Resilient NdFeB magnet recycling under the impacts of COVID-19 pandemic: Stochastic programming and Benders decomposition

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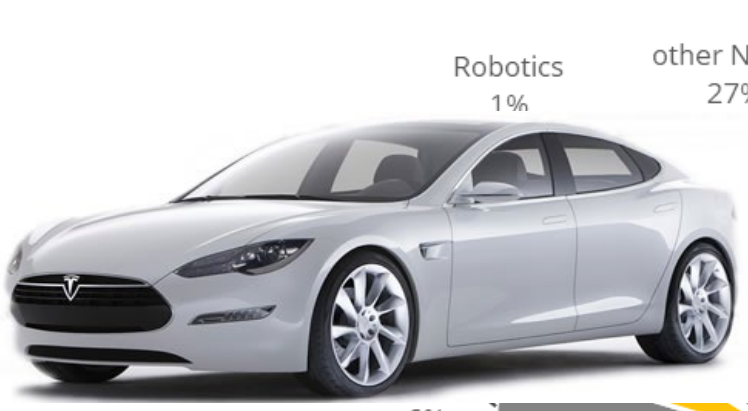
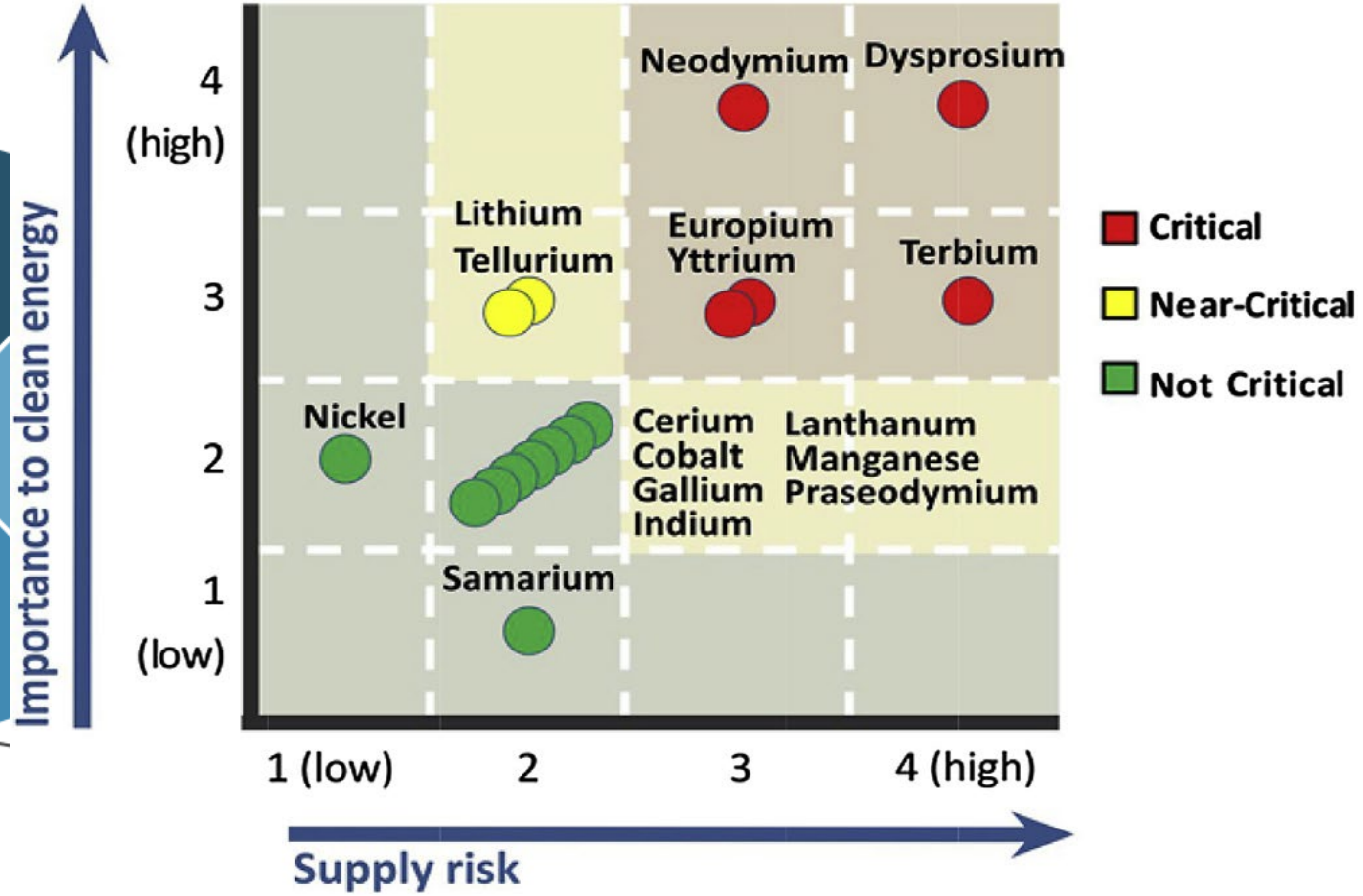
NdFeB Magnet Industry





World: Applications for NdFeB permanent magnets (Source: Roskill)

Source: Bauer et al. 2011. Critical Materials Strategy. US Department of Energy

Research Motivation

- Highly vulnerable to supply disruption

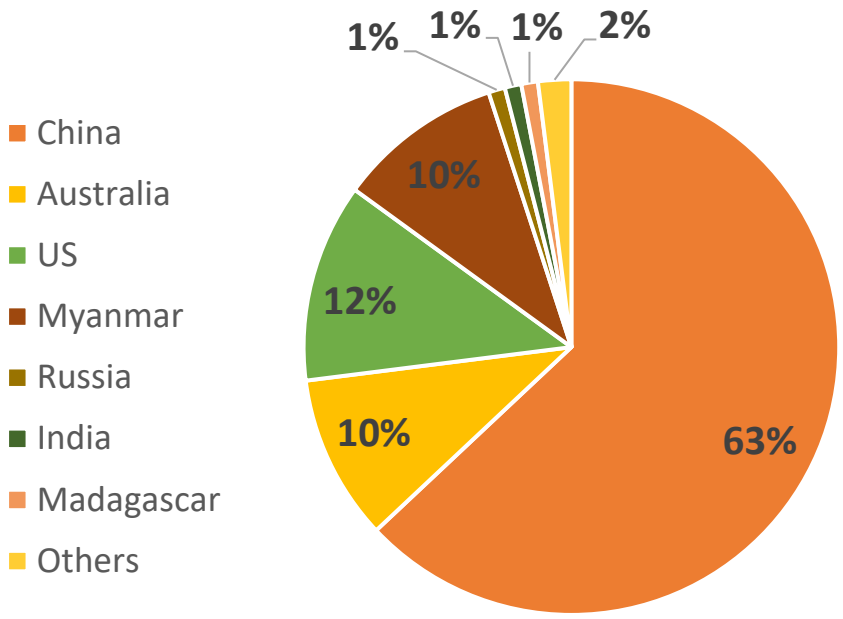
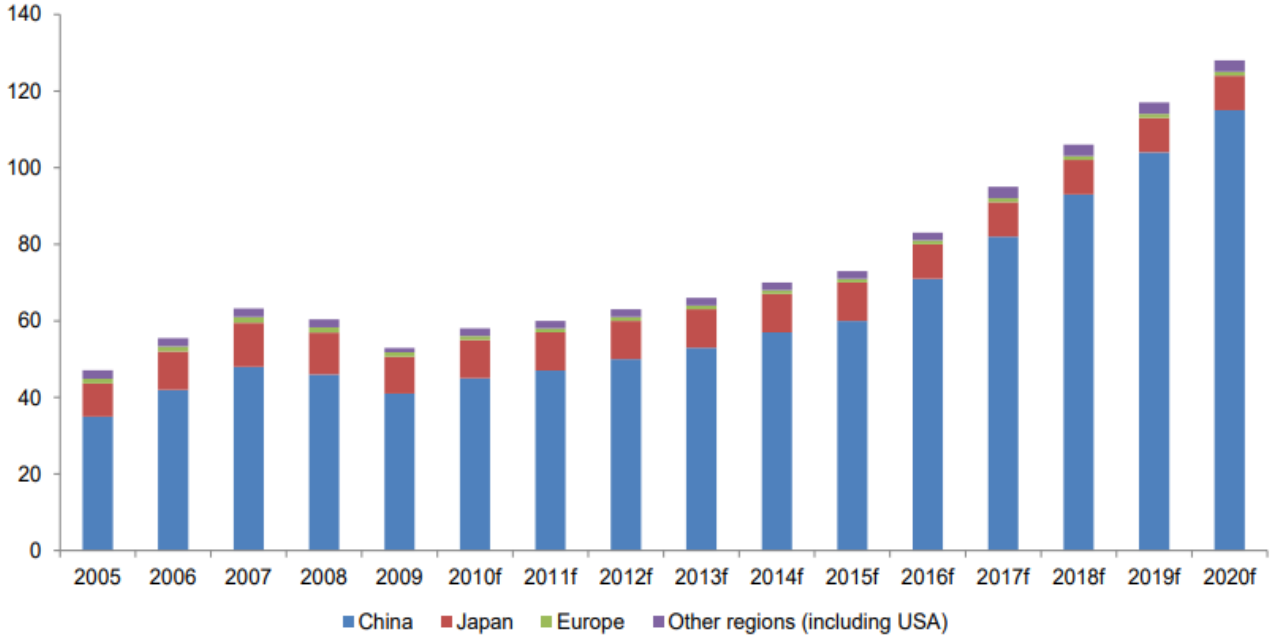


Figure: Global REE production, USGS (2019)

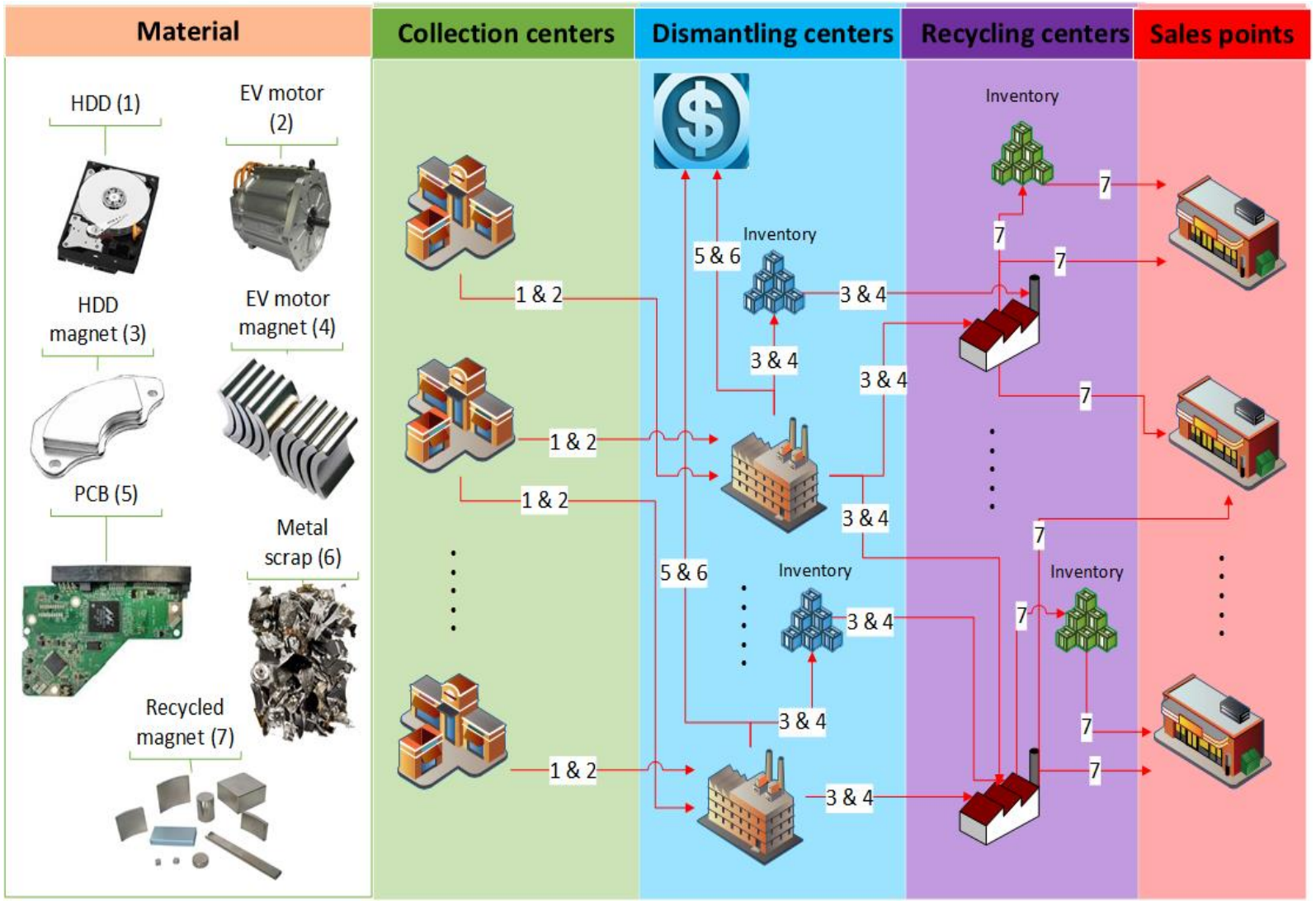


World: NdFeB magnet production by region, 2005 to 2020 (kt)

- Magnet-to-magnet recycling inside USA is a solution

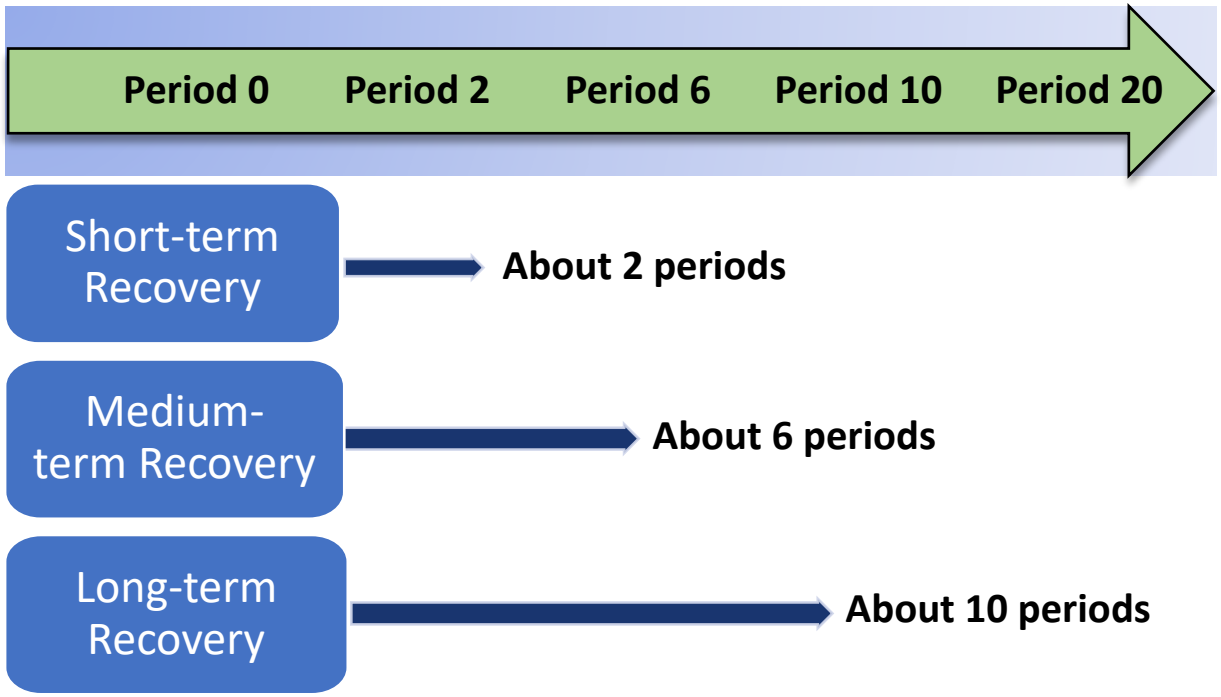
Research Goals

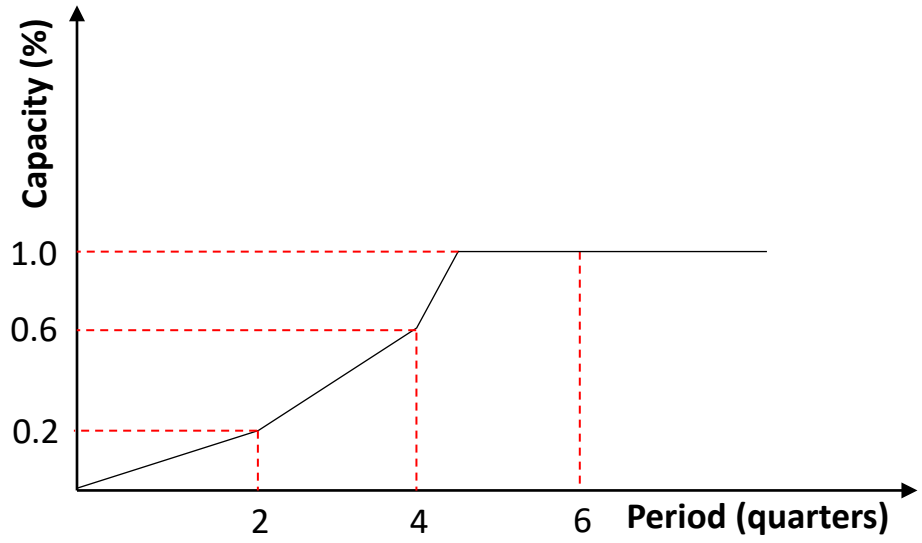
- Designing a reverse logistics network for NdFeB recycling in USA
- Making the supply chain resilient to large-scale disruptions through inventory management



Methodology

- Modeling scenarios for large-scale disruption and uncertain recovery





Medium-term Capacity Recovery

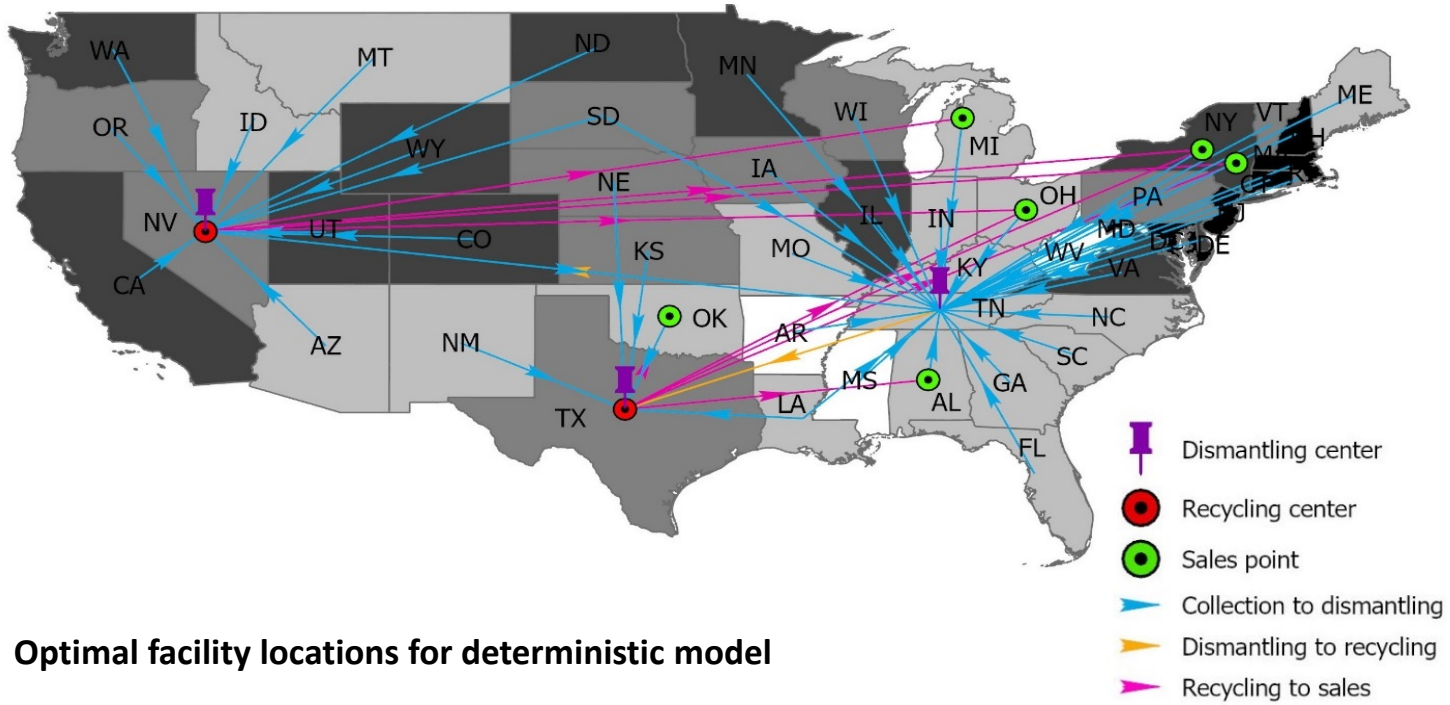
- Developing a chance constraint two-stage stochastic (CTSP) model for optimal decision making
- Applying Benders decomposition method to solve the model

Case Study

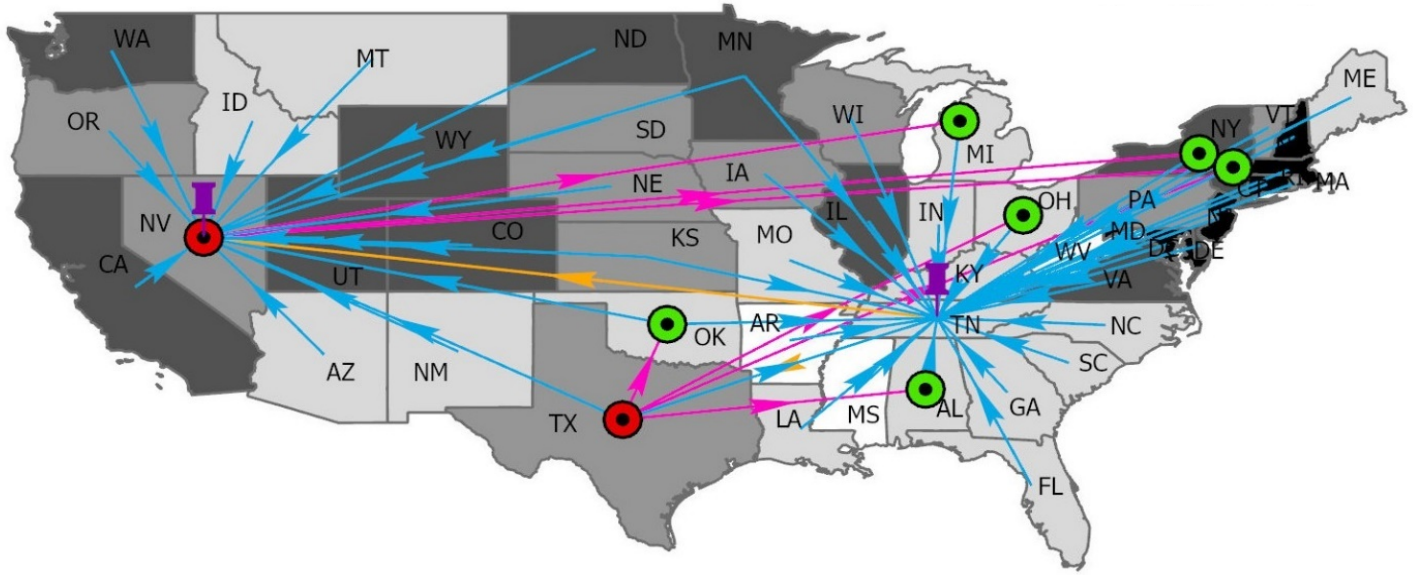
- **Problem Size**:
  - ❑ 48 Collection centers
  - ❑ 6 candidate locations for dismantling
  - ❑ 5 potential locations for recycling
  - ❑ 6 sales points
  - ❑ Five years of planning horizon
- **CTSP vs Deterministic**

	CTSP	Deterministic
Risk Tolerance	7%	100%
Profit	$165M	$168M
Shortage (%)	0.28	2.56

Optimal facility locations for CTSP model



Optimal facility locations for deterministic model



Key Insights

HIGH FACILITY SETUP COST
(63% OF TOTAL COST)

LOW INVENTORY HOLDING COST
(0.31% OF TOTAL COST)

HIGH RESILIENCY

(0.28% SHORTAGE)

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