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.
- Lifetime of PV module is 25+ and large portion of end-of-life PV modules started to retire in the U.S.
- Proper planning for managing End-of-life PV modules are necessary.
- Following data/tools are used to solve the proposed problem: Open PV, ArcGIS, mathematical modeling

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:

\[
\sum_{i} \sum_{j} \sum_{k} \left( C_j + m \cdot C_j \times (D_j + D_k) + w \cdot C_j \times W_j \times X_{jk} \right)
\]

Subject to:

\[
\sum_{j} \sum_{k} X_{jk} = 1
\]

\[
\sum_{k} (W_j \cdot X_{jk}) \leq W_j
\]

\[
\sum_{i} (W_j \cdot X_{jk}) \leq W_k
\]

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.

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Reference
