Tracing Every Tonne: Verifiable Waste Accounting and Alternative-Fuel Markets for Methane and Coal Abatement

ADEX: Climate Tech Infrastructure

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Abstract

Municipal solid waste is among the largest unmeasured flows in the global economy: once collected, most of it leaves no verifiable record of where it went, what it became, or what climate effect followed. This gap blocks two low-cost abatement pathways, the diversion of organic waste from methane-producing landfills and the substitution of coal with refuse-derived fuel (RDF) in industrial combustion. We present ADEX, a climate tech infrastructure platform: an event-based accounting system that records every custody transfer of waste with weight, evidence and approval, enforces site-level mass balance, and exposes the full record to external auditors through a live audit layer with camera feeds. On this foundation we describe an alternative-fuel marketplace that matches quality-verified RDF with cement kilns, coal-fired power stations and industrial boilers, ranking each transaction by its verified carbon saving.

1 Introduction

Global municipal solid waste (MSW) generation is projected to rise from 2.1 billion tonnes in 2023 to 3.8 billion tonnes by 2050, and in 2020 about 38% of it (810 Mt) was dumped or openly burned [1]. Waste passes through collectors, transporters, processors, recyclers and fuel buyers, each keeping separate records. Weight is measured at the gate, after which the material effectively leaves the record.

The consequence is a verification gap. Public authorities cannot confirm the outcome of processing contracts, industrial buyers cannot rely on the quality of waste-derived fuel, and carbon and producer-responsibility markets cannot accept claims they cannot audit. The abatement technologies exist; the evidence that they were applied does not.

2 Methane and Coal

Methane is the second-largest contributor to climate change after CO_2. Waste accounts for about 20% of anthropogenic methane emissions (71 Mt), mostly from landfills, and waste-sector measures could reduce emissions by 13 Mt per year by 2030 [2]. Satellite monitoring now attributes some of the world's largest methane sources to landfills [3].

On the combustion side, cement produces about 8% of global CO_2, roughly 40% of it from burning fuel in kilns [4]. The global thermal substitution rate (TSR) of alternative fuels in cement is below 10%, against an industry target of 22% by 2030; European plants average about 52% [5]. Coal also generated 10,476 TWh, about a third of global electricity, in 2025 [6]. Power stations, captive power plants, industrial boilers and lime kilns can co-fire a share of RDF, subject to fuel quality and emission controls [7].

3 Event Records

ADEX represents each movement or treatment of waste as an event $e = (b, m, c, E, a)$: a batch identifier b, measured mass m, custody transfer c (sender, receiver, time), evidence E (weighbridge slip, GPS trace, photographs, drone survey or laboratory report) and approval a. Events sharing b form a chain

[1] Forward-looking statements: market sizes and abatement estimates rely on third-party sources and stated assumptions and are not projections of Advitia Labs' performance. Carbon credits and EPR certificates are issued only by the relevant registries and authorities.

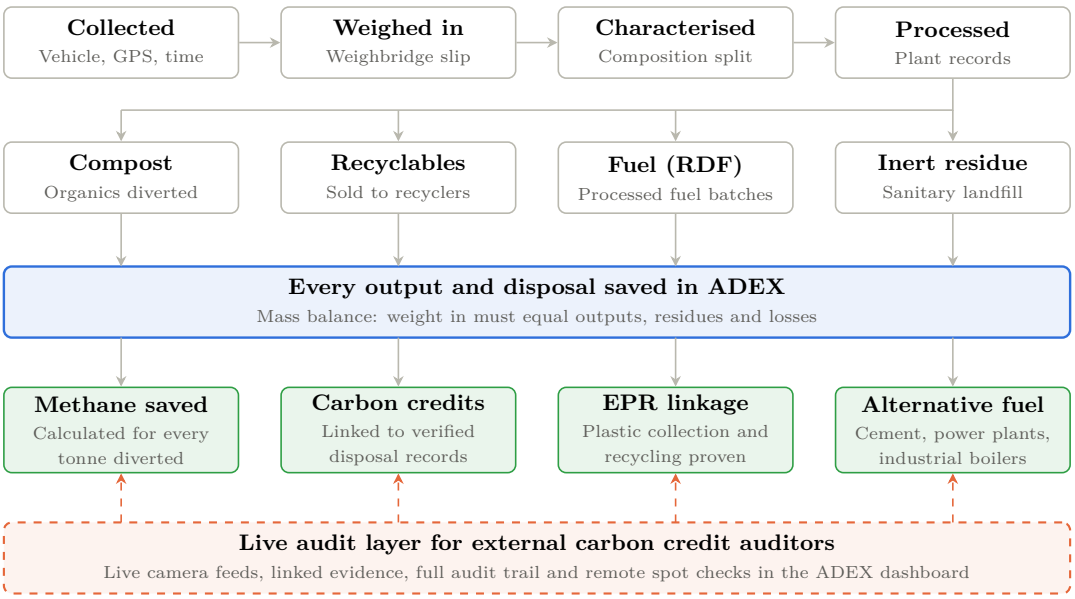


Figure 1: The ADEX event chain, from collection to verified outcome, with the live audit layer.

from collection to final destination (Figure 1). Corrections are appended as new events referencing the original; nothing is overwritten.

4 Mass Balance

For each site and period, ADEX calculates

$$\left| M_{\text{in}} - \sum_{k} M_{\text{out},k} - M_{\text{res}} - \Delta M_{\text{w}} - M_{\text{loss}} \right| \leq \varepsilon \, M_{\text{in}}$$

where $M_{\text{out},k}$ are product streams (compost, recyclables, RDF), M_{res} residues sent to landfill, ΔM_{w} moisture change, M_{loss} documented process loss and ε a configured tolerance. Any violation is flagged for investigation.

5 Live Audit

External carbon-credit auditors receive read-only access to the ADEX dashboard, including live camera feeds from weighbridges, processing lines and fuel dispatch points. Every weighment and dispatch is linked to the footage, GPS and photographs captured at that moment, and auditors can inspect the full approval history and spot-check any batch remotely.

6 Alternative-Fuel Marketplace

The marketplace exists first to reduce emissions; economic value follows from verified reductions.

1. A processor lists an RDF batch with its ADEX history and laboratory results (calorific value, moisture, chlorine, ash, sulphur).
2. Cement plants, power stations and other industrial consumers state their fuel requirements; each match shows its expected carbon saving.
3. Weighbridge confirmation and buyer acceptance close the transaction, and ADEX computes the coal displaced and CO_2 avoided against a declared baseline.

Two constraints keep claims conservative. Plastic-derived RDF is not carbon neutral, so its fossil carbon is included in the comparison with displaced coal. Boilers generally tolerate lower RDF shares than cement kilns because of chlorine corrosion and ash behaviour, so substitution limits are set per consumer.

7 Climate Accounting

For each intervention,

$$\mathrm{GHG}_{\mathrm{avoided}} = E_{\mathrm{baseline}} - E_{\mathrm{project}}$$

calculated under an applicable methodology covering waste composition, degradable organic carbon, transport, treatment emissions, uncertainty and leakage. Each result is labelled potential, modelled or independently verified, and overlapping claims on the same material are blocked.

Diverting food, garden and paper waste from landfill avoids about 250 kg CO_2e per tonne of MSW [8]. In cement kilns alone, raising global TSR to 22% could avoid roughly 100 Mt CO_2 per year, based on about 4 Gt of cement a year [4] and about 22 kg CO_2 avoided per tonne of cement for every 10 points of TSR [9]. This is an order-of-magnitude estimate.

8 Market Opportunity

Fuel, carbon and producer-responsibility markets all pay for evidenced outcomes, which is what ADEX records.

Market	**2025 size (USD)**	**Outlook (USD)**
Waste management	∼1.5 trillion [10]	–
Alternative fuels and raw materials for cement	10.3 billion [5]	16.4 billion by 2031
Refuse-derived fuel	5–8 billion [11, 12]	Estimates vary
Voluntary carbon credits	∼1.4 billion [13]	5–20 billion by 2030
Extended producer responsibility	6.8 billion [14]	14.0 billion by 2032

Table 1: Markets addressed by ADEX and the alternative-fuel marketplace.

9 Conclusion

The waste sector lacks the shared, auditable records that finance and logistics take for granted. ADEX provides them and builds on them a marketplace that replaces coal with verified fuel and turns measured reductions into carbon and EPR value. It is in production with a public-sector waste operator across 123 sites and is designed for global deployment.

References

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