Supply Chain Optimization

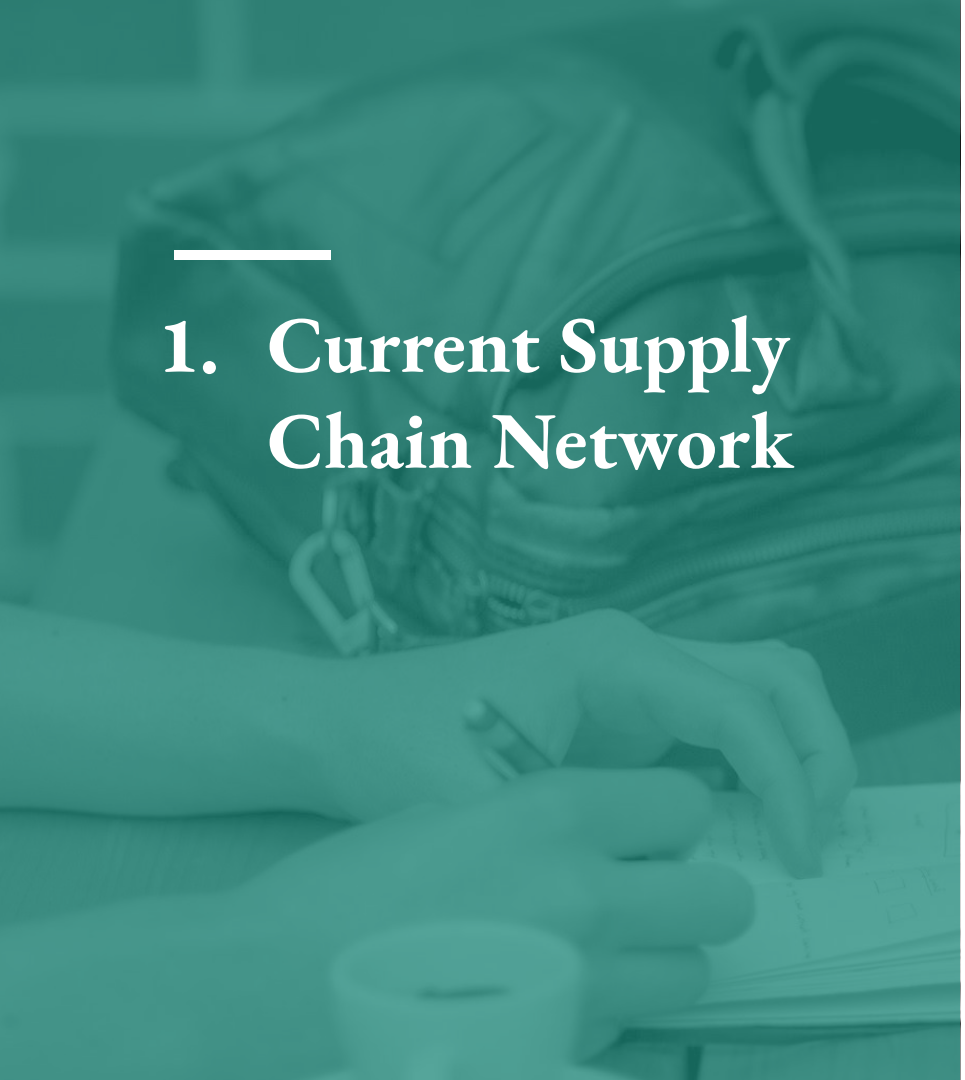
Case Study

Ankit

Supply Chain Network Optimization for a Glass Manufacturer

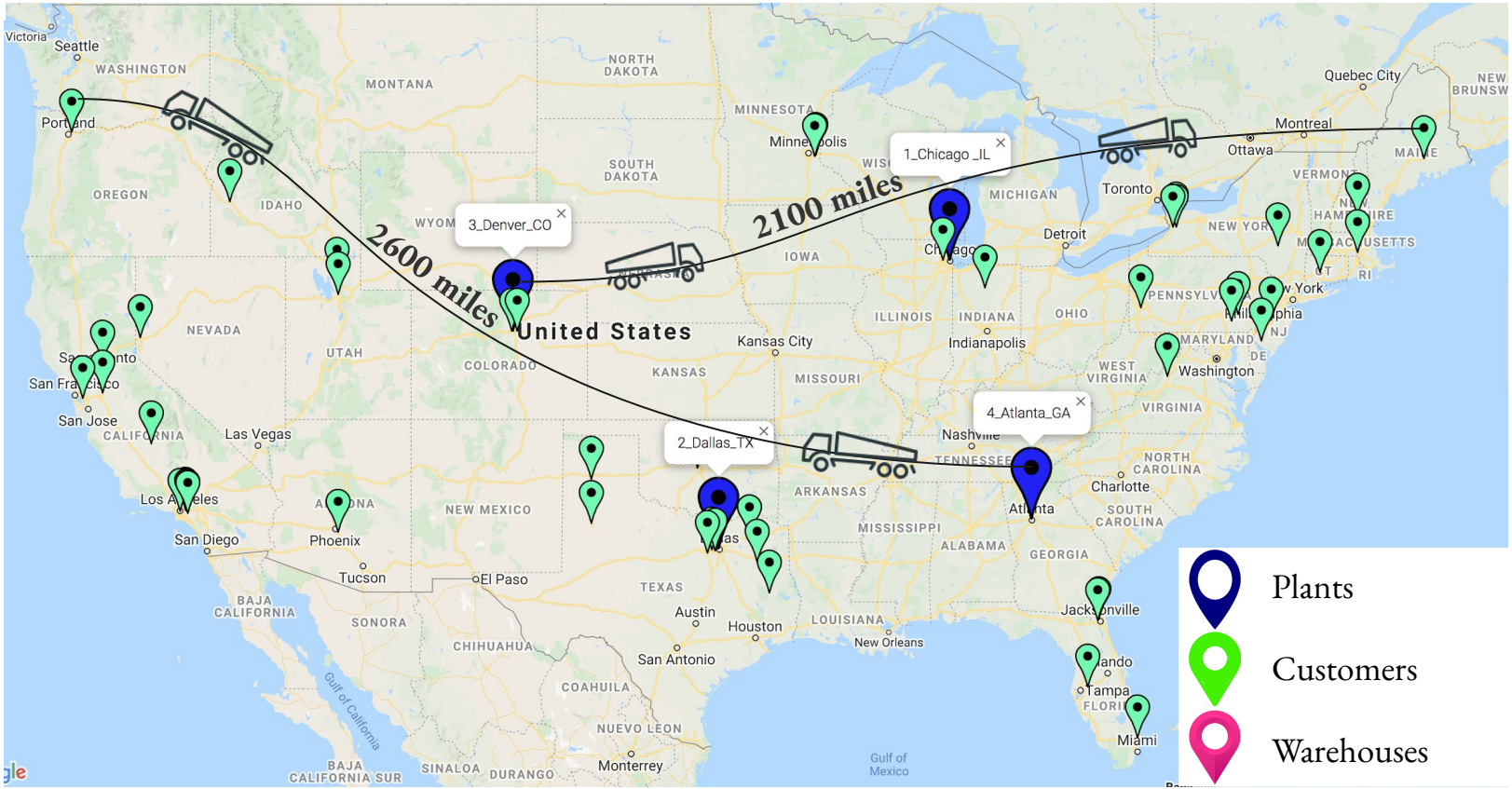
Outline

1. Current SC Network
2. Complaints
3. Potential Changes
4. New SC Networks; KPIs
5. Modeling
6. Recommendations



1. Current Supply Chain Network

1. 4 plants - $P_{1,2,3,4}$
2. 5 Products - $Pr_{1,2,3,4,5}$
3. 50 customers
4. Mode of trans. : road (trucks)


1_Chicago _IL
2_Dallas_TX
3_Denver_CO
4_Atlanta_GA
2100 miles
2600 miles
United States
Plants
Customers
Warehouses

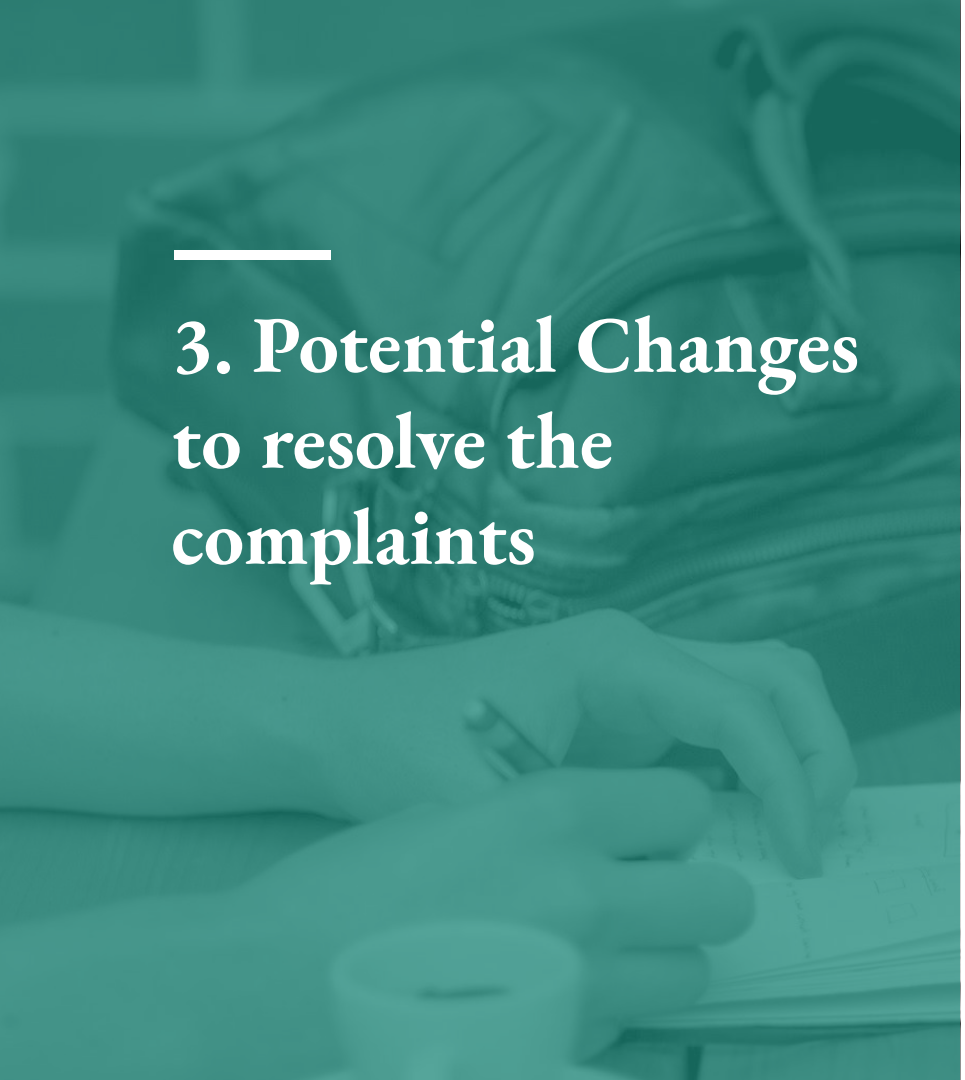
2. Complaints

1. Unreliable service* to distant customers

   **Service = % of total demand met by a facility within x miles of the customer*

2. ↑ oil prices ⟹

   ↑ transportation cost

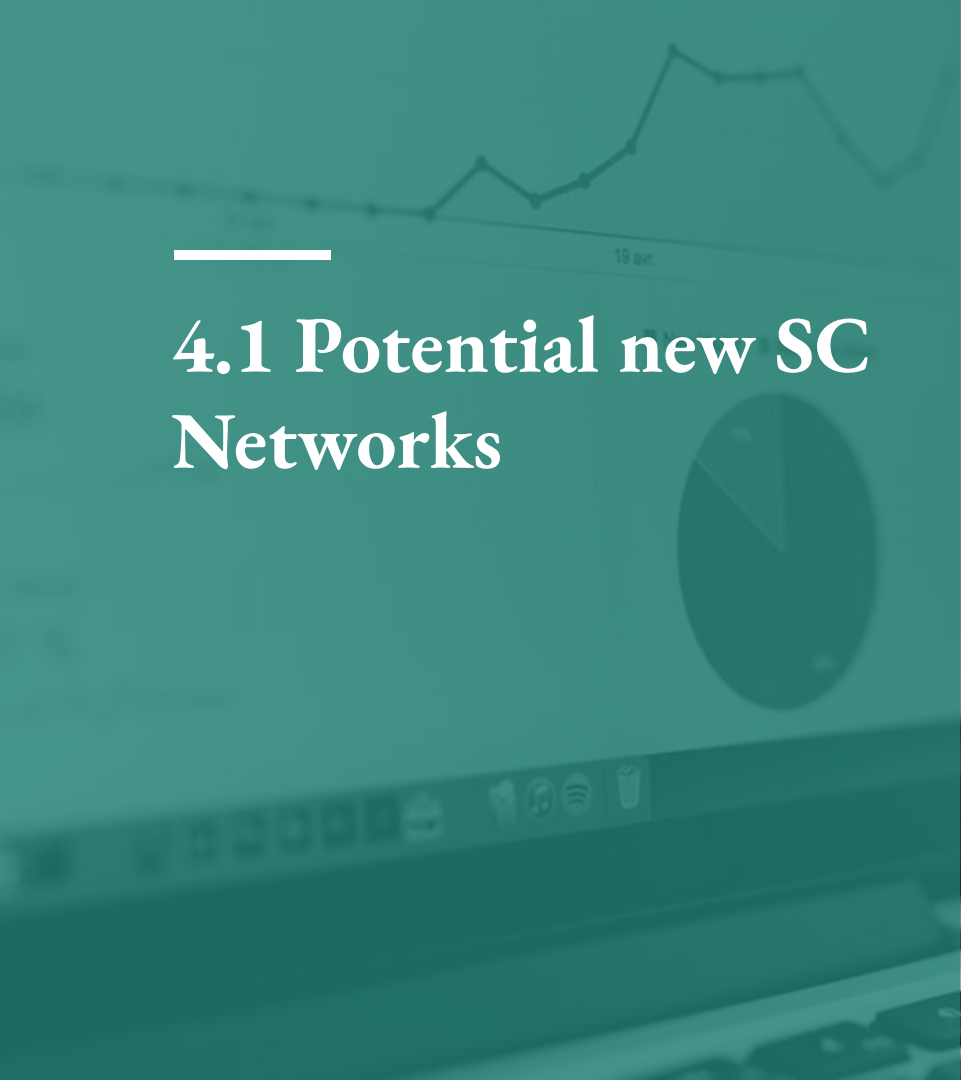


3. Potential Changes to resolve the complaints

1. Build Warehouses*

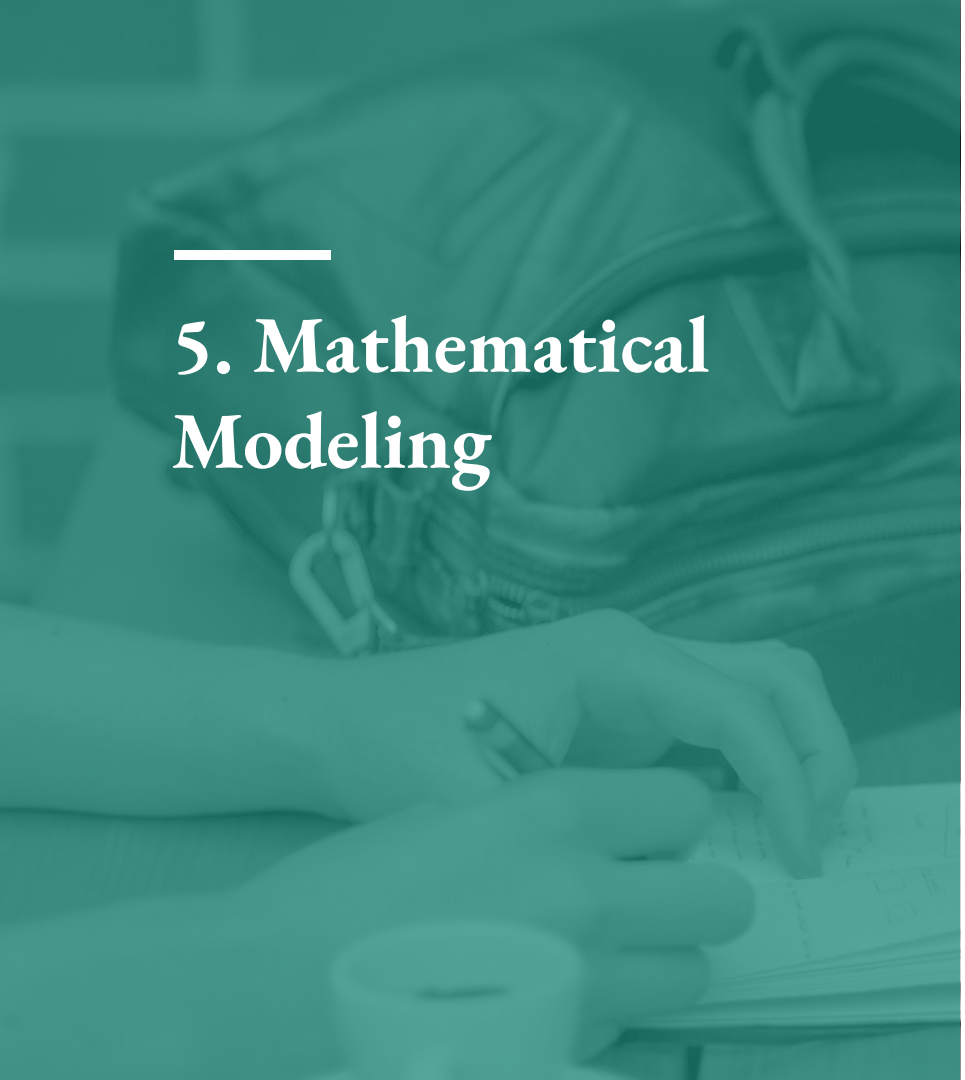
   **a warehouse can be built at a customer location only*

2. Upgrade Plants



4.1 Potential new SC Networks

1. A: Optimized Baseline
2. B: Build Warehouses only
3. C: Upgrade Plants only
4. D: Upgrade Plants + Build warehouses



5. Mathematical Modeling

1. High level notes and assumptions

2. Mathematical model

Demand and Production

1. **Demand is not seasonal**
2. Demand is constant throughout the year
3. Prod. cost of a product does not vary with plant

Costs/Profit

1. **Maintenance, labor & overhead costs do not ↑ with ↑ in prod.**
2. WH setup cost: high and unknown
3. Plant upgrade cost: $10 M
4. Changeover cost is negligible

Modeling

1. **All analysis is quarterly**
2. Model written in Pulp library in Python; solved using the CBC solver

Decision Variables(DV)

1. Production DVs (Cont.)

Whether to upgrade $Plant_j$ & whether to produce $Product_i$ at $Plant_j$

2. Distribution DVs (Binary)

Whether to transfer $Product_i$ from $Node_i$ to $Node_j$

Plants → Warehouses (first mile)
Plants → Customers (last mile)
Warehouses → Customers (last mile)

Constraints

1. Flow Conservation

Node: Input Qty. = Output Qty.

2. Demand Satisfaction

Qty. produced >= Demand

3. Capacity Constraints

Qty. produced <= Capacity
Prod. time <= Available time

4. Minimum Service Level

Objective Function

1. Primary

Minimize the no. of warehouses to be built

2. Secondary

Minimize transportation cost

Service Requirement

Service = $Q(P \rightarrow C) + Q(WH \rightarrow C) >= 80\%$

where Q = Quantity transferred

Profit/Cost Equation

Profit(P) = Revenue(R) - Cost(C)

$C = \text{Transportation}(T_c) + \text{Production}(P_c) + \text{Changeover}(Ch_c)$

$P = R^* - (T_c + P^*_c + Ch^{**}_c)$

For all 4 configurations:

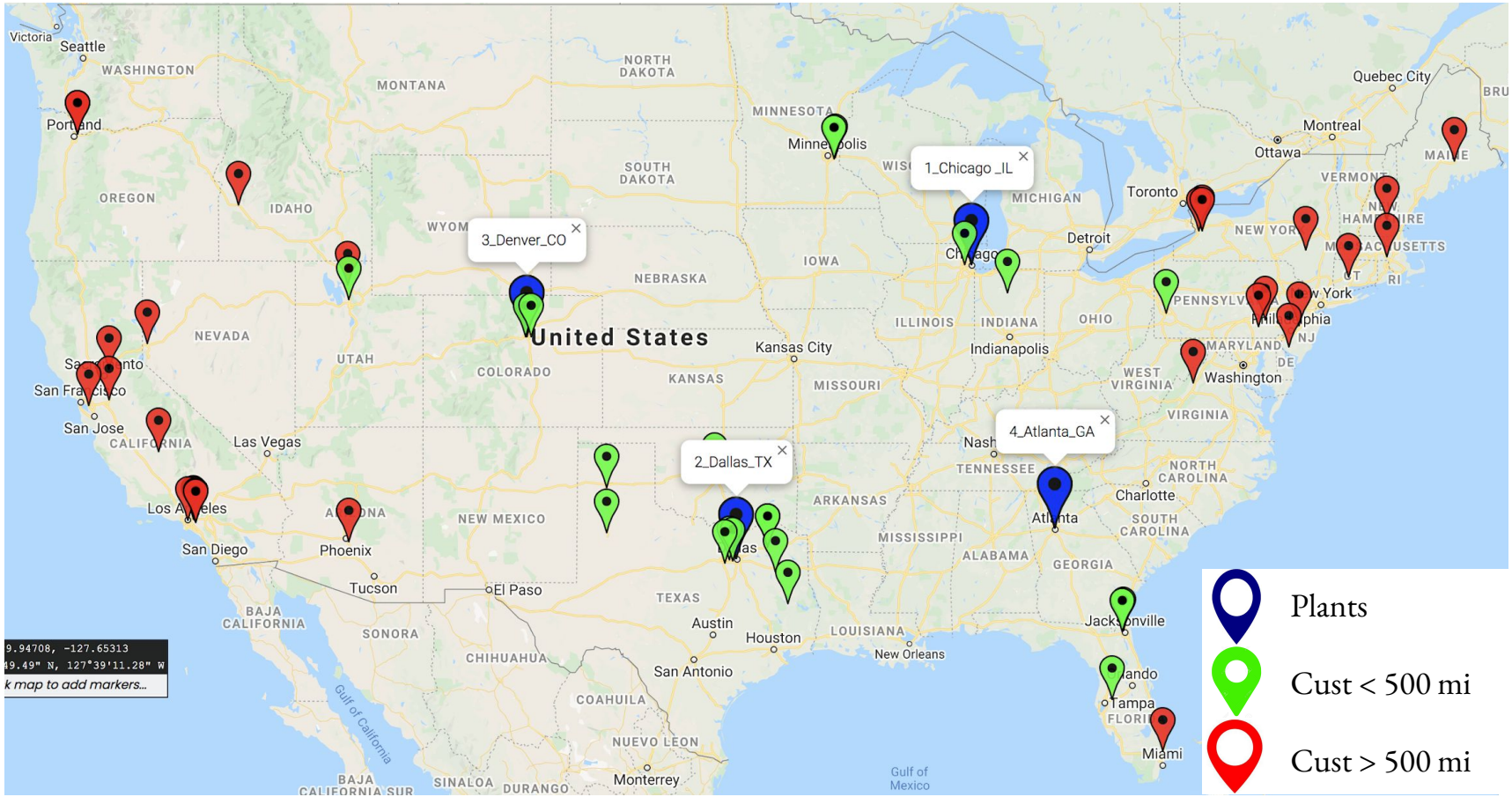
$R^* = \$430M$ $P^*_c = \$190M$

Ch^{**}_c is negligible, hence, ignored.

Configuration A

Optimized Baseline (Existing SC)

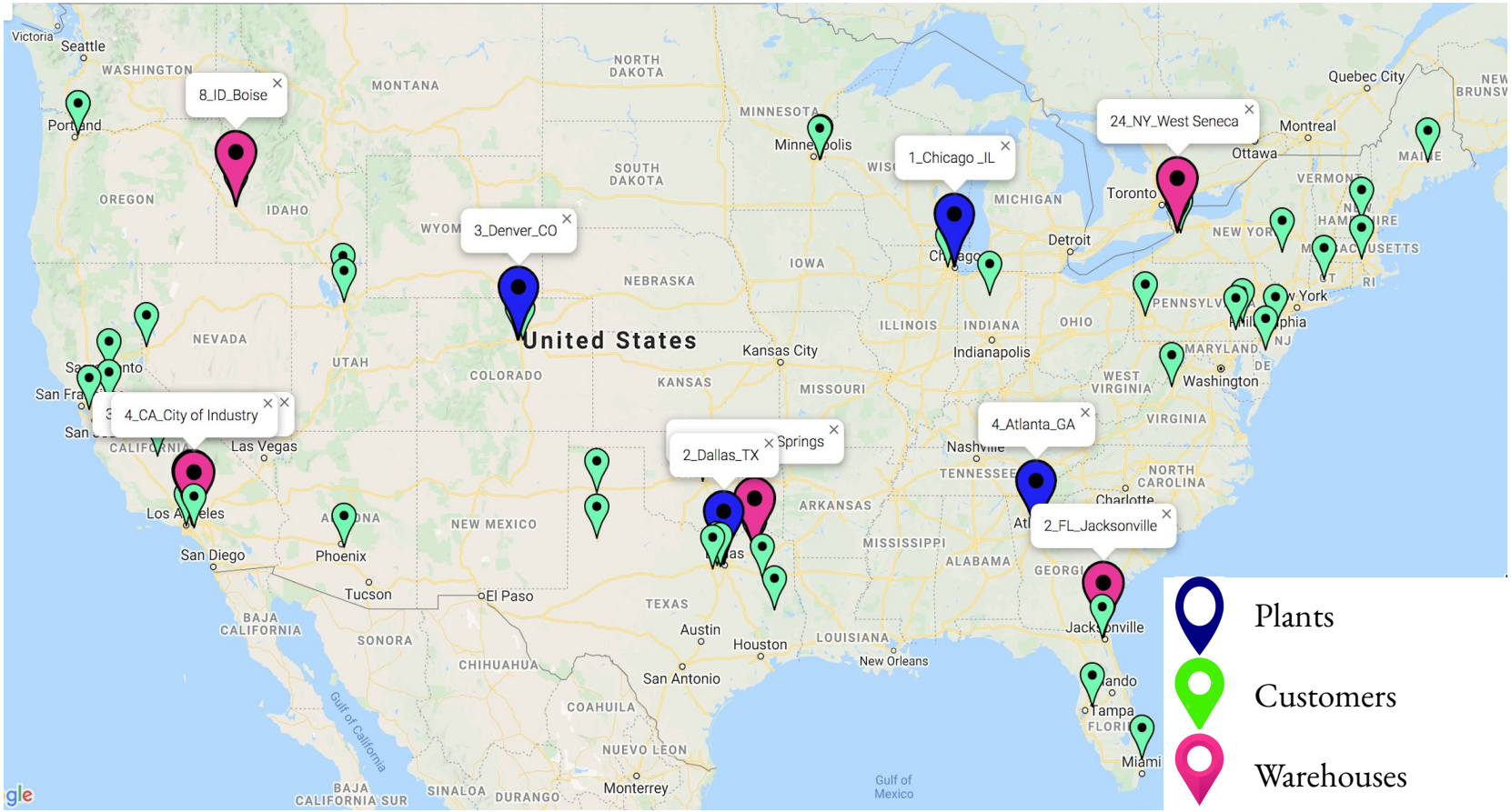
1. **Service = 11%**
2. T_c = \$98 M
3. Profit: \$143 M


1_Chicago _IL
2_Dallas_TX
3_Denver_CO
4_Atlanta_GA
United States
Plants
Cust < 500 mi
Cust > 500 mi

Configuration B

Build Warehouses only

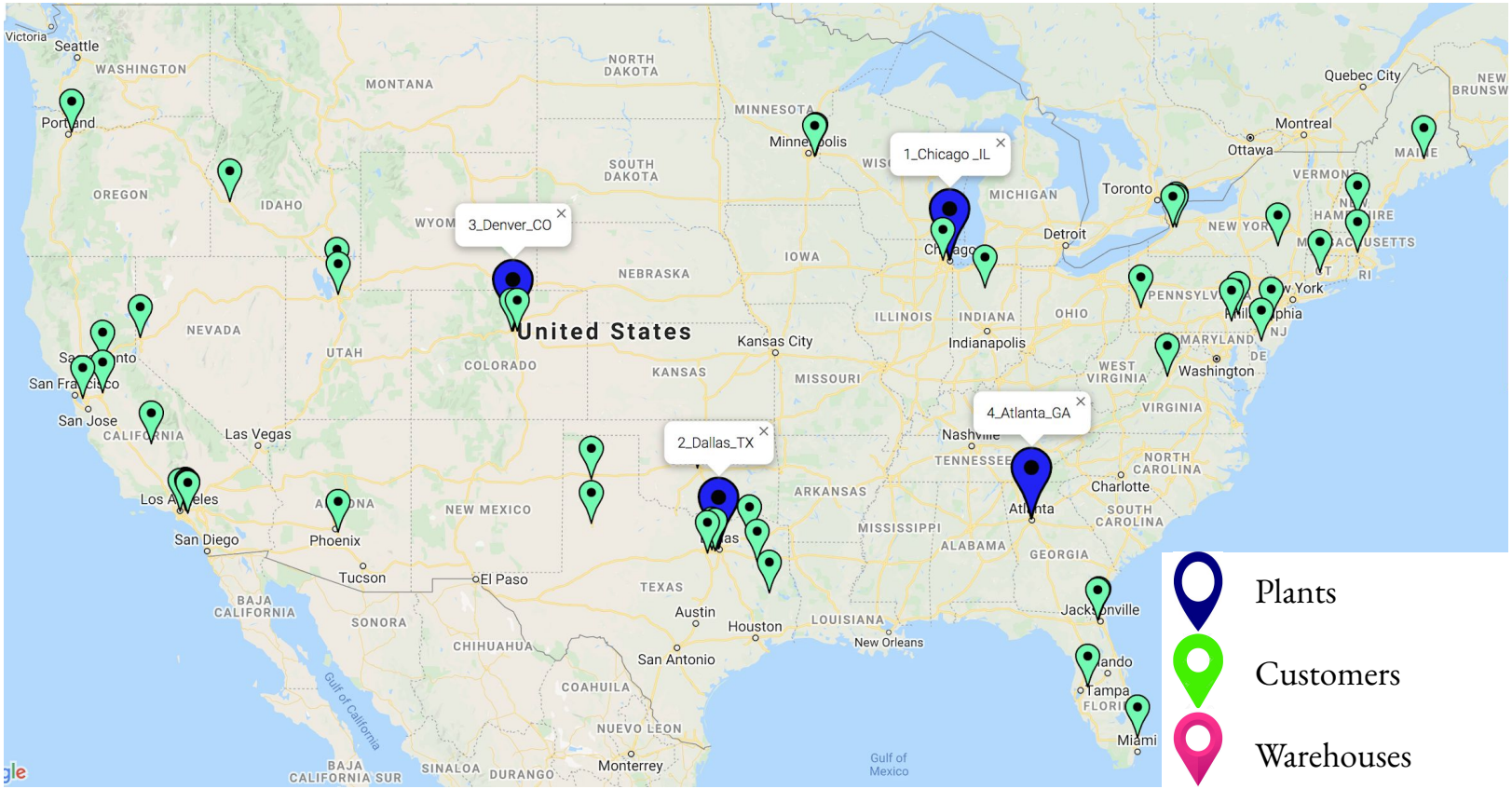
1. Warehouses built: 6
   → Jacksonville, Florida
   → City of Industry, California
   → Boise, Idaho
   → Sulphur Springs, Texas
   → West Seneca, New York
   → City of Industry, California
2. **Service = 80%**
3. T_c = $108 M
4. Profit = $135 M


8_ID_Boise
3_Denver_CO
1_Chicago _IL
24_NY_West Seneca
4_CA_City of Industry
2_Dallas_TX
4_Atlanta_GA
2_FL_Jacksonville
United States
Plants
Customers
Warehouses

Configuration C

Upgrade Plants Only

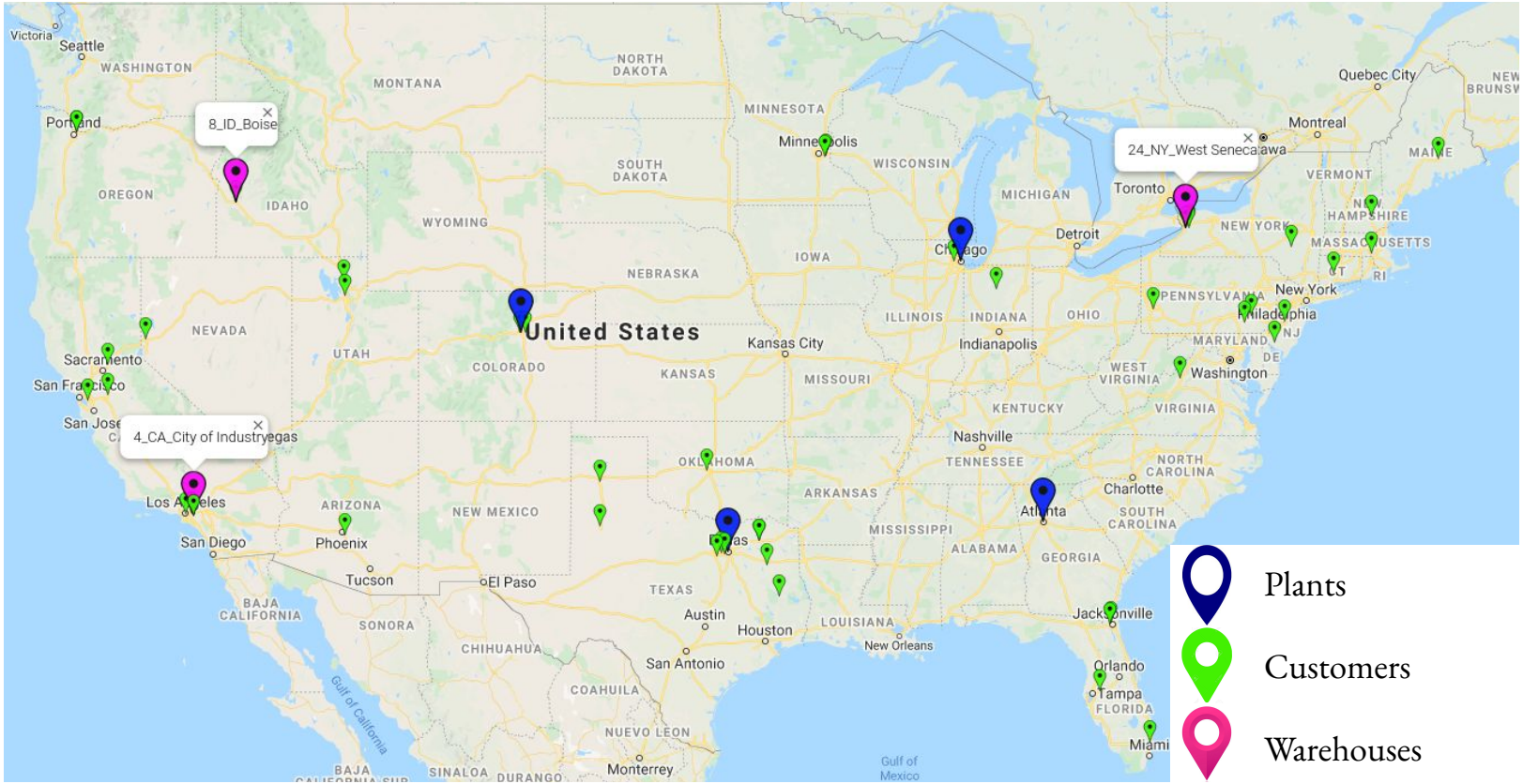
1. All 4 plants upgraded
2. **Service = 43%**
3. T_c = $98 M
4. Profit = $187 M


1_Chicago _IL
2_Dallas_TX
3_Denver_CO
4_Atlanta_GA
United States
Plants
Customers
Warehouses

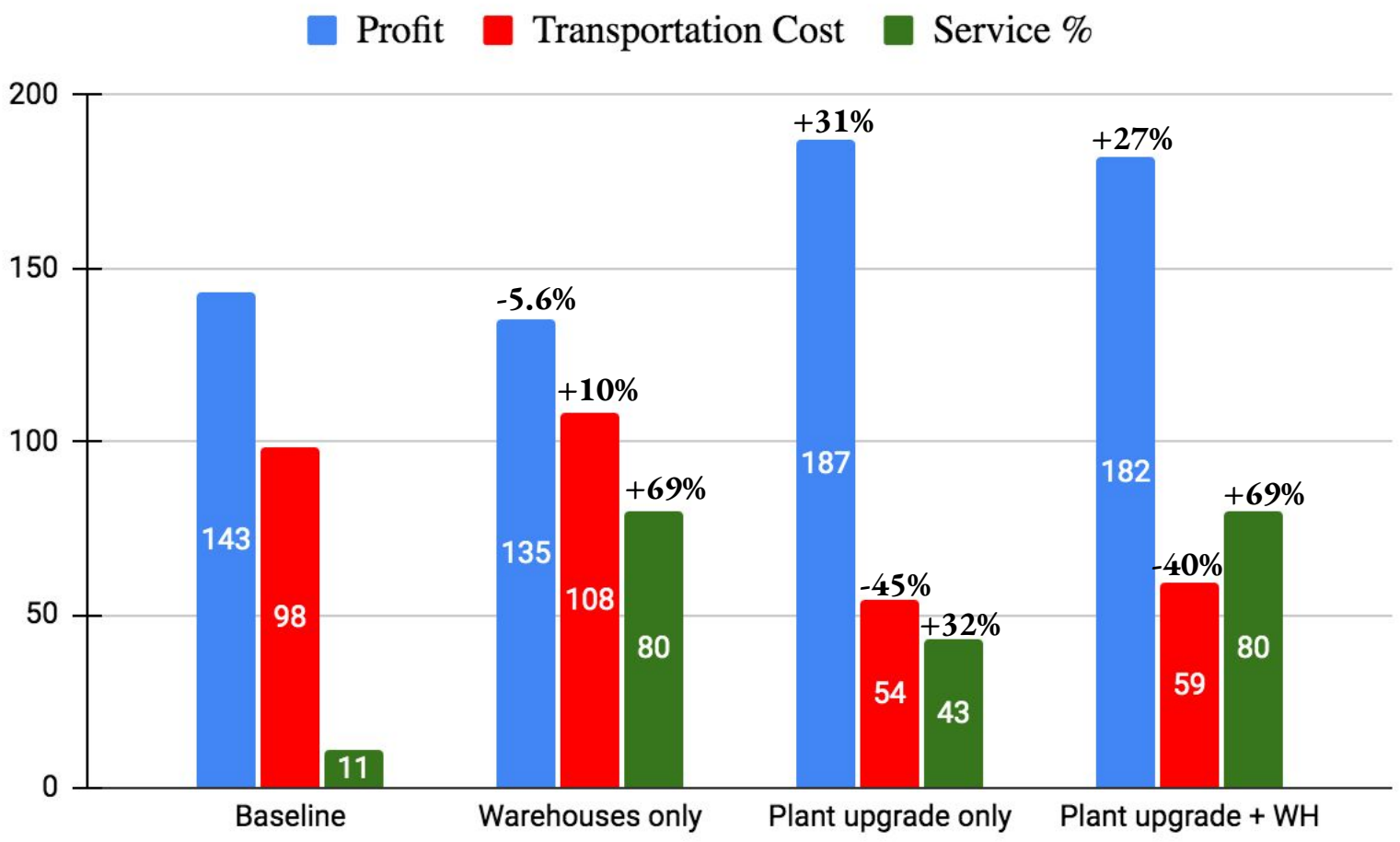
Configuration D

Build warehouses and Upgrade Plants

1. All 4 plants upgraded
2. Warehouses built = 3
   → City of Industry, California
   → Boise, Idaho
   → West Seneca, New York
3. **Service = 80%**
4. T_c = $59 M
5. Profit = $182 M


8_ID_Boise
24_NY_West Seneca
4_CA_City of Industry
United States
Plants
Customers
Warehouses

All % changes are w.r.t the baseline.



6.1 Primary Recommendations

1. Build 3 Warehouses

   → City of Industry, California
   → Boise, Idaho
   → West Seneca, New York

2. Upgrade all 4 Plants

Costs Incurred

1. Building 3 WH: $30M

$10M/ warehouse*

**assumption (exact cost not known)*

2. Upgrade 4 plants: $40M

Total cost incurred

$70M

Profit

Additional profit per year

(182 - 143) ≈ **$40 M**

Recovery Period

Cost to recover ≈ $70 M

$\Longrightarrow$

Recovery period < **2 years**

6.1 Secondary Recommendations

1. Find more customers in & around **Illinois(P_1)** and **Georgia(P_4)**
2. Negotiate truck contracts to further decrease transportation cost
3. Minimize the fixed cost incurred in setting up of warehouses

Secondary Recommendations

→ Find more customers in and around **Illinois(P_1)** and **Georgia(P_4)**

Capacity Utilizations

P_1(IL): 33% ***P_4(GE): 36%***

P_3: 85% *P_2: 67%*

Additional opportunity/year (with 75% utilization at ***P_1*** & ***P_4***)

~200k tonnes
~$200M revenue
~80 M profits

Secondary Recommendations

→ Negotiate truck contracts to further decrease transp. cost

No. of trucks

Initial: 42k → Final: 57k

+35%

Secondary Recommendations

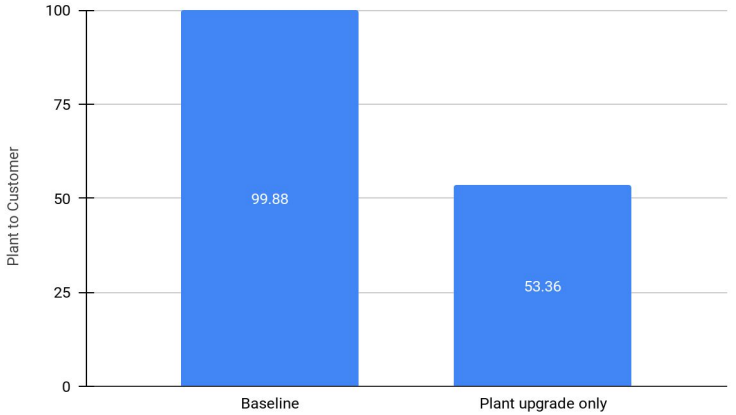
Minimize the fixed cost incurred in setting up of warehouses

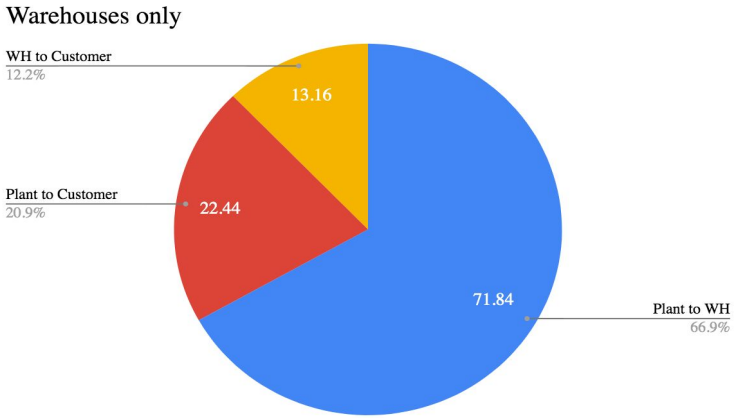
Fin.

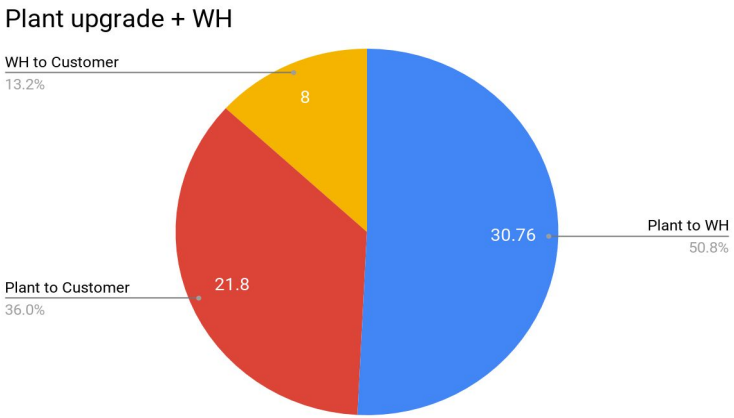
Components of Transportation cost

i) First mile: Plant to Warehouse

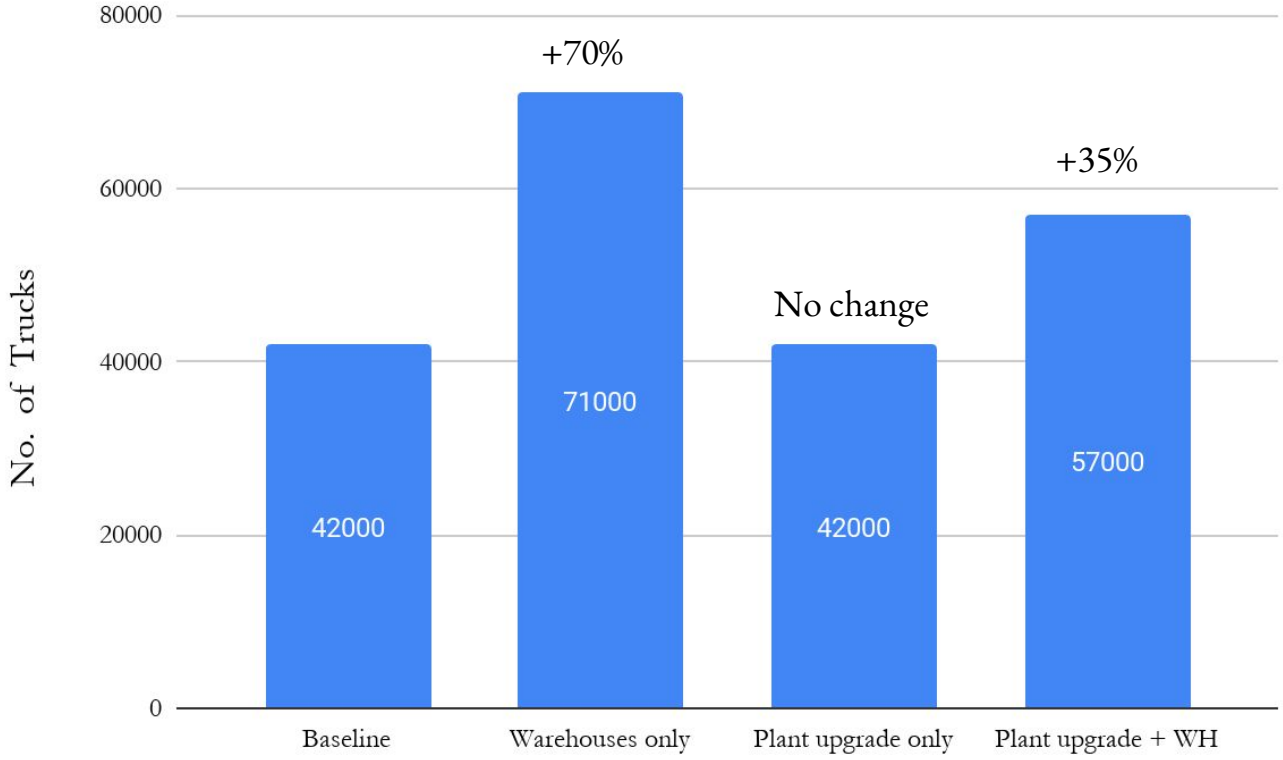
ii) Last mile
  a) Plant to Customer
  b) Warehouse to Customer

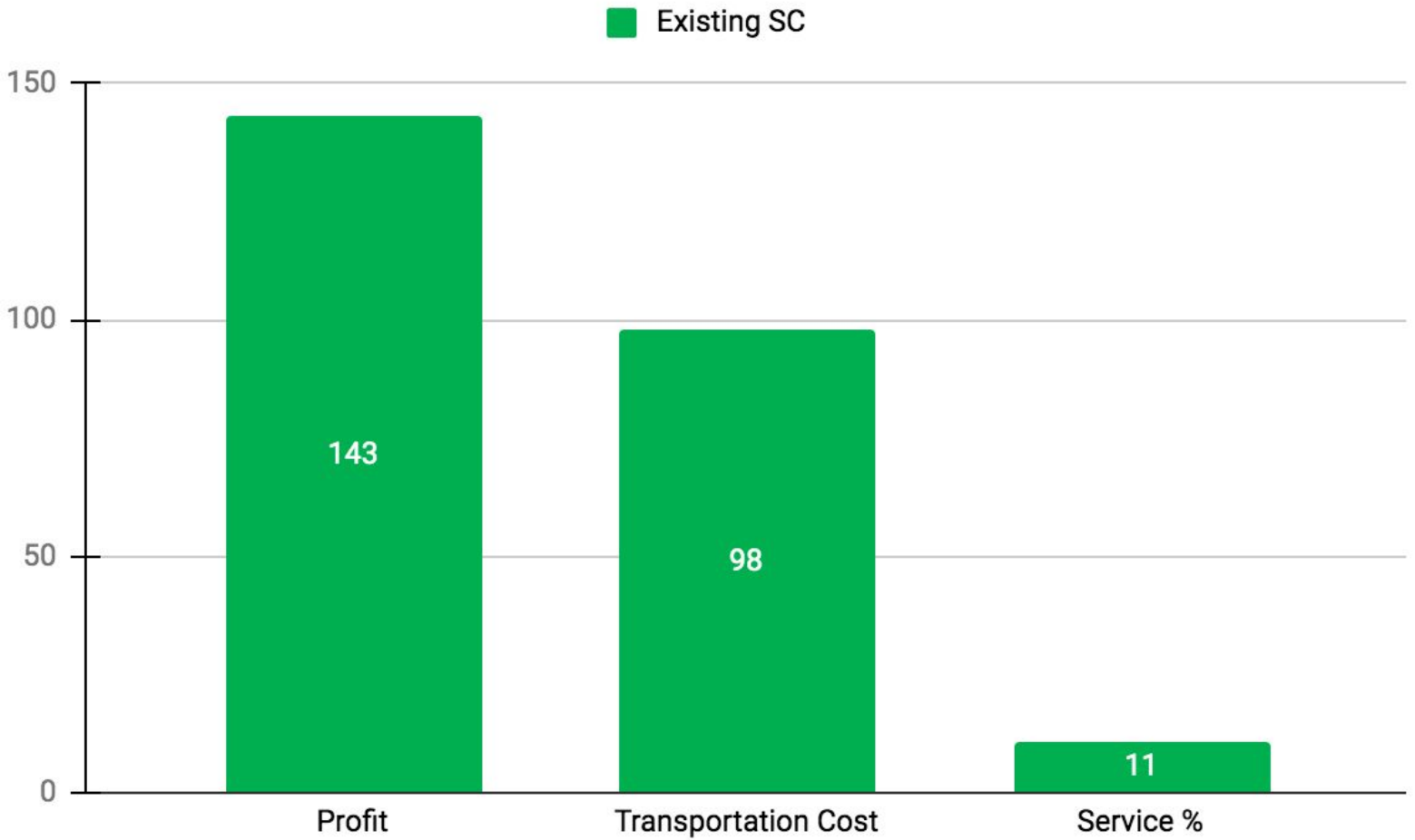


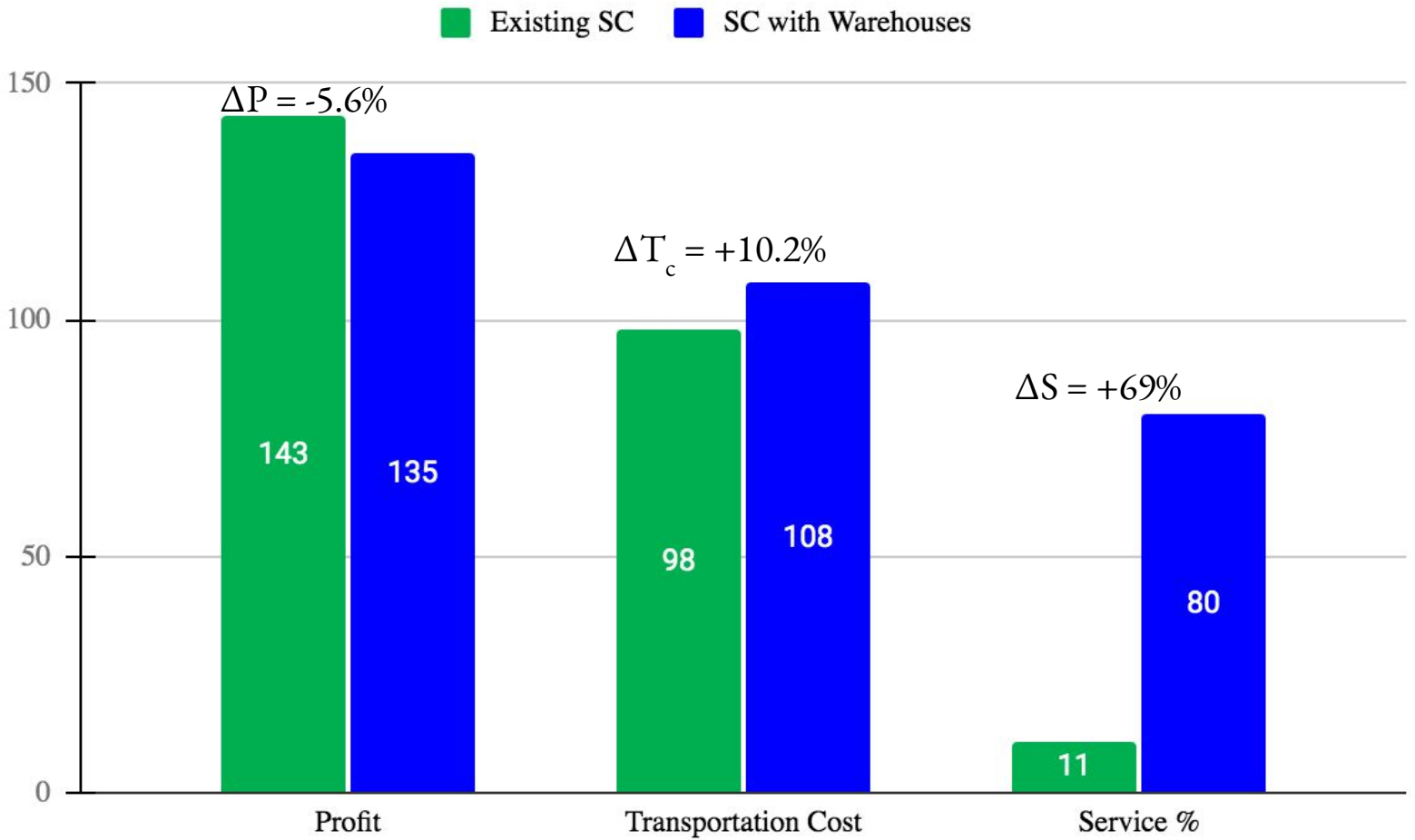


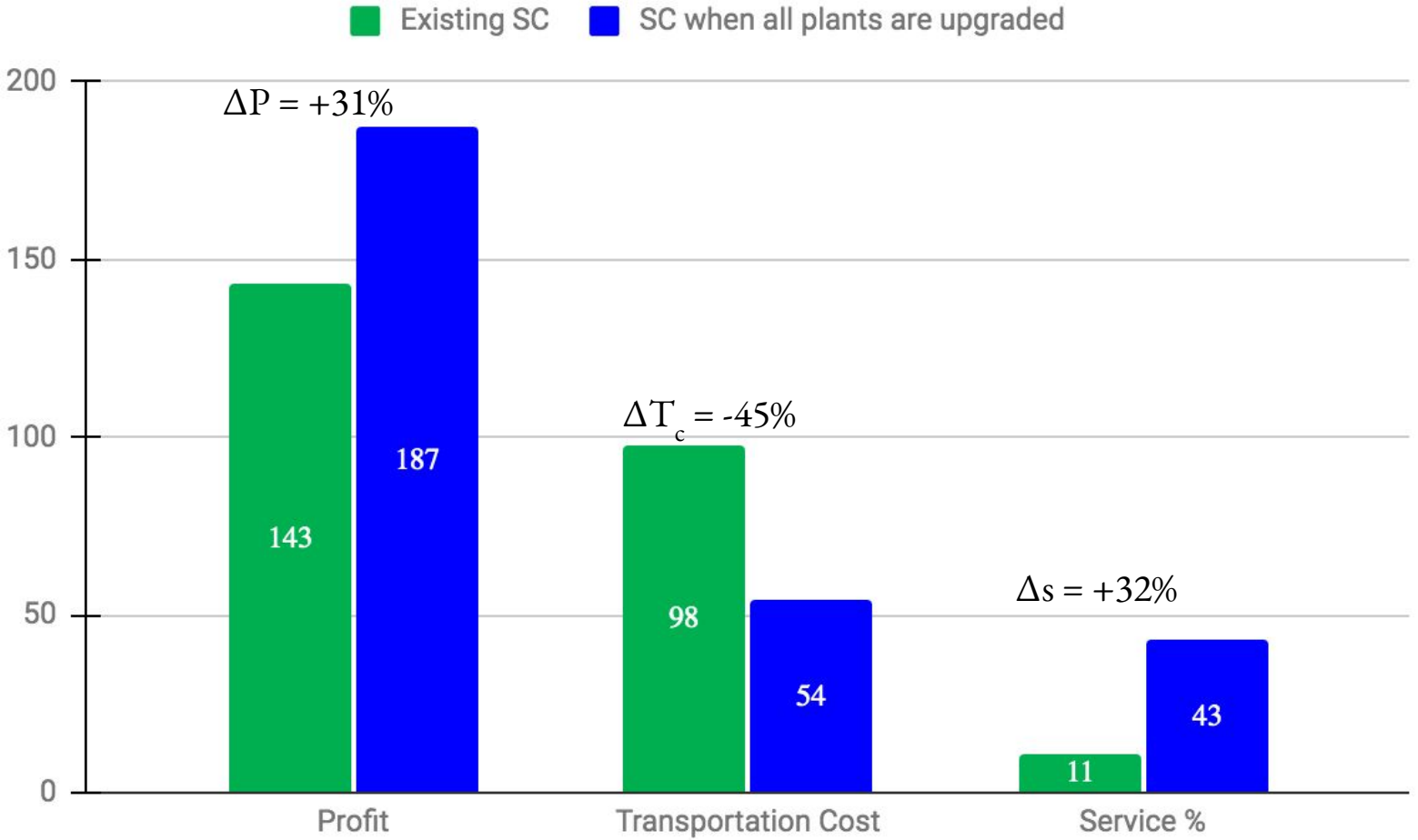


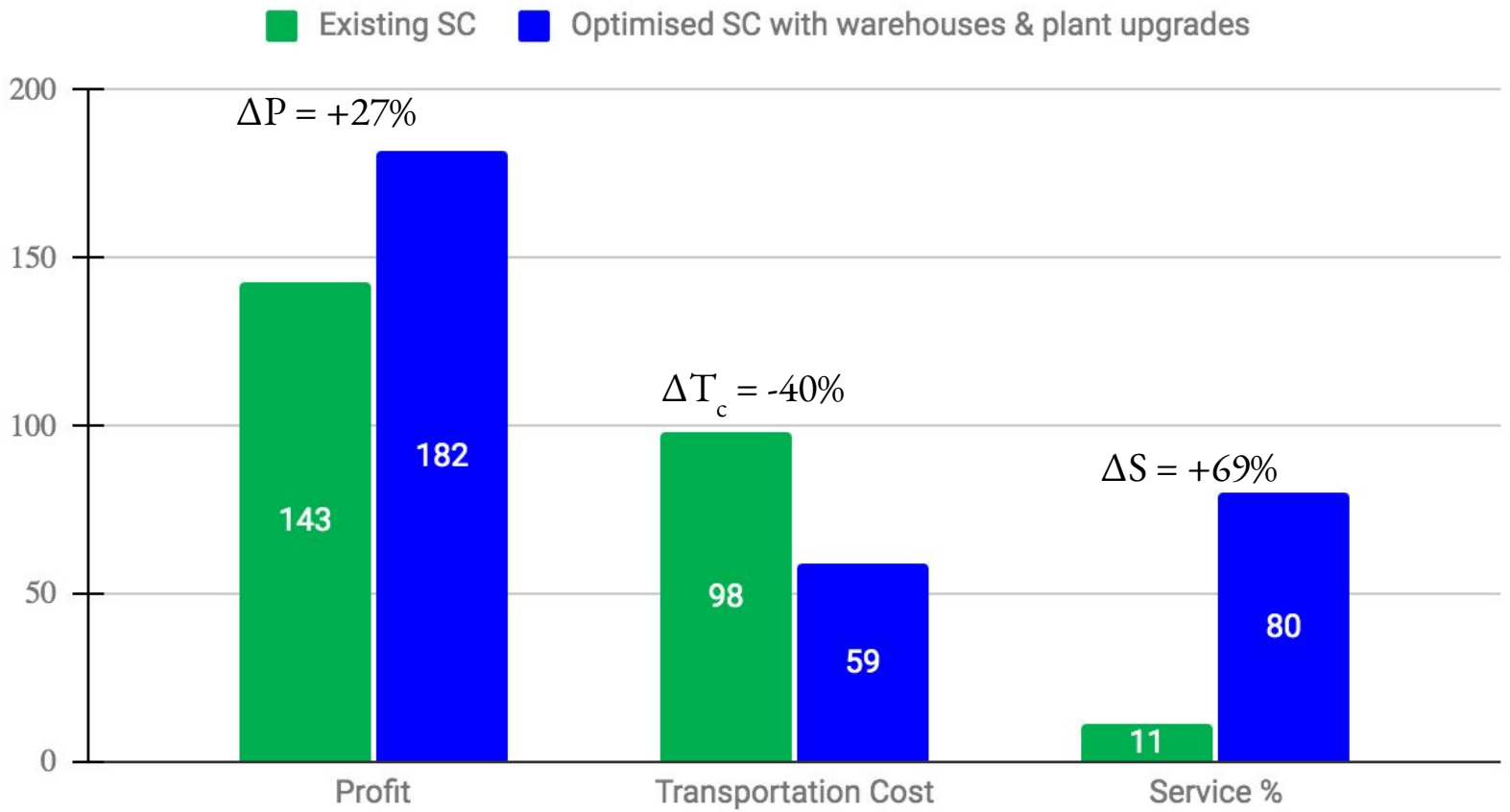
All costs are in millions of USD


80000
60000
40000
20000
0
No. of Trucks
+70%
+35%
No change
42000
71000
42000
57000
Baseline
Warehouses only
Plant upgrade only
Plant upgrade + WH


Existing SC
150
100
50
0
143
98
11
Profit
Transportation Cost
Service %


Existing SC
SC with Warehouses
150
100
50
0
ΔP = -5.6%
143
135
ΔT_c = +10.2%
98
108
ΔS = +69%
11
80
Profit
Transportation Cost
Service %


Existing SC
SC when all plants are upgraded
200
150
100
50
0
ΔP = +31%
143
187
ΔT_c = -45%
98
54
Δs = +32%
11
43
Profit
Transportation Cost
Service %


Existing SC
Optimised SC with warehouses & plant upgrades
200
150
100
50
0
ΔP = +27%
143
182
ΔT_c = -40%
98
59
ΔS = +69%
11
80
Profit
Transportation Cost
Service %