Production-Distribution Coordination for Optimal Operational Planning of an Industrial Gases supply-chain

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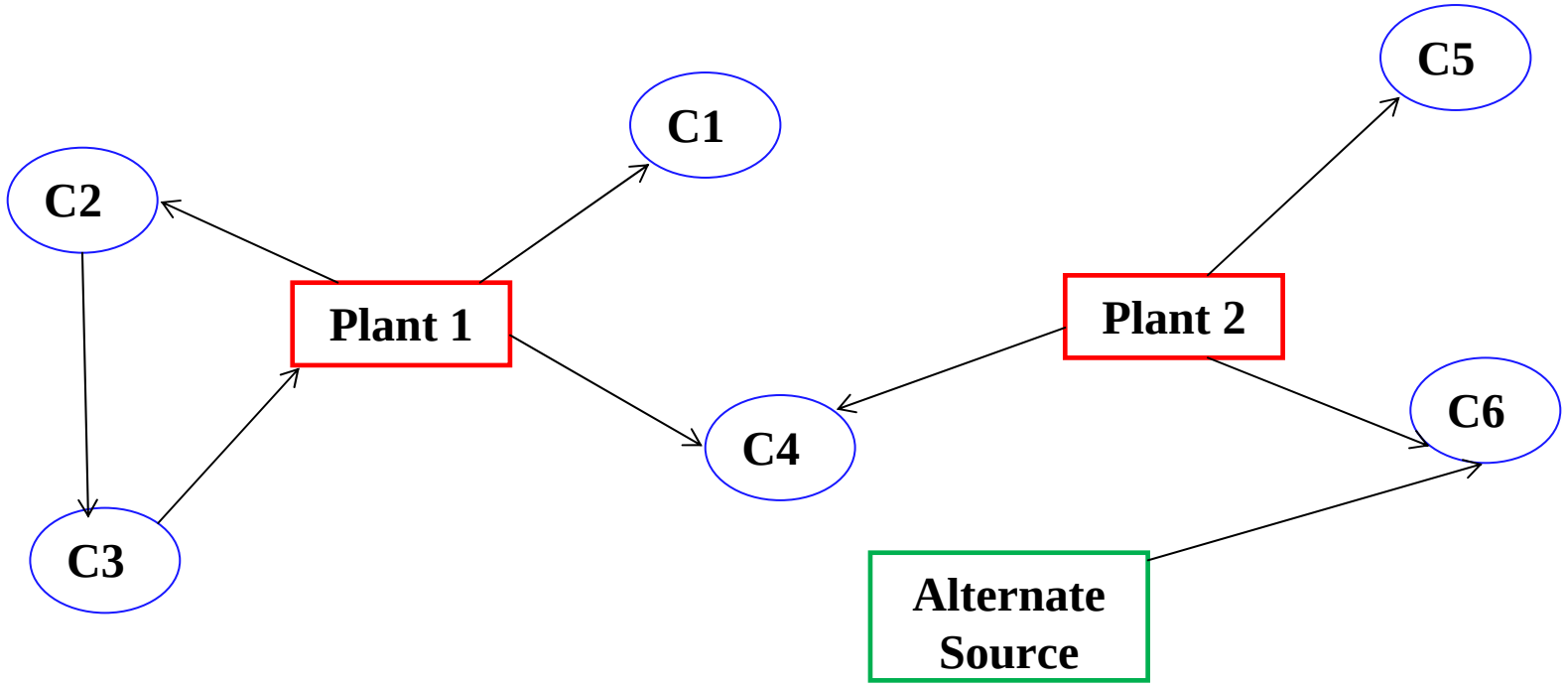
Industrial Gases Supply-Chain



- Multiple Plants
- Multiple Products (LIN Liquid Nitrogen, LOX Liquid Oxygen etc.)
- Over-the-fence, call-in and distributed customers *(some shared customers)*
- Storage facilities at production sites and customer locations
- Delivery Modes and Routes

Sequential vs. Simultaneous Approach: Key Differences

Sequential Strategy

Production Model
(based on given truck withdrawal or demand forecast)

Optimum Production Schedule

Distribution Model
(based on product availability)

Optimum Distribution Schedule

Total Cost

Simultaneous Strategy

Integrated Model
(truck withdrawal amounts and time are variables)

Optimum Production and Distribution Schedule

Total Cost

?

Goal

To quantify and access the savings associated with the Production-Distribution Coordination at Operational Level using an approximate model

Production-Distribution Coordination: Multi-plant Level

Multi-plant Sequential
(Multiple Sourcing)

Currently used

Production Schedule

Distribution Schedule

Coordination among plants for production and for Distribution Individually

Multi-plant Simultaneous
(Multiple Sourcing)

Production and Distribution Schedules

Coordination among plants as well as Production-Distribution (Fully Integrated)

Production-Distribution Coordination Levels

	Sequential		Simultaneous
	Based on Truck Withdrawal Forecast	*Based on Demand Forecast*	
Single Plant (Single Sourcing)	No Coordination b/w plants and production-distribution (production depends on truck forecast)	No Coordination b/w plants and production-distribution (production depends on demand forecast)	Coordination b/w production-distribution but No coordination b/w plants (partially integrated)
Multi-plant (Multiple Sourcing)	Coordination b/w plants but No Coordination b/w production-distribution (production depends on truck forecast)	Coordination b/w plants but No Coordination b/w production-distribution (production depends on demand forecast)	Coordination b/w production-distribution as well as plants (fully integrated)
	Truck withdrawal is a given parameter	Freeze the product demand instead truck withdrawals	Truck withdrawal is a variable in the optimization model

Toy Problem Statement

Given

- *3 Plants, 2 main products (LIN, LOX)*
- *3 modes for each plant and respective capacities (hi LOX, hi LIN, shut-down)*
- *17 Customers (truck delivery), 42 Pick-up customers, 2 alternate sources*
- *14 time periods (peak and off-peak), 20 trucks (10 for LIN, 10 for LOX)*
- *Demand, min/max inventory, distance, Electricity price etc. data*

Decisions in each time period t

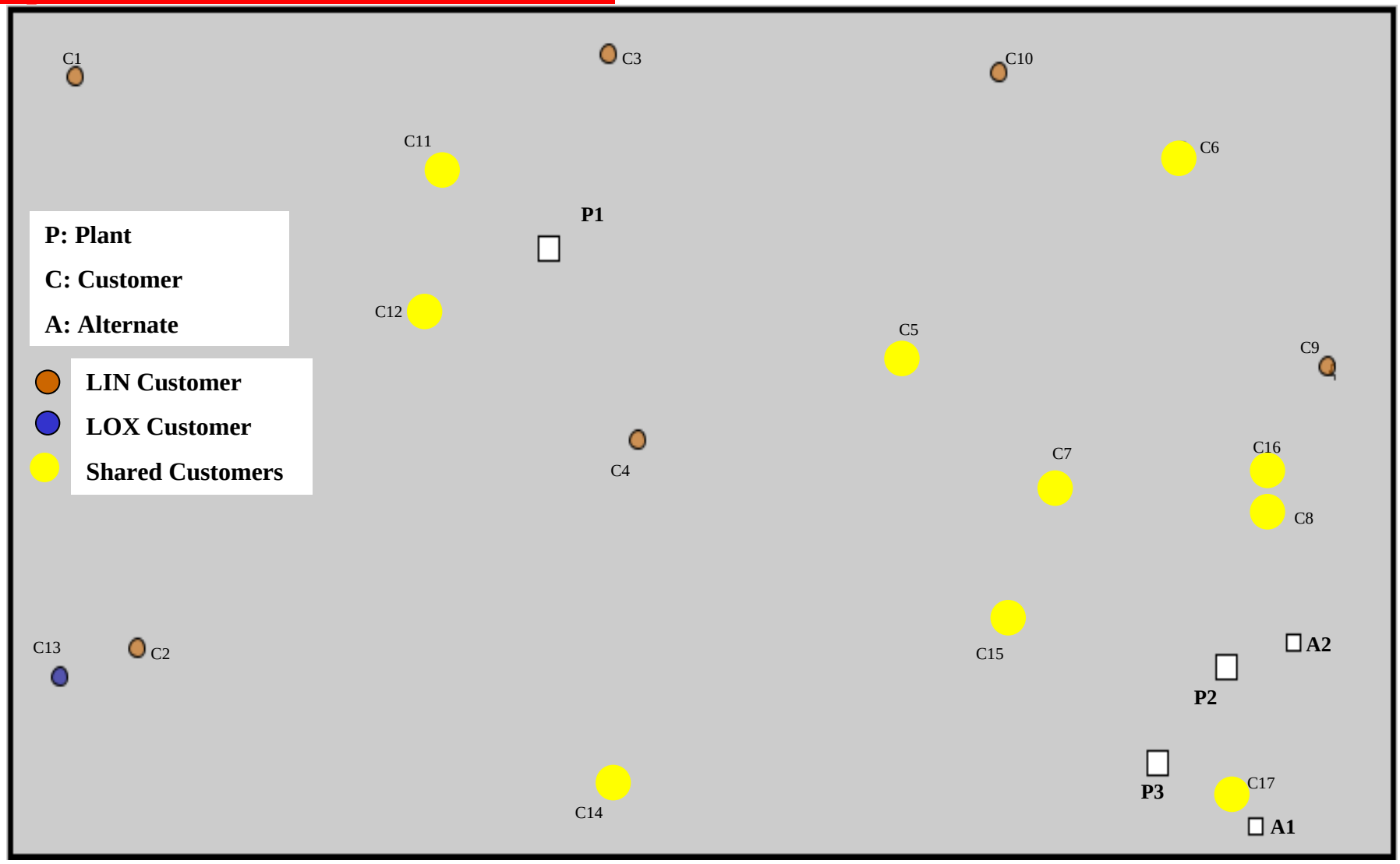
- *Production rates at each plant*
- *Inventory levels at customer locations and plants*
- *How much product to be delivered to each customer through which route*

Objective Function

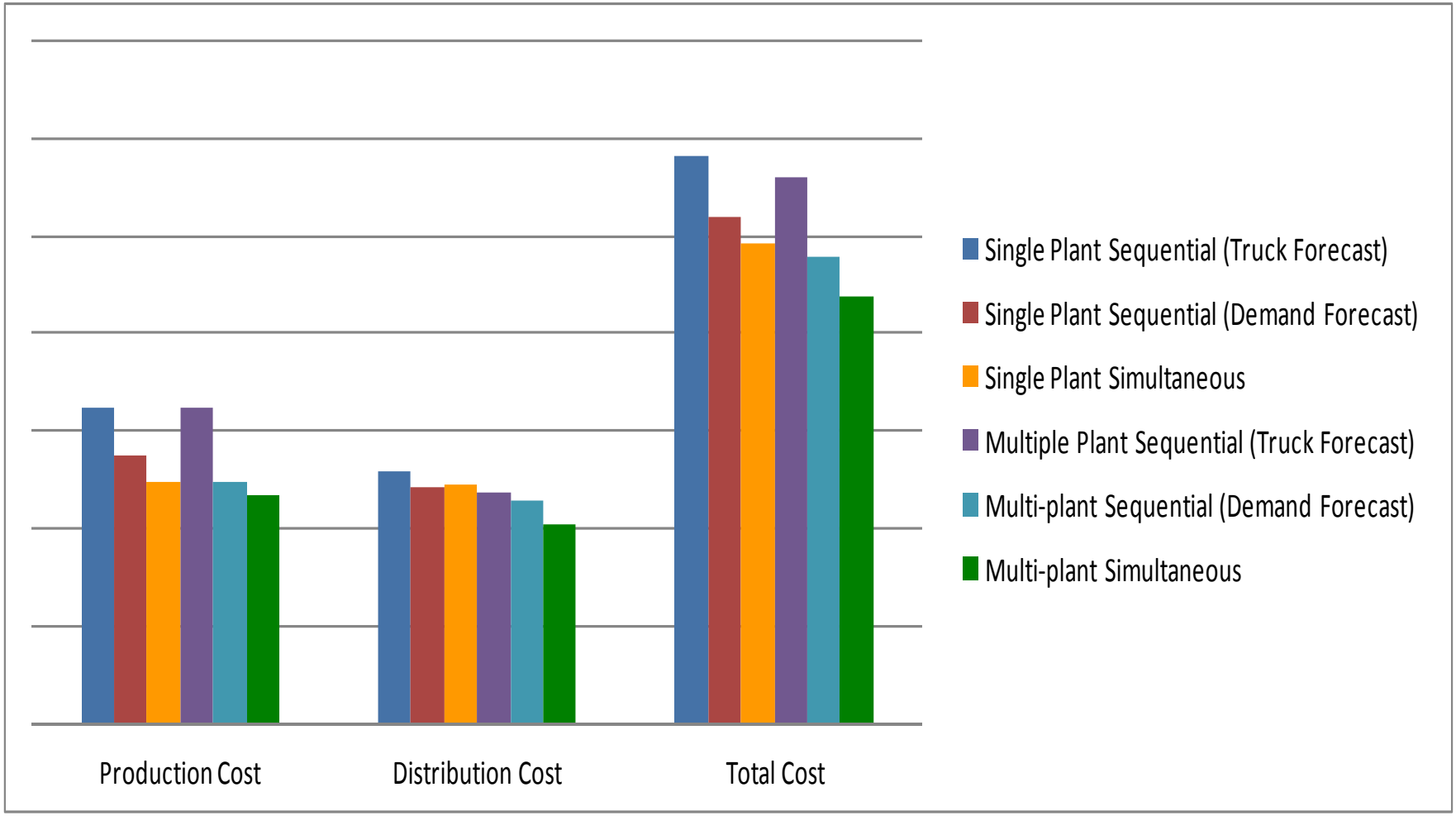
- *Minimize total production and distribution cost over planning horizon (1 week)*

Results: Multi-plant Simultaneous vs. Sequential Models

Comparison: Shared Customers Deliveries



Results: Toy problem (Production-Distribution Coordination Levels)



Conclusions

- **Simultaneous and Sequential MILP Models are proposed for optimal operational planning of industrial gases.**
  - ***Multiproduct***
  - ***Multi-plant***
  - ***Variety of customers***
  - ***Routing decisions***

- **Numerical results on test case show significant potential savings (~10%) and different production/distribution schedules with the coordination due to switching sourcing/routing strategies, electricity price differences, better inventory management...**

- **Simultaneous Model will further be extended to include other details on production and distribution sides to be more realistic. This will allow to further confirm the promising results obtained till now.**