Topic 03 Alumina and Aluminium

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This writeup is the canonical publishable synthesis for Topic 03 (alumina and aluminium). The current version is a structured baseline for evidence intake, pathway comparison, and policy-facing analysis.

Module Source Map

- Overview module: `subtopics/00_overview.qmd`
- T1 module: `subtopics/01_T1_demand-pull-and-value-chain-structure.qmd`
- T2 module: `subtopics/02_T2_processing-pathways.qmd`
- T3 module: `subtopics/03_T3_science-101.qmd`
- T4 module: `subtopics/04_T4_research-and-collaboration-landscape.qmd`
- T5 module: `subtopics/05_T5_policy-funding-and-programs.qmd`
- T6 module: `subtopics/06_T6_evidence-quality-gaps-and-confidence.qmd`

T1. Demand Pull + Value-Chain Structure

This section frames where demand pull is strongest for alumina and aluminium products that can support sustained Australian value capture.

Early evidence snapshot: - C-001 (E-002): IEA reports global aluminium demand rose by nearly 3% in 2022 while China accounted for around 60% of global primary production, indicating a structurally concentrated market context. - C-004 (E-006): Australian industry baseline data indicates strong export orientation (about 90% alumina exports and 86% bauxite exports), tying value capture to external market and logistics conditions. - C-012 (E-014): A 2024 AAC submission states demand may nearly double by 2050 and argues recycled supply growth alone is insufficient for total demand. - C-013 (E-015): The same submission highlights concentrated global supply structures and Australia's strong export linkage across the value chain.

Current focus: - Narrow demand analysis to product segments and destinations where concentration and compliance risks can still support robust Australian margin capture. - Stress test demand and market-access strategy under concentration and trade-exposure scenarios, not only base-case demand growth.

T2. Processing Pathways

This section compares technical and commercial pathway options from bauxite through alumina and primary aluminium, with focus on route-dependent cost and emissions outcomes.

Early evidence snapshot: - C-002 (E-003, E-004): IEA and IAI evidence indicates pathway competitiveness is highly sensitive to electricity cost and carbon intensity, with recent global intensity reductions demonstrating progress but not full decarbonization. - C-003 (E-005): IEA indicates inert anode technology can reduce direct process emissions by around 15% at cell level, but deployment remains conditional on clean-power availability and implementation readiness. - C-007 (E-009) and C-008 (E-010): The CSIRO DMR-3609 review indicates residue-utilization implementation has historically been constrained by a coupled volume/performance/cost/risk barrier set and requires site-specific deployment logic. - C-009 (E-011): A 3-value-opportunity and 9-KPA framework is available for structuring residue-use pathway prioritization. - C-014 (E-016): The AAC submission identifies reliable firm low-emissions electricity at internationally competitive delivered cost as the dominant near-term transition constraint. - C-015 (E-017): The submission indicates key technology deployment at scale is mainly expected around or after 2030.

Current focus: - Compare pathway combinations as coupled technology-plus-energy-system choices, not standalone technology selections. - Apply barrier scoring (volume, performance, cost, risk) and location-specific feasibility tests to each candidate residue-linked pathway. - Separate pathway scoring into pre-2030 and post-2030 readiness windows.

T3. Science 101

This section provides the minimum scientific foundation required to interpret pathway claims correctly.

Early evidence snapshot: - C-007 (E-009): Residue-use technical risk depends strongly on soda/alkalinity control and heavy-metal/NORM handling or immobilization. - C-010 (E-012): The DMR-3609 research-priority table highlights unresolved speciation and physicochemical-behavior gaps as blockers for scale-up in environmental/agronomic pathways.

Current focus: - Connect residue chemistry and impurity behavior directly to feasibility claims in T2 and risk controls in T6.

T4. Research and Collaboration Landscape

This section maps the research and collaboration ecosystem needed to move from technical potential to deployment.

T4.1 Capability Map

- Identify relevant Australian research and pilot capabilities.
- Map translational partners across industry, labs, and institutions.
- Position international collaborators that can accelerate execution.

T4.2 Collaboration Gaps

- Highlight missing links between research outputs and commercial adoption.
- Identify testing, standards, or qualification bottlenecks.
- Outline collaboration structures that can reduce deployment friction.

T5. Policy, Funding, and Programs

This section evaluates policy instruments and funding mechanisms that materially influence project bankability and timing.

Early evidence snapshot: - C-005 (E-007): Australia's 2024-25 Budget package includes a Green Aluminium Production Credit worth 10% of eligible costs over 2028-29 to 2035-36, plus additional support for Australian-made low-carbon aluminium. - C-006 (E-008): EU CBAM is in transition until 31 December 2025 and enters definitive operation on 1 January 2026, with aluminium explicitly in scope. - C-011 (E-013): DMR-3609 indicates implementation support must include standards, market development, liability/risk framing, and targeted

incentives in addition to technical R&D. - C-016 (E-018): AAC argues current low-carbon premiums are generally too small and inconsistent to finance transition at scale. - C-017 (E-019): AAC proposes production credits plus transformational infrastructure/technology funding and streamlined approvals. - C-018 (E-020): AAC frames transition-capital requirements as very large, citing an indicative global order-of-magnitude and an implied Australian share.

Current focus: - Evaluate domestic incentive design and destination-market carbon-border rules as one integrated policy-risk system. - Include implementation architecture assessment (standards, liability treatment, and adoption incentives) as a co-equal policy lens. - Test whether proposed instruments close competitiveness gaps before commodity-scale green premiums emerge.

T6. Evidence Quality, Gaps, and Confidence

This section provides the confidence posture for major claims and records unresolved uncertainty transparently.

Current confidence snapshot: - C-001: medium (strong directional evidence on concentration and demand growth; limited product-level demand disaggregation in current pass). - C-002: high (direct, convergent evidence on electricity-driven cost and emissions sensitivity). - C-003: medium (technology effect supported; commercial roll-out evidence still incomplete). - C-004: medium (Australia capability/export data is clear; independent government trade triangulation still pending). - C-005: high (policy instrument value and timing windows are explicit in primary budget documentation). - C-006: high (regulatory timeline and sector scope are explicit in primary EU documentation). - C-007: medium (strong historical synthesis support; current implementation status still requires updated validation). - C-008: medium (historical inventory and growth values are explicit but time-sensitive and require current refresh). - C-009: medium (framework is robust for structuring analysis but not a direct substitute for current techno-economics). - C-010: high (research-priority and knowledge-gap mapping is explicit and operationally useful). - C-011: high (implementation-support requirements are explicit and policy-relevant). - C-012: medium (directionally strong demand framing; requires direct triangulation with source datasets). - C-013: medium (concentration framing is plausible but should be cross-checked with independent official statistics). - C-014: high (constraint statement is explicit and repeated). - C-015: medium (timing is forecast-dependent). - C-016: medium (premium framing is informative but partly observational). - C-017: high (policy package is explicit). - C-018: medium (investment magnitude framing is useful but methodology-sensitive).

Temporal caveat: - DMR-3609 is a 2009 framework source; its quantitative baseline values are treated as historical unless refreshed by current primary datasets.

Source-positioning caveat: - The AAC 2024 paper is an industry submission; it is treated as primary evidence for stated constraints and policy asks, with quantitative claims triangulated before high-confidence neutral use.