MILP Formulation for ECU Optimization

Decision Variables

$$x_{s,m} \in \mathbb{Z}_{\geq 0} \quad \text{Number of ECU model } m \text{ assigned to shelter } s$$
$$e_s \in \mathbb{R}_{\geq 0} \quad \text{Excess BTU capacity for shelter } s$$

Parameters

$$\text{CapacityBTU}_m : \text{Cooling capacity (BTU/hr) of model } m$$
$$\text{Power}_m : \text{Power consumption (kW) of model } m$$
$$\text{Cost}_m : \text{Cost (USD) of model } m$$
$$\text{Weight}_m : \text{Weight (kg) of model } m$$
$$\text{Size}_m : \text{Size (volume units) of model } m$$
$$\text{TargetBTU}_s : \text{BTU requirement of shelter } s$$
$$w_{\text{cost}}, w_{\text{power}}, w_{\text{weight}}, w_{\text{size}} : \text{User-defined weights for each metric}$$
$$p_{\text{btu}} : \text{Penalty weight for excess BTU capacity}$$

Normalization

For use *only in the objective function*, each attribute is normalized by dividing by its maximum value across all ECU models:

$$\hat{Value}_m = \frac{Value_m}{\max_j(Value_j)} \quad \in [0, 1]$$

This normalization is applied to cost, power, weight, and size. CapacityBTU is *not normalized*, since it appears only in the constraints.

Objective Function

$$\min \quad \sum_s \sum_m x_{s,m} \Big(w_{\text{cost}} \cdot \hat{\text{Cost}}_m + w_{\text{power}} \cdot \hat{\text{Power}}_m + w_{\text{weight}} \cdot \hat{\text{Weight}}_m + w_{\text{size}} \cdot \hat{\text{Size}}_m \Big) + \sum_s p_{\text{btu}} \cdot e_s$$

Constraints

$$\sum_m \text{CapacityBTU}_m \cdot x_{s,m} \geq \text{TargetBTU}_s \quad \forall s \quad \text{(Meet shelter demand)}$$
$$\sum_m \text{CapacityBTU}_m \cdot x_{s,m} - e_s \leq \text{TargetBTU}_s \quad \forall s \quad \text{(Define excess)}$$
$$x_{s,m} \in \mathbb{Z}_{\geq 0} \quad \forall s, m$$
$$e_s \in \mathbb{R}_{\geq 0} \quad \forall s$$