BRIEF PROCESS DESCRIPTION OF 2G ETHANOL PROCESS

FOR

INDIAN OIL CORPORATION LIMITED, INDIA

BY

PRAJ INDUSTRIES LTD, PUNE - INDIA
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SECTION- 1 PROJECT OVERVIEW

1.1 Background:

Indian Oil Corporation Limited (IOCL) invites Bid for Supply of technology/Know how, Process License & Basic design Engineering Package, Proprietary Equipment (s), Catalyst(s)/Adsorbent(s)/Proprietary Chemical(s)/Solvent(s)/Yeast/Enzyme and other services for production of lignocellulosic 2G ethanol at Panipat, Haryana.

This document covers techno-commercial details of 100 KL per day Second Generation (2G) Ethanol production plant as part of bidding document.
1.2 Project Outline:

The Project will comprise of following Sections:

I. **BIOMASS PREPARATION SECTION:**
   - Biomass Storage
   - Material Handling, Milling, Conveying and Wet washing.

II. **MAIN PROCESS PLANT:**
   - Pretreatment
   - Enzymatic Hydrolysis
   - Co-Fermentation
   - Distillation
   - Dehydration

III. **RESIDUE HANDLING SECTION:**
   - Solid Liquid Separation
   - Evaporation
   - Process Condensate Treatment Plant

IV. **UTILITIES & AUXILIARIES:**
   - Boiler
   - Water Treatment Plant
   - Chemical Storage
   - Cooling Tower
   - Air Compressor
   - Product Storage
   - Enzyme and ADY Storage
   - Electrical System from grid to individual consumer
   - Control System- DCS

V. **OFF-SITE PACKAGES:**
   - Fire Fighting System
   - Weigh Bridge
1.3 Process Block Diagram:

- **Material Handling**
- **Pre-Treatment**
- **C6 Hydrolysis**
- **CO2 Vent**
- **Co-Fermentation**
- **Steam to process**
- **Process con. to recycle**
- **Solid-Liquid Separation**
- **Distillation, Dehydration**
- **Process Boiler**
- **Concentrated Syrup**
- **Supplementary Fuel**
- **Multiple Effect Evaporator**
- **Reject**
- **Treated Water to Utility**
- **Bio-Ethanol**
SECTION- 2 PROCESS DESCRIPTION:

A. MATERIAL HANDLING & WET WASHING SECTION:

The purpose of this section is to outline the technical specifications for Feed Stock Handling System for conveying the feed stock, de-stoning and screening, magnetic particle separation, intermediate storage, necessary safety controls and instrumentation for automatic operation, weighing system, vibratory screen system with rated capacity as per layout and parameters mentioned in these specifications.

The Feed Stock handling system shall be designed for all feed stock materials mentioned in technical specifications and for the levels of moisture mentioned in the feed stock.

The complete installation will be outdoor type. All components in system, instrumentation, motors, gearbox, etc. shall be suitable for outdoor installation and necessary local canopies will be provided as per good engineering practices. A closed room will be provided for installation of M.C.C Panel only.

From storage, raw material will be fed to the feed conveyor of Feed Stock handling system with the help of front end loaders etc. for further processing of size reduction, stones separation, and removal of foreign particles, intermediate storage and further conveying. A Permanent Magnet type metal separator shall be installed to remove metallic foreign particles from the feed stock. A proper access will be provided to the magnetic separator for easy removal of separated metallic particles.

The milling unit will be supplied to crush biomass up to desired particle size and integrated with upward and downward conveying system including interconnecting chutes, bellows, hoods for Dust-Extraction system; etc. will be included in the handling system.

The controlled flow rate from the silo shall be fed to the wet washing system for further processing.
Washing will be done at ambient conditions @ 3-3.5 % w/w solids. The wet biomass is further squeezed to increase solid up to 25 - 27 % w/w with the help of aqua separator and screw press. The wet washed, sized feed stock shall be conveyed from Wet Washing System to Pre-treatment section with Belt Conveyor and washed water will be sent to clarification section for recycle. The clarified water will be recycled back to washing section and clarifier bottom will be sent for further treatment in Evaporation section.

B. PRE-TREATMENT SECTION:

In this section, mainly C5 hydrolysis is done (i.e. conversion of Xylan to Xylose) in a reactor, where a slurry concentration of about 18%-20% is maintained. The mixed acid solution is continuously fed as per the requirement. The slurry is treated at about 160 - 190 deg C and 10 - 12 bar pressure. The slurry from reactor is flashed in a Flash Vessel and then pumped to Enzymatic Hydrolysis section. Water from the steam flashing shall be recycled back to process.
C. ENZYMATIC HYDROLYSIS SECTION:

The pre-treated slurry is fed to the Pre-hydrolysis reactor. Reaction conditions maintained are pH in the range of 5.0 to 5.5, temperature of about 50 to 55 deg C at atmospheric Pressure before Enzyme addition. Enzyme shall be added to the reactor as per required dose. The reaction will continue in the Pre-hydrolysis reactor for few hrs and then the contents are transferred to main Hydrolysis reactor for further processing.
D. CO-FERMENTATION SECTION:

Genetically Modified Organisms (GMO) type Activated Dry Yeast (ADY) will be mixed with water in Yeast slurry preparation tank and fed to Pre-fermenter for further propagation.

The sugar rich slurry from Hydrolysis reactor is then cooled to 32 – 34 deg C and fed to the Fermenter. Pre-fermenters are also provided for yeast propagation and different nutrients are added as per the required dosages. The Pre-fermentor volume is transferred to Main fermentor for fermentation process.

Once the desired alcohol is achieved, fermented wash is transferred from fermentor to beer well and from beer well to distillation section.

CO2 evolved during fermentation shall be vented off at safe location through GMO filter.
E. DISTILLATION SECTION:

The fermented mash from the Co-fermentation section is distilled and dehydrated to get Fuel grade ethanol.

“ECOFINE” Split Distillation consists of -

**Stripping Section:** This section consists of following distillation columns.

**Degasifying Column:**
The primary function of Degasifying Column is to remove non-condensable gases and low boiling impurities from the fermented mash. Preheated Fermented mash is fed to Degasifying Column.

**Split Mash Column:**
The primary function of Mash Column is to strip off ethanol from Fermented mash. Split Mash Column helps in reduction of overall steam consumption in Distillation Section.

**Rectification Section:** This section consists of following distillation columns.
Rectifier cum Exhaust Column:
The primary function of this column is to concentrate the ethanol. Ethanol is enriched at the top and is drawn out as hydrous ethanol and is fed to Dehydration Plant for further concentration.

F. DEHYDRATION SECTION:

The process drives the rectified feed through a system of molsieve beds. To allow for molsieve bed regeneration in continuous operation, twin beds are provided of which one is in dehydration mode while the other is in regenerating mode. Depending on feed and product specifications, the dehydration-regeneration exchange takes place based on set time cycle.

As the regeneration process releases the adsorbed water together with ethanol content, it is recycled back to system for reprocessing.

The feed is pumped to Vaporiser Tank. The overhead vapour of Vaporiser Tank is superheated in super heater to the required operating temperature and circulated to sieve bed 1 assumed in the description to be in dehydration mode. After passing through the molsieve, the vapor is condensed.
The regeneration operation forces the release of the moisture from the molsieve, making the sieve bed 2 ready for the next cycle.

The condensed liquid is fed to simmering column to enhance the product quality by removal of low boiling impurity from fuel grade ethanol. The Bottom of simmering column is taken as Fuel Grade Ethanol and sent to storage after product cooler.

The low boiling impurities removed from the top of the simmering column and send to technical alcohol storage tank as a by-product.

G. SOLID-LIQUID SEPARATION:
The Spent Mash generated in distillation shall be pumped to solid liquid separation section. The solid stream shall be used as a feed to boiler and the liquid stream (Thin Slop) shall be sent to evaporation section

H. THIN SLOP EVAPORATION:

The Thin Slop is further concentrated by water evaporation in evaporators to produce the concentrated syrup which will be mixed with solid stream generated from solid liquid separation before feed to boiler. Evaporation (water evaporated) process condensate will be Confidential
partially recycled back to process and remaining will be sent to polishing unit for further treatment.

I. PROCESS CONDENSATE POLISHING UNIT:

The process condensate from evaporation plant will be treated through anaerobic followed by aerobic biological process in addition to separation in condensate polishing unit. The treated process condensate then will be sent OSBL (outside battery limit) for utility makeup. The sludge generated out of biological process will be send as manure for agricultural field.
SECTION- 3 UTILIZATION OF BY-PRODUCTS AND RESIDUE:

Utilization of by-products and residue:

1. **Lignin rich cake** - Separated from the Solid Liquid Separation and is used as a boiler fuel along with supplementary fuel.

2. **Raw CO2 gas** – CO2 generated during Fermentation shall be vented off to atmosphere after scrubbing with water.

3. **Technical Alcohol (Impure Spirit)** – The technical Alcohol draw provision has been made to achieve the final product specifications and take care of variations in the main process plant. Technical Alcohol removed from the system may be sold in the market for production of chemicals or can be blend with fuel ethanol.

4. **Fusel Oils** – Fusel Oils (a mixture of higher alcohols) removed from the system will be burn in Boiler.

5. **Sludge from Process Condensate Treatment Plant** – It may be used as manure for agricultural field.

6. **Ash**: – Ash generated in boiler may be sold to bricks and cement industry.

7. **Biogas**: – Biogas generated in Process Condensate Treatment plant shall be burnt in flare unit.
Date: 21.11.2017

Sub: Tour Report of visit to IBP facility adjacent to Panipat Refinery to assess feasibility for installation of proposed 2G Ethanol Plant

Technology Provider: M/s PRAJ Industries Limited, Pune (Stage-1 approval)

Indian Oil Corporation Limited (IOCL) is planning to set up a Ligno-cellulosic ethanol plant to produce 100 KL per day of 2G ethanol using rice straw based ligno-cellulosic feedstock at Panipat, Haryana. M/s Praj Industries Limited is the technology provider for this 2G ethanol plant.

The proposed location for the project is the IBP facility lying redundant adjacent to Panipat Refinery. The proposed location is already having certain infrastructure like Tanks, Building, Substation and roads etc. In order to assess old existing infrastructure from reusability angle, availability of infrastructure between PR and the new plot for supply of Utilities, Size of the plot considering requirement of new infrastructure and deliberation with PR group on availability of required utilities, a committee was constituted vide office order no. RHQ/PJ-Engg./1709/1 dated: 16.11.2017 of following officers:

i) Mr. Sachin Swami, SM(AE), CO-BD
ii) Mr. Kamal Rathore, SPJM – RHQ
iii) Ms. Sunanda Nair, SPSM-PJ, RHQ
iv) Mr. Chandan Mahata, PJM, RHQ
v) Mr. Girish Gupta, PJM, RHQ
vi) Mr. Rajesh Gupta, PJM, RHQ

The committee visited Panipat on 18.11.17. Following officials of M/s Praj Industries Limited i.e. technology provider of 2G Ethanol Plant also accompanied committee members to Panipat:

i) Mr. Vasudeo Joshi
ii) Mr. Sanjay Gutle
iii) Mr. Anil Kulkarni
iv) Dr. Tushar Patil

The committee visited following locations at Panipat:

i) Proposed IBP facility selected for the plant at Panipat
ii) Panipat Marketing Complex – present custodian of the IBP facility
iii) Panipat Refinery – for discussion on supply of utilities along with route upto IBP facility
**Observations of Committee:**

A) **Assessment of old existing infrastructure from reusability angle**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>IBP Facility Existing Infrastructure</th>
<th>Observations</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Entrance and security cabin</td>
<td>Available</td>
<td>M/s PRAJ to assess available area w.r.t. requirement and refurbished &amp; used.</td>
</tr>
<tr>
<td>2.</td>
<td>S&amp;D room</td>
<td>Available</td>
<td>May be refurbished and used as per requirement</td>
</tr>
<tr>
<td>3.</td>
<td>Two Wheeler parking shed</td>
<td>Available</td>
<td>May be refurbished and used as per requirement</td>
</tr>
<tr>
<td>4.</td>
<td>Control Room includes sampling lab &amp; UPS Room</td>
<td>Available</td>
<td>May be modified/refurbished/extended and used as per requirement</td>
</tr>
<tr>
<td>5.</td>
<td>Admin/ Amenity block</td>
<td>Available</td>
<td>May be refurbished and used as per requirement.</td>
</tr>
</tbody>
</table>
| 6.     | Substation                            | Available    | • May be refurbished and used as per requirement.  
|        |                                      |              | • As per existing SLD, 11 KV incomm from GRID  
|        |                                      |              | • M/s PRAJ to assess the available space w.r.t. power requirement for the plant. |
| 7.     | Transformer Bays (2 no.)              | Available    | • As per existing SLD, 630 KVA rating Transformer was installed.  
|        |                                      |              | • 2 no. bays available  
<p>|        |                                      |              | • M/s PRAJ to validate the available space w.r.t. transformer sizing required for the plant. |</p>
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<tr>
<th></th>
<th></th>
<th>Available</th>
<th></th>
</tr>
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</table>
| 8. | DG Room | Available | 3 foundations available. As per existing SLD-320 KVA-1 no., 125 KVA-2 nos.  
May be refurbished and used as per requirement.  
M/s PRAJ to assess space required for installation of Diesel tank and tanker unloading system |
| 9. | Raw water tank  
(2800 KL) | Available | Internal condition and thickness to be reviewed.  
May be utilized as a Treated water day storage tank for process plant |
| 10. | Fire water tank & piping Network  
(2 nos- 1100 KL with pump house) | Available | Internal condition of Tanks and thickness of Tanks & Piping to be reviewed.  
Adequacy of the fire water tank/Network Capacity needs to be validated based on the requirement of overall plot plan. |
| 11. | Store/ware house and space near store/ware house | Available | Building may be refurbished and used for Chemicals storage and the adjacent space may be used for Enzyme storage. |
| 12. | Tanker filling station | Available | To be dismantled and space to be utilized for Process sections. |
| 13. | MS tanks  
(3 nos, 2500 KL capacity each) | Available | MS tanks internal condition and thickness to be reviewed.  
As per M/s PRAJ, one storage tank may be used as ethanol bulk storage. Other two tanks needs to be dismantled to accommodate daily ethanol receivers and tanker loading station. |
| 14. | Product pumps,  
Fixed foam system,  
Furfural tanks, | Available | As per M/s PRAJ, it is to be dismantled and space to be utilized for Process sections. |
| 15. | Diesel tanks  
(10000 KL capacity- 3 nos. and 5000 KL-1 no.) | Available | Diesel tanks internal condition and thickness to be reviewed.  
As per M/s PRAJ, One 10000
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Utilities required</th>
<th>Availability</th>
<th>Response from IOCL PR</th>
</tr>
</thead>
</table>
| 1.     | Total Saturated Steam required ~ 50 TPH at 3 different pressures (H.P./M.P./L.P.) | Available (To be confirmed by PR after internal discussion & approval by their management) | • It is possible to provide 50 TPH Saturated Steam at 40 Kg/cm² pressure from existing facility (PTA).  
• Required Steam pressure reduction shall |

B) Size of the plot considering requirement of new infrastructure

In view of committee members observation on the existing infrastructure & facilities as stated above M/s PRAJ to validate the available space as per process requirement. Existing facilities viz. Buildings, Roads, Tanks, Flood lights, Flood light Mast, Watch towers, Boundary wall, etc may be refurbished / modified and used as per requirement.

C) Deliberation with PR group on availability of required utilities

Utilities required for 2G Ethanol Plant were reviewed with Technical services team of IOCL PR and discussion has been summarized herewith:
<p>| | | |</p>
<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Treated water requirement- 150 m3/hr</td>
<td>Available (To be confirmed by PR after internal discussion)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Power consumption for ISBL – 6500 to 6800 kWh Power consumption for OSBL- 2500 to 3000 kWh including cooling towers, instrument air compressor</td>
<td>Not Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Due to upcoming projects, power needs to be sourced from the GRID.</td>
</tr>
<tr>
<td>4.</td>
<td>Instrument Air and Plant air -</td>
<td>Not Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Due to upcoming projects and the distance (approx. 2 to 3 KM) between Refinery and Ethanol plant which will create major pressure drop.</td>
</tr>
<tr>
<td>5.</td>
<td>Cooling water – 6000 m3/hr with 32 deg C supply temp.</td>
<td>Not Available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Due to upcoming projects process requirement and the distance (approx. 2 KM) between Refinery and Ethanol plant which will create major pressure drop. Accordingly M/s PRAJ to install Cooling Tower in their premises.</td>
</tr>
</tbody>
</table>
| 6. | Additional points discussed-
Treatment of drains, flushing / cleaning of equipment, storm water, etc | Not Available |
|   |   | Existing refinery do not have additional capacity to treat this effluent. So separate ETP to be considered in the Ethanol plant premises. The additional space needs to be accommodated in the existing plot plan |

D) Availability of infrastructure between PR and the new plot for supply of Utilities
i) PR has advised that no infrastructure is available between PR and the proposed IBP facility.

ii) Cost towards infrastructure development has to be considered while preparing the proposal.

iii) Utilities from PR to proposed IBP facility may be routed alongside the PR wall, however local state government authorities have to be involved in the same and necessary permissions have to be obtained.

E) Any other relevant point

i) The available drawings of the proposed facility is not as-built. There are differences between facility shown in the drawing and the facility available at site. Hence, it is recommended to carry out Site survey, Contour Survey and geo technical investigation along with as build auto-cad drawing of existing IBP site before finalizing plot plan.

ii) In the existing IBP area, it was observed that MS storage, Diesel storage, pump house, etc are at lower level (i.e. 1 to 2 m) along with storm water, fire fighting system, etc from the connecting roads. Due to margin space used between low level and connecting roads, the clear area available to accommodate the process section of 2G ethanol is getting limited. M/s PRAJ to validate the maximum possible available space w.r.t. process requirement. Overall site leveling may be required.

iii) Space for Canteen (if required) needs to be identified.

iv) It was observed that there is excess margin between the peripheral road and boundary wall. To maximize the available space, existing roads may be shifted to boundary wall.

v) As per equipment layout prepared by M/s PRAJ, cooling tower is not considered. However, as per discussion with refinery as per CW shall not be provided, M/s PRAJ to redraw the equipment layout accommodating cooling towers of required capacity.

vi) As the steam will be sourced from the Refinery, boiler will not be installed in the ethanol plant premises. Under these circumstances Lignin rich wet cake and Concentrated syrup will be the by-product at the outlet of Licensor’s battery limit. These need to be disposed of by IOCL for other applications like fuel, fertilizer, binder, etc to ensure the Zero effluent norm.

However, if the process boiler is to be considered in the plant then space optimization needs to be done by M/s PRAJ.
vii) In the proposed equipment layout prepared by M/s PRAJ one day biomass storage has been considered. Same needs to be validated w.r.t. considerations made during DFR stage.

Conclusion

Based on the assessment following can be concluded with respect to M/s Praj as per set objectives:

1) Old existing infrastructure of proposed IBP facility may be refurbished / modified as per requirement and may be reused subject to condition/workability of the facility.

2) As per the facilities coming in the plant, M/s PRAJ to rearrange/optimize as per available plot area. Modifications in the plot viz. road, lawn etc. may be carried out to accommodate different process sections.

3) As per discussion with PR only 2 No. utilities may be considered for this plant i.e. HP steam and Treated water, which PR shall confirm after obtaining necessary confirmation/approval from respective departments. For balance utilities viz. Power, Instrument / plant air, cooling water & effluent (if any), the ethanol plant should be self-sufficient.

Chandan Mahata
PJM,RHQ

Rajesh Gupta
PJM,RHQ

Girish Gupta
PJM,RHQ

Sachin Swami,
SM(AE), CO-BD

Kamal Rathore
SPJM - RHQ

Sunanda Nair
SPSM-PJ, RHQ
NOTES:
1) CIVIL STRUCTURE, SITE CONSTRUCTION & ERECTION FOR COMPLETE PLANT IS IN OSBL SCOPE.
2) ABOVE MENTIONED DISEL SCOPE ESTIMATE DOES NOT CONSIDER ADDITIONAL COST REQUIRED FOR CAPTIVE POWER OPTION.
3) CAPTIVE POWER GENERATION IS NOT CONSIDERED IN THE ABOVE SCOPE.
**OVERALL MASS BALANCE**

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Dry Basis</th>
<th>Mass Balance</th>
<th>Efficiency</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice Straw</td>
<td>90.00 %</td>
<td>19768.51 kg/hr</td>
<td>98%</td>
<td>Milling Loss 395.37 kg/hr</td>
</tr>
<tr>
<td>Cellulose</td>
<td>17.50 %</td>
<td>18.22 kg/hr</td>
<td>98%</td>
<td>Steel Water 18.00 kg/hr</td>
</tr>
<tr>
<td>Lignin</td>
<td>1.20 %</td>
<td>546.55 kg/hr</td>
<td>98%</td>
<td>Steam Condensate 47066.01 kg/hr</td>
</tr>
<tr>
<td>Ash</td>
<td>0.00 %</td>
<td>399.11 kg/hr</td>
<td>98%</td>
<td>Washing Sludge 9820.33 kg/hr</td>
</tr>
<tr>
<td>Silica</td>
<td>0.00 %</td>
<td>171.16 kg/hr</td>
<td>98%</td>
<td>Flashed Vapor – II 5948.60 kg/hr</td>
</tr>
<tr>
<td>Thin Slip</td>
<td>11.00 %</td>
<td>222.63 kg/hr</td>
<td>98%</td>
<td>Recycle Process Condensate 41063.90 kg/hr</td>
</tr>
<tr>
<td>Thick Slip</td>
<td>18.50 %</td>
<td>48034.51 kg/hr</td>
<td>98%</td>
<td>Steam Condensate 13730.66 kg/hr</td>
</tr>
<tr>
<td>Thin Slop Recycle</td>
<td>90.00 %</td>
<td>48034.51 kg/hr</td>
<td>98%</td>
<td>Recycle Process Condensate 41063.90 kg/hr</td>
</tr>
<tr>
<td>Nutrient</td>
<td>0.00 %</td>
<td>11.76 kg/hr</td>
<td>98%</td>
<td>Recycle Process Condensate 41063.90 kg/hr</td>
</tr>
</tbody>
</table>

**Note:**
1. The overall mass balance is given for steady state condition & based on feed stock composition mentioned above.
2. The overall mass balance should not be used to design utility, Input/Output consumptions.
3. Exclusion - Sealing water purge and Boiler blowdown, CO2 plant, BioNi8 plant, Floor washings, make up water for CT.
4. The extraneous matter like sand, mud, stones,etc considered max 1.0% w/w and any metal content must be nil.
### WATER BALANCE (WITH RECYCLE)

**Feed**

- **Rice Straw**
  - Water from Raw Material: 1976.85 Kg/hr
  - Recycle Water (Thin Slop): 44057.48 Kg/hr

- **Internal Recycle Streams**
  - 29002.11 Kg/hr
  - Recycle Process Condensate: 18063.90 Kg/hr
  - Direct Steam (in): 17116.26 Kg/hr
  - Recycle Water (Thin Slop): 0.00 Kg/hr
  - Fresh Water (Process Water): 1982.31 Kg/hr

- **Molasses**
  - 164.98 Kg/hr

- **Internal Water (Process Water)**
  - 9574.88 Kg/hr

- **Milling + Wet Washing**
  - Purge to Treatment: 19263.26 Kg/hr
  - Milling Loss: 39.54 Kg/hr
  - Wet Feed: 26731.53 Kg/hr

- **Pre-Treatment**
  - Purge to Treatment: 19182 Kg/hr
  - Water for Recycle: 19263.26 Kg/hr
  - Water Consumed: 703.81 Kg/hr

- **Co Fermentation**
  - Water Consumed: 27.50 Kg/hr

- **Distillation**
  - Purge to Treatment: 82722.88 Kg/hr
  - Water for Recycle: 82722.88 Kg/hr
  - Water Consumed: 17.03 Kg/hr

- **S/L Separation**
  - Spent Wash: 85938.76 Kg/hr
  - Recycle Water (Thin Slop): 44057.48 Kg/hr

- **Evaporation**
  - Process cond.: 28120.29 Kg/hr
  - Recycle Process Condensate: 18063.90 Kg/hr
  - Flash Steam To Distillation: 11415.24 Kg/hr

- **Process Condensate Polishing Unit**
  - 20% Process cond.: 22496.23 Kg/hr
  - 60% Process cond.: 3058.50 Kg/hr

- **Total Recycle available**: 111619.72 Kg/hr
- **Recycle Water to Process**: 91123.48 Kg/hr
- **Excess Recycle water for utility make**: 22496.23 Kg/hr

### Input/Output

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
<th>Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>60657.93</td>
<td>60657.93</td>
<td>0</td>
</tr>
<tr>
<td>703.81</td>
<td>703.81</td>
<td>0</td>
</tr>
<tr>
<td>105200.02</td>
<td>105200.02</td>
<td>0</td>
</tr>
<tr>
<td>82750.37</td>
<td>82750.37</td>
<td>0</td>
</tr>
<tr>
<td>95774.12</td>
<td>95774.12</td>
<td>0</td>
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<tr>
<td>92896.11</td>
<td>92896.11</td>
<td>0</td>
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<tr>
<td>28120.29</td>
<td>28120.29</td>
<td>0</td>
</tr>
<tr>
<td>3058.50</td>
<td>3058.50</td>
<td>0</td>
</tr>
<tr>
<td>44057.48</td>
<td>44057.48</td>
<td>0</td>
</tr>
<tr>
<td>28120.29</td>
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<td>0</td>
</tr>
</tbody>
</table>

### Note

1. The water balance is prepared at steady state operation based on the overall mass balance for Rice Straw as a feed stock document Q-ABFC-15-003A1-3: OMEB 9001.
2. The water balance should not be used to design utility, Input/Output consumptions.
3. Exclusion - Sealing water purge and Boiler blowdown, CO2 plant, BioCNG plant, Floor washings, make up water for CT.
4. Cooling towers are in owner's scope. Water required for cooling tower make up and treatment of cooling tower blow down is in owner scope.

---

**CONSUMPTION, TPH**
- Process: 86.70
- Utility: 37.13

**RECYCLE, TPH**
- Process: 73.54
- Utility: 0.00

**MAKE UP, TPH**
- Process: 13.19
- Utility: 37.12

**Total Fresh Water consumption**
- Process: 316.64
- Utility: 410.8

**FPD**
- Process: 3.16
- Utility: 4.10

---

**A**

10.01.2018

MDS

APK

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FOR IOCL REVIEW

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ESTIMATED EMISSIONS FROM PROCESS BOILER -

A. Indicative flue gas emission rates and composition

Estimated total flue gas at stack outlet based on boiler vendor: 1,62,000 – 1,75,000 kg/hr @ 180 Deg. C i.e.1,35,000 – 1,45,000 nm³/hr.

<table>
<thead>
<tr>
<th>Flue gas composition</th>
<th>% by wt.</th>
<th>% by vol.</th>
<th>mg/nm³</th>
<th>Kg/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>12 - 14</td>
<td>8 - 9</td>
<td></td>
<td>20,000 – 24,500</td>
</tr>
<tr>
<td>H₂O</td>
<td>13 - 14</td>
<td>20-22</td>
<td></td>
<td>21,000 – 24,500</td>
</tr>
<tr>
<td>N₂</td>
<td>62-64</td>
<td>60-64</td>
<td></td>
<td>1,00,000 – 1,15,000</td>
</tr>
<tr>
<td>O₂</td>
<td>8 - 9</td>
<td>7 - 8</td>
<td></td>
<td>12,500 – 15,000</td>
</tr>
<tr>
<td>SOx</td>
<td>0.2 – 0.3</td>
<td>0.1 – 0.15</td>
<td>&lt; 2931</td>
<td>325 - 500</td>
</tr>
<tr>
<td>NOx</td>
<td></td>
<td></td>
<td>&lt; 490</td>
<td>66 - 70</td>
</tr>
<tr>
<td>Dust</td>
<td></td>
<td></td>
<td>&lt; 100</td>
<td>15 - 20</td>
</tr>
</tbody>
</table>

Note:
1. The above mentioned flue gas composition is indicative and theoretically estimated on the basis of fuel compositions, optimized proportions of Lignin Rich Wet Biomass Cake, Concentrated Syrup and Rice Husk / Straw as supplementary fuel.
2. For Dust Emissions mentioned above, Bag Filter is considered as Pollution Control Equipment.
3. The SOx and NOx values mentioned above are without any flue gas treatment.

B. Indicative Stack Requirement

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Stack Diameter (m)</th>
<th>Stack Height (m)</th>
<th>SO₂ Emission, (kg/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stack Specifications</td>
<td>2.75</td>
<td>88 - 90</td>
<td>325 - 500</td>
</tr>
</tbody>
</table>

Note:
The above mentioned chimney height is calculated as per CPCB stack height requirement criteria. [Ref. EPA Notification, GSR 176 E, April 2, 1996]

The rate of SO₂ emissions are theoretically estimated based on fuel compositions, optimized proportions of fuel mixture.

Formula: Height of Chimney \( H = 14 \times Q^{0.3} \);
\( Q = \) rate of SO₂ emission in kg/hr
C. Ash from Boiler

As per Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016 – The high volume low effect wastes such as fly ash are excluded from the category of hazardous wastes.

Hence, the ash generated from boiler is categorized as “Non Hazardous”.

Indicative Ash Quantity and Quality –

The ash quantity and quality are theoretically estimated based on the operating loads and the consumptions of Lignin Rich Wet Biomass Cake, Concentrated Syrup and Rice Husk / Rice Straw in the boiler fuel mixture.

i. Theoretically Estimated Quantity of Ash Generated from Boiler

<table>
<thead>
<tr>
<th>Phase</th>
<th>Process Load (%)</th>
<th>Ash Generation (kg/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-up</td>
<td>60</td>
<td>2000 - 2200</td>
</tr>
<tr>
<td>Stabilization</td>
<td>60</td>
<td>2500 - 3000</td>
</tr>
<tr>
<td>Steady State</td>
<td>100</td>
<td>4800 - 5000</td>
</tr>
</tbody>
</table>

ii. Estimated Specifications / Quality of Ash Generated from Boiler

Theoretically Estimated Ash Analysis (Dry Basis)

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Silica</td>
<td>SiO₂</td>
</tr>
<tr>
<td>2</td>
<td>Alumina</td>
<td>Al₂O₃</td>
</tr>
<tr>
<td>3</td>
<td>Iron Oxide</td>
<td>Fe₂O₃</td>
</tr>
<tr>
<td>4</td>
<td>Sodium Oxide</td>
<td>Na₂O</td>
</tr>
<tr>
<td>5</td>
<td>Calcium Oxide</td>
<td>CaO</td>
</tr>
<tr>
<td>6</td>
<td>Copper Oxide</td>
<td>CuO</td>
</tr>
<tr>
<td>7</td>
<td>Potassium Oxide</td>
<td>K₂O</td>
</tr>
<tr>
<td>8</td>
<td>Chromium</td>
<td>Cr₂O₃</td>
</tr>
<tr>
<td>9</td>
<td>Bromide</td>
<td>Br</td>
</tr>
<tr>
<td>10</td>
<td>Sulphates</td>
<td>As SO₃</td>
</tr>
<tr>
<td>11</td>
<td>Chlorides</td>
<td>As Cl</td>
</tr>
<tr>
<td>12</td>
<td>Magnesium Oxide</td>
<td>MgO</td>
</tr>
<tr>
<td>13</td>
<td>Phosphorous Oxide</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>14</td>
<td>Mangaese Oxide</td>
<td>MnO</td>
</tr>
<tr>
<td>15</td>
<td>Zinc Oxide</td>
<td>ZnO</td>
</tr>
<tr>
<td>16</td>
<td>Vanadium Pentoxide</td>
<td>V₂O₅</td>
</tr>
<tr>
<td>17</td>
<td>Titanium</td>
<td>TiO₂</td>
</tr>
</tbody>
</table>

Note:

1. Above mentioned ash generation quantities and qualities are indicative in nature and to be used for estimation purpose. Exact quantities shall be taken from boiler vendor during detailed engineering.
Environmental Standards

Emission

BOILER (SMALL)

<table>
<thead>
<tr>
<th>Steam generation capacity (tph)</th>
<th>Pollutant</th>
<th>Emission limit (mg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 2</td>
<td>Particulate Matter</td>
<td>1200*</td>
</tr>
<tr>
<td>2 to less than 10</td>
<td>-do-</td>
<td>800*</td>
</tr>
<tr>
<td>10 to less than 15</td>
<td>-do-</td>
<td>600*</td>
</tr>
<tr>
<td>15 and above</td>
<td>-do-</td>
<td>150**</td>
</tr>
</tbody>
</table>

* To meet the respective standards, cyclone/multicyclone is recommended as control equipment with the boiler.

** To meet the standard, bag filter/ESP is recommended as control equipment with the boiler.

Note:

I. 12% of CO₂ correction shall be the reference value for particulate matter emission standards for all categories of boilers.

II. These limits shall supercede the earlier limits notified under Schedule I at Sr. No. (34) of EPA, 1986 (GSR 742E, dated 30 August, 1990)

III. Stack Height for Small Boilers

For the small boilers using coal or liquid fuels, the required stack height with the boiler shall be calculated by using the formula

\[
H = 14 Q^{0.3}
\]

Where \( H \) = Total stack height in metres from ground level

\( Q \) = Sulphur dioxide (SO₂) emission rate in kg/hr

In no case, the stack height shall be less than 11 metres.

Where providing tall stacks are not feasible using above formula, the limit of 400 mg/Nm³ for SO₂ emission shall be met by providing necessary control equipment with a minimum stack height of 11 metres.

Source: EPA Notification
[GSR 176(E), April 2, 1996]

Guidelines for Pollution Prevention in Small Boilers

Following GUIDELINES for Pollution Prevention in <2TPH small boilers are suggested. Guidelines are made for both boiler manufacture & boiler users separately.

Guidelines for Boiler Manufacturer

i. The boiler should be provided with an ID fan of appropriate capacity.

ii. A provision for sucking in secondary air above the fuel bed with adjustable opening area should be provided.

iii. A butterfly type damper with appropriate arrangement for fixing damper at various
positions easily, should be provided at the inlet side of the fan.

iv. The ID fan & damper should be located preferably nearer to the front side of boiler & should be easily accessible such that the boiler operator can access the damper easily & quickly & can operate while looking at boiler furnace condition.

v. A single cyclone of appropriate size be provided in the circuit alongwith "bottom storage hopper fitted with an air tight Rotary air lock valve with a handle".

vi. An economiser should be provided in the circuit for pre-heating boiler feed water.

vii. Proper "tube cleaning" arrangement & required tools should be provided along with its operating instructions.

viii. Proper instructions to be provided for obtaining and maintaining desired quality of boiler feed water & chemicals to be added to reduce/remove deposits on "water side of tubes".

ix. Proper information & instructions should be provided regarding, "which different fuels can be fired" in the boiler (Solid & liquid) and how it should be fired, how much at a time and desired frequency of its firing etc. (All the above mentioned information/instruction etc. could be compiled as part of the "Boiler Operating Manual" & supplied by boiler Manufacturer alongwith the boiler).

x. The flue gas carrying ducts should be sized appropriately, say for peak flowrate gas velocity of 14 to 16 m/s to be maintained.

xi. A portable and simple to operate type (say, Pyrite kit) CO\textsubscript{2} monitoring instrument should be provided.

Guidelines for Boiler Users

i. Solid fuels like coal briquettes etc. should be appropriately sized approx. 1 to 2 inch size /dia (large pieces to be broken, wherever required).

ii. Fuel should be fired uniformly and in less quantity at a time such that the bed thickness does not exceed about 6 to 9 inches (and not in big heaps). Depending on high/low steam demand, the frequency of firing could be increased or decreased (say 4 to 5 times / hour during higher steam demand, or say 2 to 3 times /hr during lower steam demand).

iii. Every time the fuel is fired, the damper should be set to "High" position for a minute or two (this would suck more combustion air required for burning volatile matter & thereby reduce soot / black smoke formation), and then it should be set back to "Low" position, till the next firing. (Setting could be made after a few trails). This damper adjustment should be done by the boiler operator throughout the boiler operation as a part of his regular duty like firing fuel for achieving optimised combustion at all time & thereby preventing pollution.

iv. "Secondary air opening" to be kept full open at the time of firing for one or two minutes. Later, the opening "Must" be reduced till next firing. (Setting by trial & error).

v. Fire bed should be cleaned at appropriate time to avoid build-up of "fire bed thickness", if not, this would reduce the primary air supply successively & result into improper combustion.

vi. Soot deposits in tubes should be cleaned from time to time with proper tool. Build up of deposits effects the steam generation adversely and result into higher fuel gas temp. & higher stack loss.

vii. The economiser should be kept properly insulated.

viii. The cyclone bottom opening should be kept air tight & leak proof, else, it would reduce cyclone efficiency. The duct collected should be taken out from time to time( say once per shift) & appropriately disposed avoiding secondary pollution.

ix. Good quality feed water should be used for boiler & appropriate chemicals should be added, as directed by boiler supplier, for avoiding tube deposits, else it would reduce steam generation.

x. CO\textsubscript{2} % should be checked frequently (say once a day initially) to ensure proper boiler operation & take corrective actions, if required, immediately.
OVERALL EFFLUENT TREATMENT BLOCK

PARAMETER | UOM | VALUE
--- | --- | ---

<table>
<thead>
<tr>
<th>STREAM</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the stream</td>
<td>Process Condensate (raw)</td>
<td>AHR Treated Effluent</td>
<td>Aerobically Treated Effluent</td>
<td>Sludge Handling (Ref.note 3)</td>
<td>Tertiary Treated Water</td>
<td>RO permeate</td>
<td>RO reject to Evaporation</td>
<td>Biogas</td>
</tr>
<tr>
<td>Effluent Flow rate m³/day</td>
<td>1008</td>
<td>1008</td>
<td>1008</td>
<td>8.0-8.5</td>
<td>1008.00</td>
<td>805-855</td>
<td>153-203</td>
<td>3620-3810</td>
</tr>
<tr>
<td>pH</td>
<td>3.4</td>
<td>7.0-8.0</td>
<td>7.0-8.0</td>
<td>7.0-8.5</td>
<td>7.0-8.0</td>
<td>8.0-8.4</td>
<td>7.0-8.0</td>
<td>NA</td>
</tr>
<tr>
<td>Total Dissolved Solids ppmw</td>
<td>100</td>
<td>6000</td>
<td>6000</td>
<td>6000</td>
<td>6000.00</td>
<td>100-160</td>
<td>35000-40000</td>
<td>NA</td>
</tr>
<tr>
<td>Total Suspended Solids mg/L</td>
<td>&lt;50</td>
<td>&lt;500</td>
<td>&lt;500</td>
<td>&lt;50</td>
<td>150000-200000</td>
<td>&lt;10</td>
<td>29-40</td>
<td>&lt;70</td>
</tr>
<tr>
<td>COD mg/L</td>
<td>12000</td>
<td>&lt;3000</td>
<td>&lt;250</td>
<td>NA</td>
<td>&lt;250</td>
<td>&lt;10</td>
<td>&lt;1700</td>
<td>NA</td>
</tr>
<tr>
<td>BOD mg/L</td>
<td>7000</td>
<td>&lt;1400</td>
<td>&lt;30</td>
<td>NA</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;200</td>
<td>NA</td>
</tr>
<tr>
<td>MO Alkalinity as CaCO3 mg/L</td>
<td>80-112</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium Hardness as CaCO3 mg/L</td>
<td>63-85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Hardness as CaCO3 mg/L</td>
<td>90-125</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Iron mg/L</td>
<td>&lt;0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORP mv</td>
<td>&lt;245</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorides ppmw</td>
<td>8-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphates ppmw</td>
<td>&lt;5-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Reactive Silica as SiO2 ppmw</td>
<td>8-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Above values are preliminary for estimation purpose and may undergo change during detailed engineering.
2. 20% Margin to be considered for designing PCTP
3. TDS in process condensate will appear only after neutralization with alkali. VFA do not show any TDS by gravimetric analysis (in Raw process condensate).
4. The dewatered sludge has to be disposed off by the owner.
5. The dewatered biological sludge can be used as organic manure. Sludge will be available for disposal after biological ETP is stabilized.
6. Biogas generated will be flared or cold vented
7. Process condensate parameters depend upon Feed Stock composition. Any change in Feed stock will cause change in PCTP parameters
8. RO reject will be feed to multiple effect evaporation system and RO permeate can be mixed with Treated Raw Water
9. NA: Not applicable

A 16-01-2018 ADD APK APK FOR EC SUBMISSION
REMARKS

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## Utility & Effluent Summary for EC Submission

### Utility Summary

<table>
<thead>
<tr>
<th>Utility Item</th>
<th>Unit</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Water (Including Water Required for DM Plant)</td>
<td>m3/hr</td>
<td>122</td>
</tr>
<tr>
<td>Water consumption distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water consumption for process plant</td>
<td>m3/hr</td>
<td>16</td>
</tr>
<tr>
<td>Wet Fresh Water make up to cooling tower (after using recycle water)</td>
<td>m3/hr</td>
<td>78</td>
</tr>
<tr>
<td>Miscellaneous water consumption: Drinking, washing, etc.</td>
<td>m3/hr</td>
<td>108</td>
</tr>
<tr>
<td>Cooling Water Circulation Flow Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling Tower-1</td>
<td>m3/hr</td>
<td>3200 @ 8 Deg. C, Delta T</td>
</tr>
<tr>
<td>Cooling Tower-2</td>
<td>m3/hr</td>
<td>1600 @ 8 Deg. C, Delta T</td>
</tr>
<tr>
<td>Cooling Tower-3</td>
<td>m3/hr</td>
<td>1200 @ 8 Deg. C, Delta T</td>
</tr>
<tr>
<td>Steam (HP) - 15 kg/cm2 g'</td>
<td>MT/hr</td>
<td>22</td>
</tr>
<tr>
<td>Steam (MP) - 6 kg/cm2 g'</td>
<td>MT/hr</td>
<td>14</td>
</tr>
<tr>
<td>Steam (LP) - 1.5 kg/cm2 g'</td>
<td>MT/hr</td>
<td>12</td>
</tr>
<tr>
<td>Total Steam for Process</td>
<td>MT/hr</td>
<td>48</td>
</tr>
<tr>
<td>Power (For ISBL &amp; OSBL) PER DAY</td>
<td>MW</td>
<td>240</td>
</tr>
<tr>
<td>Air Requirement</td>
<td>m3/hr</td>
<td></td>
</tr>
<tr>
<td>Plant Air (For Dedusting System)</td>
<td>m3/hr</td>
<td>75</td>
</tr>
<tr>
<td>Process Air (Air Blower)</td>
<td>m3/hr</td>
<td>910</td>
</tr>
<tr>
<td>仪rmount Air for Instrumentation and Solid Liquid Separation</td>
<td>m3/hr</td>
<td>3500</td>
</tr>
</tbody>
</table>

### Effluent Summary

<table>
<thead>
<tr>
<th>Source</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Effluent</td>
<td>TPD</td>
<td>8 - 9</td>
</tr>
<tr>
<td>Sewage from (Note-14)</td>
<td>TPD</td>
<td>8 - 8.5</td>
</tr>
<tr>
<td>Ash (Note-9,10,11)</td>
<td>TPD</td>
<td>120 - 130</td>
</tr>
<tr>
<td>Gaseous Effluent</td>
<td>TPD</td>
<td>78 - 82</td>
</tr>
<tr>
<td>Biogas (Note-14)</td>
<td>m3/Day</td>
<td>3600 - 3800</td>
</tr>
<tr>
<td>Fume Gas (Note-2,3,4,5,6,7,8,11)</td>
<td>TPD</td>
<td>4000 - 4500</td>
</tr>
<tr>
<td>CO2</td>
<td>TPD</td>
<td>550 - 580</td>
</tr>
<tr>
<td>H2O</td>
<td>TPD</td>
<td>570 - 600</td>
</tr>
<tr>
<td>N2</td>
<td>TPD</td>
<td>2650 - 2800</td>
</tr>
<tr>
<td>O2</td>
<td>TPD</td>
<td>150 - 170</td>
</tr>
<tr>
<td>SOx</td>
<td>TPD</td>
<td>12 - 13</td>
</tr>
<tr>
<td>NOx</td>
<td>TPD</td>
<td>2 - 3</td>
</tr>
<tr>
<td>SPM</td>
<td>TPD</td>
<td>0.35 - 0.45</td>
</tr>
<tr>
<td>Liquid Effluent</td>
<td>TPD</td>
<td>240 - 245</td>
</tr>
</tbody>
</table>

### Notes:
2. The above mentioned flue gas composition is indicative and theoretically estimated based on the basis of fuel compositions, optimized proportions of Lignin Rich Wet Biomass Cake, Concentrated Syrup and Rice Husk / Straw.
4. For Dust Emissions mentioned above, Bag Filter is considered as Pollution Control Equipment.
5. The above mentioned flue gas composition is indicative and theoretically estimated based on the basis of fuel compositions, optimized proportions of Lignin Rich Wet Biomass Cake, Concentrated Syrup and Rice Husk / Straw.

---

**Utility & Effluent Summary for EC Submission**

**Client:** Indian Oil Corporation Limited

**Plant:** 100 KLPD Biomass to Ethanol Plant

**Document No.:** Q-ABFC-15-003A1-4-UTES 9001

**Section:** ALL

**Rev. No.:** 0

**Page No.:** Page 1 of 1

**Issue Date:** 16.01.2018

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Typical Raw CO2 Composition From Fermentation

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Moisture</td>
<td>% v/v</td>
<td>1 – 2</td>
</tr>
<tr>
<td>2</td>
<td>Total Hydrocarbon</td>
<td>% v/v</td>
<td>2 – 3</td>
</tr>
<tr>
<td>3</td>
<td>Oxygen</td>
<td>% v/v</td>
<td>3 – 4</td>
</tr>
<tr>
<td>4</td>
<td>Nitrogen</td>
<td>% v/v</td>
<td>7 – 8</td>
</tr>
<tr>
<td>5</td>
<td>CO₂</td>
<td>% v/v</td>
<td>83 – 87</td>
</tr>
</tbody>
</table>
### Overall Solid, CO2 and Steam Balance

**Feedstock: Rice Straw**

- Feedstock: 427.00 Mt/day
- Acid - 1: 13.12 Mt/day
- Acid - 2: 0.44 Mt/day
- Chemical - 1: 6.17 Mt/day
- Chemical - 2: 9.58 Mt/day
- Enzyme: 2.94 Mt/day
- Nutrient - 1: 2.73 Mt/day
- Nutrient - 2: 0.00 Mt/day
- Yeast: 0.00 Mt/day
- Yeast Growth: 7.74 Mt/day
- Molasses: 14.04 Mt/day
- Solid Gain in Reaction: 17.55 Mt/day

**CO2 Balance for Process**

- CO2 from CF: 78.79 Mt/day
- CO2 to Safe location: 78.79 Mt/day

**Steam Balance**

- Direct HP Steam Injection: 17 - 22 TPH
- MP Steam to Process: 14 - 15 TPH
- LP Steam to Process: 12 - 13 TPH
- Steam Condensate: 23.4 - 25.2 TPH
- Losses (10%): 2.6 - 2.8 TPH

**Note:**

1. The water balance is prepared at steady state operation based on the overall mass balance for Rice Straw as a feed stock document Q-ABFC-15-003A1-3-OMEB 9001.
2. The overall mass balance should not be used to design utility, Input/Output consumptions.
3. Exclusion - Sealing water purge and Boiler blowdown, CO2 plant, BioCNG plant, Floor washings, make up water for CF
4. The extraneous matter like sand, mud, stones,etc considered max 0.5% w/w and any metal content must be nil.

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| Sr. No. | Description       | Value (%) | Value (%)
|---------|-------------------|-----------|-----------
| 1       | Silica SiO₂       | 68 – 70   |           |
| 2       | Alumina Al₂O₃     | 0.50 – 1.0|           |
| 3       | Iron Oxide Fe₂O₃  | 1.15 – 1.50|          |
| 4       | Sodium Oxide Na₂O | 4.0 – 6.0 |           |
| 5       | Calcium Oxide CaO | 10-Dec    |           |
| 6       | Copper Oxide CuO  | 0.01 – 0.02|         |
| 7       | Potassium Oxide K₂O | 3.0 – 4.0 |           |
| 8       | Chromium Cr₂O₃    | 0         |           |
| 9       | Bromide Br        | 0         |           |
| 10      | Sulphates As SO₃  | 2.5 – 3.0 |           |
| 11      | Chlorides As Cl   | 5.0 – 5.5 |           |
| 12      | Magnesium Oxide MgO | 5.0 – 6.0 |           |
| 13      | Phosphorous Oxide P₂O₅ | 0.3 – 0.5 |           |
| 14      | Manganese Oxide MnO | 0.1-0.2  |           |
| 15      | Zinc Oxide ZnO    | 0.03-0.04 |           |
| 16      | Vanadium Pentoxide V₂O₅ | 0.01     |           |
| 17      | Titanium TiO₂     | 0.02 – 0.03|         |