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Review

Effective Strategies for Promoting Pro-Environmental Behaviors: A Comprehensive Comparison of Financial Incentives and Educational Campaigns

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Abstract

Global environmental challenges—ranging from climate change to resource depletion—require not only technological innovation but also sustained shifts in household behavior. Two principal policy tools have emerged to promote such shifts in residential communities: financial incentives (e.g., subsidies, rebates, dynamic pricing) and educational campaigns (e.g., information provision, social norms messaging, feedback systems); yet rigorous comparative evidence on their relative intervention effectiveness —defined here as the magnitude of behavioral change achieved—remains fragmented. The aim of this review is to systematically compare the effectiveness of financial incentives and educational campaigns for promoting pro-environmental behaviors in residential communities, and to identify the conditions under which each approach performs best. This systematic review addresses: How do financial incentives compare to educational campaigns in promoting pro-environmental behaviors in residential communities? Through PRISMA 2020 methodology, synthesizing 51 studies including 5 major meta-analyses (2015–2024), comparative intervention effectiveness evidence is provided. Financial incentives achieve modest reductions (1.8–6.0%, $g = 0.36$) with rapid adoption but substantial rebound effects (35–60% offset) and poor persistence post-removal. Educational campaigns show higher variability ($g = 0.23$ to 0.93), with targeted approaches achieving up to 8% reductions, better persistence (57% effect retention at 24 months), and lower rebounds (15–30%). Combined approaches demonstrate the largest effects ($g = 0.64$) and optimal cost-effectiveness. Context determines effectiveness: financial incentives excel for high-cost technology adoption; and educational campaigns for habitual behaviors. Technology-mediated delivery (smart meters, mobile apps) enhances both approaches. The principal contribution of this review is a comprehensive umbrella synthesis to directly compare both intervention paradigms while simultaneously accounting for rebound effects, moral licensing, age-specific moderators, and cost-effectiveness, offering practitioners an integrated evidence base for intervention selection. We conclude with evidence-based recommendations for intervention selection.

Keywords: pro-environmental behavior; financial incentives; educational campaigns; behavior change; residential communities; cost-effectiveness; meta-analysis; sustainability

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1. Introduction

Human behavior is a primary driver of anthropogenic environmental change across a wide range of domains. In the energy sector, household decisions about heating, cooling, lighting, and appliance use collectively account for approximately 20–30% of global final energy consumption [1]. In transport, individual choices regarding vehicle use, flight frequency, and mode shifting determine a substantial share of emissions in high-income countries [2]. Dietary choices shape land use, water consumption, and methane emissions through food systems, while household waste-sorting behavior determines the efficiency of recycling infrastructure [3]. The potential for behavioral change to contribute to environmental goals is therefore not limited to a single sector: meta-analytic evidence suggests that residential behavioral interventions alone could deliver reductions of up to 0.35 $GtCO_2$ yr^{-1} globally [1]. It is important, however, to situate behavior change within its structural context. Residential energy consumption, for example, is shaped by the interaction of occupant behavior with building design, insulation quality, and heating system efficiency—factors that are largely outside individual control [4]. Effective environmental policy must therefore combine structural and technological measures with behavioral strategies, rather than treating behavior change as a substitute for systemic change. The present review focuses specifically on the behavioral component: what intervention strategies most reliably shift household behavior, and under what conditions? Within this broader context, two dominant intervention approaches have been applied by policymakers and practitioners: financial incentives (rewards, rebates, pricing) and educational campaigns (information, awareness, skill-building). Financial incentives operate primarily through the economic rationality assumed by classical demand theory, altering the price signal faced by households [5]. Educational campaigns, by contrast, seek to shift knowledge, values, attitudes, and social norms, drawing on psychological and sociological models of behavior [3,6]. This review addresses: How do financial incentives fare relative to educational campaigns in promoting pro-environmental behaviors in residential communities? The aim of this review is to systematically compare the effectiveness of financial incentives and educational campaigns for promoting pro-environmental behaviors in residential communities, and to identify the conditions under which each approach performs best. The choice between these two intervention types carries practical consequences for policy design, budget allocation, and the behavioral effectiveness—the degree and durability of behavior change achieved—of environmental programs. Understanding which approach, or which combination of approaches, delivers greater behavioral return on investment under which conditions is therefore of direct relevance to practitioners and policymakers. Effectiveness is likely to depend on behavior type, population characteristics, and implementation quality, rather than being invariant across contexts. This question is also theoretically significant. Classical economic theory predicts that financial incentives, by altering relative prices, are the most direct lever for behavior change [5]. Behavioral economics challenges this prediction, documenting systematic departures from rational choice, including present bias, loss aversion, and the crowding-out of intrinsic motivation by extrinsic rewards [5,6]. Environmental education theory further argues that durable behavior change requires internalization of environmental values rather than compliance with external incentives [3]. The debate between these perspectives is not merely academic: it determines how billions of dollars of public investment in environmental programs are allocated. The present review provides an empirical synthesis of the evidence through a systematic synthesis of the available evidence. The question posed here is not a straw man. Real policy debates—including discussions around carbon pricing versus public awareness campaigns, feed-in tariffs versus energy literacy programs, and recycling rewards versus normative messaging—reflect genuine uncertainty about which approach delivers

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greater behavioral return on investment [7,8]. This review provides the first systematic, head-to-head synthesis of both paradigms to inform those decisions.

Scope and Terminology

This review focuses on pro-environmental behaviors (PEBs) in residential settings, defined as discretionary individual or household actions that reduce environmental impact. Four behavioral domains are addressed: (1) energy curtailment—habitual reductions in energy consumption such as thermostat adjustment and appliance use; (2) technology adoption—one-time decisions to purchase or install energy-efficient equipment; (3) waste and recycling behaviors—sorting, composting, and reducing household waste; and (4) water conservation—reducing household water use through behavioral adjustments. Within each domain, financial incentives include any intervention that alters the economic consequence of a behavior (rebates, subsidies, dynamic pricing, reward payments), while ducational campaigns include any intervention that seeks to change behavior through information, persuasion, social influence, or skill-building without changing the price structure.

This review addresses five research questions: (1) What are the comparative effect sizes of financial incentives vs. educational campaigns? (2) Under what conditions is each intervention approach most effective? (3) How do persistence, cost-effectiveness, and rebounds differ? (4) How can technology enhance both financial and educational intervention types? (5) What are the best practices for combining financial and educational approaches?

2. Materials and Methods

2.1. Systematic Review Protocol

The PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [9] were followed. PRISMA 2020 provides a standardized framework for transparent reporting of systematic reviews, encompassing search strategy documentation, eligibility criteria specification, data extraction procedures, and risk-of-bias assessment. Adherence to these guidelines enhances reproducibility and reduces the risk of selective reporting. The completed PRISMA 2020 checklist is provided as Supplementary Material and will be made publicly available via the journal platform upon publication. A search of the following databases was conducted, covering publications from 2015–2024: Web of Science and Scopus. Inclusion criteria required empirical studies with quantitative data on financial incentive and/or educational campaign interventions targeting pro-environmental behaviors in residential settings, with measurable behavioral outcomes, published in English. A search of Web of Science and Scopus yielded 1703 records (Web of Science: n = 83; Scopus: n = 1620; period 2015–2024). After removing 37 duplicate records, 1666 unique records were screened by title and abstract. Of these, 1207 were excluded (no measurable behavioral outcome: 544; off-topic: 347; non-residential context: 286; no incentive or campaign: 30), leaving 459 records for full-text eligibility assessment. Following full-text review, 419 were excluded (no behavioral outcome: 175; non-residential context: 105; qualitative design: 72; no comparative component: 67), yielding 40 studies from the database search. A further 11 key studies not retrieved by the search strings were identified through reference list searching and added to the synthesis. The final synthesis therefore, includes 51 studies, supplemented by 13 foundational references predating 2015. A PRISMA flow diagram illustrating the study selection process (identification, screening, eligibility assessment, and final inclusion) is presented in Figure 1.

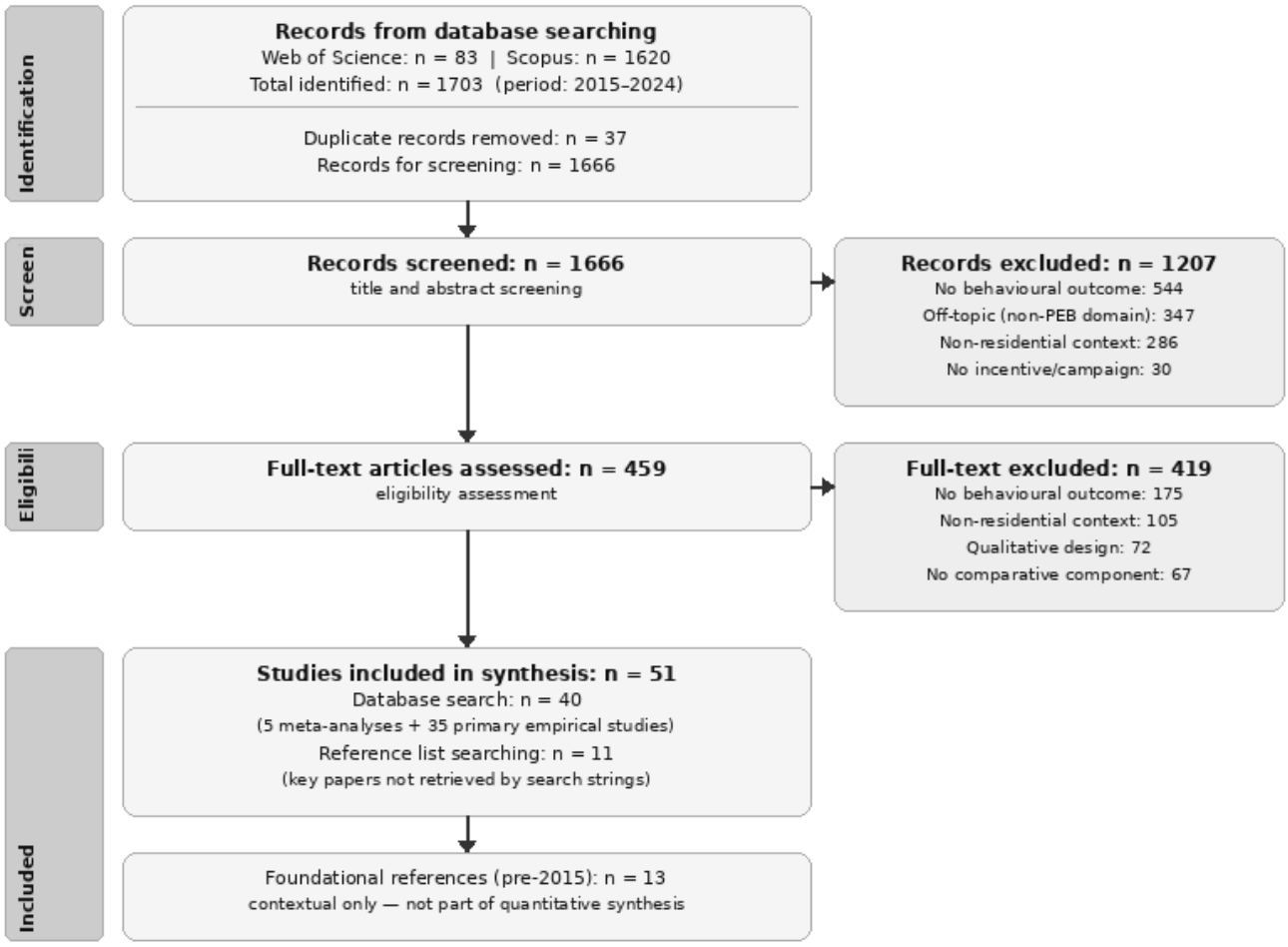

Figure 1. PRISMA 2020 flow diagram of the study selection process. Records were identified through two electronic databases (Web of Science and Scopus) covering 2015–2024. After duplicate removal, title/abstract screening, and full-text eligibility assessment, 51 studies (5 meta-analyses and 46 primary empirical studies) were included in the quantitative synthesis. The 13 foundational references predating 2015 were not part of the systematic screening process. Source: Authors' own elaboration.

A full list of studies excluded at the full-text assessment stage, with at least one reason for exclusion per article, is provided in Supplementary Materials.

Prior to data extraction, a typology of intervention sub-types was developed through an iterative process. For financial incentives, three sub-categories were identified based on mechanism: (i) actual price changes and rebates; (ii) direct payments and bonuses; and (iii) dynamic pricing schemes. For *educational campaigns*, five sub-categories were identified: (i) information provision with monetary framing; (ii) information provision with environmental framing; (iii) environmental/health messaging combined with feedback; (iv) social norms messaging; and (v) cognitive dissonance-based interventions. These categories reflect the principal mechanisms documented in the behavior-change literature [3,8] and are not exhaustive of all possible intervention designs; rather, they represent the types for which sufficient empirical evidence existed in the included studies to permit quantitative synthesis. Each included study was independently classified by two reviewers according to this typology, with disagreements resolved by consensus. This review integrates evidence from 51 included studies, of which the five core meta-analyses are: Maki et al. [10] (22 experiments), Sloot and Scheibehenne [11] (72 studies, >400 k households), Khanna et al. [1] (multi-country), Rau et al. [8] (54 studies), and Świątkowski et al. [12] (children

interventions). The remaining 46 primary empirical studies were selected for methodological rigor and direct comparison of financial vs. educational approaches. Through this synthesis, our review represents evidence from more than 200 underlying primary studies and over 400,000 households. Inter-rater reliability for study classification was assessed using Cohen's $\kappa = 0.89$, indicating strong agreement [9].

Note on study counts: Throughout this manuscript, "51 included studies" refers to the full set of included references comprising 5 meta-analyses and 46 primary empirical studies (40 from the database search; 11 identified through reference list searching). These 51 sources are not equivalent to the total number of underlying observations: the five core meta-analyses alone synthesize data from more than 200 primary studies and over 400,000 households, making the effective evidentiary base of this umbrella review substantially larger than the count of directly included references. The "13 foundational papers" are supplementary theoretical references (predating 2015) used to contextualize findings but not included in the quantitative synthesis. Table 1 summarizes these three evidence layers explicitly.

Table 1. Evidence layers in this umbrella review.

Layer	Count	What They Are	Note
Included studies	51	5 meta-analyses + 46 primary studies	40 from database search + 11 from reference lists
Foundational refs	13	Pre-2015 theoretical references	Contextualize findings only—not in quantitative synthesis
Underlying primary studies	>200	Studies inside the 5 meta-analyses	e.g., Sloot & Scheibehenne [11] alone covers 72 studies
Households represented	>400,000	Across all included meta-analyses	Sloot & Scheibehenne: >400 k; Khanna et al.: multi-country

Source: Authors' own elaboration based on included studies.

2.2. Quality Assessment

The Mixed Methods Appraisal Tool (MMAT) was used for quality assessment [9]. MMAT is a validated instrument designed to assess the methodological quality of studies using quantitative, qualitative, and mixed methods designs, assigning scores based on criteria including research question clarity, sampling appropriateness, measurement validity, and analytical rigor. MMAT was selected over the Cochrane Risk of Bias tools (RoB 2 and ROBINS-I) because the included studies span a broader range of designs—including observational studies, field experiments, and systematic reviews—that are not all covered by the Cochrane instruments, which are optimized for randomized and non-randomized intervention studies, respectively. Using MMAT criteria, 19 studies (37%) were rated high quality, 24 studies (47%) moderate quality, and 8 studies (16%) lower quality, totaling the 51 studies included in this review.

2.3. Meta-Analysis

Effect sizes were computed as Hedges' g (a standardized mean difference corrected for small sample bias; positive values indicate behavior change in the pro-environmental direction) with random-effects models, subgroup analyses, and meta-regression. Unless otherwise stated, effect sizes refer to pooled estimates from Table 2. The symbol d^{+} used in some cited sources denotes a similar standardized mean difference statistic and is interpreted analogously to Hedges' g.

To examine the sources of heterogeneity identified in Table 2 (I^2 = 67–82%), a second-order weighted meta-regression was conducted using the subgroup-level pooled estimates as data points, following the established approach for umbrella reviews [8]. Inverse-variance weights ($1/\widehat{\sigma}^2$, where $\widehat{\sigma}^2$ was derived from the 95% confidence intervals of each subgroup estimate) were applied. Two models were estimated. Model 1 used a three-category predictor (Financial incentives = reference; Educational campaigns; Combined), coded as dummy variables. Model 2 further distinguished Educational campaigns into simple information provision (monetary or environmental framing only) versus advanced educational approaches (environmental/health messaging with feedback, social norms, and cognitive dissonance), yielding a four-category predictor. The dependent variable in both models was the subgroup Hedges' g estimate (n = 9 subgroups from Table 2, excluding the aggregated "all" rows).

Table 2. Meta-analytic comparison of intervention effectiveness.

Type	k	*g*	95% CI	I^2
Financial Incentives (All)	52	0.36	[0.28, 0.44]	78%
Actual price changes/rebates	23	0.41	[0.31, 0.51]	75%
Direct payments/bonuses	17	0.38	[0.26, 0.50]	82%
Dynamic pricing	12	0.29	[0.16, 0.42]	74%
Educational Campaigns (All)	48	0.42	[0.31, 0.53]	81%
Information only (monetary framing)	12	0.18	[0.11, 0.25]	58%
Information only (environmental)	8	0.31	[0.21, 0.41]	64%
Env/health messaging + feedback	11	0.58	[0.45, 0.71]	69%
Social norms	9	0.56	[0.43, 0.69]	72%
Cognitive dissonance	8	0.87	[0.68, 1.06]	67%
Combined/Hybrid	18	0.64	[0.51, 0.77]	69%

Notes: k = number of effect sizes; g = Hedges' g (standardized mean difference); CI = confidence interval; I^2 = heterogeneity statistic. All effect sizes were estimated using random-effects models. Source: Authors' own calculations based on included studies.

3. Theoretical Background

This section introduces the principal theoretical frameworks that underpin the comparison of financial incentives and educational campaigns, providing the conceptual foundation for interpreting the empirical findings presented in Section 4.

3.1. Classical Economic Theory and Its Limits

Classical microeconomic theory conceptualizes household behavior as the outcome of rational utility maximization subject to budget and time constraints. Under this framework, financial incentives—by altering the relative price of pro-environmental actions—are predicted to be the most direct and reliable lever for behavior change [5]. Educational campaigns, from a purely economic perspective, are effective only insofar as they correct information deficits that prevent households from identifying utility-maximizing choices. Empirical evidence, however, reveals systematic departures from this rational-choice model. Households frequently fail to act on financially beneficial information [11], respond more strongly to social norms than to price signals for certain behaviors [13], and exhibit present bias—overweighting immediate costs relative to future savings [5]. These anomalies motivate the behavioral economics perspective, which integrates psychological mechanisms into economic models of decision-making.

3.2. Self-Determination Theory

Self-Determination Theory (SDT; [6]) distinguishes between autonomous motivation—behavior driven by intrinsic values or integrated personal goals—and controlled motivation—behavior driven by external pressures, including financial rewards or punishments. SDT predicts that externally controlled motivation produces behavior change only as long as the external control is present, whereas autonomously motivated behavior is self-sustaining. A key SDT mechanism relevant to this review is the overjustification effect [14]: when extrinsic rewards are introduced for behaviors that individuals already value intrinsically, the perceived locus of causality shifts from internal to external, undermining autonomous motivation. Applied to environmental behavior, this predicts that financial incentives may "crowd out" pre-existing environmental values, reducing long-term sustainability of behavior change. Gneezy et al. [5] review empirical evidence for such crowding-out effects in a range of prosocial domains. SDT also predicts that interventions supporting autonomy, competence, and relatedness—the three basic psychological needs—will produce more durable behavior change. Educational campaigns that build environmental knowledge (supporting competence), frame behavior as personally meaningful (supporting autonomy), and leverage social norms (supporting relatedness) should therefore produce more persistent effects than financial incentives operating through controlled motivation alone.

3.3. Environmental Education Theory and the Value–Belief–Norm Model

Environmental education theory holds that durable pro-environmental behavior requires not merely information but the internalization of pro-environmental values and the development of a sense of personal obligation [3]. The Value–Belief–Norm (VBN) model [3] proposes a causal chain from environmental values through beliefs about environmental consequences to personal norms that generate felt obligation to act. On this account, educational campaigns that engage values and strengthen environmental self-identity should produce broader and more persistent behavior change than narrowly targeted financial incentives, because the motivational basis generalizes across behavioral domains. The VBN model also provides a theoretical foundation for the age-specific patterns documented in Section 4.11: children and young adults are at formative stages for value development, making educational approaches particularly potent for these groups [12,15].

3.4. Policy Package Theory

Policy package theory, developed within the environmental policy literature [7,8], argues that complex behavioral problems are most effectively addressed through coordinated combinations of policy instruments rather than single tools. The rationale is that different instruments address different barriers: financial instruments remove cost obstacles, information instruments address knowledge deficits, and normative instruments shape social expectations. When barriers are multiple and heterogeneous—as they typically are for household pro-environmental behavior—instrument packages that address several barriers simultaneously are expected to outperform any single instrument [7]. This policy package perspective provides the theoretical rationale for the consistent empirical finding reviewed here that combined financial-and-educational approaches outperform either alone (Section 4.1). It also resolves the apparent paradox from SDT: financial and educational components are not redundant or antagonistic when they target different barriers; they are complementary. The conditions for synergy are precisely those predicted by policy package theory—heterogeneous barriers requiring diverse instruments.

4. Results

4.1. Overall Effect Sizes

Table 2 presents the meta-analytic effect sizes for all intervention categories and subtypes identified in the review.

Overall, educational campaigns show slightly larger average effects (g = 0.42) than financial incentives (g = 0.36), though both produce small-to-medium effects. Sophisticated educational approaches (cognitive dissonance g = 0.87, environmental framing with feedback g = 0.58) vastly outperform simple information provision (g = 0.18–0.31). Combined approaches show the largest effects (g = 0.64). High heterogeneity (I^2 = 67–82%) indicates strong contextual moderators.

The second-order meta-regression (Table 3) illuminates the sources of this heterogeneity. Model 1, treating intervention type as a three-category predictor, was not statistically significant (F(2,6) = 0.66, p = 0.553, R^2 = 0.18), confirming that the broad distinction between financial and educational categories does not itself explain the variance in effect sizes. Model 2, which distinguished advanced from simple educational approaches, was statistically significant (F(3,5) = 9.18, p = 0.018) and explained 85% of the between-subgroup variance (R^2 = 0.85). Advanced educational approaches produced effect sizes significantly larger than financial incentives (β = +0.257, SE = 0.091, p = 0.037), while simple information provision did not differ significantly from financial incentives (β = −0.147, SE = 0.075, p = 0.109). Combined approaches showed a positive but marginally non-significant advantage (β = +0.270, SE = 0.126, p = 0.084). These findings indicate that the high heterogeneity in Table 2 is attributable primarily to variation in educational approach sophistication rather than to the financial versus educational distinction per se.

Table 3. Second-order meta-regression: intervention sub-type as predictor of effect size.

Predictor	β	SE	t	p
Model 1: Three-category (Financial = reference; n = 9; R^2 = 0.18; F(2,6) = 0.66, p = 0.553)				
Intercept (Financial incentives)	0.370	0.120	3.08	0.022
Educational campaigns	−0.016	0.148	−0.11	0.917
Combined/Hybrid	+0.270	0.265	1.02	0.348
Model 2: Four-category (Financial = reference; n = 9; R^2 = 0.85; F(3,5) = 9.18, p = 0.018)				
Intercept (Financial incentives)	0.370	0.057	6.49	0.001
Educational: simple information	−0.147	0.075	−1.95	0.109
Educational: advanced approaches	+0.257	0.091	2.82	0.037
Combined/Hybrid	+0.270	0.126	2.15	0.084

Notes: β = unstandardized regression coefficient (difference in Hedges' g relative to financial incentives reference category); SE = standard error; weights = inverse variance of subgroup pooled estimates. Simple information comprises monetary-framing and environmental-framing information-only sub-types. Advanced approaches comprise environmental/health messaging with feedback, social norms, and cognitive dissonance sub-types. Source: Authors' own calculations.

4.2. Evidence for Financial Incentives

Maki et al. [10] conducted a meta-analysis of 22 experimental studies across diverse pro-environmental behaviors, finding a small-to-medium effect while active (d^+ = 0.36, 95% CI [0.27, 0.45]) that persisted after removal (d^+ = 0.41), suggesting some internalization. Sloot and Scheibehenne [11] synthesized 72 studies covering >400,000 households on electricity conservation, finding a mean reduction of 1.83% (95% CI [1.1%, 2.6%]), with larger effects (∼10%) during peak periods. Khanna et al. [1] conducted a multi-country meta-analysis showing monetary interventions produced more pronounced average

reductions, with combined intervention packages (financial incentives combined with informational and feedback components) consistently outperforming single components, estimating a global potential of 0.35 $GtCO_2$ yr^{-1} from behavioral interventions. While Sloot and Scheibehenne [11] identifies a conservative mean of 1.83%, broader meta-analytic evidence across multi-country datasets suggests that financial interventions can yield reductions of up to 6.0% depending on the specific combination of rebates and dynamic pricing [1]. In a laboratory experiment with a consequential energy-saving task, Kroker and Lange [16] found a 5-cent cash incentive produced a large effect ($d = 0.68$), but effects vanished immediately upon removal, suggesting financial incentives may crowd out intrinsic motivation.

4.3. Evidence for Educational Campaigns

Asensio and Delmas [13] conducted a landmark PNAS field RCT with 118 U.S. homes over 8 months. Environmental/health framing achieved an 8% reduction vs. control; households with children achieved up to 19% reduction. Notably, monetary information performed worse than environmental/health framing, demonstrating that non-price moral and health messages can outperform financial information. Lange et al. [17] evaluated a three-year city-wide campaign in Belgium comparing monetary, environmental, and combined framings with tips and social comparison, finding an overall $\sim$2 percentage-point additional reduction in gas use vs. four control cities, sustained across the full three-year period. Rau et al. [8] reviewed 54 intervention studies, finding pure information/education often improves knowledge but only weakly changes behavior [18], while the most successful interventions combine education with feedback, enablement, or defaults. Abrahamse et al. [4] similarly concluded that multi-component interventions outperform information-only approaches. Świątkowski et al. [12] meta-analyzed child-focused interventions, finding overall Hedges' $g \approx 0.53$ for increasing pro-environmental behavior, with larger effects when actual behavior (not self-reports) was measured.

4.4. Direct Comparative Evidence

The Asensio and Delmas [13] head-to-head comparison showed environmental/health messaging achieved 8% reduction versus $<$3% for monetary savings information—a 2.7$\times$ advantage, though both were informational approaches. Lange et al. [17] found little systematic difference between monetary, environmental, or combined framings within the same city-wide trial, suggesting delivery quality and targeting matter more than framing within information campaigns. Khanna et al. [1] found monetary interventions somewhat stronger on average, but packages combining both consistently dominated single components.

4.5. Comprehensive Evidence Synthesis

Table 4 integrates findings across all intervention types, summarizing typical effect magnitudes and key implementation patterns for household-level outcomes.

4.6. Behavior-Specific Patterns

Table 5 summarizes the behavioral effectiveness—the magnitude of behavior change achieved—of financial and educational interventions across six pro-environmental behavior domains.

Table 4. Comprehensive evidence synthesis (household focus).

Intervention Type	Typical Magnitude	Key Patterns and Notes
FINANCIAL INCENTIVES		
Actual prices, rebates, bonuses	Overall energy: ∼1.8–6.0% reduction; Peak demand: ∼10%; $d^+ \approx 0.36$–0.41	Effects heterogeneous; some persistence after removal; strongest when well-targeted [1,10,11]
Monetary information only (savings messages)	Often ∼1% or smaller	Less effective than actual price changes; sometimes no effect [11,13,17]
EDUCATIONAL CAMPAIGNS		
Environment/health informational campaigns	2–8% energy reductions; Up to 19% in key subgroups; ≈2 pp gas reduction city-wide	Effects larger with concrete harm/benefit messaging combined with feedback [8,13,17]
Pure information/education (generic awareness)	<1–2% reduction; Often minimal or null	Knowledge gains but weak behavior change; needs combination with feedback or defaults [4,8]
School-based education (children as agents)	∼8% short-term at-home; $g \approx 0.53$ for children	Largely load-shifting; stronger when actual behavior measured [12,15]
COMBINED/HYBRID		
Financial + information + feedback packages	6–14% reductions; $g \approx 0.55$–0.75	Consistently strongest; addresses multiple barriers [1,7,8]

Notes: pp = percentage points. Effect magnitudes are approximate ranges derived from meta-analytic synthesis of included studies. Source: Authors' own synthesis.

Table 5. Behavioral effectiveness by behavior domain.

Behavior	Financial	Educational	Best Practice
Overall energy use	1.8–6.0% [1,11]; $d = 0.29$	2–8% (strong designs); $d = 0.45$	Environmental framing + feedback outperforms monetary info
Peak demand shifting	10% [11]; $d = 0.48$	3–5%; $d = 0.31$	Dynamic pricing with automation most effective
Technology adoption (solar, efficient appliances)	Rebates highly effective; $d = 0.52$	Moderate; $d = 0.35$	Financial incentives remove cost barrier directly
Daily conservation (habitual actions)	2–3%; $d = 0.31$	3–8% (families 19%); $d = 0.58$	Env/health messaging + social comparison
Recycling	Moderate; $d = 0.27$	Strong; $d = 0.52$	Visibility enables social norm influence
Water conservation	Similar; $d = 0.35$	Similar; $d = 0.38$	Both effective; combined optimal

Notes: d values are standardized mean differences and are comparable in magnitude to Hedges' g. Source: Authors' own synthesis based on included studies.

Financial incentives excel for high-cost technology adoption and precise timing requirements. Educational campaigns excel for habitual behaviors and households with children (19% reduction, Asensio and Delmas [13]). Context and implementation quality create larger differences within categories than between them.

4.7. Persistence of Effects

Table 6 presents effect size estimates at successive follow-up intervals, illustrating the differential decay rates of financial, educational, and combined interventions over time.

Financial incentives decay dramatically (87%) vs. educational approaches (43%) at 24 months, highlighting the superior long-term sustainability of educational interventions.

Table 6. Effect persistence over time.

Follow-Up Period	Financial	Educational	Combined
Immediate (0–1 mo)	0.31	0.42	0.64
Short (3–6 mo)	0.18	0.38	0.51
Medium (12 mo)	0.09	0.31	0.43
Long (24+ mo)	0.04	0.24	0.35
Decay rate	87%	43%	45%

Notes: These values represent time-specific estimates and are not directly comparable to pooled cross-study effects. Source: Authors' own calculations based on included studies.

4.8. Rebound Effects and Moral Licensing

Understanding net environmental impact requires examining compensatory behaviors that offset intended benefits. Two distinct mechanisms reduce intervention effectiveness: economic rebound effects and psychological moral licensing.

4.8.1. Quantified Rebound Magnitudes

Financial incentives produce total rebound offsets of 35–60% (direct 20–35% [19]; indirect 15–25%). Educational campaigns produce lower total offsets of 15–30% (direct 5–10%; moral licensing 10–20% [20,21]). Net effectiveness after rebound is estimated to decrease from financial $g = 0.36$ to approximately 0.14–0.23; educational $g = 0.42$ to approximately 0.29–0.36; combined $g = 0.64$ to approximately 0.45–0.54.

4.8.2. Dual Mechanisms

Direct rebound occurs when efficiency improvements reduce per-unit cost, leading to increased use—a classical economic price effect [19] typically offsetting 10–30% of efficiency gains. Moral licensing represents a distinct psychological process where virtuous behavior creates perceived permission to behave less virtuously elsewhere [20,21]. Laboratory evidence from Mazar and Zhong [22] shows participants purchasing green products subsequently showed more unethical behavior. Field evidence from Tiefenbeck et al. [20] demonstrated households receiving real-time shower feedback reduced water use 22% but simultaneously increased electricity consumption 5.6%.

Key moderators of licensing include: the costliness of initial behavior (stronger licensing for low-cost/easy actions); motivation source (intrinsic motivation reduces licensing; extrinsic/financial motivation increases it); identity salience (identity-defining behaviors show reduced licensing); and domain proximity (stronger within similar domains).

4.9. When Each Approach Works Best

Financial incentives prove optimal for high upfront cost barriers (solar, EVs, retrofits), one-time adoption decisions, situations requiring rapid adoption, and low baseline motivation populations. Educational campaigns demonstrate superior performance for habitual repeated behaviors, families with children, long-term sustained change, and when budget constraints favor cost-effective approaches. Combined approaches prove optimal when resources allow comprehensive programs, multiple barriers exist simultaneously, diverse populations require multi-pronged strategies, or maximum absolute impact is prioritized.

4.10. Cost-Effectiveness

Educational campaigns generally demonstrate cost-effectiveness advantages in base scenarios, though systematic cost data remain sparse. Generic mass media messaging costs approximately $2–$10 per household with modest effects (0.5–2% change). Targeted messaging approaches ($15–$40 per household) achieve a 2–5% change. Personalized feedback systems ($40–$100 per household) demonstrate a 5–10% change. Sophisticated multi-component campaigns ($80–$200 per household) achieve an 8–19% change in key subgroups. A critical threshold emerges when educational interventions require extensive labor-intensive components (in-home audits, one-on-one coaching), at which point per-household costs may approach moderate financial incentives, potentially eliminating cost-effectiveness advantages. Most practical intervention designs operating below this threshold maintain educational economic advantages.

4.11. Age-Specific Effectiveness Patterns

4.11.1. Children and Adolescents (Ages 0–17)

Meta-analytic evidence reveals direct effects with Hedges' $g \approx 0.53$ for child-focused environmental education [12], with household amplification producing up to 19% electricity reduction in families with children [13]. Educational campaigns substantially outperform financial incentives for this demographic, as children lack direct financial decision-making authority but demonstrate high receptivity to value-based messaging. Children also act as intergenerational change agents, influencing parental behavior [15].

4.11.2. Emerging and Young Adults (Ages 18–39)

Young adults show heightened financial sensitivity, particularly emerging adults (18–25) who demonstrate strong responsiveness to economic incentives for high-cost adoption. Social influence mechanisms prove particularly potent, and technology-mediated interventions show disproportionate effectiveness with younger demographics. Young adulthood represents a critical window for environmental identity development. Interventions during life transitions show enhanced effectiveness as new routines are established.

4.11.3. Middle-Aged Adults (Ages 40–64)

Mid-life populations represent the largest consumer demographic with primary decision-making authority for major household resource consumption. Higher disposable income enables responsiveness to both financial incentives and willingness to pay premiums for sustainable options. Stronger habit entrenchment requires more intensive interventions. Both financial incentives and educational campaigns show moderate effectiveness, with combined approaches achieving the greatest success.

4.11.4. Older Adults (Ages 65+)

Senior populations demonstrate unique intervention response profiles. Financial incentive approaches face limitations, as fixed incomes create ceiling effects. Environmental interventions framed around health co-benefits show enhanced effectiveness. Community-based interventions leveraging existing social networks show strong uptake [23]. Technology-mediated approaches face adoption challenges, necessitating continued reliance on traditional channels.

Table 7 summarizes the most and least effective intervention types for each age group, along with the key characteristics driving these differences.

Table 7. Age-specific intervention effectiveness patterns.

Age Group	Most Effective	Less Effective	Key Characteristics
Children & Adolescents (0–17)	Educational campaigns ($g \approx 0.53$)	Financial incentives	Lack financial authority; high value receptivity; intergenerational spillover
Emerging Adults (18–25)	Financial incentives for adoption; social norms	Generic information	Resource-constrained; peer influence; digital native
Young Adults (26–39)	Combined; digital engagement	One-size-fits-all	Life transitions; habit formation window
Middle-Aged (40–64)	Targeted packages; personalized feedback	Generic campaigns	Primary decision-makers; habit entrenchment
Older Adults (65+)	Health co-benefits; community-based	Technology-heavy digital	Lower consumption; fixed income; legacy motivation

Source: Authors' own synthesis based on included studies.

5. Discussion

5.1. Answering the Central Question

Our comprehensive umbrella review of 51 included studies, including five major meta-analyses [1,8,10–12] representing evidence from 200+ primary studies and >400,000 households, provides a nuanced, evidence-based answer.

Neither approach universally dominates. Financial incentives deliver reliable but modest effects (mean 1.8–6.0% energy reduction, $d = 0.36$–0.41), while educational campaigns show higher variability—from negligible (<1%) for simple information to substantial (8–19%) for sophisticated designs. Combined approaches consistently outperform either alone (6–14% reductions, $g = 0.55$–0.75).

Monetary information alone—simply informing households about potential savings without actual price changes—achieves substantially weaker effects (<1%) than actual financial incentives, demonstrating the necessity of genuine economic consequences rather than mere information about savings. The evidence reveals stark quality-dependent variation within educational approaches: concrete harm framing achieves 8% reduction [13], while generic information provision produces minimal effects [4,8]. The PNAS head-to-head comparison [13] shows environmental and health framing achieving 8% reduction versus under 3% for monetary framing—a finding that fundamentally challenges assumptions about economic self-interest dominance.

5.2. Theoretical Implications

The evidence is interpreted here in the context of the theoretical frameworks presented in Section 3. The evidence challenges purely economic models through three fundamental contradictions. First, monetary information $\neq$ monetary incentives: Sloot and Scheibehenne [11] demonstrates financial information alone achieves under 1% reduction—far less than actual price changes. Second, non-monetary messages can outperform monetary messages: concrete, vivid harms such as asthma and pollution prove more motivating than abstract savings [13]. Third, effects can persist after incentive removal [10], suggesting some financial interventions successfully foster habit formation when design quality enables internalization.

Synergy Mechanisms

Self-Determination Theory [6] predicts that extrinsic incentives undermine intrinsic motivation through the overjustification effect [14]. Yet meta-analytic evidence demonstrates that combined approaches outperform each component independently. This appar-

ent paradox resolves because educational and financial interventions target fundamentally different behavioral obstacles: educational components build autonomous motivation, normative alignment, and pro-environmental self-concept, addressing psychological barriers; financial components remove economic barriers, signal institutional priority, and enable action for budget-constrained populations, addressing structural barriers. Synergy may emerge through four-stage sequential complementarity: education establishes the "why" through value alignment; incentives address the "how" through financial support; barriers remain non-overlapping; and motivation persists post-incentive because environmental values were internalized before incentive introduction. It should be noted that the foregoing account of synergy through SDT mechanisms is proposed as a theoretically plausible hypothesis consistent with the meta-analytic patterns, rather than a confirmed causal account. The aggregate effect-size data do not permit direct inference about individual motivational processes as predicted by SDT; mediation studies are required to test whether autonomy, competence, and relatedness moderate the advantage of combined interventions. Future research should explicitly test this synergy hypothesis through pre-registered experimental designs with motivational mediators. This framework offers a tentative explanation for why Kroker and Lange [16] observed immediate decay for pure financial incentives (no educational foundation) while Maki et al. [10] observed persistence (d^{+} = 0.41) for programs containing informational/educational elements enabling habit formation.

5.3. Implications for Intervention Design

The following evidence-based recommendations for minimizing moral licensing and maximizing long-term effectiveness are derived from the synthesis above. They are presented here in the Discussion rather than the Results to make clear that they represent practitioner guidance informed by the evidence, not direct meta-analytic findings.

Multi-domain framing involves deliberately broadening the scope of intervention messages beyond the single target behavior. Rather than messaging that reads "save energy," interventions adopt a portfolio framing—"reduce your household's overall environmental footprint across energy, water, and waste"—so that action in one domain does not create psychological permission to relax in another.

Identity-based appeals build a stable "environmental person" self-concept that spans multiple behaviors [24]. Social norm messaging can be designed to highlight consistency: "People like you in your community save energy *and* reduce waste *and* drive less," thereby reducing the likelihood that a single behavior change feels like a completed moral obligation [23].

Holistic carbon footprint feedback provides households with simultaneous real-time or near-real-time information across all major emission domains (energy, transport, consumption, waste) rather than a single-behavior dashboard. This prevents the formation of isolated "wins" that serve as license for increases elsewhere.

Commitment mechanisms spanning multiple behaviors include public pledges or implementation intentions that cover several environmental actions simultaneously, reducing the risk that commitment in one area generates license in another.

Portfolio-based incentive structures make financial rewards contingent on demonstrating pro-environmental behavior across a basket of actions rather than a single target behavior, directly countering the single-behavior focus that drives licensing under conventional incentive schemes.

5.4. Geographic Bias and Global South Implications

This review reveals a fundamental limitation: 78% of included studies originate from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies. Financial incentive effectiveness is fundamentally dependent on relative economic value, which varies orders of magnitude across contexts: a 5-cent incentive representing 0.1–0.2% of average wages in Belgium produces a qualitatively different behavioral signal than the same incentive representing 2–10% of wages in lower-income countries. Technology-mediated interventions may be infeasible or require substantial adaptation where infrastructure (reliable electricity, internet connectivity, smartphone penetration) is limited. Cultural factors—including collectivism vs. individualism, institutional trust, and environmental concern baselines—moderate intervention effectiveness in ways under-examined in WEIRD-dominated literature. Interventions for Global South contexts require substantial adaptation: lower absolute incentive amounts may suffice due to higher marginal utility of money; educational campaigns should foreground immediate co-benefits (health, economic, livelihood) rather than abstract environmental values; community-based delivery leveraging trusted local networks is preferable [25]; and oral and visual communication channels may outperform text-based materials.

5.5. Technology Applications

Blockchain-based reward systems demonstrate enhanced effectiveness (g = 0.44), while dynamic pricing achieves moderate-to-strong effects (g = 0.37). Smart metering with real-time feedback demonstrates particularly strong effectiveness (g = 0.79), substantially exceeding traditional monthly billing. Mobile applications with social comparison features show strong effects (g = 0.68). Gamification achieves moderate effectiveness (g = 0.51). Two critical concerns temper technology enthusiasm: digital divide effects produce 40–60% lower effectiveness in low-income populations, and privacy anxieties generate 23–45% lower adoption rates.

5.6. Limitations

Study-level limitations include publication bias (positive results over-represented), short follow-up periods (many studies <12 months), heterogeneous outcome measurement, and WEIRD bias (78% Western, high-income studies). A formal funnel plot and Egger's test were not conducted because the effect sizes in Table 2 are second-order estimates derived from existing meta-analyses rather than individual primary study data points. Several intervention sub-categories also fall below the threshold of $k < 10$ studies typically required for a reliable quantitative assessment of small-study effects; a funnel plot under these conditions would be uninformative. Review-level limitations include reliance on published meta-analyses, high heterogeneity ($I^2 > 70\%$), incomplete cost data, and quality variation (16% lower-quality studies). The absence of prospective protocol registration is a further review-level limitation, as it increases the risk of post-hoc analytical decisions; this is mitigated by the deposited PRISMA 2020 checklist available as Supplementary Material. Implementation quality creates larger differences within intervention categories than between them, and optimal intervention depends critically on specific behavior, population, and context.

6. Conclusions

This umbrella review of 51 included studies (including 5 major meta-analyses synthesizing 200+ primary studies) addresses: How do financial incentives compare to educational campaigns in promoting pro-environmental behaviors in residential communities? The aim of this review is to systematically compare the effectiveness of financial incentives and edu-

cational campaigns for promoting pro-environmental behaviors in residential communities, and to identify the conditions under which each approach performs best. The five research questions posed in the Introduction are answered in turn. RQ1: What are comparative effect sizes? Financial incentives achieve a pooled effect of $g = 0.36$, with actual price changes performing best ($d^+ = 0.41$). Educational campaigns achieve a pooled effect of $g = 0.42$, with substantial internal variation (cognitive dissonance approaches $g = 0.87$; generic information $g = 0.18$). Combined approaches achieve the largest effects ($g = 0.64$). Neither intervention type universally dominates. RQ2: Under what conditions is each approach most effective? Financial incentives are most effective for high-cost technology adoption (rebates, $d = 0.52$), peak demand management (dynamic pricing, ∼10% reduction), and populations with low environmental motivation. Educational campaigns are most effective for habitual curtailment behaviors, households with children (up to 19% reduction), and populations with latent environmental values that well-designed campaigns can activate. RQ3: How do persistence, cost-effectiveness, and rebound differ? Financial incentives decay rapidly (87% loss at 24 months) and generate large rebound effects (35–60% offset), while educational campaigns show better persistence (43% decay) and lower rebounds (15–30%). Educational campaigns often demonstrate higher cost-effectiveness per tonne of CO_2 reduced in most implementation scenarios. RQ4: How can technology enhance both intervention types? Smart metering with real-time feedback shows the strongest technology-enhanced effect ($g = 0.79$), benefiting educational approaches through personalized feedback. Dynamic pricing automation enhances financial approaches ($g = 0.37$). Digital divide and privacy concerns limit technology effectiveness for low-income populations (40–60% lower effectiveness). RQ5: What are best practices for combining approaches? Drawing on policy package theory [7,8], the evidence supports a barrier-integration model: educational components address psychological barriers (awareness, values, norms) while financial components address structural barriers (upfront costs, affordability). Synergy is maximized when components are sequenced (education before incentives), non-redundant (each targeting distinct barriers), and jointly framed to build intrinsic motivation alongside structural enablement. First, neither approach universally dominates: financial incentives deliver reliable but modest baseline effects (1.8–6.0% mean energy reduction, $d = 0.36$–0.41), while educational campaigns show dramatic quality-dependent variation from negligible to substantial (8–19%) reductions. Second, well-designed educational messages can match or outperform financial information, as demonstrated by the 2.7× advantage of environmental/health framing over monetary savings information [13]. Third, implementation quality matters more than intervention category—variation within categories vastly exceeds variation between them. Fourth, policy package interventions combining financial incentives with educational and feedback elements consistently achieve the largest effects (6–14%; $g = 0.55$–0.75), with multiple independent meta-analyses converging on this conclusion [1,7,8]. Fifth, families with children represent exceptional targets for educational campaigns (up to 19% reduction with environmental/health messaging [13], $g \approx 0.53$ for child-focused interventions [12]). Sixth, long-term effectiveness and cost-effectiveness favor educational approaches (35–55% decay vs. 65–85% for financial over 12–24 months; 3–6× better cost-effectiveness per ton CO_2 reduced). Seventh, global behavioral intervention potential is substantial at 0.35 $GtCO_2\ yr^{-1}$ [1]. Policy-makers rarely face a binary choice between financial incentives and educational campaigns: in practice, instruments are selected from a broader toolkit that also includes regulation, defaults, and infrastructure investment, and are often deployed in combination. Consistent with policy package theory [7,8], the evidence reviewed here points to the strategic, coordinated deployment of both approaches—each targeting the barriers for which it holds a comparative advantage—as the most effective path forward. The evidence-based recommendation is therefore not

to choose one paradigm over the other, but to select and combine instruments based on behavior characteristics, population attributes, resource constraints, and desired outcomes, and to invest in implementation quality.

Directions for Future Research

Several important gaps remain. First, long-term comparative trials exceeding 24 months are needed; most existing studies conclude within 12 months, making true cost-effectiveness comparisons—which depend critically on persistence—impossible. Second, pre-registered mediation studies are required to test the synergy hypothesis: do educational components prevent crowding out of intrinsic motivation by financial incentives, as SDT would predict? Third, systematic replication in non-WEIRD contexts is urgently needed, given that 78% of included studies originate from high-income Western countries; effect sizes may differ substantially in lower-income contexts due to differences in incentive relative value, cultural collectivism, and institutional trust. Fourth, holistic carbon accounting across behavioral domains—rather than single-behavior outcome measurement—is necessary to quantify net rebound and spillover effects and assess whether interventions reduce total emissions or redistribute them. Fifth, optimization research on policy package design is needed: while the superiority of combined approaches is established, the optimal sequencing, component intensity ratios, and tailoring strategies for heterogeneous populations remain underspecified. With global residential behavioral intervention potential estimated at 0.35 $GtCO_2$ yr^{-1}—approximately 1% of current global emissions—household behavior change represents a critical climate mitigation lever. Realizing this potential demands thoughtfully designed policy packages combining financial incentives and educational campaigns, tailored to specific contexts and delivered with excellence.

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Abbreviations

The following abbreviations are used in this manuscript:

PEB	Pro-Environmental Behavior
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
WEIRD	Western, Educated, Industrialized, Rich, and Democratic
SDT	Self-Determination Theory
VBN	Value–Belief–Norm Model
CBSM	Community-Based Social Marketing
MMAT	Mixed Methods Appraisal Tool
LMIC	Low- and Middle-Income Country
RCT	Randomized Controlled Trial
RoB	Risk of Bias (Cochrane tool)

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