SCM518 Final Project

Team: 333

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Problem Understanding:

Company Background & Operational Overview:

Rock Flow Dynamics is an influential player in the Oil and Gas sector, engaging across all three integral phases of the industry: upstream, midstream, and downstream operations. The company's primary objective revolves around maximizing profitability, a task intricately tied to their strategic decisions in transporting oil. With three distinct options available for oil transportation, Rock Flow Dynamics navigates through these choices to optimize the movement of resources between different locations.

In the upstream phase, Rock Flow Dynamics operates in three distinct locations, each designated for fluid production with different capacities. This phase is crucial as it directly impacts the production costs, influencing the overall profitability of the operations.

Transitioning to the midstream phase, the company faces the challenge of fluid transportation after the production process. To address limited on-site storage capacity, Rock Flow Dynamics has the choice of utilizing trucks, trains, or pipelines for transferring the oil. Drilling companies contract their services to E&P companies to extract oil and gas. Each production location can be connected to various contractors for efficient transportation management to decide where the oil should go. This stage incurs transportation costs that significantly impact the company's bottom line.

Finally, in the downstream phase, Rock Flow Dynamics are responsible for refining and the sale of the finished products. It takes on the task of separating oil mixtures. These facilities have different overall operational capabilities for Crude Oil. This approach across all three stages underscores Rock Flow Dynamics' commitment to an integrated operational model aimed at maximizing profitability through decision-making in oil transportation and resource management.

Data Overview:

Upstream Level

Rock Flow Dynamics has three different fluid production locations. This fluid can be a mixture of crude oil, natural gas, sulfur or water. Total production capacity of each location is different with differing production cost per barrel.

Production Location	Location 1	Location 2	Location 3
Total Fluid (Barrel)	**66000**	**96500**	**127200**
Crude Produced (% Percentage)	0.35	0.38	0.46
Natural Gas Produced (% Percentage)	0.18	0.12	0.06
Sulfur Produced (% Percentage)	0.03	0.04	0.02
Water Produced (% Percentage)	0.44	0.46	0.46
Production Cost Per Barrel ($)	8.1	7.4	5.6

Midstream Level:

These fluids are then transported from each production location to another location for processing. Rock Flow Dynamics partners with different vendors for the same. The distance between production location and process location is mentioned in the table below:

Mid Stream(Distance in Mile)	Location 1	Location 2	Location 3
Process Location 1	1859	3245	2107
Process Location 2	2586	1738	2621
Process Location 3	3750	1803	1876

Transportation of these fluids can be done by three different ways i.e. Truck, Train or Pipeline. Each of the transportation options has different capacity and charges associated with it.

Transport Way	Cost/Mile for each barrel ($)	Fix Charge ($)	Capacity (Barrel)
tank(truck)	0.002	5000	10000
train	0.0015	7500	30000
pipeline	0.001	10000	100000000000000000000.00

Downstream Level:

Post transporting to the location, these fluids are processed to extract crude oil and separate sulfur, natural gas and water from the same. Each of the processing locations have different capacity, efficiency and processing cost associated with different extraction. Below table include details:

Downstream	Capacity	Efficiency	Sulfur removal cost	water removal cost	Natural Gas Processing Cost	Crude Oil Processing
Process Location 1	40000	0.92	0.08	0.05	0.07	0.1
Process Location 2	132000	0.95	0.09	0.06	0.065	0.1
Process Location 3	180000	0.99	0.1	0.065	0.07	0.09

Selling Price of Extracted Outcomes:

Selling	Sulfur	water	Natural Gas	Crude Oil
Barrel Price	6.2	3.4	23.43	75.89

Modelling Objective:

- Maximize operational profit by optimizing the end-to-end cycle of oil processing from production to finally extraction, by identifying fraction of oil to be transported from production location to processing location via the most effective mode of transport. This outcome will further result in balanced partnership with their contractor and maximize the company's overall profit.

Main Challenge:

- Need to factor in different capabilities and efficiencies associated transportation type and processing location
- Since the storage capacity of production location is limited. There need to be a balance in fluids being produced and transferred without effecting the overall process

Model Setup:

1. Index

***i* ϵ {1,2,3}** : *Index to represent production location*
***j* ϵ {1,2,3}** : *Index to represent processing location*
***k* ϵ {1,2,3}** : *Index to represent transportation type*
***l* ϵ {1,2,3,4}** : *Index to represent different outcomes post fluid extraction (sulfur, water, natural gas, crude oil)*

2. Parameters (Input)

1. $\boldsymbol{P_i}$: *Total production of location i*
2. $\boldsymbol{O_i}$: *% of crude oil production in location i*
3. $\boldsymbol{PD_{il}}$: *% of different outcomes type l in the production in location i*
4. $\boldsymbol{C_i}$: *Fluid production cost per barrel in location i*
5. $\boldsymbol{D_{ij}}$: *Distance between production and processing locations i and j*
6. $\boldsymbol{CP_k}$: *CPM per barrel in transportation type k.*
7. $\boldsymbol{CH_k}$: *Fixed charge associated with transportation type k.*

8. $\boldsymbol{TC_k}$: *Total capacity of transportation type k.*
9. $\boldsymbol{PL_j}$: *Total capacity of Process location j.*
10. $\boldsymbol{E_j}$: *Efficiency of Process location j.*
11. $\boldsymbol{EX_{jl}}$: *Processing cost of extracting different outcomes l in Process location j.*
12. $\boldsymbol{SP_l}$: *Selling price of different outcomes l after processing*

3. Decision Variables

$\boldsymbol{X_{ijk}}$ **:** what fraction of production is to be transported from location i to processing location j using transportation type k

4. Objective Function

Maximize total profit

$$\boldsymbol{Max \sum i \sum j \sum k \underbrace{(X_{ijk} * E_j * PD_{il}) * SP_l}_{\text{Total Sales}})- \overbrace{(\underbrace{(C_i * P_i)}_{\text{Production Cost}} + \underbrace{(CP_k * D_{ij} * (P_i * X_{ijk}))}_{\text{Transportation Cost}} + \underbrace{CH_k * ((P_i * Xijk)/TC_k)}_{\text{Fixed Transportation Cost for diff. modes}} + \underbrace{(P_i * X_{ijk}) * EX_{jl})}_{\text{Processing Cost}}}^{\text{Total Cost}}}$$

5. Constraints

1. $\sum_{ijk} Xijk = 1$; i є {1,2,3}, j є {1,2,3}, k є {1,2,3}
(Ensuring transport if all produced fluid)

2. $\sum_{ijk} X_{ijk} * P_i \leq PL_j$ i є {1,2,3}, j є {1,2,3}, k є {1,2,3}
(The transported fluid from production location should not exceed processing capacity)

3, $\sum_{ij}.X_{ijk} \leq 0.5$; j є {1,2,3}
(Fraction of production being transported from a particular i to j, should not exceed 50% of the total production)

4. $X_{ijk} \geq 0$; i є {1,2,3}, j є {1,2,3}, k є {1,2,3}
(Non-negative Constraints)

5.$X_{ijk} \leq 0.2$; I є {1,2,3}, j є {1,2,3}, k є {1,2,3}
Total transportation from each location i to j using all modes should not exceed 20% as we want to avoid monopoly of processing to one vendor

Model Results:

Decision Variable Output:

Transportation Table	Truck	Train	Pipeline	Total	
Location 1-1	0	0.2	0.1	0.3	
Location 1-2	0	0.2	0.2	0.4	1
Location 1-3	0	0.1	0.2	0.3	
Location 2-1	0	0	0	0	
Location 2-2	0.1	0.2	0.2	0.5	1
Location 2-3	0.1	0.2	0.2	0.5	
Location 3-1	0	0.058805031	0.1	0.158805031	
Location 3-2	0	0.141194969	0.2	0.341194969	1
Location 3-3	0.1	0.2	0.2	0.5	

Profit:

Total Selling Revenue Generated	**sulfur produced**	**water cleaned**	**Natural Gas Produced**	**Crude Oil Processed**	**Total**
Processing Location 1	228160	3121.744	388087.0224	333454.5888	952823.3552
Processing Location 2	695314.5	11595.7	1196950.838	947767.443	2851628.481
Processing Location 3	808067.7	12777.336	1395522.899	989476.587	3205844.522
Total	1731542.2	27494.78	2980560.759	2270698.619	7010296.358

Profit	6036449.073

Recommendation:

- Among all three different transportation mode, pipeline is the most efficient one followed by Train. 6 out of 9 routes can use pipelines with full capacity i.e., 20%
- Trucks are least effective and can be used in only 3 out of 9 different routes with half of the allowed capacity
- Majority of the Trucks are least effective and can be used in only 3 out of 9 different routes with half of the allowed capacity
- The most preferred route for each combination of production and processing

location are listed as: (Production 1 -> Processing 2) (Production 2 -> Processing 2 & 3) (Production 3 -> Processing 3)