Study Questions to Accompany International Energy Markets

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Chapter 17. Refining, Transportation, and Linear Programming

17.1 The *Oil and Gas Journal* has a Worldwide Refining Survey, which gives gives information on process units for refineries around the world. Find the latest available survey.

17.1a What are the top 5 countries for refining capacity?

17.1b What % of total world capacity do they represent?

17.1c. Which of these seems to have the most complicated refineries? Refineries that only distill oil are the simplest. The more oil is processed beyond distillation, the more complicated the refinery. Crude processed, sometimes called crude runs to stills, is a measure of the total distillation capacity of a refinery. It is the first column in the Oil and Gas Journal Tables labeled crude. Thermal distillation, where crude is simply heated, is the simplest type of distillation. Vacuum distillation, where crude is heated in a vacuum, is slightly more complicated. Other processes are even more complicated. A crude measure of refinery capacity is to divide crude capacity by all other non-distillation capacity.

17.2 How much butane would you need to blend in for a *RVP* of 11 in the following problem?

Component	**Barrels**	**RVP**	**Motor Octane**
Straight Run Gasoline	4000	1	61.6
Reformate	6000	2.8	84.4
Light Hydrocrackate	1000	4.6	73.7
Cat Cracked Gasoline	8000	4.4	76.8
Normal Butane	x	52	92

17.3 Octane blending requirements can be computed in the same way as vapor pressure. Compute the motor octane number of the blend in 17.2. Suppose you need to raise the motor octane to 80 by blending in alkylate with an octane of 95.9. How much alkylate would you need?

17.4 (More challenging) Your alkylate has an *RVP* of 3. You will note that the blended gasoline in 17.3 no longer meets the *RVP* specification. Use a two equation model to compute both the amount of alkylate and butane to add to meet both *RVP* and octane requirements.

17.5 Astron International has software to help you compute stream blending and other refinery and petroleum related characteristics. Download a sample program and see what you think of it. http://www.astroninc.com/astron/ derlinepctkdetl.htm

17.6 In the blending problem in the text, there are two processes to produce two grades of gasoline. Process one produces straight-run gasoline (u_1) with a maximum capacity of 100,000, and process two produces cracked gasoline (u_2) with a maximum capacity of 140,000. The two products (u_1 and u_2) can be blended into two grades of gasoline (X_1 and X_2). The blending process can be represented by the following Leontief-fixed coefficient production functions:

Grade one: $X_1 = 2.5 \min(u_1, u_2/2)$

Grade two: $X_2 = 2(u_1, u_2)$

17.6a Draw two isoquants for grade two gasoline. One for a quantity of 1.75 gallons and the other for a quantity of 3.50 gallons.

17.6b. Explain how to derive the constraint for u_2, $0.8X_1 + 0.57X_2 \leq 140{,}000$.

17.7 The text has a simple refinery model, which you can solve in Excel solver as described in http://dahl.mines.edu/b1401.pdf.

17.7a First use Excel Solver to solve for optimal profits in the text example as given below.

	Type of Crude or Process					Product
	A	B	C_1	C_2	D	Demand
Profits on Crudes	10	20	15	25	7	
Products	Product Slate for Crude or Process					
G	0.6	0.5	0.4	0.4	0.3	**170**
H	0.2	0.2	0.3	0.1	0.3	**85**
F	0.1	0.2	0.2	0.2	0.3	**85**
L	0.0	0.0	0.0	0.2	0.0	**20**
Total Crude	100	100	$C_1+C_2 = 200$		100	

17.7b Change the amount of crude D available to 200 and resolve. What happens to profits, crude runs and product production?

17.8 A simple example illustrates the magnitude of the economies of scale in tankers. Suppose you have a box 10 x 10 x 10.

17.8a What is the area of the surface of the box? What is its volume?

17.8b Now double the dimensions of the box to 20 x 20 x 20. What is the area of the surface? What is the volume of the box?

17.8c. Would these same economies of scale hold for a pipeline? Explain. Remember the circumference of a circle is πd and its area is πr^2, where r is the radius of the circle and d is the diameter of the circle.

17.9 Around half of the world's oil is transported by tanker across the sea**.**

17.9a If you have a tanker that sails 15.8 knots (1 nautical mile per hour = 1.151 land miles per hour), how long will it take you to bring a cargo from the Arabian Gulf to Rotterdam via the Cape?

17.9b How about via Suez with 15 hours for traversing the canal?

17.9c. Shell has a 374,000 barrel per day refinery at Rotterdam, the world's largest oil port. Suppose that Shell is running the refinery at 84% of capacity and is using Saudi Intermediate. How many 200,000 dwt tankers would Shell require to supply their refinery for a year. Assume that each ship carries 1.5 million barrels of oil. Berthing, offloading/loading ballast, loading/unloading crude, and deberthing average 18 hrs at each end of the voyage. Your tankers come around the Cape of Good Hope with oil and go back through the Suez in ballast.

17.10 Find one other tanker port that can handle VLCCs and one other tanker port that can handle ULCCs.

17.11 You have five supply points for crude oil A, B, C, D, E. The amounts available at each point are 10, 20, 30, 80, 100. You have three refineries X, Y, Z with crude oil requirements of 40, 80, and 120, respectively. Transportation costs from each supply point to each refinery are

	A	**B**	**C**	**D**	**E**
X	7	10	5	4	12
Y	3	2	0	9	1
Z	8	13	11	6	14

17.10a Set up the objective function and constraints for the above transport cost minimization problem.

17.10b Solve the problem using Excel Solver

17.11 (contributed by Majory Cone) A gasoline blender makes a net income of $2 for each barrel of regular (R) gasoline it produces and $4 for each barrel of premium (P) gasoline it produces. The blender would like to maximize net income subject to the following blending constraints:

$0.2R + 0.75P \leq 160$

$0.8R + 0.25P \leq 70$

$R, P \geq 0$