Planning to Save Energy: How Information Format Affects Accuracy

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Introduction

- **Problem:** Energy insecurity is a critical public health concern, especially among low-income households who face difficult choices and unsafe coping strategies (Bednar & Reames, 2020; Memmott et al., 2021). Furthermore, residential energy use significantly contributes to climate change, necessitating sustainable solutions (Farghali et al., 2023).
- **Gap:** While interventions exist, success hinges on communication format (Fischer, 2008). Specifically, how do different **numerical representations (kWh, %, USD)** of energy reduction goals influence consumers' ability to create *accurate*, specific conservation plans for appliance use?
- **Concepts & Theory:** This study draws on principles of energy literacy (DeWaters & Powers, 2011), reference class effects (absolute units like kWh may simplify calculations compared to relative units like % or derived units like USD) (Gigerenzer & Edwards, 2003; Reimer et al., 2015), and the importance of procedural knowledge (knowing *how* to act on a goal) (Tonke, 2024).

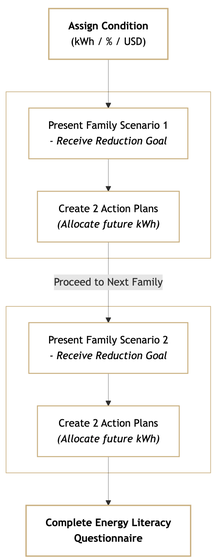
Research Questions & Hypotheses

- **Primary Question:** How does the format (kWh, %, USD) used to present an energy reduction goal influence the accuracy of household energy conservation planning?
- **H1 (Reference Class):** Presenting goals in **absolute units (kWh)** will lead to higher planning accuracy compared to percentage (%) or monetary (USD) formats.
- **H2 (Energy Literacy):** Individuals with **higher energy literacy** will demonstrate more accurate planning, regardless of format.

Methods

- **Design:** Two online experiments (N=229 & N=190 via MTurk) using a simulated household energy planning task.
- **Task:** Participants adjusted appliance energy use (kWh) for hypothetical families to meet a specified reduction goal.
- **Manipulation:** Goal presentation format (Between-Subjects): **kWh** vs. **%** vs. **USD**.
- **Exp 2 Factors:** Also varied Goal Difficulty (10/15%) & Numerical Rounding (exact/rounded).

Figure 1: Procedure and Task Example



(a) Procedure overview

	Electricity Used Last Year by the Wells Family (kWh)	Average Electricity Used Last Year by Households in Colorado (kWh)	Action Plan 1
Cooling (Central A/C)	697	498	
Heating the Home	18,052	16,411	
Water Heating	11,667	5,832	
Refrigerator	1,370	1,142	
Other (Television, Lighting, Electronics, etc.)	7,982	6,652	
Total kWh	**39,768**	**30,535**	

(b) Example of planning task interface

Results

- **Key Measures:**
  - **Planning Accuracy:** Absolute deviation between plan reduction and the goal reduction (ordinal bins: exact, minor, large error).
  - **Energy Literacy:** 8-item knowledge scale score (DeWaters & Powers, 2011).
- **Analysis:** Bayesian mixed-effects regression (Ordinal & Linear) controlling for participant and scenario random effects: Accuracy Level ~ Reference Class + Calculator + $(1|\text{id}) + (1|\text{Family Scenario})$
- **Goal Format (H1 Supported):** Planning accuracy was significantly higher when the energy reduction goal was presented in absolute units (kWh) compared to percentages (%) or U.S. dollars (USD) across both experiments.
  - *Exp 1:* USD (*OR* = 22.9) and % (*OR* = 4.2) formats had significantly higher odds of lower accuracy than kWh.
  - *Exp 2:* Similar significant effect for USD (*OR* = 9.68); the trend persisted for % (*OR* = 2.78), though the CI included 1.0. USD/percentage formats reduced the probability of exact matches and increased large errors compared to kWh.
- **Energy Literacy (H2 Supported):** Higher energy literacy scores were significantly associated with more accurate planning (lower error) in both experiments (Exp 1: B = -2.35; Exp 2: B = -3.21). (See Fig 3b).
- **Exploratory Findings (Exp 2):**
  - Using rounded numbers for prior usage slightly improved accuracy (Est. = -0.53). No effect of Goal Difficulty.

Figure 2: Reference Class Effect on Planning Error (Exp 1)

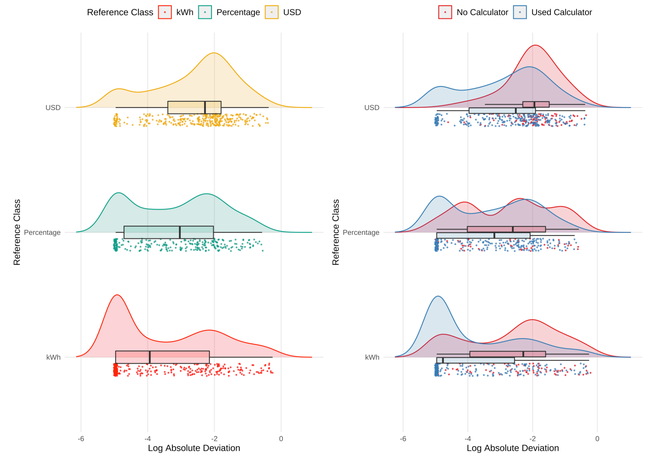
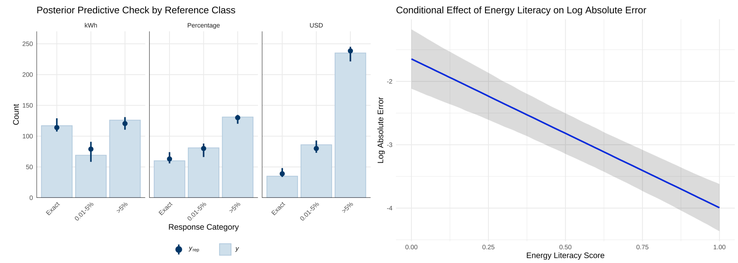


Figure 2. Distribution of log absolute error by goal format condition (Exp 1). Lower values indicate higher accuracy.

Figure 3



(a) Posterior predictive check for the ordinal regression model. Blue bars show the observed frequencies per accuracy level, dots represent the model predictions.

(b) Relationship between energy literacy score and log absolute error, controlling for random effects

Figure 4: Reference Class Effect on Planning Error (Exp 2)

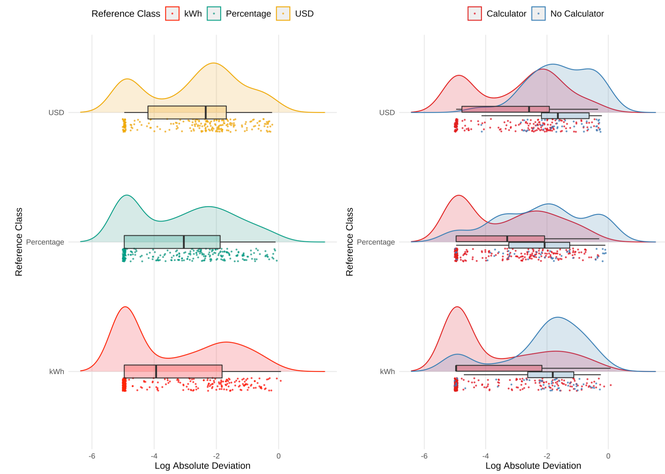


Figure 4. Distribution of log absolute error by goal format condition (Exp 2). Lower values indicate higher accuracy.

Discussion

- **Key Finding:** Goal format significantly impacts planning accuracy. **Presenting goals in absolute kWh is superior** to relative (%) or monetary (USD) formats, likely by simplifying calculations and reducing cognitive load (Gigerenzer & Edwards, 2003).
- **Energy Literacy Matters:** Higher domain knowledge consistently predicted better planning accuracy, emphasizing the role of energy education (Canfield et al., 2017).
- **Limitations:** Lab simulation, short duration, self-reported calculator use.
- **Future Directions:** Explore combining kWh format with actionable tips (Tonke, 2024); test interactive tools/visualizations.

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