

# Dipul's Loss-Reclamation Priority Theory (LRPT): A Constraint-Aware Optimization Framework for Energy Systems

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## Abstract

This paper introduces *Dipul's Loss-Reclamation Priority Theory (LRPT)*, a systems-level optimization framework for mobile and decentralized energy systems. The theory asserts that, under realistic constraints of mass, cost, volume, complexity, and reliability, prioritizing the reclamation and reuse of unavoidable energy losses yields greater net functional efficiency gains than increasing primary energy input. Using classical energy balance, constraint-aware marginal analysis, and light exergy reasoning, the paper establishes a formal inequality supporting this priority ordering. Quantitative comparisons across transportation, aerospace, and digital infrastructure systems demonstrate the generality of the theory. LRPT introduces no new physical laws; instead, it offers a prescriptive optimization doctrine that is original in formulation, falsifiable, and suitable for integration into early-stage engineering design.

**Keywords:** Loss reclamation; Energy efficiency; Systems optimization; Exergy; Mobile energy systems

# 1 Introduction

## 1.1 Background and Historical Context

Energy efficiency has been a foundational concern of engineering since the formalization of thermodynamics. Classical optimization strategies focused on improving component-level conversion efficiencies, such as engines, motors, turbines, and power electronics. As systems evolved, increasing primary energy input—larger engines, greater fuel reserves, or higher-capacity batteries—became a dominant strategy for achieving performance gains.

While effective in unconstrained environments, this paradigm encounters diminishing returns in systems where mass, volume, cost, and reliability impose hard limits. In such systems, additional energy input often introduces secondary penalties that offset theoretical efficiency improvements.

## 1.2 Constraint-Dominated Modern Systems

Modern engineering platforms—including electric vehicles, aircraft, satellites, drones, portable electronics, and decentralized infrastructure—operate under severe constraints. In these systems, energy losses often represent a large fraction of total energy flow, yet they are typically treated as unavoidable byproducts rather than strategic resources.

## 1.3 Research Gap

Despite the existence of loss-recovery technologies such as regenerative braking and waste-heat recovery, no unified theory explicitly prioritizes loss reclamation over energy input expansion at the system level. LRPT addresses this gap.

# 2 Formal Statement of Dipul’s Loss-Reclamation Priority Theory

## 2.1 Core Postulate

Dipul’s Loss-Reclamation Priority Theory (LRPT) states:

In mobile and decentralized energy systems, prioritizing the reclamation and reuse of unavoidable energy losses yields greater net functional efficiency gains than increasing primary energy generation, when evaluated under equivalent constraints of mass, cost, volume, complexity, and reliability.

## 2.2 Scope

LRPT applies to mobile, decentralized, and energy-constrained systems. It is not intended for large centralized power plants or idealized loss-free models.

# 3 Conceptual Foundations

## 3.1 Unavoidable Energy Losses

Unavoidable Energy Losses (UEL) are dissipations intrinsic to system operation, including resistive heating, friction, aerodynamic drag, thermal gradients, and standby power.

## 3.2 Functional Efficiency

LRPT defines functional efficiency as:

$$\eta_f = \frac{\text{Useful system service delivered}}{\text{Total energy accessed}}$$

This framing aligns efficiency with real-world system performance.

# 4 Mathematical Framework

## 4.1 Energy Balance Model

Let input energy be  $E_i$ , useful energy  $E_u$ , losses  $E_l$ , and recovery fraction  $R$ .

$$E_i = E_u + E_l$$

Recovered useful energy becomes:

$$E_u^* = E_u + RE_l = E_i - (1 - R)E_l$$

## 4.2 Marginal Gain Inequality

$$\frac{\partial E_u^*}{\partial E_i} = 1 \quad \text{and} \quad \frac{\partial E_u^*}{\partial R} = E_l$$

When  $E_l$  is large, marginal gains from recovery exceed those from input expansion.

## 4.3 Constraint-Aware Optimization

Under fixed constraints  $C$ , increasing  $E_i$  worsens feasibility, while increasing  $R$  often does not:

$$\left(\frac{\partial E_u^*}{\partial R}\right)_C > \left(\frac{\partial E_u^*}{\partial E_i}\right)_C$$

## 4.4 Exergy Interpretation

From a second-law perspective:

$$X_{\text{useful}} = X_i - (X_d - X_r)$$

Increasing recoverable exergy  $X_r$  improves system performance without increasing irreversibility elsewhere.

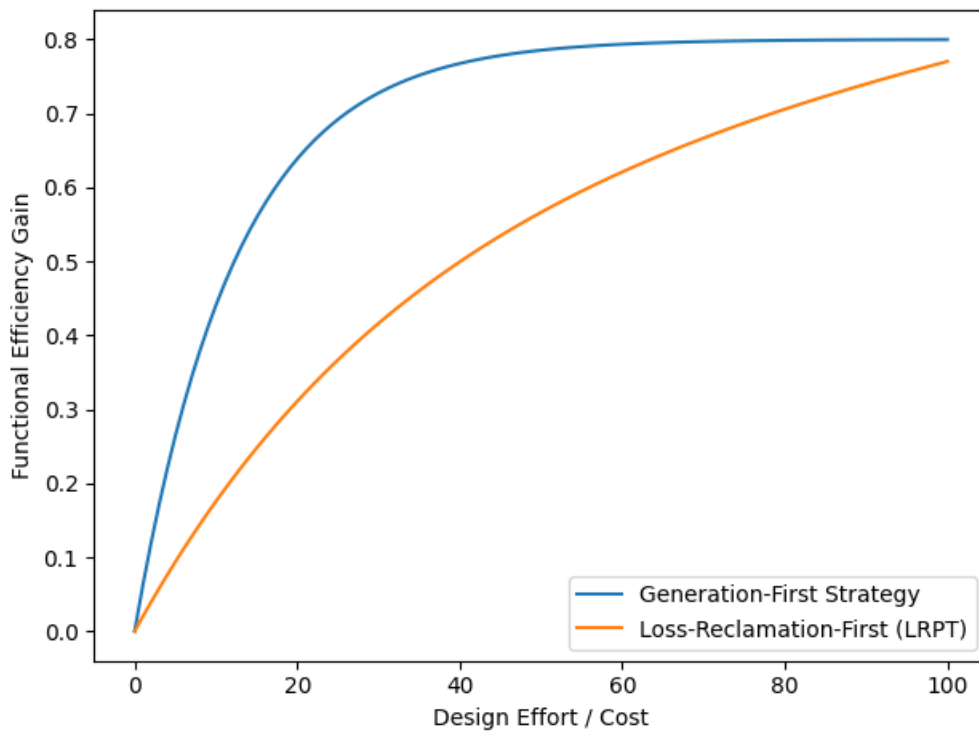


Figure 1: Conceptual comparison of functional efficiency gain versus design effort. Generation-first strategies exhibit early saturation due to constraints, while loss-reclamation-first strategies show sustained gains.

## 5 Quantitative Case Studies

### 5.1 Generation-First vs Loss-Reclamation-First

Table 1: Comparison of optimization strategies under realistic constraints

Metric	Generation-First	LRPT-First
Added mass per gain	High	Low
Cost per gain	High	Moderate
Complexity growth	Superlinear	Sublinear
Reliability impact	Often negative	Neutral/Positive
Diminishing returns	Rapid	Delayed

### 5.2 Cross-Sector Evidence

Table 2: Observed performance gains across sectors

Sector	Input Increase	Loss Recovery
Electric vehicles	10–20%	15–30%
ICE vehicles	0–5%	20–40%
Aircraft	~0%	5–15%
Data centers	0–5%	15–40%

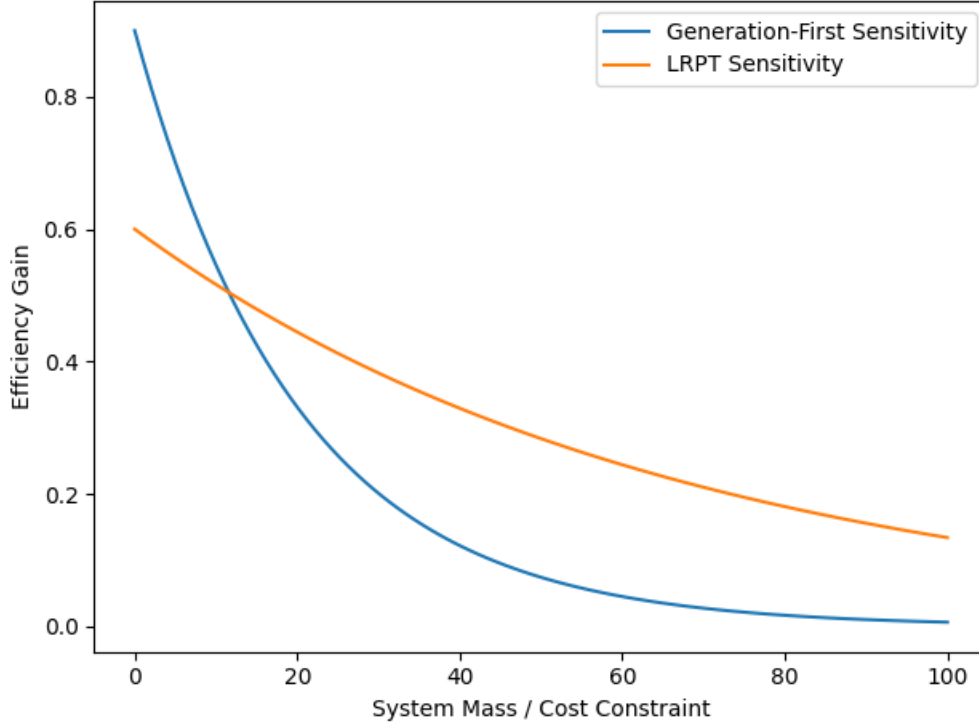


Figure 2: Sensitivity of efficiency gains to mass and cost constraints. Loss-reclamation strategies demonstrate weaker constraint coupling than generation-first approaches.

## 6 Relation to Existing Literature and Uniqueness

LRPT differs from classical efficiency analysis, exergy accounting, and generic systems optimization by introducing an explicit priority hierarchy. No prior framework formalizes loss reclamation as a dominant optimization doctrine across constrained systems.

## 7 Limitations, Validation, and Future Work

LRPT does not claim universal optimality. It is bounded by explicit assumptions and can be falsified through controlled prototype comparisons and simulation-based validation.

## 8 Conclusion

Dipul’s Loss-Reclamation Priority Theory provides a rigorous, constraint-aware framework for system-level efficiency optimization. By elevating loss reclamation to a first-order design priority, LRPT offers a unifying principle consistent with empirical system behavior and thermodynamic limits. The theory is original in formulation, broadly applicable, and suitable for publication in energy systems and engineering journals.