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# STUDY ON THE OPPORTUNITY OF AN INCLUSIVE CIRCULAR ECONOMY FOR ARMENIA

## ECONOMIC IMPACT ANALYSIS

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## Executive Summary

This report evaluates the economic impact of five priority circular economy interventions in Armenia across the textile, plastics packaging, metals, fish, and food processing (grape-based) sectors. The analysis applies a bottom-up modelling approach that translates physical material flows into economic outcomes, including gross output, value added, employment, trade effects, and fiscal revenues. The objective is to assess whether circular economy measures in Armenia are not only environmentally justified, but also economically viable and scalable under realistic conditions.

The results consistently show that circular economy interventions in Armenia are economically sound and, in several cases, highly efficient. Across all sectors, they generate positive value added, support job creation, reduce import dependency, and contribute to fiscal revenues. Payback periods are generally short to medium term, typically ranging from one to five years depending on scale and sector. Importantly, the analysis demonstrates that financial constraints are not the primary barrier to implementation. Instead, the key challenges relate to regulatory gaps, weak coordination between waste generators and processors, and the absence of structured material collection systems.

At a cross-sector level, the interventions reveal a clear pattern. Armenia's economy remains structurally dependent on imported raw materials in several industries, while simultaneously underutilising domestic waste streams that could serve as secondary inputs. Circular economy interventions therefore generate value through two parallel mechanisms: reducing material intensity in production and converting underused waste into economically valuable outputs. This dual effect is particularly visible in sectors such as plastics and food processing, where both cost savings and new revenue streams are created.

The textile sector intervention focuses on establishing a structured system for collecting and recycling institutional textile waste generated by the HoReCa sector. The analysis shows that this is a relatively low-cost and operationally feasible intervention, largely because Armenia already has a functioning mechanical recycling facility. The main constraint lies in organising predictable waste flows rather than investing in new processing capacity. Under scaled implementation, the system can divert over one thousand tons of textile waste annually, generate additional value added, and achieve payback within approximately three to four years.

In the plastics packaging sector, the selected intervention—PET bottle lightweighting—emerges as one of the most economically efficient measures in the entire portfolio. By reducing the amount of polymer used per unit of output, producers achieve immediate cost savings while simultaneously lowering import dependency and waste generation. Under the advanced scenario, annual polymer savings exceed two thousand tons, corresponding to material cost reductions of approximately 2.6 million USD. The intervention is already technically feasible within Armenia's existing production structure, but scaling depends on coordination between packaging producers and beverage companies that define product specifications.

The metals sector intervention, based on the formalisation of end-of-life vehicle flows, stands out as the most capital-efficient measure. Armenia already possesses the necessary scrap collection and processing capacity; however, the absence of a regulatory mechanism linking vehicle deregistration to formal recycling limits material recovery. Introducing such a linkage would unlock substantial economic value with minimal investment, generating immediate increases in output, import substitution, and fiscal revenues. The analysis indicates that the required capital investment is negligible relative to the economic gains, and payback is effectively immediate.

In the fish sector, the proposed intervention establishes a facility for processing fish waste into fishmeal and fish oil, products that are currently imported. This intervention addresses both environmental and economic inefficiencies, as fish waste is presently underutilised and weakly regulated. The results show that the project becomes commercially viable at sufficient scale, with payback periods of approximately four to five years. A key condition for success is the aggregation of raw material supply, as fragmented waste streams can undermine operational efficiency.

The food processing sector, particularly grape processing, presents the largest and most transformative opportunity. Armenia generates substantial volumes of grape pomace, much of which is currently underutilised. The proposed portfolio of interventions—centered on bio-compound extraction, supported by composting and energy recovery—demonstrates strong economic potential. Under the advanced scenario, annual output can reach up to approximately 21 million USD, with significant value added, export potential, and environmental benefits. Unlike other sectors, the main driver here is not cost savings but the creation of high-value products, positioning circular economy activities as a source of industrial upgrading rather than purely waste management.

Taken together, the five interventions illustrate that Armenia’s circular economy transition can be achieved through a phased and sector-specific approach. Some measures, particularly in metals and textiles, require primarily regulatory and organisational adjustments, while others, such as fish and grape processing, involve higher investment but offer greater long-term returns. The plastics intervention highlights the importance of upstream efficiency, demonstrating that reducing resource use at the production stage can deliver immediate economic benefits.

Overall, the report concludes that Armenia does not need to wait for a fully developed circular economy system before taking action. Targeted interventions, aligned with existing industrial structures and supported by appropriate regulatory frameworks, can already generate measurable economic and fiscal benefits. This provides a clear and actionable pathway for improving resource efficiency, reducing external dependency, and strengthening the resilience and competitiveness of the Armenian economy.

## Introduction

This report constitutes the third deliverable of the EU-funded project “Study on the Opportunity of an Inclusive Circular Economy for Armenia” and builds directly on the results of the preceding Value Chain Analysis. The previous deliverable examined the value chains of five priority sectors—textiles, plastics packaging, metals, fish, and food processing—mapping material flows, identifying inefficiencies, and highlighting key circular economy opportunities within each sector.

Building on this diagnostic assessment, the present report moves to the next stage by selecting priority interventions for each sector and evaluating economic implications. The focus is therefore not only on identifying circular opportunities, but on assessing their practical feasibility and economic impact under Armenian conditions.

To achieve this, a structured modelling framework was developed that translates physical changes in material use, waste generation, and recovery into measurable economic outcomes. For each intervention, the analysis estimates effects on output, value added, employment, import substitution, and fiscal revenues, using a combination of national statistics, trade data, and international benchmarks adapted to the Armenian context. Two implementation scenarios—Moderate and Advanced—are applied to reflect different levels of scale, investment, and adoption.

Overall, this report provides a quantitative continuation of the Value Chain Analysis, moving from sector diagnostics to policy-relevant economic evidence. It demonstrates how targeted circular economy interventions can generate tangible economic benefits while supporting Armenia’s transition toward a more resource-efficient and resilient development model.

# 1. GARMENTS AND TEXTILE SECTOR

## *1.1 Methodology*

### 1.1.1 Data Sources

Armstat Statistical Yearbook 2024 and Labour Market Statistics (December 2025):[1] Sectoral employment and wage benchmarks used throughout the model. The average monthly wage of women in the manufacturing sector (Sector C) is AMD 197,231 (~USD 510/month), and the average monthly wage of men in the transportation and warehousing sector (Sector H) is AMD 459,723 (~USD 1,188/month). National Accounts value-added ratios for manufacturing sub-sectors are also drawn from Armstat.

Central Bank of Armenia (CBA) exchange rate statistics:[2] AMD 387/USD 1 is applied as the 2025 annual average reference rate for all USD conversions. AMD 437/EUR 1 is applied for converting European benchmark cost data. These rates are used consistently throughout the model to allow comparison across sections.

State Revenue Committee of Armenia (SRC):[3] Armenia's 2025 total tax revenues and customs duties of AMD 2.72 trillion, used to contextualise the fiscal impact of the intervention in relative terms.

Armstat Foreign Trade Database (HS textile and apparel codes, 2022–2024):[4] Annual average Armenian textile raw material imports of approximately $120 million per year, used to calculate import substitution as a share of total textile import dependency. This figure reflects a three-year average (2022–2024) to reduce volatility from single-year fluctuations.

PwC Armenia — Individual and Corporate Tax Summary:[5] Armenian statutory tax rates applied in fiscal calculations: flat 20% personal income tax; 18% corporate profit tax; 20% VAT. Armenia does not levy an employer-side social security contribution; employee pension contributions of 5% on monthly salary up to AMD 500,000 are withheld and remitted by the employer as a withholding agent.

Pattern optimisation and waste reduction benchmarks:[6] Improvements in marker planning, pattern layout optimisation, and digital cutting technologies can reduce material waste in garment manufacturing by approximately 5–12 percent, based on international industry experience documented for textile clusters in Türkiye and Southern Europe. This benchmark is used only to contextualise the cutting optimisation alternative (Option 2) and is not an input to the main HoReCa model.

International textile waste collection and processing cost benchmarks:[7] Collection and transportation costs for textile waste are benchmarked at €200–€680 per tonne; sorting and preprocessing operations

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[1] Armstat Statistical Yearbook 2024 and Labour Market Statistics (December 2025) — sectoral employment and wage data; Sector C (manufacturing) average monthly wage for women: AMD 197,231; Sector H (transport/warehousing) average monthly wage for men: AMD 459,723. https://armstat.am/en/?nid=586&year=2024

[2] Central Bank of Armenia, exchange rate statistics — 2025 annual averages: AMD 387/USD 1; AMD 437/EUR 1. https://www.cba.am/en/sitepages/exchangearchive.aspx

[3] State Revenue Committee of Armenia — 2025 total tax revenues and customs duties: AMD 2.72 trillion. https://www.src.am/en

[4] Armstat Foreign Trade Database (HS textile and apparel codes, 2022–2024): annual average Armenian textile raw material imports approximately $120 million. https://armstat.am/en/?nid=160

[5] PwC Armenia — Individual and Corporate Tax Summary: flat 20% personal income tax; 18% corporate profit tax; 20% VAT. https://taxsummaries.pwc.com/armenia/individual/taxes-on-personal-income

[6] Sustainable Fashion Starts with Pattern Making (COKAA, 2024) — benchmark for 5–12% cutting waste reduction through lekal/marker optimisation and digital cutting technology. https://www.cokaa.in/post/sustainable-fashion-starts-with-pattern-making

[7] Textile Waste Management: Balancing Environmental and Economic Stability (Gusain, LinkedIn, 2023) — collection and transportation cost benchmark for textile waste: €200–€680 per tonne; preprocessing/sorting: additional €100–€200 per tonne. https://www.linkedin.com/pulse/textile-waste-management-balancing-environmental-economic-gusain-q3zyf

require an additional €100–€200 per tonne. These European ranges are adjusted downward to approximately $220/tonne total operating cost for Armenia, reflecting lower labour and energy costs, urban concentration of waste generators, and the relatively clean, homogeneous nature of HoReCa textile inputs.

Capital investment benchmarks for small-scale mechanical textile recycling:[8] International benchmarks indicate capital requirements of €400–€700 per tonne of annual installed processing capacity for small-scale mechanical textile recycling operations. Applied to the Armenian scenarios (450 t/year moderate; 1,050 t/year advanced), this yields total CAPEX ranges of $180,000–$310,000 and $450,000–$800,000 respectively, covering preprocessing equipment, collection vehicles, and facility upgrades at Artik PHK.

Operating cost benchmarks for mechanical textile recycling:[9] European operating costs for mechanical textile recycling facilities are benchmarked at €300–€600 per tonne processed. The $220/tonne OPEX assumption used in the Armenian model represents the lower end of this range, reflecting Armenia's significantly lower labour costs (Sector C average wage approximately USD 510/month vs. European averages of USD 2,500–3,500/month) and simplified processing requirements for clean HoReCa textile inputs.

Market prices for recycled textile fibers and secondary materials:[10] Mechanically recycled open-loop textile fibers (suitable for insulation, furniture padding, industrial cleaning applications) are priced conservatively at $390–$445/tonne for modelling purposes. This reflects secondary fiber market benchmarks for low-grade recycled outputs. High-quality closed-loop recycled fibers trade at $1,000–$2,000+/tonne but require chemical recycling technology not currently available at Artik PHK and are not modelled here.

Employment and output multiplier benchmarks:[11][12] UNIDO (2024) documents manufacturing employment multipliers exceeding 2.0 for broad manufacturing sectors. IMF (2018) documents high import dependency and limited domestic value chain depth across the Caucasus region. Both sources justify the conservative downward adjustment applied in this model: an output multiplier of 1.25 (vs. regional benchmark 1.5–1.8) and employment multiplier of 1.20 (vs. typical manufacturing benchmark 1.5–2.0), reflecting Armenia's reliance on imported fuel, equipment, and consumables.

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[8] Financial Model for Textile Recycling Facility (FinancialModelExcel, 2024) — capital investment benchmarks for small-scale mechanical textile recycling: €400–€700 per tonne of annual installed processing capacity. https://financialmodelexcel.com/blogs/cost-open/textile-recycling-services

[9] Core KPIs for a Textile Recycling Business (StartupFinancialProjection, 2024) — operating cost benchmarks: €300–€600 per tonne processed in European conditions. https://startupfinancialprojection.com/blogs/kpis/textile-recycling

[10] Recycled polyester and secondary textile fiber market price reference — open-loop mechanically recycled fibers for insulation/padding/industrial use typically sell at $350–$450/tonne; higher grades ($1,000–$2,000+/tonne) require chemical recycling not available at Artik PHK. https://www.accio.com/t-v2/plp/recycled-polyester-price

[11] UNIDO Industrial Development Report 2024 — manufacturing employment multipliers typically exceed 2.0 for broad manufacturing; 1.20 coefficient here reflects conservative downward adjustment for a simple open-loop recycling activity with limited backward linkages. https://www.unido.org/publications/industrial-development-report-series

[12] IMF (2018), 'Opening Up in the Caucasus and Central Asia' — documents high import dependency and limited domestic value chain depth in the Caucasus region, justifying downward adjustment of output multipliers from the standard 1.5–1.8 range to 1.25. https://www.imf.org/-/media/Files/Publications/DP/2018/45910mcd1807-dp-opening-ccar.ashx

Value-added ratio calibration:[13] Armstat National Accounts data show Armenia's manufacturing sector value-added/gross-output ratio at approximately 43.6% (average of 2018-2024). This model applies a conservative 40% proxy[14] coefficient, rounded downward to reflect the simpler processing nature of open-loop mechanical recycling relative to broader manufacturing.

No official Armenian dataset identifies HoReCa textile waste as a separate statistical category. The estimate of **~1,500 tonnes of annual HoReCa textile waste generation** is therefore a modelling assumption derived from international hospitality benchmarks of **14 kg of textile waste per hotel bed per year**, applied to **Armstat hotel capacity data of 38,000 beds as of 2021**, and adjusted for the growth in the number of incoming tourists using hotels.

According to this approach, Armenia had **38,000 hotel rooms in 2021**[15] and 278.393 **incoming tourists using hotels** that year. Applying the international benchmark of **14 kg**[16] **of textile waste per bed**, the estimated textile waste generated by Armenian hotels in 2021 amounted to **~532 tonnes**, equivalent to **1.91 kg of textile waste per incoming tourist using hotels**.

Taking into account that the number of **incoming tourists to Armenia reached 794,380 in 2024**, the estimated textile waste generated by hotels increased proportionally. Based on the same per-tourist waste ratio, the total textile waste from hotels in 2024 is estimated at approximately **794,380 × 1.91 kg ≈ 1,500 tonnes of textile waste**.

### 1.1.2 Modelling Framework

**Step 1 — Physical Definition of the Intervention:** The intervention targets institutional textile waste generated by HoReCa establishments (hotels, hospitals, and related facilities), diverted from municipal waste streams into a structured collection and mechanical recycling system. Physical parameters include annual tonnage of HoReCa textile waste generated nationally, diversion rates under each scenario, and material composition of institutional textile streams.

**Step 2 — Investment and Operating Costs:** Capital expenditure covers expansion of preprocessing equipment (shredders, fiber opening machines), dedicated collection vehicles, and basic storage infrastructure at Artik PHK. Costs are derived from international benchmark ranges adjusted for Armenia's lower labour and infrastructure costs. Operating expenditure covers collection and transport logistics, facility operations (labour, energy, maintenance), and administrative coordination, estimated at approximately $220/tonne based on Armenian conditions.

**Step 3 — Direct Economic Effects:** Gross output equals volume processed (tonnes) multiplied by the market price of recycled textile output ($390–$445/tonne). Value added is calculated as gross output

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[13] Armstat National Accounts (SNA tables) — Armenia's manufacturing sector value added / gross output ratio: approximately 44.4% (2022 data). The 40% coefficient applied in this model is a conservative rounding of this published figure.
https://armstat.am/en/?nid=82&id=2527

[14] International statistical manuals (SNA 2008; OECD; UNIDO; Eurostat) and economic modelling guidance explicitly allow proxies when detailed data are missing. Such proxies were used in reports like “Producing environmental accounts with environmentally extended input output analysis” (Publication by EU)
https://op.europa.eu/it/publication-detail/-/publication/07612408-91ca-11eb-b85c-01aa75ed71a1

[15] International Visitor Survey on National Level
https://www.mineconomy.am/media/32499/International%20Visitor%20Survey%202023.pdf

[16] Increasing the Circularity of Hotel Textiles.
https://www.oneplanetnetwork.org/knowledge-centre/resources/increasing-circularity-hotel-textiles

multiplied by a 40% sectoral VA ratio calibrated against Armstat manufacturing sector data. Direct employment is estimated using output-per-worker benchmarks validated against Armenian industrial wage levels. Wages and fiscal contributions are calculated using statutory Armenian tax rates.

**Step 4 — Indirect and Induced Effects:** In the absence of a sector-specific Armenian input-output table, proxy multiplier coefficients are applied: output multiplier 1.25, employment multiplier 1.20. These are adjusted downward from regional manufacturing benchmarks to reflect Armenia's high import dependency in fuel and consumables, and the relatively simple material processing involved in open-loop mechanical recycling.

**Step 5 — Trade and Resource Effects:** Import substitution is estimated as the volume of recycled domestic textile output that replaces imported textile-based materials multiplied by the average market price of recycled output. A 60% substitution rate is applied, reflecting the realistic share of production that can displace imported secondary materials in domestic industrial applications. Armenia's total annual textile raw material imports of approximately $120 million are used as the denominator for expressing import substitution in relative terms.

### 1.1.3 Assumptions and Limitations

**No national textile waste statistics:** the estimate of 1,500 tonnes of annual HoReCa textile waste generation is a modelling working assumption derived from international hospitality benchmarks of 14kg per room hotel room waste annually[17], multiplied by Armenian hotel room capacity official data. Restaurants and Cafes generate moderate amount of textile waste compared to hotels, and it is not efficient to collect that small amount of waste, thus, in our assumption, they do not position.

**Material composition:** HoReCa textile streams are modelled as predominantly cotton or cotton-polyester blends with minimal contamination from metallic accessories, consistent with standard institutional linen procurement. This homogeneity assumption supports the lower-range cost estimates applied.

**Market price for recycled output:** mechanically recycled open-loop fibers are priced at $390–$445/tonne, reflecting secondary fiber market benchmarks for insulation-grade and industrial applications.

**Armenia-adjusted operating costs:** $220/tonne represents the lower end of European benchmark ranges, adjusted for lower Armenian labour costs and the relatively clean nature of HoReCa textile inputs.

**Payback period:** since the core processing capability already exists at Artik PHK, CAPEX covers only incremental capacity expansion and logistics. Payback of 2.5–4 years reflects recovery of this incremental investment from operating surpluses.

## *1.2 Sector Overview*

Armenia's textile and garment sector operates through a mixed production structure, combining export-oriented contract manufacturing (CMT arrangements for foreign buyers) with locally managed production. From a circular economy perspective, the sector operates with minimal material recovery or recycling infrastructure. Production off-cuts are generally treated as industrial waste, and post-consumer textile flows are almost entirely unmanaged within the formal waste management system.

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[17] Increasing the Circularity of Hotel Textiles https://www.oneplanetnetwork.org/knowledge-centre/resources/increasing-circularity-hotel-textiles

Armenia possesses one functioning mechanical textile recycling operator — Artik PHK in Maralik — which processes textile waste into secondary materials including insulation-grade fibers, furniture padding, and industrial wiping cloths. This capacity, although limited in scale, represents an important institutional foundation. The HoReCa cooperation model is designed to provide Artik PHK with a stable, high-quality feedstock stream that improves capacity utilisation and operational viability.

The baseline circularity status is characterised by: no dedicated textile waste legal framework; no municipal collection system separating textiles from general waste; near-total reliance on landfill disposal for post-consumer and institutional textile waste. Annual HoReCa textile waste generation is estimated at approximately 1,500 tonnes, of which fewer than 5–10 percent currently enter formal recycling or reuse channels.

### *1.3 Selected Circular Intervention*

Three intervention directions were evaluated. The comparative assessment considered capital intensity, infrastructure readiness, feedstock stability, market creation potential, implementation speed, institutional feasibility, and strategic alignment.

**Table 1. Comparison of Circular Intervention Options**

| Criterion | Off-Cut Recycling | Cutting Optimisation | HoReCa Cooperation |
|---|---|---|---|
| Capital intensity | Medium | Medium–High | **Low–Medium** |
| Infrastructure readiness | Limited | Partial | **Existing base (Artik PHK)** |
| Feedstock stability | Moderate | N/A | **Relatively stable** |
| Market creation potential | Moderate | Low | **Moderate–High** |
| Speed of implementation | Medium | Medium | **High** |
| Institutional feasibility | Moderate | High | **High** |
| Export/cluster potential | Limited | Indirect | **Stronger** |
| **Overall Strategic Score** | ★★★ | ★★★ | ★★★★★ |

*Source: Author's calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

Off-cut recycling (Option 1) faces limitations due to the relatively small and unstable volumes of industrial textile waste generated by Armenia's garment sector and the absence of standardised sorting practices across smaller production facilities. Cutting optimisation (Option 2) can improve resource efficiency within individual firms, but primarily produces incremental gains without creating new circular material flows or supporting domestic recycling value chains. HoReCa cooperation (Option 3) combines low capital requirements with existing infrastructure readiness, relatively stable and homogeneous feedstock, and potential for domestic secondary material market development. It was therefore selected as the priority intervention.

The proposed intervention establishes a structured collection and mechanical recycling system in which participating HoReCa establishments segregate discarded textile items (bed linens, towels, bathrobes, uniforms) from general waste streams, accumulate them at designated storage points, and supply them to Artik PHK through periodic dedicated collection routes. Collected textiles undergo basic preprocessing (inspection, removal of non-textile elements, shredding, fiber opening) and are processed into secondary materials for open-loop industrial applications.

### 1.3.1 Legal and Institutional Basis

The intervention does not require new legislation in its pilot phase but would benefit from voluntary sector agreements between the Ministry of Environment and major hotel chains, green certification for participating HoReCa establishments, and over time formal waste management regulations classifying textile waste as a separately collected stream. Institutional anchors: Ministry of Environment, Ministry of Economy, Tourism Committee, Artik PHK as the designated processing operator.

### 1.3.2 Scenario Design

- Moderate Scenario: approximately 450 tonnes of HoReCa textile waste diverted annually. Partial adoption through voluntary cooperation agreements with large hotels and hospitals in Yerevan, Tsaghkadzor, and Dilijan. Adoption rate: approximately 30% of estimated annual HoReCa textile waste generation (1,500 tonnes nationally).

- Advanced Scenario: approximately 1,050 tonnes diverted annually. Structured collection system extended to medium-sized and regional establishments; formal sector agreements with major hotel chains and healthcare networks. Adoption rate: approximately 70% of estimated annual institutional textile waste flows.

### *1.4 Physical and Financial Modelling Assumptions*

All monetary values are stated in USD at the reference rate AMD 387/USD 1 (CBA annual average 2025). AMD equivalents are provided in parentheses. European benchmark data has been converted at AMD 437/EUR 1 (CBA annual average 2025).

**Table 2. Scenario and Key Modelling Assumptions**

| Parameter | Moderate Scenario | Advanced Scenario |
|---|---|---|
| **HoReCa textile waste diverted (tonnes/year)** | ~450 | ~1,050 |
| Adoption rate (% of total national HoReCa textile waste) | ~30% | ~70% |
| Primary material composition | Cotton / cotton-polyester blends | Cotton / cotton-polyester blends |
| Average recycled output value (USD/tonne) | $390–$445 | $390–$445 |
| Operating cost assumption (USD/tonne processed) | ~$220 | ~$220 |
| **Total CAPEX (USD)** | $180,000–$310,000 | $450,000–$800,000 |
| **Annual OPEX (USD/year)** | ~$99,000 | ~$230,000 |

*Source: Author's calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

HoReCa textile waste generation is estimated at 1,500 tonnes annually. Under the moderate scenario (30% diversion), approximately 450 tonnes are processed annually; under the advanced scenario (70% diversion), approximately 1,050 tonnes. The assumed market price of $390–$445 per tonne of recycled output reflects secondary fiber market benchmarks for mechanically recycled open-loop outputs. The $220/tonne operating cost assumption reflects the lower end of international benchmarks adjusted for Armenian labour and energy conditions.

**Table 3. Estimated Capital Investment Requirements**

| CAPEX Component | Moderate (USD) | Advanced (USD) |
|---|---|---|
| Preprocessing equipment (shredders, fiber openers) | 80,000–140,000 | 200,000–350,000 |
| Dedicated collection vehicles (1–2 units) | 60,000–100,000 | 150,000–250,000 |
| Storage and facility upgrades at Artik PHK | 30,000–50,000 | 80,000–150,000 |
| Logistics coordination system (IT/admin setup) | 10,000–20,000 | 20,000–50,000 |
| **Total CAPEX (USD)** | **180,000–310,000** | **450,000–800,000** |

*Source: Author's calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

*Note: CAPEX covers only incremental expansion of Artik PHK's capacity and collection logistics. Core processing infrastructure already exists. Ranges reflect uncertainty in equipment procurement costs at this stage of planning.*

## 1.5 Direct Economic Effects

The proposed intervention generates direct economic benefits through three primary channels: (i) creation of new economic activity in textile recycling and logistics, (ii) generation of domestic value added from recovered secondary materials, and (iii) direct employment creation within recycling operations and collection systems.

### 1.5.1 Gross Output

Gross output is calculated as volume of processed textile waste multiplied by average market price of recycled output. All material fractions recovered from HoReCa textile streams are consolidated into a single recycled fiber/secondary textile output category.

**Table 4. Gross Output and Net Operating Surplus**

| Output Component | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Recycled fiber / secondary textile materials (450 t / 1,050 t @ ~$415/tonne avg) | ~$156,000–$178,000 | ~$390,000–$445,000 |
| **Total Gross Output** | **~$156,000–$178,000** | **~$390,000–$445,000** |
| Annual OPEX (collection, processing, admin) | ~$99,000 | ~$230,000 |
| **Net Annual Operating Surplus (Output − OPEX)** | **~$57,000–$80,000** | **~$160,000–$215,000** |

*Source: Author’s calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

*Note: Operating surplus reflects gross output minus direct OPEX. It represents the direct financial viability of the recycling operation but is distinct from value added as defined in national accounts.*

### 1.5.2 Value Added

Value added represents the contribution of the recycling intervention to Armenia's GDP. A 40% value-added ratio is applied to gross output, calibrated against Armstat national accounts data showing Armenia's manufacturing sector VA/output ratio of approximately 44.4% (2022).

**Table 5. Direct Value Added**

| Value Added Component | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Gross output | ~$156,000–$178,000 | ~$390,000–$445,000 |
| Sectoral VA ratio applied (40%) | 40% | 40% |
| **Direct Value Added (USD/year)** | **~$62,000–$71,000** | **~$156,000–$178,000** |
| AMD equivalent | ~24–27.5 million AMD | ~60–69 million AMD |

*Source: Author’s calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

### 1.5.3 Direct Employment

Employment is estimated using output-per-worker benchmarks for waste management and recycling operations, with labour costs validated against Armenian sector wage data (Armstat, December 2025). The assumed output-per-worker coefficient of approximately $20,000–$25,000/year reflects the labour-intensive, lower-technology nature of manual textile sorting and mechanical fiber processing.

**Table 6. Direct Employment Estimates by Role Category**

| Role Category | Moderate (FTE) | Advanced (FTE) |
|---|---|---|
| Sorting and recycling facility workers | 4–5 | 8–10 |
| Logistics and collection drivers | 2–3 | 4–5 |
| Administration and coordination | 0–1 | 1–2 |
| **Total Direct Employment (FTE)** | **6–8** | **12–15** |

*Source: Author’s calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

Wage benchmarks are grounded in Armstat sector data for December 2025. Recycling and sorting positions are modelled as predominantly female manufacturing-sector roles (Sector C: AMD 197,231/month average); collection and logistics positions are modelled as transportation-sector roles (Sector H: AMD 459,723/month average). There is no employer-side social security contribution in Armenia; employee pension contributions of 5% on monthly salary up to AMD 500,000 are withheld by the employer as a remittance agent.

### *1.6 Indirect and Induced Effects*

The output multiplier of 1.25 is applied conservatively, adjusted downward from a regional benchmark of 1.5–1.8 to account for Armenia's high import dependency in fuel and consumables and the limited domestic supplier depth of the recycling sector. The employment multiplier of 1.20 reflects modest but real backward linkages in transport, fuel supply, and facility maintenance services.

Indirect effects arise through supply chain linkages: collection logistics generate demand for transport services, fuel, and vehicle maintenance; recycling equipment requires periodic servicing and spare parts. The availability of a stable secondary fiber supply may also create downstream manufacturing opportunities for producers of insulation materials, furniture padding, and industrial cleaning supplies using recycled textile inputs.

Induced effects arise through the spending of wages earned by newly created jobs in recycling operations and logistics. These household consumption flows generate additional economic activity in local markets for goods and services.

**Table 7. Indirect and Induced Effects**

| Effect | Moderate | Advanced |
|---|---|---|
| Direct Gross Output (USD/year) | ~$156,000–$178,000 | ~$390,000–$445,000 |
| Output Multiplier (adjusted for import leakage) | 1.25 | 1.25 |
| **Total Output Effect (USD/year)** | **~$195,000–$222,500** | **~$487,500–$556,250** |
| Direct Value Added (USD/year) | ~$62,000–$71,000 | ~$156,000–$178,000 |
| **Total VA Effect (USD/year)** | **~$77,500–$88,750** | **~$195,000–$222,500** |
| Direct Employment (FTE) | 6–8 | 12–15 |
| Employment Multiplier | 1.20 | 1.20 |
| **Total Employment Effect (FTE)** | **10–12** | **18–22** |

*Source: Author’s calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

*Note: Output multiplier of 1.25 and employment multiplier of 1.20 reflect conservative downward adjustments from standard manufacturing benchmarks, consistent with IMF (2018) analysis of limited domestic value chain depth in the Caucasus region and UNIDO (2024) guidance on multiplier calibration for simple recycling activities.*

### *1.7 Trade and Resource Effects*

Armenia's textile sector imports approximately $120 million worth of raw materials annually (2022–2024 average), a figure that continues to rise with sector expansion. Introducing recycled domestic fibers into value chains provides an opportunity to partially substitute imported materials in lower-grade industrial applications. A 60% substitution rate is applied to recycled output, reflecting the realistic share that can displace imported secondary materials in domestic industrial markets for insulation, padding, and cleaning applications.

**Table 8. Trade and Resource Effects**

| Trade Effect Component | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Total recycled textile output (tonnes/year) | ~450 | ~1,050 |
| Share replacing imported materials (60%) | ~240 tonnes | ~630 tonnes |
| Average market value of recycled output (USD/tonne) | $390–$445 | $390–$445 |
| **Import substitution effect (USD/year)** | **~$95,000–$108,000** | **~$250,000–$280,000** |
| AMD equivalent | ~37–42 million AMD | ~96.5–108.5 million AMD |
| As % of total textile raw material imports (~$120M/year) | ~0.08–0.09% | ~0.20–0.22% |
| Avoided landfill disposal costs ($46–$68/tonne) | ~$20,700–$30,600 | ~$48,300–$71,400 |
| Avoided municipal waste management costs ($120/tonne) | ~$54,000 | ~$126,000 |

*Source: Author’s calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

*Note: Import substitution is calculated on a replacement-cost basis and should be interpreted as a resource-efficiency proxy rather than a direct forecast of reduced import volumes.*

The intervention also reduces pressure on municipal waste management systems by diverting institutional textile waste from landfill. Based on municipal waste management benchmarks, the cost of collecting and processing recyclable waste streams in Armenia is estimated at approximately $120/tonne. Diverting 450–1,050 tonnes annually therefore reduces system costs by $54,000–$126,000/year, accruing primarily as public-sector efficiency gains. Even under the advanced scenario, recycled outputs substitute imported materials valued at approximately $250,000–$280,000 — approximately 0.2% of total annual textile raw material imports.

## *1.8 Fiscal and Distributional Effects*

### 1.8.1 Employment-Based Fiscal Contributions

Fiscal revenues from employment are calculated using Armstat wage benchmarks and Armenia's flat 20% personal income tax rate.

**Table 9. Wage Benchmarks by Role Category (Armstat, December 2025)**

| Role Category | Avg. Monthly Wage (AMD) | Annual Wage (AMD) | Scenario FTEs |
|---|---|---|---|
| Recycling/sorting (Sector C-women) | 197,231 | 2,366,772 | Mod: 4–5 / Adv: 8–10 |
| Collection/logistics (Sector H-men) | 459,723 | 5,516,676 | Mod: 2–3 / Adv: 4–5 |
| **Total wage bill (moderate)** | — | ~20.5–28.4 million AMD | — |
| **Total wage bill (advanced)** | — | ~41.0–51.2 million AMD | — |

*Source: Author's calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

### 1.8.2 Overall Fiscal Picture

VAT is estimated on a net basis (after input credits for operational purchases), applying the statutory 20% VAT rate. Profit tax is applied at 18% to estimated operating income net of OPEX and CAPEX depreciation. CAPEX midpoints depreciated over 5 years: moderate $245,000 / 5 = $49,000/year; advanced $625,000 / 5 = $125,000/year.

**Table 10. Estimated Fiscal Revenue Summary**

| Fiscal Item | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Personal income tax from employment (20% flat rate) | ~$10,600–$14,700 | ~$21,200–$26,300 |
| Net VAT effect from recycled material sales (after input credits) | ~$12,400–$14,200 | ~$31,200–$35,600 |
| Profit tax at 18% on operating income (midpoint estimate) | ~$4,500–$7,000 | ~$11,000–$15,000 |
| **Total Estimated Direct Fiscal Revenue (USD/year)** | **~$28,000–$36,000** | **~$63,000–$77,000** |
| AMD equivalent | ~10.8–13.9 million AMD | ~24.4–29.8 million AMD |
| As % of Armenia's total 2025 tax revenues and customs duties (AMD 2.72 trillion) | 0.00040–0.00051% | 0.00090–0.00110% |

| Fiscal Item | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Avoided municipal waste management costs (public-sector savings) | ~$54,000 | ~$126,000 |

*Source: Author's calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

*Note: The intervention's contribution to total Armenian tax revenues (AMD 2.72 trillion in 2025) is very small in absolute terms, proportionate to the modest scale of a pilot initiative. Avoided municipal waste management costs ($54,000–$126,000/year) are public-sector efficiency gains rather than budgetary revenues, but reduce net public expenditure.*

### 1.8.3 Distributional Effects

The intervention redistributes economic benefits across several stakeholder groups. Artik PHK benefits from new revenue streams and improved capacity utilisation. Transport operators and logistics providers benefit from stable collection contracts. Participating HoReCa establishments benefit through improved waste management solutions and potential reductions in disposal costs while strengthening sustainability profiles.

The intervention creates inclusive employment opportunities in textile sorting, collection, and preprocessing activities requiring limited formal qualifications. Because sorting positions are concentrated in manufacturing operations where female employment is historically dominant in Armenian industrial labour markets, the project contributes modestly to supporting women's employment in manufacturing-related activities. Entry-level positions are also accessible for youth workers in regions where Artik PHK operates (Shirak marz).

### *1.9 Cost–Benefit Snapshot*

Under the moderate adoption scenario, 450 tonnes of HoReCa textile waste are processed annually. Required CAPEX of $180,000–$310,000 covers incremental expansion of Artik PHK's capacity and collection logistics. Annual operating costs of approximately $99,000 are offset by recycled material revenues of $156,000–$178,000, generating a net operating surplus of $68,000–$90,000 per year. Combined with avoided waste management savings of approximately $44,000 annually, total annual economic benefits amount to approximately $116,000–$138,000. The initial investment is recoverable within approximately 2.5–4 years.

Under the advanced adoption scenario, 1,050 tonnes are processed annually. CAPEX of $450,000–$800,000 generates annual revenues of $390,000–$445,000 against operating costs of $220,000, yielding a net operating surplus of $170,000–$225,000/year. Combined with avoided waste management savings of approximately $120,000, total annual economic benefits reach approximately $290,000–$345,000. CAPEX recovery occurs within approximately 3–4 years.

**Table 11. Cost–Benefit Summary**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| **Total CAPEX (USD)** | $180,000–$310,000 | $450,000–$800,000 |
| Annual OPEX (USD/year) | ~$99,000 | ~$230,000 |
| Annual Gross Output (USD/year) | ~$156,000–$178,000 | ~$390,000–$445,000 |
| **Annual Value Added (USD/year)** | **~$62,000–$71,000** | **~$156,000–$178,000** |
| Total jobs created (FTE, incl. multiplier) | 10–12 | 18–22 |
| Import substitution (USD/year) | ~$95,000–$108,000 | ~$250,000–$280,000 |
| Annual direct fiscal revenue (USD/year) | ~$28,000–$36,000 | ~$63,000–$77,000 |
| Avoided waste management costs / public savings (USD/year) | ~$54,000 | ~$126,000 |
| **Net Annual Operating Surplus (Output − OPEX)** | **~$57,000–$80,000** | **~$160,000–$215,000** |
| **Payback period (CAPEX / net annual surplus)** | **~3–4 years** | **~3–4 years** |

*Source: Author's calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

*Sensitivity: a 20% decline in recycled fiber prices would reduce annual output by approximately $31,000–$36,000 (moderate) and $78,000–$89,000 (advanced), extending payback by approximately 0.5–1.0 year. The intervention remains operationally viable under this stress scenario.*

### *1.10 Risks and Trade-offs*

- Feedstock supply instability: without structured collection agreements, the recycling facility may face irregular feedstock supply reducing capacity utilisation. Achieving 30–70% diversion rates requires coordinated engagement with a meaningful share of Armenia's hotel and hospital sector.
- Limited domestic market for recycled outputs: mechanical recycling produces lower-grade fibers primarily suitable for open-loop industrial applications. However, given Armenia's heavy reliance on imported textile raw materials, competitive pricing of recycled outputs relative to imports mitigates this risk over time.
- Multi-stakeholder coordination challenges: effective implementation requires coordination across HoReCa businesses, logistics providers, the recycling operator, and municipal waste authorities. Voluntary sector agreements and green certification schemes are important alignment mechanisms.
- Collection logistics cost sensitivity: transport costs are relatively high compared with the value of recycled materials, particularly if collection routes are inefficient. Urban concentration of generators (Yerevan, Tsaghkadzor, Dilijan) is critical for maintaining economic viability.
- Scale constraints: even under the advanced scenario, the system processes approximately 1,050 tonnes per year — a modest volume. This should be understood as a pilot circular economy initiative rather than a large-scale industrial transformation.
- Initial public support requirement: early implementation may require limited targeted incentives (partial logistics subsidies, environmental grants for HoReCa participants, co-financing of equipment upgrades at Artik PHK) to overcome coordination barriers and establish stable waste supply flows before the system becomes self-sustaining.

## *1.11. Summary Positioning and Policy Implications*

### 1.11.1 Strategic Positioning

Among the three circular opportunities identified in Armenia's textile value chain, HoReCa textile recycling presents the most favourable combination of near-term actionability, capital efficiency, and policy alignment. It leverages an existing recycling operator whose operational viability depends on securing stable feedstock, and addresses a visible structural gap — the absence of institutional textile waste collection — that is correctable through coordination rather than capital-intensive means.

**Table 12. Strategic Positioning of Textile Circular Interventions**

| Circular Opportunity | Investment Intensity | Job Intensity | Strategic Score |
|---|---|---|---|
| **HoReCa Textile Recycling (selected)** | **Low–Medium** | **Medium** | ★★★★★ |
| Cutting Optimisation | Medium–High | Low | ★★★ |
| Off-Cut Recycling | Medium | Low–Medium | ★★★ |

*Source: Author's calculations based Armstat data, CBA exchange rates, SRC fiscal data, PwC tax benchmarks, and international industry benchmarks (UNIDO, IMF, EU textile recycling cost and technology data)*

### 1.11.2 Regulatory and Policy Changes Required

- Development of voluntary sector agreements between the Ministry of Environment and major HoReCa sector associations (hotel chains, hospital networks) formalising textile waste segregation and supply to licensed recycling operators.

- Green certification scheme for HoReCa establishments participating in textile recycling programs, administered through the Tourism Committee or Ministry of Environment, providing reputational incentives for participation.

- Over time: amendment of the Law on Waste Management to classify textile waste as a separately collected stream, with mandatory segregation requirements for large institutional generators above a threshold volume.

- Development of standards for authorised textile recycling operators, defining minimum technical requirements for material acceptance, processing, and secondary output quality.

### 1.11.3 Co-financing Rationale

Given Armenia's existing recycling infrastructure at Artik PHK, public co-financing needs are limited but targeted. Two elements justify limited public investment: partial subsidies for collection logistics during the pilot phase (covering incremental transport costs before sufficient feedstock volume makes logistics economically self-sustaining), and potential co-financing of preprocessing equipment upgrades at Artik PHK as a public good benefiting the broader institutional textile recycling ecosystem. Ongoing operational costs should become self-financing from recycled material revenues once capacity utilisation reaches approximately 60–70 percent of installed capacity.

### 1.11.4 Skills Development

The intervention requires modest skills development for two workforce groups. First, a brief orientation program (4–8 hours) for HoReCa facility managers and housekeeping staff covering textile waste segregation procedures, material storage requirements, and collection logistics. This can be delivered online or through Ministry of Environment and Tourism Committee certification channels at negligible cost. Second, basic equipment operation and quality control training for Artik PHK workers covering shredding and fiber opening equipment and quality assessment of incoming textile streams. No specialised vocational curriculum is required; Armenia's existing industrial labour market provides sufficient skills for the physical operations involved.

### 1.11.5 Incentive Design

A tiered incentive structure is recommended. During the pilot phase, participating HoReCa establishments could receive small environmental compliance credits, reduced municipal waste fees for diverted volumes, or eligibility for green certification. For the recycling operator, co-financing of collection vehicle procurement reduces the capital barrier to establishing reliable collection routes. Over time, voluntary incentives can be progressively replaced by structural regulatory requirements as operational experience is established. This sequencing minimises financial risk to both public and private actors while enabling the system to develop toward operational self-sufficiency. This approach is consistent with international best practices in institutional textile waste management, where hospitality and healthcare sectors have served as early entry points for textile recycling systems in several European countries.

# 2. PLASTICS PACKAGING SECTOR

## *2.1 Methodology*

### 2.1.1 Data Sources

The economic impact assessment is based on a combination of national statistical data, trade statistics, and international benchmarks for plastics manufacturing and packaging technologies.

The main data sources used in the analysis include:

**National Accounts and Industrial Statistics (Armstat):** Enterprise statistics for **NACE 22.22.0 – Manufacture of plastic packing goods** were used to estimate sector output, acquisitions, and value-added ratios. According to Armstat enterprise data, the sector recorded revenue of approximately **AMD 6,2 billion in 2024**, with total acquisitions of **AMD 4,7 billion**, implying a value-added share of approximately **24–25% of gross output**.

**Business Registry and Enterprise Statistics (Armstat):** Sector employment levels and wage benchmarks were derived from Armstat enterprise statistics for plastics manufacturing and related manufacturing sectors. Average wages in light manufacturing range approximately between **AMD 190,000 and AMD 210,000 per month**, depending on occupation and skill level.

**Customs and Trade Statistics (UN Comtrade Database)**: External trade data were used to estimate Armenia's import dependence on polymer raw materials. Imports of **primary plastics under HS codes 3901–3907** were used as the reference for polymer supply to the domestic plastics industry.

**Polymer price benchmarks (UN Comtrade Database):** The average import price of polymer resins used in plastics manufacturing was estimated using Armenia's recent trade data for **HS 3907 (polyesters including PET)** and related primary plastics. The resulting benchmark price used in the modelling is approximately **USD 1,100 per tonne**.

**International packaging technology benchmarks:** Investment requirements and efficiency gains associated with lightweighting technologies are based on international studies and industry reports on **PET bottle lightweighting and packaging optimization technologies**, including mold redesign, preform optimization, and blow-moulding process improvements.

### 2.1.2 Modelling Framework

**Step 1 — Physical Definition of the Intervention:** The intervention targets PET beverage bottle production through an industrial plastic reduction and lightweighting upgrade program. The physical effect is a reduction in the amount of virgin polymer resin used per bottle while maintaining product safety and performance. The key parameters are total domestic packaging production (tonnes/year), the share of production adopting lightweighting, and the average resin reduction achieved per unit. Two scenarios are modelled. In the Moderate Scenario, approximately 40% of domestic production adopts lightweighting with an average resin reduction of 15%. In the Advanced Scenario, adoption reaches around 70% of production with a reduction of 25%, resulting in annual resin savings of approximately 810 tonnes and 2,363 tonnes respectively.

**Step 2 — Investment and Operating Costs:** CAPEX consists of firm-level investments in mold redesign, preform optimization, engineering simulation, quality testing equipment, and limited upgrades to injection or stretch blow-moulding machinery. Because the intervention takes place within existing packaging production lines, no large-scale public infrastructure is required. Firm-level investment is estimated at USD 80,000–200,000 in the Moderate Scenario and USD 200,000–400,000 in the Advanced Scenario. With an estimated participation of 15–20 firms and 30–40 firms respectively, total CAPEX ranges from approximately USD 1.2–4.0 million and USD 6.0–16.0 million. OPEX includes maintenance, training, and technical advisory services.

**Step 3 — Direct Economic Effects:** The main direct economic effect arises from lower raw material consumption. Resin savings are calculated as the volume of production affected multiplied by the reduction rate. Using an average resin import price of approximately USD 1,100 per tonne, annual material savings are estimated at about USD 0.9 million in the Moderate Scenario and USD 2.6 million in the Advanced Scenario. A portion of these savings is assumed to be reinvested in additional production or technological upgrading, generating incremental output. Domestic value added is then estimated by applying the sector value-added ratio derived from Armenian industrial statistics (around 25%). The intervention is also expected to generate a limited number of new technical and quality-control jobs.

**Step 4 — Indirect and Induced Effects:** Because Armenia does not publish detailed sector input–output multipliers for plastics manufacturing, indirect and induced effects are estimated using conservative proxy multipliers derived from international manufacturing benchmarks. The model applies an output multiplier of approximately 1.20–1.35 and an employment multiplier of 1.10–1.30. These capture additional economic activity generated through supply-chain services such as equipment maintenance, engineering services, logistics, and household consumption linked to employment income.

**Step 5 — Trade and Resource Effects:** Trade effects arise through reduced imports of polymer raw materials. Since Armenia imports nearly all polymer resins used in plastics manufacturing, each tonne of resin saved translates directly into lower import demand. Import substitution is calculated as resin savings multiplied by the benchmark resin import price. This results in estimated annual import savings of approximately USD 0.9 million in the Moderate Scenario and USD 2.6 million in the Advanced Scenario. In addition, lower resin consumption reduces the volume of plastic entering the waste stream, generating downstream environmental and waste-management benefits.

### 2.1.3 Assumptions and Limitations

**Absence of detailed sector input–output tables**: Armenia does not publish sector-specific input–output multipliers for plastics manufacturing. As a result, multiplier effects are estimated using international benchmarks adjusted downward to reflect Armenia’s high import dependence.

**Production volume estimates**: Domestic plastic packaging production volumes are derived from enterprise statistics and trade data and therefore represent approximate estimates rather than precise physical production measurements.

**Polymer price volatility**: Global polymer prices fluctuate with oil and gas markets. The modelling therefore uses a representative benchmark price of approximately USD 1,100 per tonne, but actual savings may vary depending on market conditions.

**Technology adoption uncertainty**: Actual resin reduction achieved by firms depends on technical implementation and bottle design characteristics. The assumed reductions of 15–25% reflect typical lightweighting improvements reported in international packaging industry studies.

**Exchange rate fluctuations**: All financial estimates use a reference exchange rate of AMD 387/USD, which may vary over time.

## 2.2 Sector Overview

The analysis of Armenia's plastics packaging value chain, presented in the companion report, provides the analytical foundation for this economic impact assessment. The value chain study demonstrates that the sector is structurally import-dependent, downstream-oriented, and largely linear, with most plastic waste ultimately disposed of in landfills. Armenia relies almost entirely on imported polymer resins and finished plastic products, while domestic manufacturing activity is concentrated in packaging conversion.

The value chain analysis assessed a range of potential circular economy interventions across the plastics lifecycle. From these options, two interventions were identified as the most relevant candidates for economic impact assessment, based on their feasibility, policy readiness, and potential to generate measurable economic effects in the near to medium term:

- Strengthening Extended Producer Responsibility (EPR) through collection targets and eco-design incentives, linked to the establishment of a Producer Responsibility Organization
- Industrial Plastic Reduction and Lightweighting Upgrade Program

The EPR reform option was considered due to the growing policy momentum around extended producer responsibility in Armenia and its potential to reshape incentives across the plastics value chain. However, EPR implementation is already being actively pursued through ongoing institutional and legislative work. The Producer Responsibility Organization is currently in a formative stage, and preparatory processes are underway involving government bodies, industry associations, and international partners. Given this active policy trajectory, conducting a separate economic impact assessment for EPR at this stage would be largely duplicative.

The focus of this chapter is therefore on the Industrial Plastic Reduction and Lightweighting Upgrade Program, where additional analytical work can contribute more directly to policy design.

The selection of lightweighting as the primary intervention is justified by several factors.

First, lightweighting directly addresses one of the most economically significant structural characteristics of Armenia's plastics sector: its near-total dependence on imported polymer raw materials. Reducing resin consumption per unit of packaging output generates immediate import savings and improves the cost competitiveness of domestic manufacturers without requiring major new infrastructure or complex regulatory enforcement mechanisms.

Second, stakeholder consultations indicate that lightweighting is already occurring in practice among some of Armenia's leading packaging producers. Over the past 15 years, Coca-Cola HBC Armenia has progressively reduced the weight of its standard 0.5-litre PET bottle from approximately 28 grams to 18–21 grams, depending on seasonal conditions. Oval Plastic has introduced material-saving improvements across roughly 95% of its product range. These examples demonstrate that the technology is technically feasible within Armenia's manufacturing environment and that a structured program could accelerate adoption across a broader set of firms.

Third, compared with deposit-return systems or comprehensive EPR reforms, lightweighting is a relatively low-regulatory-complexity intervention. It primarily requires technological upgrades and process optimization at the firm level rather than the establishment of new regulatory institutions or complex monitoring systems. This makes it more realistically implementable in the near term within Armenia’s current governance and administrative capacity.

Finally, lightweighting complements other circular economy measures across the plastics lifecycle. By reducing the amount of plastic used per unit of packaging, it lowers the volume of waste entering the system, thereby making downstream interventions—such as EPR schemes and deposit-return systems—more cost-effective once they are implemented. In this sense, lightweighting represents a logical upstream starting point within a broader sequence of circular economy reforms.

### 2.2.1 Baseline Structure of Armenia’s Plastics Packaging Sector

Before evaluating the economic impact of the proposed lightweighting program, it is necessary to establish the baseline structure of Armenia’s plastics packaging sector. The indicators summarized below describe the current scale of production, the degree of import dependence, and the limited level of circular material recovery.

**Table 13. Key Baseline Indicators for Armenia’s Plastics Packaging Sector (2024)**

| Key Baseline Indicators — Armenia Plastics Sector (2024) |
|---|
| Total plastic packaging apparent domestic consumption: USD 44.7 million/year[18] |
| Domestic production share of plastic packaging supply: 43.3% (USD 22 million)[19] |
| Import share: 56.7% (USD 28.9 million)[20] |
| Primary polymer (resin) imports: USD 66.8 million/year; 54,484 tonnes[21] |
| Share of plastic waste recycled: <5% (estimated); remainder landfilled |
| Plastics manufacturing employment (NACE 22.2): ~3,200 workers (2024)[22] |
| No deposit-return system, no nationwide source separation, no food-grade recycling capacity |
| Lightweighting already underway at 2–3 major producers, but not systematically adopted sector-wide[23] |

*Source: Armenian industrial statistics, trade data, and sector consultations*

Armenia’s plastics sector generates substantial plastic waste while maintaining very limited recovery capacity. The absence of coordinated collection systems, deposit-return mechanisms, and food-grade recycling infrastructure means that most plastic packaging ultimately enters landfill disposal streams.

Under these conditions, source-reduction strategies—such as lightweighting—represent one of the most immediate and implementable pathways for reducing both environmental pressure and material input costs.

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[18] *Author’s calculations based on Armstat and UN Comtrade databases*

[19] *Author’s calculations based on Armstat, External Trade Database (HS 4-digit level)*

[20] *Author’s calculations based on Armstat, External Trade Database (HS 4-digit level)*

[21] *Author’s calculations based on Armstat, External Trade Database (HS 4-digit level)*

[22] *Author’s calculations based on State Revenue Committee of the Republic of Armenia (SRC). n.d. SRC Database.*

[23] *Based on Stakeholder consultations*

Enterprise-level statistics for NACE 22.22.0 (Manufacture of plastic packing goods) further illustrate the structural characteristics of the sector. In 2024, industrial statistics report sector revenue of AMD 6,2 billion, while total acquisitions amounted to AMD 4,7 billion. After accounting for inventory adjustments, the implied gross value-added proxy is approximately AMD 1,5 billion, corresponding to a value-added ratio of roughly 25%.

This relatively low value-added ratio reflects the strong dependence of the sector on imported material inputs. Raw materials alone account for approximately half of total sector revenue, confirming that polymer efficiency improvements represent the most direct lever for improving firm-level profitability.

All industrial statistics cited in this section are reported in thousand drams, consistent with the Armenian enterprise statistics database.

Taken together, these baseline conditions describe a sector where import dependence is structurally embedded, circular practices remain limited, and improvements in material efficiency can generate immediate economic benefits. The lightweighting program assessed in this chapter therefore addresses a clearly identifiable structural constraint within Armenia's plastics packaging industry.

## *2.3 Selected Circular Intervention*

The PET Beverage Bottle Lightweighting Upgrade Program is a targeted supply-side intervention designed to reduce the quantity of virgin polymer resin used per unit of plastic beverage bottle produced in Armenia. The program focuses on improving material efficiency in bottle manufacturing through technological upgrading, improved preform and mold design, and systematic optimization of bottle geometry.

Lightweighting—the process of reducing packaging weight while maintaining structural integrity, product protection, and functional performance—is a widely applied strategy in the global beverage packaging industry. By lowering the amount of polymer used per bottle, lightweighting simultaneously reduces production costs, resource consumption, and the environmental footprint of plastic packaging.[24]

In PET beverage bottle production, lightweighting is typically achieved through a combination of engineering and material innovations. These include optimization of preform design, improvements in stretch blow-moulding technologies, use of higher-performance polymer grades, and computer-aided structural simulations that allow manufacturers to reduce wall thickness without compromising mechanical strength or carbonation resistance.

Bottle lightweighting can also involve redesign of the bottle base, neck finish, and cap interface, as well as improved material distribution during the stretch blow-moulding process. Over the past two decades, these technological improvements have enabled beverage producers globally to reduce the average weight of PET bottles by 30–50% while maintaining functional performance.

A critical feature of the intervention is that the main commercial decision-makers are not only plastic converters, but also the beverage and bottled-water producers that place products on the Armenian market. In many cases, these beverage producers operate integrated production lines in which PET bottles are manufactured on-site and immediately filled with the respective liquid product. Even when bottle production is outsourced to specialized packaging suppliers, beverage companies typically determine the bottle specifications used in production. In practice, bottle weight, format, and packaging design are strongly influenced by the companies that fill and sell the liquid product, since they determine procurement requirements, branding needs, shelf presentation, and compatibility with bottling equipment. This means that successful lightweighting depends not only on the technical capacity of bottle manufacturers, but also on the willingness of beverage producers to redesign packaging specifications and adopt lighter bottle formats across their product lines.

### 2.3.1 Program Scope

The program targets domestic manufacturers producing PET beverage bottles used in the Armenian beverage industry, including bottles for water, soft drinks, juices, and other non-alcoholic beverages.

PET bottles represent one of the largest single uses of polymer resin in the packaging sector, making them an appropriate starting point for material-efficiency interventions. Because bottle production is highly standardized and produced in large volumes, even relatively small reductions in weight per unit can generate substantial cumulative savings in polymer consumption.

The program would support a range of firm-level investments and capacity-building measures, including:

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[24] European Commission. (2018). *A European Strategy for Plastics in a Circular Economy.*

- Upgrading stretch blow-moulding machinery and preform production equipment capable of producing lighter bottle formats
- Redesign of bottle preforms and molds to optimize material distribution and reduce resin intensity
- Computer-aided design (CAD) and structural simulation software for bottle engineering and stress testing
- Material testing and quality assurance equipment used to verify bottle strength, pressure resistance, and durability
- Technical advisory services and engineering training for production staff implementing lightweighting techniques

The intervention focuses on upstream production efficiency and therefore does not directly include post-consumer collection or recycling infrastructure. However, lightweighting complements downstream circular economy policies by reducing the total volume of plastic waste generated in the first place.

### 2.3.2 Program Coverage

Under the Moderate Scenario, the program is expected to involve approximately 15–20 participating firms, covering roughly 40% of domestic PET beverage bottle production.

Under the Advanced Scenario, participation could expand to 30–40 firms, covering approximately 70% of domestic bottle production.

Priority coverage would include Armenia's largest plastic packaging producers—such as Hytex, Narplast, and Oval Plastic—alongside medium-sized manufacturers supplying beverage producers across the domestic market. At the same time, the program would also involve major beverage and bottled-water producers that operate integrated PET bottling lines or directly determine bottle specifications used in production. These include companies such as Coca-Cola HBC Armenia, Jermuk Group, Dilijan Jur LLC, "NOY" Natural Spring Drinking Water Delivery Company, and other domestic producers of mineral water, soft drinks, and juices that rely heavily on PET bottle packaging. Because these firms control packaging design, procurement specifications, and filling-line compatibility requirements, their participation is essential for achieving large-scale bottle lightweighting across the market.

Geographic coverage is primarily Yerevan and the regions, where plastic packaging manufacturing is concentrated. The program would be open to firms across Armenia, with targeted outreach to manufacturers in secondary cities.

### 2.3.3 Legal and Institutional Framework

The PET bottle lightweighting program can be implemented within Armenia's existing institutional framework for industrial development and environmental policy.

Several public institutions could play key roles in program implementation:

- Ministry of Economy of the Republic of Armenia — responsible for industrial development policy and investment support programs for domestic manufacturing
- Ministry of Environment of the Republic of Armenia — responsible for plastic waste regulation and currently developing extended producer responsibility (EPR) legislation

- Producer Responsibility Organization (PRO) — currently under development in Armenia and expected to play a central role in implementing future packaging EPR systems. Eco-modulated EPR fees could incorporate incentives for lighter packaging formats.

These instruments could help reduce the financing constraints faced by small and medium-sized packaging producers when investing in lightweighting technologies.

Although technology adoption begins at the firm level, broad market uptake is unlikely to occur through voluntary action alone. A gradual regulatory approach is therefore advisable. The Government of Armenia could introduce bottle-lightweighting requirements through a combination of eco-design guidance, disclosure requirements, and phased minimum performance standards. Such measures would help prevent free-riding and ensure that all major market participants progressively transition toward lower-weight bottle formats rather than leaving adoption to a limited number of early movers.

### *2.4 Physical and Financial Modelling Assumptions*

The economic impact model is based on a simple resource-efficiency mechanism:

Lightweight PET bottles
↓
Less polymer resin used per bottle
↓
Lower raw material imports and targeted production investment
↓
Changes in sector value added, employment, imports, and tax revenue

The quantitative modelling presented in the following sections is based on a set of physical production and financial assumptions derived from Armenian industrial statistics, trade data, stakeholder consultations, and international benchmarks for PET bottle lightweighting programs.

Two implementation scenarios are defined:

- Moderate Scenario – representing a realistic near-term trajectory with partial sector uptake.
- Advanced Scenario – representing broader adoption supported by stronger policy incentives and financing instruments.

Both scenarios assume that the program targets PET beverage bottle manufacturing, which represents one of the most material-intensive segments of plastic packaging production.

#### 2.4.1 Production Baseline

Domestic plastic packaging production is estimated at approximately 13,500 tonnes per year, based on industrial statistics for NACE 22.22.0 – Manufacture of plastic packing goods, combined with implied unit values observed in Armenia's packaging trade data.

The volume of production affected by the intervention is determined by the assumed adoption rate among producers. Under the modelling assumptions:

- the Moderate Scenario covers approximately 40% of domestic production
- the Advanced Scenario covers approximately 70% of production

The corresponding production volumes affected by the program are therefore calculated as:

**Volume covered = Total domestic production × Adoption rate**

Moderate scenario: 13,500 × 40% = **5,400 tonnes**

Advanced scenario: 13,500 × 70% = **9,450 tonnes**

Resin savings are then estimated by applying the assumed reduction in polymer use per bottle:

**Resin savings = Production volume covered × Lightweighting reduction rate**

Moderate scenario: 5,400 × 15% = **810 tonnes**

Advanced scenario: 9,450 × 25% = **2,363 tonnes**

The modelling therefore assumes average resin reductions of 15% in the Moderate Scenario and 25% in the Advanced Scenario, which is consistent with typical lightweighting improvements observed in global PET bottle production.

### 2.4.2 Polymer Price Assumption

The import price of PET resin is approximated using Armenia's average unit import price for primary plastics under HS code 3907 (polyesters including PET).

Recent trade data indicate an average import price of approximately **USD 1,100 per tonne**, which is used as the baseline value for estimating material cost savings generated by lightweighting.

Annual material cost savings are calculated as:

**Annual resin savings (USD) = Resin saved (tonnes) × Import price (USD/tonne)**

Moderate scenario: 810 × 1,100 ≈ **USD 0.9 million**

Advanced scenario: 2,363 × 1,100 ≈ **USD 2.6 million**

### 2.4.3 Sector Financial Structure

Industrial statistics for NACE 22.22.0 – Manufacture of plastic packing goods provide a sector-specific basis for modelling the financial structure of packaging production.

In 2024, the sector recorded:

- Revenue: **AMD 6,2 billion**
- Total acquisitions: **AMD 4,7 billion**

After adjustment for changes in inventories and work in progress, this implies a gross value-added proxy of approximately AMD 1,5 billion, corresponding to a value-added ratio of roughly 24–25% of gross output.

This ratio is used in subsequent sections of the model to estimate the share of production value that translates into domestic value added, including wages, operating surplus, and taxes.

All industrial statistics cited in this section are reported in thousand Armenian drams.

### 2.4.4 Investment Assumptions

Investment estimates for PET bottle lightweighting are based on international benchmarks for packaging production technologies.

Lightweighting programs typically require:

- redesign or replacement of preforms and molds
- structural simulation and bottle design optimization
- quality-testing equipment
- limited upgrades to injection-moulding or stretch blow-moulding machinery

Based on these benchmarks, the modelling assumes firm-level investment requirements of approximately:

- **USD 80,000–200,000** in the Moderate Scenario

- **USD 200,000–400,000** in the Advanced Scenario

Total program investment is estimated as:

**Total CAPEX = Investment per firm × Number of participating firms**

Moderate scenario: 15–20 firms ⟶ USD 1.2–4.0 million

Advanced scenario: 30–40 firms ⟶ USD 6.0–16.0 million

The higher investment range reflects situations where firms upgrade multiple bottle formats or introduce more advanced design and testing capabilities.

**Table 14. Key Modelling Assumptions for the PET Bottle Lightweighting Program**

| Indicator | Unit | Moderate Scenario | Advanced Scenario |
|---|---|---|---|
| **Volume Affected** | | | |
| Domestic plastic packaging production[25] | tonnes/yr | 13,500 | 13,500 |
| Share of production adopting lightweighting | % | 40% | 70% |
| Volume of production covered by program | tonnes/yr | 5,400 | 9,450 |
| Average resin reduction per unit[26] | % | 15% | 25% |
| Resin savings achieved | tonnes/yr | 810 | 2,363 |
| **Investment Parameters** | | | |
| Investment per participating firm | USD | 80,000 – 200,000 | 200,000 – 400,000 |
| Number of participating firms | firms | 15 – 20 | 30 – 40 |
| Total CAPEX | USD mn | 1.2 – 4.0 | 6.0 – 16.0 |
| Annual OPEX (maintenance, training) | USD mn | 0.25 – 0.45 | 0.9 – 1.5 |
| **Price / Value Parameters** | | | |
| Average import price of PET/PE resin[27] | USD/tonne | ~1,100 | ~1,100 |
| Annual resin cost savings | USD mn | ~0.9 | ~2.6 |
| Gross output value of plastic packaging sector | USD mn | ~22 – 24 | ~22 – 24 |
| Value-added ratio (plastics manufacturing) | % | ~25% | ~28% |

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[25] Armstat. Industrial statistics for *NACE 22.22 – Manufacture of plastic packing goods*, including enterprise revenue, acquisitions, and employment data.

[26] International packaging industry benchmarks on PET bottle lightweighting, including engineering studies and industry reports documenting typical resin reductions of 15–30% through bottle redesign, preform optimization, and stretch blow-moulding improvements.

[27] UN Comtrade Database. Armenia imports of plastics in primary forms (HS codes 3901–3907), with particular reference to HS 3907 (polyesters including PET). Unit values derived from recent import statistics reported by Armenia.

| | | | |
|---|---|---|---|
| Average monthly wage (plastics sector) | AMD | ~190,000 | ~210,000 |

*Source: Statistical Committee of the Republic of Armenia (Armstat).*
*Industrial production by activity – NACE 22.22 Manufacture of plastic packing goods. UN Comtrade Database.*
*Armenia imports of plastics in primary forms (HS 3907 – PET)*

*Note: All monetary values are in USD unless otherwise stated. AMD conversions use AMD 387/USD. Ranges reflect uncertainty in production volumes, resin price trends, and participation rates*

### *2.5 Direct Economic Effects*

The direct economic effects of the PET bottle lightweighting program arise primarily through reductions in raw material input costs, as less polymer resin is required per unit of packaging produced. This mechanism is particularly important in Armenia's plastic packaging industry, where enterprise statistics for NACE 22.22.0 – Manufacture of plastic packing goods indicate that raw materials and materials account for approximately half of sector revenue. As a result, improvements in resin efficiency represent the most immediate source of financial benefit for producers.

The modelling assumes annual resin savings of approximately 810 tonnes in the Moderate Scenario and 2,363 tonnes in the Advanced Scenario. At an average PET resin import price of approximately USD 1,100 per tonne, these reductions correspond to direct annual material cost savings of approximately USD 0.9 million and USD 2.6 million, respectively.

The resulting direct economic effects are summarized in the following Table.

**Table 15. Direct Economic Effects of the PET Bottle Lightweighting Program**

| Economic Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| **Gross Output Effects** | | |
| Annual resin cost savings (direct input cost reduction)[28] | USD 0.9 mn | USD 2.6 mn |
| Incremental gross output from reinvested savings [29] | USD 0.36 – 0.71 mn | USD 1.04 – 2.08 mn |
| **Value Added Generated[30]** | | |
| Direct VA gain from efficiency improvement | USD 0.09 – 0.20 mn/yr | USD 0.26 – 0.58 mn/yr |
| Share of total sector VA (USD 7.7–9.1 mn baseline) | +1 – 4% | +4 – 10% |
| **Direct Employment[31]** | | |
| Direct jobs maintained / improved quality | 3,200 (existing) | 3,200 (existing) |
| New direct jobs created (technical & quality roles) | 20 – 40 | 60 – 100 |
| Average wage premium for new technical roles | +10 – 15% | +15 – 20% |

*Sources: Armstat, industrial statistics for NACE 22.22 – Manufacture of plastic packing goods; UN Comtrade Database (plastics imports HS 3901–3907); Author's calculations and scenario modelling*

A portion of these savings is assumed to be reinvested into additional production activity, equipment upgrades, or expansion of output. Based on the modelling assumptions used in the economic impact

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[28] Author's calculations based on estimated resin savings and average PET resin import prices. Resin price benchmark derived from UN Comtrade trade statistics for Armenia imports of plastics in primary forms (HS 3907 – polyesters including PET).

[29] Estimated assuming that 40–80% of annual material cost savings are reinvested into additional production, equipment upgrading, or operational expansion by participating firms.

[30] Value-added gains estimated using sector financial ratios derived from Armstat industrial statistics for NACE 22.22 – Manufacture of plastic packing goods.

[31] Employment effects are scenario-based estimates derived from sector employment statistics and international benchmarks for technology upgrading in plastics manufacturing. Total sector employment is based on Armstat statistics for plastics manufacturing (NACE 22.2). New jobs primarily reflect additional technical and quality-control positions associated with production optimization and equipment upgrading.

model, the reinvestment rate ranges between 40% and 80% of annual savings, reflecting uncertainty regarding firm behaviour and market conditions.

Incremental gross output generated by reinvested savings is therefore calculated as:

**Incremental output = Resin savings × Reinvestment rate**

Under these assumptions, incremental gross output generated by reinvestment ranges from:

- **USD 0.36–0.71 million** annually in the Moderate Scenario
- **USD 1.04–2.08 million** annually in the Advanced Scenario

To estimate the domestic economic contribution of this additional activity, a sector-specific value-added ratio derived from Armenian industrial statistics is applied. Enterprise data for NACE 22.22.0 indicate a value-added share of roughly 24–25% of gross output, reflecting the material-intensive nature of plastics manufacturing. For modelling purposes, the value-added ratio is set at 25% in the Moderate Scenario and 28% in the Advanced Scenario, allowing for modest efficiency gains associated with technological upgrading.

Applying these ratios results in direct value-added gains of approximately USD 0.09–0.20 million annually in the Moderate Scenario and USD 0.26–0.58 million annually in the Advanced Scenario.

Relative to the estimated baseline sector value added of USD 7.7–9.1 million, this represents an increase of approximately 1–4% in the Moderate Scenario and 4–10% in the Advanced Scenario.

Because lightweighting is primarily a process efficiency and technology upgrade, its direct employment effects are expected to be relatively limited compared with labour-intensive industrial expansion. However, the program may generate new technical and quality-control positions, including roles for process engineers, production technicians, and quality assurance specialists.

The modelling therefore assumes 20–40 new direct jobs in the Moderate Scenario and 60–100 in the Advanced Scenario, alongside improvements in job quality and wages for technical positions.

## 2.6 Indirect and Induced Effects

In addition to the direct firm-level benefits described in the previous section, the lightweighting program is expected to generate broader economic spillover effects through supply-chain linkages and household consumption.

Multiplier analysis captures these wider impacts through two channels:

- Indirect effects, which arise when firms purchase goods and services from domestic suppliers such as transport companies, equipment maintenance providers, engineering services, and professional service firms.
- Induced effects, which occur when employees spend their wages on consumption goods and services, generating additional economic activity in sectors such as retail, food services, housing, and transport.

Because Armenia does not publish a detailed national input–output multiplier matrix by sector, the multipliers applied in this analysis are derived from international input–output datasets and adjusted to reflect Armenia's structural characteristics.

In particular, Armenia's plastics manufacturing sector is highly import-dependent, with nearly all primary polymer resins imported from abroad. As a result, domestic upstream supply linkages are relatively limited. To avoid overstating the economic impact, conservative multiplier values are therefore applied.

Based on international benchmarks for manufacturing sectors in small open economies, the model assumes the following multiplier ranges:

- Output multiplier: 1.20–1.35
- Employment multiplier: 1.10–1.30

These values are broadly consistent with multiplier estimates reported in the OECD Input–Output Database and the World Input–Output Database (WIOD) for manufacturing sectors in economies with relatively high import shares.

The total economic effects are estimated using the following relationships:

**Total output effect = Direct output × Output multiplier**

**Total employment = Direct employment × Employment multiplier**

Under these assumptions, each additional dollar of economic activity generated by resin savings and reinvestment produces an additional USD 0.20–0.35 of indirect and induced economic activity in the wider economy.

The resulting multiplier-adjusted economic impacts are summarized in the following Table.

**Table 16. Multiplier Effects of the PET Bottle Lightweighting Program**

| Multiplier Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Output multiplier (plastics manufacturing, Armenia) | 1.20 – 1.35 | 1.20 – 1.35 |
| Employment multiplier (total/direct) | 1.10 – 1.30 | 1.10 – 1.30 |

|  |  |  |
|---|---|---|
| **Total Output Effect (direct + indirect)** |  |  |
| Total gross output effect | USD 0.43– 0.96 mn/yr | USD 1.25 – 2.81 mn/yr |
| Total value added effect | USD 0.11 – 0.27 mn/yr | USD 0.31 – 0.79 mn/yr |
| **Total Employment Effect** |  |  |
| Direct new jobs created | 20 – 40 | 60 – 100 |
| Indirect & induced jobs (multiplier applied) | 2 – 12 | 6 – 30 |
| Total jobs (direct + indirect) | **22 – 52** | **66 – 130** |

*Sources: OECD Inter-Country Input–Output Database; Armstat; Author's calculations*

Multiplier effects for lightweighting programs are typically more modest than those associated with large-scale industrial investment projects, such as new manufacturing plants. This reflects the fact that the primary economic mechanism of lightweighting is efficiency improvement and import substitution, rather than a large expansion of production capacity.

Nevertheless, the program is expected to generate measurable indirect demand for services such as machinery maintenance, engineering support, logistics, transport, and professional services. These supply-chain linkages, together with additional household consumption generated by employment income, contribute to the broader economic spillovers captured in the multiplier analysis.

### *2.7 Trade and Resource Effects*

The trade and resource effects of the PET bottle lightweighting program represent one of its most significant and directly measurable economic benefits. Because Armenia imports nearly all polymer raw materials used in plastics manufacturing, any reduction in resin consumption per unit of output translates directly into lower import demand. In economic terms, this represents a form of import substitution, where efficiency gains within domestic production reduce reliance on imported raw materials.

Armenia's plastics manufacturing sector is structurally dependent on imported polymer resins such as polyethylene terephthalate (PET), polyethylene (PE), and polypropylene (PP). According to Armenia's external trade statistics, imports of primary plastic materials (HS codes 3901–3907) reached approximately USD 66 million in 2024, reflecting the absence of domestic polymer production and the reliance of local manufacturers on foreign inputs.

Under the modelling assumptions presented earlier, the lightweighting program would reduce polymer consumption by approximately 810 tonnes annually in the Moderate Scenario and about 2,360 tonnes annually in the Advanced Scenario. At an average resin import price of approximately USD 1,100 per tonne, these reductions correspond to annual import savings of approximately USD 0.9 million and USD 2.6 million, respectively.

The resulting trade and resource impacts are summarized in the Table.

**Table 17. Trade and Resource Effects of the PET Bottle Lightweighting Program**

| Trade & Resource Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| **Import Substitution** | | |
| Resin import savings (direct) | USD 0.9 mn/yr | USD 2.6 mn/yr |
| As share of total plastics raw material imports (USD 66 mn, 2024) | ~1.3% | ~4.0% |
| AMD equivalent (at AMD 387/USD) | AMD 343 mn/yr | AMD 1.00 bn/yr |
| **Raw Material Savings** | | |
| PET/PE resin saved per year | ~810 tonnes | ~2,360 tonnes |
| Cumulative 10-year resin savings | ~8,100 tonnes | ~23,600 tonnes |
| **Waste & Disposal Cost Reduction** | | |
| Plastic waste generation avoided (est.) | ~810 tonnes/yr | ~2,360 tonnes/yr |
| Municipal waste cost savings (est. USD 20–30/tonne avoided) | USD 16,000 – 24,000/yr | USD 47,000 – 71,000/yr |
| **Export Opportunities** | | |
| Export premium from lighter/eco-compliant packaging | Limited near-term; potential +USD 0.2–0.5 mn in 3–5 yrs | Moderate; potential +USD 0.8–1.5 mn in 3–5 yrs |

| | | |
|---|---|---|
| Alignment with EU eco-design requirements (future export markets) | Partial compliance | Substantial compliance |

*Source: Author’s calculations based on Armstat database, and UN Comtrade Database*

Expressed relative to Armenia’s total plastics raw material imports, the estimated resin savings represent approximately 1.3% of annual polymer imports in the Moderate Scenario and about 4.0% in the Advanced Scenario. While these shares are smaller than those that might be achieved through large-scale recycling infrastructure, they nevertheless represent a meaningful efficiency improvement achieved without requiring major changes in waste collection systems or consumer behaviour.

In addition to reducing import demand, lightweighting also generates waste avoidance benefits. Each tonne of polymer resin not used in production translates into a corresponding reduction in plastic packaging entering the consumption and waste streams. This reduces the burden on municipal waste management systems and lowers landfill disposal costs.

Municipal waste disposal costs in Armenia are estimated at approximately USD 20–30 per tonne of waste disposed, based on regional benchmarks for landfill-based waste management systems in Eastern Europe and the South Caucasus. Applying these estimates to the reduction in plastic waste generated through lightweighting yields annual municipal waste management cost savings of approximately USD 16,000–24,000 in the Moderate Scenario and USD 47,000–71,000 in the Advanced Scenario.

These estimates likely understate the full social value of waste reduction, as they do not capture environmental externalities associated with plastic leakage into soils and waterways or long-term landfill management costs.

In the medium term, lightweighting may also support export competitiveness. As Armenian packaging manufacturers adopt more efficient production processes and reduce material intensity, their products become more aligned with EU packaging and eco-design standards, which increasingly emphasize material efficiency and waste reduction. Although short-term export impacts are likely to remain modest, improved compliance with international packaging standards could open opportunities in regional markets over a three- to five-year horizon, particularly for suppliers of beverage and food packaging.

### *2.8 Fiscal and Distributional Effects*

The fiscal effects of the PET bottle lightweighting program arise through three primary channels:

- Value Added Tax (VAT) generated from incremental domestic output
- Income tax contributions associated with new employment created by the program
- Corporate profit tax applied to incremental value added generated through efficiency improvements

These estimates are presented as indicative approximations rather than precise fiscal forecasts. Firms may allocate cost savings differently depending on market conditions—for example by reinvesting in production, increasing wages, reducing prices, or retaining profits. In addition, fiscal outcomes depend on whether incremental production is sold domestically (subject to VAT) or exported (VAT-exempt).

The tax rates applied in the modelling correspond to the main rates defined in Armenia's Tax Code:

- VAT: 20%
- Corporate profit tax: 18%
- Income tax: 20% (flat rate)

Fiscal revenues are estimated using the incremental economic effects calculated in previous sections.

In particular:

- VAT revenues are calculated by applying the VAT rate to incremental domestic output generated through reinvestment.
- Corporate profit tax is approximated by applying the statutory tax rate to the profit component of incremental value added.
- Income tax revenues are estimated from wages associated with new direct employment created under the program.

The resulting fiscal impacts are summarized in the following Table.

**Table 18. Fiscal Effects of the PET Bottle Lightweighting Program**

| Fiscal Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| VAT on incremental gross output (20%) | USD 0.09 – 0.19 mn/yr | USD 0.25 – 0.56 mn/yr |
| Income tax on new direct jobs | USD 0.02 – 0.04 mn/yr | USD 0.07 – 0.12 mn/yr |
| Corporate profit tax | USD 0.02 – 0.04 mn/yr | USD 0.05 – 0.10 mn/yr |
| **Total Estimated Tax Revenue** | **USD 0.13 – 0.27 mn/yr** | **USD 0.37 – 0.78 mn/yr** |

*Source: Armstat, Enterprise Statistics Database, Form 1-TG (Annual), sector C22.2 – Manufacture of plastic products, 2024*

Under the Moderate Scenario, annual tax revenues generated by the program are estimated at approximately USD 0.13–0.27 million. Under the Advanced Scenario, fiscal returns could reach USD 0.37–0.78 million annually.

Over a 10-year program horizon, cumulative fiscal returns could therefore reach approximately USD 1.3–2.7 million under the Moderate Scenario and USD 3.7–7.8 million under the Advanced Scenario.

Although these figures represent only a portion of the program’s total economic benefits, they nevertheless indicate that the intervention can generate measurable fiscal returns for the public sector, particularly when combined with broader economic and environmental benefits.

### 2.8.1 Distributional Effects: SME Participation

The lightweighting program is designed primarily to support small and medium-sized enterprises (SMEs), which represent the majority of Armenia’s plastics manufacturing sector. Sector mapping conducted in the plastics value-chain analysis indicates that Armenia has approximately 70–80 firms engaged in plastics manufacturing and packaging conversion activities, most of which operate at small or medium scale.

Larger manufacturers—such as Hytex, Narplast, and Oval Plastic—have already implemented certain efficiency improvements independently. The primary additionality of the program therefore lies in enabling smaller producers to adopt lightweighting technologies that require up-front investments in mold redesign, equipment adjustments, and process engineering. At the same time, major beverage and bottled-water producers—including Coca-Cola HBC Armenia, Jermuk Group, Dilijan Jur LLC and other beverage companies operating integrated PET bottling lines—play an important role in determining bottle specifications and packaging formats used in the market. Their participation is therefore important for ensuring that lightweight bottle designs are adopted consistently across beverage product lines.

Under the modelling assumptions, SMEs are expected to represent approximately 60–75% of participating firms, with participation supported through technical assistance, training programs, and co-financing mechanisms.

### 2.8.2 Distributional Effects: Gender and Youth Employment

Employment in Armenia’s plastics manufacturing sector remains predominantly male, reflecting broader patterns in light industrial production. However, the new technical roles associated with lightweighting—such as process engineers, quality assurance technicians, and packaging design specialists—are occupations where female participation has been increasing.

Training components embedded in the program could therefore explicitly target:

- female engineering graduates
- young professionals from technical colleges and vocational institutes

Such measures would improve the gender and age diversity of employment in the sector while strengthening Armenia’s technical workforce. Although precise quantitative estimates are not available at this stage, these indicators could be incorporated into program monitoring and evaluation frameworks.

### *2.9 Cost–Benefit Snapshot*

This section consolidates the main quantitative results of the economic impact assessment into a comparative overview of the two program scenarios

The benefit–cost ratio (BCR) is calculated over a 10-year program horizon, comparing the present value of total economic benefits with the present value of total program costs.

Economic benefits considered in the analysis include:

- Direct value-added gains generated through efficiency improvements and reinvestment
- Savings in polymer resin imports
- Avoided municipal waste management costs
- Fiscal revenues generated through additional economic activity

Program costs include:

- Initial capital investments (CAPEX) required for mold redesign, equipment upgrades, and engineering improvements
- Recurring operational expenditures (OPEX) associated with training, technical assistance, and maintenance.

A 6% real discount rate is applied to estimate the present value of future costs and benefits. This rate is broadly consistent with public investment appraisal practices commonly used in industrial policy and infrastructure evaluation in Eastern Europe and other transition economies.

Two additional indicators are used to assess the economic attractiveness of the program:

- Payback period, representing the time required for cumulative benefits to offset the initial investment.
- Benefit–cost ratio, calculated as the ratio of discounted benefits to discounted program costs.

The relatively short payback periods observed in the model reflect the program's core economic mechanism: immediate and recurring cost savings from reduced polymer consumption. Unlike demand-side circular economy policies—such as deposit-return systems or extended producer responsibility schemes—lightweighting generates direct financial benefits for firms from the first year of implementation. This makes the intervention financially attractive even in the absence of strong regulatory pressure.

Under the Moderate Scenario, the program generates smaller but still meaningful efficiency gains while requiring lower upfront investment and posing fewer implementation risks. The Advanced Scenario produces larger aggregate benefits through wider adoption of lightweighting technologies across the sector, but requires higher investment and stronger coordination among industry stakeholders.

The resulting cost–benefit indicators are summarized in the following Table.

**Table 19. Cost–Benefit Summary of the PET Bottle Lightweighting Program**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Total Investment (CAPEX) | USD 1.2 – 4.0 mn | USD 6.0 – 16.0 mn |

| | | |
|---|---|---|
| Annual OPEX | USD 0.25 – 0.45 mn | USD 0.9 – 1.5 mn |
| Annual Value Added Gain | USD 0.09 – 0.20 mn | USD 0.29 – 0.58 mn |
| Annual Resin Cost Savings | USD 0.9 mn | USD 2.6 mn |
| Total Jobs Created (direct + indirect) | 22 – 52 | 66 – 130 |
| Annual Import Reduction | USD 0.9 mn | USD 2.6 mn |
| Annual Fiscal Revenue (tax proxies) | USD 0.13 – 0.27 mn | USD 0.37 – 0.78 mn |
| **Approximate Payback Period** | **1 – 4 years** | **2 – 6 years** |
| **Benefit-Cost Ratio (10-year horizon)** | **2.0 – 3.0x** | **2.2 – 3.5x** |

*Source: Author's calculations based on UN Comtrade, SRC customs statistics, Armstat enterprise statistics (Form 1-TG, sector C22.2), RA Tax Code*

*Note: Industrial statistics used in this chapter are reported in thousand drams. Sector-specific financial ratios for plastic packing goods are derived from NACE 22.22.0 using revenue, inventory adjustments, and total acquisitions as reported in the Armenian enterprise statistics database*

## *2.10 Risks and Trade-offs*

While the economic case for the PET bottle lightweighting program is strong, several risks and trade-offs must be considered to ensure effective implementation. These risks relate primarily to financing constraints, technical capacity within the industry, and potential market dynamics affecting domestic producers.

The risk assessment presented in the table summarizes the main implementation risks identified through value-chain analysis and stakeholder consultations, together with potential mitigation measures.

**Table 20. Key Risks and Mitigation Measures for the PET Bottle Lightweighting Program**

| Risk | Severity | Description | Mitigation |
|---|---|---|---|
| **Capital intensity & financing access** | Medium–High | SMEs may face difficulties financing upfront investments in mold redesign, engineering services, and quality testing equipment. Even relatively modest investments can represent a significant share of annual turnover for small producers. | Subsidized loans, co-financing schemes with development partners, phased grant programs targeting SMEs. |
| **Import competition risk** | Medium | Imported plastic packaging products may compete with domestically produced lightweighted packaging if foreign suppliers benefit from lower production costs or economies of scale. | Alignment with Extended Producer Responsibility (EPR) eco-modulation mechanisms that favour lighter packaging; gradual strengthening of packaging standards. |
| **Skills and technical capacity gap** | Medium | Armenia has limited domestic expertise in polymer engineering, lightweight bottle design, and advanced quality testing procedures. | Technical assistance programs, industry training initiatives, and partnerships with international packaging institutes. |
| **Transition costs for smaller firms** | Medium | Smaller manufacturers may lack sufficient production volumes to recover investment costs quickly, potentially increasing market concentration if upgrades are adopted mainly by larger firms. | Gradual program rollout, SME-specific support instruments, and shared testing or design facilities. |
| **Regulatory compliance burden** | Low–Medium | Implementation of eco-design standards and reporting requirements could increase administrative costs for firms, particularly SMEs. | Simplified reporting frameworks aligned with existing waste management and EPR reporting systems. |
| **Consumer perception risk** | Low | Lighter bottles may initially be perceived as lower-quality packaging by some consumers or retailers if weight reduction is not clearly communicated. | Awareness campaigns and certification labels highlighting environmentally optimized packaging. |

| | | | |
|---|---|---|---|
| **Volatility in polymer prices** | Low–Medium | The economic value of resin savings depends partly on global polymer prices. Lower resin prices reduce the monetary value of savings from lightweighting. | Long-term procurement strategies and diversification of suppliers; volumetric resource savings remain even during price declines. |

*Source: Author’s analysis*

A key legal limitation is that Armenia operates within the EAEU technical regulation framework for packaging. The core EAEU rule, TR TS 005/2011 “On Safety of Packaging,” establishes unified mandatory safety requirements for packaging placed on the Union market, but it does not currently set explicit maximum bottle-weight standards for PET beverage bottles. As a result, while Armenia could introduce recommended weight benchmarks or eco-design thresholds for beverage bottles, any measure that directly restricts the import or circulation of bottles above a specified weight limit would require careful legal review to ensure compatibility with EAEU technical regulations. This creates an implementation constraint for national policy.

Overall, the risk profile of the PET Bottle Lightweighting Upgrade Program can be characterized as low to moderate.

The most significant implementation challenges relate to financing constraints faced by SMEs and technical capacity gaps within the domestic plastics industry. However, these risks are manageable through targeted policy instruments such as concessional financing, technical assistance programs, and partnerships with international packaging and engineering organizations.

A key risk mitigation strategy is embedding the program within a broader regulatory framework for packaging and waste management reform. In particular, linking lightweighting incentives to eco-modulated EPR fee structures—where producers using lighter or more recyclable packaging pay lower contributions—would create sustained market incentives that extend beyond the initial investment support phase.

Another factor worth monitoring is volatility in global polymer markets, which are closely linked to oil and gas prices. Although lower resin prices reduce the monetary value of material savings, the underlying resource efficiency benefits remain unchanged, and material savings continue to generate cost reductions for manufacturers.

## *2.11 Summary Positioning and Policy Implications*

The analysis presented in this chapter demonstrates that a targeted PET beverage bottle lightweighting program can generate measurable economic, environmental, and fiscal benefits for Armenia's plastics packaging sector. The modelling results show that even modest reductions in bottle weight can produce meaningful impacts because the sector remains strongly dependent on imported polymer raw materials and because PET bottle packaging is used at scale across the beverage and bottled-water market.

Under the Moderate Scenario, the program would reduce polymer consumption by approximately 810 tonnes annually, generating direct material cost savings of about USD 0.9 million per year. Under the Advanced Scenario, polymer savings could reach approximately 2,360 tonnes annually, corresponding to USD 2.6 million in annual import savings. These efficiency gains translate into wider economic benefits through reinvestment, supply-chain spillovers, and additional economic activity. Direct value-added gains are estimated at USD 0.09–0.20 million annually in the Moderate Scenario and USD 0.26–0.58 million in the Advanced Scenario, while total employment effects range from 22 to 52 jobs and 66 to 130 jobs, respectively, once multiplier effects are taken into account.

The program also produces clear trade and resource benefits. By reducing demand for imported polymer resin, lightweighting contributes to import substitution, lowers reliance on foreign raw materials, and improves the cost competitiveness of domestic packaging and beverage producers. Over a ten-year horizon, cumulative polymer savings could reach approximately 8,100 tonnes under the Moderate Scenario and 23,600 tonnes under the Advanced Scenario, reducing both material imports and plastic waste generation. From a fiscal perspective, the intervention is also expected to generate additional public revenues, with estimated annual fiscal returns of USD 0.13–0.27 million in the Moderate Scenario and USD 0.37–0.78 million in the Advanced Scenario.

A central finding of the assessment is that the key actors are not only plastic packaging producers, but also the beverage and bottled-water companies that place products on the Armenian market. In many cases, these firms operate integrated bottling lines or directly determine bottle specifications, procurement requirements, and filling-line compatibility. This means that large-scale adoption of lightweighting depends not only on the technical capacity of packaging manufacturers, but also on the willingness of beverage producers to redesign bottle formats and adopt lighter packaging across their product portfolios. For that reason, the intervention should be understood as a market-wide packaging transition involving both bottle producers and beverage fillers.

The cost–benefit analysis indicates that the intervention is economically attractive. With relatively modest capital investment requirements and immediate material cost savings, the estimated payback period ranges from approximately one to four years under the Moderate Scenario and two to six years under the Advanced Scenario, while the benefit–cost ratio reaches 2.0–3.0 and 2.2–3.5, respectively, over a ten-year horizon. Compared with more complex circular economy interventions, such as deposit-return systems or comprehensive extended producer responsibility reforms, lightweighting represents a technically feasible and institutionally manageable policy instrument. It primarily requires technological upgrading, bottle redesign, and engineering support rather than the creation of extensive new collection or enforcement infrastructure.

To achieve broad uptake, lightweighting should be supported by government-led mandatory market-wide measures rather than relying solely on voluntary firm action. These may include phased eco-design standards, differentiated EPR fee structures that reward lighter packaging formats, mandatory reporting and disclosure requirements for packaging efficiency, and—where legally feasible—minimum packaging-efficiency criteria for bottles placed on the market. Such measures would ensure that all producers progressively transition toward lower-weight bottle formats, preventing free-riding and avoiding a situation in which only a limited number of early-moving firms adopt lightweighting technologies.

A further policy consideration is that Armenia operates within the EAEU technical regulation framework for packaging. This creates a legal limitation for any national measure that would directly restrict the import or circulation of bottles above a specified weight threshold. As a result, future weight benchmarks or packaging-efficiency thresholds would need to be designed in a manner consistent with EAEU technical regulations. This does not prevent Armenia from promoting lightweighting, but it does suggest that the most feasible near-term pathway is to combine eco-design incentives, EPR fee modulation, phased standards, and industry transition measures, while ensuring legal compatibility within the Union framework.

Consumer behaviour is another important factor. Lighter PET bottles may sometimes be perceived as weaker or lower quality, especially where rigidity is associated with safety or premium positioning. This means that lightweighting should be introduced gradually and accompanied by communication measures that explain the environmental and economic benefits of lighter packaging while maintaining confidence in product safety and performance.

Overall, the results suggest that a PET Beverage Bottle Lightweighting Upgrade Program could serve as a practical and economically justified starting point for improving resource efficiency in Armenia’s plastics sector. It offers immediate savings in imported materials, measurable fiscal and employment benefits, and lower plastic waste generation, while also complementing future downstream circular economy measures such as EPR, deposit-return systems, and recycling infrastructure. In this sense, bottle lightweighting can be viewed not as a standalone solution, but as a realistic first-stage intervention in Armenia’s broader transition toward a more circular plastics economy.

# 3. METALS SECTOR

## *3.1 Methodology*

### 3.1.1 Data Sources

National Accounts (Armstat SNA tables): Sectoral value-added ratios; GDP deflators; output data for manufacturing and waste management sub-sectors.[32]

Business Registry and Enterprise Statistics (Armstat): Employment-to-output ratios in scrap processing; average wage benchmarks by sector. Reference: average private-sector monthly salary AMD 327,604 (2025); average manufacturing salary approximately AMD 270,000–300,000/month.[33]

Customs and Trade Data (State Revenue Committee, SRC):[34] Passenger car import volumes under HS 8703 (2016–2025);[35] ferrous and non-ferrous scrap trade flows; import value data for primary metals.[36]

Government Decree N 994-N (2023) and extension resolutions: Scrap export ban regulatory framework, Ministry of Economy domestic scrap consumption targets (250,000 t/year planned absorption).[37]

Exchange rate reference: AMD 387/USD 1, used as a reference rate consistent with early-to-mid 2025 market levels per Armstat/ARKA. The full-year 2025 annual average exchange rate was approximately AMD 387/USD 1, with the observed range AMD 379–401 throughout 2025.[38]

Commodity price references: Ferrous scrap global export benchmark ~USD 355/tonne (HMS 1/2, Turkey CFR, early 2025)[39]. Armenian domestic gate price at processing plants: AMD 55,000–65,000/tonne (USD 142–168/tonne, midpoint ~USD 155/tonne), based on industry consultation data. For chassis/frame components, additional cost factors apply: these are large in size and therefore inconvenient and costly to transport, which can reduce the effective net price received by vehicle owners. Aluminum scrap ~USD 870/tonne (domestic estimate; global secondary aluminum benchmark ~USD 2,015–2,400/tonne in 2025, adjusted approximately 57% downward for domestic market conditions, consistent with the same discount ratio applied to ferrous scrap);[40] copper wiring scrap ~USD 4,500/tonne.[41] Catalytic converter PGM value: USD 60–70 per unit average.[42] Primary aluminum import reference price: ~USD 2,550/tonne (consistent with 2025 LME data). Domestic aluminum scrap price estimated at USD 870/tonne, implying a net substitution value of USD 1,680/tonne.[43][44]

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[32] Armstat, National Accounts (SNA tables): https://armstat.am/en/?nid=82&id=2773

[33] Armstat, Statistical Yearbook 2024: https://armstat.am/en/?nid=586&year=2024

[34] State Revenue Committee of Armenia: https://www.src.am/en

[35] Armstat, Foreign Trade Database (HS codes): https://armstat.am/en/?nid=160

[36] Armstat, External Trade Time Series: https://armstat.am/en/?id=10003&nid=12

[37] Government Decree N 994-N, June 2023 — background and extension history: https://finport.am/full_news.php?id=49507&lang=3

[38] Central Bank of Armenia, exchange rate statistics: https://www.cba.am/en/sitepages/exchangearchive.aspx

[39] Global ferrous scrap prices are commonly benchmarked against HMS 1&2 (80:20) scrap imported by Turkish steel mills on a CFR (Cost and Freight) basis, the most widely traded scrap contract in international markets.

[40] IMARC Group, Aluminium Scrap Price Trend and Index, 2025: https://www.imarcgroup.com/aluminium-scrap-pricing-report

[41] ScrapMonster, #1 Insulated Copper Wire 85% Recovery scrap price index, 2025: https://www.scrapmonster.com/scrap-metal-prices/copper-scrap/1-insulated-copper-wire-85-recovery/21

[42] ScrapMonster, Catalytic Converter Scrap Prices: https://www.scrapmonster.com/catalytic-converter-scrap-price

[43] GMK Center, global scrap price data, February 2025: https://gmk.center/en/posts/global-scrap-prices-recovered-by-1-5-2-since-the-beginning-of-the-year/

[44] London Metal Exchange, LME Aluminium cash price: https://www.lme.com/Metals/Non-ferrous/LME-Aluminium

Net steel per ELV: 754 kg;[45] exterior waste steel sheet (WSS): 62.4 kg; metal recovery rate: ~82%.[46] adjusted for Armenia's older, steel-heavy vehicle fleet.[47]

### 3.1.2 Modelling Framework

**Step 1 — Physical Definition of the Intervention:** The intervention targets passenger vehicles (HS 8703) reaching end-of-life, linked to mandatory deregistration. Physical parameters: number of ELVs entering formal collection per year (units), material composition per vehicle, and annual tonnage recovered. Two scenarios are modelled.

**Step 2 — Investment and Operating Costs:** CAPEX is minimal in the Armenian context: existing metallurgical plants already process vehicle scrap and no new processing or dismantling infrastructure is required. The only capital outlay is a lightweight IT registry for VIN-linked deregistration tracking. OPEX consists of transport costs for collecting vehicles located outside Yerevan or distant from existing scrap aggregation points, and administrative/registry operation costs. No scrappage premium payments from the state are required under the proposed coercive mechanism: recyclers pay the vehicle owner market rate directly, and progressive property tax and local authority enforcement drive vehicle surrender. Administrative coordination costs are modest. All costs are calibrated to Armenian conditions.

**Step 3 — Direct Economic Effects:** Gross output = Volume (tonnes) × Domestic price (USD/tonne), applied separately to each material fraction. Value added = Output × Sectoral VA ratio (40%, calibrated to Armstat manufacturing sub-sector data). Direct employment estimated via output-per-worker coefficient, with labor costs validated against Armenian average industrial sector wages. CAPEX reflects only the IT registry investment, as Armenia’s existing scrap collection network and metallurgical processing capacity absorb the ELV stream without new equipment or infrastructure.[48]

**Step 4 — Indirect and Induced Effects:** In the absence of an Armenian input-output table suitable for ELV-specific modelling, proxy multiplier coefficients are used for scenario analysis: output multiplier 1.30, employment multiplier 1.20. These are adjusted downward from regional benchmarks to reflect import dependency and limited domestic supplier depth.[49][50]

**Step 5 — Trade and Resource Effects:** Import substitution estimated as volume recovered × (primary import reference price − domestic scrap price), representing the net cost saving to domestic buyers from using recovered domestic material instead of purchasing primary imported inputs.

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[45] Assessment of end-of-life vehicle recycling: Remanufacturing waste sheet steel into mesh shee; Abdullah, Z.T. (2021) - https://pmc.ncbi.nlm.nih.gov/articles/PMC8651122/

[46] European Commission, Impact Assessment SWD(2023)256 (ATF/CoD framework, unknown whereabouts analysis): https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52023SC0256

[47] Oeko-Institut / European Commission, ELV Implementation Assessment: https://op.europa.eu/en/publication-detail/-/publication/1ca32beb-316a-11e8-b5fe-01aa75ed71a1/language-en

[48] Armstat data for 2022, as reported in manufacturing sector analysis, shows Armenia's total manufacturing sector value added at USD 2.28 billion on gross output of USD 5.13 billion — an implied VA/output ratio of 44.4%; the 40% coefficient applied in this model is a conservative rounding of this published figure. - https://armstat.am/en/?nid=82&id=2527 ; https://evnreport.com/magazine-issues/armenias-manufacturing-industry-an-overview/

[49] UNIDO Industrial Development Report 2024 documents that manufacturing employment multipliers typically exceed 2.0 for broader manufacturing sectors; the 1.20 coefficient applied here reflects a conservative downward adjustment appropriate for a simple scrap collection activity with limited backward linkages. - https://www.unido.org/publications/industrial-development-report-series

[50] IMF (2018), 'Opening Up in the Caucasus and Central Asia', documents high import dependency and limited domestic value chain depth across the region, justifying a downward adjustment from standard manufacturing output multipliers of 1.5–1.8 to the 1.30 coefficient applied here. - https://www.imf.org/-/media/Files/Publications/DP/2018/45910mcd1807-dp-opening-ccar.ashx

### 3.1.3 Assumptions and Limitations

**No national I-O table:** Multiplier proxies introduce uncertainty; sensitivity ranges are stated.

**ELV stock and flow:** No official Armenian dataset currently identifies immobilized or end-of-life vehicles as a separate statistical category. Estimates of approximately 10,000 immobilized vehicles and 14,000–17,000 annual ELV flows are consultation-based working assumptions.

**Material composition:** Reflects older, steel-heavy vehicle cohort (pre-2020 imports). According to report (Abdullah; 2021), a typical passenger ELV has a net steel content of 754 kg and an average total weight of approximately 1 tonne. Aluminum content per vehicle is conservatively set at 50 kg, reflecting the lower aluminum intensity of older Armenian-fleet vehicles relative to newer European models.

**Domestic scrap prices below global benchmarks:** Ferrous scrap modelled at AMD 55,000–65,000/tonne (~USD 155/tonne average), based on actual prices paid by domestic processing plants in recent years. This represents the price available to vehicle owners after accounting for transport and dismantling costs.[51]

**Payback period:** Since Armenia already has functioning collection and processing infrastructure, CAPEX is limited to the IT registry only (USD 25,000–40,000). Under the coercive mechanism replacing scrappage premiums (progressive property tax, local authority enforcement, recycler market payments), OPEX is limited to transport and administration. Payback on this minimal investment is under 0.1 years under both scenarios. The intervention is self-financing from the outset, as the recycler pays market price for scrap directly to the vehicle owner.

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[51] *Export restrictions on raw materials create a wedge between domestic and international prices by eliminating sellers' export arbitrage option; the 35% discount applied to Armenian domestic ferrous scrap prices relative to the HMS 1/2 Turkey CFR benchmark reflects this mechanism— consistent with OECD analysis of export restriction price effects.* https://www.oecd.org/content/dam/oecd/en/publications/reports/2010/11/the-economic-impact-of-export-restrictions-on-raw-materials_g1g11e10/9789264096448-en.pdf

## *3.2 Sector Overview*

Armenia’s metals sector is structurally scrap-dependent: the country has no significant iron ore reserves, and domestic steel and aluminum production relies entirely on scrap feedstock. The sector’s circular architecture is functioning and well-established — a network of licensed scrap collectors, intermediate aggregators, and metallurgical enterprises already processes vehicle scrap effectively. The structural gap is not one of capacity or technology, but of regulatory mandate: vehicle owners are not required to surrender their vehicles at end of life, leaving a large portion of the potential ELV stream outside formal channels.

Armenia first imposed a temporary scrap metal export ban by Government Decree N 994-N (June 2023) — though export restrictions on scrap metal existed in Armenia prior to this; for example, Government Decision N28 of 14.01.2021. The current restriction has since been extended through subsequent government decisions and remained in force through August 2026, to retain domestic scrap within national borders and support expanded local metallurgical capacity. [52] Policy discussions have referred to a substantial increase in domestic scrap absorption capacity supported by ongoing metallurgical investments of approximately USD 100 million across multiple enterprises.[53][54]

The ELV stream was selected as the priority circular intervention following assessment of four alternatives: e-waste recovery (limited feedstock, low structural bottleneck), tailings valorization (long implementation horizon, high capital intensity), low-carbon metallurgy (strong strategic relevance but dependent on energy infrastructure and export market dynamics), and ELV formalization. The ELV stream is domestically available, institutionally actionable, capital-light relative to alternatives, and directly aligned with the existing scrap retention policy.

### Baseline Circularity Status

- No dedicated ELV legal framework exists. Vehicle deregistration is not linked to proof of disposal or metal recovery.
- No official Armenian dataset currently identifies immobilized or end-of-life vehicles as a separate statistical category. An estimated 10,000 vehicles are assumed to be immobilized in private yards or informal repositories at any given time — a consultation-based working assumption.
- Informal partial dismantling occurs opportunistically: high-value components (catalytic converters, copper wiring, batteries) are stripped by mechanics or traders. Vehicle hulks — representing the largest share of recoverable ferrous scrap — typically remain unretrieved.
- Annual ELV flow is estimated at 14,000–17,000 vehicles.[55] Fewer than 20–25% are believed to enter formal scrap channels.
- Armenia's post-2020 shift toward newer, higher-value vehicle imports implies a medium-term increase in aluminum-rich ELV cohorts, improving non-ferrous recovery value over time.

### Scenario Design

- Moderate Scenario: 5,000 ELVs formalized per year. Partial regulatory enforcement, voluntary incentives. Adoption rate: ~30–35% of estimated annual ELV flow.

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[52] Extension of scrap export ban to August 2026: https://finport.am/full_news.php?id=54534&lang=3

[53] GMK Center, Armenia extends ban on scrap exports: https://gmk.center/en/news/armenia-extends-ban-on-scrap-exports-for-another-6-months/

[54] Latest extension and rebar duty context: https://finport.am/full_news.php?id=54658&lang=3

[55] Data on imports from Armstat and UNComtrade.

- Advanced Scenario: 12,000 ELVs per year. Full mandatory deregistration-linked transfer, comprehensive collection network, Certificate of Destruction (CoD) issued for all processed vehicles. Adoption rate: ~70–80%.[56]

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[56] The adoption rates are benchmarked against early-phase ELV program experience in comparable transition economies, where voluntary incentive schemes typically capture 25–40% of the eligible fleet, while mandatory deregistration-linked systems with active enforcement reach 70–80% once operational. ***European Commission's own Impact Assessment SWD(2023)***

### *3.3 Selected Circular Intervention*

The intervention described below represents a proposed policy design rather than a description of the current Armenian ELV management system. The proposed intervention is the establishment of a formal, regulatory-backed ELV collection and deregistration system with the following components:

#### 3.3.1 Scope and Design

- Regulatory mechanism: Mandatory linkage of vehicle deregistration (Police Road Transport Department) to transfer of the vehicle to a licensed scrap collector or Authorized Treatment Facility (ATF). Certificate of Destruction (CoD) required as precondition for deregistration.[57][58]
- Collection infrastructure: Armenia's existing network of licensed scrap collectors and metallurgical enterprises already handles vehicle scrap. No new collection centers, dismantling equipment, or processing facilities are required. The intervention uses existing capacity, routing formalized ELV flows into channels that already operate.
- Traceability: IT-enabled national ELV registry linking Vehicle Identification Numbers (VINs) to deregistration and material flow records.
- Coercive enforcement mechanism (replacing state-funded scrappage premium): Progressive property tax on aging vehicles (those 20+ years old), applied at increasing rates as a function of vehicle age, making continued ownership of non-operating vehicles financially unsustainable. Simultaneously, local authorities are empowered to: (a) declare unidentified abandoned vehicles as ownerless property; (b) fine owners who park identified vehicles on community land. Police deregistration requires a Certificate of Destruction (CoD) issued by an authorized recycler/processor. Recyclers pay the vehicle owner market rate for scrap directly — no state subsidy is required. This mechanism is simpler, less prone to abuse than certificate-based payment systems, and more durable than premium schemes.[59]
- Processing pathway: ELV hulks transferred to existing domestic metallurgical enterprises (currently operating below target feedstock capacity due to export ban constraints). No new smelting capacity required.

#### 3.3.2 Legal Basis

Required amendments to the Law on Waste Management, the Road Transport Law, and vehicle registration regulations. Institutional anchors: Ministry of Environment, Ministry of Economy, State Revenue Committee, Police Road Transport Department.

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[57] EUR-Lex, End-of-Life Vehicles Directive summary:
https://eur-lex.europa.eu/EN/legal-content/summary/end-of-life-vehicles.html

[58] European Commission, End-of-Life Vehicles policy page:
https://environment.ec.europa.eu/topics/waste-and-recycling/end-life-vehicles_en

[59] Based on approx. transportation cost

### *3.4 Physical and Financial Modelling Assumptions*

All monetary values in USD at reference rate AMD 387/USD 1 (2025 annual average). AMD equivalents provided in parentheses.

### 3.4.1 Material Composition per Vehicle

The following composition is calibrated to Armenia's actual fleet profile: predominantly older, pre-2020 vehicles with higher steel-to-aluminum ratios than the European average. Material weights are grounded in peer-reviewed data (Abdullah; 2021) which establishes a net steel content of 754 kg/ELV for a typical passenger vehicle averaging approximately 1 tonne, of which 62.4 kg constitutes recoverable exterior waste steel sheet (WSS). Total ferrous content in the hulk skeleton is modelled at 630 kg, reflecting the ~82% metal recovery rate documented in that study, adjusted conservatively downward to account for Armenia's older, heavier vehicle cohort and manual dismantling limitations. Aluminum content is set at 50 kg, consistent with the lower aluminum intensity of pre-2020 fleet vehicles. Copper content is set at 18 kg, representing the stripped wiring harness recoverable at the ATF dismantling stage. The catalytic converter is treated separately as a PGM recovery item.

**Table 21. Estimated Recoverable Material Value per End-of-Life Vehicle (ELV)**

| Material Fraction | Weight per Vehicle | Domestic Price | Value per Vehicle |
|---|---|---|---|
| Ferrous scrap (hulk skeleton) | 630 kg | AMD 55,000–65,000/t (USD 142–168/t) | USD 89–106 |
| Aluminum (wheels, engine block, parts) | 50 kg | USD 870/t (AMD 336,690/t) | USD 43.50 |
| Copper wiring harness (stripped) | 18 kg | USD 4,500/t (AMD 1,741,500/t) | USD 81.00 |
| Catalytic converter (PGM recovery) | ~3 g PGMs | Blended PGM market rate | USD 63–67 |
| Total recoverable per vehicle | ~700 kg | — | ~USD 288 |

*Source: Armstat statistics; SRC scrap trade data; commodity price benchmarks; industry consultation data; Author's calculations*

*Note on ferrous scrap price: The global export reference price for HMS 1/2 scrap was approximately USD 355/tonne (Turkey CFR, early 2025). The Armenian domestic gate price at processing plants is AMD 55,000–65,000/tonne (USD 142–168/tonne, midpoint ~USD 155/tonne), based on industry consultation data from processing facilities. Prices at intermediary buyers are lower than at processing plants. The effective price received by the vehicle owner is therefore lower still, as it reflects the intermediary margin and transportation costs — particularly significant for large chassis/frame components which are inconvenient and expensive to transport. This domestic price level reflects the price suppression effect of the export ban, Armenia's landlocked geography, and the domestic monopsony structure of the scrap buying market.*[60]

### 3.4.2 Scenario Assumptions

**Table 22. Key Modelling Parameters for the ELV Formalization Program**

| Parameter | Moderate | Advanced |
|---|---|---|
| **ELVs formalized per year (units)** | 5,000 | 12,000 |

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[60] Average estimate based on assumptions from:
https://gmk.center/en/posts/the-polish-scrap-metal-market-myths-and-reality/
https://www.steelorbis.com/steel-news/latest-news/kazakhstan-to-ban-scrap-exports-from-may-6-1242410.htm

| Parameter | Moderate | Advanced |
|---|---|---|
| **Total scrap recovered (tonnes/year)** | ~3,490 | ~8,376 |
| — Ferrous (tonnes) | 3,150 | 7,560 |
| — Aluminum (tonnes) | 250 | 600 |
| — Copper wiring (tonnes) | 90 | 216 |
| Catalytic converters processed (units) | 5,000 | 12,000 |
| Scrappage premium per vehicle | N/A — progressive property tax | N/A — progressive property tax |
| CAPEX — IT registry and VIN traceability (one-time) | AMD 9,675,000 (USD 25,000) | AMD 15,480,000 (USD 40,000) |
| CAPEX — initial premium pool seed funding (public co-finance, years 1–2) | N/A — removed | N/A — removed |
| **Total CAPEX (USD)** | **~25,000** | **~40,000** |
| **Annual OPEX (USD/year)** | ~90,000 | ~180,000 |
| — Scrappage premiums paid to vehicle owners | N/A — coercive mechanism | N/A — coercive mechanism |
| — Transport and logistics | USD 60,000 | USD 130,000 |
| — Administration, coordination and registry operation | USD 30,000 | USD 50,000 |

*Source: Armstat statistics; SRC customs data (HS 8703 and scrap trade); Government Decree No. 994-N (2023); commodity price benchmarks; Author's calculations*

## *3.5 Direct Economic Effects*

### 3.5.1 Gross Output

**Table 23. Estimated Annual Gross Output from ELV Material Recovery**

| Material Fraction | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Ferrous scrap (3,150 t / 7,560 t @ USD 155/t avg) | 488,250 | 1,171,800 |
| Aluminum (250 t / 600 t @ USD 870/t) | 217,500 | 522,000 |
| Copper wiring (90 t / 216 t @ USD 4,500/t) | 405,000 | 972,000 |
| Catalytic converter PGMs (5,000/12,000 units @ USD66 avg) | 330,000 | 792,000 |
| **Total Gross Output** | ~1,441,000 | ~3,458,000 |

*Source: Armstat statistics; SRC customs data (HS 8703 and scrap trade); Government Decree No. 994-N (2023); commodity price benchmarks; Author's calculations*

*Note on copper: The 90 tonnes of copper wiring recovered (moderate scenario) derives from 5,000 vehicles × 18 kg stripped copper. This is distinct from the whole-vehicle copper content (typically cited at 20–25 kg including insulated wire and motor windings), as some copper remains embedded in components and is only recovered at the downstream shredder stage at lower recovery rates. The 18 kg figure reflects directly separable wiring harness copper achievable at the ATF dismantling stage. Note on ferrous: The updated ferrous weight of 630 kg/vehicle is grounded net steel content of 754 kg/ELV and an ~82% metal recovery rate for dismantling operations (Abdullah; 2021). The 630 kg figure applies a conservative adjustment to account for Armenia's older, less aluminum-intensive fleet and manual dismantling conditions*

### 3.5.2 Value Added

A 40% value-added ratio is used as a modelling coefficient calibrated against relevant Armenian sector structures and regional comparators:

- Moderate scenario: Value Added = USD 1,441,000 × 0.40 = USD 576,400 (~AMD 223,085,000/year)
- Advanced scenario: Value Added = USD 3,458,000 × 0.40 = USD 1,383,200 (~AMD 535,518,000/year)

### 3.5.3 Direct Employment and Wages

Employment is estimated using an output-per-worker coefficient of USD 65,000–70,000/year, consistent with scrap collection and dismantling enterprises in the South Caucasus. This coefficient reflects the material-value-driven nature of scrap operations, where output per worker is significantly higher than wages.

**Table 24. Estimated Direct Employment Created by the ELV Formalization Program**

| Role Category | Moderate (FTE) | Advanced (FTE) |
|---|---|---|
| Collection / dismantling workers | 10 | 24 |
| Logistics and transport drivers | 4 | 9 |
| Administrative / registry management | 4 | 7 |

| Role Category | Moderate (FTE) | Advanced (FTE) |
|---|---|---|
| Technical supervision / compliance | 2 | 4 |
| **Total Direct Employment (FTE)** | **20** | **44** |

*Source: Armstat enterprise statistics and wage benchmarks; SRC customs data; Author's calculations*

Wage benchmarks are grounded in Armstat sector data for 2025. The Armenian national average monthly salary reached AMD 303,140 (USD 798) in 2025, with the private sector averaging AMD 327,604/month (USD 862). Operational wage assumptions of AMD 225,000–320,000/month are broadly consistent with Armenian industrial wage levels. ELV dismantling and logistics roles are modelled at AMD 225,000–280,000/month (USD 582–723/month at AMD 387; annual USD 6,980–8,680), reflecting their semi-skilled physical nature. Supervisory and administrative staff are modelled at AMD 400,000–480,000/month (USD 1,034–1,240/month; annual USD 12,400–14,880), consistent with the mining sector benchmark of AMD 517,768/month — the most comparable formal industrial employment in Armenia.[61]

There is no employer-side social security contribution in Armenia. Employee-side pension contributions (5% on monthly salary up to AMD 500,000; 10% minus AMD 25,000 on salary above AMD 500,000, capped at AMD 87,500/month) are withheld by the employer and remitted to the State Pension Fund, adding no additional cost to the employer beyond gross wages. Total take-home pay for an operational worker at AMD 250,000/month gross: income tax AMD 50,000 (20%) + pension AMD 12,500 (5%) = net AMD 187,500.

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[61] Council of the EU, deal of rules for end-of-lifevehicles, 2025. https://www.consilium.europa.eu/en/press/press-releases/2025/12/12/circular-economy-council-and-parliament-strike-deal-on-rules-for-vehicle-circularity-and-management-of-end-of-life-vehicles/

## *3.6 Indirect and Induced Effects*

**Table 25. Total Economic Effects of the ELV Formalization Program (Including Multiplier Effects)**

| Effect | Moderate | Advanced |
|---|---|---|
| Direct Gross Output (USD) | 1,441,000 | 3,458,000 |
| Output Multiplier (adjusted for import leakage) | 1.30 | 1.30 |
| **Total Output Effect (USD)** | **~1,873,000** | **~4,495,000** |
| Direct Value Added (USD) | 576,400 | 1,383,200 |
| **Total VA Effect (USD)** | **~749,000** | **~1,798,000** |
| Direct Employment (FTE) | 20 | 44 |
| Employment Multiplier | 1.20 | 1.20 |
| **Total Employment Effect (FTE)** | **24** | **53** |

*Source: Armstat national accounts and sector statistics; SRC customs data; Author's calculations*

The output multiplier of 1.30 is applied conservatively, adjusted downward from a regional benchmark of 1.5–1.8, to account for Armenia's high import dependency in fuel and consumables, and the fact that a significant share of transport OPEX involves imported goods with limited local value-added chain. The employment multiplier of 1.20 reflects modest but real backward linkages in transport, fuel supply, and incremental metallurgical processing employment at existing plants.

## *3.7 Trade and Resource Effects*

### 3.7.1 Import Substitution

Import substitution is estimated on a replacement-cost basis and should be interpreted as a resource-efficiency proxy rather than a direct forecast of reduced import volumes. It is calculated as the volume of recovered domestic secondary material × (primary import reference price − domestic scrap price), representing the indicative cost advantage to Armenian metallurgical buyers.

**Table 26. Estimated Import Substitution from ELV Material Recovery**

| Material / Calculation | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Primary ferrous import price reference (USD/t) | ~USD 550 | ~USD 550 |
| Domestic ferrous scrap price (USD/t) | USD 155 | USD 155 |
| Net substitution value per tonne (ferrous) | USD 395/t | USD 395/t |
| Ferrous import substitution (3,150 t / 7,560 t) | 1,244,250 | 2,986,200 |
| Primary aluminum import price reference (USD/t) | ~USD 2,550 | ~USD 2,550 |
| Aluminum substitution value (250 t / 600 t) | 420,000 | 1,008,000 |
| **Total Import Substitution (USD/year)** | **~1,664,000** | **~3,994,000** |
| **Foreign exchange saved (AMD millions/year)** | **~644** | **~1,546** |

*Source: SRC customs data; Armstat trade statistics; global commodity price benchmarks; Armstat/ARKA exchange rate data; Author's calculations*

### 3.7.2 Export Optionality

The existing scrap export ban is a critical policy pillar that must not be modified or lifted. Scrap metal is the sole raw material source for Armenia's metallurgical sector. Thousands of jobs have been created and billions of drams in tax revenues are generated annually by enterprises that depend on domestic scrap availability. Any weakening of the export restriction would remove the feedstock supply that underpins the entire sector. This assessment does not model an export optionality scenario, as export ban modification would be detrimental to the domestic metals value chain.

### 3.7.3 Waste Management Cost Savings

Avoided environmental and remediation costs for abandoned vehicle sites, reduced soil contamination risk from leaking fluids, and improved land use constitute additional social returns estimated conservatively at USD 50,000–150,000 per year at the moderate scale. These are not included in the financial model.

### *3.8 Fiscal and Distributional Effects*

#### 3.8.1 Estimated Tax Revenues

Direct fiscal contributions include VAT on scrap transactions, employer and employee payroll taxes, and corporate profit tax. Armenian statutory rates applied: VAT 20%; employer-side social security contribution 0% (Armenia does not levy an employer payroll tax; pension contributions of 5%–10% are deducted from employee salaries and remitted by the employer as withholding agent); employee income tax flat rate 20%; profit tax 18%.[62]

Profit tax is calculated on operating profit = gross output − OPEX − depreciation. Since there is no employer-side social contribution in Armenia, and since OPEX under the coercive mechanism consists only of transport and administration costs (no state scrappage premium payments), taxable income reflects the near-full output value net of operational costs. At CAPEX midpoint of USD 25,000 (moderate, IT registry only) depreciated over 5 years, annual depreciation = USD 5,000. Taxable profit (moderate) ≈ USD 1,441,000 − USD 90,000 (transport + admin OPEX) − USD 5,000 = USD 1,346,000; tax at 18% = ≈ USD 242,000. For the advanced scenario, taxable profit ≈ USD 3,458,000 − USD 180,000 − USD 8,000 = USD 3,270,000; tax at 18% = ≈ USD 589,000. The table below reflects these estimates.

**Table 27. Estimated Fiscal Revenue Generated by the ELV Formalization Program**

| Fiscal Item | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Estimated net VAT effect from formalized scrap transactions (after input credits) | ~89,000 | ~213,000 |
| Payroll taxes (employee income tax 20% + pension contributions 5%) | ~18,000 | ~30,000 |
| Profit tax at 18% (midpoint estimate) | ~193,000 | ~470,000 |
| Vehicle deregistration / transfer fees | ~25,000 | ~60,000 |
| **Total Estimated Fiscal Revenue (USD/year)** | **~315,000–335,000** | **~930,000–960,000** |

*Source: Armstat statistics; SRC customs and vehicle registration data; RA Tax Code; Author's calculations*

#### 3.8.2 SME and Regional Participation

ELV collection is inherently SME-compatible. Reception points, dismantling operations, and logistics can be operated by small enterprises, avoiding market concentration. Under the advanced scenario, an estimated 30–40% of direct jobs could be located outside Yerevan — in marzes such as Shirak, Lori, and Gegharkunik, where informal vehicle storage is most prevalent and formal employment opportunities are most limited.

#### 3.8.3 Gender and Youth Employment

Registry management, administrative, and compliance roles within a formalized ELV system present accessible entry points for youth and female workers who are currently excluded from informal, physically intensive scrap operations. Operator licensing criteria can include gender and youth employment targets as conditions for ATF certification.

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[62] PwC, Armenia — Individual Tax Summary: https://taxsummaries.pwc.com/armenia/individual/taxes-on-personal-income

## *3.9 Cost–Benefit Snapshot*

**Table 28. Cost–Benefit Summary of the ELV Formalization Program**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| **Total CAPEX (USD)** | ~25,000 | ~40,000 |
| Annual OPEX (USD) | ~90,000 | ~180,000 |
| Annual Gross Output (USD) | ~1,441,000 | ~3,458,000 |
| **Annual Value Added (USD)** | **~576,000** | **~1,383,000** |
| Total Jobs Created (FTE, incl. multiplier) | 24 | 53 |
| Import Substitution (USD/year) | ~1,664,000 | ~3,994,000 |
| Annual Fiscal Revenue (USD) | ~315,000–335,000 | ~930,000–960,000 |
| **Net Annual Operating Surplus (output − OPEX)** | **~1,351,000** | **~3,278,000** |
| Payback period (CAPEX / net annual surplus) | < 0.1 years | < 0.1 years |

*Source: Armstat national accounts and enterprise statistics; SRC customs data (HS 8703 and scrap trade); Government Decree No. 994-N (2023); commodity price benchmarks; Author's calculations*

Given that Armenia's existing metallurgical plants and scrap collection network already handle vehicle scrap without any new infrastructure investment, the program's economics are exceptionally strong. The only real financial outlays are the IT registry (a one-time cost of USD 25,000–40,000)[63]. Under the coercive mechanism (progressive property tax + Local authority enforcement), there is no state-funded premium pool. OPEX is limited to transport (USD 60,000–130,000/year) and administration (USD 30,000–50,000/year). The program achieves payback in under 0.1 years under both scenarios.

Sensitivity: A 20% decline in scrap prices would reduce annual output by approximately USD 288,000 (moderate) and USD 692,000 (advanced). Given minimal CAPEX (IT registry only), the payback period remains under 0.1 years even under this stress scenario. The intervention remains highly viable. Steel recycling income ranges from USD 0.20–0.25/kg under conventional recycling (Abdullah; 2021); the remanufacturing pathway (WSS to mesh sheet steel) generates up to USD 3.21/kg, offering a premium processing option that substantially improves viability even under scrap price pressure.

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[63] Rough estimates made on cost of preparing an IT program of registration

### *3.10 Risks and Trade-offs*

- Low financial barriers: Unlike most circular economy interventions, this program requires no immediate investment in physical infrastructure, equipment, or processing capacity. The only public investment needed is the IT registry (USD 25,000–40,000). Under the coercive mechanism (progressive property tax, local authority enforcement), no scrappage premium pool is required. The state's financial exposure is thus extremely limited and time-bound to the registry setup only.
- In the future, depending on how the system evolves, it may become necessary to license several regional scrap collectors to strengthen collection in areas located far from metal production centeres and requiring additional logistical support.
- Risk of informal pathway persistence: If progressive property tax rates are set too low or local authority enforcement is weak, partial informal dismantling may continue. High-value component stripping without hulk processing undermines ferrous recovery targets. Regulatory enforcement quality and calibration of property tax progressivity are critical success factors. The metallurgical low quality of ELV scrap must also be considered: if the collection process becomes overly complex or expensive, there may be insufficient incentive for recyclers to collect this type of scrap — particularly when higher-quality scrap is available at competitive prices. Process simplicity is essential.
- Scrap price volatility: Domestic Armenian scrap prices are not quoted in a transparent exchange market and may diverge from international benchmarks. Domestic ferrous prices are influenced by the export ban but track global trends with a lag. A prolonged global price decline (below USD 170–180/tonne globally) could compress domestic margins significantly. Under the coercive mechanism, recyclers continue to absorb price risk as they pay market rate. Minimum gate price guidelines (non-binding) for CoD-issuing recyclers could provide transparency and support enrollment rates if domestic prices fall sharply.
- Skills and awareness: Existing scrap operators are familiar with vehicle scrap processing. The main training needs are traceability documentation, administrative procedures linked to the deregistration-CoD system, and — critically — the applicable tax legislation. When acquiring scrap from an individual, a VAT-registered buyer must withhold 10% income tax if the transaction is documented; if undocumented, a 20% income tax applies, and the acquisition cannot be expensed, resulting in profit tax on the full acquisition value. These tax compliance requirements must be addressed in the orientation program. procedures linked to the deregistration-CoD system. A short orientation program for registered collectors is sufficient; no vocational curriculum for heavy dismantling is required since this is already practiced at scale.
- Multi-agency coordination: The intervention spans Environment, Economy, Internal Affairs/Police, and Revenue Committee mandates. A formal inter-agency protocol spanning Environment, Economy, Internal Affairs/Police, and Revenue Committee is required to avoid implementation fragmentation. No new institutional unit needs to be created — existing ministerial structures are sufficient if mandates and responsibilities are clearly delineated in the enabling legislation.
- Consumer awareness: Vehicle owners are now broadly aware that metal has residual value — there is virtually no abandoned metal on public streets. Under the proposed coercive mechanism, local authorities will resolve the issue of abandoned vehicles through fines and ownerless-vehicle declarations. Communication efforts should focus on informing owners of progressive property tax implications and the mechanics of CoD issuance through recyclers, rather than advertising premiums.

## *3.11. Summary Positioning and Policy Implications*

### 3.11.1 Strategic Positioning

Among the four circular opportunities identified in Armenia's metals value chain, ELV formalization presents the most favorable combination of near-term actionability, capital efficiency, and policy alignment. It does not require new industrial infrastructure, leverages an existing scrap export ban that already creates domestic feedstock demand, and addresses a visible regulatory gap — the absence of end-of-life tracking — that is correctable through institutional rather than capital-intensive means.

**Table 29. Comparative Assessment of Circular Economy Opportunities in Armenia's Metal Sector**

| Circular Opportunity | Investment Intensity | Job Intensity | Import Substitution | Strategic Score |
|---|---|---|---|---|
| **ELV Formalization (selected)** | Very Low | Medium | High | ★★★★★ |
| Low-Carbon Metallurgy | High | Medium | Medium | ★★★★ |
| E-waste Recovery | Medium–High | Low | Low | ★★★ |
| Tailings Valorization | Very High | Low | Low | ★★ |

*Source: Author's strategic assessment*

### 3.11.2 Regulatory Changes Required

- Amendment to the Law on Waste Management to classify ELVs as regulated waste requiring formal treatment and issue a Certificate of Destruction (CoD) at the end of the process.
- Modification of vehicle deregistration regulations (Police Road Transport Department) to require a CoD or proof of transfer to a licensed ATF as a mandatory precondition for deregistration.
- Development of minimal technical standards for CoD-issuing recyclers/processors under the Ministry of Environment. Note: Licensing requirements must be kept simple and should be delegated to existing certified recyclers and metallurgical processors — which are already geographically distributed across Armenia (Charentsavan, Ararat, Karakert, Hrazdan, etc.) and have sufficient capacity to cover the entire ELV volume. Overly complex ATF licensing creates barriers that may eliminate recycler incentives to collect ELV scrap, particularly given its metallurgically lower quality relative to other scrap types. The number of licensed collectors is already sufficient; no new licensing layer is needed.
- Design of a progressive property tax on aging vehicles (20+ years) to drive voluntary surrender, combined with local authority enforcement authority. Specifically: (a) progressive property tax rates on vehicles aged 20+ years, scaled by age, making continued ownership financially unviable; (b) local authority authority to declare unidentified abandoned vehicles as ownerless and to fine owners who store identified vehicles on community land without paying property tax; (c) mandatory CoD from an authorized recycler as the sole valid precondition for police deregistration. No advance disposal levy or premium pool is required: under this mechanism, the owner is obliged to hand the vehicle over regardless, and the recycler pays market price for the scrap directly. The state does not need to collect or distribute funds.

### 3.11.3 Co-financing Rationale

Given that Armenia's existing infrastructure already handles vehicle scrap, public co-financing needs are extremely minimal. The sole public investment required is the national IT traceability registry (a public good shared by all authorized processors, estimated one-time cost of USD 25,000–40,000). Under the coercive mechanism (progressive property tax + local authority enforcement), no premium pool or advance disposal levy is required. Ongoing OPEX — primarily transport logistics and registry administration — is operationally self-sustaining at the scale modelled. No subsidies for processing, equipment, or collection infrastructure are required.

### 3.11.4 Skills Development

A brief orientation program (4–8 hours) for authorized recyclers/processors should be developed, covering traceability documentation, the Certificate of Destruction (CoD) issuance process, applicable tax compliance requirements (including income tax withholding obligations when purchasing scrap from individuals), and record-keeping requirements linked to the VIN registry. No vocational dismantling curriculum is required: Armenia's existing scrap network already processes vehicles. Delivery can be online or through Ministry of Environment licensing channels, at negligible cost.

### 3.11.5 Incentive Design

A coercive regulatory structure is recommended, combining: (1) progressive property tax on vehicles aged 20+ years, scaled with vehicle age, making prolonged ownership financially unattractive; (2) local authority to fine owners parking identified vehicles on community land, or to declare unidentified vehicles as ownerless; (3) mandatory Certificate of Destruction (CoD) — issued by an authorized recycler/processor — as the sole precondition for police deregistration; (4) clear CoD issuance process at recyclers who pay market rate for incoming scrap. Under this structure, vehicle owners face either ongoing property tax costs or surrender — and recyclers pay for scrap they receive, making the system financially self-sustaining without any state transfer mechanism. This approach avoids the abuse risks inherent in certificate-based payment systems and is administratively simpler to operate.[64]

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[64] Council of the EU, deal on rules for end-of-life vehicles, December 2025: https://www.consilium.europa.eu/en/press/press-releases/2025/12/12/circular-economy-council-and-parliament-strike-deal-on-rules-for-vehicle-circularity-and-management-of-end-of-life-vehicles/

# 4. FISHING SECTOR

## *4.1 Methodology*

### 4.1.1 Data Sources

**Customs and Trade Data:** Imports and exports of fish meal (HS code 230120) and fish oil (HS code 150420) for the period 2019–2024 were obtained from the UN Comtrade and Armstat databases.

**Exchange rate reference:** AMD 387/USD 1, used as a reference rate consistent with early-to-mid 2025 market levels per Armstat/ARKA. The full-year 2025 annual average exchange rate was approximately AMD 387/USD 1, with the observed range AMD 379–401 throughout 2025.[65]

**Commodity price references:** Import data and YCharts[66].

### 4.1.2 Modelling Framework

**Step 1 — Physical Definition of the Intervention:** The intervention envisages the establishment of a fishmeal production facility in Ararat Province of Armenia to collect and process fish-processing waste generated by fish farms and processing enterprises. The facility would serve as a centralized unit for the recovery and valorization of fish by-products, including heads, bones, viscera, and other organic residues that are currently disposed of or underutilized.

The physical infrastructure would include waste collection and transportation systems, storage and handling facilities, and a processing plant equipped with cooking, pressing, drying, and milling equipment required for fishmeal production. The plant would receive fish waste from processing enterprises only.

The collected waste would be processed into fishmeal and potentially other by-products such as fish oil, which can be used as inputs in animal feed and aquaculture feed production. By converting fish waste into marketable products, the facility would support the development of circular material flows within the fish value chain.

Overall, the establishment of a fishmeal plant would reduce the amount of fish waste disposed of in landfills, mitigate environmental impacts associated with improper waste management, and create new economic opportunities within Armenia's aquaculture sector.

**Step 2 — Investment Costs:** As there is currently no fishmeal production capacity in Armenia, the intervention assumes that the necessary processing technology and equipment will be imported, most likely from China, where relatively cost-efficient small and medium-scale fishmeal processing lines are widely available. The investment estimates therefore reflect the procurement, installation, and commissioning of a complete processing line.

Depending on the selected scenario, the required capital investment is estimated to range from USD 633K to USD 2,097K.

**Step 3 — Direct Economic Effects:** Gross output = Volume (tonnes) × Domestic price (USD/tonne), applied to fish meal. Estimates of gross value added (GVA) and employment effects are derived from the project's three-statement financial model, which integrates projected income statements, balance sheets, and cash

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[65] Central Bank of Armenia, exchange rate statistics: https://www.cba.am/en/sitepages/exchangearchive.aspx

[66] Ycharts, Fish meal price, https://tinyurl.com/yxn4j28u

flow statements. The financial projections provide detailed estimates of operating revenues, intermediate consumption, labor costs, and capital expenditures, enabling the calculation of value added generated by the fishmeal production facility.

**Step 4 — Indirect and Induced Effects:** In the absence of an Armenian input-output table suitable for ELV-specific modelling, proxy multiplier coefficients are used for scenario analysis based on literature review: output multiplier 1.77, employment multiplier 2.1[67].

**Step 5 — Trade and Resource Effects:** Given the current volume of fishmeal imports, the project assumes that the entire domestic production can be absorbed by the local market. This would enable the partial substitution of imported fishmeal with locally produced output, thereby reducing dependence on foreign suppliers.

### 4.1.3 Assumptions and Limitations

**No national input–output table:** Multipliers are approximated based on international benchmarks, which introduces limitations when applying them to the Armenian economy.

**Products:** The enterprise should produce both fish meal and oil.

**Fish waste data:** There are currently no official statistics on fish waste generation or fish waste processing. Therefore, the total volume of fish waste generated is estimated indirectly based on available data on fish production, exports, and processing activities.

**Financial assumptions:** For both scenarios, a target **internal rate of return (IRR) of 17%** was assumed.

**Exchange rate assumption:** The exchange rate is assumed to remain stable throughout the entire projection horizon.

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[67] Greig G.T, Multiplier Values for the Fishing and Fish Processing Industries in the UK and in Scotland: An Input - Output Analysis, page 2, https://tinyurl.com/yhuzthnw

### *4.2 Sector Overview*

Armenia's fish value chain follows a largely linear model, moving from resource extraction to consumption with limited resource recovery. After harvest, fish are transported to processing facilities where they are slaughtered, cleaned, filleted, frozen, smoked, or packaged in accordance with market requirements. Processing generates 6–7 thousand tons of fish waste (heads, bones, skin, blood and trimmings, caviar processing residuals), which are discarded and lost despite their potential use in animal feed or soil enrichment.

Armenian fish farms and processors largely lack the technology and infrastructure needed to transform fish-processing waste into useful products. At present, Armenia has no facilities for producing fishmeal, fish oil, gelatin, or other value-added products from fish by-products. As a result, the fish-processing waste stream remains largely untreated and unused. Most residues are discarded either as solid waste or through wastewater, representing one of the largest circular economy gaps in the sector. Although small-scale informal reuse exists, for example, using some waste as animal (pork) feed, there is no commercial system for valorizing these by-products.

Moreover, Armenia relies on imports of fishmeal (HS 230120) to meet its domestic needs. Imports have grown significantly in recent years, increasing from 1,675 tones in 2019 to 4,039 tones in 2021. In 2022, imports rose further, reaching 6,023 tones, before declining to 4,530 tones in 2024[68]. Similarly, over the reporting period the import of fish oil reached 876 tonnes[69]. Although, part of the increase in recent years is associated with re-exports to Russia, the domestic need has increased as well. This situation means that while nutrients enter the country in the form of imported feed ingredients, thousands of tons of fish-processing waste generated domestically are discarded each year rather than recovered and reintegrated into the production system. The result is both an economic loss, due to forgone revenue from by-products, and an environmental risk, as decomposing fish waste can pollute water and soil if not properly managed.

International experience demonstrates the potential benefits of closing this loop in the value chain. For example, in Norway, one of the world's leading aquaculture producers, more than 80% of fish harvest and by-products are utilized, with processing residues such as heads, skins, and viscera converted into fishmeal, fish oil, and other value-added products. This approach reduces waste, generates additional revenue streams, and strengthens resource efficiency across the value chain. In contrast, the absence of a domestic fishmeal or feed industry in Armenia means that a significant circular opportunity remains untapped.

### Baseline Circularity Status

- Fish farms and processors largely lack the technology and infrastructure needed to transform fish-processing waste into useful products (e.g. fishmeal).
- Armenia has no facilities for producing fishmeal or other value-added products from fish by-products.
- Small-scale informal reuse exists, for example, using some waste as animal feed, there is no commercial system for valorizing these by-products.

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[68] UN Comtrade database

[69] Armstat, External Trade Database, 10-digit, https://tinyurl.com/y7hpye6z

- Most fish waste generated by fish farms and processing enterprises is disposed of in landfills, leading to environmental damage, including soil and water contamination and the poisoning of wild birds feeding at landfill sites.
- Armenia relies on imports of fishmeal (HS 230120) and fish oil (Hs 150420) to meet its domestic needs. In 2024, Imports have grown significantly in recent years, reaching to 4,530 tones and 876 tones, respectively.

## Scenario Design

- Moderate Scenario: Processing 1,000 tons of fish waste annually.
- Advanced Scenario: Processing capacity starting at 3,000 tons annually and gradually increasing to 5,000 tons within five years as collection systems and market participation expand (approximately 70% of generated fish waste).

## *4.3 Selected Circular Intervention*

Within the fish value chain, one of the key recommendations is to establish a fish waste processing facility for the production of fishmeal and fish oil. Such a facility would enable the productive utilization of fish processing by-products while reducing the environmental impacts associated with landfill disposal. However, the economic viability of the processing plant largely depends on the stable, predictable, and sufficiently large supply of fish waste from aquaculture farms and fish processors.

To ensure the reliability and continuity of raw material supply, it is proposed to undertake the following actions:

### 4.3.1 Scope and Design

- Oversight mechanism: Conduct identification of fish waste generators and strengthen the enforcement of existing regulatory mechanisms to ensure effective oversight of their activities and minimize the informal disposal of fish waste in landfills.
- Economic incentive: Introduce financial incentive mechanisms encouraging waste generators to channel fish waste to the designated processing facility rather than disposing of it in landfills or utilizing it through alternative ways.
- Facilitate the establishment of a fish waste processing facility by large fish processors and aquaculture farms: Given that the economic viability of a fish waste processing enterprise heavily depends on economies of scale, it would be beneficial to involve major fish waste generators in the ownership or partnership structure of the facility. Such participation would help ensure a predictable and continuous supply of raw materials, strengthen supply chain coordination, and align incentives among stakeholders within the fish value chain.

## *4.4 Physical and Financial Modelling Assumptions*

### 4.4.1 Estimated product output

Given the results of the literature review and market analysis, the following assumptions regarding output yields and market prices for fishmeal and fish oil production are proposed.

**Table 30. Product Yield and Reference Price Assumptions for Fish Waste Processing**

| Product Extraction | As % to waste weight | Reference Prices |
|---|---|---|
| Fish meal | 21.5% | USD 1996.5/Metric ton (AMD 772,642) |
| Fish oil | 6.0% | USD 2,200/Metric ton (AMD 851,400) |

*Source: UN Comtrade; Armstat trade statistics (HS 230120, HS 150420), 2019–2024; YCharts commodity prices; Armstat/ARKA exchange rate data*

### 4.4.2 Main Scenario Assumptions

**Table 31. Key Modelling Parameters for the Fish Waste Processing Project**

| Parameter | Units/rate | Moderate | Advanced |
|---|---|---|---|
| Fish waste processing capacity | Tons/year | 1,000 | 5,000 |
| Capacity utilization - Year 1 | % | 100% | 60% |
| Capacity utilization - Year 2 | % | 100% | 70% |
| Capacity utilization - Year 3 | % | 100% | 80% |
| Capacity utilization - Year 4 | % | 100% | 90% |
| Capacity utilization - Year 5 | % | 100% | 100% |
| Loan share in capital | % | 100% | 100% |
| Effective Interest rate/WACC | % | 13% | 13% |
| Loan tenure | years | 8 | 8 |
| Local sales | % | 100% | 100% |
| Raw materials acquisition fee | AMD/per ton | 800 | 28,300 |

*Source: UN Comtrade; Armstat trade statistics (HS 230120, HS 150420), 2019–2024; YCharts commodity prices; Armstat/ARKA exchange rate data*

## *4.5 Direct Economic Effects*

### 4.5.1 Gross Output

**Table 32. Estimated Product Output and Sales Revenue from Fish Waste Processing**

| Material Fraction | Units | Moderate | Advanced |
|---|---|---|---|
| Average annual fish meal output | Tons | 215 | 860 |
| Average annual fish meal sales | '000, USD | 447 | 1796 |
| Average annual fish oil output | Tons | 60 | 240 |
| Average annual fish oil sales | '000, USD | 137 | 552 |
| Average annual total revenue | '000, USD | 584 | 2,348 |

*Source: UN Comtrade Database; Statistical Committee of the Republic of Armenia (Armstat), trade statistics for fish meal (HS 230120) and fish oil (HS 150420), 2019–2024; YCharts commodity price benchmarks*

### 4.5.2 Value Added

Because the financial model provides detailed projections of output and cost components, it allows value added to be estimated directly using the production approach. Accordingly, value added was calculated as the difference between total output and intermediate consumption, capturing the net economic value generated by the processing activity. Following this approach, the estimated annual average gross value added is presented below.

**Table 33. Estimated Gross Value Added from Fish Waste Processing by Capacity**

| Material Fraction | Gross value added in current prices, '000 USD |
|---|---|
| 1000-tons capacity | 433 |
| 5000-tons capacity | 1,568 |

*Source: UN Comtrade; Armstat trade statistics (HS 230120, HS 150420); YCharts commodity prices*

### 4.5.3 Direct Employment and Wages

Employment is estimated based on financial modelling results.

**Table 34. Employment and Wage Effects of the Fish Waste Processing Project**

| | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Total number of employees (FTE) at highest capacity utilization | 20 | 80 |
| Total wage fund ('000, USD) | 232 | 805 |
| *of which* | | |
| Factory wages ('000, USD) | 162 | 723 |
| Administrative wages ('000, USD) | 70 | 82 |

*Source: UN Comtrade; Armstat trade statistics (HS 230120, HS 150420)*

From an employment perspective, the establishment of a fish waste processing facility could generate a meaningful number of direct jobs in the fish value chain, particularly in industrial processing and plant operations. Under the moderate scenario, the facility would employ approximately 20 full-time equivalent (FTE) workers, with a total annual wage fund of about USD 232,000, of which USD 162,000 (around 70%) would be allocated to factory workers and USD 70,000 to administrative staff.

Under the advanced scenario, employment would expand significantly to around 80 FTE positions, reflecting the larger scale of operations. In this case, the total wage fund would increase to approximately USD 805,000 per year, with the majority USD 723,000 (around 90%) paid as factory wages, while USD 82,000 would cover administrative salaries.

### *4.6 Indirect and Induced Effects*

The Indirect and induced effect are estimated based on literature review. Beyond the direct economic activity generated by the plant, the project is expected to stimulate additional production, income generation, and employment in related sectors through spillover effects along the value chain.

In terms of output, the facility would generate direct gross output of approximately USD 584,000 under the moderate scenario and USD 2.35 million under the advanced scenario. Applying an output multiplier of 1.77 (adjusted for import leakage) increases the total economy-wide output effect to about USD 1.04 million and USD 4.16 million, respectively. This indicates that the operation of the processing plant would stimulate additional economic activity in related sectors such as aquaculture, transport and logistics, energy supply, and equipment maintenance services.

**Table 35. Total Economic Effects of the Fish Waste Processing Project (Including Multiplier Effects)**

| Effect | Modern | Advanced |
|---|---|---|
| Direct Gross Output (‘000, USD) | 584 | 2,348 |
| Output Multiplier (adjusted for import leakage) | 1.77 | 1.77 |
| Total Output Effect (‘000, USD) | 1,044 | 4,156 |
| Direct Gross Value Added (‘000, USD) | 433 | 1,568 |
| Value-added multiplier | 1.7 | 1.7 |
| Total VA Effect (USD) | 736 | 2,666 |
| Direct Employment (FTE) | 20 | 80 |
| Employment Multiplier | 2.1 | 2.1 |
| Total Employment Effect (FTE) | 42 | 168 |

*Source: UN Comtrade Database; Statistical Committee of the Republic of Armenia (Armstat), trade statistics for fish meal (HS 230120) and fish oil (HS 150420)*

Regarding value creation, the project is expected to generate USD 433,000 in direct value added under the moderate scenario and USD 1.57 million under the advanced scenario. Applying a value-added multiplier of 1.7 increases the total economy-wide value-added impact to approximately USD 736,000 and USD 2.67 million, respectively. These effects reflect additional income generated in supplier industries as well as increased household spending by employees.

In terms of employment, the project would create 20 direct full-time jobs under the moderate scenario and 80 jobs under the advanced scenario. Applying an employment multiplier of 2.1 increases the total employment impact to approximately 42 jobs and 168 jobs, respectively. These additional jobs are expected to emerge in upstream and supporting activities, including raw material collection, logistics, equipment maintenance, and local service sectors.

Although the macroeconomic impact of the project remains relatively modest at the national level, it represents a tangible economic contribution from a circular economy perspective, demonstrating how the productive utilization of fish waste can generate additional economic value, employment, and environmental benefits within the aquaculture value chain.

## *4.7 Trade and Resource Effects*

### 4.7.1 Import Substitution

From an import substitution perspective, the proposed fish waste processing facility could make a meaningful contribution to reducing Armenia's dependence on imported fishmeal and fish oil. In 2024, Armenia imported 4,530 tons of fishmeal and 876 tons of fish oil, with a combined value of USD 10.8 million.

Under the moderate production scenario, the facility would produce approximately 215 tons of fishmeal and 60 tons of fish oil annually, generating about USD 584,000 in sales. This output would substitute around 4.8% of fishmeal imports and 6.8% of fish oil imports, representing a modest but important initial step toward domestic production of feed inputs.

**Table 36. Import Substitution Potential from Fish Waste Processing Products**

| Material / Calculation | Moderate (USD/year) | Advanced (USD/year) |
|---|---|---|
| Average annual fish meal output, tons | 215 | 860 |
| Average annual fish meal sales, '000, USD | 447 | 1796 |
| Average annual fish oil output, tons | 60 | 240 |
| Average annual fish oil sales, '000, USD | 137 | 552 |
| Fish meal, as % to import | 4.8% | 19,0% |
| Fish oil, as % to import | 6.8% | 27.4% |

*Source: UN Comtrade; Armstat trade statistics (HS 230120, HS 150420); YCharts commodity prices; Author's calculations*

Under the advanced scenario, production would increase to 860 tons of fishmeal and 240 tons of fish oil per year, generating roughly USD 2.35 million in annual revenue. At this scale, the facility could replace around 19% of fishmeal imports and 27.4% of fish oil imports, significantly strengthening local supply capacity. Overall, the project would contribute to reducing import dependence, improving the trade balance, while also promoting the circular use of fish waste.

## *4.8 Fiscal and Distributional Effects*

### 4.8.1 Estimated Tax Revenues

**Table 37. Estimated Fiscal Revenue from Fish Waste Processing**

| Fiscal Item | Moderate (‘000, USD/year) | Advanced (USD/year) |
|---|---|---|
| Average annual estimated net VAT effect from sales of fish meal and oil | 22 | 98 |
| Average annual payroll taxes (employee income tax 20%) | 12 | 235 |
| Average annual profit tax at 18% | 46 | 137 |
| Total Estimated Fiscal Revenue | 80 | 470 |

*Source: UN Comtrade; Armstat trade statistics (HS 230120, HS 150420); RA Tax Code*

In terms of government revenue generation, the establishment of a fish waste processing facility could create additional fiscal inflows through VAT on product sales, payroll taxes associated with employment, and corporate profit tax. Under the moderate scenario, the project is expected to generate approximately USD 80,000 in annual fiscal revenue, including around USD 22,000 from the net VAT effect, USD 12,000 from payroll taxes, and USD 46,000 from profit tax.

Under the advanced scenario, the fiscal contribution increases significantly to approximately USD 470,000 per year. This amount comprises about USD 98,000 in VAT revenues, USD 235,000 in payroll taxes, and USD 137,000 in profit tax.

### 4.8.2 Environmental Tax Cost Savings

Given that the current environmental tax for the disposal of fish waste in landfills is AMD 780 per ton, the implementation of the fish waste processing project would enable fish processors to avoid landfill disposal and the associated environmental tax payments. On an average annual basis, the total environmental tax savings are estimated to range from USD 2,016 under the moderate scenario to USD 8,062 under the advanced scenario, depending on the volume of fish waste diverted to the processing facility. This reduction in disposal costs further strengthens the economic incentive for processors to supply fish waste to the processing plant rather than disposing of it in landfills.

### 4.8.3 Gender and Youth Employment

The facility is expected to generate a number of operational and logistics positions—such as machine operators, warehouse staff, drivers, and processing workers—that can provide employment opportunities for younger workers entering the labor market. Such roles typically require limited prior industry experience and can support skills development in industrial processing, equipment operation, and logistics. In addition to operational jobs, the project includes administrative, accounting, and quality supervision positions that are accessible to female professionals. These roles contribute to diversifying employment opportunities within the processing facility and supporting more balanced workforce participation.

### *4.9 Cost–Benefit Snapshot*

**Table 38. Cost–Benefit Summary of the Fish Waste Processing Project**

| Indicator | Moderate | Advanced |
|---|---|---|
| Total CAPEX (‘000, USD) | 633 | 2,097 |
| Average annual gross output (‘000, USD) | 584 | 2,348 |
| Average annual gross value added (‘000, USD) | 433 | 1,568 |
| Total Jobs Created (FTE, incl. multiplier) | 20 | 80 |
| Import Substitution (‘000, USD/year) | 584 | 2,348 |
| Annual Fiscal Revenue (‘000, USD) | 80 | 470 |
| Payback period, years | ~3.8 years | ~4.7 years |

*Source: UN Comtrade; Armstat trade statistics (HS 230120, HS 150420); RA Tax Code; YCharts commodity prices*

As shown in the table, the establishment of a fishmeal and fish oil processing facility could represent a highly attractive demonstrative project for promoting circular economy practices in Armenia. By converting fish processing waste into valuable feed inputs, the project would support the productive reuse of biological waste streams, reduce environmental pressures associated with landfill disposal, and strengthen resource efficiency within the aquaculture value chain.

In addition to its environmental benefits, the project would contribute to economic resilience by reducing dependence on imported fishmeal and fish oil, while generating domestic value added, employment opportunities, and additional fiscal revenues for the state budget. As such, the initiative could serve as a practical example of circular economy implementation, demonstrating how waste streams can be transformed into economically viable products that support both sustainable resource management and economic development.

### *4.10 Risks and Trade-offs*

- **Dependence on scale and raw materials supply risk:** Without a sufficient processing scale, fish waste processing cannot be economically viable. Therefore, the refusal of large processors to supply fish waste may pose a significant risk to the economic viability of the project.
- **Fish meal and oil price volatility:** While the model assumes a conservative selling price slightly below current international levels, a sustained decline in fishmeal prices could reduce revenues and compress margins. Conversely, rising feed demand in aquaculture could strengthen price conditions.
- **Operational scale efficiency:** The plant is designed under two capacity scenarios (1,000 tons and 5,000 tons of annual raw material processing capacity) with profitability improving as capacity utilization increases. If utilization grows more slowly than projected, fixed operating costs, could place downward pressure on operating margins.
- **Market development and feed integration:** While fish meal and oil is widely used in feed production, Armenia currently relies on imported feed inputs. The development of local markets for fish meal and oil through domestic feed producers, will be important to ensure stable demand and maximize value recovery from fish-processing by-products.

## *4.11 Summary Positioning and Policy Implications*

### 4.11.1 Strategic Positioning

The establishment of a fish waste processing facility represents a **low-investment circular economy intervention** that enables the productive utilization of fish processing by-products. When implemented at a sufficiently large scale, such a facility can be **economically viable**, contribute to the **creation of new jobs**, and support **import substitution** by increasing the domestic supply of fishmeal and fish oil used in the feed industry. In addition, the initiative would help reduce environmental pressures associated with improper disposal of fish waste while strengthening value addition within the local aquaculture and fish processing sector.

**Table 39. Strategic Assessment of Circular Economy Opportunities in the Fisheries Sector**

| Circular Opportunity | Investment Intensity | Job Intensity | Import Substitution | Strategic Score |
|---|---|---|---|---|
| Fish meal and oil production | Low | Low | Medium | ★★★★ |

*Source: Author's strategic assessment*

### 4.11.2 Financing Rationale

Financing of the proposed fishmeal and oil production facility would require capital investment estimated in the range of USD 633,000 to USD 2.097 million, depending on the scale of the selected scenario. The financial model assumes a target internal rate of return (IRR) of 17%, which is considered sufficient to attract private investors. It is further assumed that the entire investment will be financed through bank lending at an effective interest rate of approximately 13%, implying a positive return spread for investors. Under these assumptions, the projected IRR would remain acceptable for potential investors considering the associated project risks.

### 4.11.3 Skills Development

The establishment of fishmeal production in Armenia will require targeted skill development in areas such as fish waste handling, processing technologies, equipment operation, and quality control. As this technology is not currently present in the country, initial training and knowledge transfer from international equipment suppliers and technical experts will be necessary.

### 4.11.4 Contribution to fish value chain's viability

Depending on the scale of operations, the establishment of a fish waste processing facility could generate significant economic benefits for fish processors. The analysis suggests that processors may receive incremental revenues ranging from USD 2,067 to USD 292,504. In addition, diverting fish waste from landfill disposal could lead to environmental tax savings estimated between USD 2,016 and USD 8,062, further improving the overall economic attractiveness of supplying fish waste to processing facilities.

# 5. FRUIT AND VEGETABLE PROCESSING SECTOR

## *5.1 Methodology*

### 5.1.2 Data Sources

The analysis draws on six categories of sources.

1. **Armenian official statistics**. Armstat Form 1-TG (Annual Enterprise Statistics) for NACE 11.01 and NACE 11.02, covering 2023 and 2024, provides the primary economic parameters: revenue, intermediate consumption, wages, and depreciation. Data were supplied by the Statistical Committee of the Republic of Armenia in response to a formal information request dated 05 March 2026. Wage calibration uses Armstat NACE 11.01–11.02 data converted at the CBA 2024 annual average rate of AMD 387/USD.

2. **International trade data.** Export and import values for HS 2204 (wine), HS 2208.20 (grape spirits/brandy), HS 31 (mineral fertilisers), and HS 271121 (natural gas) are drawn from UN Comtrade. These data underpin the import substitution and export potential estimates.

3. **Vitivinicultural and by-product literature**. Biomass composition ratios and yield parameters draw on OIV (2023); Troilo et al. (2021); Spigno et al. (2007); Pinelo et al. (2004); Karastergiou et al. (2024); Molino et al. (2013); Bolzonella et al. (2019); and Feedipedia (grape pomace). Biogas yield assumptions for Project 3 are based primarily on Molino et al. (2013). Extraction yield parameters for Project 4 are consistent across Spigno et al. (2007), Pinelo et al. (2004), and AGRIMAX (2019).

4. **Engineering and techno-economic benchmarks**. CAPEX and OPEX estimates draw on AGRIMAX Horizon 2020 (Grant No. 720719), the European Biogas Association Annual Report 2022, the European Compost Network Data Report 2022, Jin et al. (2021) for extraction facility scaling, and equipment-level data from Alfa Laval and GEA Group. All Western European cost benchmarks are adjusted downward by 30–40% to reflect Armenian conditions, calibrated against Armstat wage data.

5. **Regional programme analogues.** Investment and operational assumptions are cross-validated against the Georgia EU4Business composting pilot (Kakheti, 2021–2023) and Georgia's NDC Financing Strategy, and the EBRD National Biogas Programme in Moldova (2019–2023). These provide the primary cost references for Projects 2 and 3 respectively in a comparable post-Soviet context.

6. **Market price data**. Grape seed oil prices are based on Tridge transaction data (2023–2024). Polyphenol extract prices draw on Tridge import statistics and public pricing from Indena SpA and DRT. Resveratrol pricing is from PharmaCompass. Compost prices are benchmarked against ECN (2022). Electricity revenue is based on the PSRC Armenian biomass tariff for 2024. Dried pomace feed prices reflect OIV (2023) and Feedipedia benchmarks adjusted for the Armenian market.

Additional references include the Companion Fruit and Vegetable Processing Sector Value Chain Report (February 2026), EBRD GEFF Armenia documentation, and IEA Bioenergy Task 37 country reports.

**Limitations.** Armenia does not publish systematic by-product volume data; all biomass estimates carry ±15–20% variability. The absence of a national input-output table requires the use of proxy multiplier coefficients with an uncertainty margin of approximately ±20–30%. Both limitations are reflected in the scenario ranges throughout the report.

### 5.1.2 Modelling Framework

**Step 1 — Physical Definition of the Intervention:** Each of the four projects is assessed independently, with a separately defined biomass allocation rather than assuming all projects process the entire pomace stream simultaneously. The total addressable pomace stream under the Moderate Scenario is 50% of the annual total (26,500–33,000 tonnes); under the Advanced Scenario, 90% (47,700–59,600 tonnes). Within each scenario, the biomass is allocated across the four projects in proportions that reflect the cascade logic: high-value seed extraction receives priority allocation of the seed-rich fraction; the skin and pulp residual is distributed among composting, anaerobic digestion, and feed pathways.

**Step 2 — Investment and Operating Costs:** Capital and operating cost estimates are derived from:

- International engineering benchmarks from AGRIMAX (2019), EBA (2022), and ECN (2022), adjusted to reflect Armenian construction and labour cost levels at approximately 60–70% of Western European equivalents;
- Analogous projects in structurally comparable countries — Georgia (EU4Business composting pilot, Kakheti, 2021–2023) and Moldova (EBRD National Biogas Programme, 2019–2023);
- Armstat wage data for calibration: NACE 11.01–11.02 combined total wages AMD 16.2 billion in 2024 across approximately 3,200 industrial production staff (Value Chain Report: ~50 grape processing enterprises), giving an average annual employer cost of approximately AMD 5.4 million per employee (approximately USD 14,000 per FTE including employer social contributions; AMD/USD rate: 387, Armstat/CBA 2024 annual average).

**Step 3 — Direct Economic Effects:** Gross output equals volume processed multiplied by market price (product-specific). Value Added equals output multiplied by the applicable sectoral VA ratio. Sectoral VA ratios are derived directly from Armstat Form 1-TG data:

- NACE 11.01 (spirits/brandy): Revenue AMD 147.3 billion (2023) and AMD 155.1 billion (2024); intermediate consumption AMD 127.8 billion (2023) and AMD 116.1 billion (2024). Implied VA ratio: 13.2% (2023) and 25.2% (2024), two-year average approximately 19%. The spirits sector's high intermediate consumption (primarily raw grape and wine distillate input) compresses the VA ratio relative to wine; the 2024 improvement reflects efficiency gains and domestic price increases.
- NACE 11.02 (wine): Revenue approximately AMD 14.2 billion in both years; intermediate consumption AMD 10.8 billion (2023) and AMD 6.8 billion (2024). Implied VA ratio: 23.9% (2023) and 52.1% (2024), two-year average approximately 38%.
- For the new circular by-product processing activities (composting, AD, extraction) — which are distinct from the primary sector and more closely resemble agri-waste processing and specialty chemicals — a VA ratio of 35–45% is applied, consistent with international benchmarks for these sub-sectors.

Direct employment is estimated via an output-per-worker coefficient calibrated to Armenian agro-industrial wages of approximately USD 14,000 per FTE per year inclusive of social contributions.

**Step 4 — Indirect and Induced Effects:** In the absence of an Armenian national input-output table applicable to agro-processing by-product activities, proxy multiplier coefficients are applied and clearly labelled. These are drawn from World Bank benchmarks for lower-middle income agri-food economies and adjusted downward for Armenia's relatively high import dependence in equipment and packaging. Output multiplier: 1.20–1.35 (varying by project type, as documented below). Employment multiplier: 1.15–1.25.

**Step 5 — Trade and Resource Effects:** Import substitution is estimated as the value of circular outputs (compost, digestate, seed oil, extracts) that substitute for imported inputs (mineral fertilisers under HS 31, natural gas, and cosmetic/nutraceutical active ingredients). Export potential is estimated for grape seed oil and polyphenol extracts based on OIV and industry pricing benchmarks and conservative market penetration assumptions in EU cosmetic and nutraceutical markets.

### 5.1.3 Assumptions and Limitations

**Biomass volume uncertainty:** Armenia does not publish systematic data on agro-industrial by-product volumes. The 265,000-tonne grape throughput figure is derived from Armstat agricultural production statistics and Ministry of Economy reports and carries an estimated annual variability of ±15–20% depending on harvest conditions.

**No national input-output table:** Multiplier proxies introduce uncertainty of approximately ±20–30%. Sensitivity ranges are indicated throughout.

CAPEX estimates carry ±30% uncertainty reflecting the early-stage nature of these interventions in the Armenian context. Project-level feasibility studies are required before investment commitment.

**Prices used:** grape seed oil USD 7,000–8,000/tonne wholesale[70] (cosmetic-grade and organic grades at premium); polyphenol OPC extracts USD ≈15,000–35,000/tonne[71]; compost AMD 12,000–20,000/tonne domestic equivalent; biogas-to-electricity AMD 55–65/kWh[72]; digestate ≈ USD 6–10/tonne[73].

**Seasonal conversion:** 1 seasonal harvest-period worker (6–8 weeks) is converted to 0.3 FTE for annual employment estimates.

**The projects are not additive in terms of biomass:** each tonne of pomace can only pass through one primary valorisation pathway. Aggregate effects use allocated (non-overlapping) biomass volumes, not the sum of standalone project maximums.

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[70] Tridge market price data 2023–2024; https://dir.tridge.com/prices/grape-seed-oil

[71] Future Market Insights (2024). Grape Seed Extract Market: Global Industry Analysis and Forecast. https://www.futuremarketinsights.com/reports/grape-seed-extract-market

[72] R2E2 Fund (Renewable Resources and Energy Efficiency Fund of Armenia) https://old.r2e2.am/en/tariffs/

[73] Task 37: Energy from Biogas https://task37.ieabioenergy.com/

## *5.2 Sector Overview and Strategic Prioritisation*

### 5.2.1 Sector Overview

Armenia's fruit and vegetable processing sector encompasses NACE 10.3 (Processing and preserving of fruit and vegetables), NACE 11.01 (Distilling, rectifying and blending of spirits), and NACE 11.02 (Manufacture of wine from grape). The sector generated total nominal output of approximately AMD 199.9 billion in 2024 (USD ~516.6 million at AMD 387/USD), compared to AMD 58.4 billion in 2010, representing 3.3-fold nominal growth over 14 years.

The grape-processing subsegment (NACE 11.01 + 11.02) dominates the sector in value terms. Based on Armstat Form 1-TG data, NACE 11.01 (spirits including cognac/brandy) generated AMD 155.1 billion in revenue in 2024 (USD ~400.7 million), while NACE 11.02 (wine) contributed AMD 14.2 billion (USD ~36.7 million). Together, these two NACE codes account for approximately 84.7% of total sector revenue. The sector is strongly export-oriented: Armenian brandy and wine are among Armenia's principal industrial export categories.

### 5.2.2 Strategic Prioritisation Rationale

The fruit and vegetable processing sector in Armenia is structurally heterogeneous, combining highly fragmented small-scale processors (NACE 10.3) with relatively concentrated and capital-intensive grape processing (NACE 11.01–11.02). Multiple product types generate residues with different compositions, moisture levels, and contamination profiles. This diversity creates two structural challenges for circular economy implementation: (1) heterogeneity of waste streams, and (2) fragmentation of processing capacity, limiting economies of scale.

Circular interventions therefore cannot be designed generically for the entire sector. Prioritisation must follow the concentration of biomass, homogeneity of residue streams, scale feasibility, export orientation, and investment readiness. Based on the value chain analysis and the quantitative data reviewed, the grape-processing segment (wine and grape spirits) presents the strongest structural conditions for piloting scalable circular solutions:

- High concentration of processing capacity (~265,000 tonnes annually)
- Large, homogeneous residue streams (grape pomace, skins, seeds, stems), generating 53,000–66,250 tonnes of pomace annually
- Spatial clustering in Armavir, Ararat, and Vayots Dzor marzes, enabling hub-based logistics
- Export orientation and high value-added profile, with operators exposed to international sustainability standards
- Industrial-scale operators with greater investment capacity compared to fragmented NACE 10.3 processors

Circular pilots should therefore start in the grape-processing segment and, following proof of concept, expand to other sub-segments.

### 5.2.3 Baseline Circularity Status

The sector's current waste management practices are elementary. The table below summarises the pre-intervention baseline across the key by-product streams. This baseline defines the gap that the four priority projects are designed to address.

**Table 40. Baseline Circularity Status: Grape Processing Sector**

| Dimension | Current Status | Gap/Opportunity |
|---|---|---|
| Pomace management | Informally transferred to farms for feed (est. 50–60%) or discarded | No formal market, no quality standard, no systematic logistics |
| Grape seed utilisation | Seeds embedded in pomace; a small number of micro-enterprises extract seed oil at very limited scale (e.g. Dikond/Korits brand) | Industrial-scale extraction absent; the majority of seeds are currently unextracted |
| Stems/marc management | Mainly discarded or occasional informal composting | No composting standard or collection system |
| Post-distillation marc (NACE 11.01) | Marc distillation for residual ethanol recovery is practised at enterprise level by larger distillers — this is existing circular practice, not a new intervention | Smaller distillers may not practice marc recovery |
| Wastewater treatment | Minimal formal treatment at smaller operators; larger facilities have basic settling systems | High organic load (COD) entering soil and water bodies |
| Regulatory framework | No by-product classification for pomace; no mandatory residue management obligation | Single regulatory change could unlock entire commercial market |
| Biomass data availability | No systematic monitoring of by-product volumes or destinations | Investment decisions constrained by data gaps |

*Source: Author's assessment based on Companion Fruit and Vegetable Processing Sector Value Chain Report (February 2026), stakeholder consultations, and Armstat enterprise data*

### 5.2.4 Cascade Logic

This report assesses four circular economy interventions within the grape-processing segment. These projects do not form a strict chronological sequence; rather, they represent distinct valorisation pathways that operate as a cascade of value: the highest-value fractions are extracted first, and lower-value fractions cascade downstream.

The operational sequence can be represented as follows:

**Table 41. Cascade Valorisation Sequence: Biomass Allocation by Project**

| Cascade Stage | What happens | Project | Biomass fraction processed |
|---|---|---|---|
| Stage 1 (Highest value) | Grape seeds separated from pomace at pressing; seeds directed to oil and polyphenol extraction | Project 4<br>Bio-Extraction | Seed fraction: ~8,000–16,000 t/year (high-value) |
| Stage 2 (Medium-high value) | Seed cake (post-extraction residue) and skin/pulp fraction directed to composting hubs | Project 2<br>Composting | Skin/pulp + depleted seed cake: variable allocation |
| Stage 3 (Medium value) | Lower-grade or moisture-rich pomace fractions co-digested with manure for biogas | Project 3<br>Anaerobic Digestion | Lower-grade pomace + stems: variable allocation |
| Stage 4 (Foundational) | Residual stabilised pomace sold as standardised animal feed | Project 1<br>Structured Feed | Dried residual fraction: variable allocation |

*Source: Author's analysis. Biomass fractions derived from OIV (2023), Troilo et al. (2021)*

This cascade logic means that in a fully developed circular economy scenario, Project 4 is operationally the first step — seed extraction at winery level — even though it requires the most capital and technical preparation and is therefore the last to reach scale. In the near term, Projects 1–3 can be initiated without waiting for Project 4, because seed extraction is not yet practised at industrial scale: the current pomace stream is a mixed residue in which seeds have not been separated.

For the economic assessments, each project is modelled independently with a specified biomass allocation. This approach avoids double-counting while allowing each project to be evaluated on its own merits. Following section then presents a combined scenario illustrating how the four projects can co-exist within the total annual pomace stream.

### 5.2.5 Key Facts: Armenia's Grape Processing Biomass

Before presenting the modelling framework, it is necessary to establish the physical baseline that underpins all project calculations. Armenia’s grape processing throughput of approximately 265,000 tonnes per year generates a range of by-product streams. The estimates presented below are derived from standard industry composition ratios reported in the international vitivinicultural literature and validated against data from the International Organisation of Vine and Wine (OIV) and peer-reviewed studies on winery by-products.

**Table 42. Annual By-Product Streams from Armenia's Grape Processing Sector (~265,000 t/year throughput)**

| By-product stream | Basis for estimate | Volume (t/year) | Source/validation |
|---|---|---|---|
| Grape pomace (total: skins, seeds, pulp) | 20–25% of grape weight | 53,000–66,250 | OIV (2023); Troilo et al., 2021[74] |
| — of which: grape seeds | 3–6% of grape weight; ~15–25% of pomace | 7,950–15,900 | Spigno et al. (2007); Pinelo et al. (2004); Karastergiou et al., (2024)[75] |
| — of which: skins and pulp | remainder of pomace after seeds | 37,000–58,000 | Calculated |
| Grape stems/stalks | 3–5% of grape weight | 7,950–13,250 | OIV (2023); Troilo M. et al., 2021 |
| Exhausted marc (post-distillation) | 15–20% of spirits-sector grape weight | ~10,000–15,000 | Applicable to NACE 11.01 only; Feedipedia – Grape pomace[76] |
| Winery/distillery wastewater | 2–10 L/kg grapes | ~530,000–2,650,000 L | Molino et al. (2013); Bolzonella et al. (2019)[77]; international winery wastewater treatment literature. |

*Source: Author's calculations based on OIV (2023), Troilo et al. (2021), Spigno et al. (2007), Pinelo et al. (2004), Karastergiou et al. (2024), Molino et al. (2013), Bolzonella et al. (2019), and Feedipedia (grape pomace). Throughput figure derived from Armstat agricultural production statistics and Ministry of Economy reports*

### 5.2.6 Scenario Design

Two scenarios are modelled for each project and for the aggregate assessment. The Moderate Scenario reflects a realistic near-term adoption trajectory: formal circular economy activities capture 50% of the total available pomace stream, with investment at low-to-medium scale per project. The Advanced Scenario reflects a well-established sector-wide circular economy: 90% capture of the available stream and full-scale investment per project. These adoption rates are consistent with the scenario design framework adopted across all sector chapters of this Economic Impact Assessment series.

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[74] Troilo M. et al., 2021 Bioactive Compounds from Vine Shoots, Grape Stalks and Wine By-Products https://www.mdpi.com/2304-8158/10/2/342

[75] Karastergiou A., 2024 https://pmc.ncbi.nlm.nih.gov/articles/PMC11428247/

[76] Feedipedia – Grape pomace https://www.feedipedia.org/node/691

[77] Bolzonella, D., Fatone, F., & Cecchi, F. (2019). Winery wastewater treatment: Critical overview of biological processes. Water Science and Technology. https://pubmed.ncbi.nlm.nih.gov/30939935/

**Table 43. Scenario Design Parameters**

| Scenario | Biomass mobilised | Investment per project | Multiplier applied | Timeframe assumption |
|---|---|---|---|---|
| Moderate | 50% of total stream (~26,500–33,000 t/year) | Low–medium CAPEX | Conservative (lower bound) | 3–5 years from inception |
| Advanced | 90% of total stream (~47,700–59,600 t/year) | Full-scale CAPEX | Optimised (upper bound) | 6–10 years from inception |

*Source: Author's strategic assessment*

## *5.3 International Experience: Grape Processing Waste Valorisation*

### 5.3.1 Scale of Winery and Distillery Waste Globally

Grape processing generates one of the most extensively studied agro-industrial residue streams globally. At the macro level, approximately 10–13 million tonnes of grape pomace are generated annually worldwide, based on global wine grape processing volumes documented in OIV production statistics and peer-reviewed literature.[78]

In addition to pomace, the winemaking process also generates substantial quantities of related residues, including grape stems and distillation marc. These streams represent several additional million tonnes of biomass globally each year, depending on vineyard practices, pressing intensity, and the share of grapes processed for distillation.[79]

Within the European Union, winery residues are particularly concentrated. The EU-27 produces approximately 4–5 million tonnes of grape pomace annually, based on a wine-grape harvest of approximately 20.5 million tonnes in recent years.[80] Assuming a standard pomace yield of 20–25% of grape weight, this residue stream is primarily concentrated in major wine-producing countries including Italy, Spain, France, and Portugal.

Grape pomace — the compressed solid residue composed of skins, seeds, and pulp remaining after pressing — typically represents 20–25% of processed grape weight in wine production.[81] In distillation processes such as brandy or cognac production, more intensive pressing can increase the share of solid residues to approximately 25–30% of grape weight.

Within pomace, grape seeds represent approximately 3–6% of total grape weight, corresponding to roughly 15–25% of pomace mass, while the remaining fraction consists primarily of skins and residual pulp.[82]

From a valorisation perspective, the economic value hierarchy of pomace fractions typically follows the cascade structure:

grape seeds → grape skin polyphenols → residual pulp and stems,

reflecting the higher market value of grape seed oil and oligomeric proanthocyanidin (OPC) extracts, followed by lower-value applications such as feed, compost, or energy recovery.[83]

### 5.3.2 Waste Streams in Wine and Cognac/Brandy Production

The table below summarises the principal by-product streams generated in grape processing, their compositional characteristics, and established international valorisation pathways. Armenia's sector generates all of these streams; the relative proportion of post-distillation marc is higher than in purely wine-producing countries due to the dominance of NACE 11.01 spirits production.

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[78] Karastergiou, A. et al. (2024). *Valorization of grape pomace: bioactive compounds, extraction methods and applications.* https://pmc.ncbi.nlm.nih.gov/articles/PMC11428247/
ScienceDirect (2024). *Environmental valorisation of winery residues.* https://doi.org/10.1016/j.scitotenv.2024.172832

[79] Troilo, M. et al. (2021). *Bioactive Compounds from Vine Shoots, Grape Stalks and Wine By-Products.*
Foods Journal. https://www.mdpi.com/2304-8158/10/2/342

[80] Eurostat (2024). *Agricultural production – crops.*
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_production_-_crops

[81] Troilo, M. et al. (2021). *Bioactive Compounds from Vine Shoots, Grape Stalks and Wine By-Products.*

[82] *Karastergiou A., 2024 https://pmc.ncbi.nlm.nih.gov/articles/PMC11428247/*

[83] *AGRIMAX Project (2019). Cascading valorisation of agri-food processing residues through flexible multi-feedstock biorefinery technologies. EU Horizon 2020 Programme, Grant Agreement No. 720719* https://cordis.europa.eu/project/id/720719

**Table 44. Key By-Product Streams from Grape Processing and Their Typical Valorisation Pathways**

| By-product | % of Grape Weight | Key Characteristics | Primary Valorisation Pathways |
|---|---|---|---|
| Grape pomace (skins, seeds, pulp) | 20–25% | High moisture (65–75%), polyphenols, dietary fibre, tannins | Seed extraction → feed, compost, biogas |
| Grape seeds (within pomace) | 3–6% of grape weight; 15–25% of pomace | Seed oil 10–15%, proanthocyanidins (OPC), high-value polyphenols | Cold-press oil extraction; polyphenol/OPC extraction |
| Grape stems/stalks | 3–5% | High lignocellulose content, lower moisture than pomace | Compost, biogas co-digestion |
| Exhausted marc (post-distillation) | 15–20% of spirits-sector grape input | Reduced sugar content, partially dried; ethanol already recovered | Compost, biogas, soil amendment |
| Winery wastewater (lees, wash water) | 2–10 L/kg grapes | High COD, tartaric acid salts | Anaerobic treatment for biogas; tartrate recovery |
| Wine/spirit lees (yeast sediment) | 1–3% | Tartrates, yeast biomass, residual ethanol | Tartrate extraction (cream of tartar); already practised industrially |

*Source: Author's compilation based on OIV (2023), Molino et al. (2013), Bolzonella et al. (2019), Feedipedia (grape pomace), and international vitivinicultural literature*

### 5.3.3 Key Valorisation Pathways: International Evidence and Benchmarks

#### *5.3.3.1 Animal Feed*

The use of dried grape pomace in ruminant nutrition is a well-documented practice in Mediterranean winemaking countries. Research indicates that grape pomace can be safely included in cattle and sheep diets at up to 10–15% of total dry matter intake without adverse health effects, due to its high content of dietary fibre and polyphenolic compounds.[84]

In Mediterranean wine regions, grape pomace is commonly utilised as a low-value feed ingredient or composting material, allowing wineries to reduce waste disposal volumes and associated management costs.[2] In practice, the material is often transferred or sold to feed compounders or livestock producers at low bulk prices typically around EUR 20–40 per tonne, while simultaneously avoiding waste treatment or disposal costs that can range between EUR 15–30 per tonne depending on regional waste management fees.[85]

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[84] Feedipedia (FAO/INRAE/CIRAD) https://www.feedipedia.org/node/691

[85] Karastergiou, A. et al. (2024). *Valorization of grape pomace: bioactive compounds, extraction methods and applications.* https://pmc.ncbi.nlm.nih.gov/articles/PMC11428247

### *5.3.3.2 Industrial Composting*

The European Compost Network (ECN) documents a well-developed composting and anaerobic digestion sector across Europe. According to the ECN Data Report 2022, the EU-27 produces approximately 17.6 million tonnes of compost annually, and agriculture is the dominant end-use market for compost.[86]

In France, the marketing and use of compost are supported by an established regulatory framework, including AFNOR NF U44-051, which sets specifications and marking requirements for organic soil improvers.[87] This makes France one of the more institutionally developed compost markets in Europe.

For winery residues specifically, the international literature confirms that grape pomace and related residues can be successfully composted, either alone or in combination with bulking agents such as green waste or straw, producing a stabilised and mature compost suitable for soil application.[88]

Available European market benchmarks indicate that compost economics vary significantly by product quality and end-use segment. ECN-related market evidence shows that compost has a low value in the largest market segment, agriculture, while higher prices are observed in retail and specialised horticultural uses. One ECN-cited benchmark reports a weighted average compost price of about EUR 10.1 per tonne (fresh mass) across market segments in Europe, while another ECN-related guidance document notes that prices can be around EUR 2 per tonne in agriculture and rise to about EUR 75 per tonne in retail markets.[89]

For the post-Soviet regional context, a credible policy benchmark exists in Georgia's NDC Financing Strategy and Investment Plan, which includes a pilot composting project for biodegradable wine and agricultural residues. The document states that such pilot composting projects may cost approximately GEL 320,000–325,000 per site, and explicitly frames them as a practical solution for farms and wineries.[90]

Taken together, the international evidence indicates that composting of winery residues is a technically established and institutionally validated valorisation pathway, but its commercial performance depends heavily on scale, feedstock logistics, access to bulking materials, compost quality standards, and the local market outlet for the final product.

### *5.3.3.3 Anaerobic Digestion for Biogas*

Anaerobic digestion of winery residues, including grape pomace, is an established valorisation pathway in several European countries. In particular, Italy, Germany, and Austria have large and mature agricultural biogas sectors in which mixed organic feedstocks, including agro-industrial residues, are routinely processed in co-digestion systems. [91]

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[86] European Compost Network (ECN). *ECN Data Report 2022: European Compost and Digestate Production and Market Data.* https://www.compostnetwork.info/ecn-data-report/

[87] AFNOR (Association Française de Normalisation). *NF U44-051 — Organic soil improvers: Designations, specifications and marking.* https://www.boutique.afnor.org/en-gb/standard/nf-u44051/organic-soil-improvers-designations-specifications-and-marking/fa125064/754

[88] Sustainability (MDPI). *Composting Waste from the White Wine Industry.* https://www.mdpi.com/2071-1050/15/4/3454

[89] European Compost Network / LIFE BIOBEST Project. *Guidelines on Compost Quality and Market Development in Europe.* https://zerowasteeurope.eu/wp-content/uploads/2024/06/240530_WP3_D3.3_GuidelineQuality_ECN_Submitted.pdf

[90] Government of Georgia. *NDC Financing Strategy and Investment Plan.* https://geo.org.ge/wp-content/uploads/2023/05/D10_Final_NDC_Financial_Strategy_Investment_Plan_v1.pdf

[91] European Biogas Association (EBA). *Statistical Report of the European Biogas Association.* https://www.europeanbiogas.eu/eba-statistical-report/

Fresh grape pomace typically has high moisture content, commonly in the range of about 65–75%, which makes it more suitable for biological conversion pathways such as anaerobic digestion than for direct combustion without prior drying. [92]

Published studies indicate that grape pomace has a meaningful biogas and methane potential, but reported yields vary materially depending on grape variety, seed content, pre-treatment, fermentation conditions, and whether results are expressed on a fresh-mass, volatile-solids, or COD basis. Recent literature reports methane potential for grape pomace in the order of about 448 $m^3$ per tonne of organic dry matter, while experimental studies also confirm that grape pomace can be anaerobically digested successfully as a standalone substrate or in co-digestion systems. [93]

From an operational perspective, co-digestion with livestock manure is widely regarded as advantageous, because manure improves buffering capacity, moisture balance, and nutrient availability, thereby supporting process stability. For this reason, grape pomace is typically considered most suitable for AD when integrated into mixed-substrate agricultural biogas systems, rather than as a single feedstock in small standalone units.[94]

For medium-scale agricultural biogas plants in Europe, capital requirements are strongly scale-dependent, but publicly available case material and techno-economic references indicate that installations processing on the order of several thousand to tens of thousands of tonnes of feedstock per year commonly require low-single-digit to several-million-euro investments. For example, one European case documented under the Biogas Action initiative reports an investment of about EUR 3.8 million for a plant processing 18,300 tonnes of biowaste per year. More broadly, IEA Bioenergy and related European cost studies consistently show that smaller plants face materially higher unit costs than larger plants, confirming the importance of economies of scale.[95]

For Eastern Europe and the wider transition-economy context, multilateral and regional programmes confirm continuing policy and investment support for agricultural residue utilisation, including biogas and composting solutions for farms and food-processing residues. In Georgia, for example, OECD/EU4Environment work has explicitly included anaerobic digestion facilities for food and beverage producers within proposed project pipelines for biodegradable agricultural residues and bio-waste.[96]

Taken together, the international evidence indicates that anaerobic digestion is a technically credible and scalable valorisation pathway for grape pomace, especially where it is integrated with manure or other wet organic substrates. Its commercial viability depends primarily on feedstock aggregation, stable year-round substrate supply, plant scale, energy off-take arrangements, and the cost of digestate management.

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[92] Abreu, T. et al. (2024). *Grape Pomace as a Renewable Natural Biosource of Value-Added Compounds.* https://www.mdpi.com/2306-5710/10/2/45

[93] Curčić, S. et al. (2025). *Assessing Biogas Production Potential from Organic Waste and Livestock Byproducts.* https://www.mdpi.com/2071-1050/17/7/3144
El Achkar, J.H. et al. (2016). *Anaerobic digestion of grape pomace.* https://pubmed.ncbi.nlm.nih.gov/26944865/

[94] Kassongo, J. et al. (2022). *Substrate-to-inoculum ratio drives solid-state anaerobic digestion of grape marc and cheese whey.* https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0262940
European Biogas Association (EBA). *Statistical Report 2024 – European Biogas Sector Overview.* https://www.europeanbiogas.eu/wp-content/uploads/2024/12/EBA_stats_report_complete_241204_preview.pdf

[95] IEA Bioenergy Task 37. *Biogas plant investment and operational cost benchmarks.* https://www.ieabioenergy.com/wp-content/uploads/2018/01/biogas_costs_task37.pdf
Biogas Action Project Case Study. https://www.czba.cz/files/ceska-bioplynova-asociace/uploads/files/Biogas%20Action%20Brochure.pdf

[96] OECD / EU4Environment Programme. *Utilising agricultural residues: experience from European countries.* https://www.eu4environment.org/events/utilising-agricultural-residues-experience-from-european-countries/

#### *5.3.3.4 High-Value Bio-Compound Extraction*

High-value bio-compound extraction represents one of the most commercially developed valorisation pathways for grape-processing residues, particularly where grape pomace and grape seeds are used as feedstocks for oils, polyphenolic extracts, and other functional ingredients. The underlying resource base is well established in the literature: approximately 1000 kg of grapes generate about 750 L of wine and around 120 kg of grape pomace, consisting mainly of skins, seeds, and pulp, while grape seeds typically account for roughly 20–25% of pomace mass, although the exact share varies depending on grape variety and processing conditions.[97]

Among the main commercial products, grape seed oil is the most transparent in terms of publicly observable market prices. Transaction-based trade data compiled by Tridge indicate that global wholesale prices for grape seed oil were approximately USD 7.12–7.15/kg in 2023 and USD 7.85–7.86/kg in 2024, while global export/import prices ranged between USD 4.71–11.69/kg in 2023 and USD 4.65–11.27/kg in 2024.[98] These values correspond to roughly USD 7,120–7,860 per tonne for wholesale trade and USD 4,650–11,270 per tonne for international transactions, depending on grade, extraction method, certification (e.g., organic), and destination market.

For grape-derived extracts, including standardized grape seed or grape skin extracts rich in polyphenols and oligomeric proanthocyanidins (OPC), publicly available trade data indicate substantial dispersion across markets and quality tiers. Tridge import statistics show grape-derived extract prices in South Korea of USD 30.5–283/kg in 2023 and USD 29–210/kg in 2024, Germany of USD 26.85–32.08/kg in 2023 and USD 27.62/kg in 2024, and Vietnam of USD 14.2–56.92/kg in 2023 and USD 18.6–63/kg in 2024[99]. This suggests that internationally traded grape-derived extracts typically fall within a broad range from tens to several hundred US dollars per kilogram, depending on purity, standardization of active compounds, formulation, and end-use applications in nutraceutical, cosmetic, or functional food markets.

One of the most valuable compounds derived from grape residues is resveratrol, a polyphenolic antioxidant widely used in pharmaceutical and nutraceutical products. Public transaction records compiled by PharmaCompass indicate highly variable international trade prices, with observed transactions around USD 205/kg, USD 390/kg, USD 405–410/kg, and in certain high-specification pharmaceutical cases up to USD 5,381/kg[100]. This confirms that resveratrol represents a high-value but niche market segment where price levels depend strongly on purity, specification, and regulatory grade.

France provides one of the clearest European reference points for commercial grape-extract production, supported by established industrial producers such as Grap'Sud and Nexira, both of which market grape seed and grape polyphenol extracts for nutraceutical and food-ingredient markets[101]. The presence of specialized processing companies in the main wine-producing regions illustrates the maturity of grape-derived bioactive ingredient production within the European agri-food sector.

At the technology-demonstration level, the EU Horizon 2020 AGRIMAX project provides additional evidence of the technical and economic feasibility of multi-feedstock biorefinery systems for agricultural residues. According to the official project documentation, AGRIMAX demonstrated integrated cascading

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[97] Pinelo, M., Arnous, A., & Meyer, A. S. (2006). *Upgrading of grape skins: Significance of plant cell-wall structural components and extraction techniques for phenol release.* Trends in Food Science & Technology. https://doi.org/10.1016/j.tifs.2006.05.003

[98] Tridge Global Market Intelligence – Grape Seed Oil Prices https://dir.tridge.com/prices/grape-seed-oil

[99] Tridge Market Data – Grape Skin Extract / Polyphenol Extract Prices https://dir.tridge.com/ko/prices/grape-skin-extract/KR

[100] PharmaCompass – Resveratrol API Prices https://www.pharmacompass.com/price/resveratrol

[101] Grap'Sud Nutraceutical Ingredients https://www.grapsud.com/en/nutrition-and-health-centre/human-nutraceuticals
Nexira Natural Ingredients https://www.nexira.com

processing of agri-food residues such as tomatoes, cereals, olives, and potatoes, producing bioactive compounds, food ingredients, packaging materials, and bio-fertilisers[102]. The project confirmed that residue-based biorefinery concepts can be technically viable within circular bioeconomy frameworks.

For grape pomace specifically, one of the most detailed techno-economic analyses is the study by Jin et al. (2021), which modelled a commercial-scale grape pomace biorefinery processing 32,659 tonnes of feedstock per year. In this model, total capital investment was estimated at approximately USD 46.9 million for a configuration producing grape seed oil and polyphenols, and USD 59.6 million for a configuration producing grape seed oil, polyphenols, and biochar. Annual operating costs were estimated at USD 16.6 million and USD 16.3 million, respectively[103]. These findings indicate that extraction-based valorisation can be economically viable at industrial scale but generally requires substantial capital investment and technically advanced processing systems.

Overall, the available evidence suggests that extraction of high-value bioactive compounds from grape-processing residues represents a commercially relevant valorisation pathway, particularly for products such as grape seed oil, polyphenolic extracts, and specialty compounds including resveratrol. However, this pathway is best characterised as high-value but technologically demanding and capital-intensive, with strong sensitivity to feedstock quality, extraction efficiency, regulatory standards, and market positioning within nutraceutical, cosmetic, and pharmaceutical value chains.

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[102] Circular Bio-based Europe Joint Undertaking – AGRIMAX Project https://www.cbe.europa.eu/projects/agrimax

[103] Jin, B. et al. (2021). *Techno-economic analysis of grape pomace biorefinery.* https://www.bioenergy.org.nz/documents/resource/Techno-economic-analysis-of-grape-pomace-biorefinery.pdf

## *5.4 Economic Impact Assessment: Priority Projects*

Each of the four projects below is assessed independently, with a specified biomass allocation under each scenario. This means each project is evaluated as if it were the sole user of its allocated fraction of the pomace stream. This approach ensures that the economic figures for each project are self-consistent and not inflated by double-counting the same biomass. The aggregate picture — including how all four projects can coexist by sharing the total pomace stream.

The term 'standalone basis' used below means: what would the economics of this project look like if this specific biomass allocation were dedicated entirely to this pathway? This provides a clear, comparable basis for evaluating each intervention on its own merits before considering portfolio combinations.

### 5.4.1 Project 1 — Structured Feed Pathway for Grape Pomace

#### *5.4.1.1 Rationale and Scope*

Currently, grape pomace disposal in Armenia is predominantly informal: wineries and distilleries transfer pomace at zero or near-zero price to nearby farms, where it is fed to livestock without standardisation, drying, or quality control. When local livestock absorption capacity is exceeded — which occurs regularly during the concentrated September–October harvest season — pomace is simply discarded near production sites rather than properly managed. This project formalises and standardises the existing informal feed pathway through drying or ensiling, basic quality testing, formal supply contracts between operators and livestock farms, and standardised inclusion protocols. It requires the lowest capital investment of the four projects and can be initiated before the other projects reach scale.

On the standalone basis: this project is assessed as if it processes its allocated share of the total pomace stream. In the cascade allocation model, Project 1 receives the residual fraction — material not selected for higher-value pathways. The standalone assessment below uses the full allocated volume to establish a clear per-tonne economics baseline.

Biomass allocated (standalone): Moderate scenario — 13,000–16,000 tonnes/year of dried/stabilised pomace (representing approximately 50% of the total stream); Advanced scenario — 24,000–30,000 tonnes/year (90% of stream). These volumes would be proportionally reduced in the cascade allocation model.

#### *5.4.1.2 Physical and Financial Modelling Assumptions*

The following parameters define the investment and operating profile of this project. CAPEX covers mobile or fixed drying/ensiling units deployed at winery clusters; OPEX covers energy for drying, labour, transport, and basic quality testing. Market price of dried pomace is based on Italian and Spanish feed market benchmarks adjusted for Armenian livestock market conditions.

The number of drying units required is estimated on the basis of equipment capacity benchmarks and the spatial distribution of processing capacity. Standard mobile agricultural belt driers with a throughput of 1,500–2,500 tonnes of fresh material per season (6–8 weeks of operation) are widely available from European suppliers (e.g., Stela Laxhuber, Bühler Group). At the Moderate Scenario volume of 13,000–16,000 tonnes per season, 3–5 units are required to achieve adequate throughput given the concentration of harvest-period supply. At the Advanced Scenario volume of 24,000–30,000 tonnes, 7–10 units are required, reflecting both higher throughput and the need for geographic distribution across Armavir and Ararat marz processing clusters to minimise transport costs. These estimates are consistent with deployment patterns observed in the Georgia EU4Business composting and drying pilot (Kakheti, 2021–2023) and in AGRIMAX (2019) cost benchmarks for mobile biomass processing units.

The dried pomace yield ratio of approximately 40% mass loss on drying reflects the moisture content of fresh grape pomace (typically 65–75% moisture as reported by Molino et al. (2013) and Bolzonella et al. (2019)) and standard drying targets to achieve a shelf-stable product at 10–12% residual moisture, consistent with Italian and Spanish commercial feed ingredient standards.

**Table 45. Physical and Financial Modelling Assumptions for Project 1 (Structured Pomace Feed Pathway)**

| Parameter | Moderate Scenario | Advanced Scenario | Basis/Source |
|---|---|---|---|
| Pomace processed (t/year, fresh weight) | 13,000–16,000 | 24,000–30,000 | 50% / 90% of total stream |
| Drying equipment (mobile/fixed units) | 3–5 units | 7–10 units | Mobile belt driers, throughput 1,500–2,500 t/season/unit; Stela Laxhuber / Bühler benchmarks; consistent with Georgia EU4Business pilot (Kakheti, 2021–2023) and AGRIMAX (2019) |
| CAPEX: drying infrastructure (USD) | 150,000–280,000 | 300,000–560,000 | AGRIMAX (2019); Georgia EU4Business pilot; Armenian construction cost adjustment (60–70% of W. European equivalent) |
| Annual OPEX: energy, labour, logistics (USD) | 80,000–130,000 | 160,000–260,000 | Armenian labour cost calibration (USD 14,000/FTE incl. employer contributions); energy benchmark for belt dryers |
| Dried pomace yield (approx. 40% mass loss) | 7,800–9,600 t dried/year | 14,400–18,000 t dried/year | Fresh pomace moisture 65–75% (Molino et al., 2013; Bolzonella et al., 2019); drying target: 10–12% residual moisture for shelf-stable feed ingredient |

| | | | |
|---|---|---|---|
| Market price of dried pomace (USD/tonne) | 18–30 | 18–30 | Italy/Spain feed market benchmarks (EUR 20–40/t: OIV, 2023; Feedipedia – Grape pomace); adjusted for Armenian livestock market purchasing capacity |
| Annual gross output (USD) | 140,000–288,000 | 259,000–540,000 | Volume × price |
| VA ratio applied | 35% | 35% | Agri-waste processing sub-sector benchmark |

*Source: Author's analysis based on AGRIMAX (2019), Georgia EU4Business pilot (Kakheti, 2021–2023), Molino et al. (2013), Bolzonella et al. (2019), OIV (2023), Feedipedia, and Armstat wage calibration. CAPEX adjusted for Armenian construction and labour cost conditions (60–70% of Western European equivalents)*

#### *5.4.1.3 Direct Economic Effects*

The table below presents the direct economic effects — value added and employment generated by the drying, quality testing, logistics, and supply chain activities of this project. These are the effects attributable solely to the formalisation and commercialisation of the pomace feed pathway, not to the wider livestock sector it supplies.

**Table 46. Estimated Direct Economic Impacts of Project 1**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Annual gross output (USD) | ~215,000 | ~400,000 |
| Value added generated (USD/year) | ~75,000 | ~140,000 |
| Direct FTE jobs created | 6–10 | 12–18 |
| Average annual wage per FTE (USD) | ~5,500–7,500 | ~5,500–7,500 |
| Wage bill (USD/year) | ~40,000–65,000 | ~75,000–120,000 |

*Source: Author's calculations. VA ratio of 35%. Employment estimated via output-per-worker coefficient calibrated to Armenian agro-industrial wages of USD 14,000/FTE (Armstat NACE 11.01–11.02, 2024)*

#### *5.4.1.4 Indirect, Trade and Multiplier Effects*

The multiplier effects for this project are intentionally conservative: the feed pathway has limited domestic backward linkages (drying equipment is largely imported; logistics services are low-value-added). The primary indirect economic benefit is a cost saving to livestock farmers from access to a standardised, affordable protein/fibre supplement that partially substitutes imported feed concentrates. At Armenian livestock feed concentrate import prices of approximately AMD 300–500/kg, the substitution value per tonne of dried pomace used in feed is USD 25–60/tonne, implying aggregate feed cost savings to farmers of USD 195,000–576,000/year across the sector at full Advanced Scenario scale.

**Table 47. Indirect and Trade Effects from Pomace-Based Feed Substitution**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Output multiplier applied | 1.20 | 1.20 |
| Employment multiplier applied | 1.15 | 1.15 |
| Total output including indirect effects (USD) | ~258,000 | ~480,000 |
| Total jobs: direct + indirect (FTE) | 7–12 | 14–21 |
| Feed cost saving to livestock farmers (USD/year) | ~70,000–140,000 | ~140,000–290,000 |
| Import substitution — feed concentrates (USD/year) | ~50,000–100,000 | ~90,000–200,000 |

*Source: Author's calculations. Output multiplier 1.20 and employment multiplier 1.15 drawn from World Bank benchmarks for lower-middle-income agri-food economies, adjusted for Armenia's import dependence in equipment and packaging*

### *5.4.1.5 Cost-Benefit Snapshot*

The cost-benefit snapshot below compares total capital investment against the annual economic value generated. The payback period is calculated as CAPEX divided by annual value added (a conservative metric; the full economic return to society including farmer feed savings would shorten the payback).

**Table 48. Cost–Benefit Overview for Project 1**

| Indicator | Moderate | Advanced |
|---|---|---|
| Total CAPEX (USD) | 150,000–280,000 | 300,000–560,000 |
| Annual VA gain (USD/year) | ~75,000 | ~140,000 |
| Annual gross output (USD/year) | ~215,000 | ~400,000 |
| Direct jobs (FTE) | 6–10 | 12–18 |
| Total jobs with multiplier (FTE) | 7–12 | 14–21 |
| Import substitution — feed (USD/year) | 50,000–100,000 | 90,000–200,000 |
| Payback period (CAPEX / annual VA) | ~2–3.5 years | ~2–4 years |

*Source: Author's analysis. Payback period calculated as CAPEX divided by annual value added; full social return including farmer feed savings would yield a shorter effective payback*

### 5.4.1.6 Fiscal and Distributional Effects

This project creates a formalised SME category — commercial pomace aggregators and drying operators — that generates modest but real fiscal revenues from activities currently occurring informally and generating no tax contribution. Estimated annual fiscal revenues per medium-scale operator: VAT on sales approximately USD 5,000–10,000; payroll tax on 6–10 FTE approximately USD 8,000–15,000; corporate profit tax approximately USD 3,000–8,000. Aggregate fiscal contribution: USD 16,000–33,000/year (Moderate); USD 30,000–60,000/year (Advanced). Rural and regional distribution: activities are located at winery clusters in Armavir and Ararat marzes, and supply linkages reach livestock farms across adjacent agricultural zones. The project creates entry-level rural employment accessible to semi-skilled workers, with a relatively low gender barrier to participation in sorting, basic testing, and logistics roles.

### 5.4.1.7 Risks, Trade-offs and Recommended Modifications

The principal risk for this project is the limited ceiling on economic value: dried pomace is a commodity feed ingredient with a low market price that competes against cheap grain and forage alternatives in the Armenian livestock sector. The project's economic case rests primarily on avoided disposal costs and farmer convenience rather than high product margins. The recommended institutional model — a licensed private company rather than a cooperative — reflects the structural weakness of collective action in Armenia's agricultural sector, as confirmed by stakeholder consultations. Georgian and Moldovan precedents show that private aggregator-processor companies operating on fee-for-service or revenue-sharing arrangements with wineries are viable at 2,000–5,000 tonnes/year throughput.

**Table 49. Key Risks and Mitigation Measures for Project 1**

| Risk | Severity | Mitigation |
|---|---|---|
| Low product margin / commodity price | Medium | Position as avoided-disposal-cost saving for wineries; target premium livestock operations |
| Seasonal supply concentration | Medium | Invest in dry storage; supplement with fruit residues from NACE 10.3 in off-season |
| Variable pomace quality | Low–Medium | Standardised testing protocol; develop basic Armenian feed quality spec for dried pomace |
| Cooperative model failure | High — mitigated by design | Private company model (not cooperative) is the recommended institutional form |
| Competition from Projects 2–4 for same biomass | Medium | Project 1 receives residual fraction in cascade; feed pathway serves material not suited for higher-value use |

*Source: Author's assessment based on stakeholder consultations, Georgia EU4Business pilot experience, and Moldovan private aggregator-processor precedents*

### 5.4.2 Project 2 — Regional Industrial Composting Hubs

#### *5.4.2.1 Rationale and Design*

Grape pomace, stems, and exhausted marc from post-distillation exceed local agricultural absorption capacity during the concentrated harvest period and represent a significant environmental risk if simply discarded: anaerobic decomposition in open stockpiles generates methane emissions, leachate can contaminate soil and groundwater, and fire risks exist at larger accumulation sites. The solution proposed is the establishment of privately operated regional composting hubs in Armavir and Ararat marzes — the two highest-throughput grape processing clusters — to aggregate, biologically stabilise, and convert grape pomace and related agro-industrial organic residues into standardised compost product for sale to farms.

The recommended institutional model is a licensed private company (not a cooperative) accepting residue inputs under service contracts and independently producing and marketing compost. This model reflects successful precedents from France (AGROCAP SAS in Languedoc-Roussillon), Georgia (Ecomedia Ltd, Kakheti, EU4Business-supported), and Moldova (Biotera LLC, EBRD-supported). In Armenia's context, cooperative ownership has historically encountered governance failures; a commercial operator model is more robust.

Biomass allocated (standalone basis): Moderate scenario — 8,000–12,000 tonnes/year of fresh pomace and stem inputs; Advanced scenario — 15,000–22,000 tonnes/year. In the cascade model, this project receives the skin/pulp fraction after seeds have been extracted, plus stems and other lower-grade residues.

#### *5.4.2.2 Physical and Financial Modelling Assumptions*

Compost hub investment reflects land preparation, aeration equipment, turning machinery, leachate collection, and basic covered windrow or in-vessel composting infrastructure. CAPEX is calibrated to Georgian and Moldovan precedents and validated against ECN benchmark data for small regional hubs in Southern European and transition economy contexts.

The number of composting hubs is determined by the spatial concentration of biomass supply and the economic unit size at which a composting operation is commercially viable. ECN (2022) data and analogous projects in Georgia and Moldova indicate that a minimum throughput of approximately 5,000–8,000 tonnes per year is required for a hub to operate profitably. This implies 1–2 hubs at the Moderate Scenario volume (8,000–12,000 tonnes/year) and 2–4 hubs at the Advanced Scenario volume (15,000–22,000 tonnes/year). Geographic distribution across Armavir and Ararat marzes is advisable in the Advanced Scenario to reduce transport costs and capture biomass from processing clusters in both marzes; establishing a single very large hub in one location would create prohibitive logistics costs for distant wineries. CAPEX per hub is higher in the Advanced Scenario because larger throughput units require more substantial infrastructure (covered in-vessel composting or tunnel systems rather than simple open windrows) to comply with hygienisation requirements and manage higher input volumes.

**Table 50. Physical and Financial Modelling Assumptions for Project 2**

| Parameter | Moderate Scenario | Advanced Scenario | Basis/Source |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Organic input processed (t/year) | 8,000–12,000 | 15,000–22,000 | Allocated fraction of pomace stream + stems |
| Number of composting hubs | 1–2 | 2–4 | Minimum viable scale ~5,000–8,000 t/year per hub (ECN, 2022); biomass concentration in Armavir / Ararat marzes; transportation radius constraint (~30 km) requiring geographic distribution at Advanced Scenario scale |
| CAPEX per hub (USD) | 450,000–850,000 | 600,000–1,100,000 | ECN (2022) benchmark for small EU regional hubs (EUR 400,000–900,000); Georgia EU4Business pilot (Ecomedia, Kakheti, 2021–2023); Armenian construction cost adjustment (60–70% of W. European); higher upper bound in Advanced Scenario reflects in-vessel/tunnel composting infrastructure |
| Total CAPEX (USD) | 450,000–1,700,000 | 1,200,000–4,400,000 | Calculated (hubs × CAPEX per hub) |
| Annual OPEX per hub (USD) | 70,000–130,000 | 90,000–160,000 | Labour + energy + transport; calibrated to Armenian wage levels (USD 14,000/FTE) and ECN operating cost benchmarks |
| Compost output (40% mass recovery) | 3,200–4,800 t/year | 6,000–8,800 t/year | Standard composting mass recovery ratio (ECN, 2022; Troilo et al., 2021) |
| Compost price (USD/tonne) | 12–22 | 12–22 | Armenian domestic fertiliser market equivalent; ECN (2022) weighted average EUR 10.1/t (agricultural segment); |

|  |  |  |  |
|---|---|---|---|
|  |  |  | premium for certified product consistent with Moldovan EBRD programme data |
| Annual gross revenue (USD) | 38,000–106,000 per hub | 72,000–194,000 per hub | Volume × price |

*Source: Author's analysis based on ECN Data Report (2022), Georgia EU4Business pilot (Ecomedia Ltd, Kakheti, 2021–2023), EBRD Moldova National Biogas Programme (2019–2023), and Armstat wage calibration. CAPEX adjusted for Armenian conditions (60–70% of Western European equivalents)*

#### *5.4.2.3 Direct Economic Effects*

Direct economic effects are generated by hub operation, including composting process management, biomass logistics, quality testing, compost marketing, and ancillary maintenance and administration roles. The hub model creates stable year-round employment (not purely seasonal), as composting is a continuous process with seasonal input peaks managed through biomass storage.

**Table 51. Direct Economic Effects of the Regional Composting Hub Model**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Annual gross output (USD) | ~200,000–350,000 | ~450,000–900,000 |
| Value added (35% VA ratio) (USD/year) | ~70,000–122,500 | ~157,500–315,000 |
| Direct FTE jobs per hub | 7–11 | 9–14 |
| Total direct FTE (all hubs) | 7–22 | 18–56 |
| Average annual wage per FTE (USD) | ~5,500–7,500 | ~5,500–7,500 |

*Source: Author's calculations. VA ratio of 35%. Employment estimated via output-per-worker coefficient calibrated to Armenian agro-industrial wages of USD 14,000/FTE (Armstat NACE 11.01–11.02, 2024)*

#### *5.4.2.4 Indirect, Trade and Multiplier Effects*

The composting hubs generate indirect effects through backward linkages (transport, equipment maintenance, basic materials) and forward linkages to the agricultural sector. The most significant trade benefit is import substitution for mineral fertilisers: standardised compost with documented NPK content displaces a portion of Armenia's mineral fertiliser imports, which totalled approximately USD 22 million in 2024 under HS 31. At a compost-to-fertiliser nutrient equivalence value of USD 100–150/tonne of compost (relative to blended NPK mineral fertiliser pricing), the import substitution value is substantial.

An additional but currently unmonetised benefit is greenhouse gas emission avoidance: preventing the anaerobic decomposition of discarded pomace avoids methane generation estimated at 80–120 kg $CO_2$-equivalent per tonne of pomace processed (based on IPCC Tier 1 default emission factors for organic waste decomposition). At full Advanced Scenario scale, this represents avoidance of 1,200–2,640 tonnes $CO_2e$ per year — a quantifiable climate benefit potentially eligible for voluntary carbon market crediting or donor green finance instruments.

This climate mitigation component significantly increases the project's eligibility for EU-supported green transition financing. Under the EU Green Deal and associated instruments — including the EU4Agriculture programme, the EBRD Green Economy Financing Facility (GEFF), and the Green Climate Fund's Enhanced Direct Access modalities — measurable greenhouse gas reductions from waste valorisation are an increasingly prominent eligibility criterion. Projects that combine organic waste diversion with verifiable emission reductions are treated as priority interventions in EU Neighbourhood climate action programmes, including those applicable to Armenia under the EU–Armenia Comprehensive and Enhanced Partnership Agreement (CEPA). Quantified GHG avoidance from the composting hubs should therefore be systematically documented from project inception, both to strengthen grant applications and to position the project for potential voluntary carbon market registration under Gold Standard or Verra VCS methodologies applicable to composting of organic waste.

**Table 52. Indirect Economic Effects, Fertiliser Import Substitution and GHG Avoidance**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Output multiplier applied | 1.25 | 1.25 |
| Employment multiplier applied | 1.20 | 1.20 |
| Total output including indirect effects (USD) | ~250,000–437,500 | ~562,500–1,125,000 |
| Total jobs: direct + indirect (FTE) | 8–26 | 22–67 |
| Fertiliser import substitution (USD/year) | ~200,000–450,000 | ~400,000–900,000 |
| GHG avoidance (tonnes $CO_2e$/year) | ~640–1,440 | ~1,200–2,640 |

*Source: Author's calculations. GHG avoidance based on IPCC Tier 1 default emission factors for organic waste decomposition. Fertiliser import substitution benchmarked against UN Comtrade HS 31 import data (USD 22 million, 2024). Output multiplier 1.25 and employment multiplier 1.20*

### *5.4.2.5 Cost-Benefit Snapshot*

The composting hub model shows a longer payback period than Project 1 (feed pathway) due to its higher capital requirement, but generates substantially greater environmental and import substitution benefits. Public co-financing of 25–35% of CAPEX — potentially provided through Armenia’s state budget environmental programmes, EBRD GEFF, EU4Agriculture, or national environmental fund mechanisms — would reduce the private investment burden and shorten the effective payback period to approximately 3–4 years.

**Table 53. Cost–Benefit Overview for Regional Composting Hubs**

| Indicator | Moderate | Advanced |
|---|---|---|
| Total CAPEX (USD) | 0.45–1.70 million | 1.20–4.40 million |
| Annual VA gain (USD/year) | ~70,000–122,500 | ~157,500–315,000 |
| Annual gross output (USD/year) | ~200,000–350,000 | ~450,000–900,000 |
| Total jobs with multiplier (FTE) | 8–26 | 22–67 |
| Fertiliser import substitution (USD/year) | 200,000–450,000 | 400,000–900,000 |
| GHG avoidance (t $CO_2e$/year) | ~640–1,440 | ~1,200–2,640 |
| Payback period (CAPEX / VA + avoided disposal) | ~3–5 years | ~4–7 years |

*Source: Author's analysis. Payback period calculated as CAPEX divided by combined annual value added and avoided disposal costs*

### *5.4.2.6 Fiscal and Distributional Effects*

Each medium-scale composting hub generates annual fiscal revenues estimated at: VAT on compost sales (20% rate, approximately USD 8,000–18,000); payroll and income tax on 7–14 FTE (approximately USD 10,000–22,000); corporate profit tax at 18% (approximately USD 5,000–14,000 if profitable). Total per-hub fiscal contribution: USD 23,000–54,000/year. Across 1–4 hubs, aggregate fiscal contribution: USD 23,000–216,000/year (Moderate to Advanced). Jobs are located in Armavir and Ararat marzes, providing rural employment in semi-skilled operational and logistics roles. The composting operation is accessible to both male and female workers; monitoring, quality testing, and administrative roles are particularly suited to agricultural college graduates in these marzes.

### *5.4.2.7 Risks, Trade-offs and Recommended Modifications*

The primary commercial risk is the thin margin between composting operational costs (USD 70,000–130,000 per hub per year) and compost sales revenues (USD 38,000–106,000 per hub per year), particularly in the early years before a stable customer base is established. Revenue viability requires a gate fee from wineries for residue acceptance of USD 5–15/tonne, in addition to compost sales revenue. This fee structure is standard in European composting models and should be factored into feasibility study assumptions.

**Table 54. Key Risks and Mitigation Measures for the Composting Hub Model**

| Risk | Severity | Mitigation |
|---|---|---|
| Thin compost margin without winery gate fees | High | Structure business model to include gate fee from wineries (USD 5–15/tonne input) |
| Compost quality variability (seed germination, heavy metals) | Medium | Apply minimum composting temperature standard (>55°C for 15 days) per ECN quality scheme |

| | | |
|---|---|---|
| Seasonal biomass surplus storage | Medium | Covered storage pad; supplement with NACE 10.3 fruit residues in off-season |
| Low farmer demand for certified compost | Medium–Low | Pilot integration with agricultural subsidy scheme; demonstration farm trials |
| Competing biomass claims from Projects 3 and 4 | Medium | Compost hubs positioned to receive skin/pulp after seed extraction and post-AD digestate |

*Source: Author's assessment based on ECN Quality Assurance Scheme guidelines, European composting industry precedents, and Georgia and Moldova programme experience*

### 5.4.3 Project 3 — Anaerobic Digestion for Bioenergy Production

#### *5.4.3.1 Rationale and Scope*

Grape pomace, stems, and winery wastewater represent a significant and currently unexploited source of bioenergy. Unmanaged anaerobic decomposition of discarded pomace releases methane directly to the atmosphere — a climate externality representing both an environmental loss and an unrealised economic value. Anaerobic digestion (AD) captures this bioenergy potential by processing organic residues in controlled conditions to produce: (a) biogas, a methane-rich gas used for electricity and/or heat generation; and (b) digestate, a nutrient-rich stabilised slurry suitable as a soil amendment in partial substitution for mineral fertilisers.

This project is designed as complementary to Project 2 (composting): lower-grade or high-moisture pomace fractions that are unsuitable or suboptimal for composting can be directed to AD co-digestion with livestock manure, which improves system stability and biogas yields. Digestate from the AD plant can also be incorporated into the composting process as a nitrogen-rich activator. Co-digestion with cattle or pig manure — available in proximity in Armavir and Ararat marzes — is essential to stabilise the feedstock, as grape pomace alone has unfavourable C:N ratios for efficient methanogenesis.

Livestock manure for co-digestion can be sourced from commercial dairy and pig farms concentrated in Armavir and Ararat marzes, which represent Armenia's main livestock production regions. Supply would be organised through contractual feedstock agreements with farms located within a collection radius of approximately 20–30 km. A circular exchange model is proposed: farms supply manure to the AD plant in exchange for priority access to digestate at below-market cost as a soil fertiliser. This arrangement is widely used in European agricultural biogas systems (EBA, 2022) and helps reduce feedstock procurement costs for the AD operator while simultaneously providing farms with a cost-effective organic fertiliser, strengthening the project's rural economic linkages and improving farmer engagement. Transport costs for manure delivery are estimated at approximately USD 3–5/tonne within the 20–30 km radius, based on Armenian road transport benchmarks, and are reflected in the OPEX estimates below.

Armenia imports approximately USD 450–500 million worth of natural gas annually (HS 271121), corresponding to roughly 2.5–2.8 billion m³ of gas. Domestically generated biogas can partially substitute for this imported energy source, reducing foreign exchange outflows and strengthening national energy security. Under Armenia's 2021 Law on Renewable Energy Sources, independent power producer (IPP) registration is available for biogas plants, and clarity on feed-in tariff levels from the PSRC (Public Services Regulatory Commission) remains a key enabling condition for project bankability.

Biomass allocated (standalone basis): Moderate scenario — 5,000–8,000 tonnes/year of fresh pomace equivalent (plus co-digestion manure); Advanced scenario — 9,000–15,000 tonnes/year of pomace equivalent. In the cascade model, this project receives lower-grade pomace fractions and stems after higher-value pathways have been allocated their share.

#### *5.4.3.2 Physical and Financial Modelling Assumptions*

Capital costs reflect modular biogas plant construction, gas handling, combined heat and power (CHP) unit, digestate storage, and grid connection. Biogas yield assumptions are based on published co-digestion data. CAPEX benchmarks are derived from the EBRD Moldova National Biogas Programme (2019–2023), the European Biogas Association (EBA) Annual Report 2022, and IEA Bioenergy Task 37 country reports, all adjusted for Armenian conditions (construction and labour costs at 60–70% of Western European equivalents per Armstat wage calibration).

Biogas specific yields of 50–75 Nm³/tonne of mixed input (pomace plus manure at a 1:2–1:3 ratio by volume) are derived from Molino et al. (2013), who report methane potential for grape pomace co-digestion with swine manure under mesophilic conditions, and from EBA (2022) operational data for mixed agro-industrial co-digestion plants in Eastern Europe. A conservative electrical conversion efficiency of 38% is applied for CHP units, consistent with standard gas engine technology at the sub-1 MW scale. The total co-digestion input volume (manure plus pomace) is calculated at a pomace-to-manure ratio of 1:2–1:3 by volume, which is standard practice in European grape pomace co-digestion systems (Bolzonella et al., 2019).

**Table 55. Physical and Financial Modelling Assumptions for Project 3**

| Parameter | Moderate Scenario | Advanced Scenario | Basis/Source |
|---|---|---|---|
| Pomace-equivalent organic input (t/year) | 5,000–8,000 | 9,000–15,000 | Allocated fraction of pomace stream + stems |
| Total co-digestion input incl. manure (t/year) | 10,000–24,000 | 18,000–45,000 | Pomace:manure ratio 1:2–1:3 (Molino et al., 2013; EBA, 2022); manure sourced via circular exchange agreements with livestock farms within 20–30 km |
| Specific biogas yield (Nm³/t mixed input) | 50–75 | 50–75 | Molino et al. (2013) co-digestion of grape pomace + swine manure (mesophilic); EBA (2022) Eastern European co-digestion benchmarks |
| Annual biogas production (Nm³/year) | 500,000–1,800,000 | 900,000–3,375,000 | Calculated |
| Electrical energy equivalent (MWh/year, η=38%) | 700–1,900 | 1,260–3,560 | Standard CHP gas engine efficiency at sub-1 MW scale (IEA Bioenergy Task 37) |
| Total CAPEX (USD) | 800,000–2,000,000 | 2,000,000–4,500,000 | EBRD Moldova National Biogas Programme 2019–2023 (average EUR 1.2–1.8 million per plant at 2,000–5,000 t/year); IEA Bioenergy cost studies; Armenian cost adjustment |
| Annual OPEX (USD) | 120,000–240,000 | 220,000–450,000 | Labour (5–12 FTE at USD 14,000 + employer contributions), maintenance (~2% of |

| | | | |
|---|---|---|---|
| | | | CAPEX/year), grid connection, manure transport (USD 3–5/t) |
| Revenue: electricity at AMD 60/kWh (USD) | 108,000–294,000 | 195,000–551,000 | PSRC Armenian tariff reference 2024 (AMD 55–65/kWh for biomass); converted at AMD/USD 387 |
| Revenue: digestate at USD 7/tonne (USD) | 35,000–84,000 | 63,000–157,500 | Digestate market value benchmark (EU average USD 6–10/t); Armenian equivalent adjusted for mineral fertiliser import prices (HS 31, USD 22 million imports in 2024) |

*Source: Author's analysis based on EBRD Moldova National Biogas Programme (2019–2023), EBA Annual Report (2022), IEA Bioenergy Task 37, Molino et al. (2013), Bolzonella et al. (2019), and Armstat wage calibration. CAPEX adjusted for Armenian conditions (60–70% of Western European equivalents). Electricity revenue based on PSRC Armenian biomass tariff reference 2024 (AMD 55–65/kWh), converted at AMD/USD 387*

#### *5.4.3.3 Direct Economic Effects*

Direct economic effects are generated by the biogas plant operating staff, grid electricity sales, and digestate distribution to farms. The AD plant creates more skilled employment than Projects 1 or 2, as it requires certified operators and engineers for plant management, gas handling, and grid interface compliance.

**Table 56. Direct Economic Effects of the Anaerobic Digestion Bioenergy Project**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Annual gross revenue (USD) | ~143,000–378,000 | ~258,000–708,500 |
| Value added (40% VA ratio) (USD/year) | ~57,000–151,000 | ~103,000–283,000 |
| Direct FTE jobs | 7–13 | 15–26 |
| Average annual wage per FTE (USD) | ~8,000–13,000 | ~8,000–13,000 |
| Wage bill (USD/year) | ~65,000–130,000 | ~140,000–260,000 |

*Source: Author's calculations. VA ratio of 40%. Employment estimated via output-per-worker coefficient calibrated to Armenian agro-industrial wages*

#### *5.4.3.4 Indirect, Trade and Multiplier Effects*

Anaerobic digestion carries the highest domestic economic linkage multiplier of the four projects, because energy production is embedded in Armenia's national grid and digestate distribution creates forward linkages to the agricultural sector. The import substitution effect is twofold: electricity generated displaces grid imports or reduces fossil fuel consumption in the energy mix; digestate displaces mineral fertiliser imports, generating a combined substitution value estimated below.

**Table 57. Indirect Economic Effects, Energy Import Substitution and GHG Mitigation**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Output multiplier applied | 1.30 | 1.30 |
| Employment multiplier applied | 1.20 | 1.20 |
| Total output including indirect effects (USD) | ~186,000–491,000 | ~335,000–921,000 |
| Total jobs: direct + indirect (FTE) | 8–16 | 18–31 |
| Energy import substitution (USD/year) | ~108,000–294,000 | ~195,000–551,000 |
| Fertiliser substitution via digestate (USD/year) | ~30,000–80,000 | ~55,000–150,000 |
| Total import substitution value (USD/year) | ~138,000–374,000 | ~250,000–701,000 |
| GHG avoidance — methane capture (t $CO_2$e/year) | ~1,250–4,500 | ~2,250–8,450 |

*Source: Author's calculations. GHG avoidance based on captured methane equivalent per IPCC Tier 1 methodology. Energy import substitution valued at PSRC electricity tariff. Digestate substitution benchmarked against HS 31 mineral fertiliser import prices (UN Comtrade, 2024). Output multiplier 1.30 and employment multiplier 1.20*

### *5.4.3.5 Cost-Benefit Snapshot*

Anaerobic digestion has the highest CAPEX of the four projects. Viability depends critically on stable biomass supply agreements and a guaranteed electricity purchase price. The payback period shown below assumes the full revenues from both electricity and digestate sales, and no public grant element. With a 25–40% CAPEX grant from concessional climate finance instruments (EBRD GEFF, Green Climate Fund), effective payback improves to approximately 5–8 years — competitive for renewable energy infrastructure.

**Table 58. Cost–Benefit Overview for the Anaerobic Digestion Project**

| Indicator | Moderate | Advanced |
|---|---|---|
| Total CAPEX (USD) | 0.80–2.00 million | 2.00–4.50 million |
| Annual gross revenue (USD/year) | ~143,000–378,000 | ~258,000–708,500 |
| Annual VA gain (USD/year) | ~57,000–151,000 | ~103,000–283,000 |
| Total jobs with multiplier (FTE) | 8–16 | 18–31 |
| Total import substitution (USD/year) | 138,000–374,000 | 250,000–701,000 |

| | | |
|---|---|---|
| GHG avoidance (t $CO_2e$/year) | ~1,250–4,500 | ~2,250–8,450 |
| Payback (CAPEX / annual revenue, no grant) | ~7–10 years | ~7–11 years |
| Payback with 30% CAPEX grant | ~5–7 years | ~5–8 years |

*Source: Author's analysis. Payback period calculated as CAPEX divided by combined annual electricity and digestate revenues. Concessional finance scenario assumes 30% CAPEX grant from EBRD GEFF or equivalent instrument*

### 5.4.3.6 Fiscal and Distributional Effects

An AD plant generating 700–3,560 MWh/year of electricity contributes to Armenia's domestic renewable energy capacity and generates fiscal revenues through: VAT on electricity sales (20%, approximately USD 10,000–30,000/year); payroll and income tax on 7–26 FTE (approximately USD 10,000–40,000/year); corporate profit tax (approximately USD 5,000–25,000/year at 18%). Aggregate fiscal contribution: USD 25,000–95,000/year (Moderate to full Advanced Scenario). Distributional effects are positive for rural marzes: the plant provides stable, semi-skilled technical employment and distributes digestate to smallholder farms at below-market cost, directly supporting farm income.

### 5.4.3.7 Risks, Trade-offs and Recommended Modifications

Anaerobic digestion is the most technically complex and capital-intensive of the four projects, and faces the greatest number of enabling conditions that must be in place before investment is justified. The three critical conditions — stable biomass supply, feed-in tariff clarity, and concessional finance access — are largely regulatory and policy matters rather than market barriers.

**Table 59. Key Risks and Mitigation Measures for the Anaerobic Digestion Plant**

| Risk | Severity | Mitigation |
|---|---|---|
| Seasonal pomace supply (6–8 week harvest) | High | Biomass aggregation model (Project 1 logistics); year-round co-digestion with manure as base substrate |
| Electricity tariff uncertainty (PSRC) | High | Secure 10–15 year power purchase agreement before investment; engage PSRC on biogas tariff framework |
| High CAPEX without concessional finance | High | Apply to EBRD GEFF (Armenia); EU4Energy; Green Climate Fund NDC window |
| Technical skills gap in plant operation | Medium | Partner with EBRD-accredited AD technology provider; structured operator training programme |
| Low C:N ratio in pure pomace — process instability | Medium | Mandatory co-digestion with manure; minimum manure share 50% of total input by volume |
| Competing biomass demand from composting hubs | Low–Medium | AD and composting are complementary: low-grade wet pomace to AD; drier stems and skin fraction to composting |

*Source: Author's assessment based on EBA (2022), EBRD Moldova programme experience, IEA Bioenergy Task 37, and Armenian regulatory framework review (Law on Renewable Energy Sources, 2021)*

### 5.4.4 Replication Potential Across the NACE 10.3 Sector

While this project is designed around the grape processing value chain, the proposed cascade utilisation model has broader relevance for Armenia’s entire fruit and vegetable processing sector (NACE 10.3). Many processing facilities generate similar organic by-products, including tomato pulp, fruit skins, vegetable trimmings, and juice press residues. These streams can be systematically allocated across the three valorisation pathways proposed in this study: higher-quality residues for animal feed production (Project 1), structurally suitable biomass for composting (Project 2), and high-moisture or mixed organic residues for anaerobic digestion and bioenergy generation (Project 3).

In this sense, the model presented in this report can serve as a pilot circular economy framework for the broader NACE 10.3 sector in Armenia, demonstrating how agro-processing waste streams can be converted into feed, fertiliser, and renewable energy rather than disposed of as unmanaged organic waste. If successfully implemented, the approach could be replicated across other fruit and vegetable processing clusters in Armenia, significantly increasing resource efficiency and reducing environmental externalities across the sector.

### 5.4.5 Project 4 — High-Value Bio-Compound Extraction (Flagship Innovation)

#### *5.4.5.1 Strategic Positioning*

This is the highest-value circular intervention available to Armenia's grape-processing sector and the one with the strongest potential to generate export revenues and create a durable competitive advantage. Grape seeds and skins contain high concentrations of commercially valuable bioactive compounds — principally grape seed oil, oligomeric proanthocyanidins (OPC), and other polyphenols — that are in growing global demand from cosmetic, nutraceutical, pharmaceutical, and functional food manufacturers.

A small number of micro-enterprises currently extract seed oil in Armenia at very limited scale, selling under brands such as Dikond/Korits. These pioneering businesses demonstrate that the raw material supply and basic market demand exist. However, the volumes involved are negligible relative to the total seed stream: the vast majority of Armenia's 7,950–15,900 tonnes/year of grape seeds remain embedded in unextracted pomace that is informally discarded or fed to animals. This project proposes moving from artisanal micro-scale to industrial-scale extraction operations, enabling Armenia to capture the full economic value of its seed resource.

In the cascade logic of this report, bio-compound extraction is operationally the first step: seeds should be separated from pomace at or immediately after the pressing stage, before the residual pomace is allocated to lower-value pathways. This means that in a mature cascade model, this project must be coordinated with winery operations to achieve seed separation at source.

Biomass allocated (standalone basis): Moderate scenario — 3,000–5,000 tonnes/year of grape seeds processed (representing approximately 25–35% of the estimated total seed stream of ~8,000–16,000 t/year); Advanced scenario — 7,000–12,000 tonnes/year (~50–75% of total seed stream). Residual pomace after seed extraction (skins, pulp, depleted seed cake) remains available for Projects 1–3.

#### *5.4.5.2 Physical and Financial Modelling Assumptions*

The cascading valorisation model for this project comprises three sequential stages: seed separation from pomace at winery or hub level; cold-press or solvent extraction of grape seed oil from separated seeds;

and polyphenol/OPC extraction from the seed press-cake residue. The depleted seed cake, skin fraction, and other residual biomass are then directed to composting (Project 2) or AD (Project 3). CAPEX covers seed separation equipment at multiple winery sites plus a centralised extraction and purification facility.

CAPEX benchmarks are primarily derived from the AGRIMAX Horizon 2020 project documentation (2019), which provides techno-economic data for integrated grape pomace biorefinery systems, and from publicly available technical and commercial data from European extraction equipment suppliers including Alfa Laval (decanter centrifuges and oil extraction lines) and GEA Group (extraction and drying systems). These are adjusted for Armenian construction and labour conditions (60–70% of Western European equivalents). The number of winery seed separation sites is determined by the geographic distribution of pressing capacity across the Armavir and Ararat processing clusters: at the Moderate Scenario level, 5–8 major winery sites account for the majority of the seed stream; at Advanced Scenario scale, 12–20 sites are required to achieve the higher seed capture rate across a wider range of medium-scale operators.

Product yield assumptions are based on standard cold-press extraction performance (oil yield ~12% of seed weight, consistent with Spigno et al. (2007) and AGRIMAX (2019)) and polyphenol extract yields (~5% of seed weight for standardised OPC/polyphenol products, consistent with Pinelo et al. (2004) and Karastergiou et al. (2024)). Market prices used — USD 7,500/tonne for grape seed oil and USD 20,000/tonne for polyphenol extracts — are derived from Tridge wholesale price data (2023–2024) and publicly available pricing from European extract producers including Indena SpA and DRT (Derives Résiniques et Terpéniques).

**Table 60. Physical and Financial Modelling Assumptions for Project 4**

| Parameter | Moderate Scenario | Advanced Scenario | Basis/Source |
|---|---|---|---|
| Grape seeds processed (t/year) | 3,000–5,000 | 7,000–12,000 | 25–35% / 50–75% of total seed stream (~8,000–16,000 t/year) |
| Seed separation equipment at wineries (USD/site) | 40,000–80,000 | 40,000–80,000 | Alfa Laval / GEA Group equipment benchmarks for seed separation units; adjusted for Armenian procurement context |
| Number of winery seed separation sites | 5–8 sites | 12–20 sites | Determined by distribution of pressing capacity across Armavir/Ararat processing clusters; 5–8 major operators cover ~25–35% of seed stream at Moderate; 12–20 broader operator set required for 50–75% capture at Advanced |
| CAPEX: centralised extraction facility (USD) | 800,000–1,800,000 | 2,000,000–4,500,000 | AGRIMAX (2019) biorefinery CAPEX benchmarks; Jin et al. (2021) commercial-scale pomace |

|  |  |  |  |
|---|---|---|---|
|  |  |  | biorefinery model (USD 46.9M for 32,659 t/year input — scaled down proportionally); Armenian cost adjustment |
| Total CAPEX (USD) | 1,000,000–2,440,000 | 2,480,000–6,100,000 | Seed separation (sites × cost/site) + extraction facility |
| Annual OPEX (USD) | 180,000–340,000 | 420,000–800,000 | Labour (25–45 FTE), energy, solvents, quality testing, certification costs; calibrated to Armenian wages and AGRIMAX benchmarks |
| Grape seed oil yield (~12% of seed weight) | 360–600 t/year | 840–1,440 t/year | Cold-press oil yield: Spigno et al. (2007); AGRIMAX (2019); consistent with standard industrial cold-press performance |
| Polyphenol extract yield (~5% of seed weight) | 150–250 t/year | 350–600 t/year | Standardised OPC/polyphenol extract yield: Pinelo et al. (2004); Karastergiou et al. (2024); AGRIMAX (2019) |
| Revenue: seed oil at USD 7,500/tonne (USD) | 2,700,000–4,500,000 | 6,300,000–10,800,000 | Tridge wholesale price data 2023–2024: USD 7,120–7,860/t; USD 7,500 midpoint applied; cosmetic-grade premium for certified product |
| Revenue: polyphenol extract at USD 20,000/tonne (USD) | 3,000,000–5,000,000 | 7,000,000–12,000,000 | Tridge: South Korea import prices USD 29–283/kg; Germany USD 27–32/kg (2023–2024); USD 20,000/t represents mid-market OPC/polyphenol extract; Indena SpA / DRT public pricing range |
| Total annual gross revenue (USD) | 5,700,000–9,500,000 | 13,300,000–22,800,000 | Oil + polyphenol revenue |

*Source: Author's analysis based on AGRIMAX Horizon 2020 (Grant No. 720719), Jin et al. (2021), Alfa Laval and GEA Group equipment benchmarks, Spigno et al. (2007), Pinelo et al. (2004), Karastergiou et al. (2024), and Tridge wholesale price data (2023–2024). CAPEX adjusted for Armenian conditions (60–70% of Western European equivalents)*

*Revenue scale note: Project 4 revenues are an order of magnitude higher than Projects 1–3 because polyphenol extracts and seed oil are specialty high-value products traded at USD 7,000–20,000/tonne, compared to USD 12–30/tonne for pomace-derived feed and compost. This difference in value density is the core economic argument for prioritising seed extraction in the cascade.*

### 5.4.5.3 Direct Economic Effects

The extraction facility creates higher-quality employment than the other three projects: operators, laboratory technicians for quality control and product certification, logistics specialists, and export sales functions. Average wages are correspondingly higher, closer to manufacturing sector benchmarks than agricultural processing.

**Table 61. Direct Economic Effects of the Bio-Compound Extraction Project**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Annual gross revenue (USD) | ~5,700,000–9,500,000 | ~13,300,000–22,800,000 |
| Value added (45% VA ratio) (USD/year) | ~2,079,000–3,465,000 | ~4,851,000–8,316,000 |
| Direct FTE jobs created | 25–45 | 55–95 |
| Average annual wage per FTE (USD) | ~10,000–16,000 | ~10,000–16,000 |
| Wage bill (USD/year) | ~300,000–560,000 | ~660,000–1,200,000 |

*Source: Author's calculations. VA ratio of 45%. Employment estimated via output-per-worker coefficient calibrated to Armenian manufacturing sector wages*

### 5.4.5.4 Indirect, Trade and Multiplier Effects

Project 4 carries the highest multiplier of the four projects due to its export orientation and its linkages to a wider innovation ecosystem. Export of seed oil and polyphenol extracts generates direct foreign exchange earnings. The domestic cosmetics and pharmaceutical manufacturing cluster in Yerevan — which currently imports active cosmetic ingredients — could progressively substitute domestic polyphenol extracts for imported equivalents, creating additional import substitution value beyond the primary export pathway. The forward linkage potential to SME cosmetic and nutraceutical product development is a significant long-run structural benefit, though not quantified in the short-to-medium-term projections below.

**Table 62. Indirect Economic Effects, Export Potential and Import Substitution**

| Indicator | Moderate Scenario | Advanced Scenario |
|---|---|---|
| Output multiplier applied | 1.35 | 1.35 |
| Employment multiplier applied | 1.25 | 1.25 |

| | | |
|---|---|---|
| Total output including indirect effects (USD) | ~6,237,000–10,395,000 | ~14,553,000–24,948,000 |
| Total jobs: direct + indirect (FTE) | 31–56 | 69–119 |
| Export revenue potential (USD/year) | ~3,000,000–6,000,000 | ~7,000,000–15,000,000 |
| Cosmetic/nutraceutical import substitution (USD/year) | ~500,000–1,000,000 | ~1,200,000–2,500,000 |

*Source: Author's calculations. Export revenue estimates based on conservative EU market penetration assumptions and Tridge price data (2023–2024). Output multiplier 1.35 and employment multiplier 1.25*

### *5.4.5.5 Cost-Benefit Snapshot*

Project 4 presents the strongest cost-benefit profile of the four interventions, with the highest absolute value-added generation and the shortest payback period relative to its capital investment. The key constraint is not economics but market access: achieving and maintaining the certifications required for cosmetic-grade polyphenol export to EU markets (COSMOS standard, ECOCERT accreditation) requires a 2–4 year certification runway. The phased certification strategy recommended below — starting with food-grade certification and progressing to cosmetic grade — manages this constraint.

**Table 63. Cost–Benefit Overview for the Bio-Compound Extraction Project**

| Indicator | Moderate | Advanced |
|---|---|---|
| Total CAPEX (USD) | 1.0–2.44 million | 2.48–6.10 million |
| Annual gross revenue (USD/year) | ~5.7–9.5 million | ~13.3–22.8 million |
| Annual VA gain (USD/year) | ~2.6–4.3 million | ~6.0–10.3 million |
| Total jobs with multiplier (FTE) | 31–56 | 69–119 |
| Export revenue (USD/year) | ~3.0–6.0 million | ~7.0–15.0 million |
| Payback period (CAPEX / annual VA) | ~0.4–1.2 years | ~0.3–1.2 years |

*Source: Author's analysis based on AGRIMAX (2019) and Jin et al. (2021). Payback period calculated as CAPEX divided by annual value added*

*Payback period note: The very short payback period (under 1 year in most cases) reflects the high value density of polyphenol extracts (USD 20,000/tonne) relative to modest CAPEX. This ratio is consistent with European extraction industry data (AGRIMAX, 2019; Jin et al., 2021). The primary implementation risk is not financial return but technical and market access readiness*

### *5.4.5.6 Fiscal and Distributional Effects*

Project 4 generates by far the largest fiscal contribution of the four projects. At USD 4.6–18.5 million in gross annual revenue, the VAT contribution alone (20% on domestic sales + applicable export VAT refund mechanisms) would represent USD 200,000–500,000+/year depending on export share and domestic sales structure. Payroll and income tax on 25–95 FTE (average wage USD 10,000–16,000): approximately USD 60,000–230,000/year. Corporate profit tax (18%): potentially USD 200,000–800,000/year once fully operational. Aggregate annual fiscal contribution: USD 460,000–1,530,000 (Moderate to full Advanced), making this project the dominant fiscal contributor among the four. The project is concentrated in the agro-industrial zones of Armavir and Ararat marzes but creates export-oriented employment with an urban–rural supply chain — seed separation at rural winery sites feeds a more technically sophisticated centralised extraction facility that could be located in a peri-urban industrial zone.

#### *5.4.5.7 Risks, Trade-offs and Recommended Modifications*

The principal risks relate to market access certification and supply chain establishment rather than economic viability, which is strongly positive once operations are at scale. The phased implementation approach — beginning with domestic food-grade products and progressing to export-grade cosmetic and nutraceutical certification — is the recommended risk management strategy.

**Table 64. Key Risks and Mitigation Measures for Project 4**

| Risk | Severity | Mitigation |
|---|---|---|
| EU market certification timeline (COSMOS/ECOCERT) | High | Phase 1: food-grade FSSC 22000 certifications (12–18 months); Phase 2: cosmetic-grade COSMOS (24–36 additional months) |
| Seed supply fragmentation across many wineries | Medium–High | Centralised seed separation hubs or winery-level seed separator investment (USD 40,000–80,000 per major winery site) |
| Polyphenol extract market price volatility | Medium | Diversify product mix: oil (stable) + OPC (growing) + resveratrol (niche); long-term offtake agreements |
| Technical expertise gap for polyphenol purification | Medium | Partnership with European technology provider (licensing or joint venture model); AGRIMAX knowledge base |
| Competition from established EU producers (Italy, Spain) | Medium–Low | Differentiate on Armenian terroir/origin branding; organic certification potential for Armenian grape growing regions |
| SME scale — difficulty accessing export markets independently | Medium | Engage Enterprise Armenia and AIFC for market linkage support; trade fair representation (in-cosmetics, Vitafoods Europe) |

*Source: Author's assessment based on AGRIMAX (2019), ECOCERT/COSMOS certification requirements, European extraction industry precedents (France, Italy), and Enterprise Armenia market linkage framework*

## *5.5 Aggregate Economic Effects and Portfolio Analysis*

### 5.5.1 Biomass Allocation Across Projects

As stated earlier, the four projects cannot each process the entire pomace stream simultaneously — they compete for the same biomass. The aggregate assessment presented here uses a portfolio allocation model in which the total annual pomace stream is divided among the four projects in proportions that reflect the cascade logic: seeds (highest value) are extracted first; residual skin and pulp fractions are directed to composting or AD; the lowest-value dried residual is available for feed.

The table below presents the illustrative biomass allocation across the four projects under each scenario. These allocations are illustrative — actual proportions will be determined by market demand, investment timing, and the practical logistics of seed separation at winery level. The key point is that the four projects are compatible and can coexist within the total stream; their aggregate economics are not the sum of four projects each using 100% of available pomace.

**Table 65. Illustrative Biomass Allocation Across the Circular Pomace Valorisation Portfolio**

| Biomass stream / Project | Total available (t/year) | Moderate allocation | Advanced allocation | Notes |
|---|---|---|---|---|
| Total pomace stream (fresh weight) | 53,000–66,250 | ~26,500–33,000 (50%) | ~47,700–59,600 (90%) | Mobilised for formal circular pathways |
| Project 4 — seed fraction extracted | ~8,000–16,000 seeds | ~3,000–5,000 seeds | ~7,000–12,000 seeds | Seeds separated at pressing; residual skin/pulp cascades down |
| Project 2 — composting (skin/pulp + stems) | Variable residual | ~8,000–12,000 | ~15,000–20,000 | Receives skin/pulp post-seed extraction + stems |
| Project 3 — AD (lower-grade wet fractions) | Variable residual | ~5,000–8,000 | ~9,000–15,000 | Lower-grade or moisture-heavy fractions + co-digestion manure |
| Project 1 — feed (dried residual) | Variable residual | ~5,000–8,000 | ~5,000–10,000 | Residual fraction not suited to other pathways |

| | | | | |
|---|---|---|---|---|
| Total mobilised (sum of allocations) | — | ~21,000–33,000 | ~36,000–57,000 | Consistent with 50% / 90% capture rates |

*Source: Author's analysis. Allocations are illustrative and based on cascade logic. Actual proportions will depend on investment timing, market conditions, and winery-level seed separation logistics*

*Note on seed fraction logistics: for Project 4 to receive its seed allocation, seed separation equipment must be installed at winery pressing lines. This is a prerequisite investment (USD 40,000–80,000 per major winery site) that enables the cascade. Without seed separation, the seed fraction remains embedded in pomace and the downstream projects (1–3) receive an unseparated mixed stream — which they can still process, but at lower economic efficiency for Project 4.*

### 5.5.2 Combined Scenario Summary

The aggregate figures below reflect the portfolio allocation model above. These are not the sum of the standalone project maxima: they account for non-overlapping biomass allocations and represent the combined annual economic contribution if all four projects were operating simultaneously at the indicated scale. The CAPEX breakdown by project is presented separately to support investment planning and sequencing decisions.

**Table 66. Aggregate Economic Impact of the Four-Project Circular Pomace Valorisation Portfolio**

| Indicator | Moderate (all 4 projects) | Advanced (all 4 projects) |
|---|---|---|
| Total pomace mobilised (t/year) | ~21,000–33,000 | ~36,000–57,000 |
| Total CAPEX required (USD) | ~2.4–6.4 million | ~5.9–15.5 million |
| including: | | |
| Project 1 — Structured Feed Pathway | 150,000–280,000 | 300,000–560,000 |
| Project 2 — Regional Composting Hubs | 450,000–1,700,000 | 1,200,000–4,400,000 |
| Project 3 — Anaerobic Digestion | 800,000–2,000,000 | 2,000,000–4,500,000 |
| Project 4 — Bio-Compound Extraction | 1,000,000–2,440,000 | 2,480,000–6,100,000 |
| Annual gross output (USD) | ~5.2–11.6 million | ~11.8–21.0 million |
| Annual value added (USD) | ~2.3–4.9 million | ~5.2–9.0 million |
| Direct FTE jobs created | 45–80 | 95–155 |
| Total jobs incl. multiplier (FTE) | 54–100 | 117–195 |
| Total import substitution (USD/year) | ~0.8–2.0 million | ~1.9–4.3 million |
| Export potential — bio-extracts and seed oil (USD/year) | ~3.0–6.0 million | ~7.0–15.0 million |
| Annual fiscal revenues (all projects) | ~0.5–1.8 million | ~1.2–3.5 million |

|  |  |  |
|---|---|---|
| GHG avoidance (t $CO_2e$/year) | ~1,900–6,000 | ~3,500–11,100 |

*Source: Author's calculations based on portfolio allocation model. Aggregate figures reflect non-overlapping biomass allocations and do not represent the sum of standalone project maxima*

*Note on aggregate interpretation: The dominant contributor to aggregate output and value added is Project 4 (bio-compound extraction), which accounts for approximately 85–90% of total gross output due to the high value density of polyphenol extracts and seed oil. Projects 1–3 contribute primarily through import substitution, environmental benefits, and rural employment creation rather than through headline output figures*

### 5.5.3 Project Comparison and Prioritisation Matrix

The table below scores each project across six strategic dimensions on a 1–5 scale (1 = lowest, 5 = highest) to support prioritisation decisions. The scoring reflects the standalone potential of each project as well as its role in the overall cascade system.

**Table 67. Strategic Project Prioritisation Matrix**

| Project | CAPEX Efficiency | Job Intensity | Import Substitution | Export Potential | Environmental Impact | Strategic Score |
|---|---|---|---|---|---|---|
| P1: Structured Feed | 5 | 3 | 2 | 1 | 2 | 13 / 30 |
| P2: Composting Hubs | 4 | 4 | 4 | 1 | 5 | 18 / 30 |
| P3: Anaerobic Digestion | 3 | 3 | 5 | 2 | 5 | 18 / 30 |
| P4: Bio-Extraction | 3 | 5 | 3 | 5 | 3 | 19 / 30 |

*Source: Author's assessment. Scores reflect standalone project potential and portfolio role across six strategic dimensions on a 1–5 scale*

Project 4 scores highest overall, driven by its exceptional export potential and job quality. However, it requires the most capital, the longest certification runway, and the establishment of seed separation logistics as a prerequisite. Projects 2 and 3 score equally and are environmentally the most impactful; they should advance in parallel given their technical complementarity (digestate from AD enriches compost from Project 2). Project 1 is the lowest-investment entry point and generates the fastest impact, making it the recommended first action regardless of the sequencing of the other three.

### 5.5.4 Implementation Sequencing

The sequencing recommendations below reflect the logical dependencies between projects, the regulatory prerequisites for each, and the relative urgency of different circular economy gaps.

**Table 68. Recommended Implementation Sequencing for the Circular Pomace Valorisation Portfolio**

| Phase | Timeframe | Projects | Key Actions and Prerequisites |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Phase 1: Foundation | Year 1–2 | Project 1 (Feed Pathway) | Classify grape pomace as by-product (Waste Law amendment); pilot 1–2 private drying operators; formal supply contracts with livestock farms; establish pomace quality testing protocol |
| Phase 2: Infrastructure | Year 2–4 | Projects 2 + 3 (Compost + AD) | Site identification and permitting in Armavir/Ararat; develop national compost quality standard; clarify biogas feed-in tariff (PSRC); access EBRD GEFF / EU4Energy climate finance; begin seed separation installation at major wineries |
| Phase 3: Innovation | Year 3–7 | Project 4 (Bio-Extraction) | Pilot extraction facility at 1–2 winery clusters; food-grade certification (FSSC 22000); build export linkages (in-cosmetics Europe, Vitafoods); progress toward COSMOS cosmetic-grade certification; SME innovation grants (SMEDNC, EU4Business) |

*Source: Author's analysis based on regulatory prerequisite mapping, investment readiness assessment, and regional precedents from Georgia and Moldova*

### *5.6 Fiscal and Distributional Effects*

### 5.6.1 Aggregate Fiscal Revenue Estimates

The table below presents consolidated fiscal revenue estimates from all four projects combined, at steady-state operation under each scenario. These estimates are based on Armenian tax code parameters: VAT at 20%, personal income tax at 20% applied to wages, and corporate profit tax at 18%. The estimates are conservative — they exclude potential future environmental levies, extended producer responsibility fees, or carbon credit revenues that could be introduced through regulatory reform.

**Table 69. Estimated Annual Fiscal Revenues Generated by the Circular Pomace Valorisation Portfolio**

| Revenue Source | Moderate (USD/year) | Advanced (USD/year) | Basis |
|---|---|---|---|
| VAT on domestic output sales (20%) | ~100,000–200,000 | ~220,000–440,000 | Applied to domestic gross output |
| Payroll / income tax on wages (20%) | ~90,000–180,000 | ~200,000–380,000 | Applied to wage bills across all projects |
| Corporate profit tax (18%) | ~70,000–150,000 | ~200,000–500,000 | Highest contribution from Project 4 |
| Custom duties on equipment imports (one-off) | ~30,000–80,000 | ~70,000–180,000 | CAPEX-stage; one-time contribution |
| Total annual fiscal revenue (excl. customs) | ~260,000–530,000 | ~620,000–1,320,000 | Aggregate steady-state |

*Source: Author's calculations based on Armenian tax code parameters: VAT 20%, personal income tax 20%, corporate profit tax 18%. Estimates are conservative and exclude potential environmental levies or carbon credit revenues*

These figures represent a significant return on any public co-financing provided: if the government co-finances 20% of total CAPEX (USD 620,000–3,240,000 across scenarios), the cumulative fiscal revenue stream recoups the public investment within 3–6 years, after which the projects generate a net positive fiscal return.

### 5.6.2 SME and Rural Economic Benefits

All four projects are structured to support SME participation and generate economic activity in Armenia's rural agricultural marzes. The distribution of benefits differs by project:

- Project 1 (feed pathway) creates a new SME category — private pomace aggregation and drying operators. Supply linkages connect peri-urban winery clusters with livestock producers across adjacent zones, generating rural value chain integration.
- Project 2 (composting) is naturally suited to medium SME scale (total investment AMD 200–700 million). Compost customers are primarily small and medium farms, keeping income in rural communities and reducing farm input costs.

- Project 3 (anaerobic digestion) establishes an SME independent power producer category under Armenia's 2021 Renewable Energy Law, with stable long-run revenue from grid electricity sales and digestate distribution to smallholder farmers.
- Project 4 (bio-extraction) is the highest-value SME innovation opportunity, with potential to anchor a broader agro-biotech cluster. Downstream cosmetic and nutraceutical product development by Armenian SMEs using domestically produced extracts creates an innovation multiplier effect beyond the primary extraction industry.

### 5.6.3 Gender, Youth and Regional Employment

The circular economy activities assessed in this report create diverse employment profiles across the skill spectrum. In terms of geographic distribution, all four projects create jobs primarily in Armavir and Ararat marzes — two of Armenia's most agriculturally significant but economically constrained regions, where off-farm employment alternatives are limited. Quality testing, laboratory, and administrative roles across all projects are accessible to young graduates of Armenian agricultural and technical colleges, creating entry-level professional employment in rural contexts. Operational roles in drying, composting, and plant management are accessible to semi-skilled workers of both genders. Project 4's extraction facility creates the highest-quality employment profile, including certified laboratory technicians and export market specialists, at wages USD 10,000–16,000/year — approximately 25–50% above the national manufacturing sector average.

### *5.7 Risks and Trade-offs*

Beyond the project-specific risks, several systemic risks apply across the portfolio of four projects. These cross-cutting risks should be addressed at the programme design level rather than individually for each project.

**Table 70. Cross-Cutting Systemic Risks and Mitigation Measures Across the Circular Portfolio**

| Risk Category | Description | Projects Affected | Mitigation Approach |
|---|---|---|---|
| Biomass data gap | No official Armenian data on grape pomace volumes, destinations, or by-product classification exists. Investment decisions and project sizing are based on derived estimates with ±15–20% uncertainty. | All | Commission biomass mapping study as a Year 1 preparatory action; require Armstat to add by-product volume reporting to Form 1-TG |
| Regulatory bottleneck — by-product status | Grape pomace is not legally classified as a tradeable by-product under Armenian Waste Law (HO-547-N). Without this classification, private operators face legal uncertainty in commercialising pomace. | All | Single regulatory amendment to Waste Law Article 4 (by-product criteria consistent with EU WFD Article 5). Low-cost, high-impact action. |
| Harvest variability risk | Grape harvest in Armenia varies ±15–30% year-on-year due to weather and disease. Projects depending on stable biomass supply must plan for lean years. | Projects 2, 3, 4 | Multi-feedstock design for composting and AD; NACE 10.3 fruit residues as supplementary inputs; biomass storage capacity |
| Capital mobilisation in an unproven market | Private investors have limited visibility of returns from agro-waste valorisation; perceived risk is elevated. | Projects 2, 3, 4 | Public co-financing instruments reduce private equity requirement; green bonds and climate finance reduce risk premium |
| Cascade coordination failure | If seed separation (prerequisite for Project 4) is delayed, the downstream projects receive lower-quality, unseparated pomace. If composting and AD | All | Programme management approach: coordinate project timelines across the four interventions under a sector-level programme office |

| | | | |
|---|---|---|---|
| | infrastructure are not in place, extraction residues have no offtake pathway. | | |
| Export market access risk (Project 4) | Failure to achieve COSMOS/food-grade certification would limit polyphenol extract sales to the lower-value domestic market only, significantly reducing Project 4 returns. | Project 4 | Phased certification; early engagement with ECOCERT certification body; dedicated export market linkage support |
| Technology transfer gap | No Armenian enterprises currently operate bio-compound extraction at industrial scale. Technology, process knowledge, and quality management systems must be transferred. | Project 4 | Licensing or joint venture with established European extractor (France, Italy); AGRIMAX knowledge base; university R&D partnership (ANAU, NPUA) |

*Source: Author's assessment based on regulatory framework review, stakeholder consultations, and international circular economy programme experience*

## *5.8 Policy Implications and Enabling Conditions*

### 5.8.1 Priority Regulatory Actions

The most critical enabling actions are regulatory rather than financial. Three regulatory changes would have high leverage across all four projects and could unlock private investment at relatively low fiscal cost.

- Establish a formal by-product / end-of-waste pathway for grape pomace.
  Armenia's core waste legislation is the Law of the Republic of Armenia "On Waste" (HO-159-N of 24 November 2004), which defines waste broadly and regulates its collection, transport, storage, treatment, recovery, and disposal. However, the law does not currently provide a clearly operational, product-specific pathway for classifying agri-processing residues such as grape pomace as a by-product or as material that has ceased to be waste under specified conditions. Armenia should therefore amend the Law on Waste and adopt implementing acts establishing technical criteria under which grape pomace can be placed on the market as a secondary raw material for feed, composting, extraction, or anaerobic digestion, in a manner broadly aligned with the logic of Article 5 of the EU Waste Framework Directive 2008/98/EC. This would reduce legal ambiguity for private operators and improve bankability of projects based on pomace valorisation.

- Develop a national compost quality standard and conformity framework.
  Armenia currently lacks a widely recognised national compost quality standard equivalent to established European reference systems such as AFNOR compost standards in France or the ECN Quality Assurance Scheme. A national standard should define minimum requirements for contaminants, heavy metals, stability or maturity indicators, hygienisation parameters, and labelling rules, allowing compost to be marketed as a certified agricultural input rather than an unregulated residue. Institutionally, such a standard should be developed through Armenia's national standardisation system under the Ministry of Economy, with technical input from ANAU, the Food Safety Inspectorate, and accredited laboratories. This reform would be particularly important for composting and digestate-based pathways, as it would create a formal route to market and improve farmer confidence in product quality.

- Clarify the tariff and grid-connection regime for small biogas projects.
  Armenia already has a renewable energy legal framework based on the Law "On Energy" and the Law "On Energy Saving and Renewable Energy," including 2021 legislative amendments. Publicly available tariff references also show an existing tariff for electricity generated from biomass. However, for investment purposes, small biogas projects still face uncertainty regarding the precise applicability of guaranteed-purchase arrangements, the duration and bankability of tariff conditions, and the practical procedures and costs of grid connection for small facilities. The priority action is therefore not simply to "introduce" a tariff, but to issue a clear, consolidated regulatory package — through PSRC decisions and related secondary acts — specifying the conditions applicable to sub-1 MW and other small biogas installations, including grid-connection procedures, technical requirements, commercial settlement rules, and the effective duration of tariff support. This would materially improve the financeability of anaerobic digestion projects.

### 5.8.2 Policy Mechanism to Enable Biomass Mobilisation

A critical enabling condition for the successful implementation of the four circular economy projects proposed for the grape processing value chain is the establishment of a regulatory mechanism that discourages uncontrolled disposal of agro-processing residues and incentivises their transfer to licensed valorisation operators. Without such a mechanism, the mobilisation of sufficient biomass streams to supply feed processing, composting, anaerobic digestion, and other circular pathways may remain uncertain, limiting the scalability and financial viability of the proposed projects.

Currently, Armenia does not operate a formal regulatory framework governing the management of grape pomace and other organic processing residues. As a result, wineries and distilleries frequently dispose of pomace informally or transfer it to farms without quality control, resulting in environmental externalities and the loss of potentially valuable biomass resources.

To address this gap, a targeted regulatory mechanism could be introduced combining three complementary instruments.

First, enterprises operating under NACE 11.01 and 11.02 should be required to report the annual volumes and destination of grape processing residues through a national organic waste registry administered by the Ministry of Environment and the Statistical Committee. This reporting requirement would create transparency regarding biomass flows and enable better planning of circular economy infrastructure.

Second, a differentiated landfill or disposal fee should be introduced for untreated organic agro-processing residues. A disposal fee in the range of USD 15–30 per tonne would align Armenia with standard European waste diversion practices and create a financial incentive for enterprises to supply residues to feed processing, composting, or anaerobic digestion facilities instead of uncontrolled disposal.

Third, the regulatory framework should introduce a “circular priority rule,” under which grape processing residues must first be offered to licensed biomass valorisation operators before landfill disposal is permitted. This rule follows the waste hierarchy principle widely applied in EU waste management policy.

Together, these measures would create a functioning biomass market in which wineries and distilleries face a clear economic incentive to supply their by-products to circular economy projects rather than disposing of them. Once established for the grape processing value chain, this regulatory approach could subsequently be expanded to the broader fruit and vegetable processing sector (NACE 10.3), where similar organic by-product streams are generated and could be valorised through comparable circular economy pathways.

### 5.8.3 Rationale for Public Co-Financing

Public co-financing of 15–30% of CAPEX is justified across all four projects on three grounds. First, market failure: the environmental benefits of avoided methane emissions, fertiliser import substitution, and rural employment creation are real economic benefits that private investors cannot fully capture through commercial revenue streams. Public co-financing corrects for this underpricing. Second, demonstration effect: the four projects are pilots in a market that does not yet exist in Armenia. First-mover investments carry disproportionate risk relative to followers; public co-financing compensates for this. Third, international leverage: EU, EBRD, and Green Climate Fund instruments typically require domestic co-financing of 20–30% as a condition of access. Government co-financing of 15–25% of total CAPEX can leverage 3–5 times that amount in international climate and development finance.

The aggregate cumulative fiscal revenue generated by all four projects — USD 260,000–1,320,000 per year at steady state — provides a clear public return on any co-financing. Government investment in

CAPEX co-financing would be recouped through fiscal revenues within 3–6 years across scenarios, after which projects generate a net positive fiscal return indefinitely.

### 5.8.4 Skills Development and Knowledge Infrastructure

All four projects require workforce development that current Armenian agricultural and technical education does not fully provide. Recommended actions: (a) introduce grape pomace valorisation and circular bioeconomy modules into the ANAU agro-processing curriculum, with practical components at pilot sites; (b) establish certified short-course training for AD plant operation in partnership with EBRD GEFF training providers or European biogas associations; (c) support laboratory technician training for polyphenol extraction quality control, in partnership with the Armenian National Polytechnic University; (d) fund student internships at European winery biorefinery facilities — Languedoc-Roussillon (France), Piedmont (Italy), and Georgian Kakheti region — through EU Erasmus+/Horizon mobility instruments.

### *5.9 Conclusions*

This Economic Impact Assessment demonstrates that Armenia's grape-processing sector holds a materially significant and currently unrealised circular economy potential. The four priority projects assessed represent a cascading valorisation hierarchy that, at full Advanced Scenario scale, would generate the following steady-state annual benefits:

- 117–195 direct and indirect FTE jobs (Moderate: 54–100), predominantly in rural Armavir and Ararat marzes;
- USD 5.2–9.0 million in annual value added (Moderate: USD 2.3–4.9 million);
- USD 7.0–15.0 million in annual export revenues from grape seed oil and polyphenol extracts (Moderate: USD 3.0–6.0 million) — a transformative contribution to Armenia's agro-processing export base;
- USD 1.9–4.3 million in annual import substitution across mineral fertilisers, energy, and specialty chemical ingredients (Moderate: USD 0.8–2.0 million);
- 3,500–11,100 tonnes $CO_2e$ avoided annually through methane capture, waste diversion, and fossil fuel substitution (Moderate: 1,900–6,000 tonnes);
- USD 0.5–1.8 million in annual fiscal revenues at steady state (Advanced: USD 1.2–3.5 million).

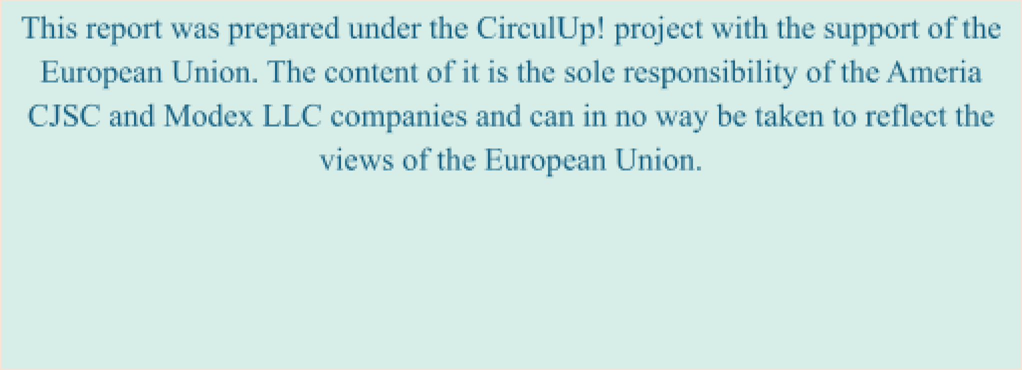
The hierarchy of value across the portfolio is unambiguous. Project 4 (bio-compound extraction) is the economic engine, generating approximately 85–90% of total portfolio output value due to the high value density of grape seed oil and polyphenol extracts relative to all other pomace-derived products. Projects 2 and 3 (composting and anaerobic digestion) deliver the greatest environmental and import substitution returns and are the most eligible for concessional green finance. Project 1 (structured feed pathway) provides the lowest-risk, fastest entry point, formalising currently wasted material flows at minimal capital cost.

The cascade logic is central to portfolio performance. Seeds must be separated from pomace before the residual stream is allocated to lower-value pathways — this single operational step is the prerequisite for unlocking the full economic value of the portfolio. In the near term, while seed separation infrastructure is being installed, Projects 1–3 can receive unseparated mixed pomace and begin generating returns. As seed separation equipment is deployed at winery level — a targeted investment of USD 40,000–80,000 per site — the cascade becomes fully operational and portfolio economics improve materially.

The primary binding constraints on implementation are regulatory, not financial. Three low-cost government actions would have the highest leverage across all four projects: classifying grape pomace as a tradeable by-product under Armenian waste law; issuing a consolidated PSRC regulatory package for small biogas feed-in tariffs and grid connection; and developing a national compost quality standard. Each of these reforms costs the public budget near-zero and would directly unlock private and international investment.

Public co-financing of 15–25% of total portfolio CAPEX — estimated at USD 2.4–6.4 million at Moderate Scenario and USD 5.9–15.5 million at Advanced Scenario — is justified on market failure, demonstration effect, and international leverage grounds, and is fully recoverable through fiscal revenues within 3–6 years of steady-state operation. The net public return on this co-financing is positive from year four or five onwards and continues indefinitely.

Taken together, the evidence presented in this report supports a clear conclusion: the circular economy potential of Armenia's grape-processing sector is investable, scalable, and policy-ready. The principal barrier to realisation is not market failure or lack of commercial logic — it is the absence of the basic regulatory infrastructure that would allow private operators to act on the opportunity that already exists.



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