surface as 'produced water' with the bitumen.

Because of the large water requirements, it is mandatory to recycling and reuse of the produced water for steam production. Current recycling rates are 90% or more. Any additional water supply is typically sourced from brackish water formations rather than fresh water. Combined, typical boiler feedwater quality characteristics are: SiO_2 < 50 mg/L (minimum, < 25 mg/L desired), Ca/Mg <0.5mg/L, 1,000- 8,000 mg/L TDS,>25 mg/L TOC

In convention InSitu designs, steam for injection is generated in large centralized processing plants, in multiple industrial sized "Once Through Steam Generators" (OTSG's). The steam is normally generated at 75-80% quality. The water portion is separated out prior to delivery to a steam distribution network delivering "100%" quality steam to all the injection wells in the field. The distribution network may have some sections as long as 10-15 km.

The thermal efficiency of OTSGs is typically 80-85% (HHV basis), with significant energy losses to the atmosphere. Significant heat losses can also occur in the steam distribution networks. Which results in lower quality steam at the well head. The reduction in steam quality impacts well productivity (oil production) and increases water production from the wells and associated water treating costs.

An "ideal" new technology would virtually eliminate current boiler flue gas heat losses to atmosphere and provide 100% quality steam downhole for all wells in the steam distribution network. It would also result in reduced energy costs and improve greenhouse gas emissions intensity by lowering fuel consumption.

The ideal technology would also be easily scalable to commercial size InSitu operations and would NOT include moving parts in the well bore (for cost/reliability reasons).

POSSIBLE APPROACHES

Possible approaches might include, but are not limited to:

- Down hole fuel combustion
- Extreme geothermal heat
- Well bore heat exchange
- Oxy-combustion

APPROACHES NOT OF INTEREST

The following approaches are not of interest:

- Direct electrical resistance heating
- Molten salt well bore circulation

These approaches do not generate steam down hole. As well, these technologies have already been trialed.

Management of the products of combustion are a critical aspect of implementing the technology, but is not specifically addressed through this COSIA Challenge.

In addition, this project is NOT seeking technology for InSitu upgrading of bitumen nor for improving oil recovery. Such objectives are outside of the current scope.

Material and energy flow diagrams for a standard 33,000 BPD Steam-Assisted Gravity Drainage (SAGD) facility are provided below.

ANTICIPATED PROJECT PHASES

Phase 1 – Program Development

Interesting technologies with the greatest improvement potential will be selected. Some approaches may be combined to form an integrated approach to solving this problem.

Phase 2 – Funding for selected technology option(s).

POTENTIAL SOLUTION PROVIDERS

COSIA member companies local or global resources, Associate Members, external companies (small to large), academic researchers, other research institutes, consultants, entrepreneurs, or inventors are welcome. For Example:

You represent an **independent process development/consulting organization** with steam generation technology available to transfer in from other areas
OR
You are an **academic researcher** with insights into potential solutions, willing to apply your knowledge to generate a novel solution

Members of COSIA should respond to this through their COSIA representative, if you do not know who your representative is please contact COSIA directly at ETAP@COSIA.ca

Non Members should submit their request through the COSIA E-TAP Process, available at http://www.cosia.ca/initiatives/etap/idea-submission-form

RESPONDING TO THIS CHALLENGE

The COSIA ETAP process is both an easy means of responding to this request, and a safe framework for best presenting your response to COSIA.

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

- Basic unit operations proposed
- Overall thermal efficiency of the steam generation
- Down hole steam conditions (T,P, quality)
- Water quality limitations
- Evidence of success (for any existing technology)
- Capital and operating cost estimates per unit of steam generated
- Utilities required for operating the process (fuel, electricity, etc.)
- IP status
- Description of existing environmental/operating permits supporting the technology. Note that the permits themselves do not need to be supplied at this stage.
- What operating environment restrictions might your technology face?
    - Explosive atmospheres
    - Severe weather
    - Power fluctuations

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Response Evaluation

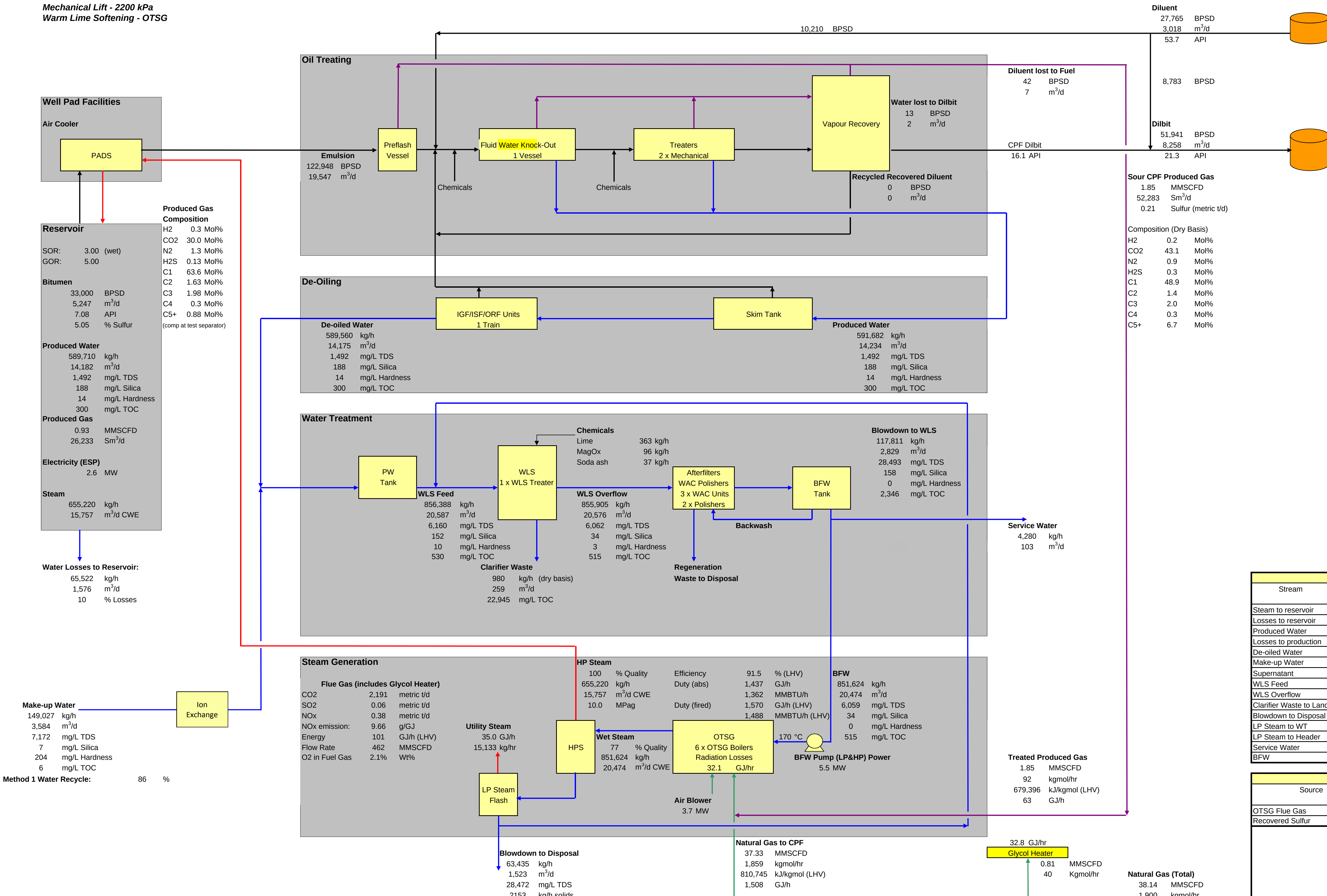
COSIA will evaluate the responses using the following criteria:

- Overall scientific and technical merit of the proposed approach
- Approach to proof of concept or performance
- Economic potential of concept
- Respondent's capabilities and related experience
- Realism of the proposed plan and cost estimates

These criteria and others will be used by COSIA to consider proposals for funding.

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

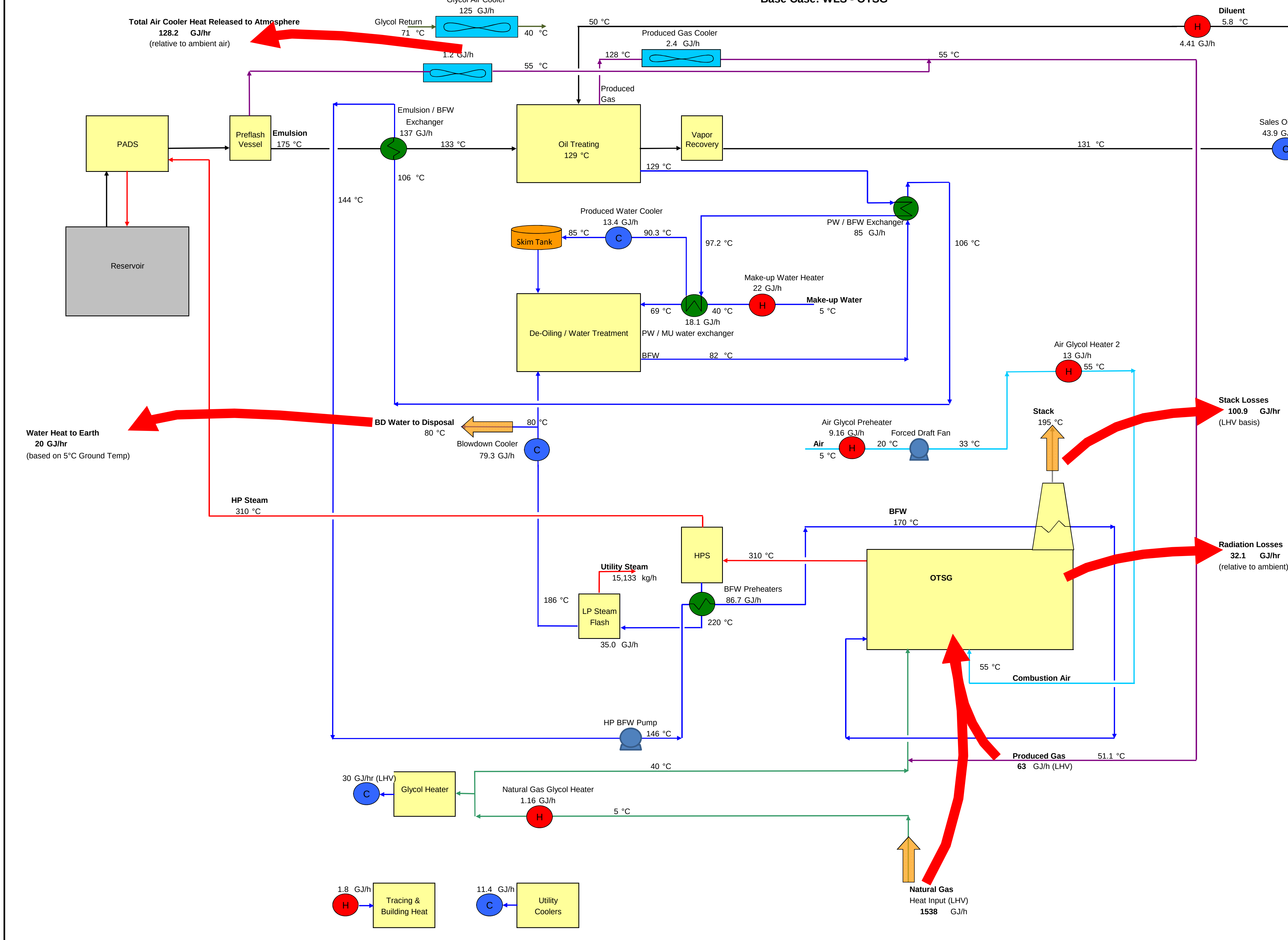
Water Balance

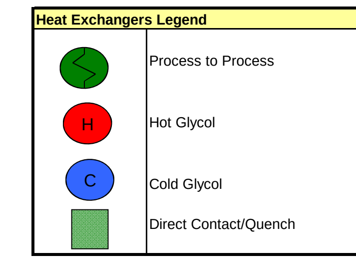
Stream	Flow	Flow	TDS	Silica	Hardness
	kg/h	m^3/d	ppm	ppm	ppm
Steam to reservoir	655,220	15,757	-	-	-
Losses to reservoir	65,522	1,576	-	-	-
Produced Water	591,682	14,234	1,492	188	14
Losses to production	85	2	-	-	-
De-oiled Water	589,560	14,175	1,492	188	14
Make-up Water	149,027	3,584	7,172	7	204
Supernatant					
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	S	CO2	NOx
	metric t/d	metric t/d	metric t/d	metric t/d
OTSG Flue Gas	0.06	0.03	2191	0.38
Recovered Sulfur	-	0.00	-	-

ENERGY FLOW DIAGRAM
Base Case: WLS - OTSG





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