SUPPLY CHAIN CASE COMPETITION

Presented by StArS

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INTRODUCTION

Building T, the corporate headquarters of XYZ Corporation, obtains water from two sources: a contracted supply from The Water Co. and its own precipitation-based Water Storage Tank, each incurring specific costs per gallon. We helped XYZ Corporation to optimize water allocation.

PROBLEM STATEMENT

OBJECTIVE 1 - FORECASTING

Building T's weekly water usage includes **Cooling** (temperature control) and **Main** (employee use), with no difference in water quality. Complete data exists from May 14, 2023, to February 16, 2025. XYZ Corporation needs total weekly water demand forecasts for the next four weeks.

OBJECTIVE 2 - OPTIMIZATION

XYZ Corporation, renewing water supply contracts with The Water Co. **every four weeks**, has received ten proposals for the next period. Using forecasts from Objective 1, we'll build an optimization model to minimize total water costs by allocating weekly usage between The Water Co. and XYZ's Water Storage Tank to meet demand.

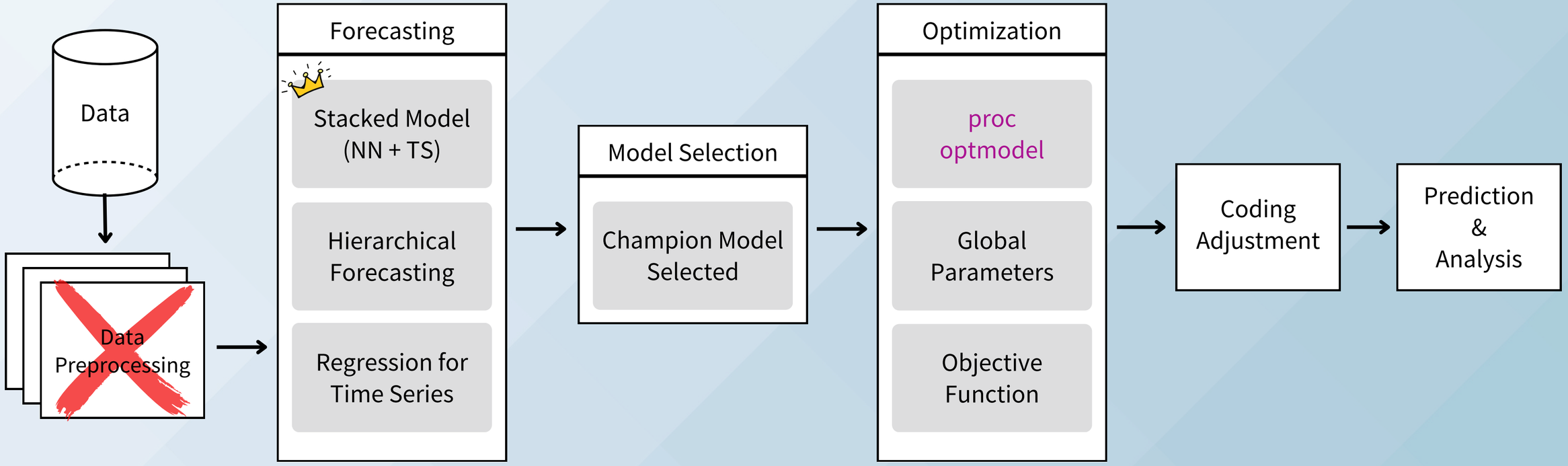
DATASET INTRODUCTION

RAWDATA

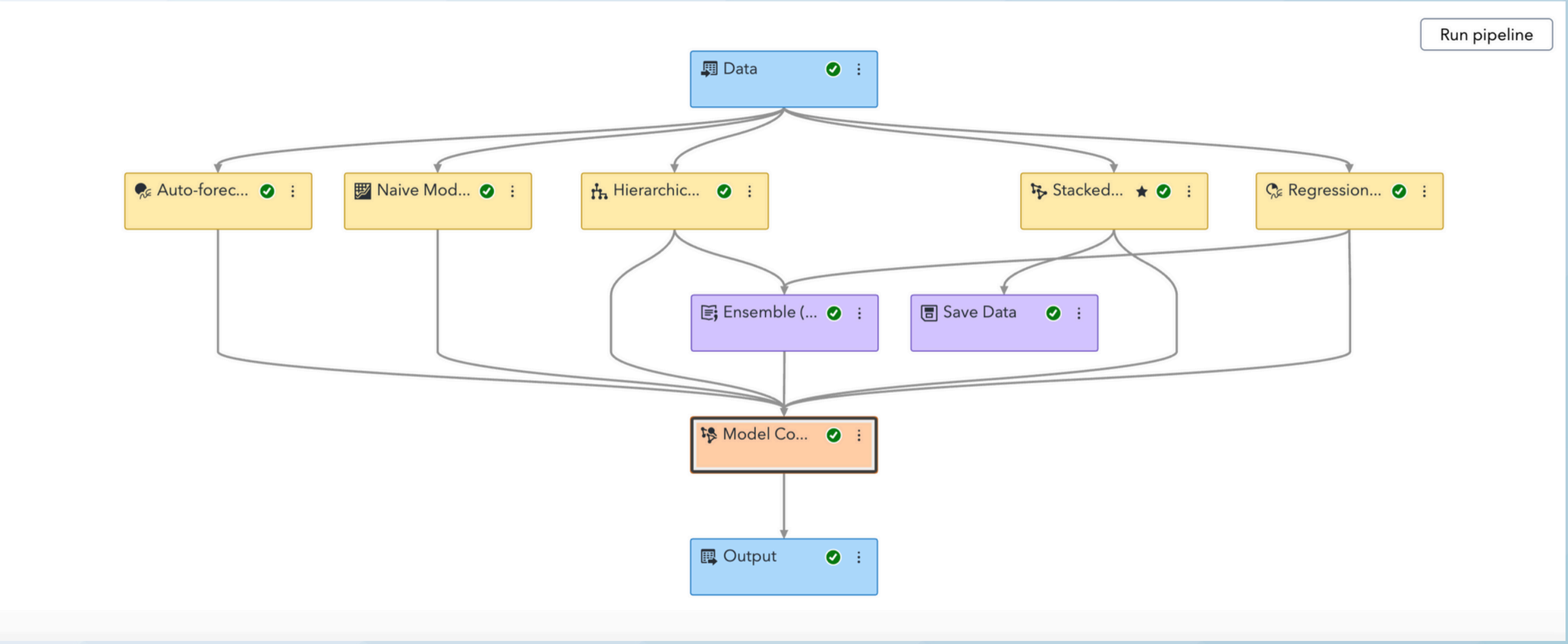
- **metername**: Building T (Cooling + Main) Water
- **date**: Date Records
- **gallons**: Water Usage

rawdata		
PK	metername	VARCHAR(50)
	date	DATE
	gallons	FLOAT

METHODOLOGICAL WORKFLOW



FORECASTING PIPELINE



MODEL SELECTION

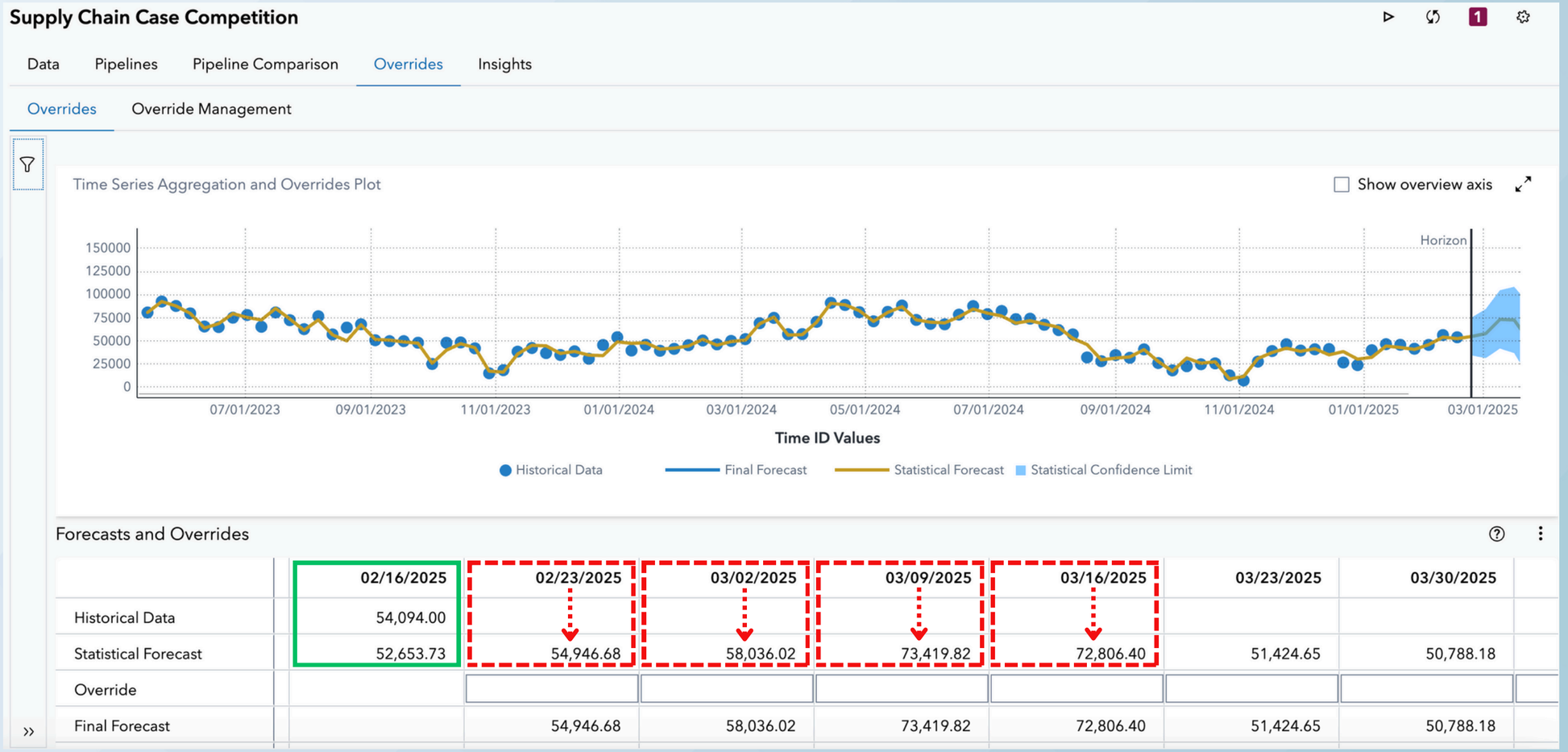
WMAPE / WRMSE Score	Stacked Model (NN + TS)	Hierarchical Forecasting (combined models)	Regression for Time Series	Naive Model
WMAPE	✅ 7.5160	20.1702	10.6946	20.3187
WRMSE	✅ 4,132.5640	10,338.1698	6,027.4797	6,027.4797

FORECASTING RESULT

HOW MANY TOTAL GALLONS OF WATER IS BUILDING T EXPECTED TO USE IN EACH OF THE NEXT FOUR WEEKS?

Final Forecasts

- **Week 1** (02/23/2025): 54,947 gallons
- **Week 2** (03/02/2025): 58,036 gallons
- **Week 3** (03/09/2025): 73,420 gallons
- **Week 4** (03/16/2025): 72,806 gallons



	02/16/2025	02/23/2025	03/02/2025	03/09/2025	03/16/2025	03/23/2025	03/30/2025
Historical Data	54,094.00						
Statistical Forecast	52,653.73	54,946.68	58,036.02	73,419.82	72,806.40	51,424.65	50,788.18
Override							
Final Forecast		54,946.68	58,036.02	73,419.82	72,806.40	51,424.65	50,788.18

OPTIMIZATION

```
*******************************
  Solve the Optimization in PROC OPTMODEL
*******************************************
proc optmodel;
   /* A. Read forecast_data */
   set<number> WEEKS;
   num demand {WEEKS};
   num tank_cost {WEEKS};
   num precip {WEEKS};
   read data forecast_data into WEEKS=[week] demand=wa

   /* B. Read contract_data */
   set<string> TIERS;
   num price {TIERS};
   num purchase_lb {TIERS};
   read data contract_data into TIERS=[tier] price purc
```

- **Objective**: Minimize total water costs over **four weeks** by optimizing Water Co. purchases and tank usage.

- **Constraints**: Meet weekly demand, maintain a **minimum** tank level (30,000 gallons), ensure at least **25%** tank usage, and comply with contractual purchase minimums.

OPTIMIZATION PROCESS FOR WATER SUPPLY COST MINIMIZATION

Data Preparation

• **forecast_data**: Weekly demand (54,947–72,806 gal), treatment costs ($0.18/$0.10 per gal), precipitation (12,000–22,000 gal)
• **contract_data**: 10 price tiers ($0.25–$0.07/gal), min purchases (10,000–100,000 gal/week)

Model Formulation in PROC OPTMODEL

• **Sets/Params**: Weeks (1–4), Tiers (1–10); loaded demand, costs, precipitation, prices, purchase mins.
• **Variables**: Buy[w], UseTank[w], Inventory[w] ≥ 0; Inventory[w] ≥ 30,000 gal.

- **DemandCon**: Buy[w] + UseTank[w] ≥ demand[w] (meet demand).
- **TankShareCon**: UseTank[w] ≥ 0.25 * demand[w] (25% from tank).
- **InvBalanceCon**: Inventory[w] = (if w=1 then 62500 else Inventory[w-1]) + precip[w] - UseTank[w] (inventory balance).
- **Objective**: Minimized TotalCost = sum {w in WEEKS} (current_price * Buy[w] + tank_cost[w] * UseTank[w]) for each tier.

Solution Approach

- Iteration: Looped over tiers; set price and minimum purchase (**Buy[w].lb**).
- Solved LP for **optimal Buy**, **UseTank**, **Inventory** per tier.
- Stored results in **buy_sol**, **tank_sol**, **inv_sol**, **cost_sol** arrays.

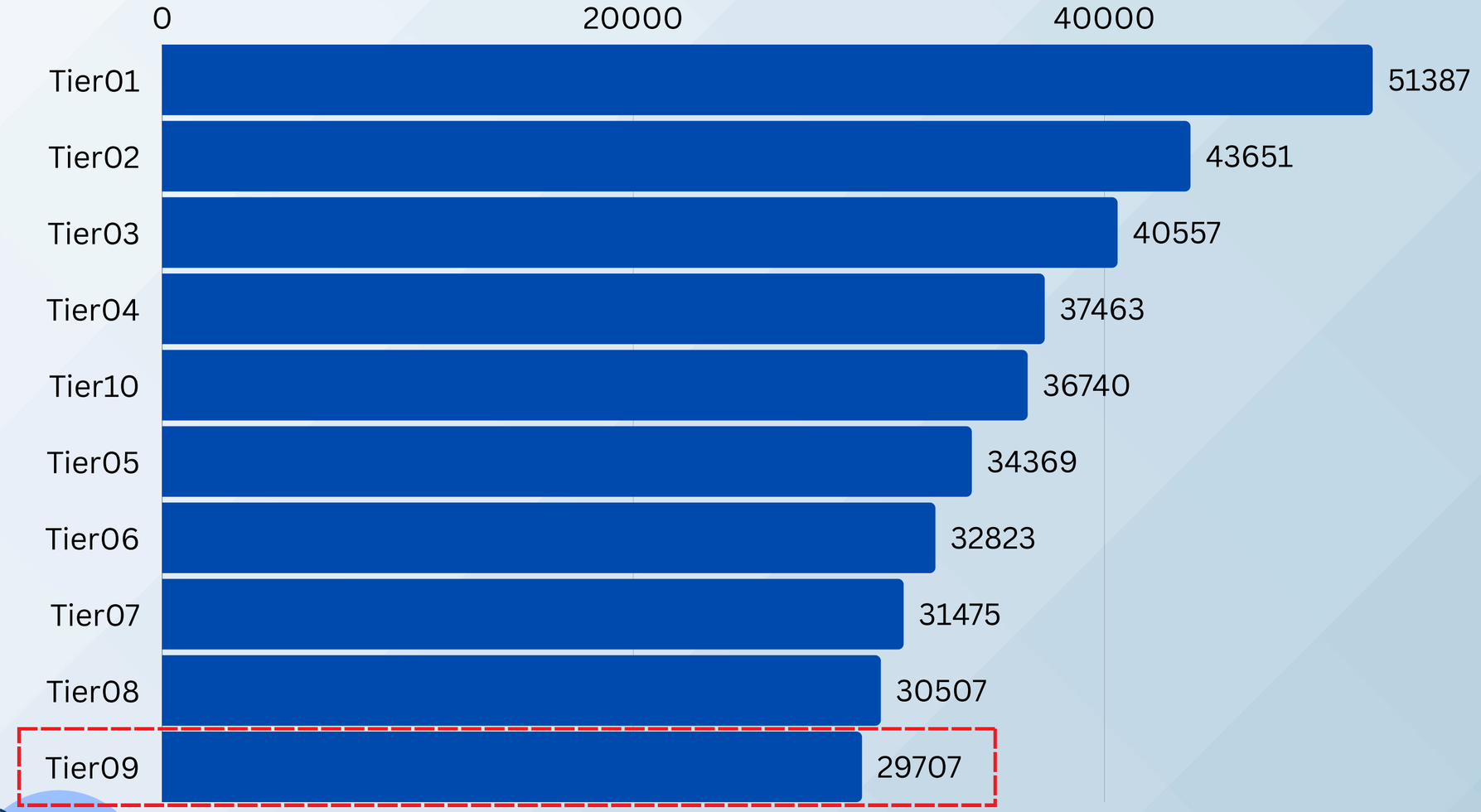
Best Solution Tracking

- Initialized **temp_best_obj = 1e10** and **temp_best_tier** = '' to track the minimum cost and corresponding tier.
- Updated **temp_best_obj** and **temp_best_tier** if a tier's **cost_sol[t] > 0 and cost_sol[t] < temp_best_obj**.
- Assigned final values to **best_obj** and **best_tier** for output.

Output and Validation

- Printed **best_tier** and **best_obj** to identify the optimal tier (Tier09) and cost (29,706.84).
- Created a **solution dataset** with 40 observations (10 tiers × 4 weeks) for detailed results.
- Verified constraints: All ending **inventories > 30,000**, **tank usage ≥ 25%** of demand, and demand met.

TOTAL COST OF EACH TIER



Obs	t	w	tier	week	buy	use_tank	end_inventory	cost
1	Tier01	1	Tier01	1	41210.25	13736.75	60763.25	12775.18
2	Tier01	2	Tier01	2	43527.00	14509.00	64254.25	13493.37
3	Tier01	3	Tier01	3	55065.00	18355.00	65899.25	15601.75
4	Tier01	4	Tier01	4	14906.75	57899.25	30000.00	9516.61
5	Tier02	1	Tier02	1	41210.25	13736.75	60763.25	10714.67
6	Tier02	2	Tier02	2	43527.00	14509.00	64254.25	11317.02
7	Tier02	3	Tier02	3	54971.75	18448.25	65806.00	12839.18
8	Tier02	4	Tier02	4	15000.00	57806.00	30000.00	8780.60
9	Tier03	1	Tier03	1	41210.25	13736.75	60763.25	9890.46
10	Tier03	2	Tier03	2	43527.00	14509.00	64254.25	10446.48
11	Tier03	3	Tier03	3	20000.00	53420.00	30834.25	8942.00
12	Tier03	4	Tier03	4	49971.75	22834.25	30000.00	11278.34
13	Tier04	1	Tier04	1	41210.25	13736.75	60763.25	9066.26
14	Tier04	2	Tier04	2	43527.00	14509.00	64254.25	9575.94
15	Tier04	3	Tier04	3	25000.00	48420.00	35834.25	8842.00
16	Tier04	4	Tier04	4	44971.75	27834.25	30000.00	9978.91
17	Tier05	1	Tier05	1	41210.25	13736.75	60763.25	8242.05
18	Tier05	2	Tier05	2	43527.00	14509.00	64254.25	8705.40
19	Tier05	3	Tier05	3	30000.00	43420.00	40834.25	8542.00
20	Tier05	4	Tier05	4	39971.75	32834.25	30000.00	8879.47
21	Tier06	1	Tier06	1	41210.25	13736.75	60763.25	7829.95
22	Tier06	2	Tier06	2	43527.00	14509.00	64254.25	8270.13
23	Tier06	3	Tier06	3	35000.00	38420.00	45834.25	8392.00
24	Tier06	4	Tier06	4	35000.00	37806.00	30028.25	8330.60
25	Tier07	1	Tier07	1	41210.25	13736.75	60763.25	7417.85
26	Tier07	2	Tier07	2	43527.00	14509.00	64254.25	7834.86
27	Tier07	3	Tier07	3	40000.00	33420.00	50834.25	8142.00
28	Tier07	4	Tier07	4	40000.00	32806.00	40028.25	8080.60
29	Tier08	1	Tier08	1	45000.00	13736.75	60763.25	7422.62
30	Tier08	2	Tier08	2	45000.00	14509.00	64254.25	7561.62
31	Tier08	3	Tier08	3	45000.00	28420.00	55834.25	7792.00
32	Tier08	4	Tier08	4	45000.00	27806.00	50028.25	7730.60
33	Tier09	1	Tier09	1	50000.00	13736.75	60763.25	7472.62
34	Tier09	2	Tier09	2	50000.00	14509.00	64254.25	7611.62
35	Tier09	3	Tier09	3	50000.00	23420.00	60834.25	7342.00
36	Tier09	4	Tier09	4	54604.50	18201.50	64632.75	7280.60
37	Tier10	1	Tier10		100000.00	13736.75	60763.25	9472.62
38	Tier10	2	Tier10	2	100000.00	14509.00	64254.25	9611.62
39	Tier10	3	Tier10	3	100000.00	18355.00	65899.25	8835.50
40	Tier10	4	Tier10	4	100000.00	18201.50	69697.75	8820.15

ANSWERS TO OBJECTIVE 2 QUESTIONS

1) Which contract tier provides XYZ Corporation with the lowest total water cost over the next four weeks while satisfying the business requirements described above?

Answer: **Tier09** provides the lowest total water cost of 29706.84 over the next four weeks while satisfying all business requirements (minimum inventory of 30,000 gallons, at least 25% of water from the Water Storage Tank, and demand satisfaction).

2) How many gallons should XYZ purchase from The Water Co. each week?

Answer (for **Tier09**):

- Week 1: **45,000 gallons**
- Week 2: **50,000 gallons**
- Week 3: **50,000 gallons**
- Week 4: **54,604.50 gallons**

3) How many gallons should XYZ use from their Water Storage Tank each week?

Answer (for **Tier09**):

- Week 1: **13,736.75 gallons**
- Week 2: **14,509.00 gallons**
- Week 3: **23,420.00 gallons**
- Week 4: **18,201.50 gallons**

4) What is XYZ's projected total water cost at the end of the next four weeks?

Answer: XYZ's projected total water cost at the end of the next four weeks is 29,706.84.

5) What is XYZ's projected ending Water Storage Tank inventory at the end of each week?

Answer (for **Tier09**):

- End of Week 1: **60,763.25 gallons**
- End of Week 2: **64,254.25 gallons**
- End of Week 3: **60,834.25 gallons**
- End of Week 4: **64,632.75 gallons**

6) How much money will XYZ save by choosing the recommended contract tier over each of the alternative contract tiers?

Answer: The savings are calculated as the difference between the total cost of each alternative tier and the recommended tier (**Tier09** at 29,706.84). Here are the savings for each tier:

- **Tier01**: 51386.91 - 29706.84 = **21,680.07** | **Tier06**: 32822.68 - 29706.84 = **3,115.84**
- **Tier02**: 43651.46 - 29706.84 = **13,944.62** | **Tier07**: 31475.31 - 29706.84 = **1,768.47**
- **Tier03**: 40557.28 - 29706.84 = **10,850.44** | **Tier08**: 30506.84 - 29706.84 = **800.00**
- **Tier04**: 37463.10 - 29706.84 = **7,756.26** | **Tier10**: 36739.89 - 29706.84 = **7,033.05**
- **Tier05**: 34368.92 - 29706.84 = **4,662.08**

VERIFICATION

- **Business Requirements**:
  - **Minimum Inventory:** All **end_inventory** values are above 30,000 gallons, satisfying the CEO's requirement.
  - **25% from Water Storage Tank**: For **Tier09**, the percentages are:
    - Week 1: 13736.75 / 54947 ≈ 25%
    - Week 2: 14509.00 / 58036 ≈ 25%
    - Week 3: 23420.00 / 73420 ≈ 31.9%
    - Week 4: 18201.50 / 72806 ≈ 25%
    - All exceed or meet the 25% requirement.
  - **Demand Satisfaction**: **buy + use_tank** meets or exceeds **demand** for each week (e.g., Week 1: 45000 + 13736.75 = 58736.75 > 54947).
- **Cost Minimization**: The model correctly selects **Tier09** with the lowest cost (29706.84), consistent with the price ($0.10/gallon) and minimum purchase (50,000 gallons/week) optimization.

THANK YOU!

Presented by StArS