

3 STUDY BASIS

3.1 Production goals of the refinery

SERESCO is studying the feasibility of expanding the Refinery, and the associated utilities to support a capacity of 400 m³/h (60,000 barrels per day of crude oil processing, BPSD). The primary concept is to maximize light oil production while minimizing the production of heavy residue.

HQCEC has contracted KBC to obtain an assessment of future market and market pricing. The market study results have been used as the basis of study.

3.2 Feeds and Products Definition

The refinery would use crude oil from neighboring countries with rich crude resource to produce high quality transportation fuels.

3.2.1 Crude Slates

Five different crudes were considered as feeds to the refinery. The five crudes are:

- VASCONIA (API 25.2, Colombia)
- MESA (API 27.9, Venezuela)
- PENNINGTON (API 33.8, Nigeria)
- MARLIM LIGHT (API 22.8, Brazil)
- CASTILLA (API 18.5, Colombia)

The reports of crude assays for the five crudes were run through H/CAMS, presented in attachments 1 to 5.

Attachment 1 is VASCONIA crude assay.

Attachment 2 is MESA crude assay.

Attachment 3 is PENNINGTON crude assay.

Attachment 4 is MARLIM light crude assay.

Attachment 5 is CASTILLA crude assay.

Table3.2-1 Basic Properties of Five Crudes

Items	Unit	VASCONIA	MESA	PENNINGTON	MARLIM LIGHT	CASTILLA
		VASEC2001	MESA1990	PNGTN338	MARLM228	CASTI190
API°		25.2	27.9	33.8	22.8	18.5
Specific Gravity	20/4 °C	0.8991	0.8837	0.8520	0.9132	0.9395
Pour Point	°C	-9	-26	2	-45	-28
Conradson Carbon	wt%	7.30	5.29	0.46	5.39	13.51
TAN	mgKOH/g	0.06	0.03	0.22	0.74	0.06
S	wt%	1.02	0.79	0.111	0.72	2.00
N	ppm, wt	2702	1700	598	3608	4080
Fe	ppm, wt	3.6	1.3	2.5	15.9	12.7
V	ppm,wt	115.3	60.541	0.16	22.13	356.1
Ni	ppm,wt	57	13.681	1.67	15.42	81.11
TBP Distillation, m%	HK~85°C	3.50	3.66	4.00	1.95	4.36
	85~165°C	8.23	9.43	15.84	6.95	11.37
	165~230°C	7.30	9.80	14.65	7.44	4.91
	230~350°C	21.01	22.12	38.35	17.81	14.07
	350~530°C	29.38	28.06	21.67	32.88	26.19
	>350°C	59.54	54.58	26.84	65.36	65.07
	>530°C	30.16	26.51	5.17	32.49	38.88
Chemical Class		Intermediate	Intermediate	Naphthenic	Intermediate	Naphthenic

Table3.2-2 Basic Properties of Atmospheric Residue

Items	Unit	VASEC2001	MESA1990	PNGTN338	MARLM228	CASTI190
		>350°C	>350°C	>360°C	>350°C	>350°C
Yield	m%	59.54	54.58	26.81	65.36	65.07
Specific Gravity	20/4 °C	0.9736	0.9626	0.9386	0.9702	1.0274
Viscosity (100°C)	cst	83.4	39.6	13.8	75.6	2038.8
Conradson Carbon	w%	9.99	9.69	1.73	8.24	20.76
C	w%	86.24	86.87	87.12	87.4	85.6
H	w%	11.2	11.9	12.1	11.5	10.7
S	w%	1.546	1.114	0.254	0.909	2.776
N	w%	4515	3107.8	2172.4	5473.1	6247.4
Asphaltene	w%	6.8	6.5	0	3.0	18.5

Items	Unit	VASEC2001	MESA1990	PNGTN338	MARLM228	CASTI190
		>350℃	>350℃	>360℃	>350℃	>350℃
Metal Content, μg/g	Ni	81.7	25.067	7.39	23.584	124.48
	V	170.4	110.929	2.615	33.845	546.502

Table3.2-3 Basic Properties of Vacuum Residue

Items	Unit	VASEC2001	MESA1990	PNGTN338	MARLM228	CASTI190
Yield	m%	30.16	26.51	5.17	32.49	38.88
Specific Gravity	20/4 ℃	1.0283	1.0212	0.9843	1.0068	1.0785
Viscosity (100℃)	cst	5.80E+04	1699.9	335.5	2024.5	3.70E+07
Conradson Carbon	w%	19.72	19.95	8.79	16.51	34.37
C	w%	86.70	88.11	87.36	86.58	85.49
H	w%	10.2	9.9	11.2	11.1	10.3
S	w%	2.058	1.381	0.382	1.012	3.417
N	w%	7687	5085.7	6106.3	8822.2	9233.4
Asphaltenes	w%	13.5	13.3	0.1	6.1	30.9
Metal Content, μg/g	Ni	161.4	51.6	39.08	47.428	207.9
	V	336.4	228.346	13.96	68.06	913.35

3.2.2 Product Slate

In the LP model, the refinery was allowed to produce the following products:

- LPG
- Gasoline (s 30ppm , RON 91and 95)
- Jet / Kero
- Diesel (cetane number 51, s 15ppm)
- HSFO (380 cSt, 1.0 % S)
- Coke
- Sulfur

There were no limitations on product production, but diesel, Jet fuel and gasoline are the top three products. Basis for operation is 8,400 hours of operation per year.

3.2.3 Feed and Product Prices

Crude and product prices are used in the initial optimization efforts (LP model) which are shown in Table 3.2-4 and Table 3.2-5. This is based on project start-up in year 2015 (KBC price; nominal dollar of 2015)

Table3.2-4 Crude Oil Price

CIF Crude (\$/mt)	bbl/mt(from KBC's report)	2015 (\$/bbl)	2015 (\$/mt)
Mesa	7.106	108.52	771.13
Vasconia	6.887	102.76	707.74
Pennington	7.364	114.08	840.07
Marlim Light	6.74	103.37	712.00
Castilla	6.655	101.34	678.45
Ethanol	7.9691	122.32	974.79

Table3.2-5 Products' Prices

Product	Density(kg/l)	bbl/mt	2015 (\$/bbl)	2015 (\$/mt)
95 Super, New	0.745	8.44295	121.65	1,027.08
91 Regular, New	0.73	8.61644	117.39	1,011.48
Jet kerosene	0.78	8.0641	124.99	1,007.92
Diesel, New	0.83	7.57831	127.22	964.08
Fuel Oil 1%S	0.93	6.76344	99.73	674.51
Fuel Oil 2.2%S	0.93	6.76344	93.83	634.58
LPG	0.53	11.8679	84.41	1,001.83
Sulphur				46.01
Coke				115.58

3.2.4 Product Specifications

3.2.4.1 Following are LPG product specifications used for the screening phase of the study

Table3.2-6 LPG Specification (from Products Manual, 2009)

Properties	Average	Minimum	Maximum	Specification limit	Method
Density, at 15°C (kg/m ³)		550	734.00	Report	ASTM-1657
REID Vapour Pressure at 37.8°C (kPa)	896		1300.00	Max 1430.0	ASTM-1267

Properties	Average	Minimum	Maximum	Specification limit	Method
Temperature of fraction at 95% evaporated (°C)			37.20	Max 37.2	ASTM-1837
Residue volume of fraction by evaporation (cm ³)	0.00	-2.20	0.10	Max 0.5	ASTM-2158
Thermal expansion coefficient of gas (10 ⁶ /°C)	1012.03	1000	1100.00	No applied	

3.2.4.2 Regular Gasoline

Table3.2-7 Regular Gasoline Specification

Characteristics	Units	ASTM Met.	Values
Additives	----	----	Report
Color	----	Visual Orange	
Lead Content	G Pb/L	D-3237	0.013max
Corrosion, copper strip, 3h,50°C		D-130	N°1 max
Stability for oxidation, Decomposition Time	Minutes	D-525	240min
Total Sulphur	%mass	D-2622	0.10 max
Doctor's Test or Mercaptanes(sulphur)	%mass	D-4952 D-3227	Negative 0.003 max
REID Vapor Pressure at 37.8°C	KPa(psi)	D-323	69(10)max
API Gravity at 15.56°C(60°F) or Density at 15°C	°API kg/m ³	D-287 D-1298	Report Report
Gums(Solvent Washing)	Mg/100mL	D-381	4max
Distillation		D-86	
10% recovered	°C		65 max
50% recovered	°C		77-121
90% recovered	°C		190 max
Final Boiling Point	°C		225 max
Residue	%volume		2 max
Octane Number:			
RON (Clear)		D-2699	91.0 min
Octane Index			
(RON+MON)/2		D-2699 D-2700	87.0 min

Characteristics	Units	ASTM Met.	Values
Aromatics	%volume	D-1319	Report
Olefins	%volume	D-1319	Report
Benzene	%volume	D-3606	Report
Oxygen	%volume	D-4815	Report
CHANGES EXPECTED IN NEAR FUTURE			
Property	Values		
Total sulphur	0.003%mass		
Clear Octane	91		
(RON+MON)/2	87 min		
Aromatics	35% volume		
Olefins	10-20% volume		
Benzene	1.0% vol max.		

3.2.4.3 Super Gasoline

Table3.2-8 Super Gasoline Specification

Method Characteristics	Units	ASTM	Value
Additives	-----	-----	Report
Colour	-----	Visual Orange	
Lead Content	g Pb/L	D-3237	0.013 max.
Corrosion, copper strip, 3 h, 50°C	-----	D-130	N ^o 1 max.
Stability for oxidation			
Decomposition Time	Minutes	D-525	240 min.
Total Sulphur	% mass	D-2622	0.10 max.
Doctor's Test	-----	D-4952	Negative
or Mercaptanes (Sulphur)	% mass	D-3227	0.003 max.
REID Vpaur Pressure at 37.8°C	Kpa (psi)	D-323	69 (10) max.
API Gravity at 15.56°C (60 °F)	^o API	D-287	
Or Density at 15°C	kg/m ³	D-1298	Report
Gums (Solvent Washing)	mg/100 mL	D-381	4 max.
Distillation			
10% recovered	°C	D-86	65 max.
50% recovered	°C		77-121
90% recovered	°C		190 max.
Final Boiling Point	°C		225 max.

Method Characteristics	Units	ASTM	Value
Residue	% volume		2 max.
Octane Number			
RON	-----	D-2699	95.0 min.
Octane Index (RON + MON)/2	-----	D-2699y D-2700	91.0 min.
Aromatics	% volume	D-1319	Report
Olefins	% volume	D-1319	Report
Benzene	% volume	D-3606	Report
Oxygen	% volume	D-4815	Report
CHANGES EXPECTED IN NEAR FUTURE			
Total Sulfur	0.003% mass		
Clear Octane	95		
Aromatics	35% volume		
Olefins	10-20% volume		
Benzene	1.0% vol max		

3.2.4.4 Jet-A1

Table 3.2-9 Jet-A1 Specification (Issue 24-1st October 2008)

Property	Limits
Appearance	
Visual	Clear, bright and visually free from solid matter and undissolved water at ambient temperature
Colour	Report
Particulate contamination, mg/l max	1.0
Particulate, at point of manufacture, cumulative	
Channel particle counts ISO Code	
≥4 μ m(c)	Report
≥6 μ m(c)	Report
≥14 μ m(c)	Report
≥21 μ m(c)	Report
≥25 μ m(c)	Report
≥30 μ m(c)	Report
COMPOSITION	
Total Acidity, mg KOH/g max	0.0015

Property		Limits
Aromatics, %vol.	max	25.0
OR Total Aromatics, %vol.	max	26.5
Sulphur, Total, %mass	max	0.30
Sulphur, Mercaptan, %mass		0.0030
OR Doctor Test		Negative
Hydroprocessed components in batch, %vol.		Report (incl. `nil` or `100%`)
Severely Hydroprocessed components in batch, %vol.		Report (incl. `nil` or `100%`)
VOLATILITY		
Distillation		
Initial Boiling Point, °C		Report
Fule Recovered		
10% vol. at °C	max	205.0
50% vol. at °C		Report
90% vol. at °C		Report
End Point, °C	max	300.0
Residue, %vol.	max	1.5
Loss, %vol.	max	1.5
Flah Point, °C	min	38.0
Density at 15°C, kg/m ³		775.0 (min), 840.0 (max)
FLUIDITY		
Freezing Point, °C	max	-47.0
Viscosity at -20°C, cst (mm ² /s)	max	8.000
COMBUSTION		
Specific Energy,net,MJ/kg	min	42.80
Smoke Point, mm	min	25.0
OR Smoke Point, mm	min	19.0
AND Naphthalenes, %vol.	max	3.00
CORRSION		
Crosion,Copperstrip,classification (2hour ±5min.at100°C ±1°C)	max	1
STABILITY		
Thermal Stability (JFTOT)		
Control temperature, °C	min	260
Filter Pressure Differential, mmHg	max	25.0

CHARACTERISTICS	UNITS	METHOD ASTM	VALUES
or Residue of carbon			
Ramsbottom in 10% residue	%wt	D-524	0.13 max
Water and Sediments	%volume	D-2709	0.05max
Flash Point	°C	D-93	52 min
Gravity API at 15.56°C(60 F)	°API	D-287	Report
or density at 15°C	kg/m3	D-1298	
Pour Point	°C	D-97	Report
Cloud Point	°C	D-2500	10 max©
Viscosity at 40°C	mm2/s(f)	D-445	1.9-4.1
Distillation:			
10% recovered	°C	D-86	Report
50% recovered	°C		Report
90% recovered	°C		360 max
Final Boiling Point	°C		Report
Aromatics	% volume	D-1319	Report(g)
CHANGES EXPECTED IN NEAR FUTURE			
Total Sulfur	15 ppm S		
Cetane number	51		
Aromatics	20%		
Lubricity	0.46 mm		

3.2.4.6 Fuel oil

Table3.2-11 Fuel oil Specification

Property	Units	Value	ASTM Test Method
Flash Point	°C	72 min	D-93
Water and Sediment	% vol.	1.0 max	D-2709
Kinematic Viscosity at 50°C	SSF	300 max	D-445
Pour Point	°C	Report(max.15°C)	D-97
Sulfur	% mass/mass	2.2(Current N° 6)/ 1.0max(future)	D-2622
Density @ 15°C	Kg/m3	Report	D-1298

Ash	% mass	0.2 max	D-482
Conradson Carbon Residue	% mass	20 max	D-524

3.2.4.7 Coke (Chinese standard)

Table3.2-12 Coke (Chinese standard, SH 0527-92) Specification

ITEM	CHARACTERISTICS							METHOD
	PRIMES	ACCEPTABLE						
		1A	1B	2A	2B	3A	3B	
S, % \nlessgtr	0.5	0.5	0.8	1.0	1.5	2.0	3.0	GB/T387
volatiles, % \nlessgtr	12	12	14		17	18	20	SH/T0026
Ash, % \nlessgtr	0.3	0.3	0.5			0.8	1.2	SH/T0029
Moisture, % \nlessgtr	3							SH/T0032
Actual Density, g/cm ³	2.08~2.13	Report						SH/T0033
Fine coke content (Particle Size <8mm) \nlessgtr	25	Report						Note A
Si, % \nlessgtr	0.08							SH/T0058
V, % \nlessgtr	0.015							SH/T0058
Fe, % \nlessgtr	0.08							SH/T0058

Notes: If the sulfur content in the coke is more than 3.0%, the coke is normally used as fuel mixed with coal.

3.2.4.8 Sulfur (Chinese standard)

Table3.2-13 Sulfur (Chinese standard, GB/T 2449-2006) Specification

Items	Quality		
	Class 1	Class 2	Class3
Purity, %wt \geq	99.9	99.5	98.5
Acidity (based on H ₂ SO ₄), %wt \leq	0.005	0.01	0.03
Organic material, %wt \leq	0.05	0.30	0.80
Ash content, %wt \leq	0.04	0.20	0.40
Arsenic, %wt \leq	0.001	0.02	0.05
Iron, %wt \leq	0.003	0.005	-
Water, % (m) \leq	0.10	0.50	1.00

3.3 Financial Analysis Assumptions

The cost estimate for all ISBL processes, utility systems, and tank farm are included in the LP model. The following is a list of financial analysis assumptions included in the LP model:

- Construction span: 3 years
- Evaluating life: 23 years
- Depreciation: 15 years
- Fixed assets salvage value: 10% of original value of fixed assets
- Income Tax exempt
- Personnel salary and overhead : 23000 thousand US\$ per year
- Maintenance cost: 3% of fixed assets
- Discount Rate: 12%

3.4 Crude Assay Attachments

- Attachment 1-VASC02001
- Attachment 2-MESA1990
- Attachment 3-PNGTN338
- Attachment 4-MARLM228
- Attachment 5-CASTI190