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San Diego, CA

AM-08-33 LC-FINING Options for Heavy Oil Upgrading

Presented By:

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Representations

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Chevron Lummus Global (CLG) uses a proprietary Bitumen Linear Programming (LP) Model for screening of process configurations during early scouting work.

The LP program was developed and tuned for Bitumen operations by CLG's Manager of Process Planning, Gary Sieli

Dr. Nash Gupta provided the reactor kinetics for the Bitumen Model

Please note:

The information contained in this presentation is not representative of CLG's licensee's actual upgrading operations in Alberta, Canada. This information is only meant to be typical of what a new operator could consider in early planning studies of bitumen upgrading.

The ISO Family of CLG Licensed Technologies for Fuels:

ISOCRACKING	Distillate Hydrocracking
ISOTREATING	Naphtha & Distillate Hydrotreating
ISOFINING	Mild Residue Hydrocracking
LC-FINING	Residue Hydrocracking
UFR	Residue Up Flow Reactor
OCR	On-line Catalyst Replacement
RDS	Residue Desulfurization
VRDS	Vacuum Residue Desulfurization

Intent of this presentation

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- **Provide example configurations of CLG residue hydrocracking units producing synthetic crude oil (SCO) from 200,000 BPSD of Steam Assisted Gravity Drainage (SAGD) Athabasca bitumen.**
- **Compare these example configurations to newly proposed cases where solvent deasphalting (SDA) is deployed for residue gasification as a source of hydrogen, CO2 and fuel for SAGD recovery and upgrading of bitumen to synthetic crude oil (SCO).**
- **Look at incremental VGO hydrocracking as a source of higher quality SCO in today's market**

Comparison of Heavy Crudes

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Heavy Crude	Arab Heavy	Orinoco	Athabasca (SAGD)	Maya
Gravity, API	27.9	8.0	8.4	22
Sulfur, wt%	2.9	3.6	4.9	3.6
Nitrogen, wppm	1700	6700	5400	2200
Vanadium, wppm	57	500	175	275
Nickel, wppm	18	120	65	50
CCR, wt%	8	17	13	11.5

Operating CLG Licensed Bitumen Units in Canada

CLG
Chevron Lummus Global

Syncrude
Securing Canada's Energy Future

PETRO-CANADA

The Athabasca Oil Sands Project
Shell Chevron Western Oil Sands

SUNCOR

ISO/LC-FINING Units BPD (3)	130,000
ISOCRACKING Units BPD (2)	52,000
ISOTREATING Units BPD (2)	105,000
Operating CLG Units BPD (7)	287,000

CLG Licensed Bitumen Units Under EP&Construction in Canada

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ISO/LC-FINING Units	74,000	BPD (2)
ISOCRACKING Units	108,000	BPD (2)
ISOTREATING Units	245,000	BPD (3)
New CLG Units	427,000	BPD (7)
Total CLG Units	714,000	BPD (14)

Schematic of CLG's Ebulated Bed Reactors for Residue Hydrocracking

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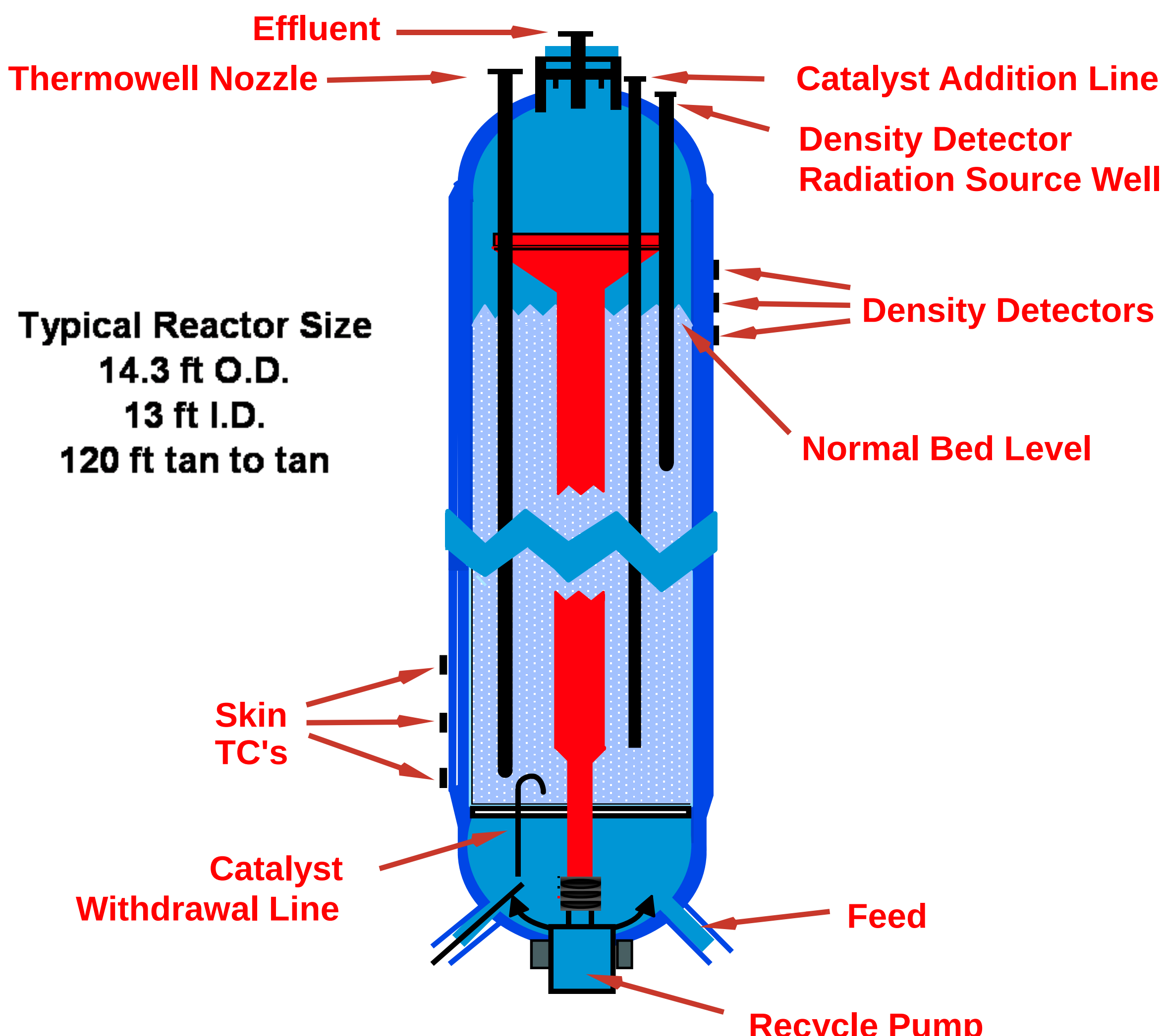

Current ISOFINING/LC-FINING Configurations

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ISOFINING Configuration

- Operating at Syncrude since 1985
- Mild Residue Hydrocracking

  (~60% 975 F conversion)
- Single Stage Ebulated Bed Reactors feeding atmospheric residue with two or more reactors in parallel per train

LC-FINING Configuration

- Operating at Shell Canada since 2003
- Moderate Residue Hydrocracking

  (~75+% 975 F conversion)
- Two or more stages of Ebulated Bed Reactors in series feeding vacuum residue with each train having at least two reactors

Bitumen Atmospheric Distillation

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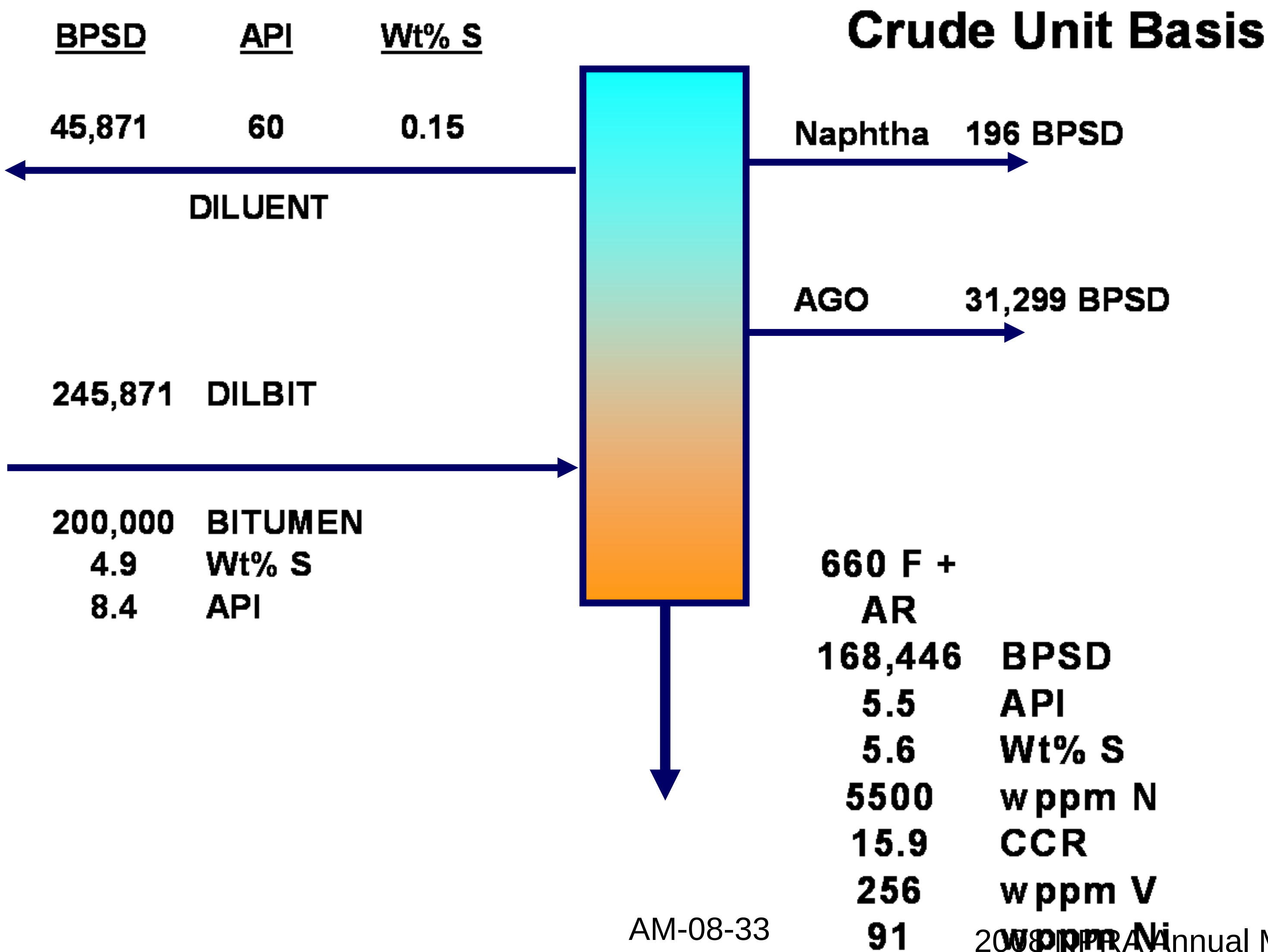

Bitumen Vacuum Distillation

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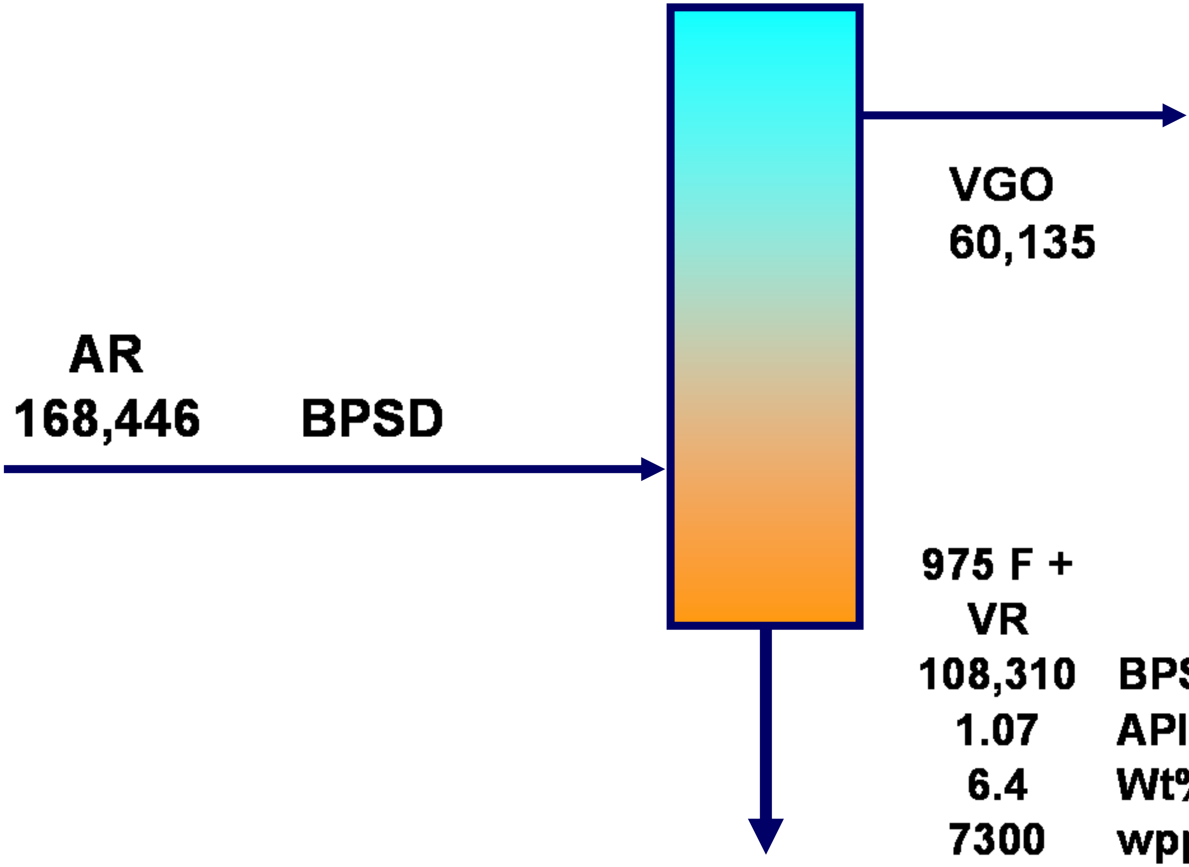

ISOFINING Configuration for Synthetic Crude Oil (SCO)

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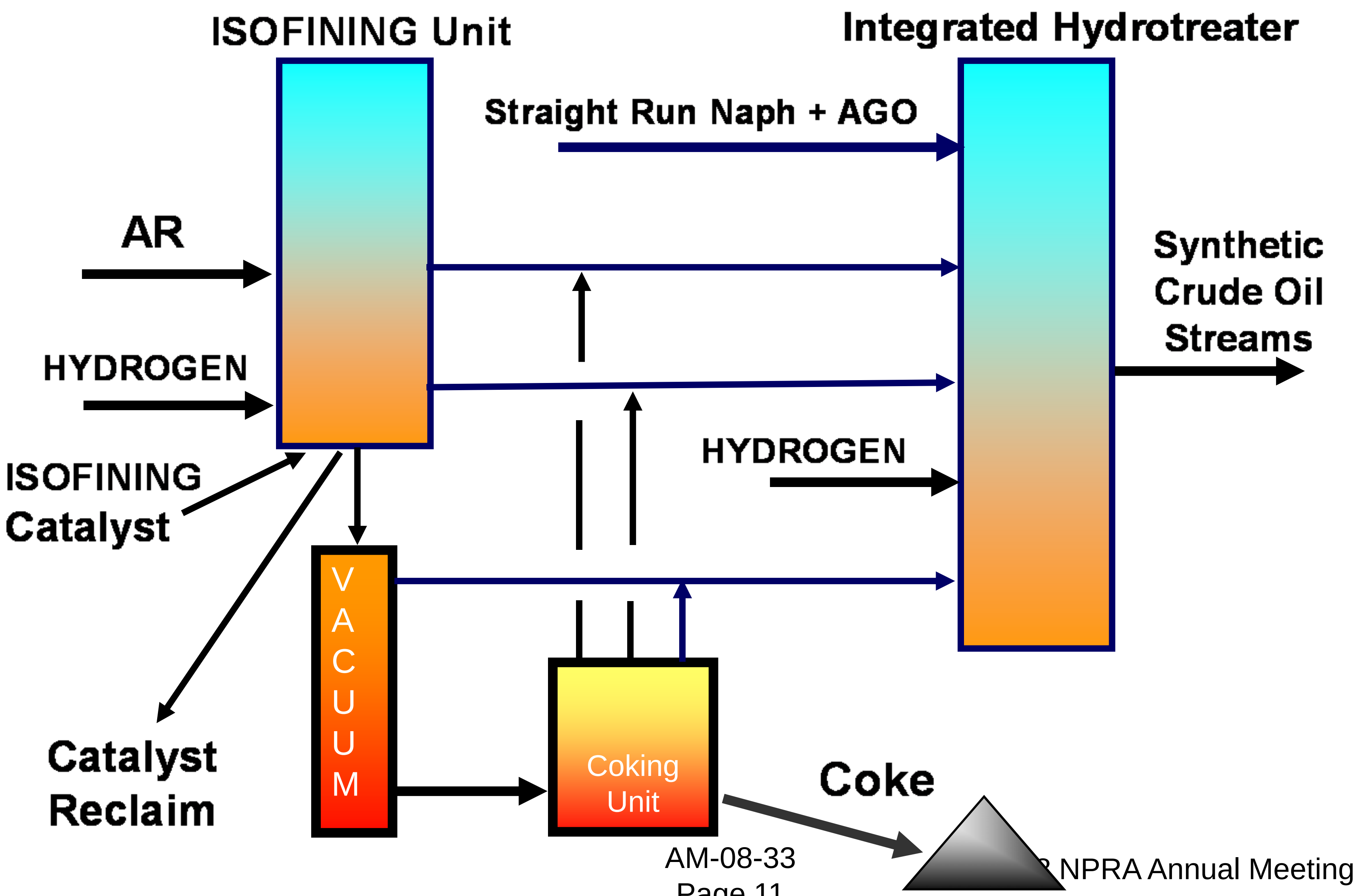

ISOFINING Streams for Synthetic Crude Oil (SCO)

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Item	Butane	Naphtha	Kero	Diesel	VGO	Resid	SCO
BPSD	3,457	34,515	28,714	67,605	68,298	0	202,587
API		66.8	39	31	22		35.3
Wppm S		5	36	21	400		200
Wppm N		4			100		
Smoke, mm			16				
Cetane Number				42			

Example ISOFINING to SCO Blending

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LC-FINING Configuration for Synthetic Crude Oil (SCO)

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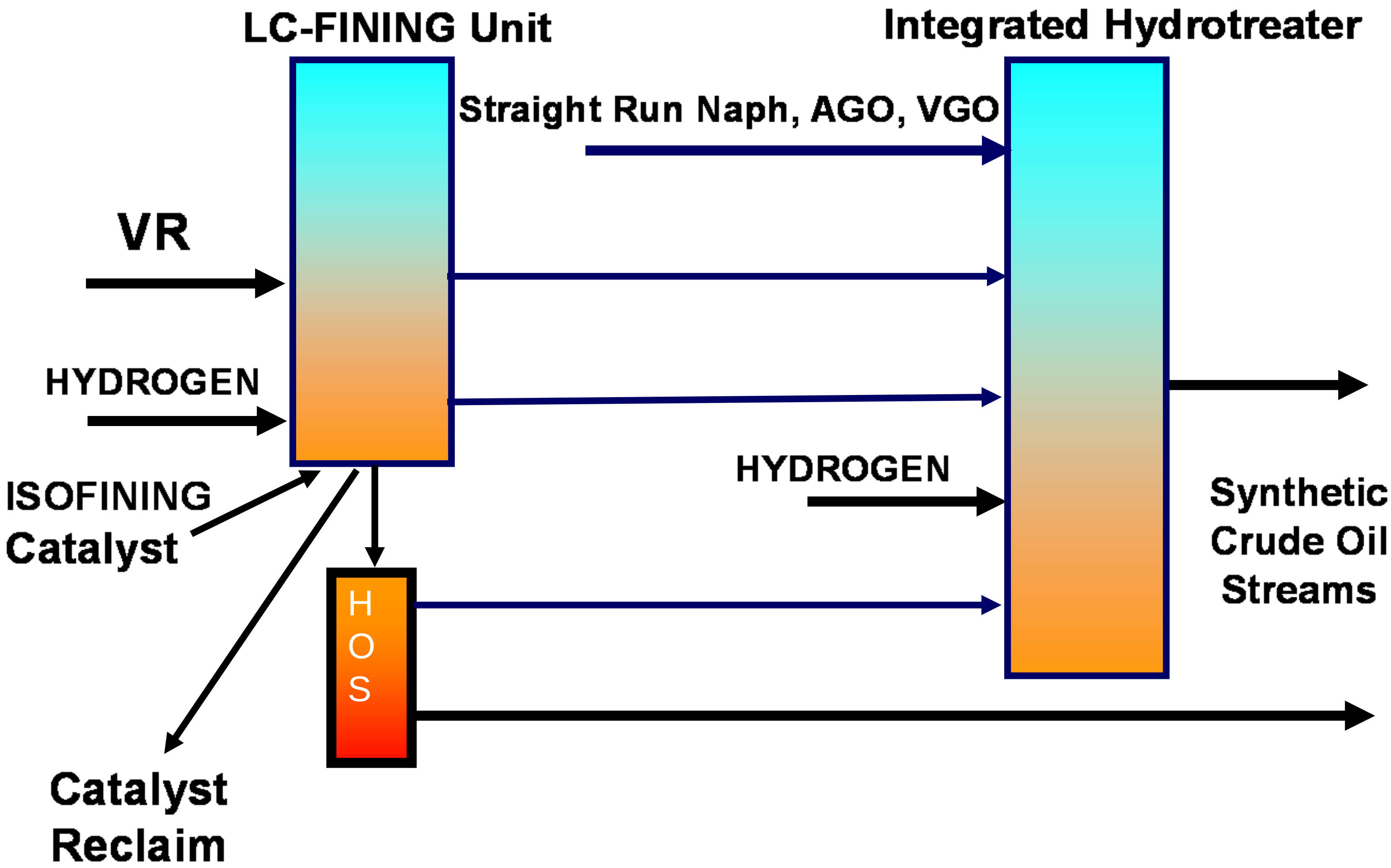

LC-FINING Streams for Synthetic Crude Oil (SCO)

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Item	Butane	Naphtha	Kero	Diesel	VGO	Resid	SCO
BPSD	3,508	29,289	27,470	53,819	81,376	21.468	216,932
API		63.1	43	33	20.1		28.6
Wppm S		5	35	26	3300		5000
Wppm N		5			860		
Smoke, mm			18				
Cetane Number				47			

Example LC-FINING to SCO Blending

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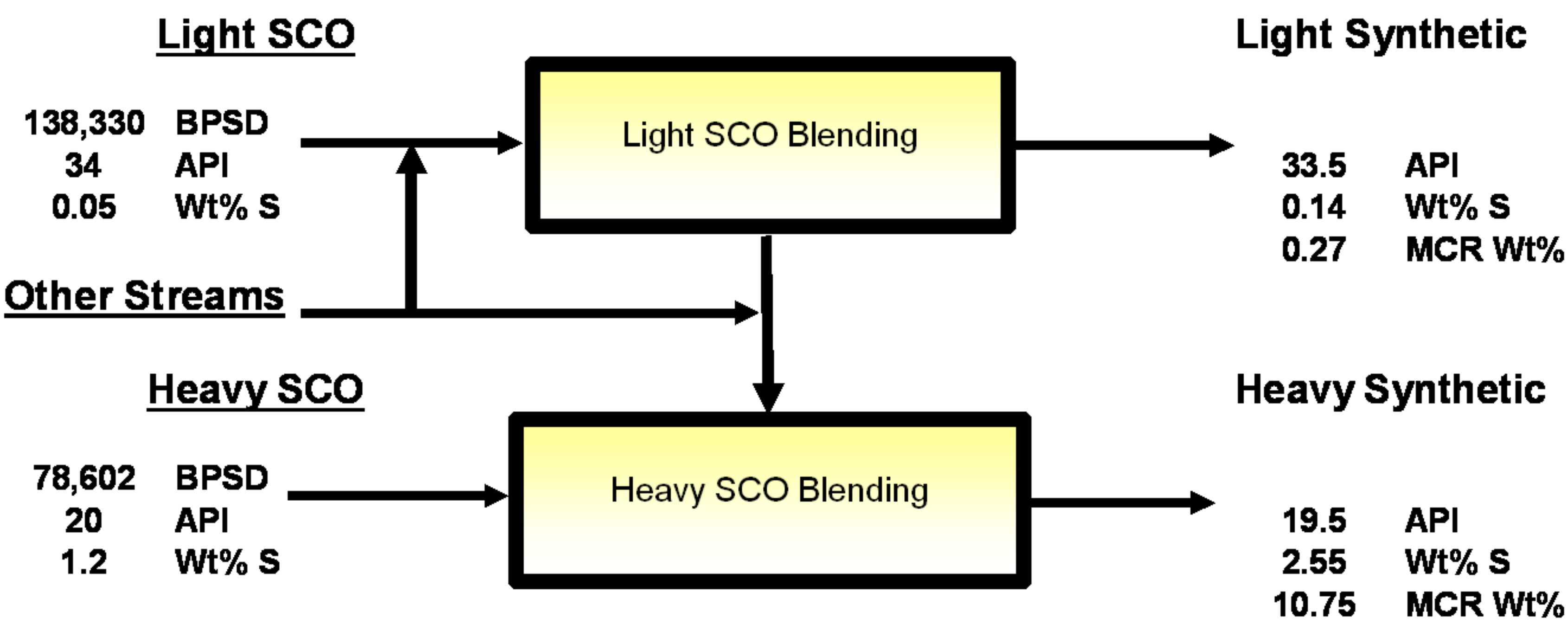

Hydrogen Production for Both ISOFINING and LC-FINING Cases

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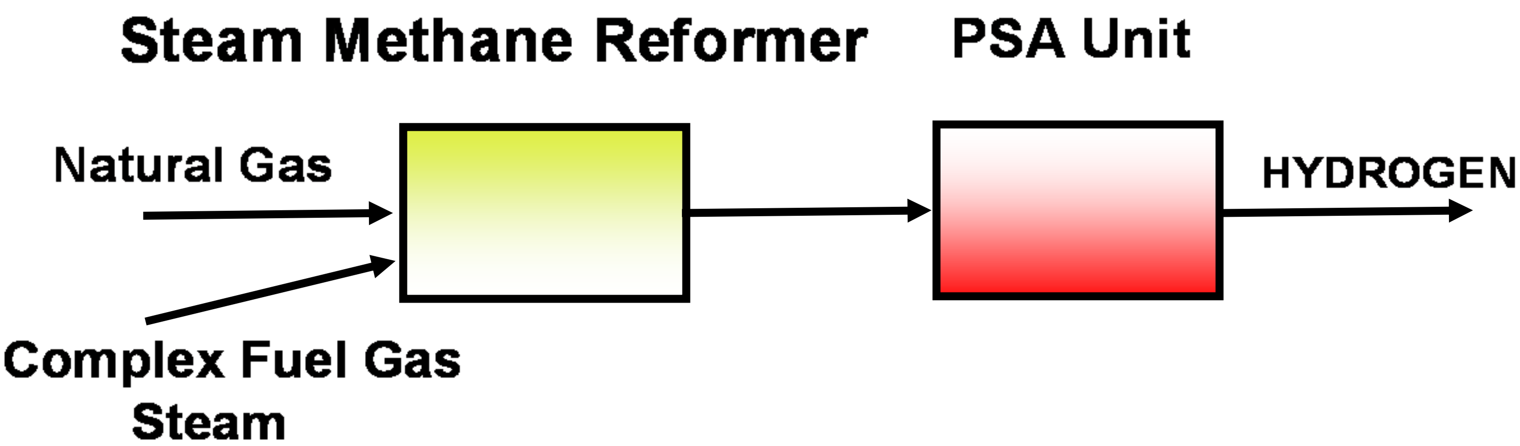

Configuration	Purchased Natural Gas MMSCFD	Feed Hydrogen, MMSCFD
ISOFINING	76	352
LC-FINING	79	329

Add Solvent Deasphalting (SDA) to LC-FINING Configuration

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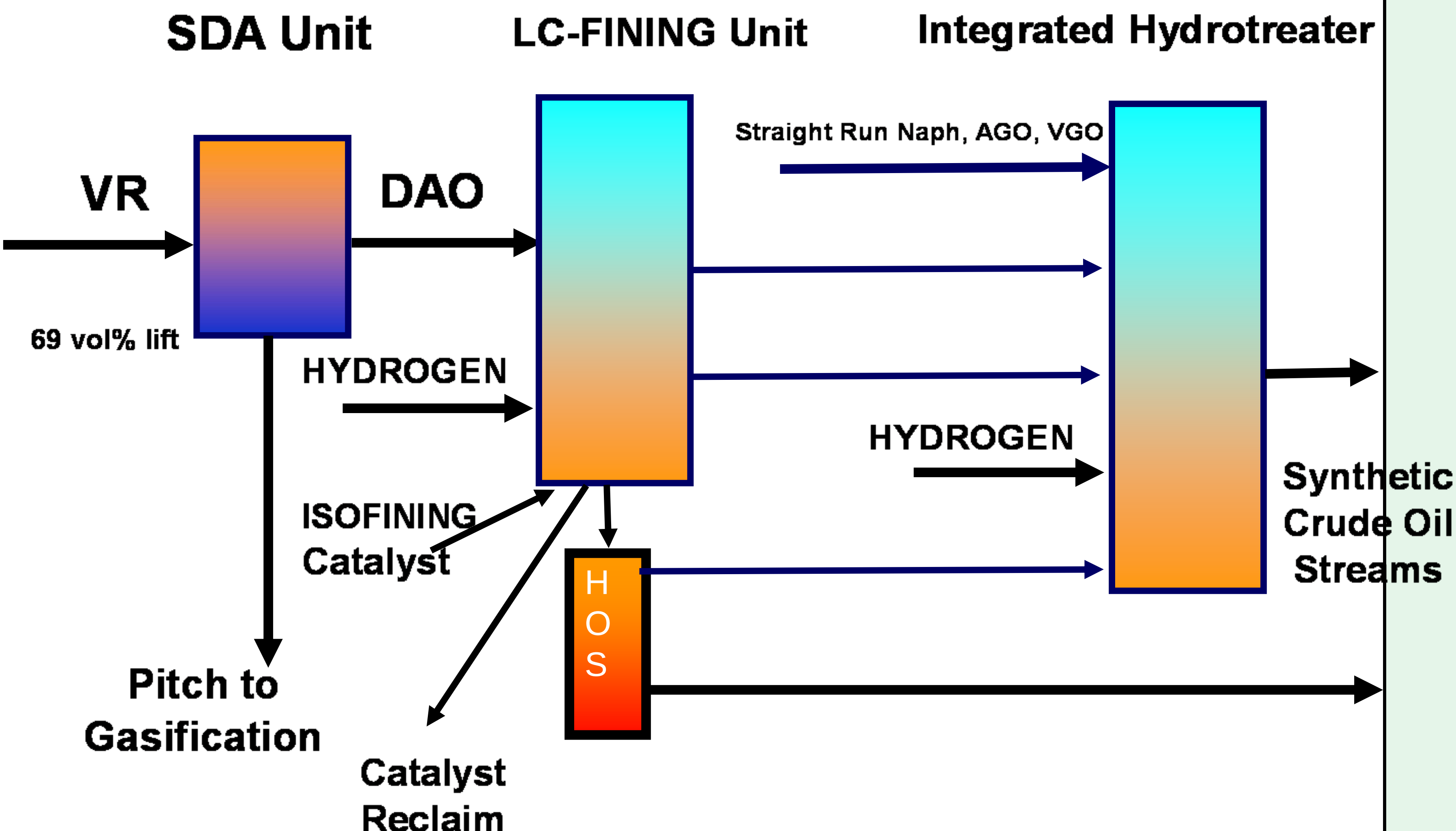

Add SDA to LC-FINING for Synthetic Crude Oil (SCO)

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Item	Butane	Naphtha	Kero	Diesel	VGO	Resid	SCO
BPSD	3,098	22,951	21,225	46,725	73,204	8,494	175,697
API		64.1	40	32	17.6		29.4
Wppm S		6	32	21	4600		4100
Wppm N		5			1400		
Smoke, mm			17				
Cetane Number				46			

Example SDA + LC-FINING to SCO Blending

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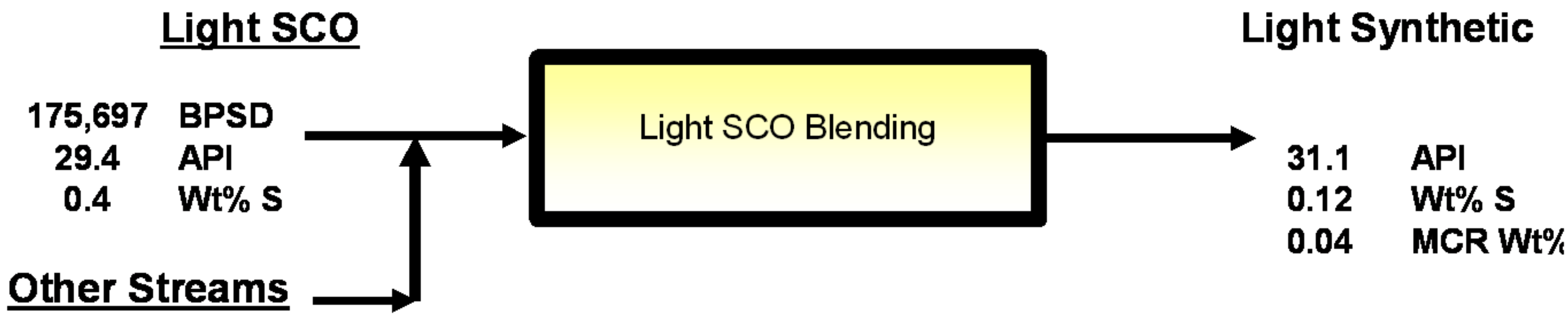

Hydrogen From Gasification add SDA to LC-FINING

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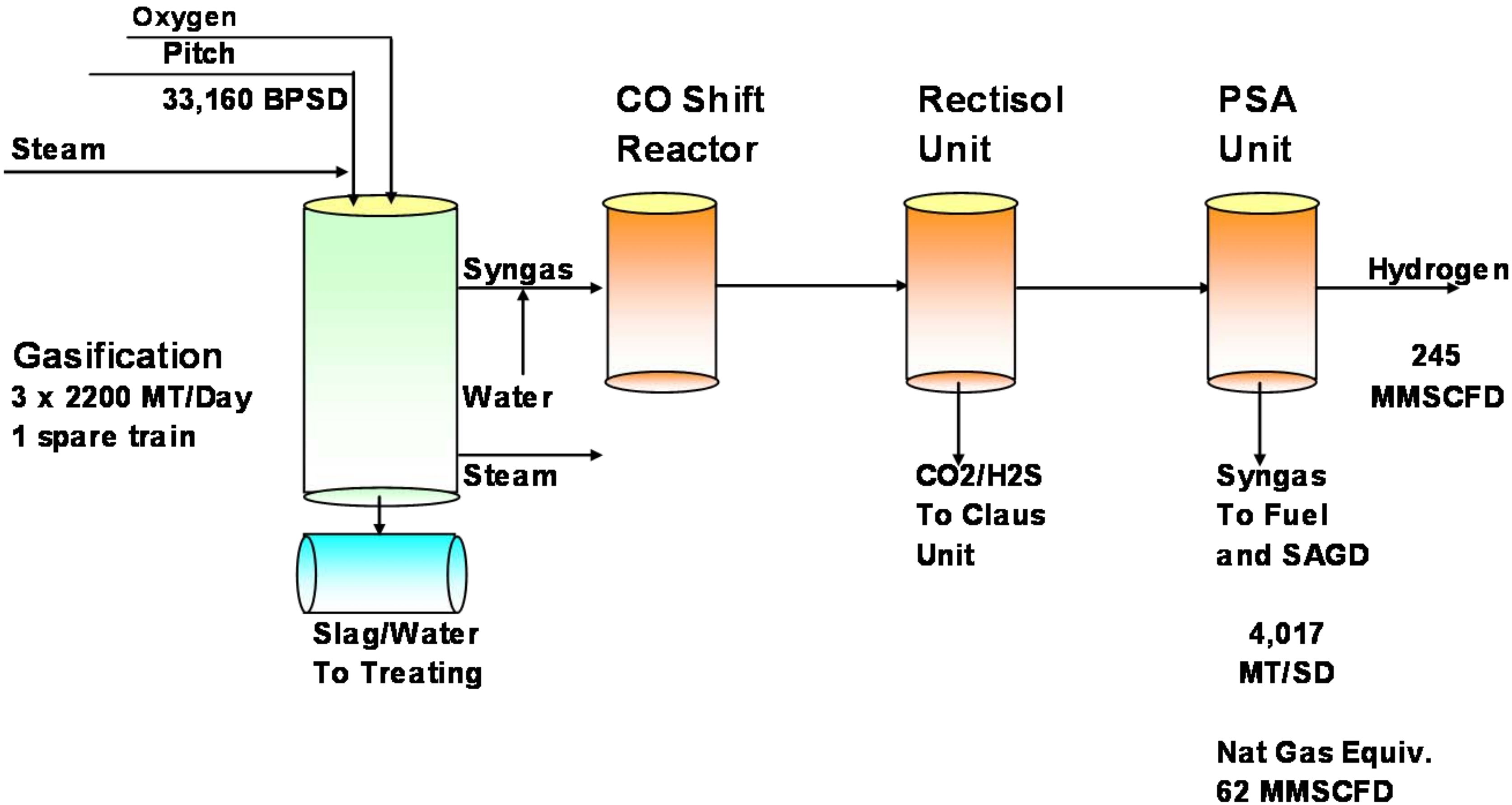

Add Hydrocracking and SDA to LC-FINING Configuration

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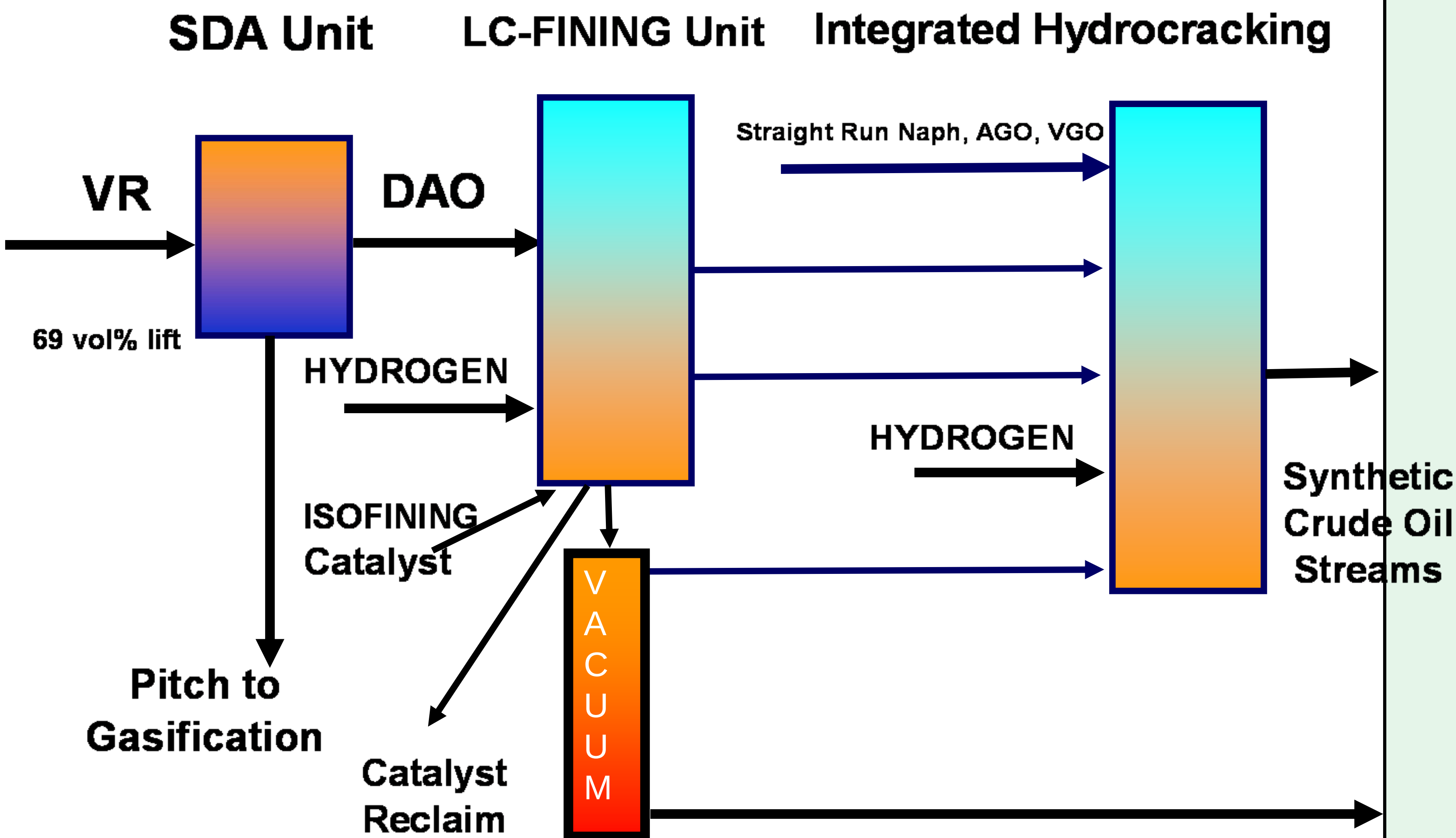

Add HCK + SDA to LC-FINING for Synthetic Crude Oil (SCO)

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Item	Butane	Naphtha	Kero	Diesel	VGO	Resid	SCO
BPSD	4,741	47,708	31,647	41,100	50,831	8,494	184,525
API		58.4	46	35	26.7		37.3
Wppm S		4	42	55	600		2200
Wppm N		2			400		
Smoke, mm			19				
Cetane Number				49			

Example HCK+ SDA + LC-FINING to SCO Blending

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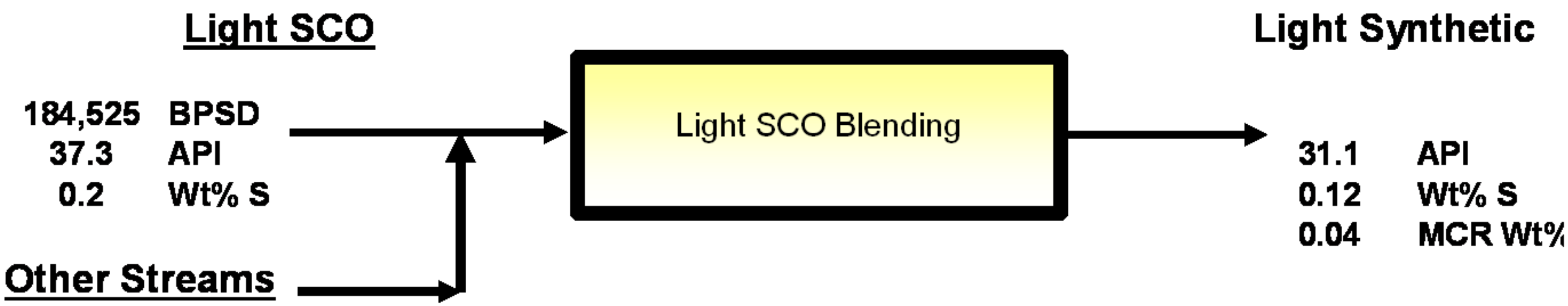

Hydrogen From Gasification add HCK, SDA to LC-FINING

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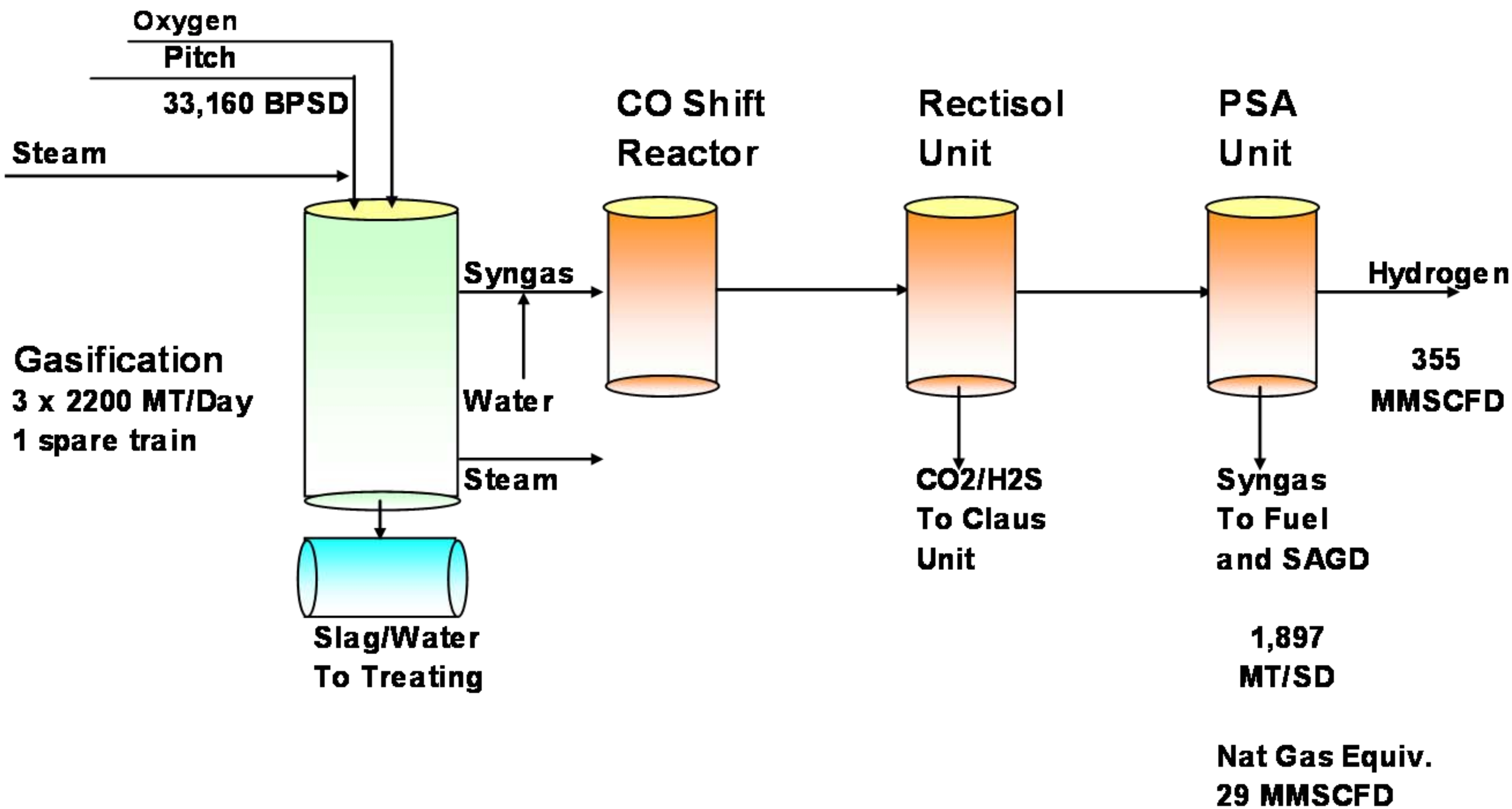

LC-FINING Options for 200,000 BPSD Bitumen Upgrading - Summary

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Item	ISOFINING	LC-FINING	Add SDA	Add HCK
SCO, BPSD	202,567	216,932	175,697	184,525
API	35.3	28.6	29.4	37.3
Wt% S	0.1	0.5	0.4	0.2
H2, MMSCFD	352	329	245	355
Power, MW	99	101	199	229
Nat. Gas MMSCFD	76	79	(62)	(29)

Summary: Bitumen LP Model

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- **The Bitumen LP Model is well suited for conceptual studies of grass roots upgrading facilities or for revamping refineries for heavy Canadian crude oils using LC-FINING, coking or SDA**
- **Model includes all normal process units, scalable offsites, utilities, capital cost vectors and economic constraints**
- **Cost escalation in Alberta has driven upgrading capital costs to 50,000 – 70,000 $/BPSD range somewhat independent of processing scheme.**
- **SDA + Gasification of heavy residues is one option under consideration to mitigate natural gas price escalation due to the decline in Canadian gas production. Options to concentrate CO_2 gas for enhanced oil recovery may also be evaluated in the Model**