REFINERY CALC
WE REFINE COMPLEXITY

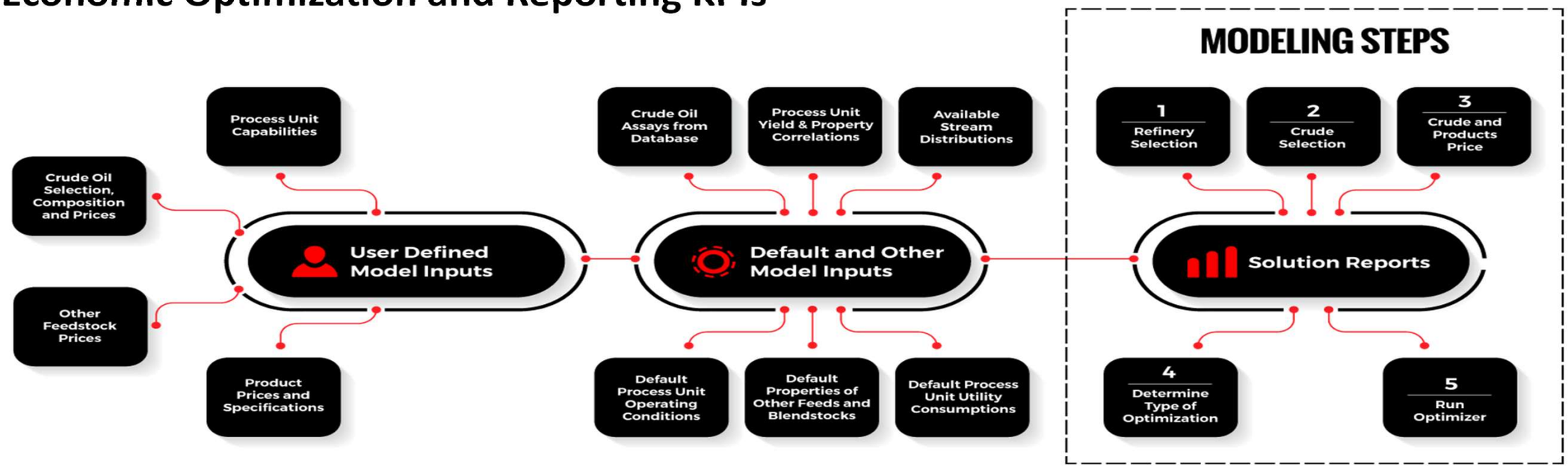
Prepared for: Monroe Energy (**Delta**)

Comparative Study and Analysis of Delta's Monroe Energy Trainer Refinery by the Refinery Calc Team on behalf of IIR

4/25/2020

Objectives

- **Use the Refinery Calculator to Model Delta's Trainer Refinery**
- **Provide various outputs from the model simulation to Monroe Energy**
  - **Product Yields**
  - **Energy Consumption**
  - **Hydrogen Balance**
  - **Optimized Crude Slate Analysis**
  - **Economic Optimization and Reporting KPIs**



Assumptions

- The Refinery Calc Team utilized the EIA's 2019 configuration for the Trainer Refinery
- Used only publicly available information except for IIR's latest downtime information for the Trainer Refinery
- Used EIA and other sources for pricing of crudes and products

Trainer Refinery EIA Configuration

Delta Trainer EIA Capacity (bbls/d)		
1	TOTAL OPERABLE CAPACITY	208,000
2	VACUUM DISTILLATION	73,000
3	ALKYLATES	12,000
4	AROMATICS	-
5	ASPHALT & ROAD OIL	-
6	CAT CRACKING: FRESH FEED	53,000
7	CAT CRACKING: RECYCLED FEED	-
8	CAT HYDROCRACKING, DISTILLATE	23,000
9	CAT HYDROCRACKING, GAS OIL	-
10	CAT HYDROCRACKING, RESIDUAL	-
11	CAT REFORMING: HIGH PRESSURE	-
12	CAT REFORMING: LOW PRESSURE	50,000
13	DESULFURIZATION, DIESEL FUEL	53,300
14	DESULFURIZATION, GASOLINE	34,000
15	DESULFURIZATION, HEAVY GAS OIL	-
16	DESULFURIZATION, KEROSENE AND JET	23,300
17	DESULFURIZATION, NAPHTHA/REFORMER FEED	80,000
18	DESULFURIZATION, OTHER	-
19	DESULFURIZATION, OTHER DISTILLATE	-
20	DESULFURIZATION, RESIDUAL	-
21	FUELS SOLVENT DEASPHALTING	-
22	HYDROGEN (MMCFD)	28
23	IDLE CAPACITY	-
24	ISOMERIZATION (ISOBUTANE)	-
25	ISOMERIZATION (ISOPENTANE/ISOHEXANE)	-
26	LUBRICANTS	-
27	OPERATING CAPACITY	208,000
28	PETCOKE,MARKET	-
29	SULFUR (SHORT TONS/DAY)	90
30	THERM CRACKING, DELAYED COKING	-
31	THERM CRACKING, FLUID COKING	-
32	THERM CRACKING, OTHER (INCLDNG GAS OIL)	-
33	THERM CRACKING, VISBREAKING	-

Product Pricing - EIA

Product ($/gal) unless noted	
Asphalt (Resid)	$ 0.25
Benzene	$ 0.92
Propane	$ 0.40
Butane	$ 0.56
Coke ($/1000 lbs)	$ 4.00
Gas Oil	$ 0.25
H2 Fuel ($/mmbtu)	$ 1.79
H2 Prod ($/mmbtu)	$ 2.18
Heating Oil	$ 0.71
Heavy Fuel Oil	$ 0.49
Kerosene	$ 0.70
Lubricant Oils	$ 0.92
Naptha	$ 0.58
Natural Gas ($/mmbtu)	$ 1.81
Pitch ($/ston)	$ 0.20
Premium Gasoline	$ 0.70
Regulary Gasoline	$ 0.61
Refinery Gas ($/mmbtu)	$ 1.79
Sour Diesel	$ 0.49
Sulfur ($/1000 lbs)	$ 8.00
Ultra Low Sulfur Diesel	$ 0.73
Xylene	$ 0.85

Assumptions

Model Capacity(bbls)		Bias	Model Capacity	Feed Rates	IIR
Naph HT	80,000	0	80,000	36,495	45,000
Reformer	50,000	0	50,000	35,506	36,750
Kero HT	23,300	-5,000	18,300	11,985	10,125
Dist HT	76,300	0	76,300	49,969	
GO HT	0	0	0	0	
FCC	53,000	0	53,000	39,256	37,500
Hydrk	0	0	0	0	
Lubes	0	0	0	0	
Coker	0	0	0	0	
SDA	0	0	0	0	
Resid	0	7,200	7,200	7,200	
Alky	12,000	0	12,000	5,964	9,000
Sulf tons	90	0	90	68	60
Gas HT	34,000	-33,999	1	1	0
Aromatics	0	0	0	0	0
Isom	0	0	0	0	0
Crude	208,000	0	208,000	150,656	151,500
Vacuum	73,000	0	73,000	27,486	36,500
H2 mm	28	0	28	0	
HydrkRsd	0	0	0	0	

Distillate includes Dist HT and Dist Hydrk

EVENT_ID	EVENT_KIND	UNIT_NAME	U_CAPACITY	CAP_OFFLINE	CAP_UOM	Running
511800	T	Crude 543 (Sweet)	101000	25250	BBL/d	75750
511802	T	Crude 544 (Sweet)	101000	25250	BBL/d	75750
511808	T	FCCU	50000	12500	BBL/d	37500
511809	T	Gasoline Hydrotreater (Tier 3)	0	0	BBL/d	0
511810	T	HF Alky	12000	3000	BBL/d	9000
511803	T	Heating Oil HT	4200	1050	BBL/d	3150
511811	T	Heavy Cat Naphtha Hydrotreater	28000	7000	BBL/d	21000
511804	T	Isocracker	24000	6000	BBL/d	18000
511812	T	Jet Fuel Hydrotreater	13500	3375	BBL/d	10125
511805	T	Naphtha Hydrotreater	60000	15000	BBL/d	45000
511817	T	Platformer CCR	49000	12250	BBL/d	36750
511813	T	SRU Train 1	40	10	T/d	30
511814	T	SRU Train 2	40	10	T/d	30
511815	T	Sour Water Stripper				0
511821	T	VGO Hydrotreater (Cat Feed Unit)	40000	10000	BBL/d	30000
511822	T	Vacuum 541	24334	6083.5	BBL/d	18250.5
511818	T	Vacuum 544	24333	6083.25	BBL/d	18249.75

- (Right) IIR provided “off line” capacity
- (Left) Refinery Calc Model Setup

Results: Feedstocks

Crude Selection	Crude No	Table No			Max	Min
Light	183	2	WTI	0.98	0.98	0.001
Intermediate 1	2	4	ArabLt	0.001	0.15	0.001
Intermediate 2	20	9	Brent	0.001	0.15	0.001
Intermediate 3	15	5	Isthmus	0.001	0.15	0.001
Heavy	159	16	WTS	0.017	0.9	0.001
				1		
	Crude Rate		**150,656.1**			

The model preferred to run predominantly WTI (to maximize profit) given the refinery's configuration

Summary Report	Delta	Trainer		Pa		
		mmscfd//	m b/d	MW//API	mLbs	m$/d
$15.90	Crude		150.7	39.75	43,569.7	$2,396.13
$15.90	Crude Adj		0.0	39.75	5.0	$0.28
$0.56	Butane		2.15	110	441.8	$50.67
$2.18	Purch H2		0.00	2	0.00	$0.00
$0.79	Tol		0.0	31.9	0.00	$0.00
$0.95	Gas Oil		0.0	19.39	0.0	$0.00
	Total		152.8		44,016.5	$2,447.08

- Feeds table showing crude feedstock pricing and total pricing

Results: Economics

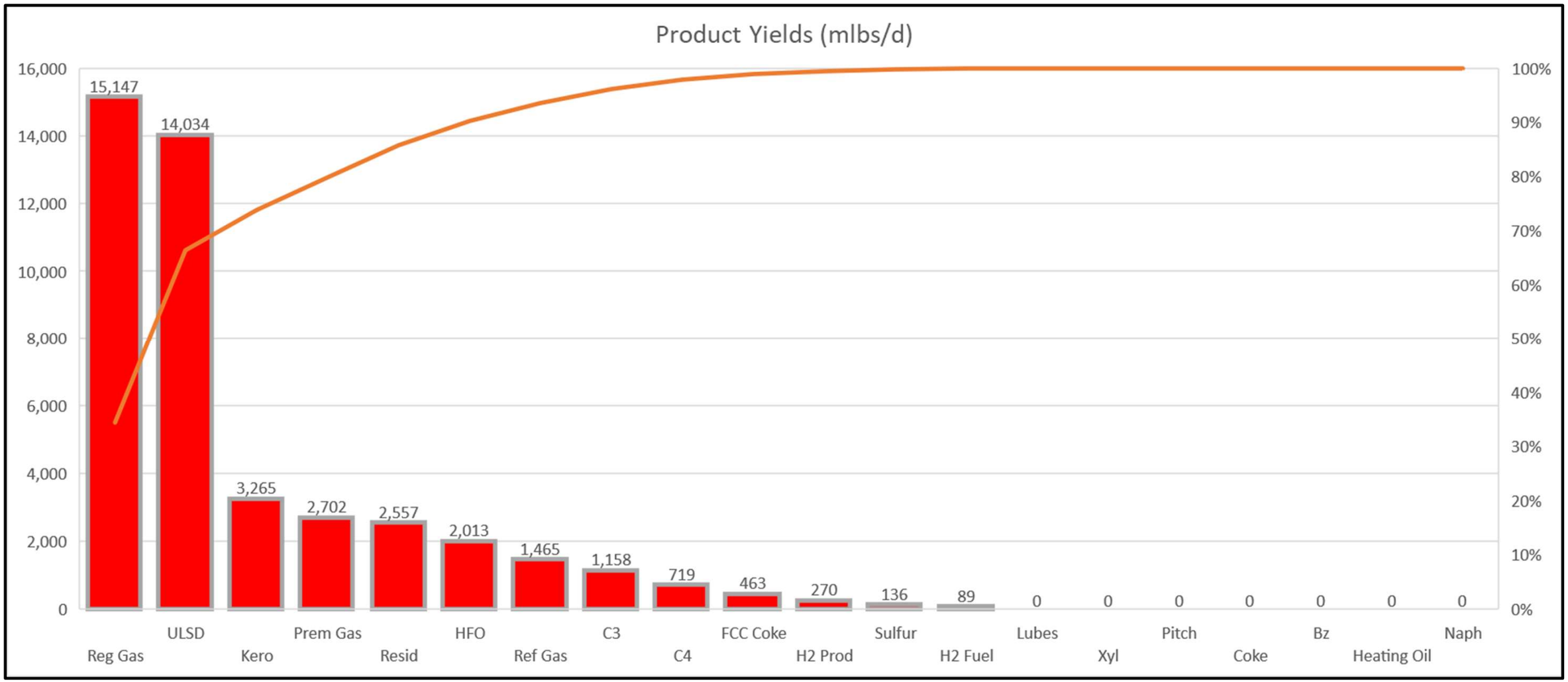
	mmscfd//mb/d	MW//API	mLbs	v%	w%	m$/d
Ref Gas	28.65	19.38	1,465		3.3%	$61.28
H2 Prod	51.2	2	270			$111.57
H2 Fuel	16.9	2	89		0.2%	$10.36
C3	6.35	140	1,158	4.2%	2.6%	$106.69
C4	3.51	110	719	2.3%	1.6%	$82.45
Reg Gas	57.90	57.8	15,147	38.4%	34.4%	$1,483.38
Prem Gas	10.22	55.8	2,702	6.8%	6.1%	$301.04
Kero	11.55	43.7	3,265	7.7%	7.4%	$339.65
ULSD	48.05	38.1	14,034	31.9%	31.9%	$1,473.10
Heating Oil	0.00	38.1	0	0.0%	0.0%	$0.00
HFO	5.59	6.17	2,013	3.7%	4.6%	$114.67
Resid	7.2	7.9	2,557	4.8%	5.8%	$74.54
Lubes	0.00	24.4	0	0.0%	0.0%	$0.00
Bz	0.00	30.0	0	0.0%	0.0%	$0.00
Xyl	0.00	31.0	0	0.0%	0.0%	$0.00
Pitch	0.00	-1.45	0	0.0%	0.0%	$0.00
Naph	0.0	58.20	0	0.0%	0.0%	$0.00
Sour Distillate	(0.001)	37.06	-0.3	0.0%	0.0%	-$0.04
Coke			0		0.0%	1.28E-05
Sulfur			136		0.0031	0.5434
FCC Coke			463		1.1%	
Total	150.37		44,016.5			
	99.8%		**100.0%**	99.8%	99.4%	$4,159.25

	m$/d	$/b
GRM	$1,712.17	$11.36
Exp	$451.42	$3.00
Profit	**1,260.7**	**$8.37**

Cash Flow Internal Rate of Return		
Profit	$460.17	mm$/y
Depr	4	10 years
Tax	28%	New Tax Rate
Project Life	15	Years
Construction	24	Months
Salvage	5%	
Capital	$1,439.55	mm$
IRR	22.5%	

- Very ‘tight’ weight balance 99.4% (99.8% by volume)
- Revenue > $4MM/day
- Profit > $1.26 MM/day *may not be that high due to diesel most likely being blended with resid

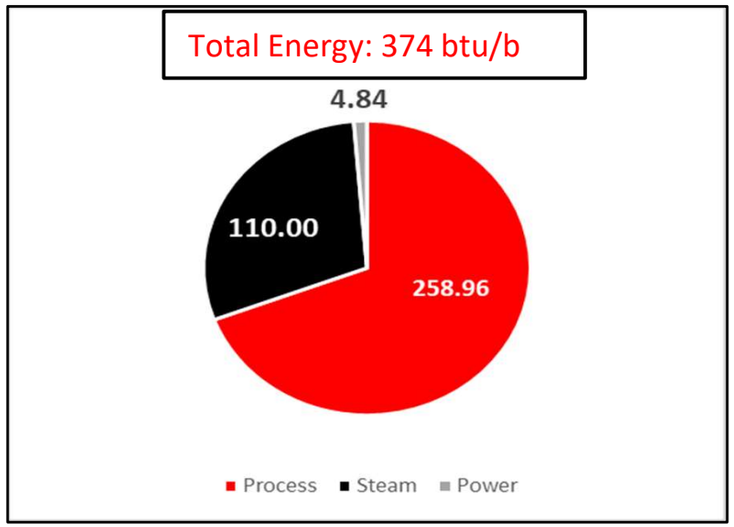
Results: Product Yields



Results: Energy and Hydrogen KPIs

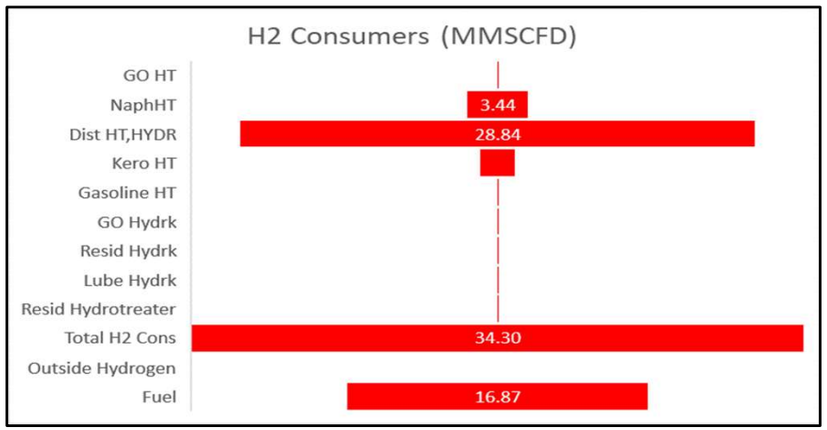
Enery Usage	
Fuel mmbtu/h	1,381.74
Steam mlbs/h	690.5
Power mw-h	30.36

Energy	btu/b crude
Process	258.96
Steam	110.00
Power	4.84



Hydrogen Production	mb/d	scf/b	mmscf/d
Reformer	35.51	1,441.3	51.2

Hydrogen Cons	mb/d	scf/b	mmscfd
GO HT	0.00	398.6	0.00
NaphHT	36.49	94.2	3.44
Dist HT,HYDR	49.97	577.2	28.84
Kero HT	11.98	168.3	2.02
Gasoline HT	0.00	175.4	0.00
GO Hydrk	0.000	1,415.1	0.00
Resid Hydrk	0.000	1,207.5	0.00
Lube Hydrk	0.00	969.2	0.00
Resid Hydrotreater	0.00	703.4	0.001
Total H2 Cons			34.30
Outside Hydrogen			0.00
Fuel	33%		16.87
Balance			51.17



- Solid energy efficiency in comparison to similar sized refineries (top quartile)

- 0 over the fence hydrogen required given the sweet crude and sufficiently sized Reformer

Conclusions

- Using the Refinery Calculator to Model Delta's Trainer Refinery… here's what we found
- The Trainer Refinery is limited by "bottom's processing", which reduces crude feedstock flexibility
- Despite the unit outages and offline crude capacity, the Refinery Calc model showed that the refinery was very close to running at an optimized state
- Simulation time: 32 seconds
- Weight balance > 99.3%
- Unknowns:
  - Actual crudes Trainer is running
  - Actual crude pricing Trainer is paying
  - Contractual Product pricing and qtys.
  - Actual maintenance costs
  - Actual labor costs
  - Actual yield correlations for process units
  - Actual crude oil transportation costs
  - Loss of diesel fuel due to blending with resid

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Lubes	0	0	0	0	
Coker	0	0	0	0	
SDA	0	0	0	0	
Resid	0	7,200	7,200	7,200	
Alky	12,000	0	12,000	5,964	9,000
Sulf tons	90	0	90	68	60
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Distillate includes Dist HT and Dist Hydrk

- "Feed Rates" column is what the Refinery Calc Model predicted that the Delta Refinery should run at to optimize profitability
- Compare to "IIR" provided actual unit rates shows very close agreement

Next Steps

- Here are the different offerings that Refinery Calculator can do
  - We have tons of data and information from each simulation…
  - What is most useful type of information to a refiner's business analyst, process engineer, crude/economics planner?
  - If you could have additional information what would it be? Unit expansion analysis? Debottlenecking analysis? What – if scenarios?
  - Sustainability Analysis?
  - Advanced unit optimization?
  - Real time modeling and dashboards?
  - Energy assessment?
  - Additional model runs changing cut points?

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- **We create value for our clients by allowing them to use an easy web based on-line refining simulation model (or our off-line model)**
- **We can perform thousands of complex simulations over the cloud at lightning fast speeds**
- **We enable users of our Refinery Calculator with the ability to generate and then download various reports with ease and simplicity**
- **We are based out of Houston Texas and our team has over 150 years of combined refining and petrochemical experience**
- **We developed our proprietary model over a course of 15 years and have validated against some of the world's largest-most complex refineries**