Warehouse Network Design For A Commodity Chemical Manufacturer

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Agenda

1. Motivation
2. Methodology
3. Results
4. Conclusion

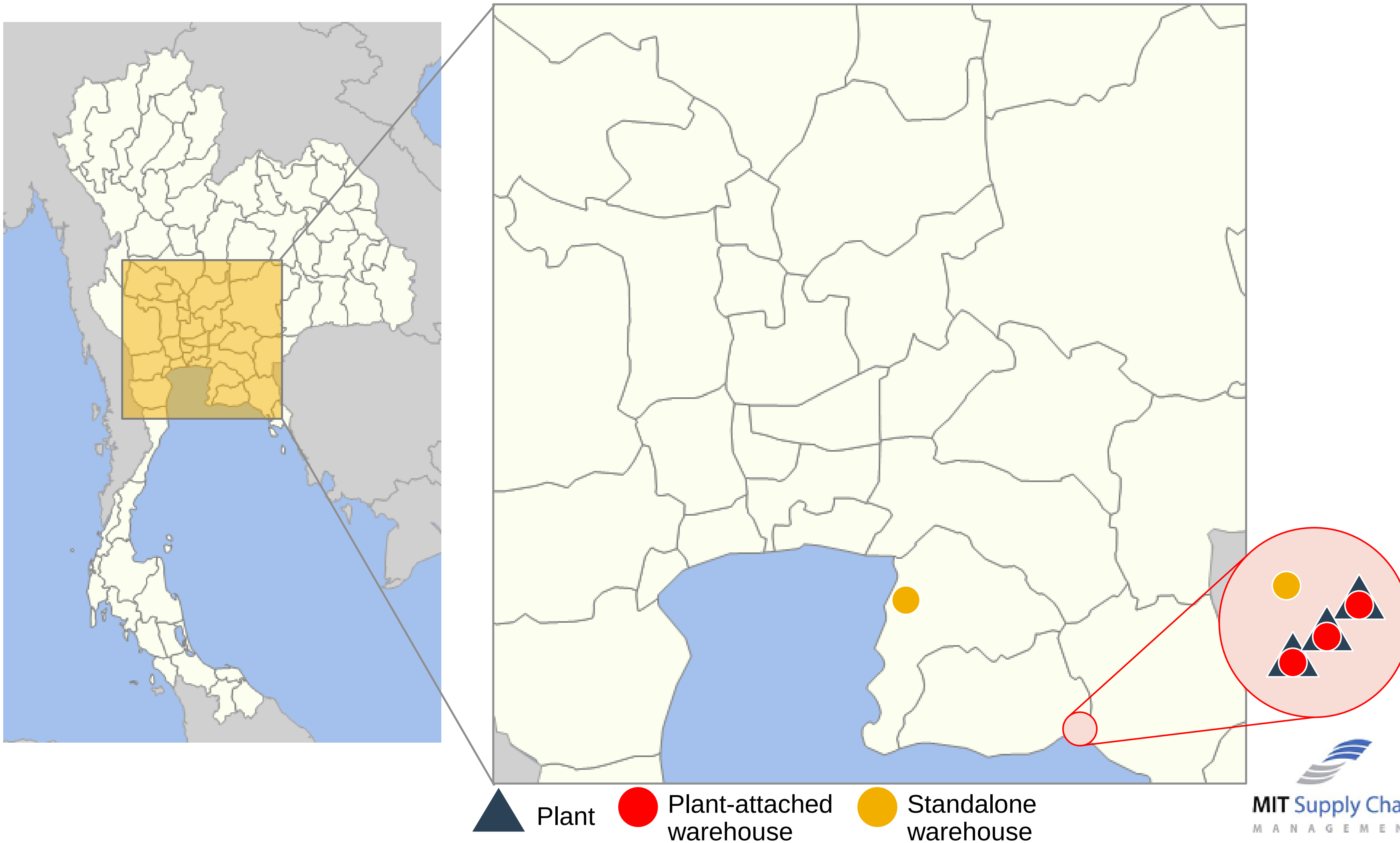
Project Background & Scope

- Sponsor company is an integrated manufacturer of petrochemical products
- Downstream and upstream manufacturing locations in Southeast Asia
- Project focuses on the plastic resins business in Thailand

Image source:
https://www.icis.com
http://www.fastflowpipes.com/wp-content/uploads/2014/10/19737_HDPE-PIPES.jpg
https://plastics-car.com/ClientResources/Images/Sm%20File%20Size%20-Taurus%20facia%20system-%20Plastics-car%20thumbnail.png
https://upload.wikimedia.org/wikipedia/commons/f/fd/Nurdles_01_gentlemanrook.jpg

Existing Warehouse Network

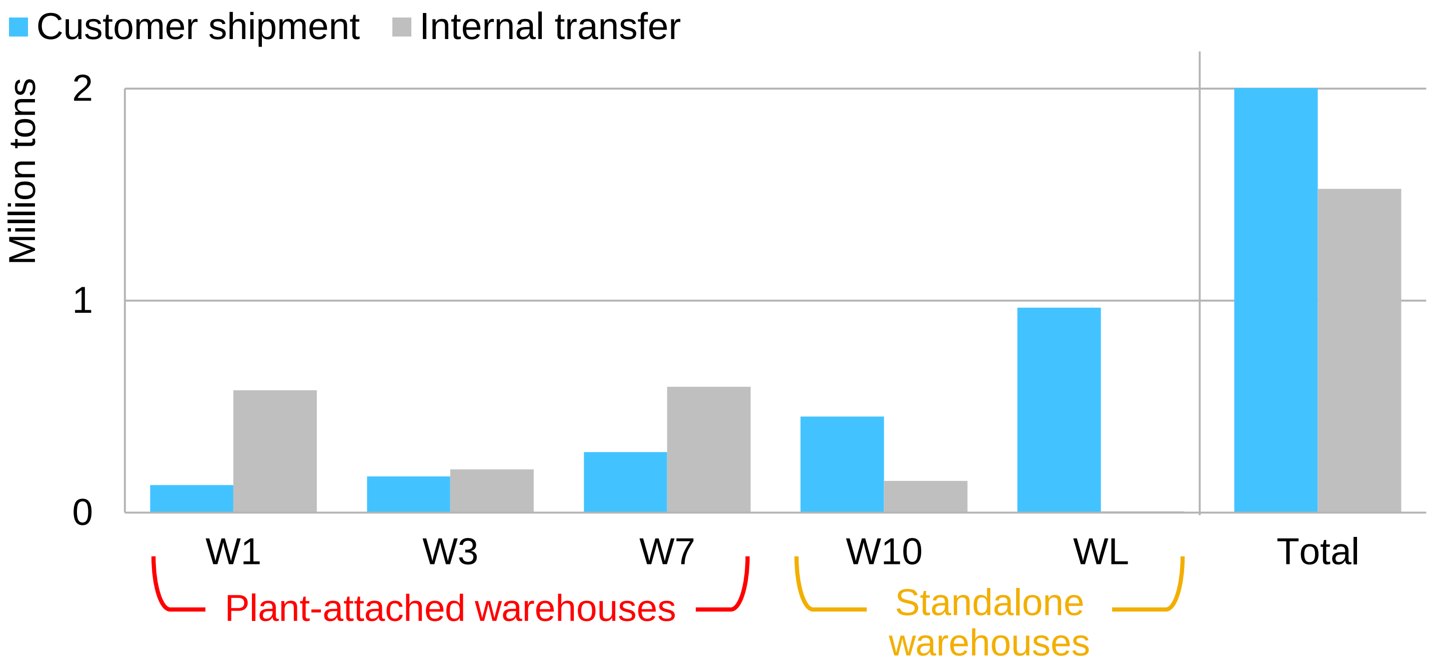
- There are **three plant attached warehouses** and **two standalone warehouses**



Operational Inefficiency

- Finished goods are moved between warehouses before they are shipped to customers. This movement, called “internal transfer”, incurs handling and transportation costs.
- Caused by limited storage space at plant-attached warehouses

Annual Shipment Volume By Type (2015)



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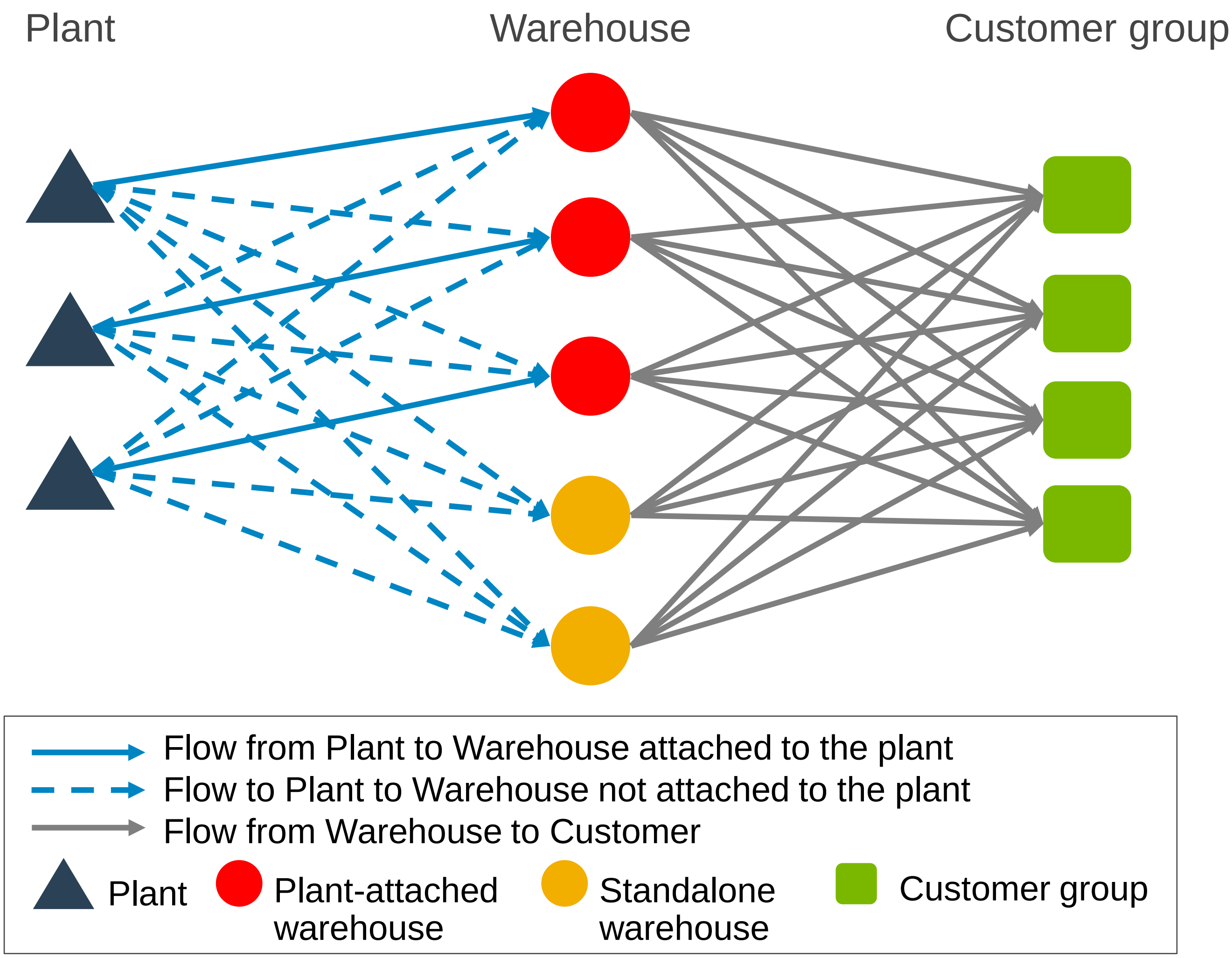
Research Question

How many warehouses should the Company have and what should their sizes be to minimize total transportation and warehousing costs?

Model Design

- A mixed-integer linear program is used to model the warehouse network



Model Inputs

1. Product data
2. Annual demand by customer location
3. Production data
4. Transportation costs
5. Warehousing costs and capacities

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Model Inputs – Warehousing Costs and Capacities

- Fixed & Variable cost
- **Throughput capacity**
  - Number of trucks each warehouse can handle per day multiplied by the number of units that can fit on a truck
- **Storage capacity**
  - Storage capacity is converted to the maximum flow that it can support, depending on the inventory turns. Example:
    - Storage space = 10,000 tons of product
    - 14.6 turns/year
    - Maximum flow = 10,000 x 14.6 = 146,000 ton/year
  - Three numbers of inventory turns are used to represent Mean, Minimum, and Maximum turns. They are calculated based on historical data.
  - Storage capacity assumes 80% utilization

Optimization Runs

1. Optimization with Transportation Costs only
2. Optimization with Transportation Costs, Warehouse Costs, and Warehouse Capacities
    - Baseline with mean, minimum, and maximum inventory turns
    - Demand increase 10% with mean, minimum, and maximum inventory turns
3. Optimization without warehouse constraints (allow expansion)

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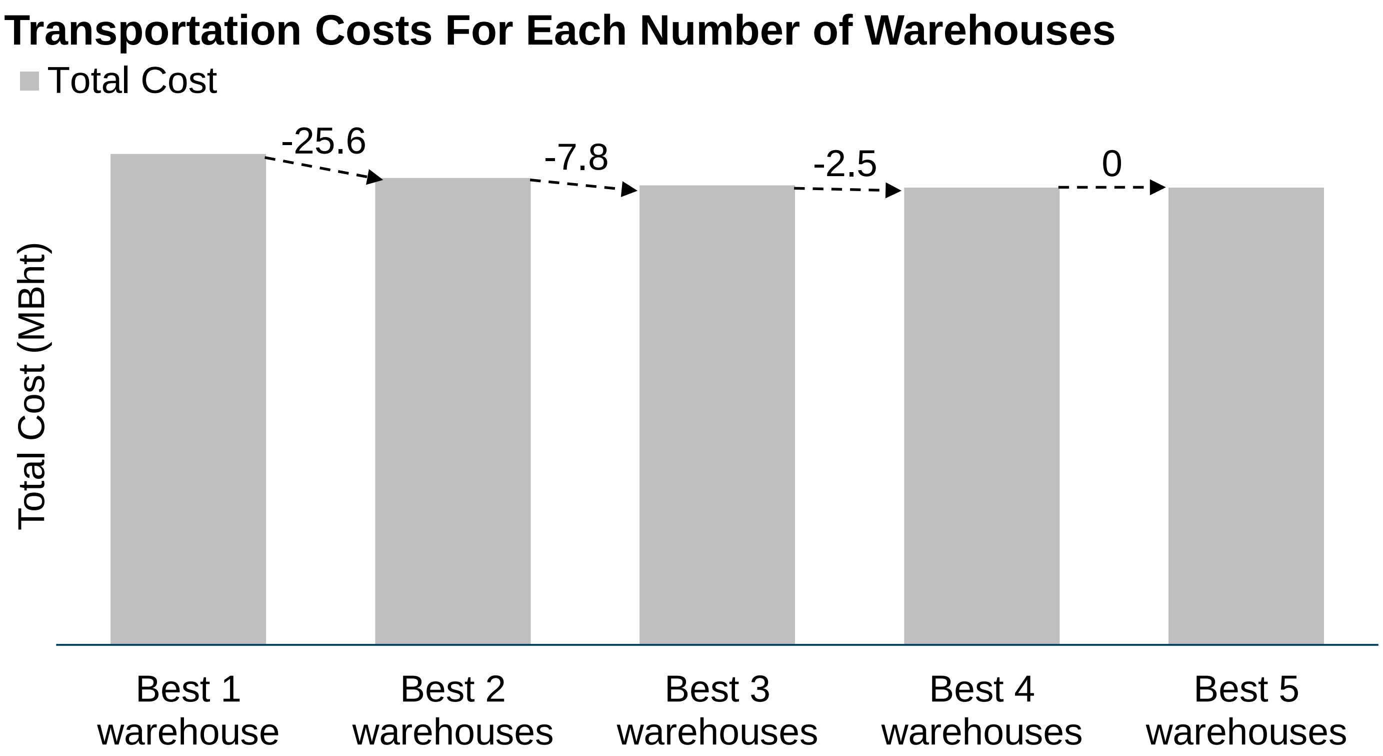
1) Optimized with Transportation Costs Only

Key findings

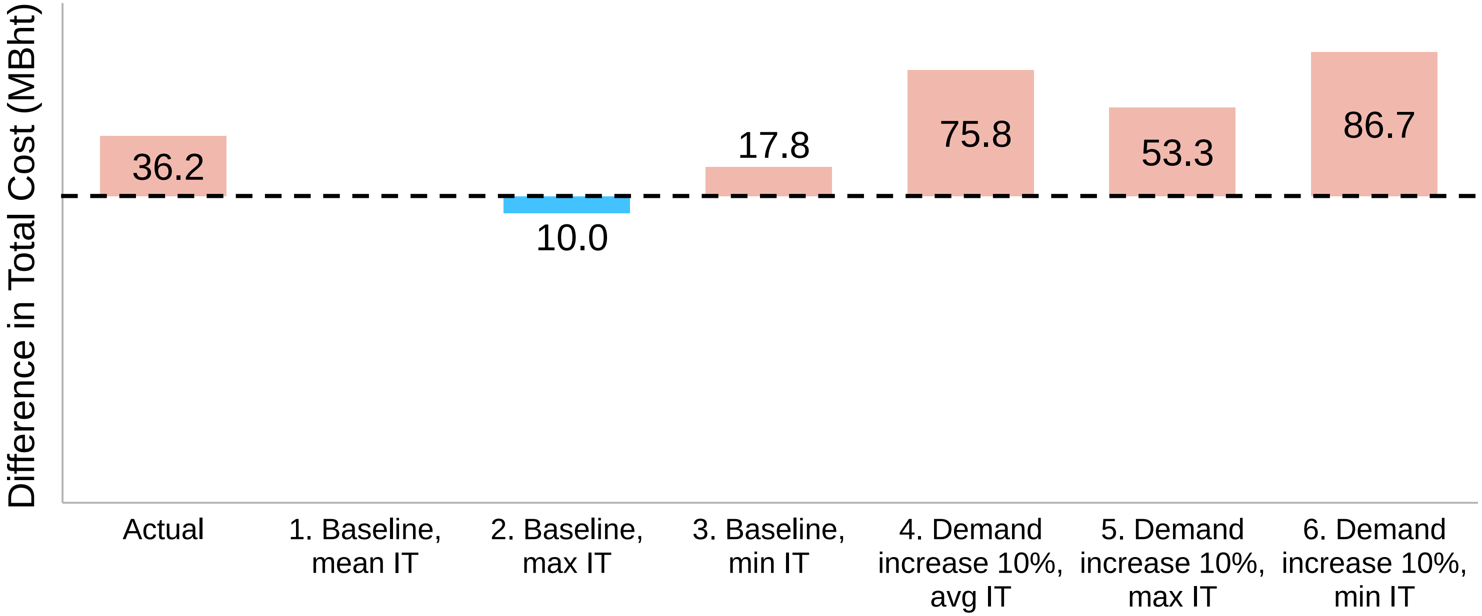
- 25M is the threshold for the cost of operating a second warehouse
- Savings diminish because existing warehouse locations are too close together



2) Optimized with Transportation, Warehouse Costs and Capacities

- Existing network can support operations but is not optimized

Difference in Total Costs Among Optimized Scenarios (compared to the baseline scenario)



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…Resulting Warehouse Utilization

Key findings

- Storage capacity is the main constraint
- Limited storage capacity drives the usage of a higher cost warehouse, W10, instead of the lower cost warehouse, W1

Capacity Utilization

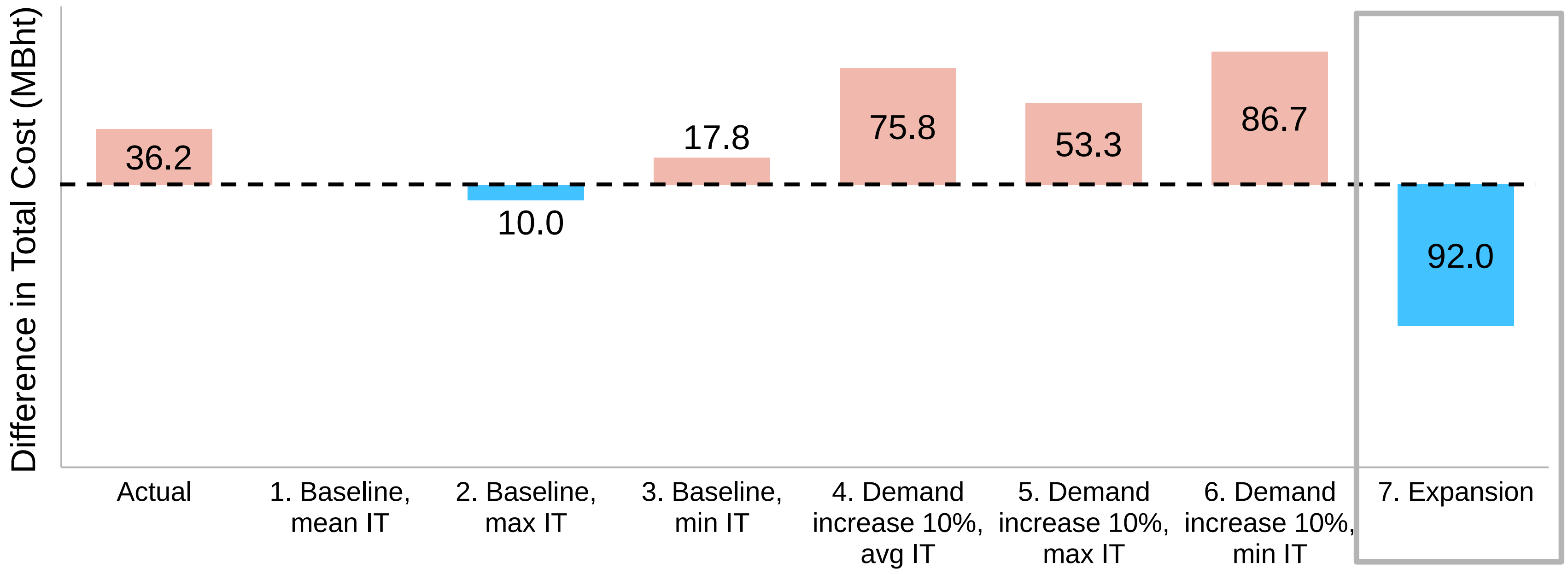
0% [color scale] 100%

	Throughput					Storage				
Scenario	**W1**	**W3**	**W7**	**W10**	**WL**	**W1**	**W3**	**W7**	**W10**	**WL**
1. Baseline, mean IT	23%	53%	36%	closed	83%	100%	100%	100%	closed	97%
2. Baseline, max IT	closed	67%	45%	closed	82%	closed	100%	100%	closed	96%
3. Baseline, min IT	closed	44%	30%	27%	86%	closed	100%	100%	60%	100%
4. Demand increase 10%, mean IT	closed	53%	36%	38%	86%	closed	100%	100%	72%	100%
5. Demand increase 10%, max IT	29%	67%	45%	closed	83%	100%	100%	100%	closed	97%
6. Demand increase 10%, min IT	19%	44%	30%	36%	86%	100%	100%	100%	81%	100%

3) Optimized Allowing Expansion

- The model expands plant-attached warehouses. Standalone warehouses are closed.
- 92M difference in cost compared to the baseline represents a threshold for expansion investment

Difference in Total Costs Among Optimized Scenarios (compared to the baseline scenario)



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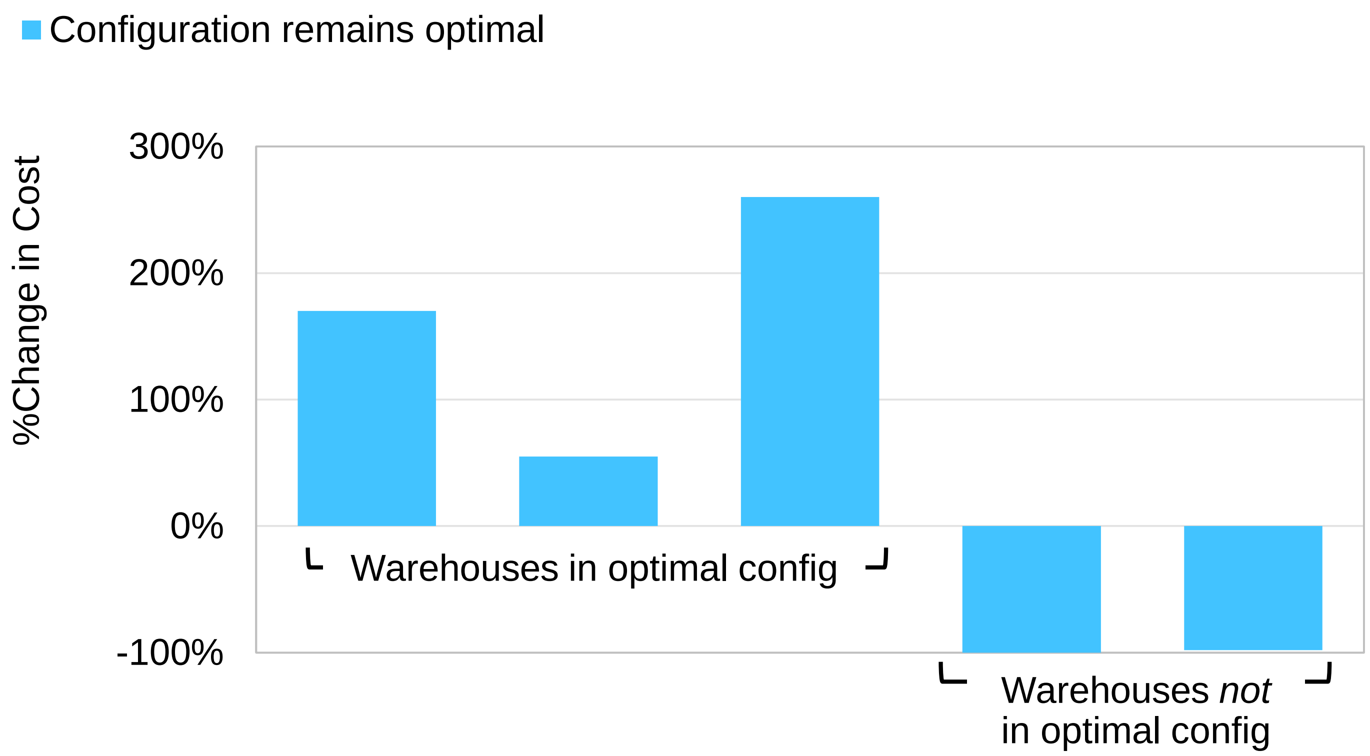
Sensitivity Analysis – Fixed Cost

- The warehouses in the optimal solution remain selected when fixed cost increase between 50-260%

Sensitivity of Fixed Cost



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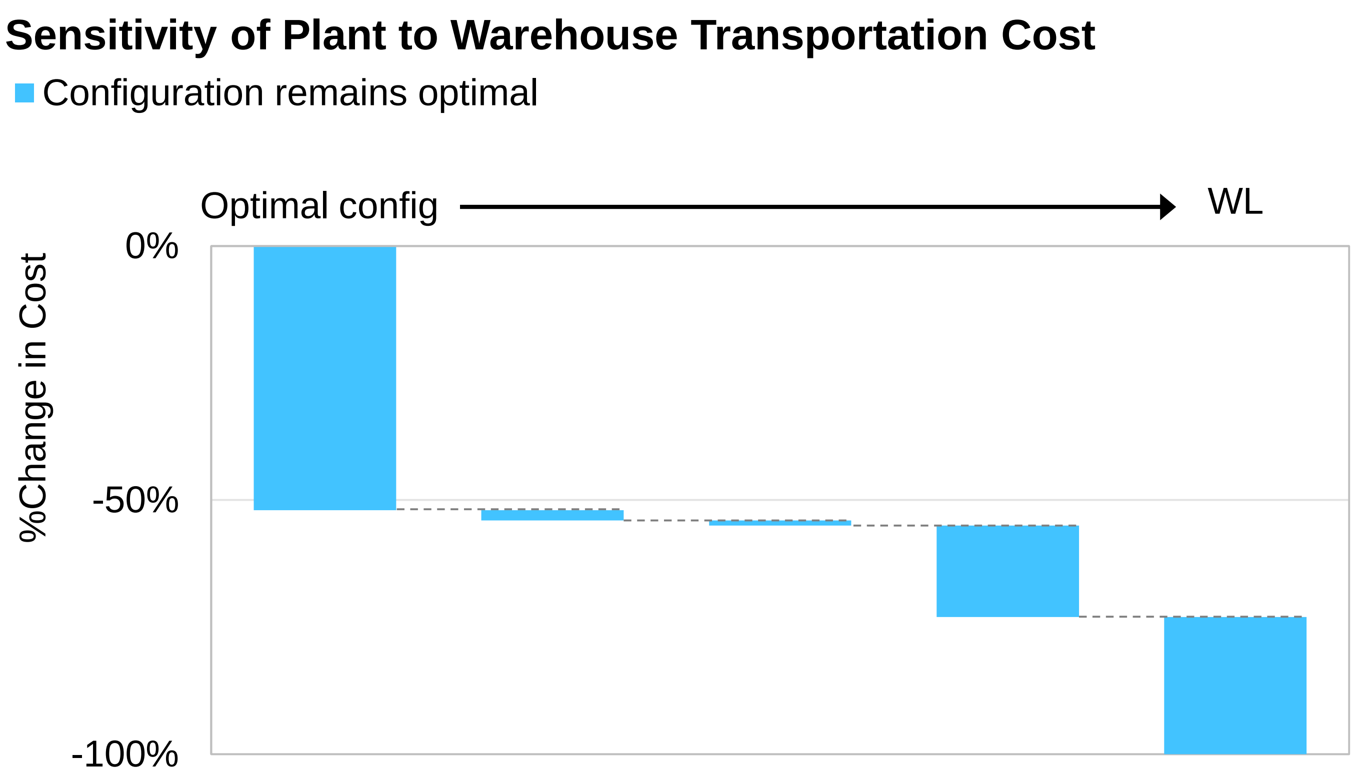
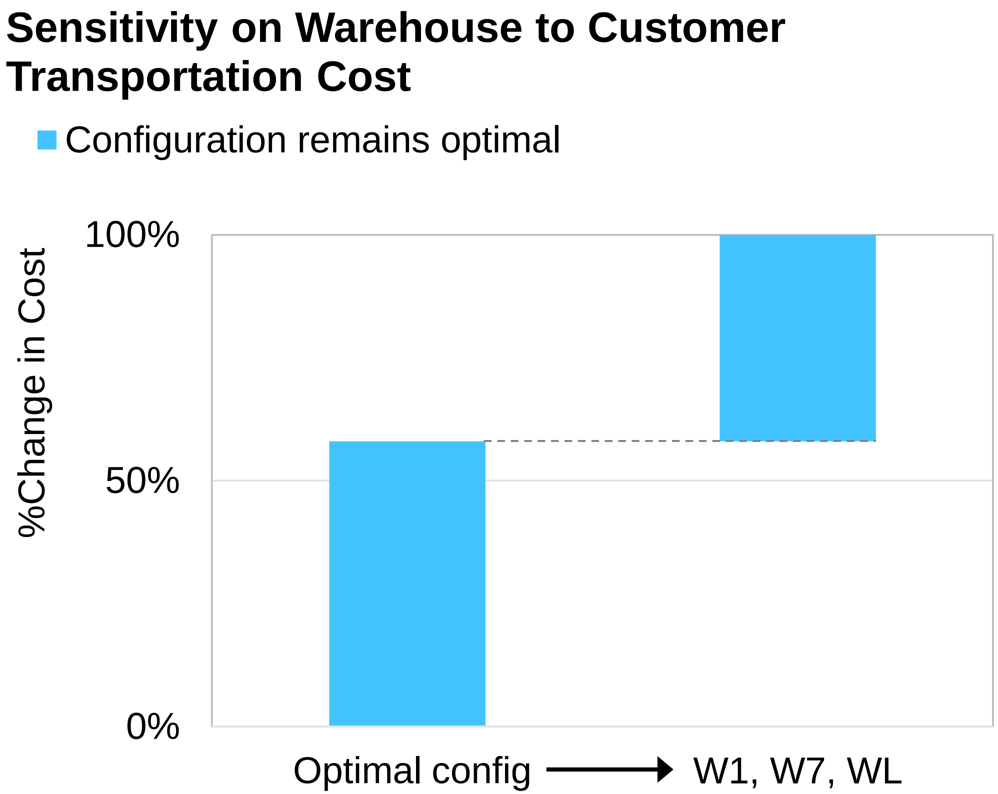
Sensitivity Analysis – Plant to Warehouse Transportation Cost

- The warehouses in the optimal solution remain selected until plant-to-warehouse transportation cost decreases more than 50%. At this point, cost of internal transfer becomes cheap enough that it's worth doing.



Sensitivity Analysis – Warehouse to Customer Transportation Cost

- The warehouses in the optimal solution remains selected until warehouse-to-customer transportation costs increases by more than 58%



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Conclusion

- Given the existing locations, it is most cost effective to ship direct. Locations are too close to benefit from pooling.
- More benefits will be gained by expanding the lower cost warehouses

Q&A