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EXPERTS TAKE

‘Boundaries between climate policy, industrial policy, trade policy, and defense procurement have become analytically and institutionally inseparable’

An Interview with Göran Roos

In an era in which decarbonization is reshaping global supply chains, industrial policy, and economic security, understanding its implications for energy systems and critical minerals has become increasingly urgent. That urgency has been reinforced by Sweden’s mineral strategy, launched in July 2026, which explicitly positions securing access to metals and minerals as a matter of security policy and a key pillar of strategic autonomy.

Few scholars analyze these dynamics as comprehensively as Göran Roos, a Visiting Professor at Cranfield University and an Adjunct Professor at Adelaide University. Göran has held management roles across Europe, the U.S., and Asia, and has founded or co-founded knowledge-based companies across multiple countries. He is a Fellow of the Australian Academy of

Technological Sciences and Engineering (ATSE) and a Fellow of the Royal Swedish Academy of Engineering Sciences (IVA).

In an interview with ISDP's Tristan Eng, Göran Roos outlines how decarbonization has evolved into a central pillar of industrial strategy, economic security, and geopolitical competition. The discussion also explores the restructuring of global supply chains and Sweden's emerging role within Europe's industrial and resource strategy.

Note: This interview was conducted before Sweden's new mineral strategy was announced and has been updated by the interviewee through early August 2026.

Tristan: You have described decarbonization policy across major OECD economies as evolving through three distinct phases, each with its own institutional logic, policy tools, and understanding of the state's role. Could you walk us through these phases and explain what changed across them?

Göran: In the first phase, from the Kyoto Protocol in 1997 to around 2020, climate policy rested on the idea that pollution should cost money. Because emissions harm society without their producers paying for them, governments introduced carbon taxes and tradable permits, expecting a price to lead businesses to the cheapest abatement. The state's role was primarily that of a price-setter correcting a market failure. The European Union Emissions Trading System (EU ETS), established in 2005, became the most extensive application of this logic and remains the world's largest carbon market by traded value.

The Paris Agreement, which entered into force on November 4, 2016, replaced Kyoto's binding targets with nationally determined contributions; that architectural innovation prioritized breadth over depth. The World Bank documented 57 carbon pricing initiatives implemented or scheduled by 2019, covering approximately 20 percent of global emissions, yet fewer than 5 percent were both covered and priced at the $40–$80 per ton levels analysis suggested were necessary.

The second phase, emerging sharply after 2020, was a competitiveness pivot from market correction to active industrial strategy, with the state recast as investor and industrial strategist. Three overlapping shocks drove it. COVID-19 exposed vulnerabilities in global supply chains and prompted fiscal stimulus that blurred the boundary between climate and industrial policy. Russia's invasion of Ukraine in February 2022 triggered an energy crisis that reinforced the strategic value of domestic clean-energy production. Intensifying U.S.–China rivalry highlighted the strategic importance of clean-technology manufacturing.

Together these shocks produced what scholars call a geoeconomic turn: governments sought not merely to cut emissions but to capture the rents of the transition. The United States Inflation Reduction Act of August 2022 was the defining policy event of this phase, though the One Big Beautiful Bill Act unwound much of its clean-energy tax architecture in July 2025. European equivalents included the Green Deal Industrial Plan and the Net-Zero Industry Act, which sets a non-binding benchmark for EU manufacturing capacity to meet at least 40 percent of annual deployment needs by 2030.

The third phase, from approximately 2024 onward, integrates decarbonization policy fully with

economic security and defense industrial strategy. The EU Carbon Border Adjustment Mechanism (CBAM) entered its definitive operational phase on 1 January 2026, with financial obligations following in 2027, and the Critical Raw Materials Act set Union-level capacity benchmarks for 2030, designating 34 critical raw materials, 17 of them also strategic.

This phase's instruments are not only carbon-based: RESourceEU set out joint purchasing and stockpiling in December 2025, and a new permanent import regime cut EU quotas by roughly 47 percent from July 2026 behind a 50 percent out-of-quota duty. The state is now simultaneously an industrial strategist, a trade regulator, and a national security manager, and the boundaries between climate policy, industrial policy, trade policy, and defense procurement have become analytically and institutionally inseparable.

Tristan: You have argued that the EU's CBAM marks a shift into a new phase of decarbonization policy. What distinguishes it from traditional carbon pricing, and why does it represent something fundamentally different?

Göran: To understand what the CBAM represents, one must first understand why traditional carbon pricing was structurally insufficient for deep industrial decarbonization. The EU ETS has progressively tightened since 2005. Its first limitation is one of level: even as prices rose, carbon costs stayed below the abatement cost of primary steel and cement, so it did not by itself trigger the capital reallocation those sectors require. The more fundamental limitation is structural, since domestic carbon pricing reaches only emissions from domestic production. A steel producer in the EU subject to carbon costs competes with an importer from a jurisdiction with weak or no carbon regulation, creating what economists term carbon leakage—the relocation or substitution of production to lower-regulation jurisdictions.

What makes the CBAM a fundamentally new instrument is institutional rather than technical. Where traditional carbon pricing regulated domestic producers through domestic environmental law, the CBAM extends EU jurisdiction to the carbon content of imports, effectively requiring foreign producers to meet EU climate standards to reach EU markets. This is a unilateral extension of domestic climate governance into the international trade system, and it is contested accordingly: the July 2025 BRICS declaration, which both Brazil and India endorsed, rejected "unilateral and discriminatory carbon border adjustment mechanisms" by name.

I would enter one caveat about its practical weight. A 2025 simplification exempted importers below 50 tons a year—roughly nine in ten of them, though not for electricity or hydrogen—while retaining over 99 percent of embedded emissions, and the extension to downstream goods remains in negotiation. For steel specifically, the EU's operative trade instrument in 2026 is the new quantitative import regime rather than the carbon border. The CBAM's significance is institutional and precedential; its commercial bite is still arriving.

Tristan: In your work, you have pointed to the rise of 'friendshoring'—the shifting of supply chains toward trusted allies—in OECD policy as a reflection of the third phase in your framework. Yet, the EU Critical Raw Materials Act (CRMA) sets a benchmark that no more than 65 percent cap of the Union's annual consumption of any strategic raw material, at any relevant stage of processing, should come from a single third

What makes the CBAM a fundamentally new policy instrument is not primarily its technical design but its institutional logic. Traditional carbon pricing regulated domestic producers through domestic environmental law. The CBAM extends EU regulatory jurisdiction to the carbon content of imports, effectively requiring foreign producers to comply with EU climate standards if they wish to access EU markets. This represents a unilateral extension of domestic climate governance into the international trade system—a development without precedent in the history of carbon pricing.

country. Are these approaches complementary, or do they create tensions in how supply chains are being restructured?

Göran: At the broad strategic level, the CRMA and friendshoring share the objective of supply chain diversification and are therefore complementary. At the operational level, significant tensions exist. The 65 percent benchmark is country-agnostic: it applies to all third countries, including allied ones, and nothing in it varies with a supplier's political alignment. That creates a tension with friendshoring, which explicitly distinguishes preferred partners from strategic rivals.

The Act also sets a benchmark that Union capacity should be able to process at least 40 percent of annual consumption of strategic raw materials. This domestic processing imperative potentially competes with the interests of resource-rich allied nations that wish to retain processing capability within their own jurisdictions. And because the CRMA's mechanism is diversification and benchmarking rather than capability-building, it leaves the most sensitive materials—gallium, for which the EU retains no primary production, and the heavy rare earths, for which China supplies effectively all of the Union's needs—subject to continued dependency.

These tensions reflect a deeper ambiguity: whether the goal is genuine diversification, compatible with deep integration with allied suppliers, or strategic autonomy through domestic capacity. That ambiguity has begun to resolve, visibly toward the former. RESourceEU's joint purchasing, the thirteen third-country Strategic Projects designated in June 2025, and the EU–US Critical Minerals Action Plan of April 2026 all point to collective supply security among allies rather than autarky.

Tristan: Some reports suggest that Sweden could become a key producer of critical minerals, particularly from mines in the north. How do you see its role within the EU's emerging critical minerals strategy, and what are the main challenges it faces?

Göran: Sweden occupies a distinctive position in the EU's critical-minerals strategy. Beyond iron ore and green steel, it has significant deposits of rare earth elements, graphite, copper, zinc, and phosphorus. Its July 2026 mineral strategy formalizes this by treating mineral access as a security question and proposing faster permitting, designation of the

major ore regions as national interests, and state participation in strategic projects.

The Geological Survey of Sweden has documented deposits of antimony, fluorite, phosphate minerals, graphite, cobalt, platinum-group metals, rare earths, bismuth, and tungsten, with elevated concentrations of gallium, indium, and niobium in Bergslagen.

The most important initiative is LKAB's ReeMAP project, designated an EU Strategic Project in March 2025. It links the Malmberget mine, a planned Luleå industrial park, and the Per Geijer deposit in Kiruna, one of Europe's largest known rare-earth deposits. Talga's Natural Graphite ONE and NorthCYCLE also hold that status, although NorthCYCLE's designation is in limbo following its promoter's bankruptcy.

LKAB's management has indicated that ReeMAP could eventually supply about 18 percent of Europe's annual rare-earth demand, initially around 2.5 percent, as well as phosphorus equal to roughly 6 percent of EU agricultural demand. This matters: the EU currently mines no rare earths and imports most of its phosphate rock.

Three challenges remain. First, accelerated permitting collides with environmental law, biodiversity protections, and obligations to consult the Sami, whose reindeer-herding lands overlie the Per Geijer deposit: Sweden has not ratified ILO Convention 169, and its 2022 Consultation Act confers a duty to consult but no right of consent. Second, capital remains uncertain: Talga has secured permits and public funding but has taken no final investment decision. Third, the constraint is electricity delivery rather than supply, to which I will return.

Tristan: How does Sweden's emerging northern industrial cluster build on its existing role in EU mining and critical minerals supply, and how do these elements integrate into the EU's emerging strategy?

Göran: A distinctive feature of the Swedish ecosystem is the dense concentration of domestically headquartered world-class enterprises supplying equipment, services, and digital technologies to every stage of the minerals value chain, alongside domestic industrial users drawing on mineral outputs as critical inputs.

At the extraction end, Boliden anchors Swedish production of copper, zinc, and other base metals: Aitik is Sweden's largest open-pit copper mine;

Sweden occupies a distinctive and increasingly multidimensional position within the EU's critical minerals strategy. That position rests not solely on iron ore and green steel—the dimensions most commonly discussed—but on a remarkably broad mineral endowment spanning rare earth elements, graphite, copper, zinc, cobalt, phosphorus, and an array of co-products that position Sweden as potentially one of the most strategically significant domestic suppliers within the EU's Critical Raw Materials Act architecture.

Garpenberg is among the world's most productive underground zinc mines; and the Rönnskär smelter has capacity to recycle 120,000 tons of electronic scrap a year, among the largest such operations in the world.

On the supply side, two Swedish-headquartered companies, Epiroc and Sandvik, sit alongside U.S.-based Caterpillar in a three-company oligopoly estimated to account collectively for around 75 percent of underground mining trucks and 88 percent of underground loaders globally. Atlas Copco provides the compression, vacuum, and industrial gas systems essential to mineral processing and hydrogen production. SKF, one of the world's largest bearing manufacturers, and Alfa Laval, whose heat exchangers and centrifuges serve hydrometallurgical processing, supply technologies without which no mine or refinery functions. Hexagon's mining division provides the planning, optimization, and autonomous systems software underpinning mine operations.

On the demand side, domestic manufacturers have made commercial commitments to that value chain. The Volvo Group has used SSAB Zero recycled, near-zero-emission steel in the frame rails of around 12,000 FH and FM trucks, cutting CO_2 per truck by two to three percent. In June 2025 Volvo Cars signed a supply agreement with SSAB for the same steel—the first such serial-production commitment by an automaker—covering the EX60 and other models on its new platform, with production beginning at Torslanda in April 2026. These are distinct from the HYBRIT route: SSAB Zero is recycled scrap melted with fossil-free electricity and biogas, whereas hydrogen-reduced primary steel is a later and much larger step.

I would nonetheless resist calling the aggregate picture a finished national innovation system. The cluster is real and rare: few economies combine a domestic mining-technology supply base with major downstream industrial users. But the layer that has repeatedly failed is neither geology, technology, nor demand; it is capital and infrastructure. Northvolt, the battery pillar of that system, went bankrupt in March 2025 and its Skellefteå assets now belong to an American owner, while Volvo Cars placed its own cell venture into hibernation in January 2026. What Sweden offers the EU is an unusually complete industrial base whose binding constraints are project finance and grid connection.

Tristan: Sweden's HYBRIT green steel initiative is often cited as a flagship example of industrial decarbonization in practice. Could you assess its progress, including its emissions impact and integration into EU climate strategy? And what are the key economic, regulatory, and coordination challenges that could affect its long-term viability?

Göran: The HYBRIT green steel initiative—the dimension of Sweden's strategy that has attracted the most international attention—has completed its pilot phase and is moving, more slowly than intended, toward industrialization. The pilot plant in Luleå, built from 2018 and operational from August 2020, produced over 5,000 tons of hydrogen-reduced sponge iron before the program reported results in 2024. HYBRIT reports that its hydrogen direct reduction and electric arc furnace route achieves under 0.05 tons of CO_2 equivalent per ton of steel in scopes one and two, against roughly 2.2 tons for blast-furnace steel—well over a 95 percent reduction.

Industrialization has proved harder than the chemistry. The demonstration plant at LKAB's Malmberget site, originally to be ready during

The HYBRIT green steel initiative—the dimension of Sweden's strategy that has attracted most international attention—has completed its pilot phase and is now moving into industrialization. The pilot plant in Luleå produced over 5,000 tonnes of hydrogen-reduced sponge iron across 61 weeks of trials, proving the fossil-free value chain from ore to steel on a semi-industrial scale, with the hydrogen-based direct reduction process achieving a reduction of approximately 95 percent.

2026, received its environmental permit only in June 2026. That ruling has been appealed, including by LKAB itself, and no final investment decision has been taken; completion is now expected no earlier than 2028–2029. SSAB's Luleå and Oxelösund conversions have slipped in parallel, on grid connection and permitting appeals.

The emissions-reduction potential remains large: SSAB puts its Swedish transformation at approximately 10 percent of the country's total CO_2 emissions. Sweden's electricity is roughly 98 percent fossil-free, a real advantage for electrolysis, but the constraint is delivery rather than endowment: the demonstration plant alone would need about 5 TWh a year, close to 4 percent of Swedish consumption.

On economic sustainability I can be more concrete than the literature allows. The Swedish National Audit Office concluded in April 2025 that, although LKAB had acted commercially reasonably, it was far from certain the investment would be profitable. The Audit Office also criticized the state, as owner, for applying a profitability target below the level it had itself calculated. The sector-wide evidence agrees: ArcelorMittal abandoned two German hydrogen-based projects in June 2025, forgoing €1.3 billion of committed subsidy, and Stegra, Sweden's greenfield plant at Boden, survived only through a €1.4 billion recapitalization completed in June 2026 that put a Wallenberg-led consortium in the lead, with no production date published.

A regulatory question compounds this. Reductions from Swedish green steel could in principle free up EU ETS allowances for use elsewhere—the waterbed effect. Since 2023 the Market Stability Reserve has permanently cancelled surplus allowances, roughly 2.9 billion by end-2024, substantially neutralizing it. That safeguard is now itself in question: in April 2026 the Commission proposed ending the invalidation mechanism and holding the allowances as a buffer. Should that be adopted, a concern many had treated as settled would return, and the climate case for the transformation depends once again on the trajectory of the cap.