JM Planning and Optimisation
JMPO Consulting Pty Ltd

Oil Refinery Optimisation using Linear Programming (LP)

Example training module 2

This module is suitable for those with limited or no Linear Programming (LP) knowledge and are curious how LP technology is used in the refining industry.

This module builds on the graphical technique of module 1 and expands the use of a simple Excel based refinery LP.

Contents

- Learning Outcomes
- The Simplex Algorithm
- LP problem setup in Excel
- Matrix Algebra
- Solution with Excel Solver
- LP Marginal Values
  - Definition
  - Excel Solver example
  - Worked Example for using Marginal Values

Included in this sample

Remainder of the training module (not incl in the sample)

Learning Outcomes

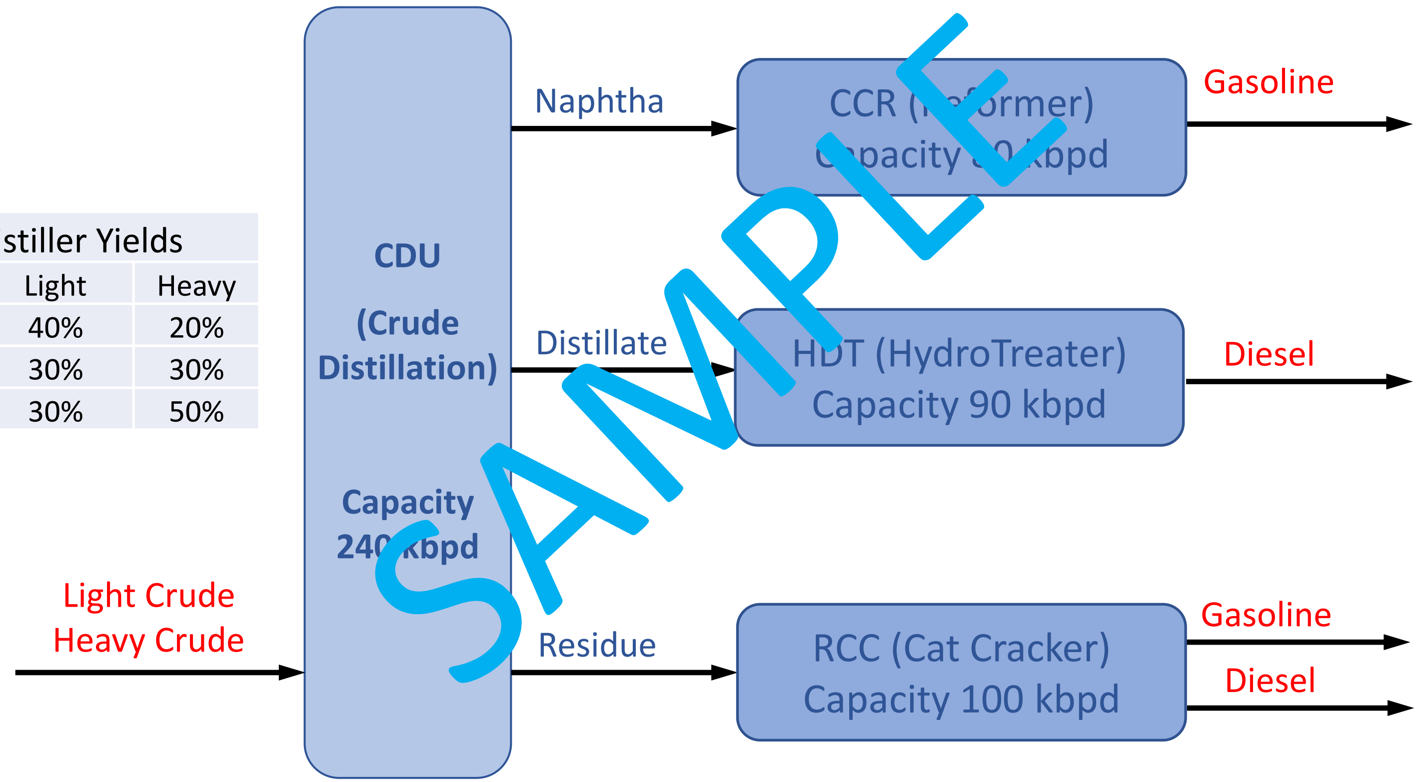
After completing this module, you will be able to:

- Understand the basic structures of an LP and matrix algebra
- Understand the basis of the LP solution algorithm (Simplex algorithm)
- Use the Excel Solver that utilizes this algorithm
- Describe and apply LP marginal values

Refinery optimisation problem

- What crude mix to buy, to make the most money?

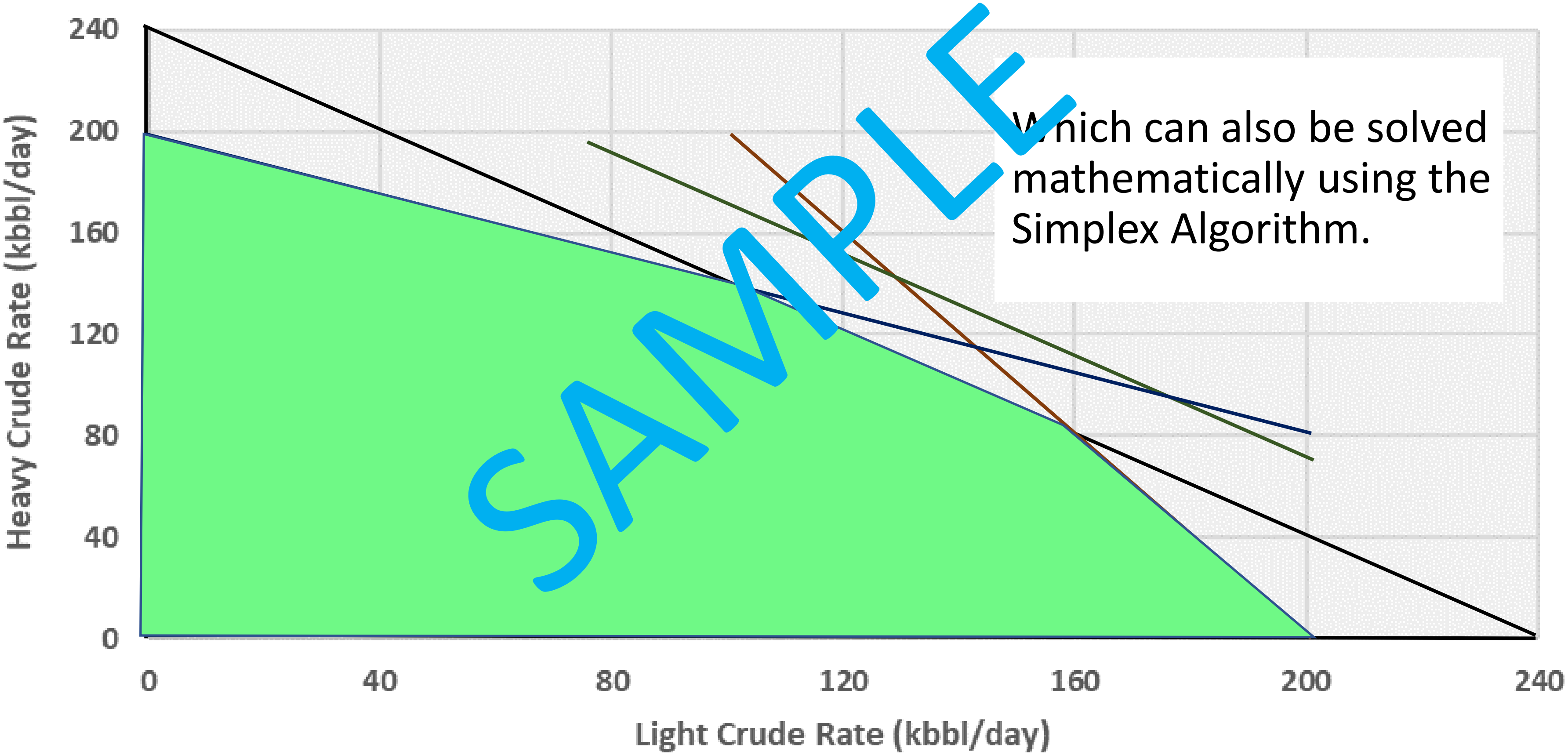
Crude Distiller Yields		
	Light	Heavy
Naphtha	40%	20%
Distillate	30%	30%
Residue	30%	50%



RCC Yields	
Gasoline	60%
Diesel	40%

Feasible Region

Recalling the graphical definition of the refinery optimization problem;



Which can also be solved mathematically using the Simplex Algorithm.

Simplex Algorithm Method

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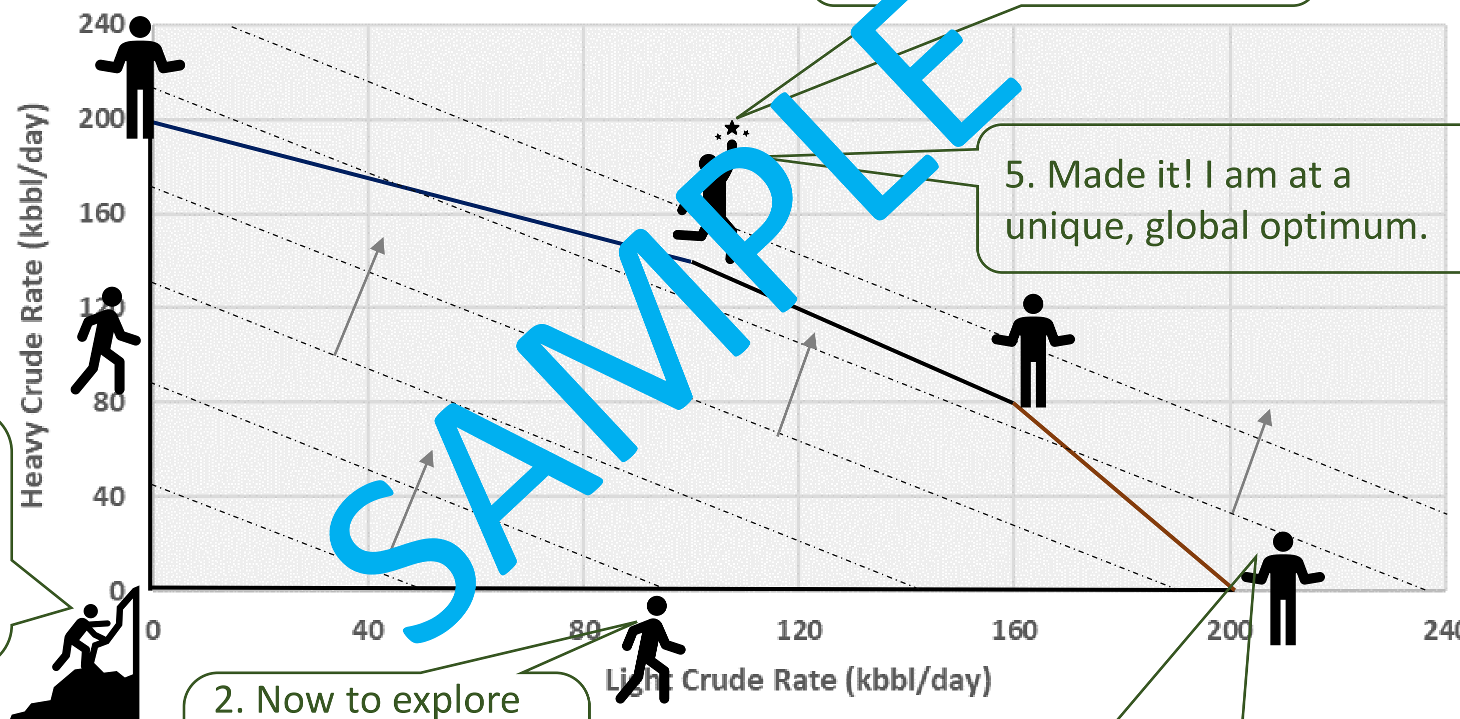
The Simplex Algorithm was developed by George Dantzig in the 1940s



1. Lots of work in finding the first feasible corner

2. Now to explore along each boundary to the next corner …

3. … and check if the Objective Function increases along any feasible boundary

4. Until there is no other corner with a higher OBJ

5. Made it! I am at a unique, global optimum.

LP Terms and Concepts

The Simplex Algorithm is a technique for solving linear programming (LP) problems

Some of the concepts used in LP problems are;

- Equations - Rows or Constraints, which may be equalities (=) or inequalities (>= or <=)
- Variables - Vectors or Columns ("Activities"), which are optimised, subject to the constraints, to satisfy an Objective Function
- Objective Function - a user defined requirement, which may be maximized or minimized. Often is financially base, but not necessarily as other functions can be used, (e.g. minimize time elapsed)

The Simplex algorithm is used to quickly and efficiently solve these optimization problems mathematically.

The LP problem

- Setting up the problem in Excel

Equations => Rows (tracking volumes and balances)

Variables => Columns (activities)

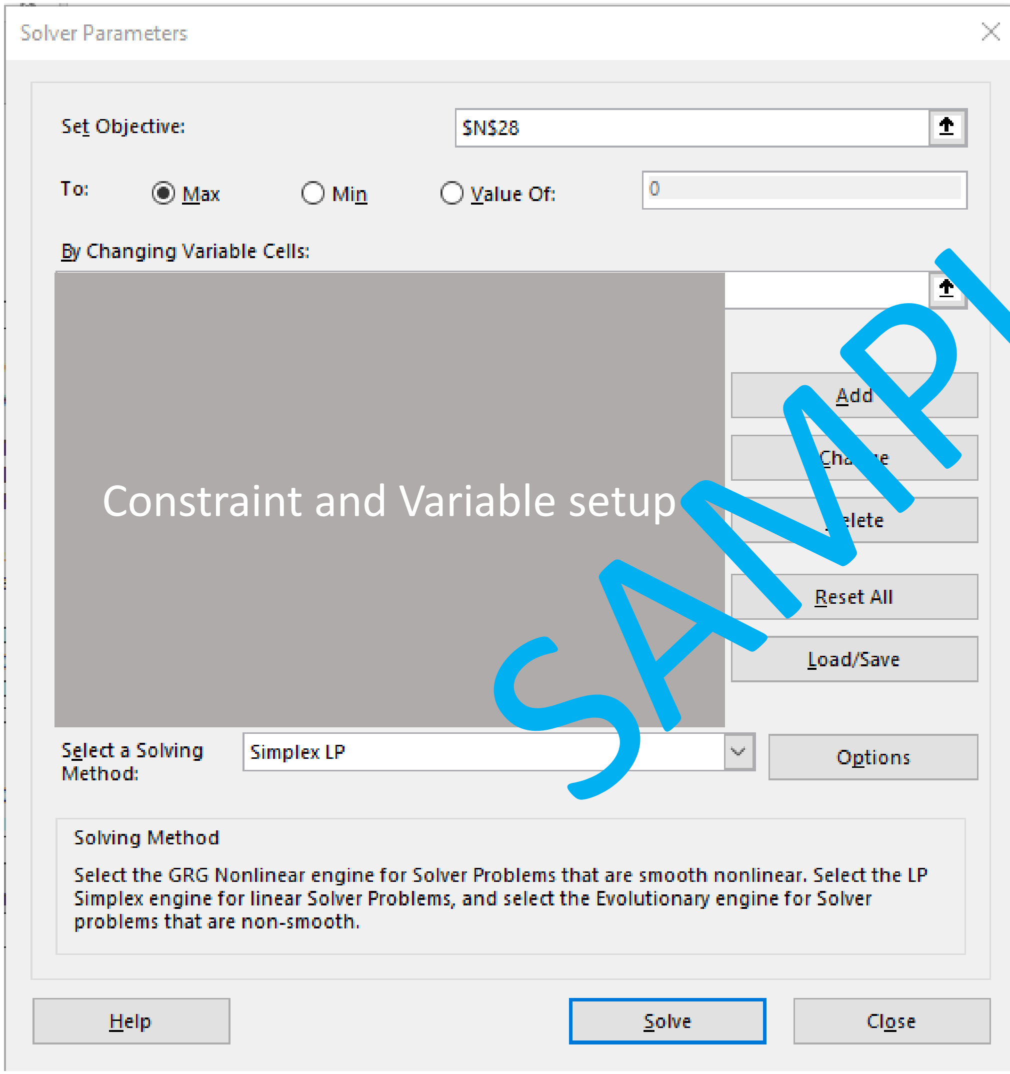
Simple Refinery LP Model

Rows		Columns	Purchase Light Crude	Purchase Heavy Crude	CDU Process Light Crude	CDU Process Heavy Crude	CCR Process Naphtha	[illegible] Process Distillate	RCC Process Residue	Sell Gasoline	Sell Diesel	Sell Fuel Oil	Constraint Maximum	Sign / RHS
Rows		Activity	100	140	100	140	68	72	100	128	112	0		
Volume Balance	Feed - Light Crude	kbbl/day												= 0
Volume Balance	Feed - Heavy Crude	kbbl/day												= 0
Volume Balance	Feedstock - Naphtha	kbbl/day												= 0
Volume Balance	Feedstock - Distillate	kbbl/day												= 0
Volume Balance	Feedstock - Residue	kbbl/day												= 0
Volume Balance	Product - Gasoline	kbbl/day												= 0
Volume Balance	Product - Diesel	kbbl/day												= 0
Capacity Constraint	Capacity - CDU	kbbl/day											**240**	< 0
Capacity Constraint	Capacity - CCR	kbbl/day											**80**	< 0
Capacity Constraint	Capacity - HDT	kbbl/day											**90**	< 0
Capacity Constraint	Capacity - RCC	kbbl/day											**100**	< 0
Economics	Feed Cost	$/bbl												
Economics	Processing Cost	$/bbl												
Economics	Product Value	$/bbl												
OBJ	Objective Function	$/day											2152	$/day

LP matrix coefficients

Objective Function => Economics, and the Variable Margin

Simplex Algorithm (using Excel Solver)



- Excel Solver has option to use the Simplex Algorithm to solver linear problems
- As part of the solution path, other valuable information about the optimum point is available from this algorithm