Optimization of Photovoltaics Recycling Network: Case Study of California

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**Motivation**

- Photovoltaics (Solar Panel) include materials: 1) Energy intensive (i.e. silicon, aluminum, copper); 2) high value (i.e. indium, tellurium); 3) Toxic (i.e. cadmium, selenium, mercury)
- PV market has been growing exponentially in recent years.

**Cost Benefit Analysis**

- The figure shows variation of each cost as the number of PVTBC increases.
- The Total Cost is the summation of all costs.
- The Minimum Total Cost is located between the two and three centers scenario.
- The two recycling center scenario has the lowest total project cost.
- The three recycling center scenario is the most environmentally friendly.

**Mathematical Modeling**

- The objective of this optimization is to minimize the total travel cost between Reverse Logistics Companies, PV installations, and the PV Recycling Centers.
- The capacity limitations of each Reverse Logistics Company and PV Recycling Center are considered constraints.

**Objective Function:**

Minimize:

\[ \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \left( C_{ij} + m C_{ij} \times (D_{ij} + D_{jk}) + w C_{ij} \times W_j \times X_{ijk} \right) \]

Subject to:

\[ \sum_{j \in J} \sum_{k \in K} X_{ijk} = 1 \]

\[ \sum_{i \in I} \sum_{k \in K} (W_j \times X_{ijk}) \leq W_j \]

\[ \sum_{k \in K} (W_j \times X_{ijk}) \leq W_j \]

**California Case**

- Finding the locations of Recycling Centers.
- Finding the locations of Reverse Logistics Companies.

**Results**

- A decentralized scenario will decrease the total travel distance and cost.
- Total transportation cost decreases as the capacity of PVTBC increases.

**Acknowledgement**

This work is supported by the University of Dayton for the research council seed grant (Grant No. IGRQ14). Part of this research was supported by the Koehler International Student award from the University of Dayton.

**Reference**
