Air Products / Lehigh University Research Collaboration

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PROJECT UPDATE

EWO MEETING, MARCH 10, 2009

Two Projects

- Project #1: Models for Designing Resilient Supply Chain Networks for Chemicals and Gases
  - Ended December 2008
- Project #2: Capacity Planning For A Gases Supply Chain With Network Disruptions And Interruptible Power
  - Began January 2009

Models for Designing Resilient Supply Chain Networks for Chemicals and Gases

PROJECT #1

(ENDED DECEMBER 2008)

Outline

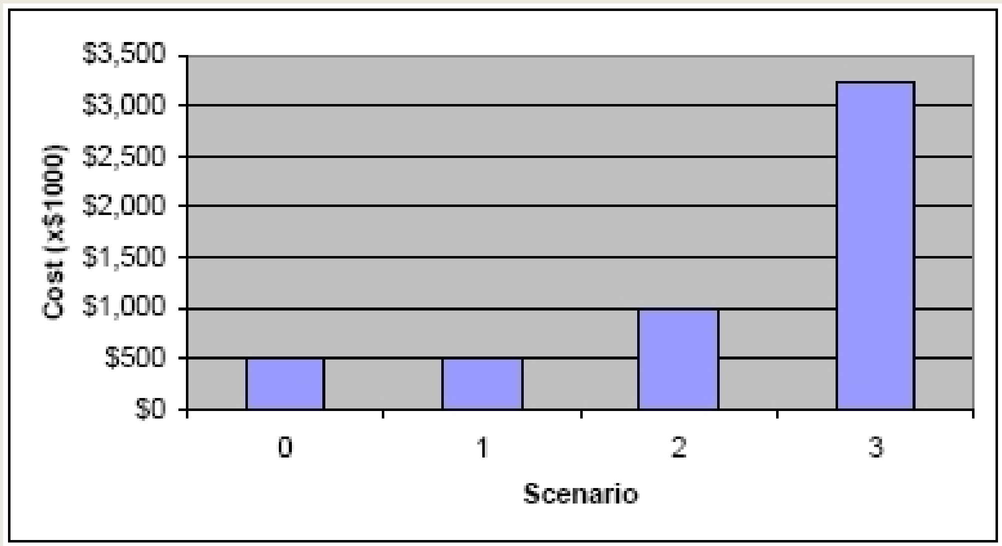
- Introduction
- Modeling approach
- Tradeoff curve

Introduction

- Objective: Design supply chain that is resilient to disruptions
  - But also performs well when disruptions do not occur
- Decisions:
  - Plant/warehouse locations
  - Arc flows (dependent on disruption scenarios)
- To minimize expected fixed + transportation cost

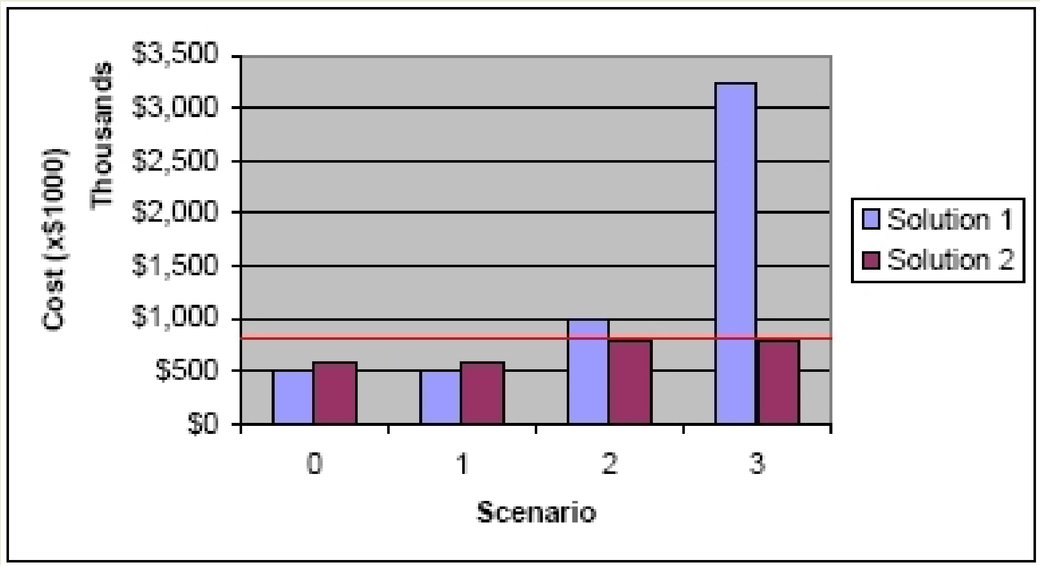
Modeling Approach

- Low-cost solutions may be good in some disruption scenarios but bad in others:



Modeling Approach

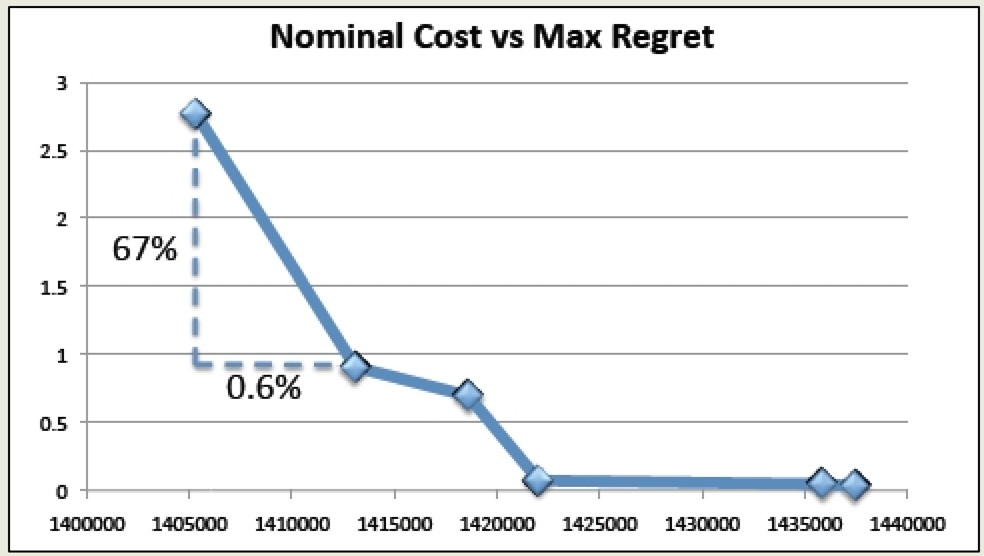
- Main idea: Add constraint that bounds cost in each scenario



- "Nominal" cost increase but scenario costs decrease
- Formulate as MIP, solve using Xpress-MP

Tradeoff Curve

- Tradeoff curve: nominal cost vs. maximum regret (across all scenarios)
  - *Regret* = % difference between cost of solution in a scenario and optimal cost in that scenario
- Example:
  - 67% lower max regret
  - 0.6% higher nominal cost



Capacity Planning For A Gases Supply Chain With Network Disruptions And Interruptible Power

PROJECT #2

(BEGAN JANUARY 2009)

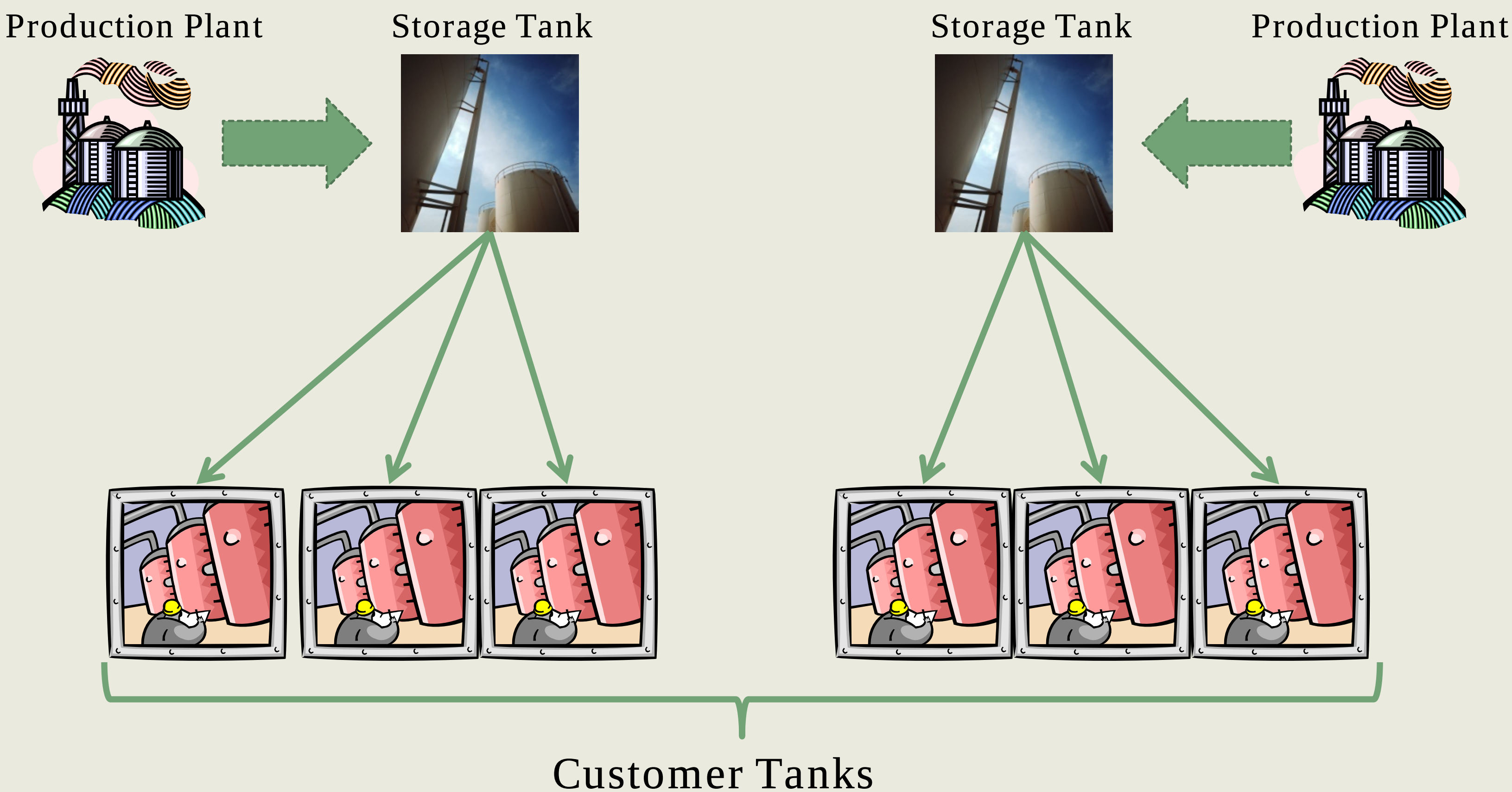
Outline

- Introduction
- Problem Description
  - Supply Network
  - Power Interruptions
- Optimization Model
- Evaluation of the Optimal Policy

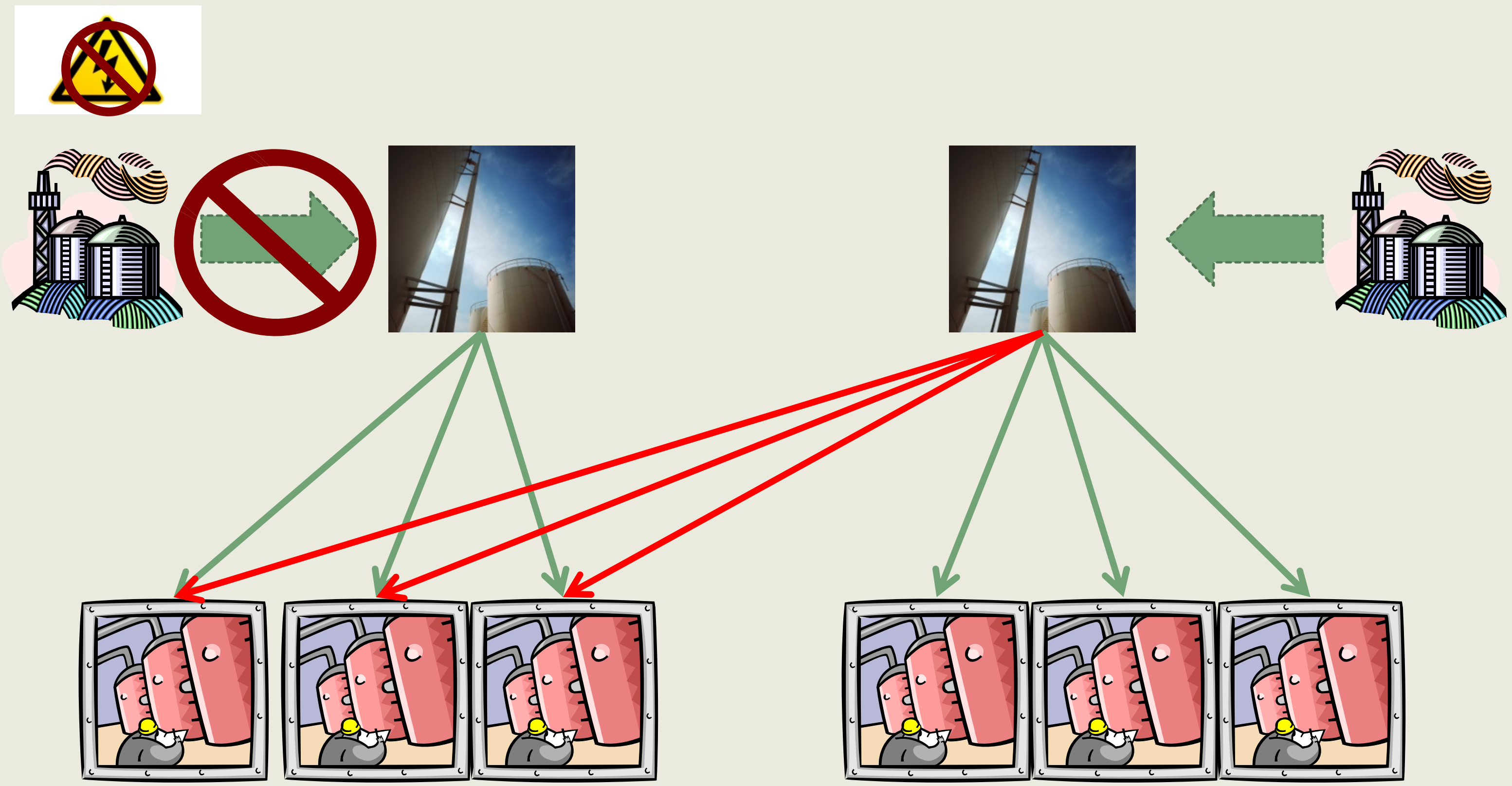
Introduction

- Motivation: Electricity companies may shut off power to plants during periods of peak demand
  - By contract with Air Products
- Objective: Use inventory as a tool for buffering against power interruptions
  - What should be production rate and inventory policy be?
  - Can we improve performance by increasing storage tank capacity?
- The optimal policy should result in increased gas availability during disruption period

Supply Network



Power Interruption



Modeling Assumptions

- Stochastic Demand
- Integrated decisions:
  - Transportation
  - Inventory
  - Production Rate
- Inventory is kept at only plant storage tanks
- Customer stock outs not allowed

Power Interruptions

- Stochastic
- Shows seasonal behavior
- Triggers failure mode in a plant (no production)
- Also triggers recovery mode when power is back (low rate of production)
- Assumption: No simultaneous interruptions at plants (different power companies)

Optimization Model

Objective:
- Minimize fixed cost of increasing storage capacity
- Plus the expected cost of transportation, inventory, and power

By choosing:
- Locations and sizes of storage tanks
- Inventory levels at those tanks
- Type of power supply (interruptible or constant) at each production facility

Subject to:
- Adequate service to all customers at all times

The resulting model will be useful for:
- Strategic (long-term) planning
- Tactical (reactive) planning.

Evaluation of the Optimal Policy

The resulting optimal policy will be evaluated using simulation.

The simulation will capture:

- Inventory
- Production
- Transportation
- Demand
- Power

Questions?