

# Feedstock Characterization and Model Reformulation for SIGMA-FCC in EcoPetrol

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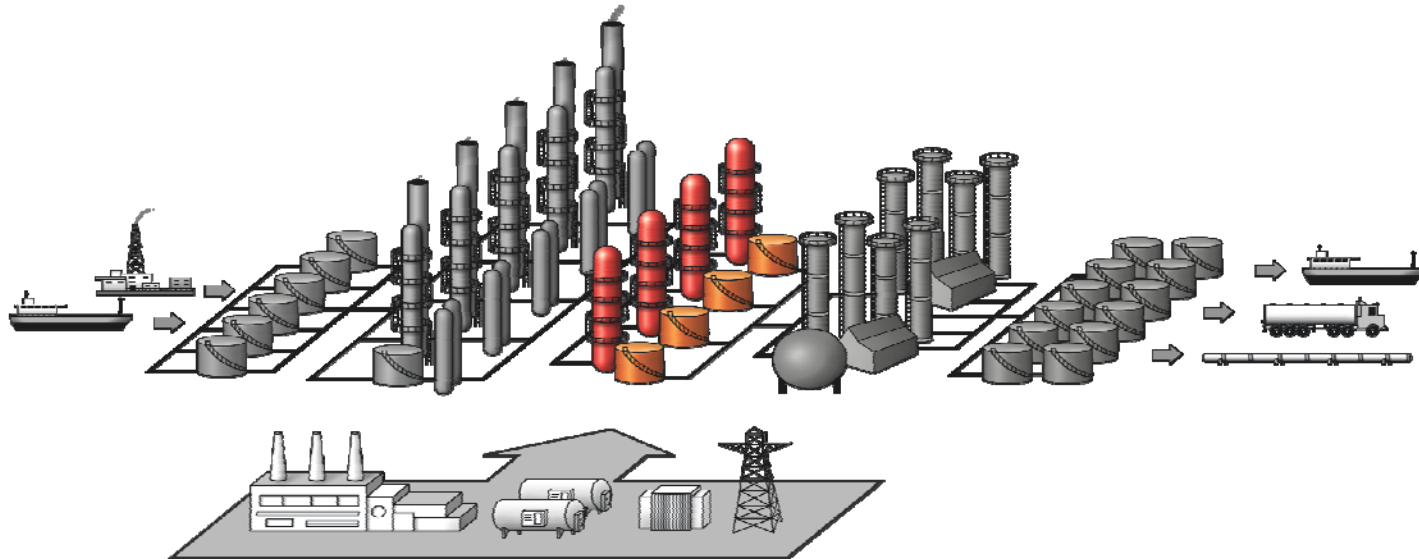
**Updated for**

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# Process Landscape



Two Scheduling and Planning Problems are formulated:

SP-RCSA

SP-GRB

## NLP Solver Failed on site in EcoPetrol

Solver performance (ECOPETROL's refineries)			
RCSA			
CONOPT			IPOPT
**** SOLVER STATUS	1 Normal Completion		**** SOLVER STATUS 3 Resource Interrupt
**** MODEL STATUS	2 Locally Optimal		**** MODEL STATUS 6 Intermediate Infeasible
**** OBJECTIVE VALUE	541.9985		**** OBJECTIVE VALUE 0
RESOURCE USAGE, LIMIT	0.109, 1000.000		RESOURCE USAGE, LIMIT 1000.216, 1000.000
GRB			
CONOPT			IPOPT
**** SOLVER STATUS	1 Normal Completion		**** SOLVER STATUS 3 Resource Interrupt
**** MODEL STATUS	2 Locally Optimal		**** MODEL STATUS 6 Intermediate Infeasible
**** OBJECTIVE VALUE	1592.2608		**** OBJECTIVE VALUE 0
RESOURCE USAGE, LIMIT	18.081, 1000.000		RESOURCE USAGE, LIMIT 1000.435, 1000.000
Note: Computer Info: Intel(R) Pentium(R) Dual CPU T2390 @ 1.86GHz (CPU:0). 2,00 GB de RAM			
GAMS version : 23.5.2			
Ipopt version: 3.8stable, running with linear solver mumps			

## Parameter Auto-Tuning (PAT) Solved Successfully at CMU

Solver performance (ECOPETROL's refineries)			
RCSA			
	Default		Tuned
Objective	532.0365		541.9985
Dual infeasibility	1.04E+02		3.15E-08
Constraint violation	2.41E-05		9.09E-13
Complementarity	6.55E-06		1.94E-12
Solver status	Maximum of Iterations Exceeded		Optimal Solution Found
Number of Iterations	3.00E+03		8.80E+01
Total CPU secs	52.84		2.25

Solver performance (ECOPETROL's refineries)			
GRB			
	Original GRB with Default Parameter Settings		Scaled GRB with Tuned Settings
Objective	1003.1108		1595.7305
Dual infeasibility	1.92E+00		6.21E-07
Constraint violation	1.16E-06		5.19E-12
Complementarity	3.86E-05		1.01E-10
Solver status	Maximum of Iterations Exceeded		Optimal Solution Found
Number of Iterations	3.00E+03		9.36E+02
Total CPU secs	969.35		170.14

# Why the problems are so difficult to be solved

## Dependent Constraints Exist

	#var	#con	#depcn	#iter (standard trick)	#iter (improved method)
SP-RCSA	833	772	~5	515, restoration phase failed	75, optimal solution found
SP-GRB	5176	4702	~70	3000, max num of iters exceeded	399, optimal solution found

## Improvement of the Algorithm

- Original Newton's method

$$\begin{bmatrix} W_k + \Sigma_k & A_k \\ A_k^T & 0 \end{bmatrix} \begin{bmatrix} d_k^x \\ \lambda_{k+1} \end{bmatrix} = - \begin{bmatrix} \nabla \varphi_k \\ c_k \end{bmatrix}$$

- Trick of current Ipopt

$$\begin{bmatrix} W_k + \Sigma_k & A_k \\ A_k^T & -\delta_c I \end{bmatrix} \begin{bmatrix} d_k^x \\ \lambda_{k+1} \end{bmatrix} = - \begin{bmatrix} \nabla \varphi_k \\ c_k \end{bmatrix} \quad + \quad \begin{bmatrix} \text{PAT} \\ \end{bmatrix}$$

- Improved method

$$\begin{bmatrix} W_k + \Sigma_k & A_k \\ A_k^T & \begin{bmatrix} -M_c I \\ 0 \end{bmatrix} \end{bmatrix} \begin{bmatrix} d_k^x \\ \lambda_{k+1} \end{bmatrix} = - \begin{bmatrix} \nabla \varphi_k \\ c_k \end{bmatrix}$$

## Conclusions

- Two scheduling and planning problems are formulated by Eco petrol.
- The problems could not be solved successfully on site.
- PAT technique is introduced and the problems are solved successfully.
- It is dug out that because of dependent constraints (Jacobian with deficit rank) the problems were difficult to be solved.
- Improved Algorithm added to Ipopt can solve the problems with dependent constraints.